March 2016

YANCOAL SOUTHEY PROJECT

Environmental Impact Statement

Submitted to:
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Saskatoon, Saskatchewan
S7K 1N1

REPORT

Report Number: 12-1362-0197 (DCN-073)

兖煤加拿大资源有限公司

Executive Summary

INTRODUCTION

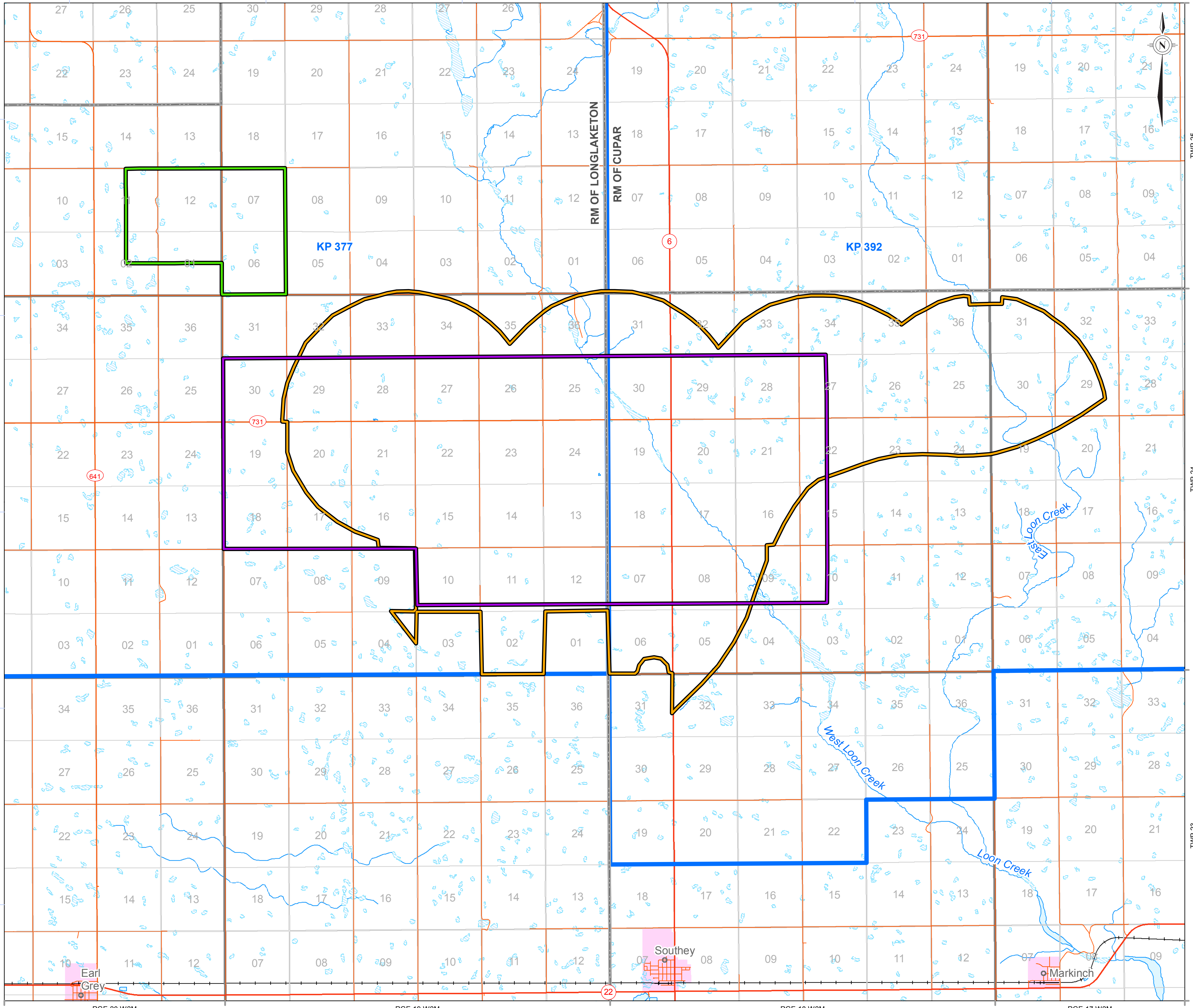
Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project). Yancoal has identified a world-class potash deposit and intends to develop the resource in an ecologically sustainable, economically efficient, and socially responsible manner.

Yancoal is a wholly owned subsidiary of Yanzhou Coal Mining Company Limited (Yanzhou Coal). Yanzhou Coal's main business is coal mining, coal chemical and fertilizer production, power generation, and equipment manufacturing. Yanzhou Coal is an international, diversified mining corporation listed on the stock exchanges of New York, Shanghai, Sydney, and Hong Kong.

The Project will be a Greenfield solution potash mine within Subsurface Mineral Permits KP377 and KP392. The Project is located in central Saskatchewan, approximately 60 kilometres north of Regina within the Rural Municipality of Longlaketon (No. 219) and the Rural Municipality of Cupar (No. 218) (Figure 1). The community of Earl Grey is located approximately 21 kilometres southwest of the Project, the community of Strasbourg lies approximately 23 kilometres west, and the community of Southey is approximately 28 kilometres southeast. The Project (including the core facilities, 65-year mine field, and indicated resource boundary) encompasses approximately 143 square kilometres (14,320 hectares) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian. In support of the Project, Yancoal has acquired approximately 1,108 hectares of freehold land for the core facilities area and 787 hectares within the mine well field area. Yancoal intends to secure (e.g., through lease agreements) the land required for the full mine well field area as it expands over time; as such, the land acquisition process will be ongoing.

Canadian potash exports have played an increasingly important role in maintaining and expanding global crop yields in recent years. This is important because of a combination of increasing population levels, rising levels of income in developing countries, poor harvests in key producing regions due to floods and drought, and the demand for biofuels. These factors have led to a steady increase in the global demand for fertilizer. Continued growth is projected because the long-term demand for potash is strong in supporting increasing global requirements for food production.

In addition to the supporting increased global food production, the anticipated benefits of the Project are extensive. Approximately 2,200 workers will be required during the peak of construction with approximately 1,500 workers required on average, during the 3.5-year construction period. Local and regional economies will benefit in many ways from the construction phase of the Project. Some of these opportunities will be job creation, purchase of local supplies and services, taxes paid to the municipalities, and road improvements. After mining commences, the long-term benefits will include royalty payments to the Government of Saskatchewan, job creation, taxes paid to the municipalities, ongoing purchase of supplies and services, and housing development.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- RURAL MUNICIPALITY BOUNDARY
- SECTION BOUNDARY
- URBAN MUNICIPALITY
- PERMIT BOUNDARY
- CORE FACILITIES AREA
- 65 YEAR MINE FIELD
- INDICATED RESOURCE BOUNDARY

REFERENCE

INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

2 0 2
SCALE 1:100,000 KILOMETRES

PROJECT
YANCOAL
SOUTHEY PROJECT

TITLE
CORE FACILITIES AND MINE FIELD AREAS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	MT	12/02/15	SCALE AS SHOWN	REV. 0
GIS	LMS/AK	20/01/16	FIGURE: 1	
CHECK	MT	20/01/16		
REVIEW	GM	20/01/16		

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1075 EIS Non-Discipline Specific\Executive Summary\12-1362-0197 - Core Facilities and Mine Well Field Area.mxd Date: 1/20/2016 11:00:07 AM

REGULATORY APPROVALS AND AUTHORIZATIONS REQUIRED FOR THE YANCOAL SOUTHEY PROJECT

Yancoal submitted a Technical Proposal to Environmental Assessment Branch of the Ministry of Environment for the Project on February 17, 2015. In anticipation of the Project being considered a development, Yancoal requested review under Section 15 of the Saskatchewan *Environmental Assessment Act* (2010).

In accordance with Section 2(d) of the Saskatchewan *Environmental Assessment Act* (2010), Yancoal, as the proponent, must submit an Environmental Impact Statement to the Ministry of Environment. Should the Environmental Impact Statement sufficiently demonstrate that the Project is environmentally acceptable; the proponent's applications will be considered for the necessary provincial approvals, permits, and licences that regulate construction and operation.

The federal environmental assessment requirements are detailed within the *Canadian Environmental Assessment Act* (2012). Under Section 8 of the *Canadian Environmental Assessment Act* (2012), a Project Description is required to initiate the screening process through which the Canadian Environmental Assessment Agency will determine if a federal environmental assessment is required for a designated project. Designated projects are defined under the *Regulations Designating Physical Activities* for the *Canadian Environmental Assessment Act*. Based on our understanding of the Project, submission of a Project Description to the Agency will not be required because potash mine development is not listed in the *Regulations Designating Physical Activities.*

Other federal legislation, such as the *Navigation Protection Act* (2012), the *Fisheries Act* (2012), the *Species at Risk Act* (2014) and the *Migratory Birds Convention Act* (1994) will be considered. Transport Canada, Fisheries and Oceans Canada, and Environment Canada will be contacted directly should the Project require further review by, or discussion with, these agencies.

PROJECT ALTERNATIVES

Alternative means of carrying out the Project were considered early in the development planning, providing a comparison of economic, environmental, and social benefits. Various alternatives considered for the Project included:

- Project location;
- mining method;
- mine well field area pipelines;
- process technology;
- tailings and brine management;
- tailings decommissioning;
- water supply;
- construction accommodations; and
- access roads.

PROJECT DESCRIPTION

The Project is a greenfield potash solution mine that will extract potash ore (sylvinite) from the Patience Lake, Belle Plaine, and Esterhazy members of the Saskatchewan Prairie Evaporite Formation.

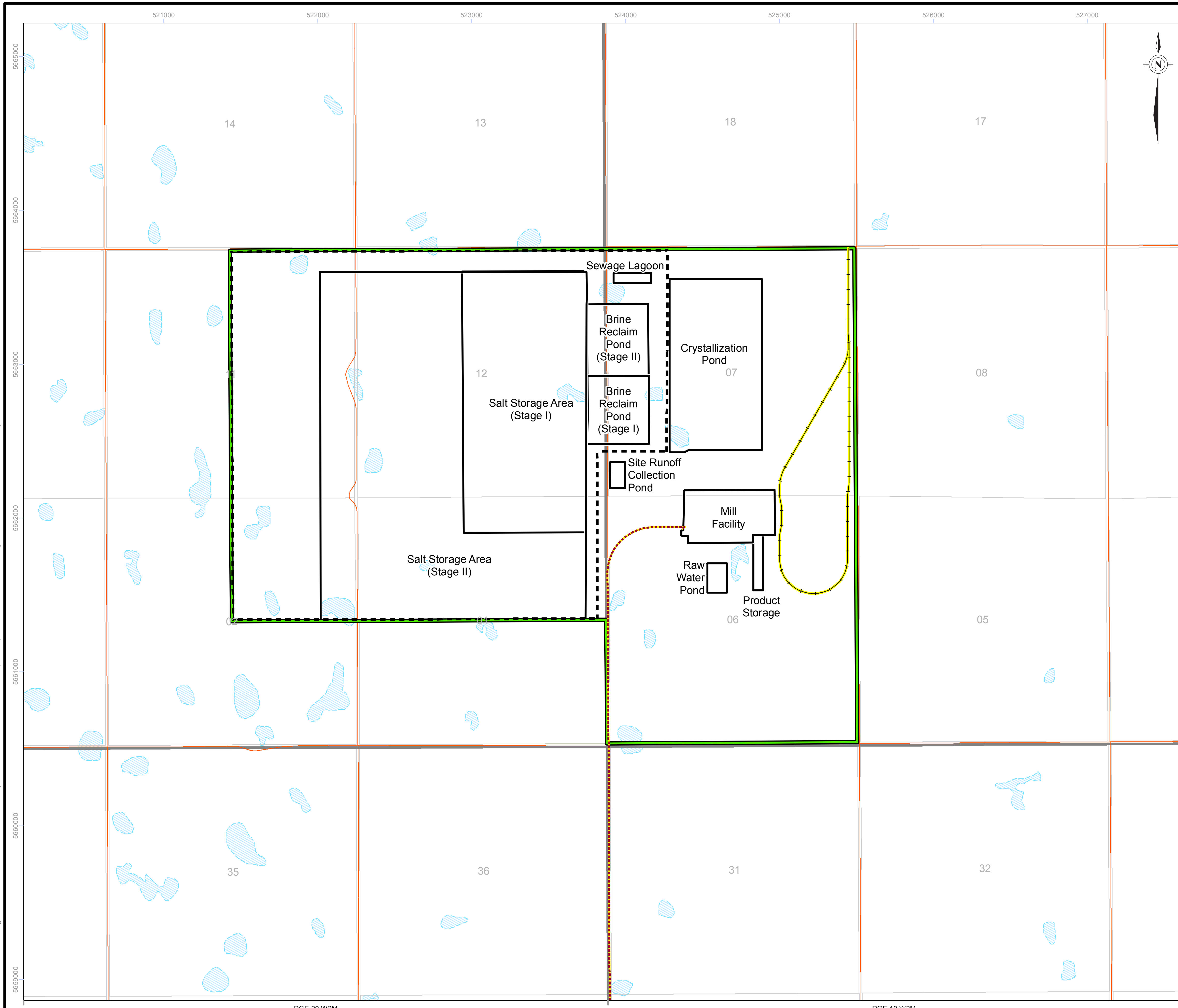
Development of the Project is planned in several phases. The construction phase is anticipated to begin in May 2016 or as soon as the relevant Project regulatory permits and approvals are in place. The operations phase will begin in 2019 and, at the proposed production rate, will remain in operation for up to 100 years. Activities following operations will include those necessary to complete decommissioning and reclamation.

The core facilities area and supporting infrastructure will be built during the construction phase (approximately 39 months). The core facilities area will include the processing plant, administration buildings, maintenance building, equipment and parts storage, tank farm, raw water pond, process upset pond, tailings management area, product storage, rail loadout, security, and parking. The tailings management area will consist of the Stage I and Stage II salt storage area, Stage I and Stage II brine reclaim pond, sewage lagoon, and surface diversion works. The general layout for the Project site is shown on Figure 2.

The operations phase (i.e., solution mining and processing of potash) will begin following construction and is anticipated to continue for up to 100 years. During the operations phase the Project will employ primary and secondary solution mining techniques to extract the potash resource. Primary mining involves the injection of hot water to the sylvinite beds to dissolve potassium chloride and sodium chloride; then the brine solution is extracted and transported by pipeline to the process plant. Secondary mining involves the injection of sodium chloride-rich brine into the cavern created during primary mining to selectively dissolve additional potash from the material remaining in the cavern. This brine solution is extracted and returned to the process plant by pipeline.

The processing plant will be designed for a production capacity of 2.8 million tonnes per year of potash. Potash processing will include:

- injection and solution recovery;
- evaporation and crystallization;
- product drying and screening;
- product compaction; and
- product storage and shipping.



LEGEND

- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- SECTION BOUNDARY
- PROPOSED ACCESS ROAD
- PROPOSED RAIL LOOP
- CORE FACILITIES AREA
- PROPOSED SITE INFRASTRUCTURE
- TAILINGS MANAGEMENT AREA

REFERENCE

INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
TMA DESIGN REVISED BY GOLDER, 2014
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

500 0 500
SCALE 1:25,000 METRES

PROJECT
YANCOAL SOUTHEY PROJECT

TITLE
GENERAL SITE LAYOUT

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	LMS/AK	20/01/16	
CHECK	MT	20/01/16	
REVIEW	GM	20/01/16	

FIGURE: 2

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1075 EIS Non-Discipline Specific\Executive Summary\12-1362-0197 - General Site Layout.mxd Date: 1/20/2016 11:01:27 AM

The Project includes underground and surface infrastructure for extracting and handling potash, and the construction or upgrading of roads. The Project is expected to produce approximately 2.8 million tonnes of potash each year over a projected 65-year operations period, based on current indicated resource estimates. It is expected that additional potash deposits will be discovered during mine development, extending the life and production of the mine. Accordingly, a 100-year life of mine was assessed in this Environmental Impact Statement.

The scope of the environmental assessment includes the activities and components associated with the construction, operation, and decommissioning phases of the Project. Construction activities include the building of surface infrastructure and support facilities, as well as construction and upgrades to access roads. Operational activities include solution mining of the potash deposit and operation of the process plant, surface infrastructure and support facilities, brine and site water management, waste salt storage, temporary storage of industrial, domestic, hazardous, and contaminated waste, and transportation of the product by rail. A conceptual Decommissioning and Reclamation Plan and supporting financial assurance mechanism will be submitted during licensing to the Ministry of Environment in compliance with the *Mineral Industry Environmental Protection Regulations*.

Mineral Resource

The Prairie Evaporite Formation is divided into three principal potash-bearing members and one auxiliary member. In ascending stratigraphic order they are: the Esterhazy Member, the Belle Plaine Member, and the Patience Lake Member. These beds are generally flat-lying and are formed of interbedded sylvite, halite, carnallite, clay seams, and minor amounts of anhydrite. The auxiliary potash member, the White Bear Member, is situated between the Belle Plaine and the Esterhazy members. The three Potash Members (Patience Lake, Belle Plaine and Esterhazy), as well as the Salt Back (above the Patience Lake) and the Interbed (between Patience Lake and Belle Plaine) are considered the key stratigraphic intervals for the Project.

Mineral resources and potassium chloride grades have been determined for the Project through an exploration program that included drill holes (with core samples) and an advanced three-dimensional seismic survey to determine the continuity of the deposit between drill holes. The potash mineral resource was classified based on the radius from the cored drill holes, the thickness, and grade of the selected solution mine interval, as well as the loss factors that account for unknown geologic anomalies.

The Project currently has an in-situ sylvinite tonnage of 5,089 million metric tonnes, and currently has defined Mineral Resources (minable sylvinite tonnage) totalling 1,529 million metric tonnes and is comprised of the following:

- measured resource: 227.0 million metric tonnes;
- indicated resource: 653.0 million metric tonnes; and
- inferred resource: 649.1 million metric tonnes.

Depending on ultimate production, this would indicate an initial mine life of 65 years. Additional exploration is anticipated in the future to further evaluate the potash resource within the current inferred resource area to upgrade it to the measured and indicated categories. It is anticipated this will extend the mine life to 100 years.

Construction Activities

Temporary buildings located on the Project core facilities area during construction activities will consist of construction offices, laydown areas, lunchrooms and washrooms, and safety trailers. A temporary construction camp will be constructed close to the core facilities area. To reduce effects on the environment, temporary infrastructure will be demobilized as permanent facilities become available for use during construction.

Temporary utilities will be provided for water, power, natural gas, and high-speed telecommunications at the beginning of construction activities. Construction of on-site infrastructure will include the installation of permanent buried services and temporary construction infrastructure. Existing roads are expected to be adequate to support early construction activities; however, road upgrades are required to connect the core facilities area to Highway 6. A rail spur is needed to connect to the Canadian National or Canadian Pacific railway lines.

Non-hazardous wastes will be collected and transferred to off-site recycling companies. Inert wastes will be collected and transferred to an off-site, permitted landfill for final disposal by a licensed contractor.

During construction, an inventory of all hazardous substances and waste dangerous goods for storage will be established and maintained. All storage and handling of hazardous materials and hazardous waste will meet the requirements of the *Hazardous Substances and Waste Dangerous Goods Act and Regulations* and *Transportation of Dangerous Goods Act and Regulations (1992)*. Fuel will be stored on-site in above ground storage tanks. These tanks will be installed and operated in compliance with provincial and federal regulatory requirements. The sewer system will include a septic tank with local contractors providing pump-out service on a regular basis. Aggregate (sand and gravel), required for the construction activities, will be obtained from regional sources.

Yancoal will develop a Health, Safety, Security, and Environmental Management System that will conform to regulatory requirements and will endorse the principles of continual improvement. Prior to commencement of construction, the Engineering, Procurement, and Construction Management contractor, in conjunction with the Yancoal environmental team, will develop the environmental program for use during construction. Management and monitoring of the environmental program will be based on the site-specific permit requirements for the Project.

Mining

The potash resource will be extracted using solution mining, which involves the dissolution of a selected sylvinite bed with removal of all the soluble minerals or, alternatively, removal of only the potash component between the bottom and top of the cavern. A primary mining production target of 2.0 million tonnes per annum of potash product can be met with approximately 35 caverns in production. The primary mining phase per cavern (after cavern development) is estimated to be completed after roughly 4.3 years, and the replacement rate is estimated to be 9 caverns or 18 wells per year.

The well pad layout is based on the assumption that up to 14 caverns will be developed from a single pad. This requires 28 wells from a pad. As many as 20 caverns could be developed from a single well pad in some locations; this would further reduce the amount of surface disturbance required within the mine well field area. The potential to increase the number of caverns per well pad is being further evaluated during the feasibility study. The chosen alternative for the mine well field area piping is to install underground pipelines with allowances made for road crossings and avoidance of environmentally sensitive areas. The installation of underground pipelines requires initial surface disturbance; however, land can be reclaimed and remain productive for further use (e.g., agricultural practices). Leak detection, monitoring, and appropriate pipeline isolation will be provided.

Primary solution mining begins by undercutting the mineralized zone by dissolving an initial cavern within the halite that underlies a potash bed. This is followed by dissolving the salt and potash upward and through the mineralized beds, while using a ceiling cap of oil or gas. The oil or gas cap inhibits vertical cavern growth until a sufficiently large area is undermined. Mining then progresses vertically by raising the cap and dissolving mineralized portions of the roof.

Secondary mining follows primary mining and differs in that the injection liquor is saturated in sodium chloride and has a relatively low concentration of potassium chloride. Secondary mining production is not possible until primary mining has been completed in the first 35 caverns, which will be available for secondary recovery 4.22 years after start-up.

With the addition of secondary mining, the cavern life is estimated at 6.8 to 6.9 years for three-bed mining and 4.1 years for two-bed mining. Secondary mining can be conducted as a continuous or an intermittent batch operation.

Environmental design features have been integrated into the mine plan and mining methods to reduce or limit effects on the biophysical and socio-economic environments. The well pad design reduces surface disturbance, and unmined pillars of the existing geological formation will be left between the caverns to increase stability during mining and reduce the potential effects of subsidence. Cavern spacing may be adjusted to reduce surface strains and limit the potential effect of subsidence on surface development.

Processing

The process plant will consist of the following main components: evaporation, crystallization, centrifuging and drying, product screening, compaction, pond crystallization, loadout and storage, salt handling, and reagent storage and preparation. The process plant will be designed for a primary production mining target of 2.0 million tonnes per annum of potash product. Production during secondary mining will increase overall production to 2.8 million tonnes per annum of potash product. The process plant is designed to produce 40 percent granular and 60 percent standard product with a potassium oxide grade of 62 percent.

The volume of salt tailings generated as a waste product during solution mining is lower than that produced by conventional underground mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only potassium chloride is removed from the caverns during this process. Site characterization studies will be conducted to support the design of the waste salt pile and containment system. A containment system will be designed to control migration of brine from the salt storage area to underlying aquifers and control the horizontal migration of brine, as required. The waste salt storage pile will be enclosed by a perimeter dyke for containment of deposited waste material and collection of brine runoff. All brine will be diverted to the brine reclaim pond. The process plant layout has been designed with features to divert freshwater runoff around the core facilities area to avoid potential contamination. Excess brine reclaimed from the tailings management area will be disposed of by deep well injection through operations and decommissioning and reclamation. A Water Management Plan will be developed for the Project to assess the potential for capture and reuse of site runoff water to reduce makeup water requirements.

Permanent buildings will be constructed to facilitate the daily operation of the Project. Major buildings include the process plant, the maintenance shop, mill warehouse, the administration office and dry facilities, the product storage building, the rail loadout building, and the powerhouse containing boilers, transformers, and water treatment facilities.

At all locations, hazardous substances will be contained with an adequately sized containment berm or contained in a double-walled tank, depending on the hazardous material. In the event of a leak or spillage, the hazardous substance will be contained, collected, and properly disposed of off-site. All hazardous substance storage facilities will be designed and permitted in compliance with Ministry of Environment requirements.

Environmental design features have been integrated into the design process for the Project to reduce or limit potential effects of brine processing on the environment. For example, the plant will be designed to reduce usage of energy and water and heat will be recovered, where possible, to reduce the thermal and electrical load on the plant. The process plant will be designed to control air and dust emissions. The compact plant layout will limit the area that is disturbed by the Project. The fuel storage and dispensing system will consist of double-walled tanks. All fuel dispensing will be performed over concrete containment pads and in accordance with applicable regulations.

Supporting Infrastructure

The raw water supply will be delivered to site by SaskWater through a buried pipeline approximately 100 kilometres long, extending from Buffalo Pound Lake to the Yancoal core facilities area. Raw water will be used for solution mining, process and utility requirements within the plant, as well as cooling water and fire-fighting water. During initial cavern development, the approximate requirement for water is 1,602 cubic metres per hour. During normal operations at full production, the maximum average requirement for water is 1,450 cubic metres per hour. The Water Security Agency has issued a water allocation to Yancoal providing raw water for the Project from Buffalo Pound Lake. The raw water pond storage capacity will be sized to accommodate the site's raw water demands and fire-fighting water demands including a maximum 48-hour surge capacity for process raw water demand of 1,602 cubic metres per hour, fire-fighting water dedicated capacity of 908 cubic metres, and a minimum pond capacity is 72,908 cubic metres.

Permanent electrical power supply for the Project will be provided by SaskPower and will be delivered by a new 230-kilovolt line, approximately 18 kilometres in length that will connect the existing Condie-Wolverine line (C1W) to the Yancoal-owned electrical terminal station located south of the core facilities area. Natural gas will be delivered to the Project via a natural gas supply pipeline constructed and operated by TransGas. The natural gas supply to site will require the installation of a new buried high-pressure steel pipeline. The service provider for telecommunications is expected to be SaskTel. SaskTel will own and maintain all telecommunications infrastructure up to the site telecommunications distribution system.

Access roads must be capable of withstanding consistent heavy traffic including construction and contractor heavy equipment, and materials delivery. The main vehicle access to the core facilities area will be from Highway 6, turning west onto rural grid road 731 for approximately 5.6 kilometres, and turning north onto an existing secondary grid road for approximately 1.6 kilometres before entering the south boundary of the core facilities area.

Worker transportation options will be explored to reduce commuter traffic. This may include using a bus or shuttle system to and from the temporary construction camp and nearby communities, or organizing a carpooling system. In summary, it is anticipated that approximately 750 vehicle trips will enter and exit the core facilities area at peak morning and afternoon traffic times during construction. It is also assumed that during construction, 15 large truck deliveries per week, and 14 over-dimension trucks per month will enter and exit the core facilities area. During operations, it is anticipated that 225 vehicle trips are anticipated to occur at peak morning and afternoon commuting times, and five large truck deliveries per week.

The proposed railway route will be designed to transport potash from the site to a port facility on the West Coast. Two options are being considered: the Canadian Pacific Lanigan line and the Canadian National Watrous line. The off-site rail line is expected to be 25- to 35-kilometres long. The railway spur will be a single track designed to handle the incoming and outgoing traffic. The tracks will be developed to provide safe operation and storage of unit trains. Carloads are anticipated at maximum 120,000 kilograms loading. Either Canadian Pacific or Canadian National will be the proponent for the new rail line.

Environmental design features have been incorporated into the supporting infrastructure to reduce or eliminate potential environmental effects from the Project. The existing road system in the area will be used, to the extent possible, to limit disturbance from new road construction. In addition, new road segments, will be located along existing corridors, where possible, to reduce disturbance to undisturbed lands. Worker transportation will be explored to reduce commuter traffic, especially at night.

Domestic and Industrial Waste Management

Domestic waste generated on-site during the life of the Project includes food wastes, wastes from construction, operations and administration offices, and sanitary sewage. Food wastes will be collected in suitable containers and covered to reduce wildlife attraction. Recyclable materials will be sorted and collected in appropriate containers. All domestic wastes will be collected and transferred to appropriate off-site disposal facilities by a licensed contractor. Non-hazardous wastes that will be generated during mine and processing operations typically will include plastics, wood, metal, and other inert materials. Yancoal will establish a recycling program for these wastes to reduce the amount of material that ultimately goes to the off-site landfill. Appropriate waste containers will be provided where materials are generated and the materials will be segregated at source for recycling. The material then will be transferred to offsite recycling companies.

All storage and handling of hazardous materials and hazardous waste will meet the requirements of the *Hazardous Substances and Waste Dangerous Goods Act and Regulations* (2004) and *Transportation of Dangerous Goods Act and Regulations* (1992), including employee training, storage facility design and operation, labelling, and material control. Hazardous industrial waste expected to be generated at the site during operations includes waste hydrocarbons, chemicals, glycols, solvents, antifreeze, and batteries. The Waste Management Plan will include collecting these wastes in suitable containers and storing them for shipment off-site to recycle or to disposal facilities via a licensed contractor. Where suppliers will accept them, empty containers used to ship these materials to site will be returned to the supplier. Those containers that cannot be returned will be shipped to recycle or disposal facilities.

Health, Safety, Security and Environmental Management System

Yancoal will develop a Health, Safety, Security and Environmental Management System that will conform to regulatory requirements, notably, *The Saskatchewan Employment Act* (2014) and *The Energy and Mines Act* (1982-83), and will endorse the principles of continual improvement. Programs included as part of the Health, Safety, Security and Environmental Management System are an Occupational Health and Safety Plan, an Environmental Protection Plan, an Emergency Response Plan, a Human Resources Plan, and a Community Relations Plan.

Decommissioning and Reclamation

The decommissioning and reclamation strategy at this stage of the Project is conceptual, however, due to the timelines envisioned for the site to be decommissioned and reclaimed, long range planning is required. A Project-specific Decommissioning and Reclamation Plan will provide a framework for decommissioning facilities and infrastructure on the site, so that the environment and the public will be protected over the long-term. Detailed plans for decommissioning and reclamation will be developed in consultation with regulatory agencies during licensing. The strategy for Project decommissioning is based on current practices and plans for other Saskatchewan potash operations. However, once the Ministry of Environment establishes decommissioning and reclamation requirements specific to the potash mining industry, the Decommissioning and Reclamation Plan will be revised accordingly.

Human Resources

A Human Resources Plan will be developed in anticipation of the commencement of construction. It is anticipated there will be approximately 2,200 workers required during the peak of construction. These jobs include equipment operators, electrical, carpentry, heating, ventilation, and air conditioning, specialized welding, safety, environmental, procurement, and administrative workers. Given the current labour market in Saskatchewan and the construction and operational personnel required, labour will likely need to be sourced from outside of Saskatchewan. About 350 full time jobs will be created for operations. These jobs are typical for a large industrial operation and include drilling, heavy equipment operators, process operators, instrumentation, environmental, safety, training, administration, and management personnel.

Yancoal will give priority to skilled local labour to the extent possible, and will look at potential partnerships with nearby communities and surrounding First Nations and Métis communities.

ENGAGEMENT

Engagement is an important aspect of the environmental assessment process as it provides an avenue to present information about the Project to local residents, communities, First Nations and Métis communities, and regulatory agencies. Similarly, it provides an opportunity for Yancoal to gather comments and concerns from various sources, and consider them during the design of the Project. Early in the Project, Yancoal determined that it was important to create and maintain relationships with the local residents, communities, and First Nations, and Métis communities who may potentially be affected by the Project. Consequently, the engagement approach was considered an integral component of the Project planning and environmental assessment process.

Various activities were carried out to establish and maintain engagement activities with members of the nearby communities. These activities included formal presentations, community information sessions, and informal meetings with nearby residents. Efforts were made to engage the communities and Rural Municipalities that are located closest to the Project, with the purpose of providing an improved understanding of the Project and the potential effects it could have on the region.

Yancoal hosted three sets of community information sessions in the Project area. Each community information session followed a “come and go” format. The first round of community information sessions were held in November 2013. The second round took place in March 2015 with the purpose of providing updated information from the Technical Proposal prepared for the Project. The third round of community information sessions took place in July 2015 with the purpose of informing the public on the current status of the Project and providing preliminary results of the environmental assessment and the predicted impacts of the Project on the environment presented in the environmental impact statement (EIS). Most attendees were supportive of the Project, with questions focussed on the potential environmental and socio-economic effects, as well as traffic and transportation, land acquisition, and groundwater.

In determining the First Nations and Métis communities to be included in the engagement process, Yancoal considered their proximity to the Project, and their potential interest in the Project or their potential to be affected by the Project. As a result, 15 First Nation and Métis communities were included in the engagement activities completed for the Project. Engagement with First Nations and Métis communities was initiated in July 2013 and has been on going through Project development. Information packages following the three rounds of community information sessions were provided to each community. The majority of communities/organizations have been supportive of the Project and requested that they be kept up-to-date on the Project activities. Engagement activities with First Nations and Métis communities will continue following submission of the Environmental Impact Statement.

Government and regulatory agencies were another important part of Yancoal's engagement approach. In June and July 2013, Yancoal met with the rural municipalities located closest to the Project, including Longlaketon (Rural Municipality No. 219), Cupar (Rural Municipality No. 218), Mount Hope (Rural Municipality No. 278), and Touchwood (Rural Municipality No. 248) to introduce representatives from Yancoal and to provide introductory information about the Project. Information packages and subsequent Projects updates were provided following the three rounds of community information sessions. The main topics of concern brought forward included the Project location, the type of mining, the water source, the drilling activities, environmental impacts, utilities required for the Project (i.e., road, rail), water containment, noise, light and dust pollution, tailings containment, land acquisition process, and the desire for more engagement activities.

Meetings with the Ministry of Environment were held in May 2013 and May 2015 to provide regulators with an overview of the Project. The objectives of these meetings were to brief the participants on the Project and schedule, and discuss any comments or concerns prior to the submission of the Environmental Impact Statement.

Overall, most of the feedback received during the engagement activities has been positive. Stakeholders are interested in the Project and want to be involved in the engagement process as much as possible as the Project progresses. Questions and concerns brought forward during the engagement activities were generally about Project details including location and timeline; how the Project would affect the environment, the landowners, and the other stakeholders in the local area; and what benefits it would provide.

Yancoal is dedicated to maintaining the relationships created during these engagement activities, and will continue to provide updates to the identified stakeholders as the Project continues to develop.

ENVIRONMENTAL ASSESSMENT APPROACH

The environmental assessment analyzed and classified the environmental effects, and determined the significance of the effects from the Project and other developments on the biophysical and socio-economic components of the environment. The environmental assessment used the following key elements for assessing effects:

- identification and definition of valued components, and the associated assessment endpoints and measurement indicators;
- definition of the spatial and temporal boundaries of the assessment and assessment cases (Base Case, Application Case, and Reasonably Foreseeable Development Case) used to evaluate the effects of the Project for each valued component;
- description of existing conditions for each valued component;

- identification of potential Project interactions (pathways), environmental design features and mitigation, and a screening level assessment (pathways analysis) of potential interactions to identify Project components or activities that have potential to result in a residual effect;
- residual effects analysis that evaluated the anticipated incremental and cumulative residual effects on valued components;
- identification of sources of uncertainty and how uncertainty was managed in the assessment to increase confidence that effects are not underestimated;
- classification of residual effects and determination of significance of predicted residual effects; and
- identification of the expected monitoring and follow-up programs to test residual effects predictions, and address the key sources of uncertainty.

A list of biophysical and socio-economic valued components was selected for the Project, based on input from on-going engagement. Valued components represent physical, biological, cultural, social, and economical properties of the environment determined to be important by the proponent, the public, First Nations and Métis communities, and government agencies. The significance of effects from the Project on valued components was evaluated by linking changes to measurement indicators to the predicted effects on assessment endpoints defined for each valued component.

The screening level analysis (pathway analysis) was used to determine the existence and magnitude of linkages (interactions) between the Project components or activities and valued components. The pathway analysis is used to focus the effects analysis on pathways that require a more comprehensive assessment of effects on valued components. Pathways were determined to be primary, secondary, or no linkage using scientific, local and traditional knowledge, logic, experience with similar developments, and environmental design features and mitigation. Pathways determined to have no linkage to a valued component or those that are considered secondary are not expected to result in environmentally significant effects on the assessment endpoint of the valued component. Primary pathways underwent further evaluation though detailed effects analysis and residual effects classification to determine the environmental significance of the Project on the valued component.

ATMOSPHERIC ENVIRONMENT

The potential environmental effect of the Project on the atmospheric environment was assessed using an air quality modelling approach. The assessment employed the Ministry of Environment approved AERMOD air quality model and was conducted in accordance with the Saskatchewan Air Quality Modelling Guidelines. The air emissions during construction and decommissioning and reclamation were determined to be less in emission intensity and in duration than air emissions during operations. Therefore, the air quality assessment focused on the Project operations. The air quality assessment for operations was completed by comparing the predicted cumulative changes to air quality and the Base Case conditions to the applicable ambient air quality standards.

The modelling results show that Application Case maximum predicted ground-level 24-hour particulate matter with aerodynamic diameter less than 10 micrometres concentrations exceed the ambient air quality standard for an average of 3 days during the modelling years. Application Case maximum predicted nitrogen dioxide, sulphur dioxide, carbon monoxide, particulate matter with aerodynamic diameter less than 2.5 micrometres, total suspended particulate concentrations, and potash (potassium chloride) deposition for all averaging periods complies with the respective ambient air quality standards. The magnitude of the changes to air quality is negligible to low and is regional in geographic extent. The Project's greenhouse gas emissions result in an approximately one percent increase in total provincial emissions and 0.16 percent increase in total national emissions.

Overall, the Project's cumulative effects on the atmospheric environment are concluded to be not significant.

HYDROGEOLOGY

The potential environmental effects of the Project on hydrogeology were assessed using groundwater flow and solute transport models. The results of the solute transport analysis provide an estimate and reasonable bounds of potential effects, taking into account uncertainty in site geology and soil properties. The results indicate that implementation of environmental design features, such as containment infrastructure (e.g., cutoff walls and recovery wells), should be based on additional site characterization at the detailed design stage of the Project, and the results of groundwater monitoring during the initial stages of operations. The design features provide two lines of defense against the release of brine from the tailings management area and may be used to contain brine along both deep and shallow seepage paths. A monitoring program for the tailings management area will be implemented at the start of operations and the monitoring results will be used to track plume development and assess the performance of containment infrastructure. If monitoring indicates unsatisfactory performance of containment infrastructures, further mitigation will be undertaken to contain brine within the tailings management area footprint.

Considering the application of environmental design features (containment infrastructure) and the ability to monitor plume development during operations and adapt mitigation strategies, long term changes to groundwater quality are expected to occur only within the footprint of the tailings management area. The residual effect on groundwater quality from vertical and lateral brine migration from the Project is negligible to low in magnitude and local in geographic extent.

Overall, the changes to groundwater from the Project are predicted to have no significant effect on the continued suitability of groundwater for human use.

HYDROLOGY

The Project will result in changes in local flows, drainage patterns (spatial distribution), and drainage areas due to the exclusion of the core facilities area from the natural drainage system, and for surface flows, drainage patterns (distribution), drainage areas, and waterbody or stream morphology due to ground subsidence.

The isolation of the core facilities area (and the well pads) from the surrounding local drainages will slightly reduce runoff and irreversibly change drainage patterns in the immediate area. The diversion channel will be an engineered design that will increase drainage efficiency around the core facilities area. The effects to annual runoff volume was classified as negligible to low and was estimated to be about a 2.3 percent decrease of the runoff reporting to the low-topography area within the West Tributary sub-basin of West Loon Creek, and negligible to low effects for West Loon Creek during the operations phase. Following decommissioning and reclamation, much of the drainage area existing in the core facilities area will be reclaimed into the natural drainage system. The area within the tailings management area will remain isolated from the drainage; however, annual runoff volume would only be reduced by about 1.1 percent in an average year. Water quantity will still be available for human use and ecosystems.

A potential measurable environmental effect will result from ground subsidence overlying the mine well field area caverns. Although the maximum calculated settlements would be about 6 metres, negligible to low effects are expected on the total annual runoff volume in the effects study area. The water conveyance efficiency in the north portion of the affected area may increase with increased slope along runoff pathways, whereas reduced conveyance efficiency in the south section of the subsided area is anticipated. Some reversal in the topographic gradient is expected along short sections of West Loon Creek. Indirect and direct hydrological effects would be local and only occur in certain areas within the Loon Creek watershed. Subsidence will be monitored on a regular basis during operation and following Project closure.

The residual effects from the Project are predicted not to have significant adverse effects on the availability of surface water quantity for human use and ecosystems.

SURFACE WATER QUALITY

Although there are no lakes present in the Project area, there are numerous ephemeral wetlands present. Most of the Project footprint is located within the Loon Creek drainage; however, the northwest portion drains towards Last Mountain Lake. Water quality chemistry collected from one location in Loon Creek, two locations in East Loon Creek, three locations in West Loon Creek, and two land-locked waterbodies, was used as a baseline for surface water quality analysis. Potential changes to surface water quality were predicted using a mass balance approach to assess effects of dust containing potassium and chloride on water chemistry.

It is anticipated that deposition of potassium and chloride will result in only very small changes to surface water quality in West Loon Creek, East Loon Creek, and Loon Creek. Changes are expected to be on the order of a few milligrams per litre and total predicted surface water concentrations of potassium and chloride during the Application Case are expected to be within the natural range of variability for West Loon, East Loon, and Loon creeks. It is considered unlikely that deposition of potassium and chloride will adversely affect surface water quality. Salinization of watercourses is not predicted to occur, and chloride concentrations will remain below Canadian Council of Ministers of the Environment water quality guidelines of 640 milligrams per litre (short-term guideline) and 120 milligrams per litre (long-term guideline) for the protection of aquatic life (Canadian Council of Ministers of the Environment 2015).

Changes to water quality from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for more than a century. Areas that become more depressional in the landscape may be expected to accumulate more snow runoff and rainfall, which may create new wetland areas. Alternatively, existing wetlands may drain and become drier. Changes in stream gradients caused by subsidence will also occur gradually and take place over a long enough period that stream bed erosional and depositional processes are expected to remain within their natural range of variability. Because subsidence will occur very gradually, no acute, adverse effects on water quality are expected.

Overall, it is anticipated that through the use of environmental design features and mitigation, the Project can be constructed, operated, and decommissioned in a manner that will result in negligible residual effects on surface water quality. The negligible residual effects from the Project are not likely to contribute to significant effects on the continued suitability of surface water for human use.

FISH AND FISH HABITAT

West Loon Creek and Loon Creek were identified as the only watercourses within the effects study area that are capable of supporting fish, at least on a seasonal basis. Small-bodied fish habitat appears to be dependent on annual flow volumes and flow durations, as well as the presence of deeper impoundments and dugouts. Barriers to fish movement were observed in West Loon Creek, East Loon Creek, and Loon Creek. Permanent wetlands within the effects study area lacked hydraulic connections to fish-bearing waterbodies or streams and are considered too shallow to provide over-wintering habitat for fish.

Based on the water quality assessment, it is anticipated that deposition of potassium and chloride will result in only very small changes to surface water quality in West Loon Creek, East Loon Creek, and Loon Creek. Therefore, the magnitude of change in potassium and chloride concentrations is not considered biologically significant and it is unlikely that deposition of potassium and chloride will adversely affect fish and fish habitat.

Changes to fish and fish habitat from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for more than a century. West Loon Creek will continue to support small-bodied fish. The changes in stream gradients caused by subsidence will take place over a long enough periods that streambed erosional and depositional processes are expected to remain within their natural range of variability. No acute, adverse effects on fish and fish habitat are expected.

Overall, it is anticipated that through the use of environmental design features and mitigation, the Project can be constructed, operated, and decommissioned in a manner that will result in negligible residual effects on fish and fish habitat. The residual effects from the Project are not likely to contribute to significant effects on self-sustaining and ecologically effective fish populations.

SOILS

The soils effects study area is approximately 804 square kilometres (80,385 hectares), and includes both unaffected (i.e., reference) areas and areas that are influenced by the Project. The maximum area of soil map units to be disturbed by the application of the Project is 1,550 hectares (1.9 percent of the effects study area). Following decommissioning and reclamation, an area of approximately 842 hectares (54 percent of the Project footprint) is expected to be reclaimed. Soils will be reconstructed in reclaimed areas. Reclaimed areas have not been assigned a specific soil type and classified as a reclaimed map unit. However, reclaimed areas will be reclaimed to an equivalent agriculture capability. The area of residual disturbance (i.e., tailings management area) is predicted to be 708 hectares (approximately 0.9 percent of the effects study area); these areas will not be reclaimed at closure.

The magnitude of residual effects from loss or alteration of soil is predicted to be negligible to low. Residual effects were determined to be local in geographic extent and continuous. Progressive reclamation is anticipated to occur during operations and residual effects on soils that will be reclaimed are predicted to be reversible after decommissioning and reclamation. The non-reclaimed tailings management area will result in a permanent loss of the soil's capability to support agriculture and other plant communities. As such, the magnitude of residual effects from residual ground disturbance is considered high in magnitude and irreversible.

Residual effects from ground subsidence are anticipated to be regional and result in a net change to agriculture capability within class groups when compared to Base Case (i.e., negligible to low magnitude). Subsidence will continuously occur over a timeframe of hundreds of years (beyond closure) and is considered permanent and irreversible. However, because the change to soil will occur gradually over hundreds of years, it should not affect the overall ability of soil to support agriculture and other plant communities.

Overall, incremental and cumulative changes to soils from the Project and other developments are predicted to have no significant adverse effects on the soil's capability to support agriculture and other plant communities.

VEGETATION

At the Base Case, cumulative changes from sustained agricultural practices over the last 100 years have resulted in adverse effects on plant populations and communities, specifically native grassland and wetlands in the effects study area. Cultivated, Modified Grassland and Existing Disturbance cover 75.5 percent of the effects study area under the Base Case. The maximum area of vegetation to be disturbed by the Project footprint is 1,550 hectares. The cumulative reduction in natural habitat through application of the Project and previous and existing developments is approximately 75.8 percent of the effects study area, with an incremental contribution from the Project of 0.3 percent. Following decommissioning and reclamation, an area of approximately 842 hectares (54 percent of the Project footprint) is expected to be reclaimed.

Not all areas that were assessed to be disturbed by the Project are expected to be altered during construction; therefore, the assessment of effects from direct loss or alteration and fragmentation of vegetation in the effects study area is overestimated. The siting of well pad locations will be modified to avoid wetlands during the final design phase. Avoidance of wetlands will reduce the contribution of the Project to existing cumulative effects in the effects study area. The incremental effects from the Project are expected to be reversible after closure (long-term), except for localized effects from the tailings management area and crystallization pond (708 hectares [0.8 percent of the effects study area]), which will be permanent and irreversible.

The Project is predicted to contribute little to the existing cumulative effects on natural (native) plant populations and communities in the effects study area. Overall, the weight of evidence from the analysis of the primary pathways predicts that cumulative changes to measurement indicators from previous and existing developments have had an adverse effect on self-sustaining and ecologically effective plant populations and communities. The cumulative residual effect on natural (i.e., native) plant populations and communities present in the Application Case is expected to be high in magnitude because of the previous and existing disturbances in the effects study area. However, several large areas of native dominated grassland in the effects study area are likely self-sustaining and ecologically effective. The incremental effects from the Project are small (low magnitude; 0.3 percent relative to Base Case conditions), local to regional in geographic extent, and long-term to permanent in duration. The incremental contribution of the Project to regional cumulative effects is not likely to decrease the resilience and increase the risk to remaining local or sub-regional self-sustaining and ecologically effective plant populations and communities in the effects study area. The Project will not influence the large, intact natural grasslands and wetlands that exist in the effects study area. Therefore, the cumulative changes from the Project and other developments are predicted not to have significant adverse effects on plant populations and communities.

The Project will avoid listed plants as much as possible; however, if a patch of listed plants is removed, it could be measurable at the regional level, but would not be predicted to alter the state of existing listed plant populations. The incremental contribution of the Project to regional cumulative effects is not likely to decrease resilience and increase the risk to remaining local self-sustaining and ecologically effective listed plant populations; the Project will not influence the large, intact natural grasslands and wetlands that exist in the effects study area. The incremental and cumulative effects from the Project and other developments are predicted not to significantly influence self-sustaining and ecologically effective listed plant populations.

The residual effect of the Project on traditional use plant populations is expected to be low in magnitude. Some areas disturbed by the Project are expected to be reclaimed after closure except for localized effects from residual disturbance, which will not be reclaimed. Changes to traditional use plant habitat will be permanent and irreversible because the type of vegetation in reclaimed areas is unknown at this time. Residual effects from the Project on traditional use plant species are expected to be small and at the local scale (confined to the Project footprint). The incremental and cumulative effects from the Project and other developments are predicted not to significantly influence self-sustaining and ecologically effective traditional use plants.

Changes to vegetation from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for more than a century. Areas that become more depressional in the landscape may be expected to accumulate more snow runoff and rainfall, which will increase soil moisture and may create wetland plant communities. Alternatively, existing wetlands may drain and become upland plant communities. Changes in soil moisture are expected to occur at a rate slow enough to allow for reciprocal changes in the distribution of plant communities. These changes in soil moisture and distribution of upland and wetland vegetation are not expected to result in a net decrease in vegetation. The distribution of upland and wetland vegetation is expected to change, but will compose similar proportions of the landscape after subsidence has occurred.

Overall, the Project is not expected to affect the ability of plant communities, listed plants, and traditional use plants to be self-sustaining and ecologically effective.

WILDLIFE

Previous and existing human developments, including cultivated and modified grassland habitats, are estimated to have removed 75.5 percent of wetland and native grassland habitats that were present in the effects study area prior to human settlement. Consequently, cumulative effects from previous and existing human activities are expected to have adversely affected ferruginous hawk, short-eared owl, and northern leopard frog populations as well as some upland breeding bird and waterbird populations in the Project area.

The Project is predicted to contribute little to cumulative effects on wildlife in the Project area. The Project is expected to result in a 1.5 percent loss of wetland habitat and a less than 0.1% loss of native grassland habitat. Yancoal is committed to following the wetland mitigation hierarchy presented in Ministry of Environment (2014). As such, during construction, Project infrastructure will be sited to avoid wetlands, and the anticipated direct loss to wetlands will be less than predicted.

In addition to direct habitat loss, indirect changes from sensory disturbance associated with existing developments and the Project may influence wildlife abundance and distribution by altering movement and behaviour among habitats at the population scale. When compared to a landscape with only direct disturbance, sensory disturbance is affecting 50.1 percent (40,139 hectares) of the effects study area under Base Case conditions. Sensory disturbance effects combined with direct effects from removal of habitat by cultivated, modified grassland, and existing disturbance habitats are predicted to have altered 87.2 percent (70,082 hectares) of the effects study area under the Base Case. Sensory disturbance from Project construction and operations is predicted to affect an additional 6.7 percent (5,455 hectares) and 8.0 percent (6,444 hectares) of the effects study area, respectively, relative to the Base Case.

Overall, the weight of evidence from the analysis of the primary pathways predicts that cumulative changes to measurement indicators from previous and existing developments have had an adverse effect on self-sustaining and ecologically effective wildlife populations in the Project area. However, there are remaining large areas of contiguous native grasslands and wetlands in the Project area that likely support self-sustaining and ecologically effective wildlife valued components. The incremental effects from the Project are small (low magnitude), local to regional in geographic extent, and long-term to permanent in duration. The incremental contributions of the Project to regional cumulative effects are not likely to decrease resilience and increase the risk to remaining local self-sustaining and ecologically effective wildlife populations; the Project will not influence the large, intact natural grasslands and wetlands that currently exist in the Project area. Therefore, the cumulative changes from the Project and other developments are predicted not to have significant adverse effects on wildlife populations.

Overall, the Project is not expected to affect the ability of wildlife valued components to be self-sustaining and ecologically effective.

HERITAGE RESOURCES

The Project will implement several environmental design features and mitigation to avoid or limit effects on heritage resources. The Project will be located in an area that has largely been disturbed previously by agricultural activities. No known heritage resources are located within the core facilities area, and the land is not considered heritage sensitive by the Heritage Conservation Branch. The mine well field area contains no recorded heritage resources, and most of the land is considered to have low heritage potential. However, areas of native prairie adjacent to West Loon Creek will require additional Heritage Resources Impact Assessment if development occurs in these areas. Any proposed facility plans (e.g., well pads and well field pipelines) located in the E1/2 25-24-19 W2M, NW and S1/2 30-24-18 W2M, and N1/2 and SE 19-24-18 W2M will be submitted to the Heritage Conservation Branch for review to determine further Heritage Resources Impact Assessment requirements. Any conflicts with heritage resources will be addressed in advance of construction. Similarly, any Project plans located near historic structures or markers located in the NE-23-24-19 W2M, NE-26-24-19 W2M, SE-29-24-19 W2M, and SE-13-24-19 W2M will require consultation with the Rural Municipality of Longlaketon to address any concerns prior to construction.

Management options for archaeological or heritage materials fortuitously discovered during construction activities will be developed in consultation with the Saskatchewan Ministry of Parks, Culture and Sport - Heritage Conservation Branch. In the event that unanticipated archaeological materials or features are encountered during construction or unplanned events, all work in the immediate area will cease and the Heritage Conservation Branch will be contacted. Decommissioning and reclamation activities are expected to have no effects on heritage resources because no new disturbance will occur during this Project phase.

Overall, the Project is not predicted to affect heritage resources.

SOCIO-ECONOMIC ENVIRONMENT

The Project is predicted to result in residual effects on the socio-economic environment related to employment and economy, community services and infrastructure, traffic and transportation, quality of life, and traditional and non-traditional land use.

Skilled local workers will be given priority during hiring; however, based on the existing labour force conditions, the Project is expected to require an out of province workforce to meet construction and operations labour demand. Most of the construction workforce is expected to be a temporary workforce, largely residing in a construction camp near the Project, although some of the construction workforce may relocate to the Project area. Depending on the availability of skilled labour, some or most of the Project operations workforce may come from outside the province and relocate to the area permanently, often accompanied by family.

The Project will result in increased training and experience in the labour force, which will affect future opportunities. Project spending will result in increased Gross Domestic Product, and Project operations will generate tax revenue for municipal, provincial, and federal governments.

The Project workforce will result in an increased local population from the Project operations workforce and any of the Project construction workforces that relocate. This population increase is expected to result in a significant residual effect on community services and infrastructure. The region has experienced a steadily increasing population for most of the past decade and correspondingly, demand has been increasing for services and infrastructure. Some services, such as schools and health care are operating near or at capacity. The real estate market has been expanding rapidly and has met demand up to this point, but house prices have risen substantially and vacancy rates are low. Most residual effects on community services and infrastructure are expected to occur in Regina, where most of the relocated population is expected to live. The City of Regina and service providers are aware of the rapid increase in population and corresponding demand for services and infrastructure, which is predicted to continue in the future, and are planning accordingly.

The Project will increase traffic in the area and could potentially affect transportation infrastructure. Some traffic will come from outside the province or region, but the noticeable traffic increase is expected mainly to occur north of Regina (where most of the workforce is expected to live) on Project access routes. A traffic impact assessment was completed and identified required road upgrades and mitigation to reduce the effects on traffic and transportation. Yancoal will build a construction camp near the core facilities area and encourage carpooling. Project-related traffic could increase the potential for traffic accidents; however, appropriate training will be provided and safety measures put in place. The Project will require the closing of two stretches of grid road within the core facilities area. Yancoal will work with the rural municipalities and the provincial government to facilitate local traffic movement. Overall, the residual effect on traffic and transportation is not considered significant.

Quality of life was defined in relation to air quality, water quality, visual aesthetics, and noise. Air modelling indicated that emissions will be within guideline values, while the water assessment determined that there would be no significant residual effects on water quality. Potential for changes to noise and visual aesthetics from the Project may affect quality of life for residents near the Project. Noise levels were predicted to be within guideline values at all noise receptors except one. This may result in a significant effect for individuals at this receptor. The Project will alter visual aesthetics for some distance, as the terrain will provide unobstructed views of the Project for numerous farmyards, residences, and possibly from several communities. However, this residual effect is not expected to deteriorate socio-economic conditions in the area and is not considered significant.

The Project will have minor residual effects on traditional and non-traditional land use. Changes to surface water quality, vegetation, soil, wildlife, fish and fish habitat, and the atmospheric environment can affect land use, as can ground subsidence. These residual effects were all determined to have little or no effect on land use. The main land use in the area is agriculture. No known traditional land use exists within the Project footprint or immediately surrounding area, and activities, such as recreation, tourism, hunting, and fishing, are limited by private land ownership and the extensive modification of the landscape. The Project will reduce the area of agricultural land, which could affect landowners and nearby residents. However, landowners will be compensated and the permanent loss of agricultural land is small compared to the quantity of land in the area. Overall, residual effects on traditional and non-traditional land use are considered not significant.

MONITORING AND FOLLOW-UP

Upon approval of the Project, the development will enter into the licensing process at which time the monitoring and follow-up programs will be designed and implemented under the following categories.

- Compliance inspections - monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments.
- Follow-up monitoring - programs designed to test the accuracy of effect predictions, reduce uncertainty, determine the effectiveness of environmental design features, and provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices. Results from these programs can be used to implement further mitigation as required and increase the certainty of effect predictions in future environmental assessments.

The Yancoal Health, Safety, Security, and Environmental Management System will include a variety of management plans and monitoring programs, including:

- Emergency Response Plan;
- Occupational Health and Safety Plan;
- Community Relations Plan;
- Human Resources Plan;
- Environmental Protection Plan;
- Erosion and Sediment Control Plan;
- Spill Response and Control Plan;
- Weed Management Plan;
- Waste Management Plan;
- Waste Salt Management Plan;
- Water Management Plan; and
- Decommissioning and Reclamation Plan.

These plans focus on limiting negative residual effects and enhancing positive residual effects of the Project. They outline specific actions and guidelines for Project construction and operations. Many of these plans include monitoring programs to determine the accuracy of the effects assessments and whether additional actions need to be taken.

An Environmental Monitoring Program has already been implemented at the Project and includes meteorological monitoring and ambient air quality monitoring. The meteorological tower measures temperature, relative humidity, wind speed, wind direction, solar radiation, and precipitation. The on-site ambient air quality monitoring station is measuring nitrogen dioxide, particulate matter, and total suspended particulates.

During the operations phase, monitoring for the tailings management area will be undertaken for the collection of data related to slope stability and brine migration (groundwater chemistry, hydraulic head, and geophysical surveys). Monitoring data will provide the basis for evaluating the effectiveness of brine containment within the tailings management area and will provide timely feedback required to implement additional mitigation, if required. Monitoring station locations and monitoring frequencies will be selected to provide a data record sufficient to evaluate the development of brine plumes associated with the tailings management area and assess the effectiveness of containment infrastructure. Threshold criteria will be selected so that further mitigation may be implemented in a timely manner to contain brine within the tailings management area footprint, and thus mitigate effects on the surrounding subsurface environment, should it be required. Brine migration rates are predicted to occur at a rate of centimetres per year, therefore conventional monitoring practices employed by the potash mining industry are expected to be adequate to assess the timing for implementation of engineering controls or mitigation measures.

Local surface water level monitoring will continue and will be extended to include the diversion channels through Project operations and into decommissioning and reclamation. A follow-up monitoring program will be implemented to monitor the progress of ground subsidence and an adaptive management approach will mitigate potential effects and uncertainty related to ground subsidence and streamflow. Monitoring potential changes in topographic elevations in the mining area due to subsidence will be completed regularly. To monitor surface water conditions, compliance inspections of environmental design features and mitigation measures (e.g., silt fences and water diversion structures) will be completed to confirm they are used and operating properly. Regular inspections will confirm the integrity of tanks, ponds, and above-ground and below-ground pipelines in order to detect potential leaks.

A monitoring program for soil erosion will be managed on site by qualified personnel, as outlined in the Erosion and Sediment Control Plan. Detailed site assessments will be completed to collect specific information for topsoil depth and soil chemistry, as required. Compliance inspections and environmental monitoring will be used to confirm that best practices are being used to help mitigate soil erosion, admixing, compaction, and associated changes to soil quality. Soil conditions will be monitored to estimate reclamation success during the Project. Results from this program can be used to support adjustments to the reclamation and closure plan and incorporate them into ongoing reclamation activities.

Surveys of areas mapped as native grassland, wetlands, and wooded areas will be completed in the Project area prior to Project construction. If these areas are determined to be important natural areas, mitigation to avoid or limit effects on these areas will be developed in conjunction with the Ministry of Environment. Appropriate mitigation practices and protocols will be implemented should any listed plant species be identified; additional wetland surveys may be required prior to construction. Monitoring of revegetation success will be completed following decommissioning and reclamation of the Project. Yancoal's Weed Management Plan will be implemented and will include surveys for weed species during the Project. Yancoal will incorporate routine weed inspection and maintenance programs to protect areas of natural vegetation. Topsoil will be salvaged in sensitive habitats (e.g., native grassland) to maintain the seed bank contained in the topsoil. This material will be returned to these areas and will be spread over reclaimed/contoured area to help re-establish a vegetation cover, in combination with an approved, certified weed free seed mixture. Follow-up monitoring will include an assessment of the success of plant community establishment following reclamation.

Surveys for federally and provincially listed wildlife species will be completed prior to construction. If listed wildlife species are identified, appropriate mitigation will be identified and implemented in consultation with Ministry of Environment. Compliance inspections and environmental monitoring data reporting will be undertaken to provide flexibility to effectively identify and respond to unanticipated changes to wildlife and to adapt to new regulatory frameworks. Data reporting is expected to occur annually, with data analysis being undertaken every five years and communicated in the form of Status of the Environment reports.

As part of the Environmental Protection Plan, a heritage management program will be developed to handle archaeological or heritage materials fortuitously discovered during construction activities or because of unplanned events. The management plan will be developed in consultation with the Heritage Conservation Branch.

Recognizing people's interest in understanding and participating in decisions that affect them, Yancoal will proactively seek, engage, and support meaningful consultation on issues and opportunities related to business and operations of the Project. A plan for ongoing engagement will be developed and reviewed with local communities. Yancoal will continually evaluate both the process and the outcome of the ongoing engagement and communication activities to address and manage issues as they arise.

SUMMARY AND CONCLUSION

Based on the Project information and analysis provided in this Environmental Impact Statement and proposed mitigation aimed at reducing negative effects, the Project is not likely to cause significant adverse residual effects on most valued components of the biophysical and socio-economic environments. The Project workforce requirements and tax revenue will have significant positive residual effects on employment and economy. The population increase associated with the Project, including workers and their families who migrate to the area, will result in an increase in demand for infrastructure and services in the area. Cumulatively, this will act with previous, existing, and future projects and have the potential to result in a significant adverse residual effect on community infrastructure and services. For all other components of the environment, adverse residual effects from the Project are predicted not to significantly influence the following assessment endpoints:

- compliance with regulatory air emission guidelines and standards;
- continued suitability of groundwater for human use;
- availability of surface water quantity for human use;

- continued suitability of surface water for human use;
- self-sustaining and ecologically effective fish populations;
- soil capability to support agriculture and other plant communities;
- self-sustaining and ecologically effective plant populations and communities;
- self-sustaining and ecologically effective wildlife populations;
- protection of heritage resources; and
- sustainability of social and economic properties.

Based on the detailed Project information and assessment of effects provided in this Environmental Impact Statement, Yancoal believes that the Project can be constructed, operated, and decommissioned in a manner that, taking into account environmental design features and mitigation, is not likely to cause significant adverse effects on the biophysical or socio-economic environments. This Project is expected to result in positive effects on employment levels and socio-economic conditions in the rural municipalities of Longlaketon and Cupar and the province of Saskatchewan.

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List of Abbreviations

Abbreviation	Definition
3-D	three-dimensional
AADT	average annual daily traffic
AAFC	Agriculture and Agri-Food Canada
AANDC	Aboriginal Affairs and Northern Development Canada
AEEI	Ministry of Advanced Education, Employment, and Immigration
Al^{3+}	aluminum
ALS	ALS Environmental Ltd.
ANPC	Alberta Native Plan Council
AQMG	Saskatchewan Air Quality Modelling Guideline
BGS	below ground surface
BPC	Belarusian Potash Company
BSA	baseline study area
CAAQS	Canadian Ambient Air Quality Standards
CAD	computer-aided design
Ca^{+}	calcium
$CaCl_2$	calcium chloride
$CaCO_3$	calcium carbonate
CBC	Canadian Broadcasting Corporation
CCME	Canadian Council of Ministers of the Environment
CEC	cation exchange capacity
CH_4	methane
Cl^-	chloride
CMA	Census Metropolitan Areas
CMHC	Canada Mortgage and Housing Corporation
CN	Canadian National
CO	carbon monoxide
CO_2	carbon dioxide
CO_{2e}	carbon dioxide equivalents
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CEAA	*Canadian Environmental Assessment Act*
CP	Canadian Pacific
CPR	Canadian Pacific Railway
CPUE	catch-per-unit-effort
CTRC	Carleton Trail Regional College
CWQG	Canadian Water Quality Guidelines for the Protection of Aquatic Life
D&R	decommissioning and reclamation
DEM	digital elevation model
DFO	Fisheries and Oceans Canada
DL	detection limit

Abbreviation	Definition
DVI	detailed vegetation inventory
E	east
EA	Environmental Assessment
EAA	*The Environmental Assessment Act*
EAB	Environmental Assessment Branch
EC	electrical conductivity
EIS	Environmental Impact Statement
e.g.	for example
ELC	ecological landscape classification
EM	electromagnetic
EMS	emergency medical services
EPB	Environmental Protection Branch
EPCM	Engineering, Procurement, and Construction Management
EPP	Environmental Protection Plan
ERP	Emergency Response Plan
ESA	effects study area
et al.	And more than one additional author
ETS	electrical terminal station
FTPCCCEA	Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment
FPV	First Potash Ventures
GDP	Gross Domestic Product
GHGs	greenhouse gases
GIS	geographic information system
Golder	Golder Associates Ltd.
GPS	global positioning system
H^+	hydrogen
HBC	Hudson's Bay Company
HDPE	high density polyethylene
Hg	mercury
HRIA	Heritage Resources Impact Assessment
HSSE	Health, Safety, Security, and Environmental
HVAC	heating, ventilation, and air conditioning
i.e.	that is
ICMM	International Council of Mining and Minerals
ID	Identification/identifier
IMPROVE	Interagency Monitoring of Protected Visual Environments
ISQG	Interim Sediment Quality Guideline
IUCN	International Union for Conservation and Nature
K^+	potassium
K_2O	potassium oxide
KCl	potassium chloride
LFN	low frequency noise

Abbreviation	Definition
LiDAR	Light Detection and Ranging
LMI	Labour Market Information
LMDMF	Last Mountain District Music Festival
LSA	local study area
LNC	Loon Creek
MDNN	mean distance to nearest neighbour
Mg^{2+}	magnesium
$MgCl_2$	magnesium chloride
$MgSO_4$	magnesium sulphate
MHI	Ministry of Highways and Infrastructure
Mn^{2+}	manganese
MOA	Ministry of Agriculture
MOE	Ministry of Environment
MRGGA	*Management and Reduction of Greenhouse Gases Act*
N	north
n.d.	no date
n/a	not applicable
NaCl	sodium chloride
$NaSO_4$	sodium sulphate
NO_2	nitrogen dioxide
N_2O	nitrous oxide
NO_x	oxides of nitrogen
NIHL	noise-induced hearing loss
NRC	Natural Resources Canada
NW	northwest
OH	hydroxide
PDSA	pre-disturbance site assessment
PEL	Probable Effects Level
PM	particulate matter
PM_{10}	particulate matter with aerodynamic diameter less than 10 micrometres
$PM_{2.5}$	particulate matter with aerodynamic diameter less than 2.5 micrometres
PN	provincial nominees
PotashCorp	Potash Corporation of Saskatchewan
pop.	population
Project	Yancoal Southey Project
PSL	Permissible sound level
PVSD	Prairie Valley School Division
QA/QC	quality assurance/quality control
R.M.	Rural Municipality
RCMP	Royal Canadian Mounted Police
RCSD	Regina Catholic School Division
RFD	reasonably foreseeable development

Abbreviation	Definition
RPSD	Regina Public School Division
RQHR	Regina Qu'Appelle Health Region
RROC	Regina Regional Opportunities Commission
RSA	regional study area
RTK	real time kinematics
RV	recreational vehicle
S	south
SAAQS	Saskatchewan Ambient Air Quality Standards
SARA	*Species at Risk Act*
SaskPower	Saskatchewan Power Corporation
SaskTel	Saskatchewan Telecommunications Holding Corporation
SaskWater	Saskatchewan Water Corporation
SCQG	Soil Classification Working Group
SE	southeast
SEARP	Saskatchewan Environmental Assessment Review Panel
SEC	Saskatchewan Environmental Code
SHR	Saskatoon Health Region
SIAST	Saskatchewan Polytechnic
SIIT	Saskatchewan Indian Institue of Technoliges
SINP	Saskatchewan Immigrant Nominee Program
SKCDC	Saskatchewan Conservation Data Centre
SLMC	Saskatchewan Labour Market Commission
SLRU	Saskatchewan Land Resource Unit
SO_2	sulphur dioxide
SSD	Surficial Stratified Deposits
SSWQO	Saskatchewan Surface Water Quality Objective
STM	Sask Trends Monitor
TAC	Transportation Association of Canada
TBD	to be determined
TDS	total dissolved solids
TIA	traffic impact assessment
TMA	tailings management area
TOR	Terms of Reference
TSP	total suspended particulate matter
TSS	total suspended solids
U of S	University of Saskatchewan
US EPA	United States Environmental Protection Agency
USDA NRCS	United States Department of Agriculture Natural Resources Conservation Service
V/C	volume to capacity ratio
VC	valued component
W2M	West of the Second Meridian
WDPM	Wetland DEM Ponding Model

Abbreviation	Definition
WHMIS	Workplace Hazardous Materials Information System
WSA	Water Security Agency
WSC	Water Survey of Canada
Yancoal	Yancoal Canada Resources Company Limited
Yanzhou Coal	Yanzhou Coal Mining Company Limited

Units of Measurement

Unit	Definition
%	percent
<	less than
>	greater than
°C	degrees Celsius
$	dollars
CAD/tonne	Canadian dollar per tonne
cm	centimetres
cm^2	square centimetres
cm/m	centimetres per metre
dam^3	cubic decametre
dBA	A-weighted decibels
ds/m	deciSiemens per metre
$\mu g/m^3$	micrograms per cubic metre
µm	micrometre
g/GJ	grams per gigajoule of energy input
GJ/d	gigajoules per day
GJ/h	gigajoules per hour
h	hour
ha	hectare
kg	kilogram
kg/d	kilograms per day
kg/h	kilograms per hour
kg/ha-d	kilograms per hectare per day
km	kilometre
km^2	square kilometre
km/h	kilometres per hour
kV	kilovolt
L	litres
m	metres
m^2	square metre
m^3	cubic metres
m^3/d	cubic metres per day
m^3/h	cubic metres per hour

Unit	Definition
m/km	metres per kilometre
m^3/km^2	cubic metres per square kilometre
m^3/min	cubic metres per minute
meq/100g	milliequivalent per one hundred grams
m BGS	metres below ground surface
mg	milligram
mg/cm^2	milligrams per square centimetre
$mg/cm^2/month$	milligrams per square centimetre per month
mg/kg	milligrams per kilogram
mg/L	milligram per litre
mm	millimetres
Mm^3	million cubic metres
MMT	million metric tonnes
MPa	megapascal
Mt	million tonnes
Mtpa	million tonnes per annum
MVA	megavolt ampere
NTU	nephelometric turbidity unit
pH	Potential of hydrogen; a quantitative measure of the acidity or basicity
ppm	parts per million
s	second
t	tonne
t/m^3	tonnes per cubic metre
tonnes/yr	tonnes per year
µg/L	microgram per litre
$µg/m^3$	microgram per cubic metre
µm	micrometre
µS/cm	microSiemens per centimetre
USD/tonne	United States dollar per tonne
V	volt

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1.0 INTRODUCTION

1.1 Project Proponent

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project). Yancoal has identified a world-class potash deposit and intends to develop the resource in an ecologically sustainable, economically efficient, and socially responsible manner.

Yancoal is a wholly owned subsidiary of Yanzhou Coal Mining Company Limited (Yanzhou Coal). Yanzhou Coal's main business is coal mining, coal chemical and fertilizer production, power generation, and equipment manufacturing. Yanzhou Coal is an international, diversified mining corporation listed on the stock exchanges of New York, Shanghai, Sydney, and Hong Kong.

In August 2011, Yancoal established an office for the Project in Saskatoon, Saskatchewan, which is located at:

Unit 300 – 211 4th Avenue South
Saskatoon, Saskatchewan
S7K 1N1

The main contact person for the Project is Mr. Asad Naqvi, Lead for the Project Coordination Department for Yancoal. Mr. Naqvi can be reached at (306) 668-5558 or by e-mail at a.naqvi@yancoal.ca.

Yancoal received technical assistance and expertise from several consultants to complete the environmental assessment (EA) and prepare the Environmental Impact Statement (EIS) for the Project. The consultants, technical advisors, and the area of their technical contribution to the EA and EIS are listed in Table 1.2-1.

Table 1.2-1: Consultants and Technical Advisors

Consultant	Technical Contribution
Golder Associates Ltd.	Environmental Assessment
	Tailings Management Area and Brine Pond
	Conceptual Decommissioning and Reclamation Plan
AMEC Foster Wheeler	Engineering Design Process Plant and On-site Infrastructure
Agapito Associates Inc.	Resource, Mine Plan and Cavern Design
RPS BoydPetroSearch	Seismic Operations and Interpretation
North Rim Exploration Ltd.	Mineral Resource Exploration
Scott Land and Lease Ltd.	Land Administration

1.2 Project Location and Environmental Setting

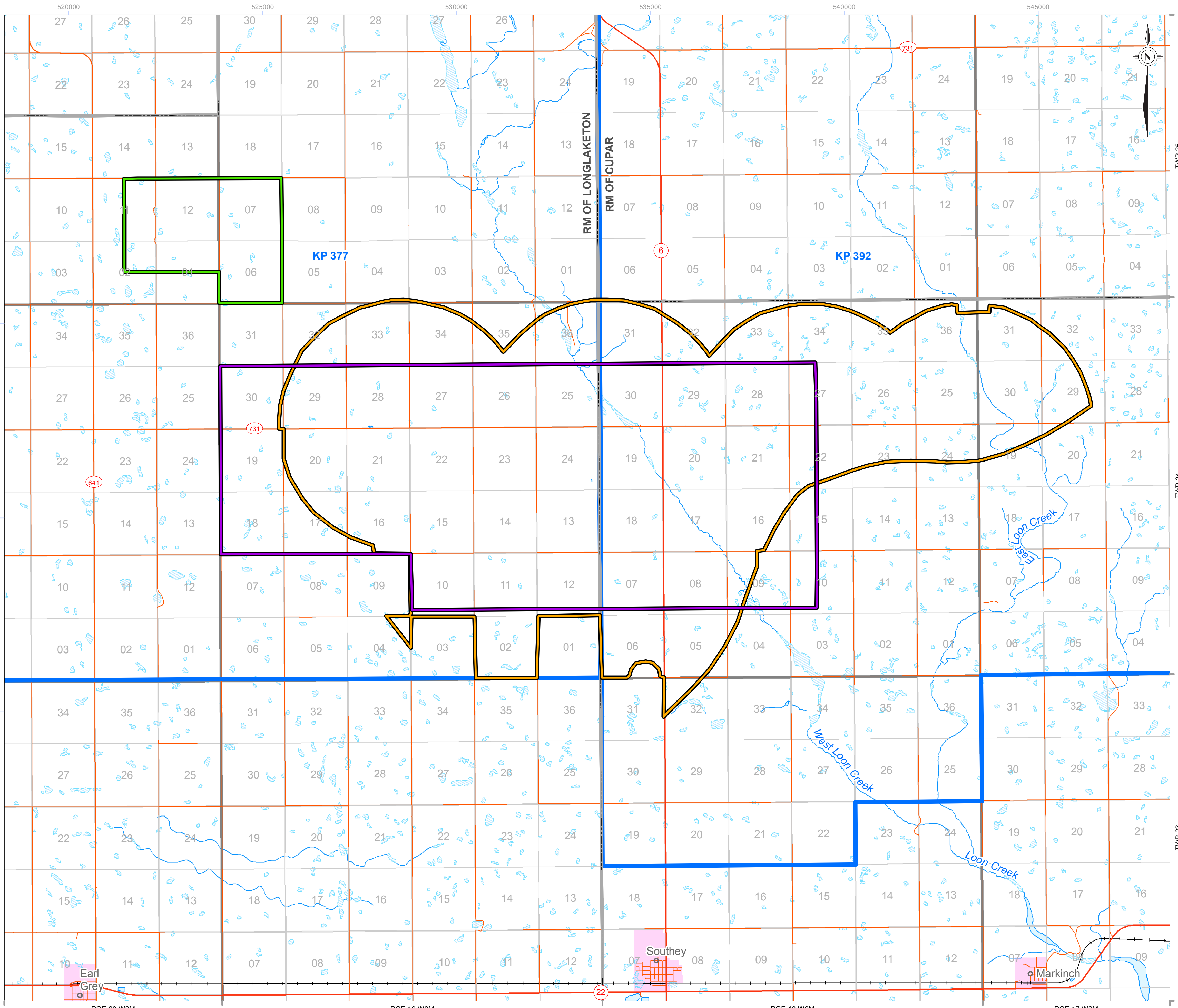
The Project will be a greenfield solution potash mine within subsurface mineral permits KP377 and KP392. The Project will be located in central Saskatchewan, approximately 60 kilometres (km) north of Regina within the Rural Municipality (R.M.) of Longlaketon (No. 219) and the R.M. of Cupar (No. 218) (Figure 1.2-1). The community of Earl Grey is located approximately 21 km southwest of the Project, the community of Strasbourg is approximately 23 km west, and the community of Southey is approximately 28 km southeast. The Project (including the core facilities, the 65-year mine field, and the indicated resource boundary) encompasses approximately 143 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M). In support of the project, Yancoal has acquired approximately 1,108 ha of freehold land for the core facilities area, and 787 ha within the mine well field area (Figure 1.2-2). Yancoal intends to secure (e.g., through lease agreements) the land required for the full mine well field as it expands over time; as such, the acquisition process will be ongoing.

An existing network of municipal grid roads, provincial highways, and rail lines provides access to the Project. The Project is located east of grid road 641 and north of grid road 731, with the mine well field area being located on both sides of Highway 6. A Canadian Pacific (CP) rail line is located approximately 20 km west of the Project, and a Canadian National (CN) rail line is located approximately 32 km north of the Project.

The Project is located east of Last Mountain Lake and north of the Qu'Appelle Valley in a transitional area between the boundaries of the Moist Mixed Grassland and Aspen Parkland Ecoregions of the Prairie Ecozone in Saskatchewan (Acton et al. 1998). Specifically, the Project will be located in central Saskatchewan in the Strasbourg Plain Landscape Area of the Mixed Grassland Ecoregion (Acton et al. 1998). The landscape within the Moist Mixed Grassland is characterized by intermittent areas of native grassland, woodland, and shrubland on a broad, mostly level plain with the occasional deep valley, such as the Qu'Appelle Valley (Flory 1980; Acton et al. 1998). The Aspen Parkland Ecoregion is characterized by hummocky landscapes where woodlands or wetlands occur in lower areas associated with pot and kettle topography and grasslands occurring on upper slopes (Acton et al. 1998). Native vegetation is limited to hummocky morainal areas, and is interspersed with cropland.

The Project is located in a region with a subhumid continental climate, with warm summers and cold, dry winters, and is prone to extreme weather at any time of the year. Approximately 79 percent (%) of the mean annual precipitation in the region falls as rain; the remaining 21% occurs as snowfall (Environment Canada 2015).

The Project, including KP377 and KP392, is located within the Qu'Appelle River drainage, specifically within the Loon Creek basin, although a small portion of KP377 drains west towards Last Mountain Lake. The main streams in the Loon Creek basin include West Loon and East Loon creeks, which join to form Loon Creek about 2 km south of the KP392 boundary. There are no major lakes in the Loon Creek basin, however there are numerous wetlands. Surface runoff in the streams occurs mainly in response to spring snowmelt, although rainfall-runoff events can also be important under some conditions (e.g., if antecedent moisture conditions are high). In general, streamflow in Loon Creek is lower than the surrounding watersheds.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- RURAL MUNICIPALITY BOUNDARY
- SECTION BOUNDARY
- URBAN MUNICIPALITY
- PERMIT BOUNDARY
- CORE FACILITIES AREA
- 65 YEAR MINE FIELD
- INDICATED RESOURCE BOUNDARY

REFERENCE

INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

2 0 2
SCALE 1:100,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE

CORE FACILITIES AND MINE FIELD AREAS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	MT	12/02/15	SCALE AS SHOWN	REV. 0
GIS	LMS/AK	04/05/15	FIGURE: 1.2-1	
CHECK	MT	23/12/15		
REVIEW	BC	23/12/15		

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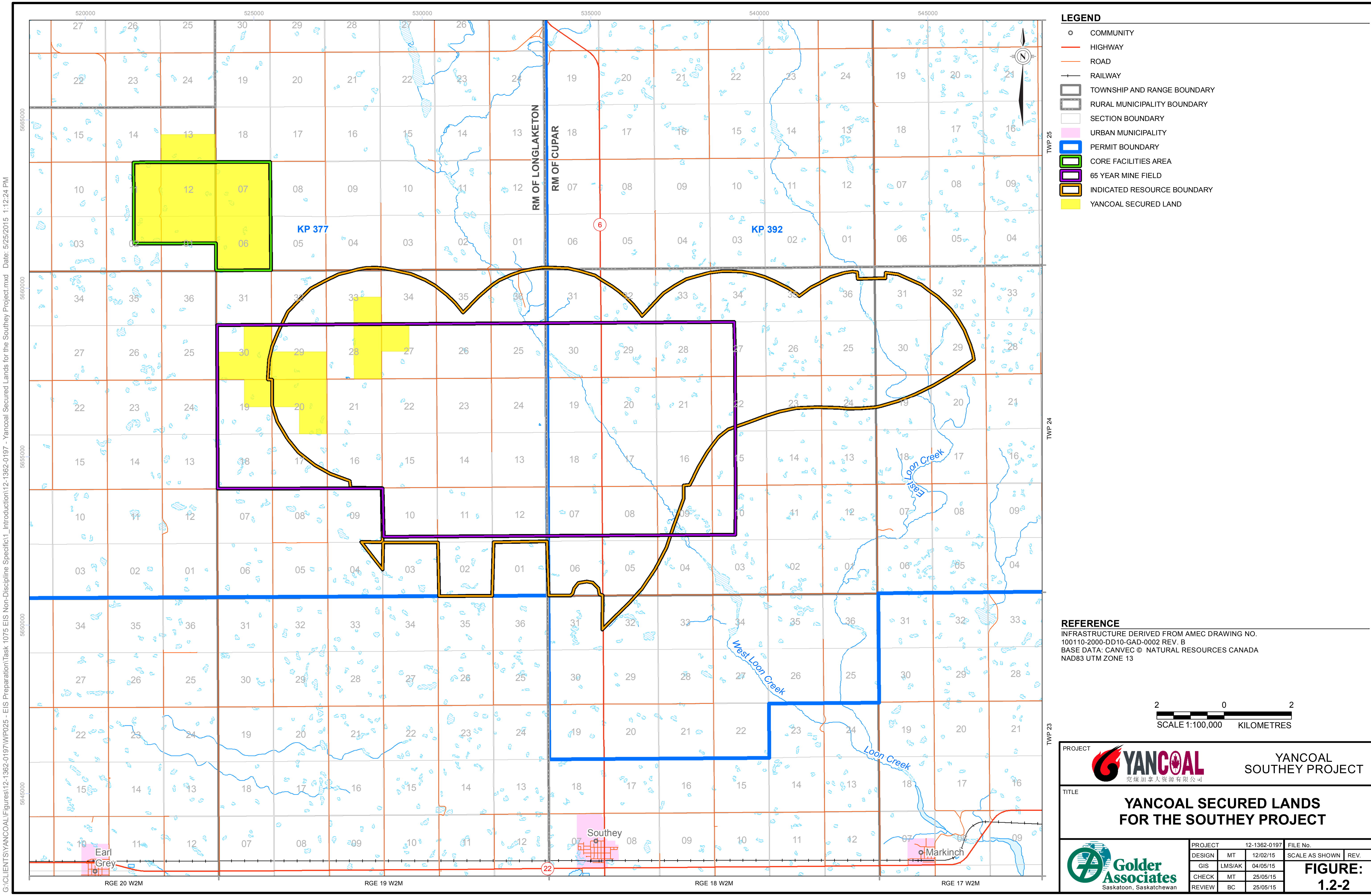


LEGEND
COMMUNITY
HIGHWAY
ROAD
RAILWAY
TOWNSHIP AND RANGE BOUNDARY
RURAL MUNICIPALITY BOUNDARY
SECTION BOUNDARY
URBAN MUNICIPALITY
PERMIT BOUNDARY
CORE FACILITIES AREA
65 YEAR MINE FIELD
INDICATED RESOURCE BOUNDARY
YANCOAL SECURED LAND
RM OF LONGLAKETON
RM OF CUPAR
KP 377
KP 392
East Loon Creek
West Loon Creek
Loon Creek
Southey
Earl Grey
Markinch
RGE 20 W2M
RGE 19 W2M
RGE 18 W2M
RGE 17 W2M
TWP 25
TWP 24
TWP 23
REFERENCE
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13
2 0 2
SCALE 1:100,000 KILOMETRES
PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT
TITLE
YANCOAL SECURED LANDS FOR THE SOUTHEY PROJECT
Golder Associates
Saskatoon, Saskatchewan
PROJECT 12-1362-0197 FILE No.
DESIGN MT 12/02/15 SCALE AS SHOWN REV. 0
GIS LMS/AK 04/05/15
CHECK MT 25/05/15
REVIEW BC 25/05/15
FIGURE: 1.2-2
G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1075 EIS Non-Discipline Specific\1_Introduction\12-1362-0197 - Yancoal Secured Lands for the Southey Project.mxd Date: 5/25/2015 1:12:24 PM

1.3 Project Overview

The Project will extract potash ore (sylvinite) from the Patience Lake, Belle Plaine, and Esterhazy members of the Saskatchewan Prairie Evaporite Formation. The Prairie Evaporite Formation is divided into three principal potash-bearing members and one auxiliary member. In ascending stratigraphic order they are: the Esterhazy Member, the Belle Plaine Member, and the Patience Lake Member. These beds are generally flat lying and are formed of interbedded sylvite, halite, carnallite, clay seams, and minor amounts of anhydrite. The auxiliary potash member, the White Bear Member, is situated between the Belle Plaine and the Esterhazy members. The three Potash Members (Patience Lake, Belle Plaine and Esterhazy), as well as the Salt Back (above the Patience Lake) and the Interbed (between Patience Lake and Belle Plaine) are considered the key stratigraphic intervals for the project.

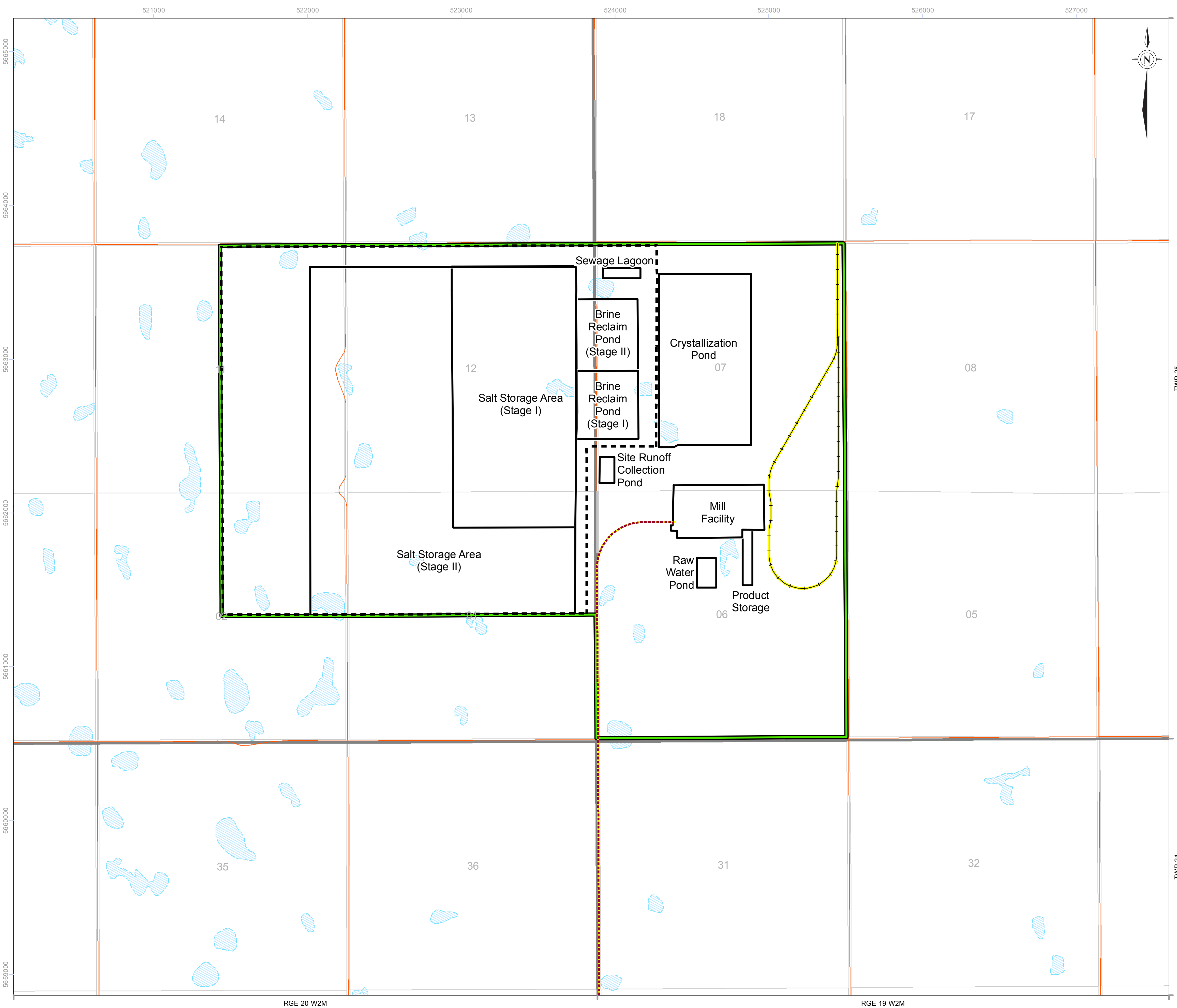
Development of the Project is planned in several phases. The construction phase is anticipated to begin in May 2016 or as soon as the relevant Project regulatory permits and approvals are in place. The operations phase will begin in 2019 and, at the proposed production rate, will remain in operation for up to 100 years. Activities following operations will include those necessary to complete decommissioning and reclamation (D&R).

The core facilities area and supporting infrastructure will be built during the construction phase (approximately 39 months). The core facilities area will include the processing plant, administration buildings, maintenance building, equipment and parts storage, tank farm, raw water pond, tailings management area (TMA), product storage, rail loadout, security, and parking. The TMA will consist of a salt storage area (Stage I and II), a brine reclaim pond (Stage I and II), sewage lagoon, and surface diversion works. The general layout for the Project site is shown on Figure 1.3-1.

The operations phase (i.e., solution mining and processing of potash) will begin following construction and is anticipated to continue for up to 100 years. During the operations phase the Project will employ primary and secondary solution mining techniques to extract the potash resource. Primary mining involves the injection of hot water to the sylvinite beds to dissolve potassium chloride (KCl) and sodium chloride (NaCl); then the brine solution is extracted and transported by pipeline to the process plant. Secondary mining involves the injection of NaCl-rich brine into the cavern created during primary mining to selectively dissolve additional potash from the material remaining in the cavern. This brine solution is extracted and returned to the process plant by pipeline.

The processing plant will be designed for a production capacity of 2.8 million tonnes per annum (Mtpa) of potash. Potash processing will include the following:

- injection and solution recovery;
- evaporation and crystallization;
- product drying and screening;
- product compaction; and
- product storage and shipping.



LEGEND

- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- SECTION BOUNDARY
- PROPOSED ACCESS ROAD
- PROPOSED RAIL LOOP
- CORE FACILITIES AREA
- PROPOSED SITE INFRASTRUCTURE
- TAILINGS MANAGEMENT AREA

REFERENCE

INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
TMA DESIGN REVISED BY GOLDER, 2014
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

500 0 500
SCALE 1:25,000 METRES

PROJECT
YANCOAL SOUTHEY PROJECT

TITLE
GENERAL SITE LAYOUT

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	LMS/AK	25/05/15	
CHECK	MT	25/05/15	
REVIEW	BC	25/05/15	

FIGURE: 1.3-1

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1075 EIS Non-Discipline Specific\1_Introduction\12-1362-0197 - General Site Layout.mxd Date: 5/25/2015 1:09:51 PM

Supporting infrastructure for the Project includes a water supply (provided by SaskWater), electrical power (provided by SaskPower), natural gas (provided by TransGas), and communication services (provided by SaskTel). Access to the core facilities area will be from Highway 6 and grid road 731 via an upgraded road to be constructed. Two options considered for rail access are a rail spur line to the CP rail line (located approximately 20 km west of the Project) or a spur line to the CN rail line (located approximately 32 km north of the Project).

Domestic waste, non-hazardous industrial waste, and hazardous industrial waste will be properly collected, stored, and disposed of on a contract basis to an approved facility. All storage and handling of hazardous materials and hazardous waste will meet the requirements of *The Hazardous Substances and Waste Dangerous Goods Act* (2004) and *Transportation of Dangerous Goods Act* (1992), including employee training, storage facility design and operation, labelling and material control (e.g., WHMIS).

Progressive reclamation for the Project will be completed during operations, where possible. Conceptual D&R plans will be submitted during licensing to the Ministry of Environment (MOE) in compliance with the *Mineral Industry Environmental Protection Regulations* (1996). A Project-specific D&R Plan will be developed during Project permitting and will evolve over the life of the Project to incorporate new research and technologies. The D&R Plan provides a framework for the decommissioning of facilities and infrastructure at the Project site in such a way that the environment and the public will be protected over the long-term. Geotechnical, geochemical, and hydrogeological considerations will be integrated into the D&R Plan. Final D&R activities will be completed once mining operations have ceased.

1.4 Project Schedule

A general overview of the Project schedule is shown in Table 1.4-1. The main Project phases and estimated timelines are indicative of the overall Project design and planning throughout 2013 and 2014. The schedule may change pursuant to finalizing Project design and because of the regulatory approval process.

Based on the resource calculation and on a 2.8 Mtpa production facility, the minimum design life for potash production, including the ramp up of production capacity is 65 years. For assessment purposes, a 100-year mine life has been assumed. After Yancoal has received EA approval to proceed and the required licensing applications have been submitted, the Project would proceed in three phases:

- construction (2016 to 2019);
- operation (2019 to 2119); and
- decommissioning and reclamation (2119 onward).

Table 1.4-1: Yancoal Project Schedule

Project Phase	Year																										
	2013				2014				2015				2016				2017				2018				2019		
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Environmental Impact Assessment																											
Baseline Study	■	■	■	■																							
EIS Preparation					■	■	■	■	■	■	■																
EIS Review and Approval											■	■	■														
Construction Approvals													■														
Construction/Operation																											
Construction														■	■	■	■	■	■	■	■	■	■	■	■	■	■
Wellfield Development																		■	■	■	■	■	■	■	■	■	■
Begin Operations																											■

1.5 Need for and Benefits of the Project

The "need for" the Project is defined as the problem or opportunity that the proposed Project is intending to solve or satisfy; that is, "need for" establishes the fundamental justification or rationale for the Project (Canadian Environmental Assessment Agency 2007). The "benefit of" the Project outlines what is to be achieved by carrying out the Project.

Canadian potash exports have played an increasingly important role in maintaining and expanding global crop yields in recent years. This is important because of a combination of increasing population levels, rising levels of income in developing countries, poor harvests in key producing regions due to floods and drought, and the demand for biofuels. These factors have led to a steady increase in the global demand for fertilizer. Continued growth is projected because the long-term demand for potash is strong in supporting increasing global requirements for food production.

Global consumption of potash is projected to see continued growth. With the world population expected to grow more than one third by 2030, there will be an increased need to feed people through increased crop yields and better diets. However, expanding populations, coupled with the long-term trend of improving standards of living, especially in the developing countries, are anticipated to continue to put pressure on the demand for potash. In addition, increasing fossil fuel prices are expected to continue to raise the cost of food production and transportation and, thereby, increase pressure on local food production rather than imports. In general, the long-term demand for potash is strong and is projected to continue as populations continue to grow, incomes in developing countries grow, and arable land decreases.

The Project will provide benefits in addition to supporting increased global food production noted above. Approximately 2,200 workers will be required at the peak of construction. During the construction phase, the local and regional economies will benefit from creation of jobs, purchase of local supplies and services, and improvement of roads. After mining commences, the long-term benefits will include royalty payments to the Government of Saskatchewan, job creation, taxes paid to the municipality, ongoing purchase of supplies and services, and housing development.

1.6 Report Organization

The EA investigates the risks and benefits of the Project in the context of the existing biophysical and socio-economic conditions. In addition to identifying potential risks and specifying appropriate mitigation designs and policies, the assessment incorporates plans for final decommissioning and reclamation of the site. The EA process considers a number of components, including issue scoping, baseline studies, effects predictions, and recommended monitoring and follow-up programs. Although the EA evaluates all potential Project-environment interactions, the intent is to focus the effects analysis on those interactions with the greatest potential to result in significant effects to the biophysical and socio-economic environments.

The EIS is organized into a main document and support documents (appendices and annexes). The main document provides Project-related information and assessments of environmental effects. The assessment of potential effects on the biophysical and socio-economic environments is organized by discipline; that is, all information pertaining to a discipline is provided within each discipline section.

Appendices support the sections of the main document; however, they are not stand-alone documents. The text within the main document interprets and summarizes the data, whereas the data to support the discussion is provided in the appendix. The annexes are stand-alone technical documents and include reports of previous studies that were completed during baseline studies and Project development. These documents provide important pieces of supporting information for review by technical subject-matter experts, for example, stand-alone Baseline Reports, which are summarized within each discipline section (i.e., Existing Environment section) of the main document.

The main document of the EIS is organized into 19 main sections. The following describes the information that is presented within each EIS section.

- Section 1.0 **Introduction -** introduces the proponent, provides an overview of the Project location, Project components and schedule, and describes the need for the Project.
- Section 2.0 **Regulatory Framework –** describes the anticipated regulatory processes.
- Section 3.0 **Project Alternatives -** describes any alternative means of carrying out the Project that were considered during the Project planning phase.
- Section 4.0 **Project Description -** provides a description of the Project as it is planned to proceed through construction and operations. The description will include a timeline for all phases of the Project and a discussion of associated Project components and activities, including supporting infrastructure, which will be required for the Project. The scope of the description will be conceptual and will incorporate reasonable assumptions, as appropriate.
- Section 5.0 **Engagement -** describes the approach to engagement of First Nations and Métis communities and groups, regulatory agencies, and the public. This section includes a summary of the meetings and discussions that have occurred, the issues raised, and a description of additional engagement activities to be completed.
- Section 6.0 **Environmental Assessment Approach -** outlines the overall assessment approach used for analyzing and determining the significance of effects from the Yancoal Southey Project (the Project) on the biophysical and socio-economic (human) environments.
- Sections 7.0 **to** 16.0 **-** present the results of the EA on a discipline-specific basis for the biophysical and socio-economic (human) environments at or near the Project. Topics covered within each of these discipline-specific sections include identification of valued components (VCs), definition of the spatial and temporal boundaries of the assessment, summary of the existing conditions, pathways analysis, residual effects analysis, prediction confidence and uncertainty, residual effects classification, determination of significance, and monitoring and follow-up. The environmental disciplines evaluated in the EIS are:
  - Section 7.0 – Atmospheric Environment;
  - Section 8.0 – Hydrogeology;
  - Section 9.0 – Hydrology;
  - Section 10.0 - Surface Water Quality;
  - Section 11.0 – Fish and Fish Habitat;

- Section 12.0 – Soils;
- Section 13.0 – Vegetation;
- Section 14.0 – Wildlife;
- Section 15.0 - Heritage Resources; and
- Section 16.0 – Socio-economic Environment.

- **Section 17.0 Monitoring and Follow-up -** includes environmental management and monitoring plans and a summary of follow-up programs that will be undertaken for the Project.
- **Section 18.0 Corporate Commitments -** includes a summary of commitments made by Yancoal throughout the EIS.
- **Section 19.0 Summary and Conclusions -** includes a summary of residual effects, predicted significance, and an overall conclusion for the EIS.

1.7 References

Acton, D.F, G.A. Padbury, and C.T. Stushnoff. 1998. *The Ecoregions of Saskatchewan.* Canadian Plains Research Centre, University of Regina. Hignell Printing Limited, Winnipeg, Manitoba. 205pp.

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Mineral Industry Environmental Protection Regulations. 1996. Chapter E-10.2 Reg 7, Available at: http://www.publications.gov.sk.ca/details.cfm?p=1060. Accessed: May 26, 2015

Transportation of Dangerous Goods Act. 1992. SC, c 34. Available at: http://canlii.ca/t/529sv. Accessed: May 26, 2015

2.0 REGULATORY FRAMEWORK

This section is intended to describe the regulatory framework within which the Environmental Impact Statement (EIS) for the Project will be completed.

2.1 Federal Process

The federal environmental assessment requirements are detailed within the *Canadian Environmental Assessment Act* (CEAA 2012). Under Section 8 of the CEAA, a Project Description is required to initiate the screening process through which the Canadian Environmental Assessment Agency (the Agency) will determine if a federal environmental assessment is required for all designated projects. Designated projects are defined under the *Regulations Designating Physical Activities* for the CEAA (2012). Based on our understanding of the Project, submission of a Project Description to the Agency will not be required because the Project is not listed in the *Regulations Designating Physical Activities.*

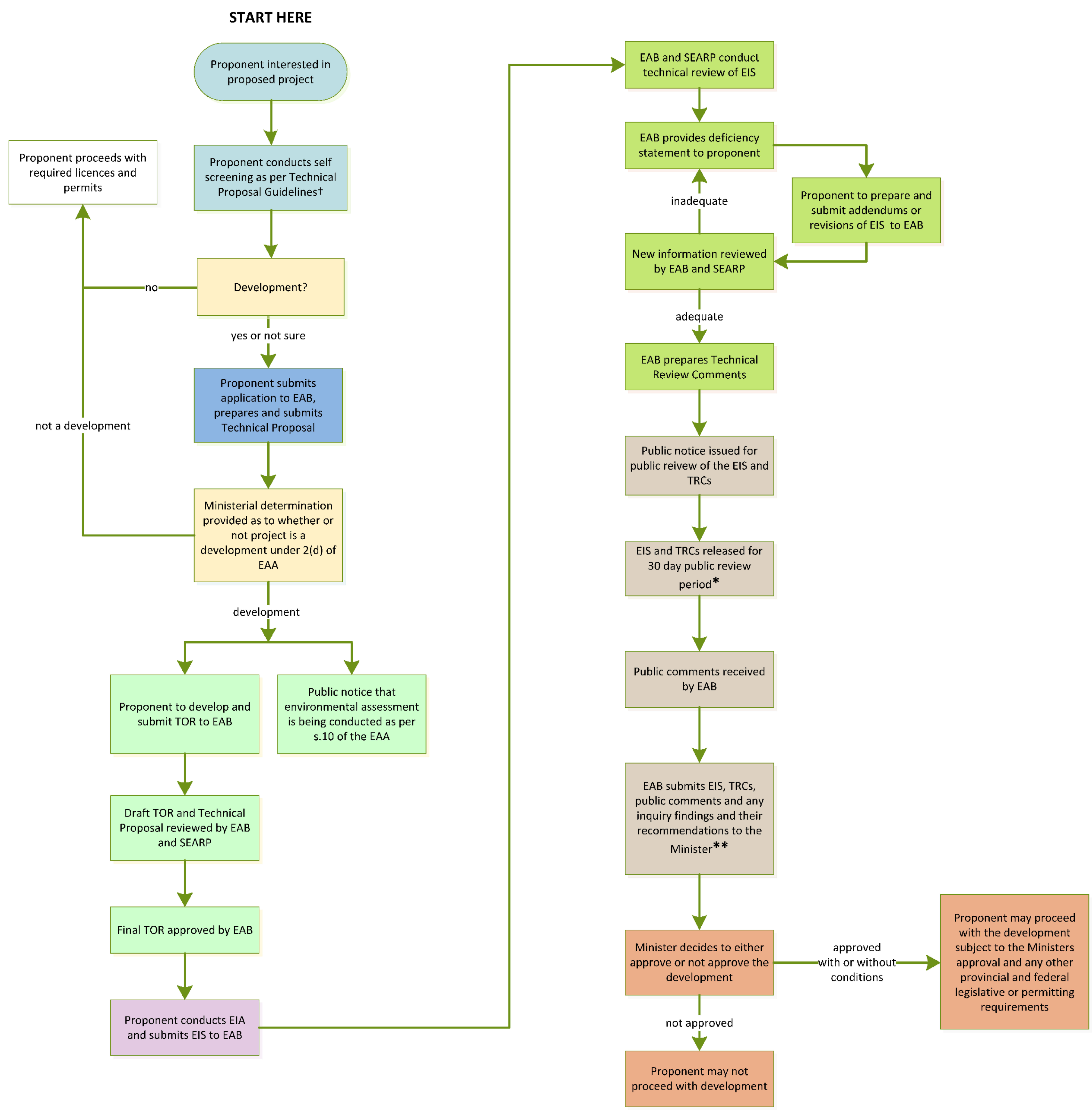
Other federal legislation, such as the *Navigation Protection Act* (2012), the *Fisheries Act* (2012), the *Species at Risk Act* (SARA 2002), and the *Migratory Birds Convention Act* (1994) will be considered. Transport Canada, Fisheries and Oceans Canada (DFO), and Environment Canada will be contacted directly should the Project require further review by or discussion with, these agencies.

2.2 Provincial Process

A flow chart of the provincial environmental assessment process is presented in Figure 2.2-1. The provincial environmental assessment process begins with the submission of a Technical Proposal to the Environmental Assessment Branch (EAB) of the Ministry of Environment (MOE) to determine if the Project is considered a “development”. The MOE will coordinate an inter-ministry review of the Technical Proposal and the EIS using a standing panel of representatives from provincial departments and agencies, which is known as the Saskatchewan Environmental Assessment Review Panel (SEARP). A “development”, as defined in *The Environmental Assessment Act* (EAA 2013), is any project, operation, or activity, or any alteration or expansion of any project, operation, or activity, which is likely to:

- have an effect on any unique, rare, or endangered feature of the environment;
- substantially use any provincial resource and, in so doing, pre-empt the use or potential use of that resource for any other purpose;
- cause the emission of any pollutants or create by-products, residual, or waste products, which require handling and disposal in a manner that is not regulated by another act or regulation;
- cause widespread public concern because of potential environmental changes;
- involve a new technology that is concerned with resource use and that might induce significant environmental change; or
- have a significant effect on the environment or necessitate a further development, which is likely to have a significant effect on the environment.

The Saskatchewan Environmental Assessment Process



Key

Proposal Development	Impact Assessment
Application	Review
Screening	Public Comment
Scoping	Decision by Minister

†Changes to a development with prior Ministerial Approval require review by EA Branch

TPG – Technical Proposal Guidelines
EAB – Environmental Assessment Branch
EAA – The Environmental Assessment Act
TOR – Terms of Reference
SEARP – Saskatchewan Environmental Assessment Review Panel
EIA – Environmental Impact Assessment
EIS – Environmental Impact Statement
TRCs- Technical Review Comments

* Any person may: make a written submission to the minister within 30 days from the date when the minister first gives notice or if the minister considers it appropriate, within an additional period of 30 days.

**Minister may require public meetings or public inquiry into all or any aspect of the development at any time prior to making a decision about the development

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
ENVIRONMENTAL ASSESSMENT PROCESS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	MT	03/12/14	SCALE AS SHOWN	REV. 0
GIS	LMS/AK	04/05/15		
CHECK	MT	26/05/15		
REVIEW	BC	26/05/15		

FIGURE: 2.2-1

REFERENCE
MINISTRY OF ENVIRONMENT, GOVERNMENT OF SASKATCHEWAN, 2014

A Technical Proposal was submitted to EAB for the Project on February 17, 2015. In anticipation of the Project being considered a development, Yancoal requested review under Section 15 of EAA. The Ministerial Determination was received on March 3, 2015, confirming that an EIS was required for the Project. The EIS will be reviewed by the SEARP to determine if the requirements of the EAA have been met prior to the Minister of Environment making a decision about the Project. A copy of the determination is provided in Appendix 2-A.

When a project is considered a "development", the proponent is requested to draft Terms of Reference (TOR) for the preparation of the EIS. The TOR outlines the required scope of the environmental assessment, identifies the key effects to be studied, and provides a set of criteria to judge the completeness of the EIS by regulatory agencies. In anticipation of the Project being considered a development, the draft TOR was submitted as an appendix to the Technical Proposal. Comments on the draft TOR were received from the SEARP on April 8, 2015. The TOR was subsequently revised to address the comments, and a final version was approved by the MOE and SEARP on May 11, 2015 (Appendix 2-B).

This EIS has been prepared following the approved TOR. If the EIS does not contain all required information, the MOE will issue Technical Review Comments and direct the proponent to provide additional information to address deficiencies, and/or potentially complete additional studies. Once a revised EIS is submitted and deemed satisfactory by MOE, the EIS will be made available for public review and comment.

Following the completion of the public review period, the EAB will make a recommendation to the Minister of Environment for a decision on whether the Project can proceed. The Minister of Environment may or may not include approval conditions on a decision to allow the Project to proceed. Once approval is granted, the necessary regulatory permits and authorizations can be obtained.

2.3 Regulatory Permitting

Regulatory permitting (i.e., licensing) occurs after EIS approval and includes the submission of specific applications and supporting design and project management documentation seeking specific construction and operating approvals. Federal and provincial permits, licences, approvals, and authorizations that may be required for the Project are listed in Table 2.3-1.

Table 2.3-1: Federal and Provincial Acts and Regulations that May be Required for the Project

Jurisdiction	Related Regulations	Permits Required
Federal Acts		
Canadian Emission Reduction Incentives Agency Act, S.C., 2005, c. 30	■ No specific regulations related to this *Act.*	■ No specific permit required under this *Act.*
Canadian Environmental Assessment Act, 2012, S.C., 2012, c.19, s.52	■ Regulations Designating Physical Activities, SOR/2012-147. ■ *Prescribed Information for the Description of a Designated Project Regulations*, SOR/2012-148. ■ *Cost Recovery Regulations*, SOR/2012-146.	■ No specific permit required under this *Act.*
Canadian Environmental Protection Act, 1999, C-15.1	■ *Environmental Emergency Regulations*, SOR/2003-307. ■ Federal Above Ground Storage Tank Technical Guidelines, P.C. 1996-1233. ■ *Federal Halocarbon Regulations*, 2003 SOR/2003-289. ■ Federal Underground Storage Tank Guidelines. ■ *Inter-provincial Movement and Hazardous Waste Regulations*, SOR/2002-301. ■ National Pollutant Release Inventory and Municipal Wastewater Services May 2003. ■ *Ozone-depleting Substances Regulations*, 1998 SOR/99-7.	■ No specific permit required under this *Act.*
Canadian Wildlife Act, R.S.C., 1985, c. W-9	■ *Wildlife Area Regulation*, C.R.C., c. 1609.	■ No specific permit required under this *Act.*
The Fisheries Act, R.S.C., 1985, c. F-14 (amended 2012)	■ *Fisheries Act Regulations*, SOR/2013-191.	■ Authorization For Work that May Result in Serious Harm to Fish (Section 35 [2] [b]).
Migratory Birds Convention Act, S.C., 1994, c. 22	■ *Migratory Bird Regulations*, 2010 C.R.C., c. 1035.	■ No specific permit required under this *Act.* ■ Notification only.

Table 2.3-1: Federal and Provincial Acts and Regulations that May be Required for the Project

Jurisdiction	Related Regulations	Permits Required
Navigation Protection Act, R.S., 2012, C. N-22	■ No specific regulations related to this *Act.*	■ No specific permit required under this *Act.*
Species at Risk Act, S.C. 2002, c. 29	■ No specific regulations related to this *Act.*	■ No specific permit required under this *Act.* ■ Adhere to species specific activity restrictions and recovery initiatives.
Transportation of Dangerous Goods Act, 1992, C.34	■ *Transportation of Dangerous Goods Regulations*, SOR/2001-286.	■ No specific permit required under this *Act.*
Provincial Acts		
The Environmental Assessment Act, S.S. 1979-80, E-10.1	■ no specific regulations related to this *Act*	■ Environmental Assessment Approval
The Environmental Management and Protection Act, R.R.S. 2010, c. E-10.22	■ Environmental Code Chapter B.1.1 Discharge and Discovery Reporting. ■ Environmental Code Chapter E.1.1 Halocarbon Control. ■ Environmental Code Chapter E.1.2 Industrial Source (Air Quality). ■ *The used Petroleum and Antifreeze Products Collection Regulations, E-10.21 Reg 6.* ■ *The Mineral Industry Environmental Protection Regulations, 1996, E-10.2 reg 7.* ■ *The Hazardous Substances and Waste Dangerous Goods Regulations*, R.R.S., c. E-10.2, Reg 3. ■ *The Waterworks and Sewage Works Regulations*, 2002, R.R.S. c. E-10.22 Reg 3.	■ Hazardous Substances and Waste Dangerous Goods Permit to Construct (Section 10). ■ Hazardous Substances and Wastes Dangerous Goods Permit to Operate (Approval to Store - Section 9). ■ Approval to Construct – Pollutant Control Facility. ■ Approval to Operate – Pollutant Control Facility. ■ Approval to Construct - Water Works. ■ Approval to Operate - Water Works. ■ Permit to Construct - Aquatic Habitat Protection Permit. ■ Environmental Protection Plan. ■ Permit for the potable water treatment plant and associated reservoir if design capacity exceeds 18 m^3/d. ■ Permit for the sewage lagoon if the design capacity exceeds 18 m^3/d.
The Fire Prevention Act, S.S. 1992, F-15.001	■ *The Saskatchewan Fire Code Regulations*, F-15.001 Reg 1. ■ *The Fire Insurance Fees and Reporting Regulations*, F-15.001 Reg 2.	■ No specific permit required under this *Act.*

Table 2.3-1: Federal and Provincial Acts and Regulations that May be Required for the Project

Jurisdiction	Related Regulations	Permits Required
Provincial Acts		
The Fisheries Act (Saskatchewan), S.S. 1994, F-16.1	■ *The Fisheries Regulations*, 1994, F-16.1.	■ No specific permit required under this *Act.*
The Heritage Property Act, S.S. 1979-80, H-2.2	■ *The Heritage Property Regulations*, Sask. Reg 279-80.	■ No specific permit required under this *Act.*
The Highways and Transportation Act, S.S. 1997, H-3.01	■ *The Controlled Access Highways Regulations*, H-3 Reg 7. ■ *The Highways and Transportation Regulations*, H-3.01 Reg 1. ■ *The Erection of Signs Adjacent to Provincial Highways Regulations*, 1986.	■ Approach Permit. ■ Oversize/Overweight permits. ■ Roadside Permit. ■ Off-premise Sign Application. ■ On-premise Sign Application.
The Saskatchewan Employment Act S-15.1 2014	■ Part III Occupational Health and Safety. ■ *The Occupational Health and Safety Regulations, 1996.* ■ *The Mines Regulations, 2003.* ■ *The Radiation Health and Safety Regulations, 2005.*	■ No specific permit required under this *Act.*
The Provincial Lands Act, S.S. 1978, P-31	■ *Saskatchewan Wetland Conservation Corporation Land Regulations*, 1993, P-31, Reg 14. ■ *Crown Resource Land Regulations*, P-31, Reg 17. ■ *Provincial Lands Regulations*, SR145/68.	■ No specific permit required under this *Act.*
The Water Security Agency Act, S.S. 2005, W-8.1th	■ *Saskatchewan Watershed Authority Regulations*, R.R.S., c. S-35.03 Reg 1.	■ Water Rights Licence.
The Weed Control Act, 2010, S.S. W-11.1	■ *Weed Control Regulations*, W-11.1, Reg 1.	■ No specific permit required under this *Act.*

Table 2.3-1: Federal and Provincial Acts and Regulations that May be Required for the Project

Jurisdiction	Related Regulations	Permits Required
The Wildlife Act, S.S. 1998, c. W-13.12	■ *Wildlife Regulations*, W-13.1, Reg 1. ■ *Wildlife Management Zones and Special Areas Boundaries Regulations*, 1990, W-13.1 Reg 45. ■ *Wildlife-Landowner Assistance Regulations*, 1981, W-13.1, Reg 48. ■ *Wild Species at Risk Regulations*, W-13.1 Reg 1.	■ No specific permit required under this *Act.*
Oil and Gas Conservation Act, S.S. 1978, O-2	■ *The Oil and Gas Conservation Regulations*, 2012, O-2 Reg 1	■ Drilling License. ■ Wastewater Disposal Well Permit.
Planning and Development Act, S.S. 2007 P-13.2	■ *The Statement of Provincial Interest Regulations.* ■ *The Subdivision Regulations, 2014.* ■ *The Dedicated Lands Regulations, 2009.*	■ Development Permit. ■ Discretionary Use Approval. ■ Road Haul Agreement.
Reclaimed Industrial Sites Act, S.S. 2007, R-4.21	■ *The Reclaimed Industrial Sites Regulations*, R-4.21, Reg 1.	■ Release from site Approval.
The Public Health Act, S.S. 1994 c. P-37.1	■ *The Plumbing and Drainage Regulations*, P-37.1, Reg 1. ■ *The Public Sewage Works Regulations*, 2011, P-37.1, Reg 14. ■ *The Food Safety Regulations*, 2009, P-37.1, Reg 12. ■ *The Public Accommodation Regulations*, 1997, P-37.1, Reg 3.	■ Permit to construct and operate a private sewage works. ■ Licence for a public eating establishment. ■ Approval for an itinerant use accommodation. ■ License to operate an itinerant use accommodation.
The Pest Control Act,1978, P-7	■ No specific regulations related to this *Act.*	■ No specific permit required under this *Act.*

2.4 References

Canada Emission Reduction Incentives Agency Act. 2005. S.C. c 30, s 87. Available at: http://canlii.ca/t/j5m4.

Canadian Environmental Assessment Act. 2012. S.C. c 19, s 52. Available at: http://canlii.ca/t/51zdg.

Canadian Environmental Protection Act. 1999. S.C. c 33. Available at: http://canlii.ca/t/52brt.

Canada Wildlife Act. 1985. R.S.C. c. W-9. Available at: http://laws-lois.justice.gc.ca/eng/acts/W-9.

Fisheries Act. 2012. R.S.C. c F-14. Available at: http://canlii.ca/t/524r4.

The Forest Resources Management Act. 1996. SS. F-19.1. Available at: http://canlii.ca/t/52d0q.

Migratory Birds Convention Act. 1994. S.C. 1994, c 22. Available at: http://canlii.ca/t/kzkt.

Navigation Protection Act. 2012. R.S.C. c N-22. Available at: http://canlii.ca/t/527pw.

Provincial Lands Act. 1978. SS c P-31. Available at: http://canlii.ca/t/52bjq.

Species at Risk Act. 2002. S.C. c 29. Available at: http://canlii.ca/t/520l0.

The Clean Air Act. 1986-87-88. S.S. C-12.1. Available at: http://canlii.ca/t/529b0.

The Environmental Assessment Act. 1979-80. S.S. c E-10.1. Available at: http://canlii.ca/t/523.

The Environmental Management and Protection Act. 2002. S.S. c E-10.21. Available at: http://canlii.ca/t/52bd1.

The Fire Prevention Act. 1992. S.S. F-15.001*.* Available at: http://canlii.ca/t/529gz.

The Fisheries Act (Saskatchewan). 1994. S.S. F-16.1. Available at: http://canlii.ca/t/527tg.

The Heritage Property Act. 1979-80. S.S. H-2.2. Available at: http://canlii.ca/t/52bdl.

The Highways and Transportation Act. 1997. S.S. H-3.01. Available at: http://canlii.ca/t/52bdm.

The Oil and Gas Conservation Act. 1978. O-2. Available at: http://www.publications.gov.sk.ca/details.cfm?p=745.

The Pest Control Act. 1978. P-7. Available at: http://www.qp.gov.sk.ca/documents/English/Statutes/Statutes/P7.pdf.

The Pipelines Act. 1998. P-12.1. Available at: http://www.publications.gov.sk.ca/details.cfm?p=754.

The Planning and Development Act. 2007. P-13.2. Available at: http://www.publications.gov.sk.ca/details.cfm?p=23220.

The Public Health Act. 1994. P-37.1. Available at: http://www.qp.gov.sk.ca/documents/English/Statutes/Statutes/P37-1.pdf.

The Saskatchewan Employment Act. 2014. S.S. c S-15.1. Available at: http://canlii.ca/t/52bl0.

The Water Security Agency Act. 2005. S.S. Available at: http://canlii.ca/t/52bm2.

The Weed Control Act. 2010. S.S. W-11.1 Available at: http://canlii.ca/t/529hq.

The Wildlife Act, 1998. 1998. SS c W-13.12. Available at: http://canlii.ca/t/527tf.

Transportation of Dangerous Goods Act. 1992. SC, c 34. Available at: http://canlii.ca/t/529sv.

3.0 PROJECT ALTERNATIVES

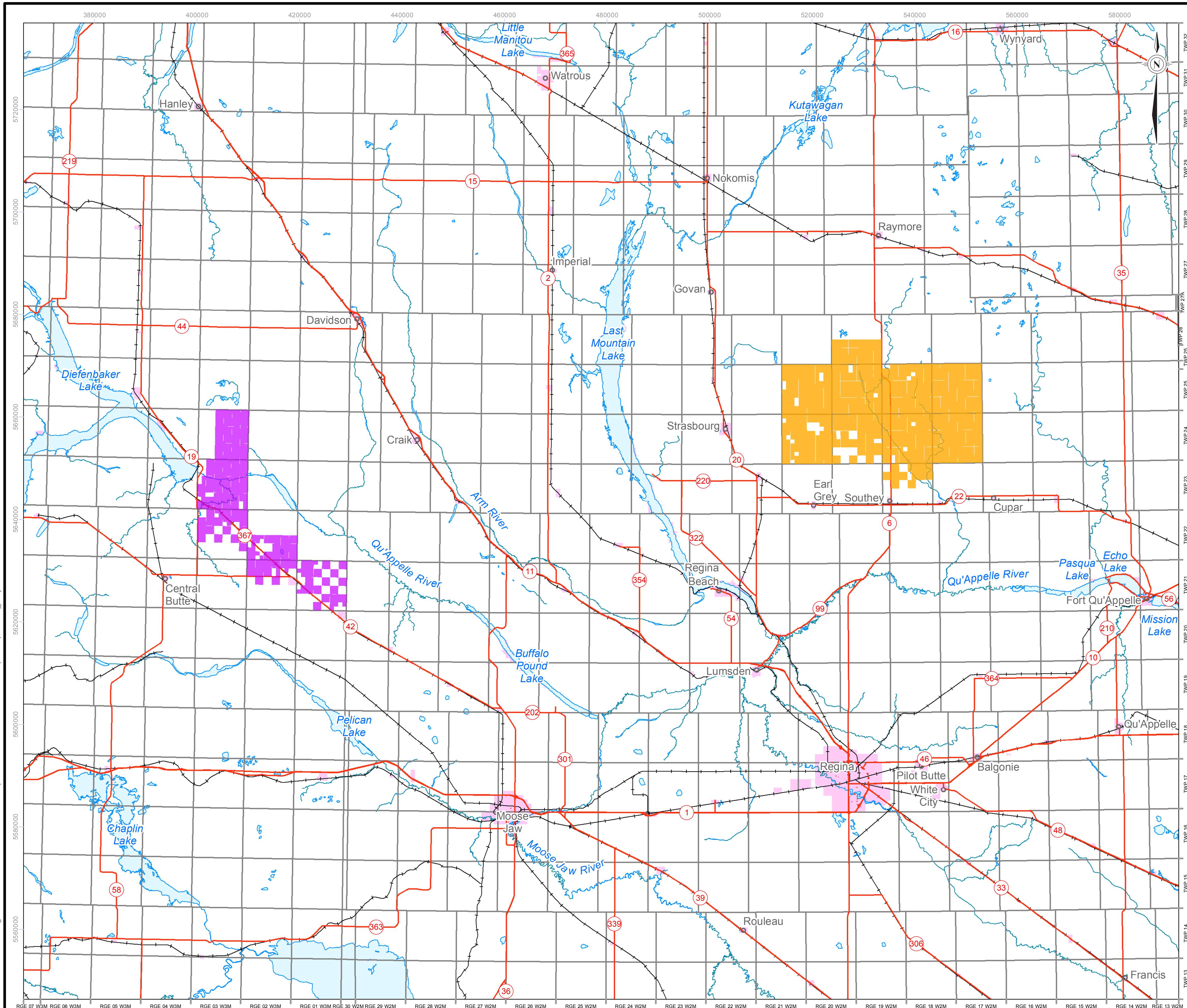
This section will describe the various technically and economically feasible ways the Yancoal Southey Project (the Project) can be implemented or carried out. Alternative components, activities, management systems, environmental design features, or mitigation considered during the Project planning will be described in enough detail to clearly illustrate the differences, advantages, and disadvantages of each option. This section will discuss the criteria (environmental, engineering, and economic) used to evaluate the design alternatives and to provide an explanation for their acceptance or rejection. The criteria used to evaluate alternative design options will reflect the potential concern for short-term (during operations) and long-term (post-decommissioning and reclamation) environmental effects. Economic, social, or environmental considerations that were relevant to the selection of the preferred alternative will be described. Yancoal Canada Resources Company Limited (Yancoal) has undertaken trade-off studies as part of overall Project planning and development to evaluate Project options such as the location of the Project and mining method, based on available information.

3.1 Project Location

The Project will be located within subsurface mineral permit areas KP377 and KP392. Two areas initially were considered for development during the early stages of exploration (Figure 3.1-1). Focus Area 1 is located approximately 60 kilometres (km) north of Regina, Saskatchewan and includes subsurface mineral permits KP377 and KP392 within an area of 78,203 hectares (ha). Focus Area 2 is located approximately 110 km northwest of Regina and includes subsurface mineral permits KP363 and KP483 within an area of 30,873 ha. A trade-off study was completed to select one focus area to advance to the scoping study stage.

Exploration wells were drilled to gather information on the potash resource and existing geology in both focus areas. Additional factors considered as part of the trade-off study included the following:

- mining and processing methods and feasibility;
- mine life;
- mine ramp-up duration;
- capital expenditure;
- water supply;
- utility supply (e.g., natural gas and electrical power);
- rail access;
- road access;
- environment;
- mineral and surface rights; and
- operations safety.



LEGEND

- COMMUNITY
- HIGHWAY
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- FOCUS AREA #1
- FOCUS AREA #2

REFERENCE

FOCUS AREAS PROVIDED BY AMEC, 2014
CANVEC © NATURAL RESOURCES CANADA
NTS MAPSHEET: 62L/M, 72I/J/O/P
NAD83 UTM ZONE 13

15 0 15
SCALE 1:750,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
LOCATIONS CONSIDERED FOR THE YANCOAL SOUTHEY PROJECT

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	MT	03/12/14	SCALE AS SHOWN REV. 0
GIS	LMS	29/12/14	FIGURE: 3.1-1
CHECK	MT	26/05/15	
REVIEW	BC	26/05/15	

Both focus areas have similar challenges of available existing infrastructure. Focus Area 1 has sufficient available land, excluding heritage sensitive land, to support up to 100 years of mine life, while Focus Area 2 has limited available land that may not be sufficient to support the desired mine life. In addition, the environmental approval process for Focus Area 2 could be more difficult and take more time because of the greater potential for occurrence of protected wildlife and plant species. Focus Area 1 will require more effort for engagement because there are more First Nations communities near Focus Area 1 than Focus Area 2. In addition, Focus Area 1 was selected to advance through a scoping study because it is more than twice the size of Focus Area 2; given the results of the exploration drilling, Focus Area 1 conceivably has twice as much resource potential.

Six potential locations for the core facilities area were evaluated within Focus Area 1 (Figure 3.1-2). Each location was evaluated based on the following criteria:

- geology (e.g., location of the resource);
- land constraints (e.g., access to mineral and surface rights);
- access to utilities (e.g., water, electrical power, natural gas);
- access to rail lines;
- existing road infrastructure;
- wellfield piping (e.g., maintaining close proximity to the well field); and
- environmental sensitivities (e.g., based on preliminary baseline surveys).

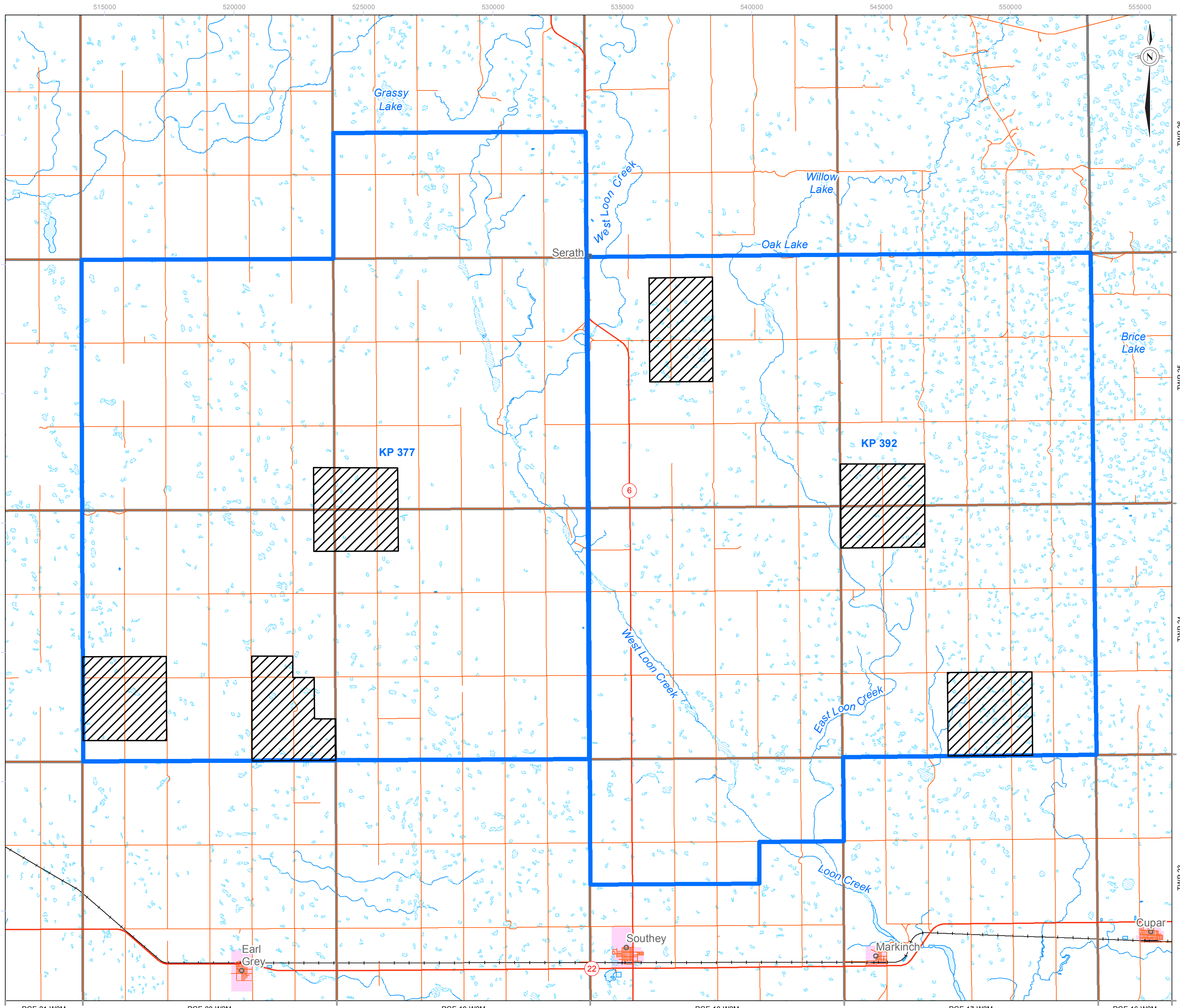
The preferred option is described in Section 4.0.

3.2 Mining Method

Solution mining is the preferred mining method for the Project; however, both conventional and solution mining methods were evaluated. The following section outlines the considerations for potash mining methods.

3.2.1 Conventional Mining

Conventional potash mining uses underground mining practices, where sylvinite ore is cut with machines and transported to the surface for processing. Conventional mining involves the construction of mineshafts and underground mine workings. Conventional mining requires that workers are sent underground to facilitate mining operations.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- PERMIT BOUNDARY
- LOCATION OPTION

REFERENCE

PERMIT BOUNDARY: POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT

YANCOAL
SOUTHEY PROJECT

TITLE

LOCATION OPTIONS CONSIDERED WITHIN FOCUS AREA 1

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197		FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
GIS	LMS	26/05/15		
CHECK	MT	26/05/15		
REVIEW	BC	26/05/15		

FIGURE: 3.1-2

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1075 EIS Non-Discipline Specific\3_Project Alternatives\12-1362-0197 - Locations Options Considered within Focus Area 1.mxd Date: 5/26/2015 9:47:58 AM

Depth of mining generally corresponds with how much ground stress will be encountered when mining takes place in the potash-bearing member. This is important in conventional mining because the required protective measures (i.e., bolting) for ground control are proportional to the ground stress. Conventional mine operating costs can increase dramatically with the number of measures required to ensure ground stability.

The processing plant for a conventional mine must receive raw sylvinite ore as mine feed. Crushing and conventional flotation is used for potash benefaction for most potash operations in Saskatchewan.

3.2.2 Solution Mining

Solution mining involves the dissolution of sylvinite with water. Wells are drilled into the potash-bearing members. Water, and later brine, is pumped down the wells, dissolving the potassium chloride (KCl) and sodium chloride (NaCl) in the sylvinite ore. Brine is returned to surface and is conveyed to the process plant through pipelines. It is possible to mine multiple potash-bearing members using solution mining. No underground workers are required, as the sylvinite is accessed by drilling from surface.

For a solution mine, feed comes to surface as potassium chloride/sodium chloride (KCl/NaCl) brine and is separated by mechanical evaporation and crystallization.

3.2.3 Mining Method Selection

The shallowest potash member at the Yancoal deposit is at an average depth of 1,280 metres (m), which is amenable to solution mining, whereas conventional potash mining in Saskatchewan is generally limited to depths of about 1,000 m. Potash solution mining in Saskatchewan has been successfully performed for over 40 years. Benefits to solution mining include lower capital cost, faster timelines to production, safer working conditions, and better recovery of the resource. Therefore, solution mining was selected as the preferred mining method.

3.3 Well Field Pipelines

The well field pipelines will be buried with a minimum cover of 2.4 m. Buried pipelines were selected over above ground pipelines for the following reasons:

- buried pipelines have significantly less interference with farming operations and access in the area;
- buried pipelines have lower heat loss as the ground acts as a partial insulator;
- buried pipelines are less likely to freeze; and
- buried pipelines do not require a surface expansion loop because the soil interaction limits pipe movement.

It is planned to run the pipeline corridor beside existing grid roads as much as possible, while still minimizing the pipeline length.

3.4 Process Technology

Mechanical evaporation followed by crystallization is the selected process for producing potash from the brine produced by solution mining. Mechanical evaporation recovers hot water from the process, which is reused in solution mining. The recycling of hot water to the mining caverns optimizes the use of water and heat of the Project. The following three mechanical evaporation technologies are available.

- Multiple Effect Evaporation (MEE) uses steam energy to evaporate water from the brine in a series of evaporator effects, each operated at a lower temperature than the previous vessel. This allows the vapour boiled off one vessel to be used to heat the next vessel. An MEE plant requires cooling water or cold brine to condense the vapour from the final effect. The multiple-effect configuration allows for lower steam consumption than would be required for the same evaporation rate in a single effect configuration. The MEE plant has a high degree of operational flexibility and a low susceptibility to magnesium chloride ($MgCl_2$).

- Mechanical Vapour Recompression (MVR) uses electrical energy from compressors or fans to evaporate water from the brine in parallel evaporators. The vapour from the vapour head is used as the heat source for evaporation by condensation in a heat exchanger. Since the vapour is condensing in the heater and there is no final effect, a large cooling water supply and condenser are not required. The MVR plant has higher capital costs, require skilled maintenance technicians, and is more susceptible to $MgCl_2$ than MEE plants.

- Thermal Vapour Recompression (TVR) is similar to MEE except that a TVR plant uses a thermo compressor to recompress a portion of the vapour from the first effect and recycles it to the first effect heat exchangers. The remaining vapour from the first effect is used to drive the remaining stages of the MEE. TVR plants have a higher capital cost than a MEE plant but are lower than a MVR plant. The use of thermo compressors on a TVR fixes the first effect temperature which makes the TVR plant less flexible that the MEE plant. TVR plants require less maintenance than an MVR plant; however it is also more susceptible to $MgCl_2$ than MEE plants.

The MEE technology was selected for the Project based on a number of criteria including cost and operational flexibility but, primarily, because it has less specialized maintenance requirements, and higher tolerance to $MgCl_2$ in the brine.

3.5 Additional Trade-off Studies

3.5.1 Comparison of Vertical and Horizontal Solution Mining Caverns

The solution mining technologies and economics of vertical and horizontal potash solution mining caverns were evaluated. Currently, vertical solution mining caverns are used in Saskatchewan at Mosaic Belle Plaine and K+S Legacy (currently under development) and in Michigan at Mosaic Hersey. Horizontal caverns are used in Utah at Intrepid Potash's Moab operations, as well as in NaCl, nahcolite ($NaHCO_3$), trona ($Na_3(CO_3)(HCO_3)\bullet 2H_2O$), and sodium carbonate (Na_2CO_3) mining.

There are two basic types of potash solution mining, non-selective (also known as primary) and selective (also known as secondary). Non-selective potash solution mining uses fresh water to dissolve NaCl and KCl from the ore. Non-selective mining requires a blanket material to control the vertical growth of the cavern during solution mining. Selective potash solution mining uses a saturated NaCl brine to dissolve only the KCl from the ore. Selective mining does not require a blanket material to prevent vertical growth of the cavern during solution mining because only the KCl is dissolved.

Selective solution mining requires a higher grade of KCl to ensure that the NaCl crystals do not surround the KCl crystals and prevent brine from contacting the KCl. The need for higher grade of KCl probably reduces the number of KCl beds that can be mined successfully using selective mining and lowers the overall resource utilization. Since selective solution mining only dissolves KCl, NaCl is not produced. This eliminates the need to process, market, dispose of, or store NaCl on the surface.

The study looked at two variations of the Belle Plaine Method, which use non-selective and selective solution mining techniques, and four methods that only use non-selective solution mining techniques.

The Belle Plaine Method of solution mining is proven in Saskatchewan at Mosaic Belle Plaine and, more recently, at K+S Legacy. Some of the selective solution mining techniques using horizontal caverns studied for this Project have been adapted from potash solution mining in other locations (e.g., Intrepid Potash in New Mexico and Utah) while the remainder have been adapted from solution mining of other minerals (e.g., White River nahcolite mining in Piceance Creek Basin, Colorado). None of the selective solution mining only techniques has been proven effective for Saskatchewan ores.

Yancoal decided to progress with the proven method of potash solution mining in Saskatchewan. This method, described as the Belle Plaine method, is the base case for this study. The process is described further in Section 4.0.

3.5.2 Surface Cooled Crystallization Trade-Off Study

Crystallization ponds take advantage of Saskatchewan's climate to precipitate KCl from brines by cooling the brine, as the ambient temperature is less than the brine temperature. As the brine cools, KCl is precipitated, which settles to the bottom of the pond. An alternative to crystallization ponds is using surface cooled crystallizers, which use colder fluids to remove heat from the brine and achieve a lower end temperature similar to that achieved in a crystallization pond.

A crystallization pond was used for the prefeasibility design because of the lower capital expenditure (CAPEX) requirement versus a surface cooled crystallizer.

3.5.3 Combined Heat and Power Plant Trade-Off Study

In considering the most feasible electrical power option, it is important to consider reliability of supply. Current base load power generation for industrial applications in Saskatchewan is considered most reliable in terms of having the fewest supply interruptions. Alternative power supply options including wind and solar are not base load supply options and cannot be considered feasible options for this Project. Geothermal and biomass are currently unproven technologies for industrial purposes in Saskatchewan and cannot be considered feasible. The most feasible and preferred electrical power supply option is a 230-kilovolt (kV) overhead transmission line supplied by SaskPower. Any power grid modifications that may be required to bring electricity to the site would be managed by SaskPower.

Three options to supply steam for processing were considered as part of a trade-off study. These are described below.

- Case 1 – Low-pressure boilers supply steam to the process and the site's electrical power is drawn from the SaskPower grid.
- Case 2 – High-pressure boilers supply steam to a backpressure steam turbine. The steam turbine would supply approximately 70 megawatts (MW) of power to the site. The low-pressure steam downstream of the turbine would be used in the process.

- Case 3 – Simple cycle natural gas turbine produces 70 MW of site power with a heat recovery system generator (HRSG); an auxiliary boiler provides the balance of steam to the process.

Case 1 was determined to be the preferred option for the Project.

3.5.4 Dryer Technologies

Rotary dryers were compared with fluid bed dryers; both technologies are proven in potash mills in Saskatchewan. The CAPEX, operational expenditure (OPEX), operability, maintainability, and the advantages and disadvantages of the two drying systems were compared. The analysis of the two drying systems does not clearly identify one as the better dryer. Fluid bed dryers were selected for consideration in the prefeasibility design.

3.5.5 Tailings and Brine Management

Several options for providing containment of brine solutions were evaluated based on expected performance, constructability, and cost. Options considered included:

- site selection for natural containment;
- construction of a synthetic liner system beneath the tailings management area (TMA) and ponds;
- construction of an amended soil cutoff wall to provide lateral containment; and
- installation of a network of recovery wells to provide hydraulic containment.

3.5.5.1 Natural Containment

The site selection process (Section 3.1) considered the presence of natural geological materials capable of providing containment of brine solutions. The stratified clay and clayey tills of the Saskatoon Group are the main geological units that would mitigate the vertical migration of seepage from the TMA. Hydraulic conductivity values representative of these materials typically range over several orders of magnitude ($1x10^{-11}$ to $1x10^{-7}$ metres per second [m/s]) and are dependent upon factors such as clay content, degree of consolidation, and secondary structure (e.g., fracturing). Testing completed indicates that hydraulic conductivity values for the Saskatoon Group tills encountered include 7.5×10^{-9} m/s (Battleford Formation) and 5.7×10^{-10} m/s (Floral Formation) (Annex II; Section 4.0). In general, the shallower, fractured, and oxidized materials possess hydraulic conductivities within the upper end of the range and deep, clayey, and over-consolidated materials exhibit values within the lower range.

Natural materials may provide adequate containment of brine solutions over the life of the Project where sufficient thicknesses of low-permeability clay deposits overlie aquifer units. Therefore, it is advantageous to optimize the location of waste salt and brine management infrastructure to benefit from natural containment.

Geological and hydrogeological site characterization and groundwater flow modeling indicates the presence of aquifer units within the vicinity of the proposed TMA. Two potential pathways for brine migration from the salt storage area: isolated deposits of Saskatoon group sands; and the intertill stratified sand and gravel deposits have been identified. The TMA site was selected to rely on natural materials to provide primary containment of brine solutions to reduce impingement on aquifer units; however, engineered containment systems may be required as a means of secondary containment to supplement the natural system. The technology, engineering, design, construction, operation, monitoring, and performance of these containment works are well understood, and such containment infrastructure are presently licensed and widely used at various potash operations in the province.

Containment berms and dykes will be constructed around the tailings management area to contain salt tailings and decanted brine, as well as divert surface water. The containment dykes will be keyed into native materials to a depth as required to control potential surface expression of brine by lateral migration through potentially jointed oxidized clay or shallow stratified deposits. The key in will be constructed by excavating, moisture conditioning, and compacting native clay till material to eliminate secondary structure (jointing), thus providing an effective barrier to lateral migration.

Although native soils may be relied upon for adequate containment of brine as for the tailings impoundment, an unlined brine pond may require erosion control measures to protect submerged slopes. These measures may consist of rip-rap and/or liner materials to provide slope protection. A final decision on the necessity and extent of a liner and erosion protection will be made during subsequent detailed design phases of the Project.

3.5.5.2 Synthetic Liners

Synthetic liners can be effective barriers to solute migration and as such were considered for the design of the TMA and crystallization pond. In practice, the effectiveness of synthetic liner systems is governed by the frequency of perforations, which can be controlled by an effective field quality control/quality assurance system. The major technical challenge associated with this option relates to the relatively large stress-induced deformation that will occur within foundation materials under the load of the salt pile. This would translate into large tensile strains within the liner resulting in extensive tearing of the material and rendering the liner ineffective. In addition, long term information is unavailable for characterizing the performance of a synthetic liner over the extensive periods of time (i.e., hundreds of years) anticipated for a tailings management scenario at a potash mine. On the basis of technical feasibility and anticipated poor environmental performance this option was not selected as the preferred option.

3.5.5.3 Cutoff Wall

Amended soil cut-off wall technology has been proven to be feasible and economically constructed to the depths required to isolate aquifer units that occur within the footprint of the proposed TMA. Soil-bentonite cut-off walls have been effectively employed throughout the Saskatchewan potash industry to contain seepage through preferential flow zones. Cutoff walls will be constructed as required to contain brine in areas where shallow stratified sand and gravel deposits are present. This is the preferred means of brine containment and will be incorporated into the TMA design.

3.5.5.4 Recovery Wells

Recovery wells may be used to locally reverse hydraulic gradients within coarse-grained sediments along the periphery of the TMA such that hydraulic containment of a brine plume could be maintained. If used in conjunction with cut-off walls, positive containment may be maintained by ensuring a low hydraulic head condition within occluded portions of coarse-grained sediments beneath the TMA, with little to no effect on hydraulic head conditions within adjacent aquifers.

In addition, water produced by the recovery wells could be pumped to the TMA and used to dissolve salt for disposal by deep-well injection. Given the apparent advantages of this approach and the moderate associated costs, this option may be considered as a supplemental means of controlling lateral seepage, when used in conjunction with cut-off walls, as required.

3.6 Tailings Decommissioning

3.6.1 Enhanced Dissolution

The duration of the decommissioning period may be reduced through active dissolution of waste salt and disposal of the resulting brine by deep-well injection. This method is severely limited by the availability of water to re-dissolve the salt and provide a transport media to relocate the salt from the surface into the deep geologic formations where it is not a threat to the environment. Fresh water resources (i.e., surface water and groundwater) in the area are limited and highly valued as sources for human consumption and livestock watering. Poor quality groundwater, which does not meet guidelines for human consumption, livestock watering or irrigation, may be considered for dissolution and disposal of waste salt. This option has been considered within the Saskatchewan potash industry for other operations, but has not been found to be effective.

3.6.2 Reduction in Tailings Volume

Along with potash, tailings will be produced as byproduct of the potash mining process. However, unlike conventional mining, solution mining allows for the extraction of almost no insoluble rock or mineral. The tailings in solution mining are almost entirely salt (e.g., NaCl or $MgCl_2$); the non-soluble tailings produced in solution mining are less than in conventional mining. Also, solution mining eliminates the need for the shafts and drifts required in conventional mining, further reducing the tailings produced.

Secondary mining is being considered for the Project. This process uses a NaCl-saturated brine and KCl poor brine to preferentially leach additional KCl. Recovered KCl slurry is pumped to the crystallization pond where KCl will precipitate from solution. Recovered KCl slurry from the crystallization pond will be pumped to product de-brining via a floating dredge, thickened in product centrifuges, and then sent to drying, screening, and compaction to obtain standard product size material. Secondary mining has a much slower extraction rate compared to primary mining, and tends to require lower brine flow rates to maintain target concentrations. Thus, intermittent pumping is often considered so that some caverns are pumped at a much higher rate, while other caverns are left to recharge.

As KCl is dissolved, NaCl precipitates in the cavern, resulting in a reduction of the total NaCl tailings that must be stored in the TMA. The ability to proceed with secondary mining will be determined by the brine concentration and cavern behaviour, and can only be determined once mining operations begin.

3.7 Water Supply

During initial cavern development, the approximate requirement for water is 1,602 cubic metres per hour (m^3/h). During normal operations at full production, the maximum average requirement for water is 1,450 m^3/h. Potential sources for provision of a water supply for the project included groundwater and surface water.

The Manville Aquifer is the most promising of the bedrock aquifers if a high total dissolved solids water supply was found to be acceptable, however, due to its highly variable nature, numerous deep water wells likely would be required to meet the Project's water requirements.

Most Quaternary aquifers in the Project area are of limited extent and thickness and do not have the potential to provide adequate water supply. Regionally, the Hatfield Valley Aquifer system in the area of Focus Area 1 is a potential source of groundwater; however, additional investigations would be required to determine the current extent of allocation for the aquifer and better determine the ability of the aquifer to deliver the proposed pumping rates.

It is uncertain if a single groundwater source could be allocated to provide and sustain the proposed water supply. There are no plans to use groundwater for any portion of the water supply required for the Project.

For potential surface water supplies, the most likely option to be suitable for water supply would be a waterbody as opposed to a streamflow source. Potential surface water supplies were identified within the project area and surface water was identified as the preferred water supply option. Discussions with Saskatchewan Water Security Agency (WSA) indicated that a regional supply pipeline from Buffalo Pound Lake is preferred for a surface water supply.

A water allocation for Buffalo Pound Lake has been issued by the WSA for the Project. Water availability from Buffalo Pound Lake was assessed within the SaskWater Buffalo Pound Non-Potable Water Supply System Expansion Project Environmental Impact Statement. On March 18, 2015 the Ministry of Environment concluded that any adverse environmental effects associated with SaskWater's Buffalo Pound Non-Potable Water Supply System Expansion Project can be eliminated or minimized.

3.8 Construction Accommodations

Preliminary investigation has shown that Regina, the largest community near the Project, does not have sufficient accommodations to accommodate the anticipated construction workforce required for the Project and other construction projects that may occur near Regina on a similar timeframe. While smaller communities located closer to the Project may have accommodations and infrastructure to accommodate a portion of the workforce, it is unlikely this would be sufficient during peak construction periods. As such, a construction camp will be located as near to the construction site, as practical.

It is anticipated that the camp will be built to house up to 1,500 workers. During the pre-feasibility study the construction camp selected was a self-contained camp that included water and effluent treatment plants on-site. As part of the feasibility study, Yancoal is in the process of evaluating options for the location of the camp, camp security, and alternative water and effluent options.

It is anticipated that the camp will be located as close to the core facilities area as possible to reduce the amount of traffic on the roads. However, efforts will be made to locate the camp away from existing natural drainages, areas of native grassland, or other environmentally sensitive locations. Transportation to site from the construction camp (e.g., carpooling or shuttles) will also be considered to reduce traffic.

3.9 Access Road

Primary access to the core facilities area was considered from the west, south and north. Highway 6 was determined as the primary access to the core facilities area because it is in good condition, has a good rating, and provides suitable access to major traffic corridors to the north and south.

Several access points to the core facilities area from Highway 6 were considered. This included access from grid road 641 from the north or south, and paralleling grid road 731 further north. The rationale behind the selection of grid road 731 included the following:

- the Highway 6 turnoff to grid road 731 provides suitable sight lines for anticipated additional traffic;
- the grid road 731 corridor between Strasbourg and Highway 6 is an established traffic corridor;
- grid road 731 allows for the potential to provide access to the core facilities area from the west;
- the turnoff towards the core facility area from grid road 731 appears suitable for road widening and all season surfacing; and
- the turnoff to the core facilities area from grid road 731 is an existing grid road which reduces capital costs and minimizes the effects of having to develop a new road.

4.0 PROJECT DESCRIPTION

4.1 Introduction

This section of the Environmental Impact Statement (EIS) for the Yancoal Southey Project (the Project) provides a detailed description of the Project components and activities through the construction and operations phases of the Project to support a comprehensive assessment of the Project's effects on the biophysical and socio-economic environments. Environmental design features and mitigation that will be implemented to minimize or avoid the effects of the Project on the environment are described. A conceptual decommissioning and reclamation plan is described. Project activities are described in sufficient detail to enable an accurate assessment of the potential environmental effects from the Project.

4.2 Mineral Resource Review

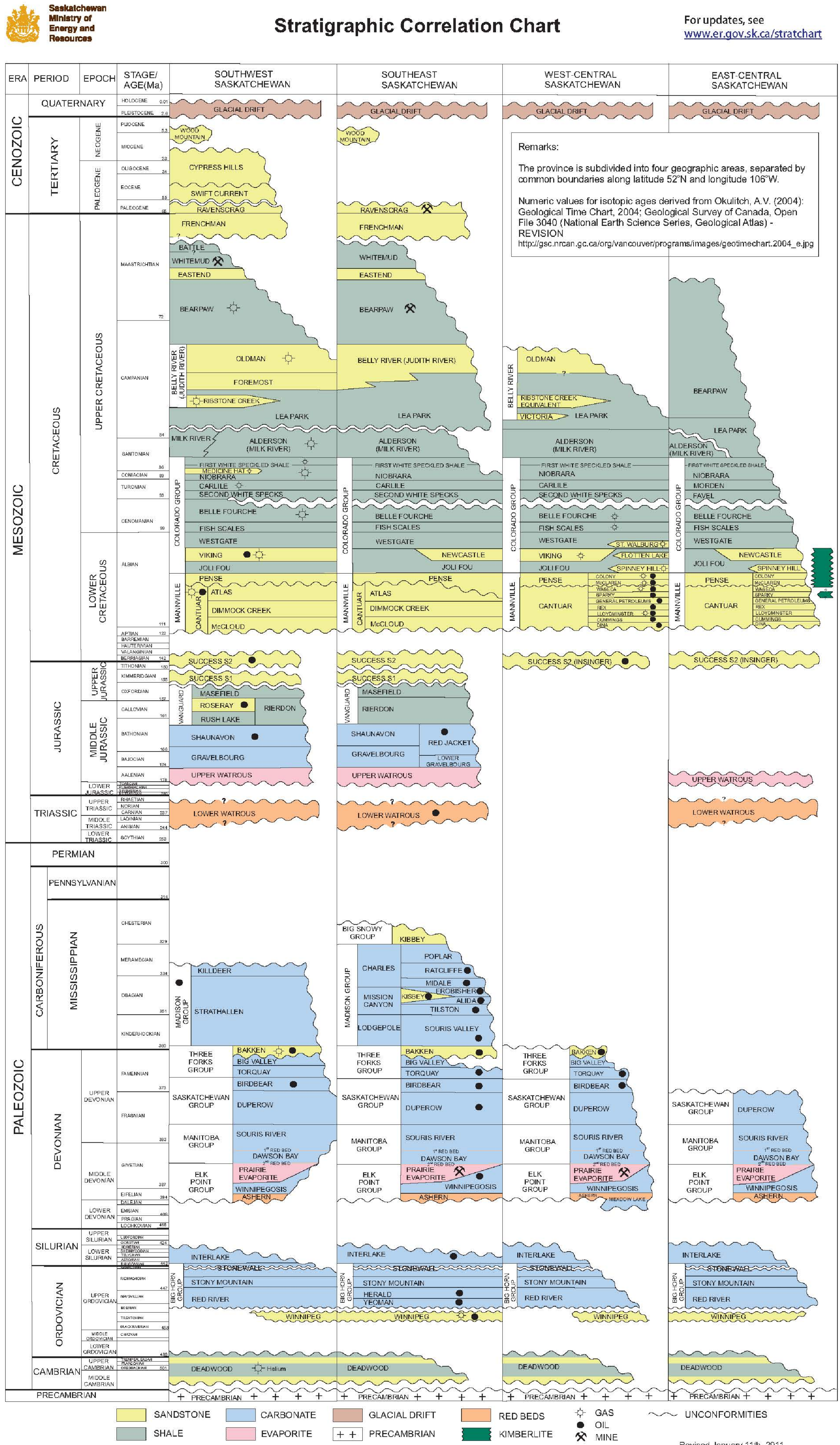
The Project is located in the southern region of the Saskatchewan potash basin, which hosts the Prairie Evaporite Formation. This formation can be mapped from central Alberta to Manitoba, North Dakota, and Montana. The formation contains the Patience Lake, Belle Plaine, and Esterhazy members. The Project is contained within the Elk Point Basin, which is a primary sedimentary feature located predominantly in Alberta and Saskatchewan.

4.2.1 Mineral Formations

A modified version of the Saskatchewan Industry and Resources Regional Subsurface Stratigraphic Correlation Chart, shown on Figure 4.2-1, provides a representation of the regional geological markers encountered within the southeastern Saskatchewan potash belt.

The key Mesozoic and Paleozoic formations were interpreted from the 2012 and 2013 drilling results for the Project area. The average depths and lithology descriptions for these formations are summarized in Table 4.2-1. Formations deeper than the Prairie Evaporite were not penetrated by the exploration drilling and have not been interpreted at this time.

The Prairie Evaporite Formation is divided into three principal potash-bearing members and one auxiliary member. In ascending stratigraphic order, the principal potash-bearing members are the Esterhazy Member, the Belle Plaine Member, and the Patience Lake Member. These beds are generally flat lying and are formed of interbedded sylvite, halite, carnallite, clay seams, and minor amounts of anhydrite. The auxiliary potash member, the White Bear Member, is situated between the Belle Plaine and the Esterhazy members.



REFERENCE

MINISTRY OF ENERGY AND RESOURCES, GOVERNMENT OF SASKATCHEWAN, 2014

PROJECT

YANCOAL SOUTHEY PROJECT

TITLE

SASKATCHEWAN STRATIGRAPHIC CORRELATION CHART

PROJECT	12-1362-0197	FILE No.	
DESIGN	MT	03/12/14	SCALE AS SHOWN	REV. 0
GIS	LMS/AK	04/05/15	
CHECK	MT	27/05/15	FIGURE:
REVIEW	BC	27/05/15	4.2-1

Golder Associates
Saskatoon, Saskatchewan

Table 4.2-1: Project Area Formations

Era	Formation Name	Average Depth (mbgs) in Project Area	Lithology Description
MESOZOIC	Second White Speckled Shale	389	black calcareous shale and mudstone with accumulations of fish-skeletal debris
	Lower Colorado Group	423	noncalcareous, grey and black shales with interbedded sandstone lenses
	Viking Sandstone	517	relatively well-washed, fine to coarse grained sandstone
	Manville	559	interbedded sands and shales
	Upper Watrous	660	massive anhydrite bed
PALEOZOIC	Bakken Shale	726	Calcite-cemented, quartzose sandstone and siltstone with black, organic rich shales
	Torquay	754	grey to red dolomite, shale, and anhydrite
	Birdbear	805	upper unit is comprised of non-argillaceous limestone and dolomites, lower unit is mainly dolomite with interbedded evaporites
	Duperow	847	pale coloured limestone and dolomites with anhydrite and argillaceous dolomites
	Souris River	1,026	dolomites and limestone with intervals of anhydrite and halite
	Upper Harris Halite	1,078	halite, average thickness of 3.6 m within Project area
	Lower Harris Halite	1,114	halite, average thickness of 2.4 m within Project area
	Upper Davidson Halite	1,120	halite, average thickness of 50.4 m within Project area
	First Red Beds	1,195	red and grey/green dolomitic mudstones
	Dawson Bay	1,207	split into six units – dolomitic mudstone, fossiliferous limestone, dolomitic mudstone, bituminous limestone, dolomite, anhydrite, and halite
	Second Red Beds	1,248	grey and reddish brown, dolomitic mudstone, locally mottled
	Prairie Evaporite	1,253	generally halite with potash members consisting of varying amounts of sylvite, carnallite, anhydrite, and insolubles

mbgs = metres below ground surface; m = metres

The three Potash Members (i.e., Patience Lake, Belle Plaine, and Esterhazy), as well as the Salt Back (i.e., above the Patience Lake) and the Interbed (i.e., between Patience Lake and Belle Plaine) are considered the key stratigraphic intervals for the Project that will have the greatest influence on potential for solution mining in the area.

4.2.2 Mineral Resource and Grade

Mineral resources and potassium chloride (KCl) grades have been determined for the Project through an exploration program that included drill holes (with core samples) and an advanced three-dimensional (3-D) seismic survey to determine the continuity of the deposit between drill holes. The potash mineral resource was classified based on the radius from the cored drill holes, the thickness, and grade of the selected solution mine interval, as well as the loss factors that account for unknown geologic anomalies.

The Project currently has an in-situ sylvinite tonnage of 5,089 million metric tonnes (MMT), and currently has defined Mineral Resources (minable sylvinite tonnage) totalling 1,529 MMT and is comprised of:

- measured resource: 227.0 MMT;
- indicated resource: 653.0 MMT; and
- inferred resource: 649.1 MMT.

Depending on ultimate production, this would indicate an initial mine life of 65 years. Additional exploration is anticipated in the future to further evaluate the potash resource within the current inferred resource area to upgrade it to the measured and indicated categories. It is anticipated this will extend the mine life to 100 years.

4.3 Construction

4.3.1 Facilities and Infrastructure Required During Construction

It is anticipated the following temporary buildings and facilities will be required during construction:

- construction offices;
- temporary construction camp;
- power supply and lighting;
- communication infrastructure;
- health, safety, security, and environmental (HSSE) facilities;
- fire-fighting water supply;
- equipment maintenance area;
- laydown areas;
- storage facilities;
- fuel storage facilities;
- hazardous substances and waste dangerous goods storage;
- waste management facilities;
- water and wastewater management infrastructure;
- common lunchroom and washroom facilities for the workers; and
- parking.

Construction of infrastructure installations will be scheduled in the priority sequence to support the main construction. Temporary infrastructure will be demobilized as permanent facilities become available for use during construction.

It is anticipated that the initial work force will be small and will build up over time; the peak construction workforce will be approximately 2,200 people; the average construction workforce will be approximately 1,500 people (Section 4.12). Preliminary investigation has shown that Regina does not have sufficient accommodations for the incoming construction workforce. A temporary construction camp will be located as near to the construction site as practical to house up to 1,500 workers. During the pre-feasibility study the construction camp selected was a self-contained camp that included water and effluent treatment plants on-site. As part of the feasibility study, Yancoal is in the process of evaluating options for the location of the camp, camp security, and alternative water and effluent options.

It is anticipated that the camp will be located as close to the core facilities area as possible to reduce the amount of traffic on local roads. However, efforts will be made to locate the camp away from existing natural drainages, areas of native grassland, or other environmentally sensitive locations. Transportation to site from the construction camp (e.g., carpooling or shuttles) will also be considered to reduce traffic. Existing infrastructure at the site is limited and major utilities are a significant distance from site. It is assumed that permanent access to water, power, natural gas, and high-speed telecommunications will not be available for the beginning of construction activities; as such, temporary utilities will be provided. Construction of on-site infrastructure will include the installation of permanent buried services and temporary construction infrastructure. The buried services (e.g., power, natural gas, telecommunications, and water lines) will be installed and tested in parallel with construction earthworks and will require coordination with the earthworks program to ensure efficient installations.

Process and potable water lines are expected to be constructed early in the Project development to support initial mine and cavern development, and various other construction activities. The site water supply and management will primarily consist of temporary facilities and operation, until implementation of the permanent facilities and supply systems are in place.

The water supply requirements are anticipated to be low during the early phase of construction, allowing for locally sourced water. The water supply required for the early phase of construction will be obtained from locally sourced entities (e.g., community water systems, local available wells, or trucked in). Bottled water will be used for human consumption for the entire construction phase. Water for various construction purposes will be provided on an as required basis, and identified in the early phase of the Project. In the peak stages of construction the water supply requirements are anticipated to be of sufficient demand to potentially require multiple short-term sources if the permanent water supply is not yet available. Water availability, source, supply requirements and the various regulatory approvals and requirements will be addressed in the feasibility study and early detail design stage of the Project.

Existing roads are expected to be adequate to support early construction activities; however, road upgrades are required to connect to Highway 6. Road upgrades will be one of the first activities completed during construction so that the roads are capable of supporting transportation of equipment and materials to the Project. A rail spur is needed to connect to the Canadian National (CN) or Canadian Pacific (CP) railway lines.

Temporary natural gas facilities will be provided by TransGas Ltd. or SaskEnergy Ltd. during construction. Electrical power requirements during construction will be met with a 25kV temporary line provided by SaskPower Corporation. Cable and cell towers will be provided by SaskTel during the construction phase.

Non-hazardous wastes generated during construction typically will include plastics, wood, metal, and other inert materials. Appropriate waste containers will be provided where materials are generated; waste materials will be segregated at source for recycling. The materials will be transferred to off-site recycling companies. Inert wastes will be collected and transferred to an off-site, permitted landfill for final disposal by a licensed contractor.

An inventory of all hazardous substances and waste dangerous goods for storage will be established and kept current during construction. All storage and handling of hazardous materials and hazardous waste will meet the requirements of the *Hazardous Substances and Waste Dangerous Goods Act and Regulations* and *Transportation of Dangerous Goods Act and Regulations*. Contractors will be contractually obligated to follow Workplace Hazardous Materials Information System (WHMIS) guidelines and to establish inventories of all hazardous substances. All on-site workers will be required to have WHMIS training. Appropriate storage areas will be constructed, maintained, and monitored for all hazardous substances and waste dangerous goods. These areas will include containment and may include secure storage (lock and key). Policies and procedures related to handling spills of hazardous substances will be established and enforced. When the use of nuclear materials is required, only workers who are licensed to handle and store nuclear materials will be involved. Scheduling of the transport, storage, and use of hazardous substances will aim to minimize the amount on site at any given time. Arrangements will be made with approved waste handling firms to remove and dispose of hazardous waste. All hazardous waste will be transported, stored, handled, and disposed of in accordance with statutory requirements and the Project's environmental policies.

Sewage will be generated during the construction phase, and sewage disposal will conform to provincial and municipal regulations. During the construction phase, the sewer system will include a septic tank with local contractors providing pump-out service on a regular basis. During operations, sewage will be managed with an on-site sewage lagoon conforming to Saskatchewan Ministry of Environment (MOE) requirements.

Fuel will be stored on-site in above ground storage tanks. These tanks will be installed and operated in compliance with provincial and federal regulatory requirements. Secondary containment will include double-walled tanks for smaller tanks and single-walled tanks with liners and berms or dykes for larger tanks. These fuel tanks will be located at the construction site and will supply all fuel requirements for the construction equipment. Fuel trucks will service the tanks on an as-needed basis.

Aggregate and concrete supply facilities will be established, including borrow pits, a crusher, and a batch plant. Aggregate (sand and gravel) will be required for the following construction activities:

- site development;
- concrete production;
- high-quality fill below concrete slabs;
- roadways and parking areas; and
- road improvements.

The Project site has a large quantity of clay that could be used as borrow material. It is anticipated that the excavated material will be managed, characterized, and stockpiled on-site for re-use for lining ponds and creating containment structures. Suitable fill material will be used to construct the dykes for ponds and for general site fill.

4.3.2 Environmental Design Features for Construction

Yancoal will develop a HSSE Management System that will conform to regulatory requirements and will endorse the principles of continual improvement. The Engineering, Procurement, and Construction Management (EPCM) contractor, in conjunction with the Yancoal environmental team, will manage the environmental program during construction. Management and monitoring of the environmental program will be based on the site-specific permit requirements for the Project. These plans and programs will be compliant with the overall HSSE objectives described in Section 4.11.

Diesel and gasoline will be stored in accordance with applicable regulations. Spill control kits will be maintained at the fuel storage area. Contaminated soil from spills will be stored in sealed containers, removed from site by a licensed contractor, and transported to an appropriate disposal facility. In addition, waste lubricating oil and filters from vehicle maintenance, oil rags, and paint will require appropriate disposal. Waste material generated on-site during construction may include metal, wood, plastics, miscellaneous waste, and domestic garbage. A licenced waste contractor will be engaged to provide appropriate waste containers on-site and to remove waste materials to licenced recycle and disposal facilities.

An Environmental Protection Plan will be developed for the Project prior to construction, which will include plans for topsoil stripping, erosion and sediment control, spill response and control, invasive species (e.g., weeds) management, and waste management. Training on the Environmental Protection Plan will be provided on-site for employees and contractors.

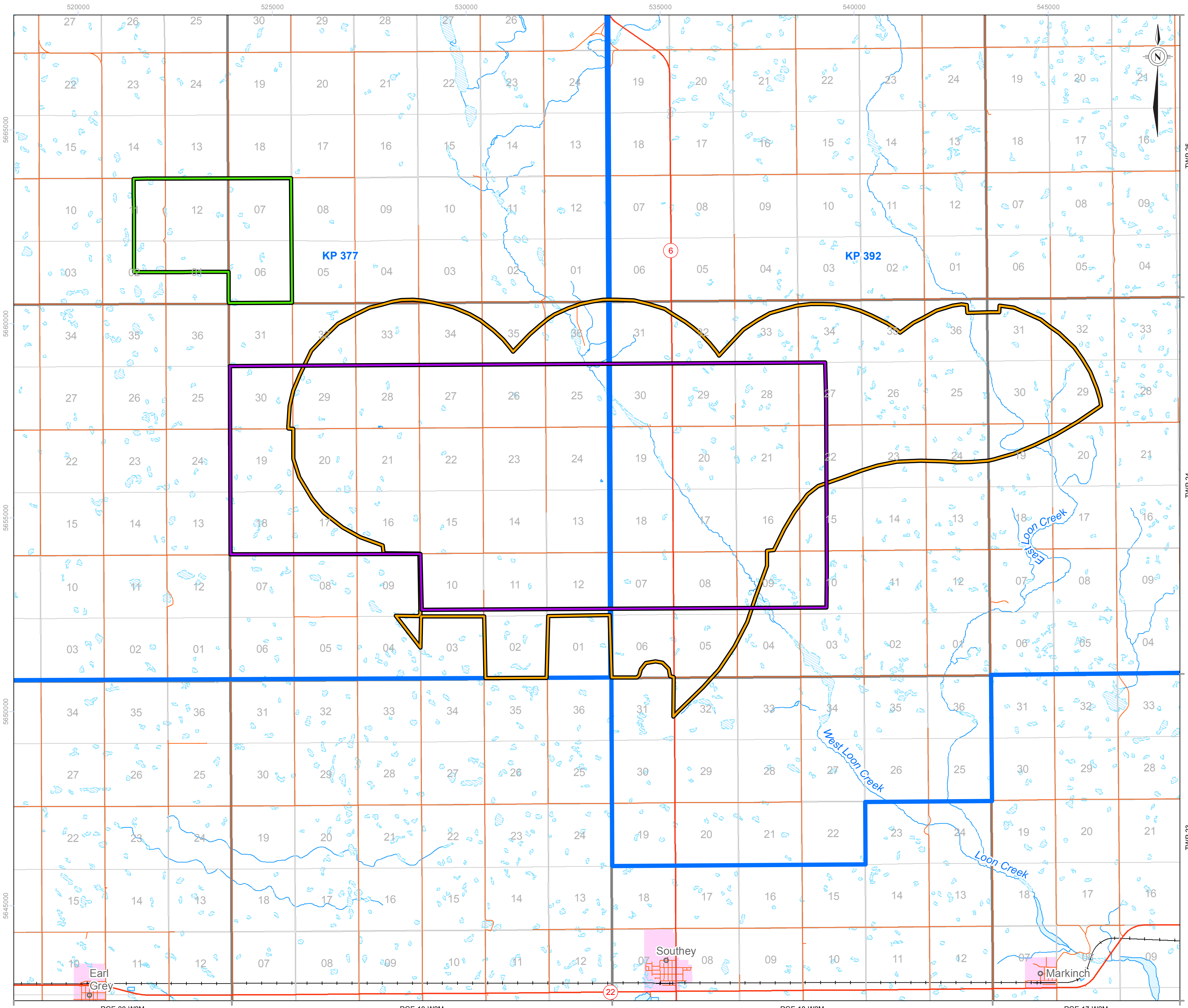
4.4 Mining

Solution mining, a proven technology in Saskatchewan for over 40 years, is a general term referring to the dissolution of water-soluble minerals, such as sodium chloride (NaCl) or KCl, using borehole wells to inject water into mineral-bearing geological formations and removing the resulting saturated brine. The solution mining techniques for the Project will be similar to the mining techniques used at the Mosaic Belle Plaine potash mine.

4.4.1 Mine Plan

The Project is being designed to have a minimum 65-year mine life based on the resource calculation and a 2.8 million tonnes per annum (Mtpa) production facility. Expansion of the assumed resource is anticipated to result in a significantly longer mine life. For assessment purposes in this EIS, a 100-year mine life is assumed. A primary mining production target of 2.0 Mtpa of potash product per year can be met with approximately 35 caverns in production. The primary mining phase per cavern (i.e., after cavern development) is estimated to be completed after 4.3 years for three-bed mining and 2.5 years for two-bed mining. The replacement rate is estimated to be nine caverns (i.e., 18 wells) per year. The conceptual mining boundaries are shown on Figure 4.4-1.

Mining is planned to start from the northwest section of the mine boundary and then migrate to the east. All three potash beds will be mined for most caverns; however, the Esterhazy bed will not be mined in some areas because of high carnallite concentrations.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- SECTION BOUNDARY
- URBAN MUNICIPALITY
- PERMIT BOUNDARY
- CORE FACILITIES AREA
- 65 YEAR MINE FIELD
- INDICATED RESOURCE BOUNDARY

REFERENCE

INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

2 0 2
SCALE 1:100,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
CONCEPTUAL MINE WELL FIELD AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	MT	04/12/14	SCALE AS SHOWN	REV. 0
GIS	LMS/AK	13/05/15	FIGURE:	
CHECK	MT	26/05/15	4.4-1	
REVIEW	BC	26/05/15		

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Secondary mining follows primary mining and differs in that the injection liquor is saturated in NaCl and has a relatively low concentration of KCl. The oil blanket will be recovered. The NaCl grade at saturation will be slightly reduced as the KCl is dissolved and its concentration in solution increases, precipitating some NaCl within the cavern. During secondary mining, the KCl on the walls and on the roof of the cavern will be mined. The NaCl within the cavern remains in-place in the walls of the cavern.

Secondary mining production is not possible until primary mining has been completed in the first 35 caverns, which will be available for secondary recovery 3.98 years after start-up. Production from 35 caverns operating in secondary mining mode will increase muriate of potash production to 2.6 million tonnes (Mt). Forty-nine caverns are required to produce 0.8 Mtpa from secondary mining. This projection is based on a flow rate for the secondary caverns similar to that assumed for the primary caverns. The target production from secondary mining of 0.8 Mt will be reached after the second group of caverns transfers from primary to secondary mining.

With the addition of secondary mining, the cavern life is estimated at 6.8 to 6.9 years for three-bed mining and 4.1 years for two-bed mining. Secondary mining can be conducted as a continuous or an intermittent batch operation.

4.4.2 Mine Components and Infrastructure

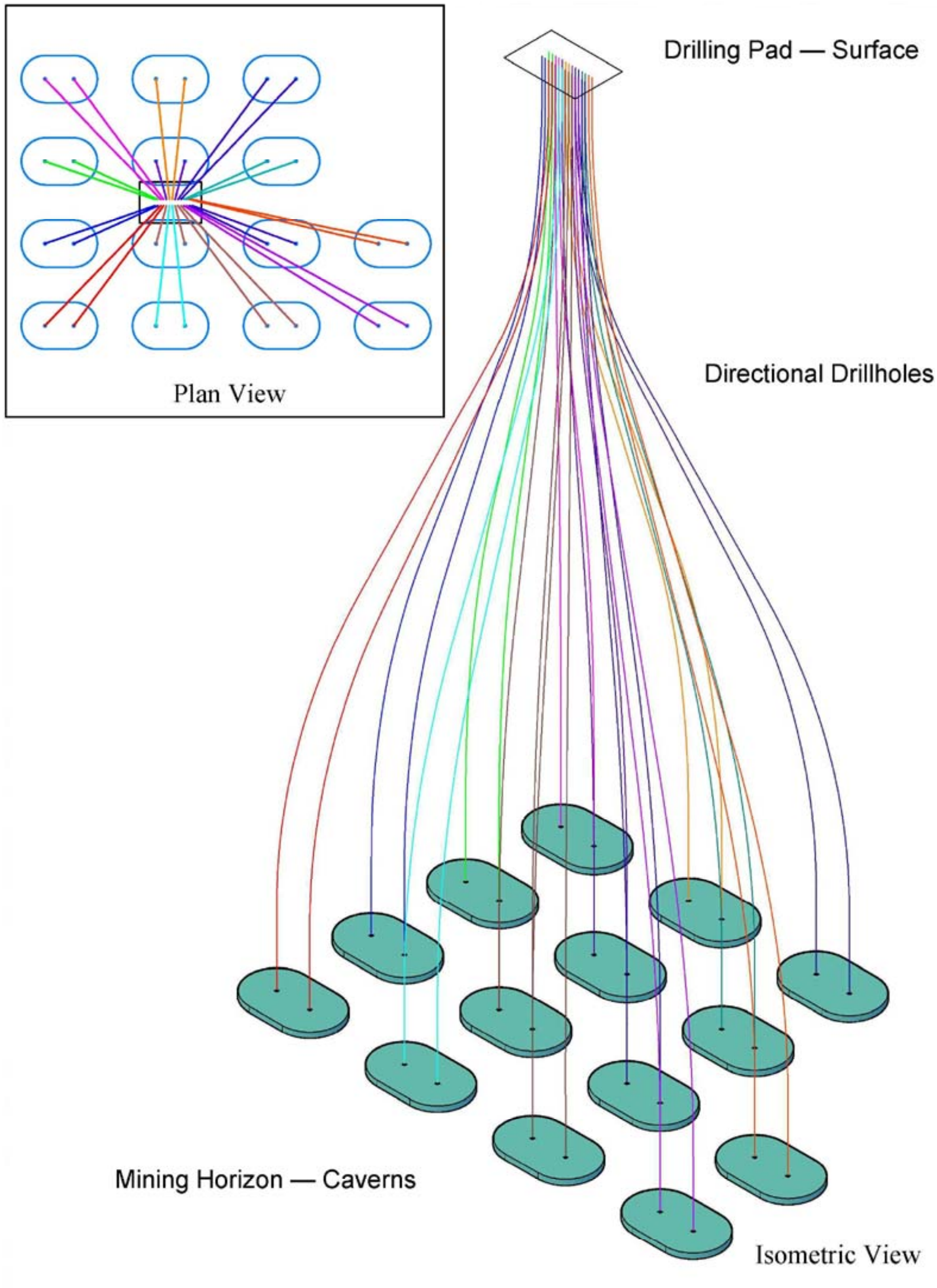
4.4.2.1 Well and Pad Layout

The well pad layout is based on the assumption that 14 caverns will be developed from a single pad. This requires 28 wells from a pad (Figure 4.4-2). As many as 20 caverns could be developed from a single well pad in some locations; this would further reduce the amount of surface disturbance required within the mine well field area. The potential to increase the number of caverns per well pad is being further evaluated during the feasibility study.

Directional drilling is assumed and included in the production drilling cost estimate. A pillar of unmined material is required between caverns to maintain isolation of the caverns and to support the overlying strata. The cavern dimensions and pillar sizes have been selected to control cavern closure during mining. The pillar dimension has been set at 80 metres (m), the cavern radius is 75 m, and the spacing between the wells is 80 m. These cavern dimensions are based on stress analysis and site-specific data. The cavern dimensions are similar to those at Mosaic's Belle Plaine mine, which has an 80 m separation between wells and a cavern radius of at least 70 m. These dimensions result in a cavern spacing of 310 m by 230 m (Figure 4.4-3 and Figure 4.4-4).

The selection of cavern dimensions considers the following.

- Cavern Stability - Cavern stability needs to be considered due to the relative depth and temperature of the deposit. Caverns must remain intact long enough to complete all primary and secondary mining activities.
- Subsidence - Subsidence is a key issue that must be considered due to the flat surface topography of the Project area. Subsidence is more dependent on cavern height than cavern dimensions.



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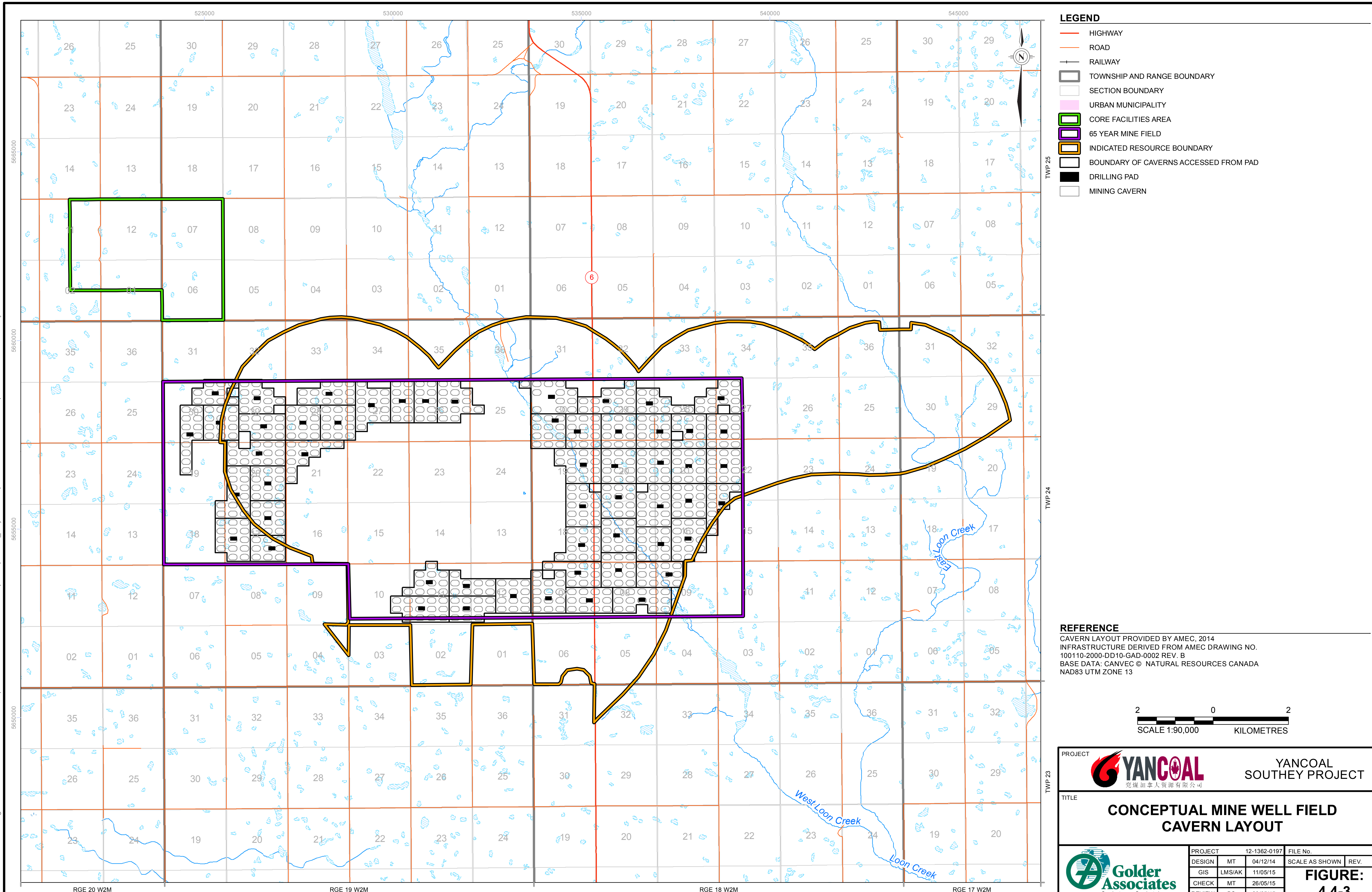
REFERENCE
DRAWINGS PROVIDED BY AMEC

PROJECT
YANCOAL
兖煤加拿大资源有限公司
YANCOAL
SOUTHEY PROJECT

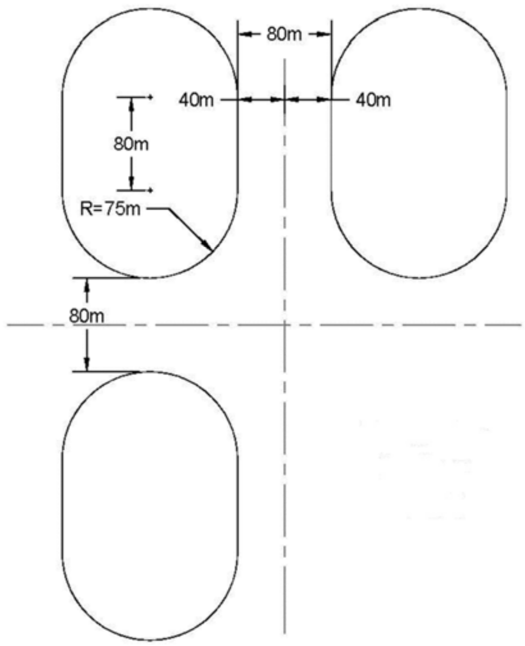
TITLE
TYPICAL CAVERN WELL TRAJECTORY FOR 14 CAVERNS DEVELOPED FROM ONE PAD

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	MT	03/12/14	SCALE AS SHOWN REV. 0
CADD	MKH	04/05/15	FIGURE: 4.4-2
CHECK	MT	26/05/15	
REVIEW	BC	26/05/15	



G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1075 EIS Non-Discipline Specific\4_Project Description\12-1362-0197 - Conceptual Minefield Cavern Layout.mxd Date: 5/26/2015 4:23:08 PM



REFERENCE
DRAWINGS PROVIDED BY AMEC

PROJECT

YANCOAL
SOUTHEY PROJECT

TITLE

DESIGN BASE CAVERN SHAPE AND PILLAR DIMENSION

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.		
DESIGN	MT	03/12/14	SCALE	AS SHOWN	REV. 0
CADD	MKH	04/05/15	FIGURE: 4.4-4		
CHECK	MT	26/05/15			
REVIEW	BC	26/05/15			

4.4.2.2 *Mine Well Field Pipelines*

Mine well field pipelines will be installed below ground with a nominal depth of cover of 2.4 m (i.e., at a sufficient depth that they will not be affected by frost or disturbed by surficial activities such as farming). Double-walled pipe for secondary containment will be used in critical crossing areas (i.e., based on site-specific analysis to meet environmental conditions). All pipelines will be insulated to maintain the required temperature for the process with the exception of the cold water and the early brine return pipelines.

The pumps and the main isolation valves can be activated remotely from the central control centre in the mill. The system's operating pressures, temperatures, and flows can be monitored from the control room.

Leak detection, monitoring, and appropriate pipeline isolation will be provided. Leak detection and monitoring of the well field pipelines will be based on flow and pressure measurements. Flow meters will be located along the pipeline. An imbalanced flow between two monitoring points and a drop in pressure from the normal established pressure pattern will signify that a leak has developed and will activate an alarm.

The installation of underground pipelines requires initial surface disturbance; however, land can be reclaimed and remain productive for further use (e.g., agricultural practices). Pipeline corridors will be installed along grid roads and existing corridors to the extent feasible to minimize new disturbance and minimize pipeline length.

4.4.2.3 *Mine Well Field Waste Storage*

The brine-holding pond at each well pad site will be designed to provide a storage facility for draining the product lines during scheduled maintenance and for disposing of the brine when servicing the wellheads. The brine-holding pond will be lined with 80 mm high density polyethylene (HDPE) and will be designed to hold a volume of 600 cubic metres (m^3). An oil-holding tank, complete with injection pumps, will be located at each wellfield pad. The oil tank will be surrounded by a containment dyke.

4.4.3 Mining Method

Solution mining is a general term most often referring to the dissolution of water-soluble minerals, such as salt or potash, using borehole wells to inject water into mineral-bearing geological formations, and removing the resulting saturated brine. Solution mining is a proven technology in Saskatchewan for over 40 years; the techniques for the Project will be similar to the mining techniques used at the Mosaic Belle Plaine potash mine.

The Project will be mined using a dual-well cavern technique, which uses two wells that penetrate the potash bed vertically about 80 m apart. This dual-well technique is well suited for potash solution mining as flow can be controlled for a uniform cavern size. The solution mining process includes cavern development, primary mining, and secondary mining. A large, thin cavern is developed first, surrounding these two wells in the halite bed below the Belle Plaine Member (where two beds will be mined) or the Esterhazy Member (where three beds will be mined). Solution mining of the potash proceeds in vertical slices with the vertical growth controlled by an oil cap. The oil cap is raised at each mining level. Cavern closure is the final phase of the mining process and is completed after secondary mining.

4.4.3.1 Cavern Development

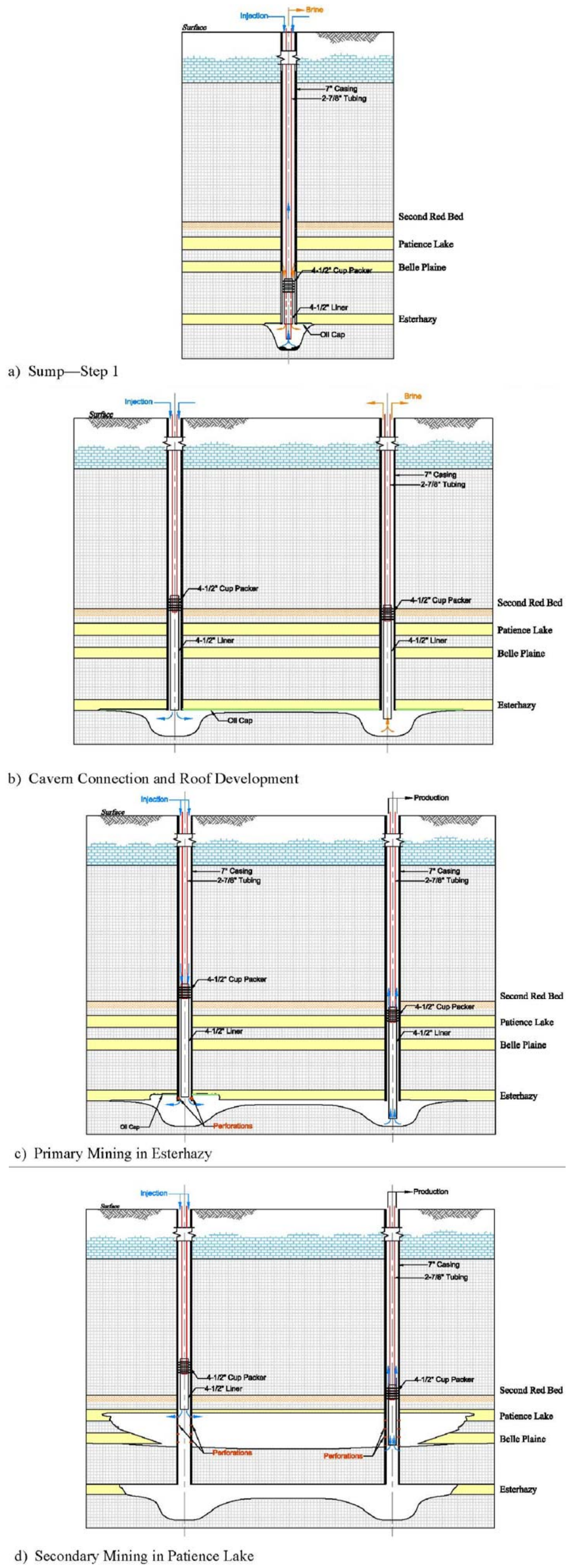
The steps in developing and mining a cavern containing the Patience Lake, Belle Plaine, and Esterhazy Members are shown on Figure 4.4-5. These steps include the following:

- Step 1 - sump development;
- Step 2 - connection and roof development;
- Step 3 - primary mining in the Belle Plaine and Esterhazy members; and
- Step 4 - secondary mining in the Patience Lake Member.

The initial step is the creation of a sump at each well below the Belle Plaine or Esterhazy member potash horizon, then injecting water and oil to expand the diameter of each cavern. The oil, being lighter than the water, floats to the top to inhibit vertical growth of the cavern and causes the cavern to grow laterally. Water is injected in the tubing and recovered from the annulus during initial sump development. During sump and sump-connection phases, water is injected in the annulus of each well and saturated salt brine is recovered in the tubing located near the bottom of the sump.

Roof development follows immediately after the two caverns connect. The roof is expanded by injecting water into one well and recovering the brine from the other. To maintain symmetry in the cavern shape, the flow is reversed with the tubing repositioned so that production is always from the lowest point in the sump. When the roof has been expanded from 60% to 70% of its target dimension, the oil cap is raised by perforating the casing and a layer of potash and halite is dissolved. The process is repeated until the floor of the Belle Plaine or Esterhazy Member is encountered, depending on whether the cavern is located in a two- or three-bed zone, respectively.

The steps are the same for mining two seams except that the sump is created at the bottom of the Belle Plaine Member instead of the Esterhazy Member.



a) Sump—Step 1

b) Cavern Connection and Roof Development

c) Primary Mining in Esterhazy

d) Secondary Mining in Patience Lake

REFERENCE
DRAWINGS PROVIDED BY AMEC

PROJECT
YANCOAL
兖煤加拿大资源有限公司
YANCOAL SOUTHEY PROJECT

TITLE
MINING STEPS FOR THREE-BED MINING AT THE YANCOAL SOUTHEY PROJECT

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	MT	03/12/14	SCALE NTS REV. 0
CADD	MKH	04/05/15	FIGURE: 4.4-5
CHECK	MT	26/05/15	
REVIEW	BC	26/05/15	

4.4.3.2 Primary Mining

Primary mining of the potash member can begin once the cavern roof is fully developed to the desired cavern span. Hot water is injected down one well and brine is extracted through the other well. Primary mining will progress in lifts, with occasional additions of oil to maintain the oil blanket. Each lift will be approximately 1 to 1.5 m thick. When a lift has been completed, the casing is perforated and the new lift is solution-mined. Injection will alternate between the two cavern wells so that a symmetrical cavern develops.

Once primary mining is completed in the Esterhazy Member, tubing and casings are raised and cement plugs are installed to isolate the existing cavern from both wells.

4.4.3.3 Interbeds

The mine plan does not include mining of the low-grade interbedded material between the roof of the Esterhazy Member and the floor of the Belle Plaine Member, and the roof of the Belle Plaine Member and the floor of the Patience Lake Member. To skip these lower and upper interburdens, salt can be separated hydraulically from the bases of the Belle Plaine and Patience Lake members, respectively. Hydraulic pressure can be applied through perforations focused at the layer of mudstone or insolubles at the base of the Belle Plaine Member or of the Patience Lake Member, these mudstone or insoluble layers form separation planes between the salt interburden and the overlying members. Solution mining above the overlying members can proceed once these separations have been initiated.

4.4.3.4 Secondary Mining

Upon completion of the primary production phase, the injection fluid will be changed to brine saturated in NaCl and the oil blanket will be recovered. Secondary mining can be conducted as a continuous or an intermittent batch operation. The NaCl grade at saturation will be slightly reduced, precipitating some NaCl within the cavern as the KCl is dissolved, and its concentration in solution increases. The KCl on the walls and on the roof of the cavern will be mined during secondary mining. The NaCl within the cavern essentially remains in-place in the walls of the cavern. At 29% secondary mining, the cavern life is estimated to be from 6.8 to 6.9 years for three-bed mining and 4.1 years for two-bed mining.

During later stages of secondary mining, the solution mining cavern may develop communication with the permeable Dawson Bay Formation above the cavern roof or, possibly, communication with an adjacent cavern. This communication could limit the cavern's ability to maintain enough pressure to lift production brine to the surface. In this instance, a submersible pump can be installed in the production well to assist lifting the production brine to the surface.

4.4.4 Environmental Design Features and Mitigation for Mining

Environmental design features have been integrated into the mine plan and mining methods to reduce or limit effects on the biophysical and socio-economic environments.

- Seismic surveys were used to detect and avoid geological anomalies, structures, faults, and tight folds.
- The design involves directional drilling from a centralized pad, resulting in a pad that incorporates the development of 14 to 20 caverns from one pad and reduces surface disturbance.
- Unmined pillars will be left between the caverns to increase stability during mining and reduce potential subsidence.
- The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface development.
- Extraction ratios will be monitored to within the maximum allowable strain on surface infrastructure.
- A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence.
- Where possible, existing roads will be used to provide access to the well pads to reduce the amount of new road construction required for the Project.
- Final site selection for well pads and pipeline corridors will avoid environmentally sensitive areas (e.g., permanent wetlands, drainages, native grassland) to the extent possible.
- Siting and construction of the Project will be planned to avoid environmentally sensitive areas (e.g., critical wildlife habitat, listed plants species, and wetlands) as much as possible.
- If avoidance of sensitive areas is not feasible, consultation with MOE will be completed to determine the significance of the area and identify mitigation strategies.
- Where practical, natural drainage patterns will be maintained.
- Culverts will be installed along site access roads, as necessary, to maintain drainage.
- The Project will avoid listed plants as much as possible; however, if avoidance of listed plants is not possible, consultation with MOE will be completed to determine the significance of the area and identify feasible mitigation strategies.
- If a listed plant species is encountered that was not expected, appropriate mitigation will be applied prior to further construction activities.
- After construction of the mine well field pipelines has been completed, disturbed areas within pipeline corridors will be re-contoured and reclaimed to support current land uses.

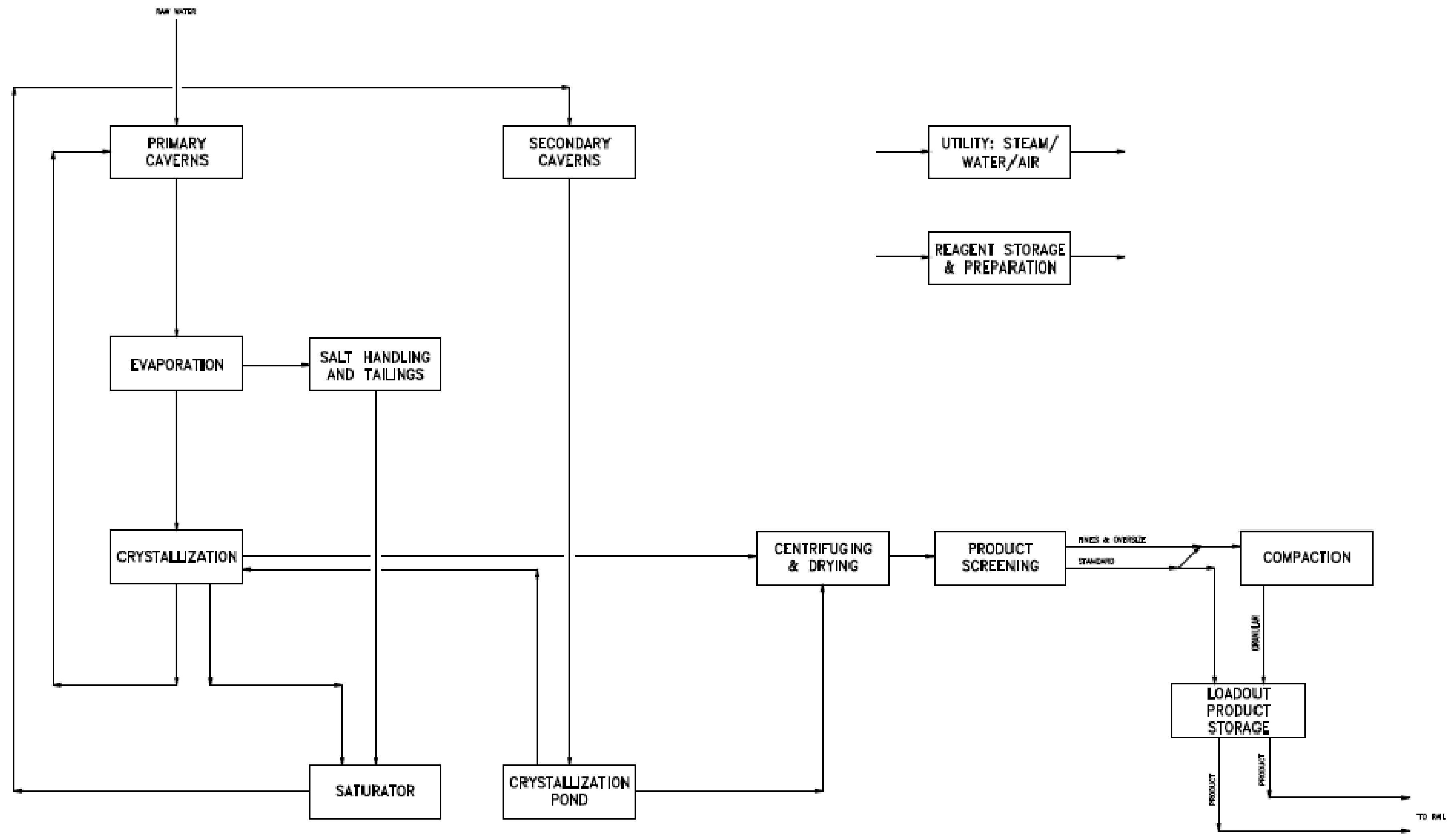
4.5 Processing

4.5.1 Process Plant

The process plant is composed of the following main components:

- evaporation;
- crystallization;
- centrifuging and drying;
- product screening;
- compaction;
- pond crystallization;
- loadout and storage;
- salt handling; and
- reagent storage and preparation.

The process plant will be designed for a primary production mining target of 2.0 Mtpa of potash product. Production during secondary mining will increase overall production to 2.8 Mtpa of potash product. The processing plant is designed to produce 40% granular and 60% standard product with a potassium oxide (K_2O) grade of 62%. A simplified schematic diagram of the process is illustrated on Figure 4.5-1.



PROJECT

YANCOAL
SOUTHEY PROJECT

TITLE

SIMPLIFIED BLOCK DIAGRAM SHOWING THE PRODUCTION OF POTASH FROM PRIMARY AND SECONDARY CAVERNS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	MT	03/12/14	SCALE AS SHOWN REV. 0
CADD	MKH	04/05/15	FIGURE: 4.5-1
CHECK	MT	26/05/15	
REVIEW	BC	26/05/15	

REFERENCE
DRAWINGS PROVIDED BY AMEC

4.5.2 Process Details

4.5.2.1 Evaporation and Crystallization

Brine from the wellfield is pumped to the process plant for processing. Brine from primary mining is directed to the evaporation circuit. In the evaporation circuit, water is evaporated using a five-effect evaporation train and the hot condensate from effects two through five will be sent to the injection tank for use in primary mining. Recycling the hot condensate back to the primary caverns improves water and heat efficiencies. During evaporation, a portion of the NaCl is precipitated out of the cavern fluid. Evaporation leaves a high-temperature brine enriched in KCl that is sent to the KCl crystallizer circuit by way of the clarifier. The precipitated NaCl is separated from the brine (i.e., the brine is sent to the clarifier), re-slurried with reclaim brine, and pumped to the tailings management area (TMA).

Crystallization of KCl is performed in a four-stage draft tube baffle crystallizer circuit. Brine from the clarifier is fed to the first stage of crystallization. Product slurry is carried through the crystallization circuit by mother liquor (i.e., the part of a solution that is left over after crystallization). The final product from the fourth stage crystallizer is transferred to the centrifuge and drying circuit. Brine from the fourth effect crystallizer is sent to the brine tank for recirculation through the evaporation/crystallization circuit. In each stage, the brine is cooled by flashing the brine to a lower pressure; the KCl starts to precipitate as the brine cools.

A portion of the mother liquor is bled from the fourth effect crystallizer and is sent to the brine injection tank for deep well disposal. The magnesium chloride ($MgCl_2$) purge stream controls the $MgCl_2$ level in the mother liquor.

Four natural gas-fired boilers will supply steam for the process. A portion of the condensate is sent to the injection water tank for use in primary mining. The remainder of the condensate is treated and collected in a tank prior to return to the boilers. A cooling tower will provide cooling for the evaporation and crystallization areas.

4.5.2.2 Crystallization Pond

During secondary mining, brine from the secondary caverns is pumped into the crystallization pond. The brine cools in the crystallization pond because the ambient temperature is less than the brine temperature. The brine is directed through a series of channels where the KCl crystallizes and settles to the bottom of the pond.

Dredges are used to harvest the KCl as slurry from the pond. Pumps on the dredges pump the slurry to a pair of thickening tanks located at the northwest corner of the crystallization pond. These tanks provide surge capacity and thicken the slurry to approximately 40% solids. Then the slurry is pumped to the crystallization pond product centrifuges for debrining.

Depleted secondary brine from the crystallization pond overflow is pumped to the fourth stage barometric condensers on both crystallizer trains and preheated before being returned to the secondary caverns.

During primary mining, cavern development brine will be stored in the crystallization pond. This brine will provide cooling for crystallization in place of cooling water.

4.5.2.3 Centrifuging and Drying

Product debrining is accomplished in two stages. Four product centrifuges and two crystallization pond product centrifuges are used to debrine the slurry to approximately 95% solids. Concentrate from the product and crystallization pond product centrifuges re-circulates to the process, while solid cake proceeds to drying. Two fluid bed dryers create a product stream with approximately 0.2% moisture. Dryer off-gas dust is recovered and returned to the crystallization circuit.

Each dryer has a set of cyclones, one wet scrubber, and one stack. The cyclone and scrubber are located before the stack to recover dust from the air before being released to the environment. Slurry from the scrubber is returned to the process.

4.5.2.4 Product Screening

Dried product from the product dryers is fed to a series of multi-deck product screens. The product is separated into three size fractions: standard product, oversize, and undersize. The standard product is fed to a product cooler before being conveyed to loadout or to product storage. The oversize and undersize fractions and a portion of the standard fraction (i.e., its tonnage varies depending on market conditions) are fed to the compaction plant.

Dust from the product screening area is collected and sent to a cyclone and baghouse located in the compaction area. Dust from the cyclone and baghouse is returned to the process (e.g., re-compacted to create product or dissolved and sent to the crystallizers).

4.5.2.5 Compaction and Product Treatment

The compaction circuit generates granular-sized product through compaction, flake breaking, and screening. Oversize material from the screens is crushed and rescreened. The material that meets specifications proceeds to the glazing circuit and the fine material returns to the compactors. The glazing process increases the surface hardness of the material giving it greater durability for handling and transport. A small amount of water is added to the product prior to the product being fed to a dryer/cooler. The product is screened prior to transport or storage after exiting the glazing dryer/cooler. Oversize product from the glazing screens is crushed and rescreened, and the fines are returned to compaction. Dust from the glazing dryer/cooler is collected and sent to a cyclone and baghouse. Dust from the cyclone and baghouse is returned to the process (e.g., re-compacted to create product, or dissolved and sent to the crystallizers).

4.5.2.6 Product Storage and Loadout

Granular and standard products are conveyed to the product storage building by belt conveyor and are transferred to separate storage areas within the product storage building. Potash is reclaimed from the piles in the building using a portal reclaimer and then conveyed to the product loadout building. Standard product is screened to remove any oversize material and granular product is screened to remove any oversize and undersize material. An anticaking agent is applied to the standard and granular product before product storage and before loading the product into railcars for shipping.

Dust from the loadout circuit is collected and sent to a cyclone and baghouse. The cyclone and baghouse recover dust from the air before it is released to the atmosphere. Dust from the loadout baghouse is returned to the process.

4.5.2.7 Salt Handling

A portion of the cake from the NaCl centrifuges is used to saturate the secondary brine before it is returned to the secondary caverns. The remainder is sent to the repulp tank. Reclaimed brine is added to the repulp tank to dilute the slurry to a suitable percent of solids for pumping to the TMA.

4.5.2.8 Reagent Storage and Preparation

4.5.2.8.1 Anticaking and Dedusting Agents

An anticaking agent is applied to the product before shipping to prevent coalescence of the product during transport. The anticaking agent is made by mixing together anticaking oil and dedusting oil. The anticaking and dedusting oils are brought to the site by bulk tanker trucks and stored in separate tanks. The two oils are mixed together in a batch process before applying to the product.

4.5.2.8.2 Flocculant

Flocculant is added to the clarifiers to enhance the settling of the solids. Flocculant is brought to site in tote bags and mixed in a vendor-supplied make down system. The flocculant is mixed using water and then diluted with reclaim brine before it is added to the clarifier. Using reclaimed brine for dilution results in lower water consumption.

4.5.2.8.3 Ammonia

Aqueous ammonia is added to neutralize the hydrochloric acid that is generated in the product dryers, which otherwise can be corrosive to components in this area. The aqueous ammonia is delivered by bulk tanker and stored in a vendor-supplied tank; it is added to the dryer off-gas streams just before the product dryer scrubbers.

4.5.2.8.4 Antifoaming Agent

Antifoaming agent is added to the brine tank before evaporation. The presence of organic material can cause foaming in the evaporators, which could have an undesirable effect on the vacuum systems. The antifoaming agent is added to minimize the amount of foaming. The antifoaming agent is delivered to site in liquid chemical totes.

4.5.2.8.5 Hydrochloric Acid

Inhibited hydrochloric acid at 2% concentration is used to clean scale off the heat transfer surfaces in the evaporators. The hydrochloric acid is brought to site in totes.

4.5.2.8.6 Cooling Tower Chemicals

Sulphuric acid, anti-scale, and bleach are added to the basin of the cooling tower to control pH, scale, and algae growth. These reagents are delivered to site in liquid chemical totes.

4.5.2.8.7 Boiler Chemicals

Chemicals typically added to boiler water include corrosion inhibitors and chemicals required for internal boiler treatment. The equipment required for the addition of the boilers chemicals is vendor-supplied.

4.5.2.8.8 Deoxygenation Chemical

Sodium bisulphite is added into the cavern development water, primary mining injection water and secondary mining injection brine to reduce the amount of dissolved oxygen in the well field. The sodium bisulphite is brought to site in liquid chemical totes.

4.5.3 Environmental Design Features for Processing

Environmental design features have been integrated into the design process for the Project to minimize or avoid potential effects on the biophysical and socio-economic environments. For example, the pond crystallization process will use Saskatchewan's relatively cool climate to increase the crystallization capacity and to reduce energy requirements compared to adding additional evaporator/crystallization trains. Liquid, solid spills, and wash-down within the processing facilities will be contained within the mill facility or the engineered site area. Salvageable product spills will be recycled to the process feed.

The process plant will use cyclones, baghouses, and wet scrubbers to reduce air and dust emissions so that an acceptable working environment is achieved and government standards are met. The dryer burners will be high efficiency, low oxides of nitrogen (NO_x) burners to limit the amount of NO_x present in the exhaust stream.

Several vent pick-up inlets will be provided for collecting dust at all critical transfer points and from dryer exhausts. Dust control systems will discharge to proven scrubber systems in areas where product is handled (e.g., product screening, storage, and loadout). Particulate matter in the form of dust will be controlled and all conveyors between buildings will be enclosed.

Some NaCl remains in the caverns following the secondary mining process, which reduces the amount of on-surface waste salt storage.

The Project design will include conventional insulation, baffles, and noise suppressors on equipment. Most stationary equipment will be housed inside buildings, reducing the amount of noise.

A storm water pond will be built to prevent suspended solids from entering the environment and to capture water for process use. A process upset pond will be built to prevent the release of solution from the evaporation circuit into the environment during a power outage.

4.6 Tailings Management Area

The TMA will consist of a salt storage area, brine reclaim pond, and surface diversion works (Figure 4.6-1). The Project core facilities area and waste salt storage area will be designed based on the digital elevation model obtained from the 2013 LiDAR topographic data.

4.6.1 Waste Salt Storage

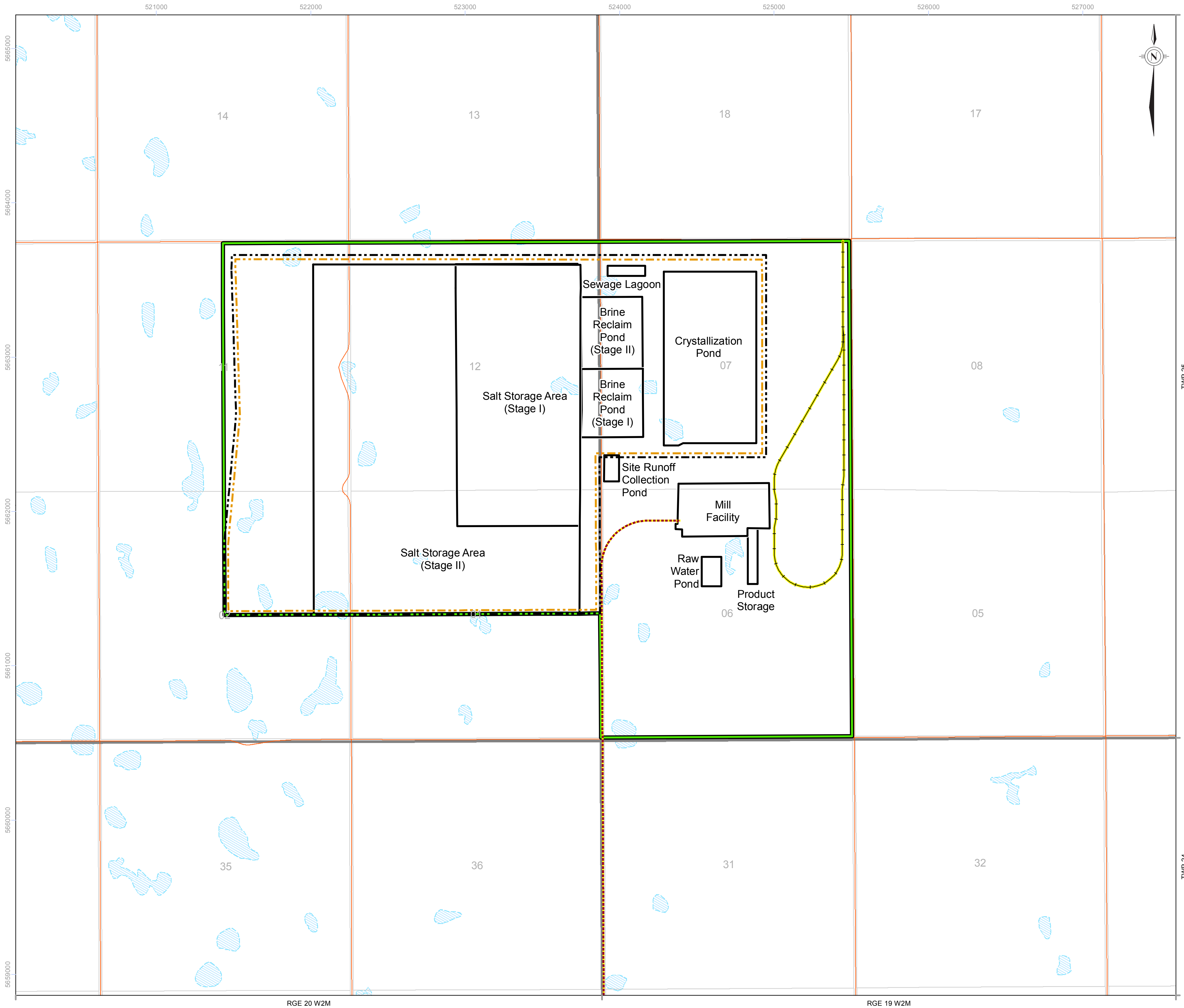
Salt tailings are generated as a waste product of the solution mining process. The volume of tailings produced by solution mining is lower than conventional underground mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only KCl is removed from the caverns during this process.

Based on a production rate of 2.8 Mtpa muriate of potash, salt tailings are expected to be generated at a rate of 3.24 Mtpa over the life of the Project. This would result in the production of 323 Mt of salt tailings. At a placed dry density of 1.45 tonnes per cubic metre (t/m^3), approximately 211 million cubic metres (Mm^3) of salt tailings will be stockpiled over the operating life of the Project. The initial salt storage area in the TMA (Stage I) has been sized to store approximately 20 years of salt tailings production. As the initial salt storage area nears its storage capacity, the salt storage area will be expanded as shown on Figure 4.6-1 (Stage II).

Salt tailings will be discharged through a pipeline to the TMA as slurry. The solids (primarily NaCl) will settle out in the salt storage area. Free brine will drain by gravity to the brine reclaim pond, for recycle to the process or disposal via deep well injection. Control of tailings deposition and surface brine flow will be accomplished using equipment to construct salt berms on the pile, develop pile side slopes, or create drainage ditches within the salt pile.

Salt tailings stockpile stability is governed primarily by the pile height, shear strength of the underlying soils, and the degree to which soil pore water pressures are generated in response to the surcharge load of the stockpile. Preliminary stability analysis indicates that pile heights of 40 to 70 m are feasible for a 3H:1V side slope configuration based on currently available information. Detailed slope stability analysis for the salt pile will be completed to determine the optimal salt pile height for the Project. The final design of the waste salt storage area will provide for flexibility to expand the storage area in stages through modifications to the footprint or increasing the pile height should additional storage be required.

Containment berms and dykes will be constructed around the TMA to contain salt tailings and decanted brine, as well as to divert surface water. Topsoil will be stripped during construction below the dyke footprint and stockpiled for future use. The dykes will be constructed of low permeability clay obtained from excavation of the brine reclaim pond or from general site earthworks. The containment dykes of the brine return channels surrounding the salt storage area will be keyed into native materials to a depth as required to control potential surface expression of brine by lateral migration through potentially jointed oxidized clay or shallow stratified deposits. A cutoff wall will be required on the north side of the salt storage area, where the Saskatoon Group aquifer is present, to control migration where the area is near the TMA boundary. Deep seepage to the stratified intertill sand within the footprint of the salt storage area will be contained by means of amended soil cutoff walls extending to competent till materials and recovery wells, as required to prevent off-site migration of brine in groundwater. Figure 4.6-2 presents the conceptual containment design for the TMA. Further characterization studies will be conducted focussing on definition of soils in the waste salt storage area to support the detailed design of the salt pile and below surface containment system.



LEGEND

- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- SECTION BOUNDARY
- PROPOSED ACCESS ROAD
- PROPOSED RAIL LOOP
- CORE FACILITIES AREA
- PROPOSED SITE INFRASTRUCTURE
- SOIL CUTOFF WALL
- TAILINGS MANAGEMENT AREA

REFERENCE

INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
TMA DESIGN REVISED BY GOLDER, 2014
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

500 0 500
SCALE 1:25,000 METRES

PROJECT
YANCOAL SOUTHEY PROJECT

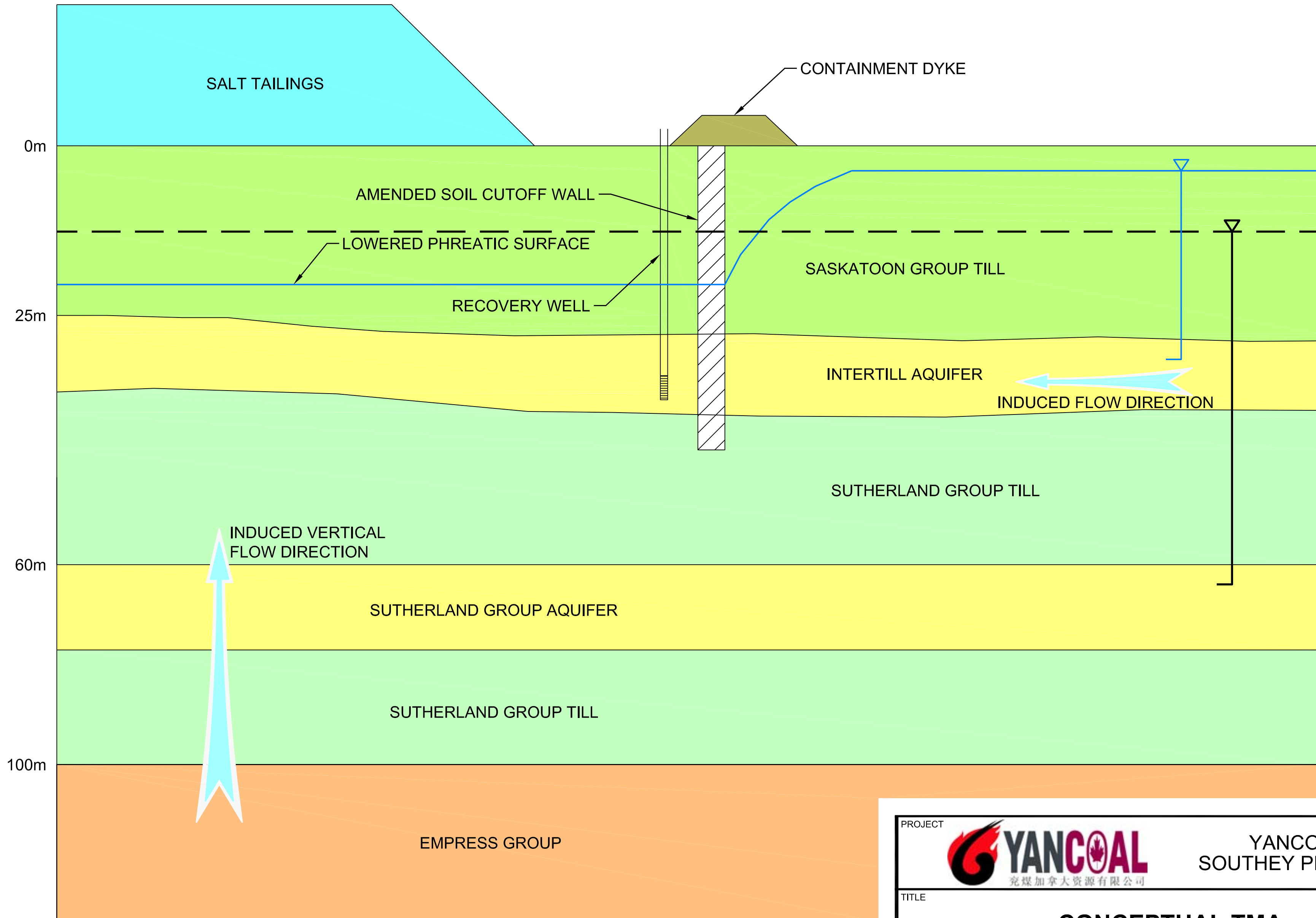
TITLE

GENERAL SITE LAYOUT

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197		FILE No.
DESIGN			SCALE AS SHOWN REV. 0
GIS	LMS/AK	13/01/16	FIGURE: 4.6-1
CHECK	MT	13/01/16	
REVIEW	BC	13/01/16	

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1075 EIS Non-Discipline Specific\4_Project Description\12-1362-0197 - General Site Layout.mxd Date: 1/13/2016 9:54:15 AM



NOT TO SCALE

PROJECT	YANCOAL SOUTHEY PROJECT					
TITLE	**CONCEPTUAL TMA CONTAINMENT STRATEGY**					
Golder Associates, Saskatoon, Saskatchewan	PROJECT		12-1362-0197	FILE No.		
	DESIGN	MAT	15/12/15	SCALE	AS SHOWN	REV. 0
	CADD	JDS	16/01/20	**FIGURE: 4.6-2**		
	CHECK	MAT	16/01/20			
	REVIEW	GM	16/01/20			

Monitoring programs for the waste salt storage area will be incorporated into the design and will include key attributes of pile stability and brine migration. Instrumentation will include nests of vibrating wire piezometers within the foundation soils and base of salt pile to monitor development of pore water pressure beneath the pile and at the toe of the slope, slope inclinometers at the toe of the salt pile to detect slope instability and movement, geophysical electro-magnetic downhole casing to monitor brine migration and soil salinity, and monitoring wells for groundwater sampling and hydraulic conditions.

4.6.2 Brine and Surface Water Management

The general site layout has been developed to use natural topography to assist site drainage to the extent practical. The topography in the area is gently sloping toward the south and slightly to the west. A diversion channel is required to intercept water flows from upland areas along the north and east borders of the core facilities area. The highest elevation of the diversion channel invert will be located at the northeast corner of the core facilities area. From this point, the flow in the diversion channel will be directed westward or southward.

A Water Management Plan is required to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the facility. The surface water diversion will be designed to convey the runoff associated with the 300-millimetre (mm) 24-hour design storm event. Erosion protection of the surface water diversion channel will be provided by topsoil replacement and hydro seeding to establish grass cover within the diversion channel. A tackifier may be used to increase the temporary soil stability prior to vegetation establishing of permanent root systems.

Contaminated areas will be enclosed by a perimeter containment berm to contain and collect local runoff and wastewater for final disposal through deep well brine injection. Salt storage area internal channels (i.e., brine return channels) are designed to collect and redirect runoff originated from precipitation and brine discharges on the tailings areas to the brine reclaim pond. The TMA will be graded to drain free brine to the brine reclaim pond by gravity. Internal salt tailings dykes and ditches may be required to direct surface flow to the collection ditch during early stages of deposition.

The brine reclaim pond will be constructed to provide containment of brine during operations and decommissioning and reclamation. The brine reclaim pond will be designed to provide sufficient storage capacity to contain brine decant from the salt storage area during normal operations, runoff resulting from the design storm event, and maintain a minimum freeboard of 0.9 m to accommodate wind-induced setup and wave run-up on the sides of the pond slopes. Normal operating levels in the ponds are associated with practical operational requirements under normal climatic conditions. The total brine reclaim pond depth is the summation of the required depth for normal operations plus depth for major storms, plus freeboard.

Monitoring instrumentation will be required to enable groundwater sampling and monitoring of the brine plume migration within the sub-surface stratigraphy. Provisions for monitoring the brine reclaim pond will facilitate collection of geophysical electro-magnetic survey, groundwater chemistry, and hydraulic head monitoring.

4.6.3 Deep Well Injection

Natural surface water flow will be diverted around the core facilities area to allow the fresh water to remain part of the natural water cycle, while brine will be contained within the TMA and then disposed of through deep-well injection. It is assumed that all runoff generated within the TMA footprint would be redirected to the brine reclaim pond to be used as process make-up water, or to be disposed of through deep-well injection into the Winnipeg and Deadwood formations. Deep well injection requirements will be developed as part of the Waste Salt Management Plan over the life of the Project.

An evaluation of the capacity potential of deep injection to a suitable disposal zone well is provided in Appendix 4-A. The wastewater disposal requirements for the Project are estimated to be 20,000 cubic metres per day (m^3/d) during operations, and 8,500 m^3/d during decommissioning and reclamation. An assessment of target zones for brine disposal has been completed to allow selection of formations with adequate capacity to accept waste brine solution from the Project and sufficient separation from overlying fresh-water aquifers to provide adequate containment of brine. The Winnipeg Formation and the Deadwood formations were found to be separated from fresh water resources and have multiple intervening low permeability layers, which provide adequate containment of the brine. The target formations were also found to have very large capacity, considering thickness and lateral extent.

The number of disposal wells required will depend on well efficiency, local hydraulic properties, injection tests after well completion, and monitoring during operations. It is anticipated that injection wells will be added progressively over the life of the Project as the footprint of the waste salt storage area develops and additional capacity is needed to dispose of excess brine.

During operations, the disposal volumes and well head pressures will be measured. In addition, a permanent downhole pressure gauge will be installed in the initial disposal well and annual fall-off tests will be conducted in each well to allow for an assessment of disposal well performance.

4.6.4 Environmental Design Features and Mitigation for the Tailings Management Area

Environmental design features have been integrated into the TMA to prevent or to limit the effects of the Project on the natural environment.

- Site characterization studies will be conducted to support the design of the salt pile and containment system.
- A containment system will be designed to control migration of brine from the salt storage area to underlying aquifers and control the horizontal migration of brine, as required to prevent off-site migration.
- Information collected from baseline field studies and transport modelling will be used to develop a containment strategy to control brine migration from the salt storage area.
- Compliance monitoring and environmental monitoring will be implemented to verify that appropriate management practices are being used to confirm the design criteria for operational site monitoring programs and, ultimately, the reclamation and abandonment objectives and planning procedures.
- The process plant layout has been designed with features to divert freshwater around the Project site to avoid potential contamination.

- A Water Management Plan will be developed for the Project to assess the potential for capture and reuse of site runoff water to reduce makeup water requirements.
- The environmental performance of the brine reclaim pond and waste salt storage area will be monitored over the life of the operation.
- Excess brine reclaimed from the TMA will be disposed of by deep well injection through operations and decommissioning and reclamation.
- Monitoring programs for the waste salt storage area will be incorporated into the design and will include monitoring of pile stability.

4.7 Site Infrastructure

4.7.1 Permanent Buildings

Permanent buildings will be constructed to facilitate the daily operation of the Project. Major buildings required for the Project are described below and shown on Figure 4.6-1.

- **Process Plant** - This will be the largest building on site and will contain the evaporation, crystallization, centrifuging, drying, product screening, and compaction areas. The process plant will be a multi-storey building consisting of a combination of concrete and structural steel floors. The process plant will contain most of the KCl processing equipment, as well as offices and a control room. This building will be centrally located and will contain the highest concentration of site personnel. Emergency response equipment will be stored in the process plant to optimize response time.
- **Maintenance Shop** - The maintenance shop will provide space to rebuild and repair process equipment. This building will house the process control room, additional office space, and lunch room facilities for plant workers.
- **Mill Warehouse** – This building will be used for storage of supplies and equipment.
- **Administration Building and Dry Facilities** – This will be a single story complex consisting of office space, dry facilities, safety and first aid facilities, lab facilities, and security facilities.
- **Product Storage Building**- The product storage building will be a wood glulam beam structure and will be designed to store 125,000 tonnes (t) of product. The product storage building is designed for granular and standard product.
- **Rail Loadout Building**- This building will contain the equipment required to load the product into rail cars and will be arranged to limit traffic across the rail lines.
- **Powerhouse** – This building will contain boilers, transformers, and water treatment facilities.

4.7.2 Hazardous Substance Storage

All hazardous substances storage facilities will be designed and permitted in compliance with the MOE requirements; scheduling of the transport, storage, and use of hazardous substances will aim to limit the amount on-site at any given time.

Hazardous substances will be stored in several locations on the site. The fuel tank farm will be located adjacent to the process plant and will contain a 4,000 litres (L) hydrochloric acid mixing tank and a 1,454 L hydrochloric acid holding tote. The tank farm will house a 1,454-L anti-foaming agent holding tote. A 24,000 L oil tank will be located north of the tank farm. A 14,000 L hydrous ammonia tank will be located at the northwest corner of the plant.

The transfer house will contain an 80,000 L anticaking oil storage tank, a 55,000 L dedusting oil storage tank, and a 26,000 L anticaking agent mix holding tank.

A 170,000 L injection oil tank will be stored at each cluster wellhead grouping house. The cooling tower pump house will contain a 1,454 L anti-scale holding tote, a 1,454 L bleach holding tote, and a 1,454 L sulphuric acid holding tote. Additional totes will be stored in the warehouse. Used oil will be stored in a 10,000 L tank in the cold storage building along with other hazardous materials.

Pure ethylene glycol will be transported to site by tanker and pumped to the glycol storage tank located in the boiler house. Glycol from the storage tank is pumped to the glycol mix tank where it is mixed with treated water to obtain a 50/50 glycol water mix. The locations for pumping stations for diesel and gasoline equipment are yet to be determined.

At all locations, the hazardous substances will be contained with an adequately sized containment berm or contained in a double-walled environmental tank, depending on the hazardous material. The hazardous substance will be pumped and properly disposed of off-site in the event of a leak or spillage.

As required during the construction phase, all personnel on-site will be required to have WHMIS training. Policies and procedures related to handling spills of hazardous substances will be established and enforced.

4.7.3 Other Buildings

In addition to major buildings as listed above, the following buildings will be located on-site.

- Various pumphouses will be required, including the raw water pumphouse, brine pond pumphouse, and crystallization pond pumphouse.
- A cluster house will be required at each wellhead grouping (or cluster) in the well field.
- An equipment storage shed will be required for indoor storage and repair of site mobile equipment.
- A multiple-cell cooling tower will provide cooling for the evaporation and crystallization areas.
- A separate gas-insulated switchgear will be remotely located to accept power from the SaskPower line (i.e., electrical substation).

4.7.4 Environmental Design Features for Site Infrastructure

The following environmental design features have been integrated into the site plan to prevent or limit effects from the Project on the biophysical environment.

- The plant will be designed to reduce usage of energy and water. Heat will be recovered, where possible, to reduce the thermal and electrical load on the plant. Control systems will be used to optimize energy usage.

- The plant will be ergonomically designed to reduce exposure to dust and noise and to optimize accessibility.
- Site infrastructure will incorporate natural colours and materials for buildings and features, such as tree rows, to reduce the visual effect of the Project.
- Lighting will be designed to limit off-site light disturbances. Low-glare fixtures will be used, where possible, and lighting will be covered and will face downwards to illuminate the ground, not the sky.
- The compact plant layout will limit the area that is disturbed by the Project.
- Double-walled diesel storage tanks will be used for the fuel that is required to operate the back-up generators, fire-fighting water pumps, and fuel dispensing for on-site vehicles.
- The fuel storage and dispensing system will consist of double-walled tanks. All fuel dispensing will be performed over concrete containment pads and in accordance with applicable regulations.

4.8 Supporting Infrastructure

4.8.1 Water Supply

Water requirements for the Project were assessed under steady state operating conditions at the maximum planned production of 2.8 Mtpa, with primary and secondary solution mining in operation. Raw water will be used in solution mining, process, and utility requirements within the plant, cooling water, and fire-fighting. During initial cavern development, the approximate requirement for water is 1,602 cubic metres per hour (m^3/h). During normal operations at full production, the maximum average requirement for water is 1,450 m^3/h.

Water availability from Buffalo Pound Lake was assessed within the SaskWater Buffalo Pound Non-Potable Water Supply System Expansion Project Environmental Impact Statement. On March 18, 2015 the MOE concluded that any adverse environmental effects associated with SaskWater's Buffalo Pound Non-Potable Water Supply System Expansion Project can be eliminated or minimized; this included effects downstream to the Qu'Appelle system (MOE-EAB 2015).

The Water Security Agency (WSA) has issued a water allocation to provide raw water for the Project from Buffalo Pound Lake. Yancoal applied to the WSA for the water supply required for the Project and a positive response has been received. SaskWater will be the responsible service provider for the water supply infrastructure (e.g., intake and pipeline).

The raw water supply to site will be through a 760 millimetre diameter buried pipeline approximately 100–kilometre (km) long, extending from Buffalo Pound Lake to the Yancoal core facilities area. Raw water supply to the site will likely enter the Yancoal property from the southwest.

SaskWater will be the proponent of the water pipeline project and will be responsible for all regulatory approvals required for providing the new water supply pipeline to the site, including requirements for an environmental assessment if required. SaskWater is in the preliminary stages of identifying a potential pipeline corridor and engineering design; as the process continues, a higher level of accuracy regarding the pipeline routing, length, pump sizing, pipe sizing, and booster pumphouse requirements will be available. SaskWater will be responsible for the design, construction, and operation of the water pipeline to the Yancoal core facilities area. A high level description of SaskWater's pipeline route selection and environmental review process is provided in Appendix 4-B.

The raw water pond storage capacity will be sized to accommodate the site's raw water demands and fire-fighting water demands as follows:

- raw water maximum 48-hour surge capacity for process raw water demand of 1,450 m^3/h or 69,600 m^3;
- fire-fighting water dedicated capacity of 10.6 cubic metres per minute (m^3/min) for 4 hours or 3,816 m^3; and
- minimum pond capacity is 73,500 m^3.

The pond design incorporates an average winter ice depth of 0.3 m with the operation of an aerator/bubbler system to maintain an open surface, primarily around the pond intake structure.

The following design features conserve water on site.

- The brine from primary mining is processed by mechanical evaporation, which results in the water in the brine being collected as condensate and recirculated to the primary caverns. This reduces the volume of fresh water required for primary mining.
- The crystallization pond brine is used in secondary mining.
- The crystallization pond brine is used for cooling in the crystallization condensers before being pumped to the secondary caverns. This reduces the amount of cooling water required in the process.
- Brine from the brine reclaim pond is recirculated and used in the process.

Potable water for the core facilities area will be drawn from the raw water pond and delivered through an on-site water treatment plant (WTP) and stored in the potable water storage tank. From the potable water storage tank the potable water will be distributed through the mill and to the administration building. The WTP and the potable water storage tank will be located at the process plant facilities.

4.8.2 Electrical Power

It is expected that permanent electrical power supply for the Project will come from a new 230-kilovolt (kV) line approximately 18 km in length that will connect the existing Condie-Wolverine line (C1W) to the Yancoal owned electrical terminal station (ETS) located south of the core facilities area. SaskPower will be the proponent responsible for all regulatory approvals required for providing the new electrical service to the site, including the environmental assessment, if required. A high level screening of SaskPower's environmental review process is provided in Appendix 4-B.

The ETS feeds the two main 50-megavolt ampere (MVA) power transformers located near the boiler house through buried high-voltage power cables. These transformers step down the voltage to 25 kV for primary distribution. Power is distributed to electrical rooms in all areas of the plant, ancillary buildings, and the wellfield from the main 25 kV switchgear, located near the boiler house. Electrical rooms accommodate unit substations or switchgear connected to nearby outdoor transformers. Unit substations and outdoor transformers step down the voltage to utilization levels of 600 volt (V) or 4.16 kV.

4.8.3 Natural Gas

Natural gas will be delivered to the Project site via a natural gas supply pipeline by TransGas. The natural gas supply to site will require the installation of a new buried high pressure steel pipeline, with a nominal pipe size 16" (NPS 16). Natural gas supply to site will extend approximately 95 km from a tie-in point approximately 1 km southeast of Regina. From the connection point southeast of Regina, the pipeline will head in a northern direction, ending at or near the core facilities area. The supply pipeline will enter the Yancoal property from the south and extend to the natural gas regulator station, which is located southwest of the administration building and parking lot.

The proposed consumption of natural gas required for the Project is 48,000 gigajoules per day (GJ/d). The proposed hourly flow of natural gas is 2,400 gigajoules per hour (GJ/h). The supply is provided with two pressure systems from the natural gas regulator station. A higher-pressure system will supply the mill's boiler house. A low-pressure system, reduced at the regulator station, is distributed through buried carbon steel yellow-jacketed pipelines to the loadout building, maintenance shop, and administration building.

TransGas will be the proponent responsible for all regulatory approvals required for providing the new natural gas service to the site, including the environmental assessment, if required. A high level screening of TransGas's environmental review process is provided in Appendix 4-B.

4.8.4 Steam

For this Project, four natural gas boilers work in parallel to provide the steam for each of the process trains. The main boiler system creates steam from condensate or make-up water to drive the main processing plant. Steam is used to heat propylene glycol through a shell and tube heat exchanger.

The boilers pull condensate from the condensate tank and heat it to create 99% saturated steam at 7.8 megapascal (MPa). All four boilers have a common intake, but each has an individual economizer that uses heat from the exhaust stack to preheat the outside air before it contacts the burner. The boilers have a main burner and pilot burner system that is regulated to ensure high efficiency and minimal pollution through a perfect burn. Each boiler has its own exhaust stack.

4.8.5 Telecommunications

SaskTel is expected to be the telecommunications service provider. SaskTel will own and maintain all telecommunications infrastructure up to the site telecommunications distribution system. SaskTel will be the proponent responsible for all regulatory approvals required for providing the new telecommunication services to the Project, including the environmental assessment, if required. A high level screening of SaskTel's environmental review process is provided in Appendix 4-B.

4.8.6 Roads

Access roads must be capable of withstanding consistent heavy traffic including construction and contractor heavy equipment, and materials delivery. The main vehicle access to the Project site will be from Highway 6, turning west onto grid road 731 for approximately 5.6 km and turning north onto an existing secondary grid road for approximately 1.6 km before entering the south boundary of the core facilities area. The site access is shown on Figure 4.8-1.

Highway 6 is an existing asphalt-surfaced all-season road under the jurisdiction of the Ministry of Highways and Infrastructure. The highway requires the addition of new turning lanes and acceleration and deceleration lanes at the turnoff to grid road 731. Grid road 731 is an existing gravel-surfaced primary grid road under the jurisdiction of the local rural municipality. The grid road requires upgrades to bring it to a full width, asphalt-surfaced, all-season road from the Highway 6 turnoff to the Project access road turnoff. Discussions between the Rural Municipality (R.M.) of Longlaketon, the R.M. of Cupar, the Ministry of Highways and Infrastructure, and Yancoal regarding access road construction and maintenance are on-going.

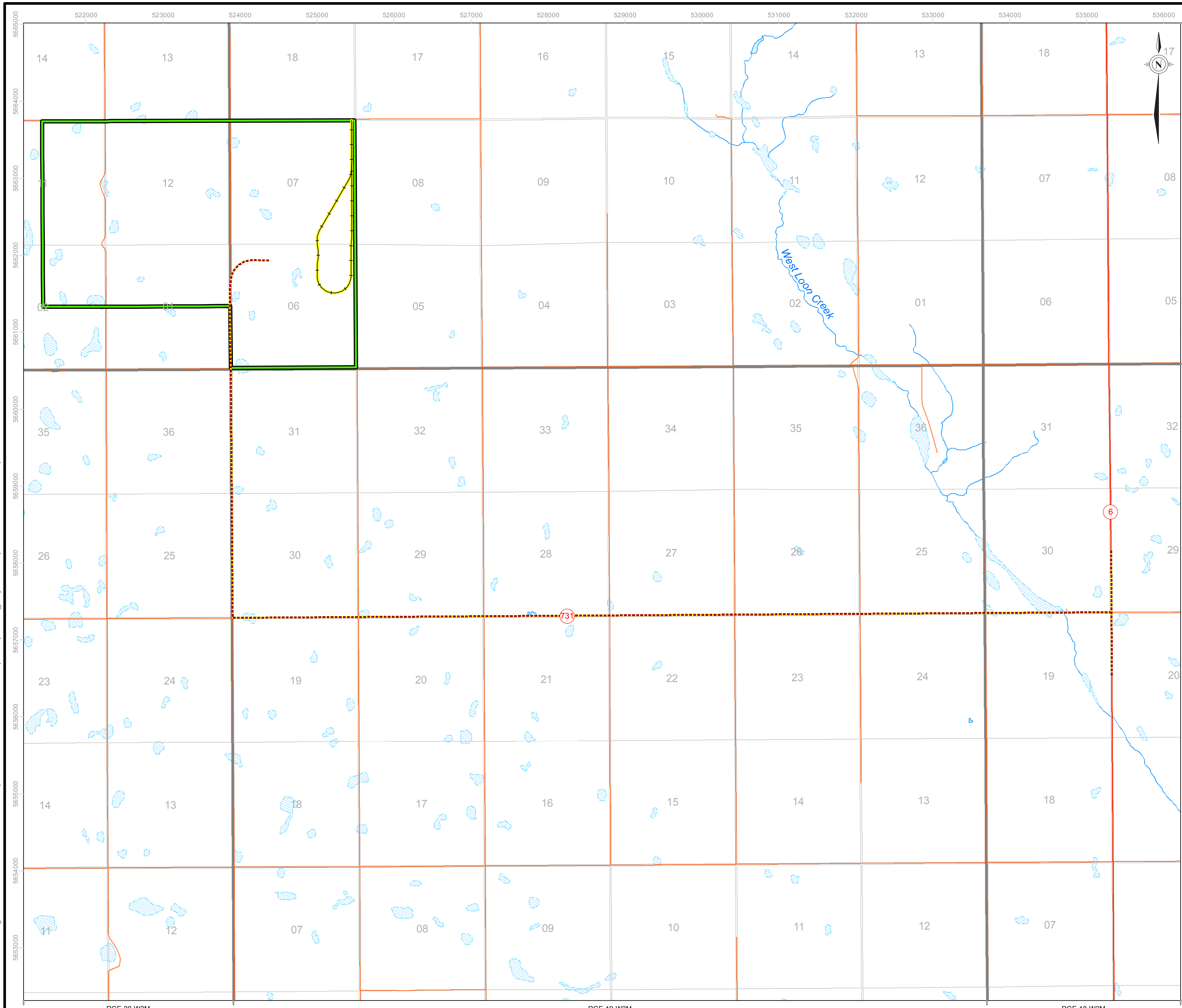
The core facilities area access road from the turnoff at grid road 731 is an existing gravel-surfaced, secondary grid road, servicing local farming operations and farmyards. The core facilities area access road requires upgrades to bring this road to full-width, asphalt-surfaced, all-season road conditions.

Worker transportation options will be explored to reduce commuter traffic. This may include using a bus or shuttle system to and from the temporary construction camp, and nearby communities, or organizing a carpooling system. Vehicles and workers coming to the site will use the main parking lot and access the site through the controlled access point at the main security gate. All vehicular access to site will access the site through the main security gate on the northwest side of the administration building. All other gated access points around the property will remain closed and locked.

On-site roads will be required for both heavy and light vehicle access to buildings on-site, as well as the laydown area. High traffic areas, such as the loadout building, will have separate and restricted access. Site roads and infrastructure will be designed for minimum pedestrian exposure to vehicular traffic.

The core facilities area road layout accommodates general site traffic for operating and maintaining the property. The road layout considers anticipated vehicle and equipment turning geometrics and clearances, while maintaining safe traffic flow and access. Core facilities area roads are divided into main access roads, service roads, and utility roads. Access roads to the well pads for mining will be developed off existing grid roads, to the extent possible, to reduce surface disturbance. Yancoal will work with the local rural municipality for road improvements and new access roads that may be required to access the site.

A traffic impact assessment (TIA) was completed for the construction and operations phases of the Project and is provided in Appendix 4-C. The TIA considered baseline traffic near the Project, potential traffic increases over time without the Project, and estimated traffic increases from the Project during construction and operations, and recommended road improvements. In summary, it is anticipated that approximately 750 vehicle trips will enter and exit the Project site at peak morning and afternoon traffic times during construction. It is also assumed that during construction, 15 large truck deliveries per week, and 14 over-dimension trucks per month will enter and exit the Project site. During operations, 225 vehicle trips are anticipated to occur at peak morning and afternoon times, and 5 large truck deliveries per week. Details on road improvements, channelized intersection requirements, and suggested turning lanes are provided in Appendix 4-C.



LEGEND

- HIGHWAY
- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- SECTION BOUNDARY
- CORE FACILITIES AREA
- PROPOSED RAIL LOOP
- PROPOSED ACCESS ROAD

REFERENCE

INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
TMA DESIGN REVISED BY GOLDER, 2014
CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

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SCALE 1:50,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
PROPOSED SITE ACCESS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	MT	04/12/14	SCALE AS SHOWN	REV. 0
GIS	LMS/AK	04/05/14	**FIGURE: 4.8-1**	
CHECK	MT	27/05/15		
REVIEW	BC	27/05/15		

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4.8.7 Rail

The railway route is designed to transport potash from the plant to a port facility on the west coast.

Two options are being considered as the preferred railway line routes.

- The CP Lanigan line is located west of the Project and roughly follows Highway 20.
- The CN Watrous line is located north of the plant and roughly follows Highway 15.

Both lines are reasonably accessible and are about the same distance from the project. For both options, the off-site rail line is expected to be 25 to 35 km long. The railway spur will be a single track designed to handle the incoming and outgoing traffic. At this phase of the study, there are no plans for railway bridges on-site. The tracks will be developed to provide safe operation and storage of the unit trains. Carloads are anticipated at maximum 120,000 kilograms (kg) loading. Only one rail line will be selected for the Project.

The on-site rail line is designed to store one decoupled unit train of empty railcars and one decoupled unit train of full railcars. The trackage layout on site provides for loading railcars from either of the storage tracks to either of the two loadout bays in the loadout facilities. There is sufficient track length provided on site to couple a full unit train on the property before it leaves the site.

One unit train will consist of approximately 170 railcars and 3 locomotives with a maximum unit train length of 2,500 m. On-site track maximum speed is 25 kilometres per hour (km/h), with final speed considerations dependant on track slope.

There will be approximately 11 km of on-site rail lines, including the following:

- yard track (empty and full): 6,000 m;
- yard track (run-around): 3,100 m; and
- single track (staging): 1,700 m.

The rail company that is selected will be responsible for the selection of the route for the rail line, completing the required environmental assessment, and obtaining the necessary easements and permits to construct. The rail company will be the proponent responsible for all regulatory approvals required for construction of the new rail line to the Project.

4.8.8 Environmental Design Features for Supporting Infrastructure

Environmental design features have been incorporated into the supporting infrastructure design process to reduce or eliminate potential environmental effects from the Project.

- The existing road network will be used where possible to limit surface disturbance from new road construction.
- New or upgraded roads required for access to the core facilities area will be paved to reduce fugitive dust emissions from road traffic.

- Where possible, roads, railways, and utility lines (e.g., water, power, and gas) will be routed along existing utility corridors to limit effects on undisturbed areas.
- Upgrades to existing public highways and roads may also be required to facilitate safe movement of heavy equipment traffic.
- Although only one primary access route is being considered (Highway 6 and grid road 731), the Project site is situated between two major highways, which will help to distribute traffic to and from the site.
- Worker transportation will be explored to reduce commuter traffic, especially at night. Options may include bussing workers from selected locations during operations or organizing carpooling and creating employee incentives to car pool.

4.9 Domestic and Industrial Waste Management

4.9.1 Domestic and Non-hazardous Industrial Waste

Domestic waste generated on-site during the life of the Project includes food waste and waste from construction, operations and administration offices, and sanitary sewage. Garbage and food waste will be collected in containers designed to limit wildlife attraction. Recyclable materials will be sorted and collected in appropriate containers. All domestic waste will be collected and transferred to appropriate off-site disposal facilities by a licensed contractor. Bins and receptacles will be allocated around the site in appropriate areas (e.g., cardboard recycling bin in the warehouse, metal recycling bin in the machine shop, and garbage bins outside office areas).

Non-hazardous wastes generated during mine and processing operations typically will include paper, cardboard, plastics, rubber, wood, metal, and other inert materials. Yancoal will establish a recycling program for this waste to reduce the amount of material transferred to the off-site landfill. Appropriate waste containers will be provided where materials are generated and the materials will be segregated at source for recycling. The material will then be transferred to offsite recycling companies. Inert waste will be collected and transferred to an off-site, permitted landfill for final disposal by a licensed contractor.

Sanitary sewage will be collected from washroom and toilet areas into lift stations and pumped to a two-cell sewage lagoon treatment system. The sewage lagoon will be designed and managed according to the MOE Guidelines for Sewage Works Design January 2008 EPB 203 (EPB 2008). The sewage lagoon is planned to be a facultative sewage lagoon which will discharge to the nearest local drainage course capable of handling the bi-annual discharges. The sewage lagoon will be designed as follows:

- the lagoon will be located at least 0.3 km from isolated human habitation and 0.6 km from built-up areas, with consideration given to the direction of spring prevailing winds;
- the lagoon will be constructed of cut and fill earthworks; complete with an in situ clay till liner (considering feasibility geotechnical report defines in situ clay till material as sufficiently impermeable);
- the primary cell will have a 1.5 m operating depth (primary cell size based on BOD5 loading of 30 kilograms per hectare per day **(**kg/ha-d);

- the secondary cell will have a 2.1 m operating depth. (secondary cell size based on a minimum of 180 days storage);
- perimeter dykes a minimum of 5 m wide to permit maintenance vehicle access;
- freeboard a minimum of 1 m; and
- the lagoon will be enclosed within a chain link fence.

4.9.2 Hazardous Industrial Waste

All storage and handling of hazardous materials and hazardous waste will meet the requirements of *The Hazardous Substances and Waste Dangerous Goods Act* (2004) and *Transportation of Dangerous Goods Act* (1992), including employee training, storage facility design and operation, labelling, and material control (e.g., WHMIS). Hazardous industrial waste expected to be generated at the site during operations includes waste hydrocarbons, chemicals, glycols, solvents, oil, fuel, acid, reagents, antifreeze, and batteries. These materials will be kept in cold storage. At all locations, the hazardous substances will be contained within an adequately sized containment berm or contained in a double-walled environmental tank, depending on the hazardous material. A licensed contractor will be responsible for disposal of hazardous waste.

Most of the hazardous and contaminated waste is anticipated to be generated from the maintenance shop, which services plant equipment, and the equipment repair shop, which services the mobile equipment. If a major spill occurs, the cleanup, treatment, and disposal of the contaminated waste and soil will be handled by a specialized subcontractor who is certified to dispose of the substance spilled. Batteries will be recycled by a provincially recognized recycler.

A Waste Management Plan will be developed in accordance with regulatory requirements and will include collecting wastes in suitable containers and storing them for shipment off-site to recycling or disposal facilities using a licensed contractor. Where suppliers will accept them, empty containers used to ship these materials to site will be returned to the supplier. Those that cannot be returned will be shipped to recycling or disposal facilities.

4.9.3 Environmental Design Features for Waste Management

The following environmental design features will be integrated into the waste management procedures for the site to protect the biophysical and socio-economic environments.

- A Waste Management Plan will be implemented.
- A recycling program will be implemented and recycling receptacles will be made accessible for site workers.
- Storage facilities for non-hazardous and hazardous wastes will meet appropriate regulatory requirements and site workers will be properly trained.
- Disposal of hazardous wastes will be handled by a licensed contractor; hazardous wastes will be hauled to an approved facility.
- Spill response materials will be located around the Project site.

4.10 Health, Safety, Security, and Environmental Management System

Yancoal will develop HSSE management systems that will conform to regulatory requirements, notably, *The Saskatchewan Employment Act* (2014) and *The Energy and Mines Act* (1982-83), and will endorse the principles of continual improvement. These programs are described below.

In addition, the EPCM contractor will be required to prepare a site-specific construction HSSE program and will include the following:

- corporate HSSE policies and procedures of the owner;
- corporate HSSE policies and procedures of the EPCM contractor;
- HSSE risk assessment of the site;
- Occupational Health and Safety Association (OHSA) requirements;
- environmental permit requirements and site regulations; and
- current industry best practices.

4.10.1 Occupational Health and Safety Plan

Yancoal's Occupational Health and Safety (OH&S) Plan will be developed in conformance to regulatory requirements, notably, *The Saskatchewan Employment Act* (2014) and *The Energy and Mines Act* (1982-83). Safe working conditions will be in effect from the commencement of construction and in consultation with the Saskatchewan Construction Safety Association.

All contractors will be required to have safety programs that are approved by the Saskatchewan Construction Safety Association. Contractors will be required to be registered with Workers Compensation Board. Basic elements of the OH&S program will be training, on-site job observations, safety program audits and monitoring, incident reporting, safety meetings and hazardous awareness, random drug and alcohol testing for contractors and employees, and the proper use of equipment.

4.10.2 Environmental Protection Plan

Yancoal will develop an Environmental Protection Plan (EPP), in conformance to regulatory and corporate requirements. The EPP outlines site-specific environmental protection practices or procedures to be implemented during each phase of the Project. The plan will include environmental mitigation, environmental monitoring, training, auditing, and the concept of continual improvement. The EPP will be based on regulatory requirements as established by MOE during all stages of construction, operations, and decommissioning and reclamation.

4.10.3 Emergency Response Plan

An Emergency Response Plan (ERP) will be developed to provide rapid and competent response to incidents that may occur. Requirements of *The Energy and Mines Act* and *The Saskatchewan Employment Act (Part III Occupational Health and Safety)* will form the principles of the ERP. Continual employee and contractor training will be foremost in the ERP. Rapid site response to fire, medical emergencies, hazardous material incidents, and natural incidents (e.g., extreme weather events) will be fundamental to the ERP. The ERP will be developed in conjunction with local and regional first responders including fire, medical, and hazardous materials response agencies.

Fire safety measures and response will be developed in conjunction with local and regional first responders, applicable regulatory agencies and will be reviewed with the R.M. of Longlaketon and the R.M. of Cupar.

A Spill Response and Control Plan will be developed in conjunction with a qualified spill response contractor. Employees will receive training on handling spills and appropriate spill response materials (e.g., absorbent pads or booms) and equipment will be located at strategic locations on-site. Employees will be trained to implement the Spill Response and Control Plan.

4.10.4 Employee Education and Training

Employee education and training will be provided by Yancoal. An employee-training program will be established to provide employees with the training necessary to complete their job in a safe and technically competent manner. Supervisor job observations will be implemented as part of the safety program. Technical training will be provided to workers in technical positions (e.g., engineering and environment) so that jobs tasks are completed as required.

4.10.5 Community Relations

Community relations workers will be involved in all aspects of the environmental assessment process, construction, and ongoing operational aspects of the Project. Yancoal has been communicating actively with the local public, First Nations, and Métis communities through face-to-face meetings and open houses. Yancoal will continue to update local communities with the Project's progress so they have an opportunity to provide input.

4.11 Decommissioning and Reclamation

This section will propose decommissioning and reclamation criteria for the Project and associated infrastructure, and outline commitments for decommissioning monitoring prior to abandonment. The decommissioning and reclamation strategy at this stage of the Project is conceptual, however, due to the timelines envisioned for the site to be decommissioned and reclaimed, long range planning is required. A conceptual reclamation plan is provided as a supporting appendix (Appendix 4-D).

A Project-specific Decommissioning and Reclamation (D&R) Plan will be developed to provide a framework for decommissioning facilities and infrastructure on the site, in such a way that the environment and the public will be protected over the long-term. Detailed plans for decommissioning and reclamation will be developed in consultation with regulatory agencies during licensing. The current strategy for Project decommissioning is based on current practices and plans for other Saskatchewan potash operations. However, it is understood that the MOE is working to establish decommissioning and reclamation requirements specific to the potash mining industry. Once these requirements are in place, the D&R Plan will be revised accordingly.

4.11.1 Regulatory Requirements

During regulatory permitting for the Project, a D&R Plan will be submitted in keeping with industry best practices and in consultation with the MOE and applicable regulatory agencies. The D&R plan will be prepared to comply with Section 12(a) and 14(2), (a), (b) and (c) of the *Mineral Industry Environmental Protection Regulations* (1996) of the *Environmental Management and Protection Act* (2002).

The D&R Plan will provide the technical details, costing, and financial assurance mechanism for decommissioning the Project. Section 14 of the *Mineral Industry Environmental Protection Regulations* requires submission and approval of a plan to decommission the site, and an assurance fund to provide for site decommissioning. A financial assurance mechanism will be put in place at the time of licensing of the Project to limit the financial risk to society for the financial costs associated with the implementation of the D&R Plan. Financial assurances will be established in consultation with MOE.

4.11.2 Site Specific Activities

4.11.2.1 Tailings Management Area

The TMA will consist of a salt storage area, brine reclaim pond, and surface water diversion works. The present containment system for the TMA consists of a perimeter dyke, brine reclaim pond, and various internal dykes and ditches. This containment system will be maintained throughout the decommissioning period. Details of the TMA, including size, compositions, and configuration of the salt storage area, are described in Section 4.6.

Decommissioning of the salt storage area will follow current potash industry to remove salt tailings from the TMA through the re-dissolution of salt using water from precipitation and/or unsaturated brines. The resulting brine will then be disposed of through deep-well injection into the Deadwood and Winnipeg formations. This method is limited by the availability of fresh or slightly brackish water to re-dissolve the salt and provide a transport media to relocate the salt from the surface into the deep geologic formations. Therefore, the dissolution process is estimated to take hundreds of years and will involve an extended operations and monitoring program. It is anticipated that injection wells will be added progressively over the life of the Project as the footprint of the waste salt storage area develops and additional capacity is needed to dispose of excess brine.

No land reclamation is planned until after the salt pile has been completely dissolved and disposed. During decommissioning and reclamation, access to the salt storage area will be controlled to prevent access by the public or wildlife.

4.11.2.2 Processing Plant and Site Infrastructure

The Project processing plant and site infrastructure includes facilities where the potash product will be processed, as well as associated buildings. Processing plant details are described in Section 4.5 and site infrastructure is described in Section 4.7. Supporting infrastructure, including utilities, roads, and railways are described in Section 4.8.

Non-permanent infrastructure, including drilling pads, pipelines, and access roads will be progressively reclaimed throughout the operations phase. Permanent buildings and supporting infrastructure not required for the support of long-term decommissioning and reclamation activities associated with the Project will be removed following completion of the operational phase.

Decommissioning and reclamation of the core facilities area and site infrastructure will follow current practices for other Saskatchewan potash mines; however, as decommissioning and reclamation requirements from regulatory agencies become available, decommissioning and reclamation strategies will be updated.

Processing plant and site infrastructure decommissioning and reclamation activities include the following:

- All buildings, equipment, and steel will be demolished to grade. Equipment and materials will be removed from the site and either salvaged for other use, recycled or disposed of in an approved facility.
- Concrete structures will be demolished to a general depth of one metre below surface elevation and the affected surfaces contoured to meet drainage requirements.
- An assessment of soil contamination in the core facilities area will be completed and impacted soils will be disposed of conforming to legislated requirements.
- The core facilities area will be graded to ensure natural drainage. Drainage will be directed to a control point, potentially the brine reclaim pond, for sampling prior to release. If necessary, drainage will be treated to meet water quality standards or disposed of via disposal well.
- Railways owned by the proponent for use in the Project (e.g., rail loop) will be removed and contoured to meet site drainage requirements.
- Below grade utilities, including pipelines and electrical, will be abandoned in place following purging, capping and/or isolation at the nearest isolation point to the Project.
- Raw water supply facilities, including raw water pond, culvert, docks, will be demolished and removed.
- All waste products, that are not salvaged or recycled, will be disposed of at an approved facility.
- Hazardous materials will be disposed of conforming to legislated requirements.
- Available stockpiled topsoil will be spread over the core facility area and the area will be revegetated.
- Natural re-vegetation will be allowed to occur. Seeding, hydroseeding or other measures will be considered to assist development of a vegetative cover.
- Access to the site will be controlled until reclamation is considered acceptable and the land turned over to other uses.
- A monitoring program will be designed and established to monitor surface water quality and revegetation. Groundwater monitoring wells will be decommissioned as the final action of the D&R Plan.

4.11.2.3 Well Field and Disposal Wells

The mine well field area will be progressively decommissioned as the wells are abandoned. Upon completion of primary and secondary mining of each cavern, salvageable components of the liner and casing will be removed from the wells. The drill hole casings will remain open to relieve pressure as the cavern will be allowed to close naturally (i.e., salt creep); following this, the casings can be plugged with cement. In this manner, cavern closure will take place progressively over the operational life of the Project, to the extent possible. Additional decommissioning activities that will take place at each pad site within the mine well field area include the following:

- Buildings, materials, and equipment may be used for future well development, salvaged, or disposed of in an approved facility.
- Concrete and piles will be removed to one metre below grade. Concrete will be recycled.
- Caverns and wells will be depressurized.
- Well casings will be cut off one metre below grade. Concrete plugs will be placed and a cap welded on the well casing.
- Permanent markers will indicate well locations.
- Well pad site and access roads will be cultivated and graded to ensure natural drainage.
- Previously stripped topsoil will be spread over the mine well field and the area revegetated.
- Natural re-vegetation will be allowed to occur. Seeding, hydroseeding or other measures will be considered to assist development of a vegetative cover.

Brine disposal wells will be used during decommissioning of the TMA. Once the TMA has been decommissioned, the disposal injection wells will be decommissioned in accordance with all requisite legislation in place at the time for deep well decommissioning.

4.11.3 Conceptual Reclamation Plan

A conceptual reclamation plan is provided in Appendix 4-D. The conceptual reclamation plan presents proposed methods and practices to mitigate Project effects to the surrounding environment to the extent practical, and allow disturbed areas to return to equivalent capability and structure as the surrounding environment and period. The conceptual reclamation plan also outlines monitoring programs for testing the effectiveness of these methods and practices.

4.11.4 Post-Decommissioning Monitoring and Contingency Planning

Monitoring programs will continue throughout the decommissioning process, and meet requirements of the day as agreed to with the MOE and other applicable regulatory agencies. The required environmental management staff, equipment, and regulatory reporting protocols will be kept in place for the duration of the decommissioning and reclamation phase until such time that the regulatory agencies have approved abandonment of these works.

Sampling locations and parameters will be evaluated on an as needed basis as decommissioning progresses. It is expected that sampling would be annual, until a stable site condition is achieved. Sampling requirements and frequency at the time of decommissioning will be discussed with the MOE and other applicable regulatory agencies.

4.11.5 Financial Assurance

Section 14 of the *Mineral Industry Environmental Protection Regulations* requires the submission and approval of a D&R Plan, and establishing an assurance fund to provide for site decommissioning. Financial assurance will be put in place to cover the costs associated with Yancoal's commitment to decommissioning and reclamation, and will be established in consultation with the MOE during permitting of the Project, likely in the form of a letter of credit held by the Province of Saskatchewan. The financial assurance will be created for the sole purpose of ensuring that the site is managed, decommissioned, and reclaimed.

Financial assurance will grow as the Project moves through the various phases. Initially, during the construction phase (approximately first three years) the decommissioning liability accumulating at the site will be modest. As construction is completed and the Project transitions into the operations phase, potash production and the associated tailings output will increase to eventually reach and maintain design capacity. As the Project approaches the decommissioning and reclamation phase, the Project will have generated its maximum decommissioning liability, largely due to the accumulated tailings stored on surface at the site. Financial assurance will consider Project components, including:

- construction of the core facilities area, mining area, and the first stage of the TMA;
- expansion of the TMA to the ultimate footprint;
- routine mining operations over the design operational life of the facilities;
- decommissioning of the production facilities at the end of operations; and
- decommissioning of the salt pile and reclamation of the residual disturbed area.

Any contamination outside of the core facilities area and mine well field will be identified through routine monitoring and managed as appropriate. It is anticipated that the financial assurance will always be slightly larger than the decommissioning and reclamation cost estimates that will be generated. This is in order to allow for a reasonable contingency amount in the event unforeseen circumstances occur.

4.11.6 Decommissioning and Reclamation Considerations

4.11.6.1 Research and Development

During the first several years of Project operations, site-specific research and development initiatives will be established. It is anticipated that Yancoal will work in collaboration with various industry organizations, such as Saskatchewan Potash Producers Association Inc. and the MOE, to build on previous research and development work that has been completed. Research and development initiatives would focus on strategies related to the D&R Plan, in particular the decommissioning of the TMA, the processing plant, and the mine well field and disposal wells.

The number of successful, proven, or cost effective decommissioning and reclamation methods presently being used at operational sites is limited at this time. This is largely because existing potash projects are within the operational phase, and are not in the decommissioning and reclamation phase. During the operation phase, potash projects dispose of excess brine while also trying to reduce the salt inventory from the TMA. The full scale decommissioning and reclamation of a potash production site has not been completed in the province to date.

Further, it appears that there is no immediate answer to balance the time required to decommission a potash TMA with the available technology or the volumes of fresh water required to do so. Therefore, in order to find a way to balance the competing pressures associated with decommissioning potash TMAs it will be necessary to conduct targeted research and development that is tangible, sustainable, and has a reasonable likelihood of success.

The results of the research and development initiatives, and any particularly innovative solutions that may be found with respect to tailings decommissioning, may influence the timing and value of the financial assurance. The results of the research and development program and the implications for the decommissioning timing and financial assurance will be captured in the periodic reviews and updating of the D&R Plan and financial assurance that will be submitted to MOE.

4.11.6.2 Monitoring and Adaptive Management

Through the life of the Project, the HSSE management system, in conjunction with established operating principles, will need to capture and implement the learnings of operational experience and the results pf research and development programs. These learnings will contribute to a well-maintained site that is adequately monitored and has detailed documentation as to how the Project is interacting with the surrounding environment.

Compliance monitoring and environmental monitoring (of the TMA in particular) will be implemented to verify that appropriate management practices are suitable and are being used. This will confirm the design criteria for operational site monitoring programs and ultimately the reclamation and abandonment objectives and planning procedures. Adaptive management will be implemented as necessary where monitoring programs and management plans need to be updated based on identified learnings.

Based on the environmental protection performance of the containment works in particular, as measured by the monitoring network, it is expected that the compliance and environmental monitoring results will guide the adaptive management of the Project and the TMA such that changes can be made to the operating procedures, the enhanced containment works, and the D&R Plan, if necessary.

4.11.6.3 Contingency Planning

The Project is an industrial site and appropriate contingency plans will be in place for emergencies such as fire, extreme weather events or accidents. Environmental considerations outlined in this EIS, including decommissioning and reclamation, demonstrate that the environmental implications of the Project are reasonably well understood. This knowledge, plus the forthcoming decades of operating experience, site performance monitoring information, and research findings will demonstrate and document the environment’s response to the Project. However, should the environmental performance of the site not be meeting corporate or regulatory expectations, a targeted mitigation plan would be implemented as a contingency measure. While this situation is viewed as a low risk, the financial assurance costing will carry a modest allocation for contingency planning until such time that the operational or decommissioned and reclaimed site is stable and no longer in need of such activity.

4.12 Human Resources

A Human Resources Plan will be developed in anticipation of the commencement of construction. This plan will be subject to continual monitoring, as labour conditions in the province change.

It is anticipated there will be approximately 2,200 workers required during the peak of construction. These will include equipment operators, electrical, carpentry, heating, ventilation, and air conditioning (HVAC), specialized welding, safety, environmental, procurement, and administration. About 350 full-time jobs will be created for operations. These jobs include drilling, heavy equipment operators, process operators, instrumentation, environmental, safety, training, engineering, administration, and management. Given the current labour market in Saskatchewan and the construction and operational personnel required, labour likely will need to be sourced from outside of Saskatchewan. However, Yancoal will give priority to skilled local labour to the extent possible. If the Project proceeds, Yancoal will also look at potential partnerships with communities and surrounding First Nations and Métis communities.

Employee education and training will be provided by Yancoal. An employee-training program will be established to provide employees with the training necessary to complete their job in a safe and technically competent manner. Supervisor job observations will be implemented as part of the safety program. Technical training will be provided to workers in technical positions (e.g., engineering and environment) so that jobs tasks are completed as required.

Based on recent projects in Saskatchewan and Western Canada, the site will be constructed on a managed open shop basis and will not be exclusively union or non-union. Industry standards, accommodation, and hours of work will be adapted to either labour arrangement. Labour relations guidelines and site-specific regulations will be developed before construction begins so any potential labour concerns are minimized. These guidelines will address items such as hiring other contractors' workers, drug and alcohol policy, rotations and hours of work, general site and HSSE rules, and other pertinent policies. The labour relations guidelines and regulations will be included in the tender packages with appropriate contract language to provide suitable enforcement.

4.13 Accidents, Malfunctions, and Unplanned Events

Potential accidents, malfunctions, and unplanned events that may occur during construction, operations, and decommissioning of the Project will be identified during the execution phase of the Project. This will include the completion of a risk assessment. Environmental design features, mitigation practices, and emergency response plans to manage these events will be identified. For example, within the ERP, procedures will be established for rapid site response to fire, medical emergencies, hazardous material incidents, and natural incidents such as extreme weather events.

4.13.1 Effects of the Environment on the Project

The environmental setting in the region can affect the design, construction, operations, and decommissioning and reclamation of the Project. Environmental considerations of particular interest include extreme events (e.g., severe rainstorms, tornadoes, fires, and earthquakes) and long-term climatic fluctuations associated with global climate change. Appendix 4-E provides a detailed discussion on the interactions of these environmental considerations with the Project and the environmental design features that will be put in place to limit effect. A summary of Appendix 4-E is provided in Table 4.13-1.

Table 4.13-1: Potential Interactions with Environmental or Socio-economic Effects

Environmental Consideration	Potential Effects	Mitigation Strategy
Short-term Events		
Extreme Rainfall	■ Overtopping of water management infrastructure, including brine reclaim ponds, site drainage infrastructure (e.g., containment system of berms and dykes, drainage ditches, and culverts). ■ Erosion to water management infrastructure. ■ Erosion of tailings from the tailings management area.	■ Mitigated through design standards and operational guidelines. ■ Water management infrastructure will be designed to accommodate a design storm event (300 millimetres [mm] in a 24-hour period. ■ The tailings management area will be sized to accommodate a design storm event (300 mm in a 24-hour period) and additional capacity will be provided by an overflow spillway. ■ Water management infrastructure, as well as the salt storage piles will be inspected regularly. ■ Erosion control measure will be implemented as required. ■ Water will be diverted around the tailings management area to reduce the amount of surface runoff to be managed. ■ The site will be graded and/or buildings will be strategically placed within the core facilities area to avoid locations where flooding may occur. ■ An Emergency Response Plan will be developed and an Emergency Response Team will be on-site to provide rapid and competent response.
Lightning and Hail	■ Electrical storm could cause power outage from SaskPower supply potentially disabling safety equipment. ■ Lightning strike to the ground could start a grass fire. ■ Storm could damage equipment and/or building, including safety equipment. ■ Could result in unsafe working conditions.	■ Backup generators will be in place to provide power to critical infrastructure. ■ Fire-fighting water will be accommodated on-site. ■ An Occupational Health and Safety Plan will be developed in conformance with regulatory requirements. ■ An Emergency Response Plan will be developed and an Emergency Response Team will be on-site; the plan will be developed in conjunction with local and regional first responders including fire, medical, hazardous materials response agencies, and applicable regulatory agencies.

Table 4.13-1: Potential Interactions with Environmental or Socio-economic Effects

Environmental Consideration	Potential Effects	Mitigation Strategy
High Winds and Tornadoes	■ Could cause damage to Project infrastructure. ■ Power outage from SaskPower supply potentially disabling safety equipment. ■ Wave-up on water management infrastructure areas (e.g., brine reclaim ponds and crystallization pond)	■ Buildings will be designed to meet the National Building Code of Canada. ■ Water management areas will be designed with sufficient freeboard to accommodate wind set-up and wave run-up. ■ Erosion control measure will be implemented as required. ■ Backup generators will be in place to provide power to critical infrastructure. ■ An Emergency Response Plan will be developed and an Emergency Response Team will be on-site; the plan will be developed in conjunction with local and regional first responders including fire, medical, hazardous materials response agencies, and applicable regulatory agencies.
Winter Storm and Conditions	■ Could cause snowdrifts and icy conditions affecting driving conditions. ■ Can cause accumulation of snow resulting in structural damage to Project infrastructure or off-site utilities.	■ Buildings will be designed to meet the National Building Code of Canada. ■ A snow management and removal plan will be developed. ■ Adequate on-site product storage will be designed to accommodate temporary interruption of off-site shipping. ■ Backup generators will be in place to provide power to critical infrastructure. ■ Local weather and highway conditions will be monitored. ■ An Occupational Health and Safety Plan will be developed in conformance with regulatory requirements, and training will be provided to all employees. ■ Timely snow removal and sanding will occur on site access road to improve traction.
Temperature Extremes	■ Can create difficult or unsafe working conditions. ■ Can cause strain to building materials. ■ Equipment may not operate efficiently. ■ Can cause Power outage from SaskPower supply potentially disabling safety equipment.	■ An Occupational Health and Safety Plan will be developed in conformance with regulatory requirements and training will be provided to all employees. ■ Buildings will be designed to meet the National Building Code of Canada, specifically, requirements for high and low air temperatures. ■ Equipment will be chosen to withstand extreme temperatures possible for the Project location and kept in good working condition. ■ Backup generators will be in place to provide power to critical infrastructure.

Table 4.13-1: Potential Interactions with Environmental or Socio-economic Effects

Environmental Consideration	Potential Effects	Mitigation Strategy
Grass Fires	■ Could cause damage to Project infrastructure. ■ Could create unsafe working conditions.	■ Buildings will be designed to meet the National Building Code of Canada. ■ Backup generators will be in place to provide power to critical infrastructure. ■ Fire-fighting water supply will be accommodated on-site. ■ An Emergency Response Plan will be developed and an Emergency Response Team will be on-site; the plan will be developed in conjunction with local and regional first responders including fire, medical, hazardous materials response agencies, and applicable regulatory agencies.
Seismic Hazards	■ Could cause damage to Project infrastructure. ■ Can cause Power outage from SaskPower supply potentially disabling safety equipment. ■ Could create unsafe working conditions.	■ Buildings will be designed to meet the National Building Code of Canada. ■ Underground pipes will be designed to withstand strain as much as possible. ■ Backup generators will be in place to provide power to critical infrastructure. ■ An Emergency Response Plan will be developed and an Emergency Response Team will be on-site; the plan will be developed in conjunction with local and regional first responders including fire, medical, hazardous materials response agencies, and applicable regulatory agencies.
Seasonal Effects		
Hydrological Drought Conditions	■ Could result in a regional water shortage, with possible limitation on raw water withdrawals. ■ Less runoff water supply on-site storage ponds. ■ Increased risk of fire.	■ A reliable water source has been identified and preliminary assurances have been obtained regarding a water rights licence. ■ Operations have been designed to limit water requirements, as much as possible. ■ Buildings will be designed to meet the National Building Code of Canada. ■ Backup generators will be in place to provide power to critical infrastructure. ■ Fire-fighting water supply will be accommodated on-site. ■ An Emergency Response Plan will be developed and an Emergency Response Team will be on-site; the plan will be developed in conjunction with local and regional first responders including fire, medical, hazardous materials response agencies, and applicable regulatory agencies.

Table 4.13-1: Potential Interactions with Environmental or Socio-economic Effects

Environmental Consideration	Potential Effects	Mitigation Strategy
Seasonal or Extended Wet Conditions	■ Overtopping of water management infrastructure, including brine reclaim ponds, site drainage infrastructure (e.g., containment system of berms and dykes, drainage ditches, and culverts). ■ Erosion to water management infrastructure. ■ Erosion of tailings from the tailings management area.	■ Mitigated through design standards and operational guidelines. ■ Water management infrastructure will be designed to accommodate a design storm event (300 mm in a 24-hour period. ■ The tailings management area will be sized to accommodate a design storm event (300 mm in a 24-hour period) and additional capacity will be provided by an overflow spillway. ■ Water management infrastructure, as well as the salt storage piles will be inspected regularly. ■ Erosion control measure will be implemented as required. ■ Water will be diverted around the tailings management area to reduce the amount of surface runoff to be managed. ■ The site will be graded or buildings will be strategically placed within the core facilities area to avoid locations where flooding may occur. ■ An Emergency Response Plan will be developed and an Emergency Response Team will be on-site to provide rapid and competent response.
Snow Accumulation and Management	■ Could cause snowdrifts and icy conditions affecting driving conditions. ■ Can cause accumulation of snow resulting in structural damage to Project infrastructure or off-site utilities.	■ Buildings will be designed to meet the National Building Code of Canada. ■ A snow management and removal plan will be developed. ■ Adequate on-site product storage will be designed to accommodate temporary interruption of off-site shipping. ■ Backup generators will be in place to provide power to critical infrastructure. ■ Local weather and highway conditions will be monitored. ■ An Occupational Health and Safety Plan will be developed in conformance with regulatory requirements and training will be provided to all employees. ■ Timely snow removal and sanding will occur on site access road to improve traction.

Table 4.13-1: Potential Interactions with Environmental or Socio-economic Effects

Environmental Consideration	Potential Effects	Mitigation Strategy
Long-Term Changes		
Effects of Climate Change on Project Operations ■ Changes to air temperature range ■ Changes to precipitation levels ■ Changes to relative humidity ■ Changes to wind speed ■ Changes in occurrence of severe weather events	■ Could cause higher annual air temperatures. ■ Could cause more frequent and intense rainfall events. ■ Lower relative humidity during the summer months.	■ An Occupational Health and Safety Plan will be developed in conformance with regulatory requirements and training will be provided to all employees. ■ Buildings will be designed to meet the National Building Code of Canada, specifically, requirements for high and low air temperatures. ■ Equipment will be chosen to withstand extreme temperatures possible for the Project location and kept in good working condition. ■ Backup generators will be in place to provide power to critical infrastructure. ■ Water management infrastructure will be designed to accommodate a design storm event (300 mm in a 24-hour period. ■ The tailings management area will be sized to accommodate a design storm event (300 mm in a 24-hour period) and additional capacity will be provided by an overflow spillway. ■ Water management infrastructure, as well as the salt storage piles will be inspected regularly. ■ Erosion control measure will be implemented as required. ■ Water will be diverted around the tailings management area to reduce the amount of surface runoff to be managed. ■ The site will be graded and/or buildings will be strategically placed within the core facilities area to avoid locations where flooding may occur. ■ A reliable water source has been identified and preliminary assurances have been obtained regarding a water rights licence. ■ Operations have been designed to limit water requirements, as possible. ■ Fire-fighting water supply will be accommodated on-site.

4.14 References

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5.0 ENGAGEMENT

5.1 Introduction

This section of the Environmental Impact Statement (EIS) for the Yancoal Canada Resources Company Limited (Yancoal) Southey Project (the Project) outlines the engagement activities with the stakeholders that have been completed for the Project to date.

5.2 Engagement

Engagement activities for the Project were designed to provide stakeholders with details about the Project, including environmental and economic information, to collect feedback, and to address any concerns. Stakeholders were identified as those who live near the Project or who could be interested or potentially affected by the Project. For this Project the stakeholders identified include:

- First Nations and Métis;
- the public; and
- government and regulatory agenies.

5.3 Identification of Stakeholders

5.3.1 First Nations and Métis

A total of 15 First Nation and Métis communities were contacted for the Project. These communities were identified based on their proximity to the Project location, and based on having potential interest in the Project or the potential to be affected by the Project. The First Nations and Métis communities include:

- Carry the Kettle First Nation;
- Day Star First Nation;
- George Gordon First Nation;
- Kawacatoose First Nation;
- Little Black Bear First Nation;
- Muscowpetung First Nation;
- Muskowekwan First Nation;
- Okanese First Nation;
- Pasqua First Nation;
- Peepeekisis First Nation;
- Piapot First Nation;
- Standing Buffalo First Nation;
- Star Blanket First Nation;
- Métis Eastern Region 3; and
- Métis Western Region 3.

5.3.2 Public

The Project is located within two Rural Municipalities (R.M.), the R.M. of Longlaketon (No. 219) and the R.M. of Cupar (No. 218). The nearest communities include the Town of Cupar, the Town of Southey, the Village of Earl Grey, and the Town of Strasbourg. Engagement activities have been focused within the R.M. of Longlaketon and the towns of Southey and Strasbourg.

5.3.3 Government and Regulatory

To date, the regulatory agencies that have been included in Project engagement activities include:

- The Ministry of Environment (MOE); and
- The Water Security Agency (WSA).

Yancoal has also contacted five R.M. councils and one town council in engagement activities to date. These R.M.s include:

- R.M. of Longlaketon (No. 219);
- R.M. of Cupar (No. 218);
- R.M. of Mount Hope (No. 279);
- R.M. of Touchwood (No. 248);
- R.M. of McKillop (No. 220); and
- the Town of Strasbourg.

5.4 Engagement Activities Completed to Date

Engagement activities for the Project were initiated in spring 2013. Engagement activities to date have included face-to-face meetings, informal discussions, site visits, and community information sessions.

5.4.1 First Nations and Métis

5.4.1.1 Carry the Kettle First Nation

Engagement activities with Carry the Kettle First Nation were initiated in July 2013. Carry the Kettle First Nation expressed initial interest in the Project, however no response has been received to requests made for a meeting.

Engagement activities with Carry the Kettle First Nation are summarized in Table 5.4-1.

Table 5.4-1: Summary of Carry the Kettle First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
July 3, 2013	Text Message - Phil Anaquod (Golder) - Chief Kennedy (Carry the Kettle First Nation)	Phil Anaquod provided a brief introduction about the Project through text messaging. Chief Kennedy expressed interest in the Project and in meeting to receive additional information. A meeting date and time was requested; however, no response was received.
March 9, 2015	Telephone Conversation - Phil Anaquod (Golder) - Reception (Carry the Kettle First Nation)	Invitation extended to the round two community information sessions.
March 23, 2015	Face-to-face - Phil Anaquod (Golder)	Attempts were made to meet with the Chief and Council to provide updated Project information. The Chief and Council were not available. However a discussion did take place with the Band Manager and an information package was left for her to pass on to the Chief and Council. The Band Manager indicated the Band Lands Manager would handle the information and would be in touch if there is any interest to meet with Yancoal.
July 6, 2015	Face-to-face - Phil Anaquod (Golder) - Reception (Carry the Kettle First Nation)	Information sheet pertaining to July 2015 Community Information left for Councillor Thomson and the Band Manager (Councillor Vance Thomson had previously expressed an interest in attending future sessions).
August 10, 2015	Band Office Manager	Round 3 CIS information package delivered. The Band Office Manager indicated that the information will be passed on to Councillor Vance Thomas and Band Manager.
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

Golder = Golder Associates Ltd.; CIS = community information session

5.4.1.2 Day Star First Nation

Engagement activities with Day Star First Nation were initiated in June 2013. Activities carried out to date include introducing the Project, providing updates on the Project, and collecting traditional land use information. The main topics of conversation were water supply, business opportunities, and traditional land use activities.

Engagement activities with Day Star First Nation are summarized in Table 5.4-2.

Table 5.4-2: Summary of Day Star First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 18, 2013	Face to Face Meeting - Lyle Bear, Phil Anaquod (Golder) - Chief Lloyd Buffalo (Day Star First Nation)	Information about the Project was provided to Chief Lloyd Buffalo. The Chief inquired about meetings with other First Nations and asked where the water supply for the Project would come from. The offer for Yancoal to meet with Chief and Council members was extended; the Chief did not give any indication if he wanted to meet further with Yancoal.
January 13, 2014	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Lloyd Buffalo (Day Star First Nation)	The purpose of this discussion was to provide an update on the status of the Project. The Chief is interested in meeting with Yancoal in the future; however, this may be a joint interest with their business group KDM that represents three First Nations (Kawacatoose First Nation, Day Star First Nation, and Muskowekwan First Nation). The Chief indicated that they are interested in learning about potential business opportunities.
June 9, 2014	Face-to-face Meeting - Phil Anaquod, Megan Tyman (Golder) - Elder and three Council members (Day Star First Nation)	The purpose of this discussion was to collect traditional land use information for the Project area. It was indicated that very few people currently carry out traditional land use activities; however some of the participants did feel that the Project had potential to impact hunting and berry picking.
March 5, 2015	Telephone Conversation - Phil Anaquod (Golder) - Reception (Day Star First Nation)	Invitation extended to the round two community information sessions.
March 17, 2015	Face-to-face Meeting - Phil Anaquod (Golder)	Attempts were made to meet with the Chief and Council to provide updated Project information. No one was available. An information package was left at reception.
July 7, 2015	Face-to-face - Phil Anaquod (Golder) - Reception, and Councillor Delbert Kinequon (Day Star First Nation)	Information sheet pertaining to July 2015 Community Information Sessions left with Front Desk for Chief Buffalo. Also spoke with Councillor Kinequon.
August 7, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor Delbert Kinequon (Day Star First Nation)	Round 3 CIS information package delivered. No concerns were expressed and Councillor Kinequon will make copies of the information for the council and will contact Phil Anaquod if a briefing on the information is required.
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

Golder = Golder Associates Ltd.; CIS = community information session

5.4.1.3 George Gordon First Nation

Engagement activities with George Gordon First Nation were initiated in June 2013. Activities carried out to date include introducing the Project, providing updates on the Project, introducing Yancoal, and collecting traditional land use information. The main topics of conversation include the Treaty Land Entitlement process, potash mining, baseline studies, traditional land use activities, water, and employment and business opportunities.

Engagement activities with George Gordon First Nation are summarized in Table 5.4-3.

Table 5.4-3: Summary of George Gordon First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 18, 2013	Face-to-face Meeting - Lyle Bear, Phil Anaquod (Golder) - Chief and Council (George Gordon First Nation)	A brief presentation about Yancoal and the Project was provided by representatives from Golder Associates Ltd. to the George Gordon First Nation Chief and Council. Information sheets were left with each member in attendance. Discussion items at this meeting included the corporate social responsibility of Yancoal, land and the Treaty Land Entitlement process, interest in the potash mining process, and the approach to Elders providing input into baseline studies. Chief Longman indicated that they would be interested in a face to face meeting with Yancoal.
December 2, 2013	Face-to-face Meeting - Lyle Bear and Phil Anaquod (Golder) - Chief and Council (George Gordon First Nation)	The purpose of the meeting was to provide information about the status of the Project; it was clearly stated that this meeting was not related to Duty to Consult. The Project information sheet and a copy of the panels prepared for the round one community information sessions was provided to everyone in attendance. Concerns identified during the meeting included the potential impacts to traditional lands used for hunting; existing exploration permits, and their relation to treaty land entitlement land; completion of the environmental impact statement; water usage; general environmental concern; air quality; and water seepage. The Band is also interested in employment and business opportunities should they arise from the Project. The Band would like to develop a relationship and on-going communication with Yancoal early in the Project and would like to schedule a face to face meeting.

Table 5.4-3: Summary of George Gordon First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
February 26, 2014	Face-to-face Meeting - Phil Anaquod, Brad Novecosky (Golder) - Yatong (Mandy) Chen, Jiqiu Han, Lei Niu, Yanxin Liang (Yancoal) - Chief Shawn Longman, Director of Operations, Chief Executive Officer, Chief Finanical Officer, and approximately 27 other observers (George Gordon First Nation)	The purpose of this formal face to face meeting was to introduce Yancoal and provide an update on the Project. Topics discussed at this meeting included the Treaty Land Entitlement Process.
June 5, 2014	Face-to-face Meeting - Phil Anaquod, Tam Huynh (Golder) - Elder Council (George Gordon First Nation)	The purpose of this discussion was to collect traditional land use information for the Project area. It was indicated that some members of the George Gordon First Nation currently carry out traditional land use activities (i.e. hunting). The main concerns identified include the potential for waste water to impact wildlife and future reclamation of the area.
June 30, 2014	Face-to-face Meeting - Jiqiu Han, Jianqiang Ma, Xianwen (Stan) Qin, Leina Liao (Yancoal) - Chief Longman, TLE Coordiantor, and 3 other participants (George Gordon First Nation)	Meeting was held to discuss the Treaty Land Entitlement process.
March 5, 2015; March 9, 2015	Telephone Conversation, Text Message and Email - Phil Anaquod (Golder) - Reception, Chief Shawn Longman, and Councillor Jason Morris (George Gordon First Nation)	Invitation extended to the round two community information sessions.

Table 5.4-3: Summary of George Gordon First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
March 17, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Shawn Longman, Councillors Jason Morris and Dennis Hunter (George Gordon First Nation)	Met with Chief and Council members to provide updates on the Project. An information package was also provided to them. The Chief extended an invitation to Yancoal to meet with the Chief and Council in April.
May 12, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Shawn Longman (George Gordon First Nation)	Met with the Chief and presented another copy of the Project information. Chief Longman indicated that they are interested in further meetings with Yancoal and would like to schedule a meeting for early June.
June 3, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Jiqiu Han and Adam Cook (Yancoal) - Chief Shawn Longman, and Councillors Byron Bitternose, John McNab, Corey Blind, Jason Morris, Hugh Pratt, and Ashley Whitehawk, as well as two Business Support Members (George Gordon First Nation)	Met with Chief and Council members to provide updates on the Project. Yancoal provided an update on the status of the Project, including the anticipated submission of the EIS in July. George Gordon First Nation is interested in economic development to assist in advancing the community and building a relationship with Yancoal.
July 7, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Reception (George Gordon First Nation)	Information sheet pertaining to July 2015 Community Information Sessions left with Reception, who indicated that the materials would be hand delivered to the Chief as the council was currently in session.
August 7, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Director of Operations (George Gordon First Nation)	Round 3 CIS information package delivered.

Table 5.4-3: Summary of George Gordon First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
September 19, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Asad Naqvi (Yancoal) - Band member (George Gordon First Nation)	A band member felt the community was not being consulted about the Project and there are concerns about the Project and the use of water. The environmental approval process was described and the engagement activities that have been carried out to date were communicated; this included the community information sessions and the meetings specifically held with the Chief and council. The band member was provided with information about the Ministry of Enivronment's public review process for the EIS. It was confirmed that water would be provided from Buffalo Pound and that SaskWater would be the utility provider.
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

Golder = Golder Associates Ltd.; EIS = Environmental Impact Statement; CIS = community information session

5.4.1.4 Kawacatoose First Nation

Engagement activities with Kawacatoose First Nation were initiated in June 2013. Activities carried out to date include introducing the Project, providing updates on the Project, and collecting traditional land use information. The main topics of conversation include water, duty to consult, and traditional land use.

Engagement activities with Kawacatoose First Nation are summarized in Table 5.4-4.

Table 5.4-4: Summary of Kawacatoose First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 18, 2013	Face-to-face Meeting - Lyle Bear, Phil Anaquod (Golder) - Councillors Sanford Strongarm, Glen Worm, Yvette Machiskinic, and Dean Kay, as well as four other band members (Kawacatoose First Nation)	Council member Sanford Strongarm was the main spokesperson and did not make many statements about the information other than saying that he would provide the information to the Chief and Council at the next council meeting. Council member Sanford Strongarm did indicate that a meeting with Yancoal might fall under their duty to consult guidelines. Contact information was left with the meeting attendees for future correspondence or if any questions or concerns came up following the meeting.

Table 5.4-4: Summary of Kawacatoose First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
December 7, 2013	Face-to-face Meeting - Phil Anaquod (Golder)	A meeting time was scheduled; however, the Band administrator failed to mention to the Golder Representatives that the meeting was to be held in Calgary, Alberta. Golder representatives were not able to attend the meeting in Calgary, and will re-schedule for another time.
January 13, 2014	Face-to-face Meeting - Phil Anaquod (Golder) - Band Office (Kawacatoose First Nation)	Project information sheets and information panels from the round one community information sessions were provided to be include in all Council member portfolios for review. The Band Office will be in touch with Golder regarding a potential opportunity to meet again in January if Chief and Council are interested and available.
June 12, 2014	Face-to-face Meeting - Phil Anaquod, Megan Tyman (Golder) - 19 Elders, 2 community members, and 1 RCMP officer (Kawacatoose First Nation)	The purpose of this discussion was to collect traditional land use information for the Project area. It was indicated that some members of the Kawacatoose First Nation currently carry out traditional land use activities (i.e. hunting and fishing). The main concerns identified include potential impacts to water and dust from the Project.
March 5, 2015; March 6, 2015	Telephone Conversation and Email - Phil Anaquod (Golder) - Reception (Kawacatoose First Nation)	Invitation extended to the round two community information sessions.
March 16, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Finance Director (Kawacatoose First Nation)	Attempts were made to meet with the Chief and Council to provide updated Project information. The Chief and Council was unavailable, however a discussion did take place with the Band's Finance Director and an information package was left for him to pass on to Council.
July 7, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor Delmont Asapace (Kawacatoose First Nation)	Information sheet pertaining to July 2015 Community Information Sessions left with the Councillor.
August 7, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Councillors Caroline Poorman, Yvette Machiskinic, and Jamie Medicine Rope (Kawacatoose First Nation)	Round 3 CIS information package delivered. No concerns were expressed and Councillors were interested in socio-economics as the project is nearby.

Table 5.4-4: Summary of Kawacatoose First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

Golder = Golder Associates Ltd. ; CIS = community information session

5.4.1.5 Little Black Bear First Nation

Engagement activities with Little Black Bear First Nation were initiated in June 2013. Activities carried out to date include providing information and materials on the Project for the Chief and Council. Little Black Bear First Nation has indicated that they would be in touch if they had any questions or concerns.

Engagement activities with Little Black Bear First Nation are summarized in Table 5.4-5.

Table 5.4-5: Summary of Little Black Bear First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 27, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor Holly Bellegarde (Little Black Bear First Nation)	Met with Holly Bellegarde, a member in council for the Little Black Bear Band to provide information about Yancoal and left the information sheet. Holly Bellegarde indicated she was involved in lands and resources, and that she would discuss the information with the Chief and they would be in touch if they had any questions or concerns.
November 27, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Band Ofice (Little Black Bear First Nation)	The purpose of this meeting was to provide information about the Project, and provide copies of the Project information sheet and information panels from the round one community information sessions. It was explained that the Project is still in the early planning phase. Chief and Council will be provided a summary of the information at the next Chief and Council Meeting scheduled for December 3, 2013. The Band will be in touch if there are any questions following the meeting.
March 5, 2015	Telephone Conversation - Phil Anaquod (Golder) - Reception (Little Black Bear First Nation)	Invitation extended to the round two community information sessions.
March 16, 2015	Face-to-face Meeting - Phil Anaquod (Golder)	Attempts were made to meet with the Chief and Council to provide updated Project information. No one was available. An information package was left at reception.
July 6, 2015	No contact: Office closed	Band Office closed.

Table 5.4-5: Summary of Little Black Bear First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
July 7, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor Albert Bellegarde (Little Black Bear First Nation)	Information sheet pertaining to July 2015 Community Information Sessions delivered. Met directly with Councillor Bellegarde who was interested in the Southey session.
August 10, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Clarence Bellegarde (Little Black Bear First Nation)	Chief Bellegarde indicated he is not in the position to discuss or accept any information on the project or any project as they are in some legal negotiations at the current time.

Golder = Golder Associates Ltd.; CIS = community information session

5.4.1.6 Muscowpetung First Nation

Engagement activities with Muscowpetung First Nation were initiated in June 2013. Activities carried out to date include introducing the Project, providing updates on the Project, and collecting traditional land use information. It was indicated that Muscowpetung First Nation Chief and Council did not want to meet with industry at this time.

Engagement activities with Muscowpetung First Nation are summarized in Table 5.4-6.

Table 5.4-6: Summary of Muscowpetung First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 25, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Cappo, and Councillor Byron Toto (Muscowpetung First Nation)	The purpose of this meeting was to provide information about the project and leave copies of the Project information sheet. Councillor Toto indicated that he would pass the information on to the rest of the council at their next meeting in a couple of days. Met Chief Cappo in Fort Qu'Appelle and introduced the Project. Chief Cappo mentioned that the council would be having a meeting on July 4 and might be able to provide time on the agenda for a presentation.
July 4, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Cappo and Council (Muscowpetung First Nation)	This meeting was intended as an introduction to the Yancoal project to discuss the Project information sheet that was previously delivered to the Band office and as a follow-up to Chief Cappo's suggestion of attending the council meeting. The meeting did not proceed as the Council indicated that they would not be meeting with industry at the current time, and have no interest for any meetings.
May 29, 2014; June 3, 2014; June 4, 2014	Face-to-face Meeting - Phil Anaquod (Golder) - 7 Elders (Muscowpetung First Nation)	The purpose of these discussions was to collect traditional land use information for the Project area. It was indicated that some members of the Muscowpetung First Nation currently carry out traditional land use activities (i.e. hunting and fishing). The main concerns identified include potential impacts to water, plants and wildlife.

Table 5.4-6: Summary of Muscowpetung First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
March 9, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Council members Leonard Anaquod and John Lerat (Muscowpetung First Nation)	Invitation extended to the round two community information sessions.
March 23, 2015	Face-to-face - Phil Anaquod (Golder)	Attempts were made to meet with the Chief and Council to provide updated Project information. No one was available. An information package was left at reception.
July 6, 2015	Face-to-face - Phil Anaquod (Golder) - Reception and Councillor John Lerat (Muscowpetung First Nation)	Information sheet pertaining to July 2015 Community Information Sessions delivered. Councillor Lerat indicated an interest in the Southey session.
August 10, 2015	Face-to-face - Phil Anaquod (Golder) - Chief Todd Cappo and Councillors Byron Toto and Joyce Keepness (Muscowpetung First Nation)	Round 3 CIS information package delivered. No concerns were expressed and Chief Cappo indicated they are looking for opportunities for work and contracts and had formed partnerships.
November 27, 2015	Face-to-Face Meeting - Asad Naqvi (Yancoal), and Robin Kusch (Yancoal) - Senior Business Advisor (Muscowpetung First Nation)	Senior Business Advisor with Muscowpetung First Nation to discuss project timelines and the employment/contractor opportunities anticipated. It was a very positive and helpful discussion, and he identified that now that Vale's project was on hold Yancoal's project had moved up on their priority list.
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

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5.4.1.7 Muskowekwan First Nation

Engagement activities with Muskowekwan First Nation were initiated in June 2013. Activities carried out to date include introducing the Project, providing updates on the Project, and collecting traditional land use information. The main topics of conversation include water supply, mining in Saskatchewan, Treaty Land Entitlement, and traditional land use.

Engagement activities with Muskowekwan First Nation are summarized in Table 5.4-7.

Table 5.4-7: Summary of Muskowekwan First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 18, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor Jamie Wolfe (Muskowekwan First Nation)	An introduction to the Project was provided, along with information sheets to share with Chief and Council. Jaime Wolfe inquired about the water supply for the project. Jaime Wolfe indicated that following a discussion with the Chief, someone would be in touch if there was further interest.
December 2, 2013	Face-to-face Meeting - Lyle Bear, Phil Anaquod (Golder) - Counicllors Calvin Wolfe and Leon Wolfe, as well as one band member Reception (Muskowekwan First Nation)	The purpose of this meeting was to provide information about the status of the Project. The information sheet and a copy of the information panels prepared for the round one community information sessions were provided to each attendee. Interest was expressed in participation in a traditional land use study as well as a face to face meeting with Yancoal. General concerns about the Project were identified, such as the environment, the water source, and the concern over the number of mines coming up in the area.
December 12, 2013	Face-to-face Meeting - Jiqiu Han, Stan Qin and Lei Niu (Yancoal) - Chief Reginald Bellerose and three band members (Muskowekwan First Nation)	The Chief of Muskowekwan and three others visited the Yancoal office. There was an exchange of information on Yancoal and the Project, information about Muskowekwan First Nation, and Treaty Land Entitlement regulations.
May 26, 2014; June 6, 2014	Telephone Conversation - Phil Anaquod (Golder) - Councillor Alvin Campeau (Muskowekwan First Nation)	Contact was made with Council member Alvin Campeau to discuss Elder involvement in the traditional land use survey. Alvin Campeau indicated that if there was Elder interest he would follow up.
March 5, 2015	Telephone Conversation - Phil Anaquod (Golder) - Reception (Muskowekwan First Nation)	Invitation extended to the round two community information sessions.
March 17, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Band Manager (Muskowekwan First Nation)	Attempts were made to meet with the Chief and Council to provide updated Project information. Elections are currently underway and therefore the Chief and Council were available. However a discussion did take place with the Band Manager and an information package was left for her to pass on to the new Council when they take office.
July 7, 2015	Face-to-face - Phil Anaquod (Golder) - Reception (Muskowekwan First Nation)	Information sheet pertaining to July 2015 Community Information Sessions left for Council Leon Wolfe Jr.

Table 5.4-7: Summary of Muskowekwan First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
August 7, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Band Manager (Muskowekwan First Nation)	Round 3 CIS information package delivered. The Band Manager expressed no concerns and indicated that copies of the information will be made and attached to the Chief and Council's files.
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

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5.4.1.8 Okanese First Nation

Engagement activities with Okanese First Nation were initiated in June 2013. Activities carried out to date include providing information and materials on the Project for the Chief and Council. It was indicated that if there was any interest in the Project then Okanese First Nation would be in touch.

Engagement activities with Okanese First Nation are summarized in Table 5.4-8.

Table 5.4-8: Summary of Okanese First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 17, 2013	Face to Face Meeting - Phil Anaquod (Golder) - Band Ofifce (Okanese First Nation)	The purpose of this meeting was to introduce the Project and leave the Project information sheet for the Chief's file.
June 27, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor Daniel Walker (Okanese First Nation)	Met briefly with Daniel Walker to follow-up on the Project information sheet left previously. Daniel Walker indicated that he would provide the information to the rest of the Council in early July and if there was interest in further information they would be in contact.
December 2, 2013	Face-to-face - Phil Anaquod (Golder)	Council meeting was cancelled upon Phil's arrival at the Band Office and rescheduled for December 9, 2013.
December 9, 2013	Face-to-face - Phil Anaquod (Golder)	This meeting was again cancelled by Okanese First Nation.
March 2, 2014	Face to Face - Phil Anaquod (Golder)	Project information sheet and a copy of the information panels prepared for the community information sessions were left with reception for the Chief's business file. Contact information was also provided in case the Chief had any questions or concerns.

Table 5.4-8: Summary of Okanese First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
March 6, 2015	Face-to-face - Phil Anaquod (Golder)	Invitation extended to the round two community information sessions.
March 17, 2015	Face-to-face - Phil Anaquod (Golder)	Attempts were made to meet with the Chief and Council to provide updated Project information. No one was available. An information package was left at reception.
July 6, 2015	Face-to-face - Phil Anaquod (Golder) - Reception (Okanese First Nation)	Information sheet pertaining to July 2015 Community Information Sessions left for Chief Daywalker Peltier.
August 11, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor Richard Stonechild (Okanese First Nation)	Round 3 CIS information package delivered. Councillor Stonechild asked about opportunities for members and how it will be coordinated (i.e., Aboriginal strategy). He also indicated he would pass the file on to the Chief.
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

Golder = Golder Associates Ltd.; CIS = community information session

5.4.1.9 Pasqua First Nation

Engagement activities with Pasqua First Nation were initiated in June 2013. Activities carried out to date include introducing the Project, providing updates on the Project, introducing Yancoal, and providing updates on the Project. The main topics of conversation include Project schedule, water supply, land requirements, and business opportunities.

Engagement activities with Pasqua First Nation are summarized in Table 5.4-9.

Table 5.4-9: Summary of Pasqua First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 13, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Peigan (Pasqua First Nation)	The purpose of this meeting was to provide information about the Project, including providing the Project information sheet. The Chief briefly went over the fact sheet and asked a few questions about the Project. The invitation to meet with Yancoal in the future was extended to the Chief. The Chief indicated that sometime in July or August may work for a meeting.
November 29, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Peigan (Pasqua First Nation)	The purpose of this meeting was to provide an update on the status of the Project, provide copies of the information sheet and the information panels prepared for the round one community information sessions. Phil indicated that in the future Golder would like permission to interview community Elders. Chief Peigan indicated that they would be open to meeting with Yancoal in the future.

Table 5.4-9: Summary of Pasqua First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
February 25, 2014	Face-to-face Meeting - Brad Novecosky, Phil Anaquod (Golder) - Yatong (Mandy) Chen, Jiqiu Han, Lei Niu (Yancoal) - Chief Peigan, and Councillors Lindsay Cyr, Lyle Peigan, Beverly Chicoose, and Leroy Obey, as well as one band member in Business Development/TLE (Pasqua First Nation)	Face-to-face meeting to introduce Yancoal and provide status updates on the Project. Information discussed included the Project schedule, opportunities for Pasqua First Nation to be involved in the Project, water supply, and land requirements. Chief Peigan asked to be kept informed on the status of the Project.
June 16, 2014	Email - Band member in Business Development/TLE (Pasqua First Nation) - Yancoal	Band member emailed Yancoal requesting to have a meeting between Yancoal, Pasqua First Nation and on of their business partners. Yancoal responded that mid to late August would work the best for Yancoal to meet.
August 25, 2014	Face to Face Meeting - Chairman Jianqiang Ma, Jiqiu Han, Leina Liao (Yancoal) - Chief Todd Peigan, and eight other participants (Pasqua First Nation)	The focus of this discussion was on opportunities for Pasqua First Nation to establish a business relationship with Yancoal and to determine when and how they may be able to become involved in the Project. Pasqua First Nation has a number of services that may be of interest and an employment service. Pasqua First Nation discussed water supply and invited Yancoal for a tour. Yancoal indicated that the Project was still in the early stages; however, would keep Pasqua First Nation informed about the Project.
June 10, 2014	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Todd Peigan, Councillor Lindsay Cyr (Pasqua First Nation)	Contact was made with Chief Todd Peigan and Council member Lyndsay Cyr to discuss Elder involvement in the traditional land use survey. It was indicated they would follow-up after an internal meeting to discuss involvement.

Table 5.4-9: Summary of Pasqua First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
March 9, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Todd Peigan, and Councillors Lindsay Cyr, Leroy Obey, Kevin Missens, J Pasqua, F. Strongeagle (Pasqua First Nation)	Invitation extended to the round two community information sessions.
March 10, 2015	Community Information Session in Southey - Jiqiu Han, Asad Naqvi, Galen Slimmon and Leina Liao (Yancoal) -Greg Misfeldt, Megan Tyman, Brad Novecosky, Catherine Fairbairn (Golder) - Councillor Kevin Missens, and one band member in Business Development/TLE (Pasqua First Nation)	Council member Kevin Missens and band member attended the round two community information session in Southey, SK to gather information about the Project.
April 20, 2015	Face-to-face Meeting - Asad Naqvi, Yanxin Liang, Galen Slimmon, Leina Liao (Yancoal) - Chief Todd Peigan and one band member in Business Development/TLE (Pasqua First Nation)	Yancoal met with Chief Todd Peigan and band member to discuss potential opportunities to work with Yancoal. Other topics of discussion included Yancoal's procurement plan, construction camp, construction costs, marketing, First Nation involvement, updates on the environmental assessment and Project, Treaty Land Entitlement, water supply options, and concerns for water quantity downstream. Pasqua First Nation indicated that they would like to meet with Yancoal on a quarterly basis moving forward.
July 6, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Band Office Reception and one band member in Business Development/TLE (Pasqua First Nation)	Information sheet pertaining to July 2015 Community Information Sessions delivered. Band member looking after business development indicated an interest for the Southey session.
August 12, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Reception (Pasqua First Nation)	Round 3 CIS information package delivered. Chief Peigan attended the Southey session.

Table 5.4-9: Summary of Pasqua First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

Golder = Golder Associates Ltd.; CIS = community information session

5.4.1.10 Peepeekisis First Nation

Engagement activities with Peepeekisis First Nation were initiated in June 2013. Activities carried out to date include introducing the Project, providing updates on the Project, introducing Yancoal, and collecting traditional land use information. The main topics of conversation include duty to consult, employment opportunities, investing in Yancoal, and the environment.

Engagement activities with Peepeekisis First Nation are summarized in Table 5.4-10.

Table 5.4-10: Summary of Peepeekisis First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 17, 2013	Face-to-face Meeting - Phil Anaquod (Golder Associates) - Councillor Richard Ironquill and one other band member (Peepeekisis First Nation)	Information about the Project was provided and the Project information sheet and contact information were left with a band member to pass on to the council at the next council meeting scheduled for the following week. Information about the Project was also provided to Richard Ironquill later in the day. An invitation was extended to meet with Yancoal in the future if the Band was interested.
November 27, 2013	Face-to-face Meeting - Phil Anaquod (Golder Associates) - Chief Mike Koochicum, and Councillors Stuart McNab, Richard Ironquill, Francis Deiter, Vanessa Starr, and Martine Desnomie (Peepeekisis First Nation)	The purpose of this meeting was to provide an update on the status of the Project, and leave copies of the information sheet and the information panels prepared for the round one community information sessions. Phil indicated that in the future Golder would like permission to interview community elders. Council members identified that they did not consider this meeting as part of the Duty to Consult. Questions were raised regarding how close Yancoal is working to the Peepeekisis First Nation and about payments to private landowners for accessing their land. The Chief and Council indicated their interest in meeting with Yancoal in the future.

Table 5.4-10: Summary of Peepeekisis First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
February 25, 2014	Face-to-face Meeting - Brad Novecosky, Phil Anaquod (Golder Associates) - Yatong (Mandy) Chen, Jiqiu Han, Lei Niu (Yancoal) - Chief Koochicum and Councillor Vanessa Starr (Peepeekisis First Nation)	The purpose of this meeting was a face-to-face meeting to introduce Yancoal and provide an update on the status of the Project. Items discussed at this meeting included potential for employment opportunities, investment in Yancoal, and environmental concerns related to pipelines.
March 5, 2015	Telephone Conversation - Phil Anaquod (Golder) - Reception (Peepeekisis First Nation)	Invitation extended to the round two community information sessions.
March 9, 2015	Telephone Message and Text Messaging - Phil Anaquod (Golder) - Chief Mike Koochicum (Peepeekisis First Nation)	Invitation extended to the round two community information sessions.
March 17, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor Blaine Pinay (Peepeekisis First Nation)	Met with Council member Blaine Pinay to provide updates on the Project. An information package was also provided to him. Blaine Pinay indicated that we would pass the information along to the Chief and extended an invitation to Yancoal to meet with the Chief and Council in April.
May 13, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Mike Koochicum, Councillors Allan Bird, Stuart McNab, Blaine Pinay, Doug McKay, and Francis Deiter, as well as two technical personnel. (Peepeekisis First Nation)	Met with the Chief and Council and presented another copy of the Project information. Chief and Council indicated that they are interested in further meetings with Yancoal in the future and that they are interested in potential opportunities. They also indicated that they will review the EIS once it becomes available.
July 6, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Technical Officer and Councillor Blaine Pinay (Peepeekisis First Nation)	Information sheet pertaining to July 2015 Community Information Sessions delivered. Councillor Pinay indicated that he will attend the Southey session.

Table 5.4-10: Summary of Peepeekisis First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
August 6, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Mike Koochicum and Councillor Blaine Pinay	Round 3 CIS information package delivered. Chief Koochicum and Councillor Pinay asked about what types of business opportunities are currently available and indicated they are interested business developments and schedules. They said they are not high on the employment side as the workers need training. Chief Koochicum also asked whether Yancoal understands the Treaties and indicated they should become aware of the Treaties.
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

Golder = Golder Associates Ltd.; CIS = community information session

5.4.1.11 Piapot First Nation

Engagement activities with Piapot First Nation were initiated in June 2013. Activities carried out to date include introducing the Project, providing updates on the Project, and collecting traditional land use information. The main topics of conversation include water supply, environment, community involvement, business opportunities, and traditional land use.

Engagement activities with Piapot First Nation are summarized in Table 5.4-11.

Table 5.4-11: Summary of Piapot First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 17, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor Harold Kaiswatum (Piapot First Nation)	An introduction to the Project was provided, along with information sheets to share with Chief and council. An invitation was extended for a face-to-face meeting with Yancoal if there was any interest. Harold Kaiswatum indicated that the next council meeting is scheduled for July 30 and he will be in contact if there is any interest in meeting with Yancoal.
December 3, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Jeremy Fourhorns, and Councillors Vern Anaskan, Lorne Carrier, Murry Ironchild, Harold Kaiswatum, Conrad Obey, Linda Obey Lavallee, George Toto, Randall Lavellee, and Della Chicoose (Piapot First Nation)	The purpose of this meeting was to provide information about the status of the Project, the information sheet, and a copy of the panels prepared for the round one community information sessions was provided to all attendees. An invitation was extended to the Piapot First Nation to have Elders from their community participate in the traditional land use information gathering. Discussion occurred regarding the type of mine Yancoal is proposing, where the water would come from for the Project, and environmental concerns surrounding water and air quality. The Band expressed interest in opportunities for community involvement and development with Yancoal, and is interested to know what they can expect from Yancoal as a corporate entity working in the area in addition to potential employment, training, and business opportunities. Again, an invitation for Piapot First Nation to meet with Yancoal was extended; however, there was no commitment at this time.

Table 5.4-11: Summary of Piapot First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 10, 2014	Face-to-face Meeting - Phil Anaquod (Golder) - 4 Elders (Piapot First Nation)	The purpose of this discussion was to collect traditional land use information for the Project area. It was indicated that some members of the Piapot First Nation currently carry out traditional land use activities (i.e. hunting). Most of the Elders agreed that the Project would not impact their ability to carry out these activities, although some concern was shown for the impact to wildlife.
March 9, 2015	Face-to-face - Phil Anaquod (Golder) - Chief Lavallee, and Councillor Harry Francis (Piapot First Nation)	Invitation extended to the round two community information sessions.
March 23, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Executive Officer to the Chief and Councillor Harold Kaiswatum (Piapot First Nation)	Attempts were made to meet with the Chief and Council to provide updated Project information. The Chief and Council were not available. However a discussion did take place with the Executive Officer to the Chief and an information package was left for her to pass on to the Chief and Council. On the way out Phil also ran into Council member Harold Kaiswatum. He also took an information package and indicated that he would be in touch to confirm if there is any interest to meet with Yancoal.
May 20, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Chief Ira Lavallee, and Councillors Murray Ironchild, Vern Anaskan, Harold Kaiswatum, John Rockthunder, Claude Friday and technical personnel (Piapot First Nation)	Met with the Chief and presented another copy of the Project information. The Chief and Council indicated that they would review the information.
July 6, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Reception and Councilor Harold Kaisowatum (Piapot First Nation)	Information sheet pertaining to July 2015 Community Information Sessions delivered. Information will be circulated out to the Chief.
August 6, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor Vernon Anaskan (Piapot First Nation)	Round 3 CIS information package delivered. Councillor Anaskan took notes and information and indicated he would pass it on to the Chief.

Table 5.4-11: Summary of Piapot First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
August 7, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor Harold Kaisowatum (Piapot First Nation)	Round 3 CIS information package delivered. Councillor Kaisowatum indicated he was interested in the project and concerned about water entering Loon Creek as they have land downstream of Loon Creek.
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

Golder = Golder Associates Ltd.; CIS = community information session

5.4.1.12 Standing Buffalo First Nation

Engagement activities with Standing Buffalo First Nation were initiated in June 2013. Several attempts have been made to engage Standing Buffalo First Nation; however there have been no responses to meeting requests to date.

Engagement activities with Standing Buffalo First Nation are summarized in Table 5.4-12.

Table 5.4-12: Summary of Standing Buffalo First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 27, 2013	Face to Face - Phil Anaquod (Golder)	Stopped in at Standing Buffalo Band office; however, the Chief and Council were not available. The Project information sheet and contact information was left with the reception to provide to the Chief. This council may not be available until after August 02, 2013 as they are preparing for an election.
March 9, 2015	Telephone Conversation - Phil Anaquod (Golder) - Reception (Standing Buffalo First Nation)	Invitation extended to the round two community information sessions.
March 23, 2015	Face-to-face - Phil Anaquod (Golder)	Attempts were made to meet with the Chief and Council to provide updated Project information. No one was available. An information package was left at reception. Standing Buffalo First Nation continues to abstain from any Project engagement as they pursue other legal matters.
August 13, 2015	-	Not accepting any information pertaining to industry.

Golder = Golder Associates Ltd.

5.4.1.13 Star Blanket First Nation

Engagement activities with Star Blanket First Nation were initiated in June 2013. Information packages have been provided to Star Blanket First Nation and it was indicated that if there was interest in the Project that they would be in touch.

Engagement activities with Star Blanket First Nation are summarized in Table 5.4-13.

Table 5.4-13: Summary of Star Blanket First Nation Engagement Activities

Date	Type of Communication	Summary of Communication
June 17, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Councillor James Starblanket (Star Blanket First Nation)	Information about the project was provided and the Project information sheet and contact information were left with James Starblanket to discuss with the Chief. James Starblanket indicated that if there was interest in meeting with Yancoal in the future the Chief would be in contact.
March 6, 2015	Face-to-face - Phil Anaquod (Golder)	Invitation extended to the round two community information sessions.
March 16, 2015	Face-to-face - Phil Anaquod (Golder)	Attempts were made to meet with the Chief and Council to provide updated Project information. Elections are currently underway and therefore no one was available. An information package was left at reception.
July 6, 2015	Face-to-face - Phil Anaquod (Golder) - Chief Mike Starr, and Councillors Edgar Starr and James Starblanket (Star Blanket First Nation)	Information sheet pertaining to July 2015 Community Information Sessions delivered. Chief Starr interested and stated that they may attend the Southey session.
August 6, 2015	Face-to-face - Phil Anaquod (Golder) - Chief Mike Starr (Star Blanket First Nation)	Round 3 CIS information package delivered. Chief Starr said the project was something they would pay attention to because it is the closest of the potash projects and he indicated that they would research in what role they would like to be involved.
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

Golder = Golder Associates Ltd.; CIS = community information session

5.4.1.14 Métis Nation Eastern Region 3

Engagement activities with Métis Nation Eastern Region 3 were initiated in June 2013. Activities carried out to date include introducing the Project and providing updates on the Project. Métis Nation Eastern Region 3 indicated that Yancoal would have to provide resources if they wanted to meet with the community.

Engagement activities with Métis Nation Eastern Region 3 are summarized in Table 5.4-14.

Table 5.4-14: Summary of Métis Nation Eastern Region 3 Engagement Activities

Date	Type of Communication	Summary of Communication
June 13, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Area Director Bev Worsley (Métis Nation Eastern Region 3)	The purpose of this meeting was to provide an information sheet about Yancoal and the Project. Area Director Bev Worsley indicated that Métis Nation Eastern Region 3 will not meet with Yancoal unless resources to attend the meeting are provided.
December 3, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Area Director Bev Worsley (Métis Nation Eastern Region 3)	Information about the Project was presented, including an information sheet and a copy of the information panels prepared for the round one community information sessions. Area Director Bev Worsley did not have any questions at this time; however, she did indicate that the Métis Nation East Region 3 would participate in information gathering (e.g., Elder interviews).
June 10, 2014	Telephone Conversation - Phil Anaquod (Golder) - Area Director Bev Worsley (Métis Nation Eastern Region 3)	Area Director Bev Worsley indicated that she would not be able to work on identifying elders for involvement in the traditional land use surveys.
July 6, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Area Director Beverly Worsley	Information sheet pertaining to July 2015 Community Information Sessions delivered. Met with Ms. Worsley, who indicated that she may not be able to attend but would look forward to some follow-up information material.
August 6, 2015	Face-to-face - Phil Anaquod (Golder) - Reception	Round 3 CIS information package left at reception with business card, as Beverly Worsley was on leave.
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

Golder = Golder Associates Ltd.; CIS = community information session

5.4.1.15 Métis Nation Western Region 3

Engagement activities with Métis Nation Western Region 3 were initiated in June 2013. Activities carried out to date include introducing the Project and providing updates on the Project. The main topics of conversation include employment and business opportunities.

Engagement activities with Métis Nation Western Region 3 are summarized in Table 5.4-15.

Table 5.4-15: Summary of Métis Nation Western Region 3 Engagement

Date	Type of Communication	Summary of Communication
June 25, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Area Director Lela Arnold (Métis Nation Western Region 3)	The purpose of this meeting was to introduce the Project, and provide the Project information sheet. An invitation to meet directly with Yancoal was extended. Area Director Lela Arnold indicated that Métis Nation Western Region 3 would be interested in meeting with Yancoal and that they will be having their annual meeting in September, which would be a good opportunity for Yancoal to present to the whole region. Contact information was provided in case any additional questions or concerns came up following the meeting. Representatives were not able to attend the meeting in September.
December 3, 2013	Face-to-face Meeting - Phil Anaquod (Golder) - Area Director Lela Arnold (Métis Nation Western Region 3)	The purpose of the meeting was to provide information about the status of the Project and was not related to Duty to Consult. The information sheet and information panels prepared for the round one community information sessions were provided to Area Director Lela Arnold. The areas of concerns for the Métis Nation Western Region 3 are in regards to employment and potential business opportunities going forward. Phil Anaquod indicated that there would be an opportunity for the Métis Nation Western Region 3 to participate in a traditional land use study as part of the environmental impact statement in 2014 and that Métis Elders would be invited to participate. An invitation to participate in a face-to-face meeting with Yancoal was also extended. Area Director Lela Arnold indicated that members do not have the resources to travel to attend meetings and would like to know if there would be any form of accommodation provided.
June 10, 2014	Telephone Conversation - Phil Anaquod (Golder) - Area Director Lela Arnold (Métis Nation Western Region 3)	Area Director Lela Arnold indicated that she was unable to identify elders for involvement in the traditional land use surveys.
March 9, 2015	Telephone Conversation - Phil Anaquod (Golder) - Area Director Lela Arnold (Métis Nation Western Region 3)	Invitation extended to the round two community information sessions.
March 23, 2015	Telephone Conversation - Phil Anaquod (Golder) - Area Director Lela Arnold (Métis Nation Western Region 3)	Conversation with Area Director Lela Arnold about the Project updated and information package. Area Director Lela Arnold requested that the information package be dropped off at her office and she indicated that she would review and distribute the information as necessary and would also be in contact if there was any interest to meet with Yancoal.
July 6, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Area Director Lela Arnold	Information sheet pertaining to July 2015 Community Information Sessions delivered. Ms. Arnold indicated that they will attend Southey Session.

Table 5.4-15: Summary of Métis Nation Western Region 3 Engagement

Date	Type of Communication	Summary of Communication
August 7, 2015	Face-to-face Meeting - Phil Anaquod (Golder) - Reception	Round 3 CIS information package left for Lela Arnold (Area Director), who also attended the Southey session.
December 14, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, update the project progress, and notification that face-to-face meetings are anticipated for Q1 of 2016 to discuss socio-economic benefits and Yancoal's willingness to meet during EIS public review period as requested to discuss environmental assessment.

Golder = Golder Associates Ltd.; CIS = community information session

5.4.2 Public

The main form of engagement used by Yancoal for public engagement to date has been community information sessions. Community information sessions are hosted in the local communities, they are open to the public, and they provide an opportunity for interested stakeholders to gather information, ask questions of Project personnel, and provide feedback on the Project. A neighbour relations program will be carried out with stakeholders that reside within two miles from the core facilities area.

5.4.2.1 Community Information Sessions

Yancoal has hosted three rounds of community information sessions for the Project in the nearby communities. The objectives of the community information sessions were to provide the public with an opportunity to learn more about Yancoal, the Project, the environmental assessment process, and to collect any feedback about the Project. Each community session followed a "come and go" format, in which Project information posters were placed around the room and key Project personnel were available to answer any questions or discuss any concerns.

The first round of community information sessions took place in November 2013 with the purpose of introducing Yancoal and the Project. The second round of community information sessions took place in March 2015 with the purpose of providing updated information on the Project and the information presented in the Technical Proposal that was submitted to the Ministry of Environment. The third round of community information sessions took place in July 2015 with the purpose of informing the public on the current status of the Project and providing preliminary results of the environmental assessment and the predicted impacts of the Project on the environment presented in the environmental impact statement (EIS).

5.4.2.1.1 Round One Community Information Sessions

The first round of community information sessions were carried out on November 5, 6, and 7, 2013 in the communities of Southey, Cupar, and Strasbourg. A summary report of the first round of community information sessions is included in Appendix 5-A.

Advertising for the community information sessions ran in the Regina Leader-Post from October 31, 2013 through to November 7, 2013 and in the Last Mountain Times for the week of October 29, 2013. Posters were placed in 12 locations throughout the communities of Southey, Cupar, and Strasbourg, and the notice was also shown on the Southey Community Cable Channel.

A total of 175 people attended the three community information sessions. Of these, 109 people filled out and returned feedback forms (Table 5.4-16). The majority of people were satisfied with the information available about the Project. The most common feedback received was in regards to Project timeline, general impacts and benefits to the communities, methods used to engage the public, the location of the Project, and the potential employment opportunities.

Table 5.4-16: Round One Community Information Sessions Attendants and Feedback

Community	Date	No. of Attendees	Feedback Forms
Southey	November 5, 2013	78	41
Cupar	November 6, 2013	47	36
Strasbourg	November 7, 2013	50	32
Total		**175**	**109**

No. = number

5.4.2.1.2 Round Two Community Information Sessions

The second round of community information sessions were carried out on March 10 and 11, 2015 in the communities of Southey and Strasbourg. A summary report of the second round of community information sessions is included in Appendix 5-B.

Advertising for the community information sessions ran in the Regina Leader-Post on Saturday March 7, 2015 and in the Last Mountain Times for the week of March 3, 2015. Posters were placed in four locations throughout the communities of Southey, Strasbourg and Earl Grey, and the notice was also shown on the Southey Community Cable Channel and on the Southey Community Facebook page. In addition to this, 3,168 mail-out invitations were mailed to all mailboxes in ten local communities/postal codes in the area. In addition, an invitation was emailed to five R.M.s, two town offices, and MOE. Invitations were also extended to 14 First Nations and Métis communities.

A total of 242 people attended the two community information sessions. Of these, 91 people filled out and returned feedback forms (Table 5.4-17). The majority of people were satisfied with the information available about the Project. The most common feedback received was related to hiring and employment, general impacts and benefits to the communities and local people, Project location, general landowner concerns, general Project details, general environmental concerns, traffic and transportation, land acquisition, and groundwater.

Table 5.4-17: Round Two Community Information Sessions Attendants and Feedback

Community	Date	No. of Attendees	Feedback Forms
Southey	March 10, 2015	133	51
Strasbourg	March 11, 2015	109	40
Total		**242**	**91**

No. = number

Following the second round of community information sessions, Yancoal sent out a letter and information package to all attendees, as well as individuals who had emailed or called to request information about the community information session (who provided email or mailing addresses). The information package included a consolidated list of the questions received during the community information sessions and responses to them (Appendix 5-C). This information package is also available on the Yancoal website.

5.4.2.1.3 Round Three Community Information Sessions

The third round of community information sessions were carried out on July 23, 29, and 30, 2015 in the communities of Earl Grey, Southey, and Strasbourg. A summary report of the third round of community information sessions is included in Appendix 5-D.

Advertising for the community information sessions ran in the Regina Leader-Post on Saturday July 18, 2015 and in the Last Mountain Times for the week of July 13 and July 20, 2015. Posters were placed in three locations within the communities of Earl Grey, Southey, and Strasbourg, and the notice was also shown on the Southey Community Cable Channel and on the Southey Community Facebook page. In addition to this, 3,168 mail-out invitations were mailed to all mailboxes in ten local communities/postal codes in the area. In addition, an invitation was emailed to five R.M.s, two town offices, and MOE. Invitations were also extended to 14 First Nations and Métis communities.

A total of 351 people attended the three community information sessions. Of these, 48 people filled out and returned feedback forms (Table 5.4-18). The majority of people were satisfied with the information available about the Project. The most common feedback received was related to hiring and employment, general impacts and benefits to the communities and local people, Project location, general landowner concerns, general Project details, general environmental concerns, traffic and transportation, land acquisition, and groundwater.

Table 5.4-18: Round Three Community Inforamtion Sessions Attendants and Feedback

Community	Date	No. of Attendees	Feedback Forms
Earl Grey	July 23, 2015	168	17
Southey	July 29, 2015	112	16
Strasbourg	July 30, 2015	71	15
Total		**351**	**48**

No. = number

Following the third round of community information sessions, Yancoal sent out a letter and information package to all attendees, as well as individuals who had emailed or called to request information about the community information session (who provided email or mailing addresses). The information package included a consolidated list of the questions received during the community information sessions and responses to them (Appendix 5-E). This information package is also available on the Yancoal website.

5.4.2.2 Neighbour Relations Program

The purpose of the neighbour relations program is to provide an opportunity to discuss the project and the environmental assessment with the people who live closest to the Project and to collect their feedback. A letter and feedback form was sent by mail to people who reside within two miles of the core facilities area in May 2015 (Appendix 5-F). This program includes face-to-face meetings with stakeholders who reside within two miles of the core facilities area. Postage paid return envelopes were provided for those stakeholders who preferred to fill out and return the feedback form by mail.

Six stakeholders responded to the neighbour relations package. Yancoal scheduled face to face meetings with these stakeholders in June 2015. The purpose of these meetings was to discuss and respond as necessary to the feedback received from each stakeholder.

Feedback received during the open houses held in March and July 2015 indicated that a local engagement liaison with good communication skills would be beneficial. On December 14, 2015 a site office was opened in Earl Grey (103 Bates Street) with set office hours of 10:30 am to 3:30 pm on Tuesday, Wednesday, and Friday. Appointments can also be made for times that are convenient for stakeholders. An announcement was placed in the Last Mountain Times, and local landowners were notified using contact information provided in feedback forms collected during the open houses.

A summary of the public and neighbour relations correspondence that has occurred following the third round of community information sessions is provided in Table 5.4-19.

Table 5.4-19: Summary of Public and Neighbour Relations Program Engagement Activities

Date	Type of Communication	Summary of Communication
August 31, 2015	Letter correspondence – Asad Naqvi (Yancoal)	An information package containing the questions and answers compiled from the 2015 open houses was mailed out to over 3,168 residents. The cover letter provided contact information for Asad Naqvi and encouraged recipients to ask questions and provide feedback.
September 17, 2015	Email correspondence – Asad Naqvi (Yancoal)	A local Southey Resident, Emailed Asad Naqvi and inquired when and who would be doing the well pad drilling as he would be interested in acquiring winter work closer to home. Asad responded the same day, indicating construction of the project would take 3 to 3.5 years, that no contraction contracts had been awarded yet, and that he would be kept up to date on the project's progress.
September 9, 2015	Email correspondence – Asad Naqvi (yancoal)	Email received outlining that some locals have concerns regarding water supply and that it would be viewed as favourable if the project could use the water in the Quill Lakes located north of the Project. Asad Emailed back reassuring that Yancoal was aware of these concerns and the high water levels in Quill Lakes.
November 4, 2015	Email to Administrator (R.M. Council of Longlaketon)	During a meeting with Wilfred Retzler (Councillor) on November 3, 2015 it was communicated that some community members were concerned by hearsay that the water levels in Lake Diefenbaker were down 7 m this summer and that things would become worse after the Project was added to the system as a user. Robin Kusch contacted Jeff Hovdebo with the Water Security Agency of Saskatchewan (WSA), who provided reassurance that the levels in Lake Diefenbaker this year were not a concern. He provided links to "real-time" water level data that ratepayers could consult. He also, once again, provided reassurance that the volumes of water required for the Southey Project are very small compared to the volumes in Lake Diefenbaker and the flows in the South Saskatchewan River. This information was sent on to R.M. 219 through the administrator

Table 5.4-19: Summary of Public and Neighbour Relations Program Engagement Activities

Date	Type of Communication	Summary of Communication
November 9, 2015	Face to Face presentation at R.M. Longlaketon Public Hearing regarding proposed zoning bylaw amendment	Yancoal (Robin Kusch) and MLT (Ranji Jeerakathil) presented opposition to proposed zoning bylaw amendment. Messages were that the current separation distance from dwellings (500 m) is supported by the results of the EA and that increasing the separation distance by 6-fold (500 m to 3200 m) would be perceived as direct effort to stifle potash development in the R.M. The bylaw amendment was tabled by the R.M.
November 9, 2015	Face to Face meeting – Robin Kusch (Yanocal)	After the Public Hearing concluded, Robin Kusch gave local landowner and Havelock Special Projects Committee (HSPC) member her contact information and expressed that Yancoal would like to meet and discuss her concerns and the environmental effects assessment results. Robin outlined that in addition to Yancoal being interested in input, and they would also have the opportunity to provide feedback on the EIS as part of the provincial review process. Landowner mentioned that the fact that Yancoal was a Chinese company was not favourable and Robin asked why they thought the socio-economic benefits or environmental approval process would be any different in relation to other publicly traded companies with headquarters outside of Canada, for example, K+S or PCS Cory. Robin asked landowner to meet with her and it was indicated that they might meet with Yancoal in the future, but that they thought it might be too late. Yancoal is not sure why it would be too late, when the environmental assessment has not even been released yet for consideration.
November 10, 2015	Face to Face – Asad Naqvi and Robin Kusch (Yancoal)	Visited local landowners at their home. Yancoal was checking up on their quality of life since the agreement to purchase their land if the project becomes a development.
November 16, 2015	Email correspondence – Robin Kusch (Yancoal),	Asad Naqvi received an Email from local landowners asking for a meeting on November 21, 2015; however, it could not be accommodated. Robin Kusch sent these landowners an Email and left a phone message introducing herself and providing her contact information, as well as announcing the new site office and website postings.
November 17, 2015	Email correspondence – Robin Kusch (Yancoal)	Robin Kusch discussed with HSPC member via Email Yanocal's telecommunication needs for the Southey Project and that his company could be an asset in terms of "leading edge real-time monitoring" throughout the life of the project. Robin outlined that the only opportunity she could think of was in regards to leak detection systems; it was concluded that they should be able to identify more opportunities in the future.
November 25, 2015	Email correspondence	Yancoal received notification from RPS Canada that a local landowner communicated that he thinks his well was damaged (cracked casing) as a result of seismic activity completed on his land. Yancoal confirmed that all activities were completed in accordance with regulations (activities actually completed beyond the recommended setback distance) and RPS Canada has concluded they are not at fault.
December 3, 2015	Email correspondence – Robin Kush (Yancoal), Havelock Special Projects Committee (HSPC)	In a series of Emails Robin expressed that Yancoal hoped the HSPC would meet with Yancoal and provide an opportunity for Yancoal to identify and respond to their concerns, as well as provide feedback in relation to project planning and execution.

Table 5.4-19: Summary of Public and Neighbour Relations Program Engagement Activities

Date	Type of Communication	Summary of Communication
December 6, 2015	Face to Face meeting – Asad Naqvi and Robin Kusch (Yancoal)	Robin Kusch received a call from local business owner, and a meeting was scheduled for December 6th and requested to meet with Asad to discuss project timelines and the company's Hanson Lake Sand Project. Yancoal met with business management team to discuss their project's feasibility and initiate talks to see if Yancoal would be interested in being part of their project. It was suggested that a meeting including Yancoal management be scheduled in 2016.
December 7, 2015	Website posting	EIS Executive Summary posted to the Yancoal website: http://www.yancoal.ca/website/news.php?lang=
December 8, 2015	Phone conversation – Robin Kusch (Yancoal)	On December 1, 2015 resident of Fort San, Saskatchewan expressed concerns regarding the Project during the SaskWater open house about the water pipeline. Community member returned Robin Kusch's call and Robin answered their questions. Robin also followed up with written letter on December 9, 2015 providing answers to two questions she could not answer at the time of the phone call and website links with newly posted information regarding the project.
December 16, 2015	Face to Face meeting – Robin Kusch (Yancoal)	Robin Kusch attended a Christmas gift exchange at the Southey Hotel and Steak Pit and met local landowner who stated that although her family lives only a quarter of a mile from the tailings pond they have not been contacted by anyone from Yancoal. She has concerns, particularly as she and her neighbours have small children. Robin told her about the new office hours in Early Grey, gave the landowner her business card, and told her to call and they would setup a meeting to talk about the project and her concerns. Following their conversation Robin checked and homestead in question is just over 3 kilometres (km) away from the core facility area. No contact from the landowner has been made with Yancoal to-date; therefore, a mail out of the fact sheets (Section 5.4.2.3) will be completed.
December 21, 2015	Website posting	Fact sheets were posted on the Yancoal website: http://www.yancoal.ca/website/factSheets.php?lang= (Section 5.4.2.3).
December 22, 2015	Face to Face meeting at the site office – Robin Kusch (Yancoal)	Local landowner came into the office to get some information regarding the economic benefits that can be expected for the local communities. Discussion focused on the Municipal Potash Tax Sharing program. The landowner doesn't want to see the project stopped if the environment and people will be protected and the local economic benefits will outweigh the inconvenience to those local landowners close to the project. Robin also outlined the development of a hiring and procurement strategy that would benefit local businesses and community members.
December 22, 2015 to January 4, 2016	Email correspondence - Robin Kusch (Yancoal)	Eighty-eight Emails were sent to local community members announcing the opening and hours of operation for the Earl Grey office, as well as providing updated information relating to questions provided including relevant fact sheets. Mail-out to follow.
December 29, 2015	Face to Face meeting at the site office – Robin Kusch (Yancoal)	Local landowner with land adjacent to the core facility area, wanted to talk about the need for economic benefits to the local communities. Robin outlined Yancoal's development of a hiring and procurement strategy that would benefit local businesses and community members, as well as tax revenues.

Table 5.4-19: Summary of Public and Neighbour Relations Program Engagement Activities

Date	Type of Communication	Summary of Communication
December 30, 2015	Email correspondence – Robin Kusch (Yancoal)	Confirmation of Southey Town Council luncheon to occur on January 5, 2016, the Strasbourg Town Council luncheon to occur on January 6, and the Last Mountain Valley Business Association evening presentation on January 6. Confirmation that meetings with the Town of Buylea and the R.M. of McKillop being pursured.
December 31, 2015	Email correspondence – Robin Kusch (Yancoal), Havelock Special Projects Committee	In an email announcing the opening of the Earl Grey site office, Robin reiterated Yancoal's hopes that the HSPC would meet with Yancoal at their convenience. HSPC member's response was that he would not be at the opening but would be present on January 6, 2016 when Yancoal would be meeting with the Last Mountain Valley Business Association. He stated that the HSPC would wait to meet with Yancoal after they received the draft environmental impact statement. He said it wouldn't be productive to regurgitate the same things that were already said.

Yancoal = Yancoal Canada Resources Company Ltd.; R.M. = Rural Municipality; WSA = Water Security Agency; EA = environmental assessment; EIS = Enivronmental Impact Statement.

5.4.2.3 Fact Sheets

Fact sheets have been developed to inform local community members about the Southey Project, in that these fact sheets address common questions that have come to Yancoal's attention through engagement activities. Currently the following 14 fact sheets have been finalized:

- agriculture (effects to soil);
- traffic;
- air quality;
- noise;
- subsidence;
- water supply;
- groundwater;
- surface water;
- Waste Water Management;
- Solution versus Conventional Mining;
- Yancoal – Company Profile;
- Economic Benefits – Jobs;
- Economic Benefits – Taxes and Royalties; and
- Economic Benefits – Infrastructure.

These fact sheets will be provided as handouts to locals that drop into the office, as well as be available through rural municipality, town, and village offices. Copies of the handouts are included in Appendix G.

5.4.3 Government and Regulatory

5.4.3.1 Rural Municipalities

In June 2013, Yancoal met with the R.M. of Cupar No. 218. In July 2013, Yancoal met with the R.M.s of Longlaketon No. 219, Mount Hope No. 279, and Touchwood No. 248. The purpose of these meetings was to introduce representatives from Yancoal and to provide introductory information about the Project.

In April 2014, subsequent meetings occurred with the R.M.s of Cupar No. 218 and Longlaketon No. 219 to provide an update on the status of the Project. In March 2015, Yancoal emailed invitations for the round two community information sessions to five R.M.s, (R.M. of Cupar, R.M. of Longlaketon, R.M. of McKillop, R.M. of Mount Hope, and the R.M. of Touchwood). In addition to this information packages from the round two community information sessions were provided.

In April 2015 Yancoal met with the R.M. of Longlaketon, and in May 2015 with the Town of Strasbourg. The purpose of both meetings was to provide an update on the Project and to address any R.M. and town council questions or concerns. A request was also made by Yancoal to be included in the next R.M. council meeting for the R.M. of Cupar to discuss various Project components. Yancoal has regularly attended R.M. council meetings and has maintained regular communication with the R.M. of Longlageton throughout 2015 and will continue to request time at future R.M. council meetings to provide additional updates. Workshops and meetings will be planned to discuss the Project Proposal and the EIS and to request feedback from regulators.

The main topics during these meetings include the Project location, the type of mining, the water source, the drilling activities, environmental impacts, utilities required for the project (i.e., road, rail), traffic, water containment, water treatment, waste, noise, light and dust pollution, tailings containment, land acquisition process, housing, and the desire for more engagement activities.

Engagement activities with R.M.s are summarized in Table 5.4-20.

Table 5.4-20: Summary of R.M. Engagement Activities

Regulatory Agency or Government Body	Date	Type of Communication	Summary of Communication
R.M. of Cupar No. 218	June 10, 2013	Face-to-face Meeting - Yatong (Mandy) Chen, Yanxin Liang (Yancoal) - Brad Novecosky, Katie Zdunich (Golder) - R.M. Council of Cupar	The purpose of this meeting was to provide the R.M. of Cupar an introduction to Yancoal and the Project. Representatives from the R.M. of Cupar had questions about the scoping study, the Project location, the type of mining, the water source, the drilling program, and general environmental impacts.

Table 5.4-20: Summary of R.M. Engagement Activities

Regulatory Agency or Government Body	Date	Type of Communication	Summary of Communication
R.M. of Mount Hope No. 279	July 9, 2013	Face-to-face Meeting - Yatong (Mandy) Chen, Xianwen (Stan) Qin (Yancoal) - Katie Zdunich (Golder) - R.M. Council of Mount Hope	The purpose of this meeting was to provide the R.M. of Mount Hope an introduction to Yancoal and the Project. Representatives from the R.M. of Mount Hope had questions about the type of mining, other mining in the area, and mapping for the Project.
R.M. of Longlaketon No. 219	July 9, 2013	Face-to-face Meeting - Yatong (Mandy) Chen, Xianwen (Stan) Qin (Yancoal) - Katie Zdunich (Golder) - R.M. Council of Longlaketon	The purpose of this meeting was to provide the R.M. of Longlaketon an introduction to Yancoal and the Project. Representatives from the R.M. of Longlaketon had questions about the type of mining, the drilling program, utilities for the Project (i.e. rail and road), and mapping for the Project.
R.M. of Touchwood No. 248	July 9, 2013	Face-to-face Meeting - Yatong (Mandy) Chen, Xianwen (Stan) Qin (Yancoal) - Katie Zdunich (Golder) - R.M. Council of Touchwood	The purpose of this meeting was to provide the R.M. of Touchwood an introduction to Yancoal and the Project. Representatives from the R.M. of Touchwood had questions about the type of mining, the permit areas, the drilling program, the water source, the Project location, and water contamination.
R.M. of Longlaketon No. 219	April 8, 2014	Face-to-face Meeting - Xianwen (Stan) Qin (Yancoal) - R.M. Council of Longlaketon	Yancoal attended a council meeting with the purpose of providing an update for the Project, listening to concerns and responding to questions. Yancoal provided responses to various concerns regarding land, taxes, dust, tailings containment/groundwater protection, and roads.
R.M. of Cupar No. 218	April 14, 2014	R.M. Rate Payers Supper - Yancoal - R.M. of Cupar (rate payers	Yancoal attended a relationship building event hosted by the R.M. of Cupar. Yancoal provided a brief presentation and update on the Project and the company.
R.M. of Longlaketon No. 219	May 22, 2014	Email correspondence - Megan Tyman (Golder) - Administrator (R.M. Council of Longlaketon)	The Administrator was inquiring about the public review of the environmental studies carried out for the Project. Megan Tyman responded that the Project is still in the pre-feasibility study stage and that the results of the baseline studies will be included in the EIS.

Table 5.4-20: Summary of R.M. Engagement Activities

Regulatory Agency or Government Body	Date	Type of Communication	Summary of Communication
R.M. of Cupar No. 218, R.M. of Longlaketon No. 219, R.M. of McKillop No. 220, R.M. of Touchwood No. 248, R.M. of Mount Hope No. 279	February 25, 2015	Email correspondence - Asad Naqvi (Yancoal)	Invitation extended to the round two community information sessions.
R.M. of Cupar No. 218, R.M. of Longlaketon No. 219, R.M. of McKillop No. 220, R.M. of Touchwood No. 248, R.M. of Mount Hope No. 279	March 6, 2015	Email correspondence - Asad Naqvi (Yancoal)	Information package from the round two community information sessions was provided.
R.M. of Longlaketon No. 219	April 14, 2015	Face-to-face Meeting - Jiqiu Han, Leina Liao, Asad Naqvi, Galen Slimmon (Yancoal) - Megan Tyman, Greg Misfeldt (Golder) - Paul O'Hara, Brian Pozniak (AMEC Foster Wheeler) - R.M. Council of Longlaketon - Ratepayers	Yancoal attended a council meeting with the purpose of providing an update for the Project, listening to concerns and responding to questions. Yancoal provided responses to various questions and concerns regarding environmental monitoring, groundwater, water sources, aggregate supply, need for a new potash mine, road upgrades and closures/re-routing, drilling equipment (cleaning between jobs), land agent and procurement, ownership of land in mining area, land use agreements, buffer zones, rail lines, further engagement and public meetings, and noise and light pollution.
Town of Strasbourg	May 13, 2015	Face-to-face Meeting - Jianqiang Ma, Jiqiu Han, Xianwen (Stan) Qin, Asad Naqvi, (Yancoal) - Megan Tyman, Greg Misfeldt (Golder) - Town Council of Strasbourg	Yancoal attended a council meeting with the purpose of providing a presentation for the Project, listening to concerns and responding to questions. Yancoal provided responses to various questions and concerns regarding demand for potash, waste and water treatment, housing, road infrastructure and traffic, and water sources.

Table 5.4-20: Summary of R.M. Engagement Activities

Regulatory Agency or Government Body	Date	Type of Communication	Summary of Communication
R.M. of Longlaketon No. 219	June 15, 2015	Face-to-face Meeting - Jiqiu Han, Leina Liao, Asad Naqvi, Galen Slimmon (Yancoal) - Megan Tyman (Golder) - R.M. Council of Longlaketon	Yancoal attended a council meeting to discuss the creation of a communication plan for the Project, preparations for upcoming community information sessions and to provide an update on the status of the feasibility study. Discussion occurred regarding gravel requirements, the camp location, roads, utility corridors, and sewage lagoon for the Project. Scott Hegglin (Councillor) mentioned that he observed an oil spill on the access road; Yancoal and Golder requested photos of the spill to look into the matter further.
R.M. of Longlaketon No. 219	July 14, 2015	Face-to-face Meeting - Jiqiu Han, Leina Liao, Asad Naqvi, (Yancoal) - Greg Misfeldt, Megan Tyman (Golder) - R.M. Council of Longlaketon	Yancoal attended a council meeting to discuss preparations for the July 23 public meeting in Early Grey. Yancoal reviewed the presentation materials for the meeting.
R.M. of Longlaketon No. 219	October 13, 2015	Face-to-face Meeting - Asad Naqvi, Jiqiu Han and Leina Liao (Yancoal) - Greg Misfeldt (Golder) - R.M. Council of Longlaketon	Yancoal attended the council meeting to discuss the proposed Southey Yancoal Potash Project, the feasibility process for the Project was reviewed and Yancoal responded to questions about the Project. Asad provided a slide presentation to council reviewing the preliminary results of the EIS (previously communicated), and describing Yancoal's feasibility study process. Questions and responses were discussed regarding the location of the camp site, size of the core facilities area, need for a sewage lagoon on site, road upgrades, on-going communication, and timing for the EIS to be available for public review.
R.M. of Longlaketon	November 4, 2015	Email to Administrator (R.M. Council of Longlaketon)	During a meeting with Wilfred Retzler (Councillor) on November 3, 2015 it was communicated that some community members were concerned by hearsay that the water levels in Lake Diefenbaker were down 7 m this summer and that things would become worse after the Project was added to the system as a user. Robin Kusch contacted Jeff Hovdebo with the Water Security Agency of Saskatchewan (WSA), who provided reassurance that the levels in Lake Diefenbaker this year were not a concern. He even provided links to "real-time" water level data that ratepayers could consult. He also, once again, provided reassurance that the volumes of water required for the Southey Project are very small compared to the volumes in Lake Diefenbaker and the flows in the South Saskatchewan River. This information was sent on to RM 219 through the administrator Loretta Young.

Table 5.4-20: Summary of R.M. Engagement Activities

Regulatory Agency or Government Body	Date	Type of Communication	Summary of Communication
R.M. of Longlaketon	November 6, 2015	Face to Face meeting (R.M. Council of Longlaketon monthly meeting)	During a meeting with Brent Tallentire (Councillor) concerns regarding aggregate supply were communicated. Robin Kusch followed up with Golder Associates Ltd. who completed an aggregate study for the Southey Project as part of the feasibility work. It was confirmed that supply would not be a concern as it is estimated that the Southey Project would only require about 10% of the currently indicated supply. The following information was conveyed during the November 10 RM 219 Council meeting: the project would not be a big consumer of aggregate, especially considering the intention to use paved roads as much as possible; and, that a plan should be derived to communicate the fact that aggregate demand and price are not anticipated to increase locally.
R.M. of Longlaketon	November 10, 2015	Face to Face meeting (R.M. Council of Longlaketon monthly meeting)	Yancoal proposed establishing a working group with RM 219, Yancoal, AMEC (project design manager) and Golder (environmental manager) representatives to discuss issues associated with the Project. The current discussion topics will include: the separation distance (zoning bylaw No. 6-2013), construction camp location, and traffic routes. This group will not be empowered to make decisions on behalf of Yancoal or RM 219, the purpose is to facilitate the timely and throughout transfer of information to be considered during the established decision making processes.
R.M. of Cupar No. 218, R.M. of Longlaketon No. 219, R.M. of McKillop No. 220, R.M. of Touchwood No. 248, R.M. of Mount Hope No. 279, R.M. of Last Mountain Valley, Village of Bulyea, Town of Cupar, Village of Duval, Village of Earl Grey, Town of Govan, Village of Markinch, Town of Southey, and Town of Strasbourg	November 27, 2015	Letter correspondence – Asad Naqvi (Yancoal)	Letter announcing the addition of Robin Kusch (Community and Public Relations – Lead) and Keith Schneider (ADVOCO Consulting Ltd.) to the engagement team, and notification that face-to-face meetings are requested.

Table 5.4-20: Summary of R.M. Engagement Activities

Regulatory Agency or Government Body	Date	Type of Communication	Summary of Communication
R.M. of Longlaketon	December 10, 2015	Email to Administrator (R.M. Council of Longlaketon)	At the public hearing on November 9, 2015, it was communicated by Havelock Special Projects Committee (HSPC) that traffic volumes for the K+S Legacy Project were significantly underestimated in the Potash One EIS. It was stated that traffic count data as high as 3,800 were reported, while the Potash One EIS indicated that traffic would increase by only 700. It was inferred by the committee members that if volumes were underestimated for the Legacy Project (700 vehicles) then they were being underestimated for the Southey Project (roughly 750 vehicles). Rodney Audette, the administrator for RM 190, supplied the 2013 data and stated that the traffic was indeed grossly underestimated. After carefully considering the data, Robin Kusch concluded that the data provided did not support the conclusion that the traffic volumes were grossly underestimated, but that it did indicate the percentage of traffic on each roadway may have been inaccurately predicted. Regarding the reference of count data as high as 3,800, the data provided to Yancoal did have a vehicle count of 3,797 vehicles; however, this was over 63.7 hours (1,431 vehicles per day). The location was also for an area predicted in the Potash One Traffic Assessment to experience an average daily traffic of 2,722 (background plus project-related traffic). An email outlining Robin Kusch's evaluation was sent to the HSPC and the Administrator on December 10. It was concluded that although the Dufferin traffic count data received did not provide a clear indication of if or how the Southey Project's traffic assessment could be inaccurate, based on community concerns and Rodney Audette's statement that volumes were grossly underestimated, the concern would be conveyed back to Golder for consideration (Golder hired Stantec to do the traffic assessment for Yancoal). Further, that there would be traffic monitoring within RM 219, as there is with RM 190, to confirm that proponents are accountable for all project-related traffic.
R.M. of Longlaketon (Southey Project Working Group)	December 21, 2015	Face to Face meeting (Southey Project Working Group)	Kick-off meeting for the working group was held at the Yancoal office in Saskatoon. The group developed a RACI matrix to facilitate communication and accountability, as well as identify a list of prioritized issues to be addressed. Meetings will be held monthly as appropriate for now then bi-weekly during the licensing and permitting stage of the project (anticipated in the summer or early fall of 2016).

R.M. = Rural Municipality; EIS = Environmental Impact Statement; No. = number

5.4.3.2 Regulatory Agencies

In May 2013, representatives from Yancoal and Golder met with the MOE and the WSA to provide introductions on the company and the Project. In April 2014, a second meeting occurred with the MOE to provide an update on the status of the Project. In May 2015, a third meeting occurred with the MOE to provide further updates on the Project. To date these meetings have served to keep the regulatory agencies up to date on the Project and to involve them in the discussion on various requirements and the environmental assessment approach. Subsequent meetings have occurred with MOE to discuss the draft EIS.

Engagement activities with regulatory agencies are summarized in Table 5.4-21.

Table 5.4-21: Summary of Regulatory Agency Engagement

Regulatory Agency or Government Body	Date	Type of Communication	Summary of Communication
Water Security Agency	April 25, 2013	Face-to-face Meeting - Greg Misfeldt, Ron Barsi, Brent Topp, Megan Tyman (Golder) - Jianqiang Ma, Yatong (Mandy) Chen, Jiqiu Han, Lei Niu (Yancoal) - Wayne Dybvig, Jim Gerhart, Jim Waggoner (Water Security Agency)	Yancoal and Golder had a discussion with the Water Security Agency about water supply options for the Project and the process for obtaining a water rights licence.
Saskatchewan Ministry of Environment	May 9, 2013	Face-to-face Meeting - Greg Misfeldt, Ron Barsi, Megan Tyman (Golder) - Yatong (Mandy) Chen, Jiqiu Han, Lei Niu (Yancoal) - Brady Pollock, Liz Quarshie, Mark Wittrup, Sharla Hordenchuk (Ministry of Environment)	Yancoal and Golder representatives met with the Ministry of Environment to discuss the Project and seek guidance on how to proceed with the Project.
Saskatchewan Ministry of Environment	April 22, 2014	Face-to-face Meeting - Ron Barsi (Golder) - Erika Ritchie, Brady Pollock, Sharla Hordenchuk (Ministry of Environment)	Ron Barsi of Golder conducted a Project update meeting with Senior Personnel from the Saskatchewan Ministry of Environment. The purpose of the meeting was to provide an overview of Yancoal as a company, Yancoal potash permit holdings, and the plan for the Project. Discussion items included the status of the Technical Proposal, the environmental assessment approach, engagement activities, and Project schedule.

Table 5.4-21: Summary of Regulatory Agency Engagement

Regulatory Agency or Government Body	Date	Type of Communication	Summary of Communication
Saskatchewan Ministry of Environment	May 13, 2015	Face-to-face Meeting - Jianqiang Ma, Jiqiu Han, Xianwen (Stan) Qin, Asad Naqvi, (Yancoal) - Megan Tyman, Greg Misfeldt (Golder) - Kim Davis, Aimann Sadik, Alvin Yuen and Ashley Oleson (Ministry of Environment)	Yancoal and Golder representatives met with the Ministry of Environment to discuss the Project, engagement activities, schedule, and permitting.
Saskatchewan Ministry of Environment Saskatchewan Ministry of Economy	July 14, 2015	Face-to-face Meeting - Jiqiu Han, Asad Naqvi, Leina Liao (Yancoal) - Greg Misfeldt, Megan Tyman (Golder) - Kim Davis, Alvin Yuen (Ministry of Environment) - Bram Nelissen, Cory Hughes, Jason Berenyi, Gary Delaney (Ministry of Economy)	Yancoal and Golder representatives met with the Ministry of Environment and Ministry of Economy to provide an update on the Project, discuss preparations for the July 23 public meeting in Early Grey.
Saskatchewan Ministry of Environment Water Security Agency	December 3, 2015	Online Meeting – Asad Naqvi, Robin Kusch (Yancoal) - Megan Tyman, Greg Misfeldt, Mike Tremblay (Golder) - Anatoly Melnik, Kei Lo (Water Security Agency) - Sharla Hordenchuk, Brady Pollock, Aimann Sadik, Alvin Yuen, Kelley Lynn, (Ministry of Environment)	Yancoal and Golder representatives met with Ministry of Environment and Water Security Agency representatives to discuss addressing the second round of comments for the EIS technical review.
Saskatchewan Ministry of Environment Water Security Agency	December 17, 2015	Face to Face meeting – Asad Naqvi, Robin Kusch (Yancoal) - Megan Tyman, Greg Misfeldt, Mike Tremblay (Golder) -Jeff Hovdebo, Anatoly Melnik, Kei Lo (Water Security Agency) - Brady Pollock, Kelley Lynn, Aimann Sadik, Alvin Yuen (Ministry of Environment)	Yancoal and Golder representatives met with Ministry of Environment and Water Security Agency representatives to discuss addressing the second round of comments for the EIS technical review.

Golder = Golder Associates Ltd.

5.4.4 Issues and Responses from Engagement Activities

Throughout the engagement activities various topics and concerns were discussed. A summary of the issues and concerns identified, and the responses provided throughout engagement activities is provided below (Table 5.4-22).

Table 5.4-22: Summary of Issues and Responses from Engagement Activities

Topic	Issue	Stakeholder Category	Response	EIS Section
Engagement Approach	Concern for the lack of information, format of community information sessions, and lack of advertising.	Public	Early in the process, Yancoal did not have a lot of information to provide the public on the Project; therefore, engagement activities were not as common. However as the Project developed more engagement activities have occurred. Engagement activities to date have included meetings with the R.M.s, community information sessions, and mail out information packages. Future meetings are planned with the R.M.s, communities, and neighbours to discuss the results of the environmental assessment. The neighbour relations program will include Face-to-face engagement of all interested stakeholders with residences within two miles of the Project. Advertisements for the community information sessions were placed in two local newspapers, on community Facebook pages, on community cable channels, and through mail outs to all mailboxes in 10 communities in the local area.	Section 5.0
General Land Owner Concerns	Concern for impacts to current rental agreements, loss of income on farm land, property values, and proximity to Project.	First Nations and Métis, Public	Yancoal will develop guidelines for leasing agricultural land and pastureland that is not used for Project activities. There is no current data to answer the property value concern for this region. However, based on observations of other potash mines in Saskatchewan, it seems clear that people are able to successfully live, work, and farm near other existing potash mines in the Province, many of which have been in operation for over 40 years.	Section 16.0

Table 5.4-22: Summary of Issues and Responses from Engagement Activities

Topic	Issue	Stakeholder Category	Response	EIS Section
Hiring and Employment	What employment opportunities will there be? What type of subcontractors will be required? Will employees be sourced locally?	Public	The Project will require approximately 2,200 workers during peak construction in 2017 and 2018. Construction jobs will include carpenters, electricians, welders, concrete workers, equipment operators, pipe fitters, and sheet metal workers. Project operations will require approximately 300-350 workers and will include millwrights, process engineers, electricians, mechanics, drillers, safety, health, and environmental personnel, and other trades and contractors. Yancoal will give priority to skilled local people when offering job opportunities and will work with educational institutions, universities, and communities in the area.	Section 16.0
Land Acquisition	Concern for the land acquisition process and communication with Scott Land and Lease.	Public, Regulatory and Government	Yancoal has engaged Scott Land and Lease, a local land company to assist Yancoal with their landowner discussions and negotiations for the Project. A preferred location for the Project was selected based on the Prefeasibility assessment and baseline environmental studies. Sufficient land has been acquired for the core facilities area. If the Project proceeds, discussions and negotiations with landowners will be on-going over the course of the Project as the mine well field expands.	n/a

Table 5.4-22: Summary of Issues and Responses from Engagement Activities

Topic	Issue	Stakeholder Category	Response	EIS Section
Quality of Life	Concern for the negative impact to surrounding communities from the increase in population, as well as the impacts from noise, dust, smell, air quality etc.	Public	During the construction phase of the Project it is expected that the workers will be housed in a self-contained construction camp near the project site. This will reduce potential negative interactions with surrounding communities. During Project operations, the entire workforce is expected to relocate to the socio-economic LSA, including Regina. Population growth in the socio-economic LSA is expected to benefit the local economy; however, demand for services and infrastructure could increase. Noise and air quality were assessed as part of the environmental assessment for the Project. Engineering design of the Project is being completed so that applicable provincial and federal regulations, guideline and best practices related to noise and air quality will be met.	Section 7.0; Appendix 14-B; Section 16.0
Non-specific Benefits/Effects	How will the Project benefit/effect the local communities and R.M.s?	First Nations and Métis, Public, Regulatory and Government	During the construction phase, the local and regional economies will benefit from creation of jobs, purchase of local supplies and services, and improvement of roads. After mining commences, the long-term benefits will include royalty payments to the Government of Saskatchewan, job creation, taxes paid to the municipality, ongoing purchase of supplies and services, and housing development.	Section 1.0; Section 16.0
Non-specific Benefits/Effects	How will the Project impact existing community infrastructure?	First Nations and Métis, Public, Regulatory and Government	The environmental assessment includes examining effects to community infrastructure. Appropriate mitigation will be developed to reduce any potential effects to community infrastructure.	Section 16.0
Non-specific Environmental Concerns	Concern for the impacts the Project have on the environment?	First Nations and Métis Public, Regulatory and Government	An environmental assessment was carried out for this Project to determine any potential environmental impacts and to help design mitigation measures to avoid or minimize these impacts.	Section 7.0 to 16.0

Table 5.4-22: Summary of Issues and Responses from Engagement Activities

Topic	Issue	Stakeholder Category	Response	EIS Section
Traffic and Transportation	Concern for road closures, increased traffic, and maintenance of roads.	Public	Road closures will be necessary within the core facilities area; however alternative access can be identified and incorporated into the design. Yancoal will work with the R.M. to discuss the need for road closures and facilitating local traffic movement around the core facilities area. Traffic studies were carried out to determine if the increase in traffic can be managed safely and will not have a detrimental impact on the existing road infrastructure. Yancoal is also committed to working closely with the Ministry of Highways and Infrastructure, the R.M.s and the surrounding communities to ensure that the existing roadways are managed properly to handle the increase in traffic.	Appendix 4-C; Section 16.0
Project Utilities	Concern for rail lines splitting up farmland.	Public	During operations a rail line will be required to transport potash from the core facilities area. Two options are being considered, however a decision has not yet been made regarding which option will be selected. The rail company that is selected will be responsible for the selection of the route for the rail line, completing the required environmental assessment, and obtaining the necessary easements and permits to construct.	n/a

Table 5.4-22: Summary of Issues and Responses from Engagement Activities

Topic	Issue	Stakeholder Category	Response	EIS Section
Water Quantity and Quality and Source	How much water is required for the Project? Where will the water come from for the Project?	First Nations and Métis, Public, Regulatory and Government	During initial cavern development, the approximate requirement for water is 1,602 cubic metres per hour (m^3/h). During normal operations at full production, the maximum average requirement for water is 1,450 m^3/h. The WSA will provide raw water for the Project from Buffalo Pound Lake. Yancoal applied to the WSA for the water supply required for the Project, and a positive response has been received that provides preliminary assurance that the water allocation is available and can be supplied without affecting other users of the Buffalo Pound Lake Reservoir. It is anticipated that water will be brought to site by Saskatchewan Water Corporation (SaskWater).	Section 4.0
Water Quantity and Quality and Source	How will the Project impact the amount of water in the region, and the quality?	First Nations and Métis, Public, Regulatory and Government	To reduce the potential environmental effects of extracting water from Buffalo Pound Lake, the Project will make use of other sources of freshwater, including storm and precipitation water, snowmelt runoff, and recycled waste and process water. As much as possible, freshwater will be recycled and reused to reduce the total amount of water required for the Project. Effects to water quality from the project are expected to be negligible, and occur in the local area of the Project. It is unlikely that increases in surface water quality concentrations would be discernable from natural variation. Regional changes to hydrology and water quality due to the SaskWater regional water supply project would be assessed and approved by WSA prior to construction, but are not included in the environmental assessment for this Project.	Section 9.0; Section 10.0

LSA = local study area; WSA = Water Security Agency; R.M. = Rural Municipality; Project = Yancoal Southey Project; EIS = Environmental Impact Statement

5.5 Engagement Plan

Yancoal has developed a high level engagement plan to continue to engage and communicate with all stakeholders as the Project moves forward from a proposal to a development. The engagement plan is designed as a living document and will evolve as the Project evolves and will also incorporate feedback from stakeholders. Key messages, plans for direct community contact, and message delivery (e.g., face-to-vace meetings, website updates, media and mail out programs) are discussed in the document. A copy of the engagement plan is provided in Appendix H.

5.6 Summary

Overall, the majority of the feedback received during the engagement activities has been positive. Stakeholders are interested in the Project and want to be involved in the engagement process as much as possible, as the Project progresses. Questions and concerns brought forward during the engagement activities were generally about the Project details including location and timeline; how the Project would impact the environment, the landowners, and the other stakeholders in the local area; and what benefits it would provide.

Yancoal is dedicated to maintaining the relationships created during these engagement activities, and will continue to provide updates to the identified stakeholders as the Project continues to develop.

6.0 ENVIRONMENTAL ASSESSMENT APPROACH

6.1 Introduction

This section describes the assessment approach used for analyzing and determining the significance of effects from the Yancoal Southey Project (the Project) on the biophysical and socio-economic (human) environments as provided by the Terms of Reference (TOR) (Appendix 2-B). The purpose of this section is to meet the requirements of the TOR for the Project, which includes describing the assessment approach to complete the environmental assessment (EA) to prepare the Environmental Impact Statement (EIS).

The assessment approach is based on ecological, cultural, and socio-economic principles, and EA best practice. The approach involves a systematic consideration of how Project components and activities may interact with the environment and result in an effect on one or more environmental components. Where potential adverse effects are identified (either from normal activities or from potential accidents and malfunctions), feasible environmental design features and/or mitigation practices are implemented to avoid or minimize (limit) the effects. Environmental design features can include Project engineering design elements, environmental best practices, management policies and procedures, and social programs. Mitigation practices can include contingency plans and emergency response plans to prevent effects that could result from accidents and malfunctions (i.e., corrective actions).

In addition to determining the effects from the Project, the assessment includes an analysis of cumulative effects that are likely to result from the Project in combination with other developments. Importantly, the EA process is a tool for developers to integrate environmental and social factors into Project planning and decision-making to reach the following goals:

- to engage First Nation, Métis, government agencies, and the public; and
- to assess whether the Project is likely to have significant adverse effects after mitigation.

The use of the EA process as a planning tool for design of the Project is accomplished through an iterative process between the Project's engineers and environmental scientists to mitigate effects, where possible. The EA team worked closely with the Project design team to incorporate appropriate mitigation into the Project design and implementation plans, so that predicted environmental effects should be acceptable. In cases where an initial analysis of effects indicated unacceptable results, the EA team collaborated with the Project design team to identify additional Project design elements to reduce effects. The design of the Project is described in Section 4.0, and forms the basis for the assessment and prediction of effects of the Project.

6.1.1 Scope of the Environmental Assessment

The EA will analyze and classify environmental effects, and determine the significance of the effects from the Project and other developments on the biophysical and socio-economic components of the environment. The approach will be applied to the analysis and assessment of effects from the Project using information from the Project Description (Section 4.0) and existing conditions for each component of the environment. Key elements for assessing effects on the biophysical and socio-economic components include:

- identify and define the valued components (VCs) and the associated assessment endpoints and measurement indicators for VCs (Section 6.2);

- define the spatial and temporal boundaries of the assessment, including the assessment cases (Base Case, Application Case, and Reasonably Foreseeable Development [RFD] Case) used to evaluate the effects of the Project for each VC (Section 6.3);
- provide a summary of the existing conditions for each VC (not presented in Section 6.0, but included in all applicable sections of the EIS [Sections 7.0 to 16.0]);
- provide the definition of pathways, environmental design features and mitigation, and approach and methods for evaluating relevant effects pathways (interactions) between the Project and the biophysical and socio-economic VCs (Section 6.5);
- present the approach for analyzing Project-specific and cumulative effects on biophysical and socio-economic VCs after implementing environmental design features and mitigation (Section 6.6);
- identify and manage the uncertainty in the assessment to increase confidence that effects are not underestimated (Section 6.7);
- define the residual effects criteria and the approach and methods for classifying and determining significance of predicted residual effects (Section 6.8); and
- identify the expected monitoring and follow-up programs to test predicted residual effects, evaluate success of planned mitigation and environmental design features, and address key sources of uncertainty (Section 6.9).

Several elements of the approach can be consistently applied to all biophysical and socio-economic components. However, certain elements of the assessment approach may need to be modified for some components. For example, the definition of a VC can be applied to all disciplines, and the approaches for identifying the interactions that link the Project to potential effects on VCs of the biophysical and socio-economic environments are consistent. Similarly, the approach to determining the spatial and temporal boundaries for the effects analysis and assessment is consistent across biophysical and socio-economic VCs.

In contrast, the methods for analyzing effects, classifying residual effects (e.g., direction, magnitude, and duration) and predicting environmental significance can differ between biophysical and socio-economic components. For example, biophysical components are influenced simultaneously by natural and human-related factors. For many biophysical components, Project-specific effects can be quantified (e.g., incremental changes to groundwater and surface water supply, air quality, soil, and wildlife habitat). Socio-economic effects of a specific project are difficult to isolate from the ongoing processes of interdependent social, cultural, and economic change. Evolving social trends, government policy and programming decisions, and individual choice all have effects that will occur concurrently with potential Project effects. The socio-economic status of different communities, subpopulations, and individuals may vary; so the socio-economic effect may have both positive and negative aspects.

The following sections describe the key elements presented above, and details specific to each VC are provided in their respective sections in the EIS (Sections 7.0 to 16.0).

6.2 Selection of Valued Components, Assessment Endpoints, and Measurement Indicators

6.2.1 Valued Components

Valued components represent physical, biological, cultural, social, and economical properties of the environment determined to be important by the proponent, the public, First Nations and Métis communities, and government agencies. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have potential to be adversely affected by Project development and, therefore, are used to predict the effects of the Project on all environmental components. Examples of physical properties that may be considered VCs include air quality, groundwater, and hydrology. Aquatic and terrestrial plant and animal populations represent biological properties that may be considered VCs. Traditional and non-traditional uses of plants, wildlife, and other biophysical properties (e.g., ecological services or resources) can be VCs of the socio-economic environment.

The selection of VCs is a process that reflects a combination of information including the design of the Project, the existing environment where the Project is located, and an understanding of concerns and issues associated with the development of the Project. A preliminary evaluation was completed at the Project concept stage to identify key interactions between the Project and various components of the biophysical and socio-economic environments. This evaluation identified key issues to support the initial VC selection process. This preliminary evaluation also provided a basis for understanding the interactions that are present for each of the major phases of the Project (i.e., construction, operations, and decommissioning and reclamation, as well as accidents and malfunctions) and how anticipated events can be mitigated.

The selection of VCs considered the following factors:

- presence, abundance, and distribution within, or relevance to, the Project area;
- potential for interaction with the Project and sensitivity to effects;
- species conservation status or concerns;
- previous and on-going engagement with First Nation and Métis communities;
- previous and on-going engagement with the general public, Rural Municipalities, and government; and
- experience with similar projects in Saskatchewan.

The initial VC list was refined based on the input from on-going engagement, identified concerns related to the Project (Section 5.0), and input on the draft TOR. These factors were used to select the final list of biophysical and socio-economic VCs as follows:

- atmospheric environment;
- groundwater;

- hydrology;
- surface water quality;
- fish and fish habitat;
- soil;
- plant populations and communities;
- wildlife (white-tailed deer, elk, upland birds, waterbirds, ferruginous hawk, short-eared owl, northern leopard frog);
- heritage resources; and
- socio-economics (employment and economy, community services and infrastructure, traffic and transportation infrastructure, quality of life, traditional and non-traditional land use).

6.2.2 Assessment Endpoints and Measurement Indicators

Assessment endpoints are qualitative expressions used to determine the significance of residual effects on VCs and represent the key properties of VCs that should be protected for future human generations (i.e., incorporates sustainability). For example, suitability of water quality, self-sustaining and ecologically effective wildlife populations, and sustainability of social and economic properties may be assessment endpoints for surface water quality, wildlife, and socio-economics, respectively.

Assessment endpoints are typically not quantifiable and require the identification of one or more measurement indicators that can be directly linked to the assessment endpoint. Measurement indicators represent properties of the environment and VCs that, when changed, could result in, or contribute to, an effect on assessment endpoints. Measurement indicators may be quantitative (e.g., concentrations of metals in surface water) or qualitative (e.g., movement and behaviour of wildlife from disturbance to habitat). Measurement indicators provide the primary factors for discussing the uncertainty of effects on VCs and, subsequently, can be key variables for study in monitoring and follow-up programs.

The significance of effects from the Project on a VC is evaluated by linking changes in measurement indicators to effects on the assessment endpoint. For example, changes in the quantity and connectivity of plant communities, and the abundance and distribution of habitat for listed plant species (measurement indicators) are used to assess the significance of residual effects of the Project on self-sustaining and ecologically effective plant populations and communities (an assessment endpoint). Self-sustaining populations continue to be resilient and are capable of withstanding changes in environmental conditions and random fluctuations in population processes. Ecologically effective VCs are highly interactive with the environment and can change in abundance and distribution, but still maintain ecosystem function.

The assessment endpoints of measurement indicators selected are shown in Table 6.2-1.

Table 6.2-1: Assessment Endpoints and Measurement Indicators Associated with Valued Components

Valued Component	Assessment Endpoint	Measurement Indicators
Atmospheric Environment	■ Compliance with regulatory air emission guidelines and standards	■ Carbon monoxide (CO) ■ Sulphur dioxide (SO_2) ■ Nitrogen dioxide (NO_2) ■ Particulate matter (PM) ■ Potash (KCl) ■ Greenhouse gases (GHGs) ▪ carbon dioxide (CO_2) ▪ nitrous oxide (N_2O) ▪ methane (CH_4)
Groundwater	■ Continued suitability of groundwater for human use	■ Groundwater chemistry ■ Groundwater levels ■ Vertical and horizontal migration
Hydrology	■ Availability of surface water quantity for human use and ecosystems	■ Spatial and temporal distribution of water ■ Drainage boundaries ■ Stream channel gradients
Surface Water Quality	■ Continued suitability of surface water for human use	■ Surface water quality (i.e., physical analytes, chemical properties)
Fish and Fish Habitat	■ Self-sustaining and ecologically effective fish populations	■ Spatial and temporal distribution of water ■ Surface topography, drainage boundaries, waterbodies, and water pathways ■ Surface water quality (i.e., physical analytes, chemical properties) ■ Fish habitat quantity and fragmentation ■ Fish habitat quality ■ Abundance and distribution of fish species
Soil	■ Soil capability to support agriculture and other plant communities	■ Soil quality (i.e., physical, biological, and chemical properties) ■ Soil quantity and distribution
Plant Populations and Communities	■ Self-sustaining and ecologically effective plant populations and communities	■ Quantity, arrangement, and connectivity (fragmentation) of plant communities ■ Abundance and distribution of habitat for listed plant species ■ Abundance and distribution of habitat for traditional use plant species ■ Presence of weed and invasive plant species

Table 6.2-1: Assessment Endpoints and Measurement Indicators Associated with Valued Components

Valued Component	Assessment Endpoint	Measurement Indicators
Wildlife ■ White-tailed Deer ■ Elk ■ Upland Birds ■ Waterbirds ■ Ferruginous Hawk ■ Short-eared Owl ■ Northern Leopard Frog	■ Self-sustaining and ecologically effective wildlife populations	■ Habitat quantity, arrangement, and connectivity (fragmentation) ■ Habitat quality ■ Survival and reproduction ■ Abundance and distribution of wildlife valued components (VCs)
Heritage Resources	■ Protection of heritage resources	■ Archaeological and sacred sites
Socio-economics ■ Employment and Economy ■ Community Services and Infrastructure ■ Traffic and Transportation Infrastructure ■ Quality of Life ■ Traditional and Non-Traditional Land Use	■ Sustainability of social and economic properties	■ Employment ■ Labour income ■ Tax revenue ■ Gross domestic product ■ Project workforce requirements ■ Potential changes in the demand for housing, accommodations, social, health, emergency and protective services, and physical infrastructure ■ Commitments regarding employment training ■ Project traffic volumes ■ Commitments regarding safety measures and reducing traffic ■ Changes in land use ■ Changes in visual aesthetics ■ Changes in noise levels and air quality ■ Changes in water quality and quantity

6.3 Environmental Assessment Boundaries

Assessment boundaries define the geographic and temporal scope or limits of the analysis for the determination of significance of effects from the Project and other developments on the environment. The response of physical, chemical, and biological processes to changes in the environment can occur across a number of spatial scales at the same time (Holling 1992; Levin 1992). Therefore, these boundaries encompass the areas within (i.e., spatial boundaries) and times (i.e., temporal boundaries) that the Project and other developments are expected to interact with VCs.

6.3.1 Spatial Boundaries

Individuals, populations, and communities function within the environment at different spatial and temporal scales (Wiens 1989). Because the responses of physical, biological, cultural, and economic properties to natural and human-induced disturbance will be unique and occur across different scales, a multi-scale approach was used for describing the existing conditions and predicting effects from the Project on VCs. The spatial boundaries for analyzing and predicting effects from the Project should be appropriate for capturing the processes and activities that influence the geographic distribution and movement patterns specific to each VC.

The location of the Project footprint was unknown at the initiation of most baseline field programs; therefore, a preliminary focus area was delineated for the Project. Baseline study areas were then defined based on each VC to encompass this area as well as at broader, regional levels. Data collected within the baseline study areas were used to provide descriptions and measures of baseline conditions for predicting the direct and indirect changes from the Project on VCs (e.g., changes to terrestrial and aquatic habitat from the physical footprint and dust and air emissions). Data collected at larger scales were used to provide regional context for the combined direct and indirect effects from the Project on VCs. Baseline study areas may not necessarily represent the spatial boundary for the effects analysis.

The selection of the boundary for the effects analysis (i.e., effects study area) is based on the physical and biological properties of a VC. The effects study area is designed to capture the maximum spatial extent of potential effects from the Project and other previous, existing, and reasonably foreseeable future developments (if applicable). Effects from the Project on the biophysical environment typically are stronger at the local scale, while larger-scale effects are more likely to result from other ecological factors and human activities. For example, Project-specific effects on environmental components with limited movement (e.g., soil and vegetation) will likely be restricted to local changes from solution mining and associated infrastructure. Some indirect changes to vegetation from dust deposition and air emissions may occur, but the effects would be limited to the local scale of the Project. For VCs with more extensive distributions, such as hydrology and surface water quality, effects from the Project have a higher likelihood of combining with effects from other human developments and activities at a larger scale. A watershed is influenced by the multiple users and activities that could contribute to cumulative effects on water resources. The spatial boundaries considered for each VC and the rationale for their selection is provided in the applicable section of the EIS (Sections 7.0 to 16.0).

6.3.2 Temporal Boundaries

The EA was designed to evaluate the short- and longer-term changes from the Project on the biophysical and human environments. The duration of effects may extend beyond specific phases of the Project, and is dependent of the physical and/or biological properties of each VC. The Project phases are as follows:

- construction (2016 to 2019);
- operations (2019 to 2119); and
- decommissioning and reclamation (2119 onward).

Baseline studies associated with each VC identify temporal variation (e.g., annual or seasonal changes in water flow or habitat use, or trends over time in populations and employment) and other biophysical constraints relevant to the assessment of the Project. For all VCs, residual effects are assessed for all phases of the Project, but not necessarily for each specific phase. For example, effects on wildlife begin during the construction phase with the removal and alteration of habitat (results in direct and indirect changes), and continue through the operation phase and for a period after the decommissioning and reclamation phase until effects are reversed (unless determined to be irreversible or permanent). Therefore, effects on wildlife are analyzed and predicted from construction through decommissioning and reclamation, which generates the maximum potential spatial and temporal extent of effects and provides confident and ecologically relevant effects predictions.

Alternately, for some VCs, the assessment is completed for those phases of the Project where predicted effects would be expected to peak, or at several key snapshot points in time. These snapshots may be taken at several points within a Project phase or phases. For example, the air quality assessment considers the operations phase of the Project because this is the point during the Project where the maximum emissions profile is expected. The evaluation of hydrology considers two periods during the Project that are expected to contribute to a maximum effect to surface water hydrology: the period where the maximum extent of the Project footprint would be isolated from an existing hydrology system (in an early stage of the operation period) and the period when the settlement due to mine subsidence would be the maximum expected (many years after decommissioning and reclamation).

Similarly, the temporal boundaries identified for cumulative effects assessments are specific to the VCs being assessed. Temporal boundaries include the duration of residual effects from previous and existing developments that overlap with residual effects of the Project, and the period during which the residual effects from reasonably foreseeable developments will overlap with residual effects from the Project. The temporal boundaries considered for each VC are provided in the applicable section of the EIS (Sections 7.0 to 16.0).

6.3.3 Assessment Cases

Although the assessment considers all Project phases listed above, assessment cases are used to characterize the ESA landscapes and facilitate quantitative and qualitative comparisons in the EIS. The concept of assessment cases is applied to the spatial boundary of the assessment to estimate the incremental and cumulative effects from the Project and other developments (Table 6.3-1). The approach incorporates the temporal boundary for analyzing the effects from previous, existing, approved, and reasonably foreseeable developments before, during, and after the anticipated life of the Project. Analyzing the temporal changes to the biophysical and socio-economic environments is fundamental to predicting the cumulative effects from development on VCs with more extensive distributions (e.g., hydrology and surface water quality) or that move over large areas (e.g., wildlife and humans).

Table 6.3-1: Contents of Each Assessment Case

Base Case	Application Case	Reasonably Foreseeable Development Case
Change in environmental conditions from natural factors and previous and existing developments before the Project	Base Case plus the Project	Application Case plus reasonably foreseeable developments

6.3.3.1 Base Case

The Base Case represents the existing environment before the application of the Project. Baseline studies were completed to provide an understanding of the existing physical, biological, and social conditions that may be influenced by the Project and are used to describe the Base Case. The Base Case includes the cumulative effects from previous and existing developments and activities in the study area defined for a VC.

Previous and existing developments and activities include agriculture (e.g., crop and livestock production), mining, oil and gas, commercial and industrial development (e.g., borrow/gravel pits), roads and ditches, residences, and communities. This information was obtained from multiple sources, including Rural Municipality maps, satellite imagery obtained for the Project, available digital data (e.g., roads and communities from CanVec [NRC 2012]), and field surveys completed for the Project. The previous and existing development and activities included in the Base Case for each VC are described in the applicable section of the EIS (Sections 7.0 to 16.0).

6.3.3.2 Application Case

The Application Case includes predictions of the cumulative effects from the previous and existing developments in the Base Case combined with the effects from the Project. Where relevant, this case is also used to identify the incremental changes from the Project that are predicted to occur between the Base and Application cases.

The temporal boundary of the Application Case begins with the anticipated first year of construction of the Project, and continues until the predicted effects reach their maximum predicted extent, and then are reversed following decommissioning and reclamation (Section 6.3.2). For several VCs, the temporal extent of some effects likely will be greater than the lifespan of the Project because the effects will not be reversible until beyond decommissioning and reclamation. For other VCs, the effects may be determined to be irreversible within the temporal boundary of the Application Case. Such effects may be permanent, or the duration of the effect may not be known, except that it is expected to be extremely long (i.e., more than 100 years past decommissioning and reclamation).

6.3.3.3 Reasonably Foreseeable Development Case

The RFD Case includes the Application Case plus the cumulative effects of future projects. The RFDs are defined as projects that:

- are currently under regulatory review or have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project; or may be induced by the Project;
- have been approved but not yet developed; or
- have the potential to change the Project or the effects predictions.

The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future developments and activities. The minimum temporal boundary for the Application Case and RFD Case is the expected lifespan of the Project that, like the Base Case, includes a range of conditions over time. The difference between the Application Case and RFD Case is that the Application Case considers the incremental effect from the Project in isolation of potential future land use activities. For the EIS, the RFD Case includes the maximum number of potential future projects that could occur within each study area defined for a VC and where the effects from future developments and activities could overlap with the spatial and temporal boundaries of VCs and the Project.

Unlike the analyses of cumulative effects for the Base and Application cases, which are largely quantitative, the analysis for the RFD Case is quantitative where possible and qualitative where necessary. The analysis was quantitative for those future projects that could be assigned a location and known or hypothetical physical footprint area on the landscape. Analysis was qualitative for developments for which this information was not available. For all future developments and activities, the EIS used the best and most current information available for the location, size, and type of activity associated with a project. Not all VCs include an RFD Case in the EIS, and rationale for inclusion or exclusion is described in the applicable section of the EIS (Sections 7.0 to 16.0).

6.3.3.3.1 Reasonably Foreseeable Projects and Activities

The cumulative effects analysis (where applicable) included RFDs that could overlap with the spatial and temporal boundaries of VCs and the Project. The Government of Saskatchewan Environmental Assessment Registry (Government of Saskatchewan 2015a), the Canadian Environmental Assessment Registry (CEA Registry 2015), and the Saskatchewan 2015 Major Projects Inventory (Government of Saskatchewan 2015b) were reviewed to identify the potential RFDs. The potential future projects that could contribute to cumulative effects on VCs of the biophysical and human environments are described below.

Muskowekwan Potash Mine Project

First Potash Ventures (FPV) is proposing to develop a greenfield solution potash mine located approximately 52 kilometres (km) to the northeast of the Project. The Muskowekwan Potash Mine would be located entirely on Muskowekwan First Nation land and is anticipated to produce 2.8 million tonnes of potash per year for at least 50 years (FPV 2012). Although the final location for the proposed mine facility will be determined during final siting and design, it is anticipated to be located within ten contiguous quarter sections of land located within Sections 25, 26, 35, and 36 Township 27 Range 15, and Section 2 Township 28 Range 15 West of the Second Meridian (W2M). An EIS is underway for this project and if approved, construction is anticipated to begin in 2016.

Vale Kronau Project

Vale Potash Canada Limited is proposing to construct and operate a new potash mine approximately 71 km south of the Project near Kronau, Saskatchewan. The Vale Kronau Project is anticipated to produce up to 2.9 million tonnes of potash per year using solution mining techniques (Vale 2015). The location for the proposed mine is anticipated to be within Township 16, Ranges 16 and 17, W2M. The Ministry of Environment (MOE) approved the development in October 2013 (Government of Saskatchewan 2013a) and the final feasibility stage has been approved to proceed (Vale 2015). Construction is anticipated to begin in 2016.

Milestone Potash Project

Western Potash Corporation is proposing to construct and operate a new potash mine approximately 92 km south of the Project. The Milestone Potash Project is a solution mine with an anticipated ultimate production rate of 2.8 million tonnes of potash per year for up to 49 years (Western 2013). The location for the proposed mine is anticipated to be within Township 14, Ranges 17 and 18, W2M. The MOE approved the development in March 2013 (Government of Saskatchewan 2013b). Construction is anticipated to begin in 2016 (Western 2013).

Supporting Infrastructure for the Project

Once the Project is approved, supporting infrastructure will be required for the Project and will include a water supply pipeline (provided by Saskatchewan Water Corporation [SaskWater]), power transmission lines (provided by Saskatchewan Power Corporation [SaskPower]), natural gas pipeline (provided by TransGas), telecommunications (provided by Saskatchewan Telecommunications Holding Corporation [SaskTel]), and rail access (provided by Canadian Pacific [CP] or Canadian National [CN]). These linear developments will be induced by the Project if it proceeds. However, the individual utility and rail providers will be the proponents responsible for completing the environmental assessments that will be submitted under separate applications, and obtaining approvals and regulatory permitting required for development of the supporting infrastructure. Final route selection for supporting infrastructure has not been determined; as such, the potential cumulative effect of one or all of these linear developments will be discussed qualitatively in the individual environmental assessment sections where applicable.

Other Commercial, Infrastructure, Institutional, Recreation and Tourism, and Residential Developments

Approximately $3.4 billion in commercial, infrastructure, institutional, recreation and tourism, and residential developments are proposed and have potential to contribute to cumulative economic effects. The majority of these developments (e.g., wastewater treatment plant upgrade, railway renewal project) are within the City of Regina, however, a planned bypass that will connect Regina to Highway 11 and other recreational developments are planned. These projects are discussed in detail in the socio-economic assessment (Section 16.0).

6.4 Existing Environment

Each section of the EIS includes a description of the existing environment (Base Case) to provide the basis for the evaluation of potential changes from the Project. Relevant information from published and unpublished data sources were reviewed for establishing Base Case conditions relevant to each VC. Baseline studies were also completed to provide additional site-specific information on the existing physical, biological, and social conditions that may be influenced by the Project.

The existing environment (Base Case) conditions represent the historical and current developments and activities that have shaped the existing distribution of VCs. Existing conditions are described recognizing that Base Case conditions typically fluctuate within a range of variation through time and space depending on which natural and human-related factors are currently driving changes to VCs.

The methods and results of the data collection that are directly relevant to the assessment of Project effects are summarized in the applicable section of the EIS (Sections 7.0 to 16.0). Detailed methods and results are provided in the baseline reports (Annexes I to V).

6.5 Pathway Analysis

Interactions (e.g., pathways) between Project components or activities and potential changes to measurement indicators of the environment are identified by a pathway analysis, or screening of Project interactions, which are then used to assess residual effects on VCs after considering mitigation.

The first part of the pathway analysis is to identify all potential effects pathways for the Project that may affect a VC. Each pathway is initially considered to have a linkage to potential effects on VCs. Potential pathways through which the Project could affect VCs were identified from a number of sources including the following:

- a review of the Project Description (Section 4.0) and scoping of potential effects by the environmental and engineering teams for the Project;
- information obtained from community engagement sessions (Section 5.0);
- scientific knowledge and experience with other potash mines in Saskatchewan; and
- consideration of potential effects identified from the TOR.

Identification of potential pathways is followed by the development of environmental design features and mitigation that can be incorporated into the Project to remove a pathway or limit (i.e., mitigate) the effects on VCs. Mitigation has been developed for the Project according to the following hierarchy proposed by the MOE (2014):

- avoidance;
- minimize (limit);
- restoration; and
- compensation.

Environmental design features and mitigation include engineering design elements, environmental best practices, management policies and procedures, spill response and control, and emergency response plans, and social programs. Environmental design features and mitigation are developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to mitigate adverse effects identified by the pathways analysis.

Knowledge of the environmental design features and mitigation is then applied to each of the pathways to determine the expected amount of Project-related changes to the environment and the associated residual effects (i.e., effects after mitigation) on VCs. Changes to the environment can alter physical measurement indicators (e.g., groundwater chemistry or the amount and distribution of available habitat), and biological measurement indicators (e.g., animal behaviour, movement, and survival). For an effect to occur there has to be a Project component or activity that results in a measurable change to the measurement indicators and a corresponding effect on a VC:

Project Activity ➔ Change in Environment ➔ Effect on VC

After applying environmental design features and mitigation, a screening level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on VCs. Pathways are determined to be primary, secondary or no-linkage using scientific, local and traditional knowledge, logic, experience with similar developments, and environmental design features and mitigation. Each potential pathway is assessed and described as follows.

- **No linkage** – analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change. Therefore, the pathway would have no residual effects on a VC relative to the Base Case (Section 6.3.3) or guideline values (e.g., air, soil, or water quality standards or guidelines).
- **Secondary** – the pathway could result in a measurable minor environmental change, but would have a negligible residual effect on a VC relative to the Base Case or guideline values (e.g., a measureable change in water flows or levels that is small compared to the Base Case values, but is well within the range of natural fluctuation for that watercourse) and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect.
- **Primary** – the pathway is likely to result in an environmental change that could contribute to residual effects on a VC relative to the Base Case or guideline values.

Pathways with no linkage to a VC are not assessed further because implementation of environmental design features or mitigation will remove the pathway and result in no measureable change to a VC. Pathways that are assessed to be secondary and are demonstrated to have a negligible residual effect on a VC through simple qualitative or semi-quantitative evaluation of the pathway are also not advanced for further assessment. In summary, pathways determined to have no linkage to a VC or those that are considered secondary are not expected to result in environmentally significant effects on the assessment endpoint of the VC. Primary pathways require further evaluation though more detailed quantitative and/or qualitative effects analyses (Section 6.6) and classification to determine the environmental significance of the Project effects on VCs (Section 6.7).

6.6 Residual Effects Analysis

6.6.1 Project-specific Effects

In the EIS, the residual effects analysis considers all primary pathways that are likely to result in measurable environmental changes and residual effects on VCs, after implementing environmental design features and mitigation. Thus, the analysis is based on Project-specific (incremental) effects that were identified as primary in the pathway analysis (Section 6.5). Residual effects on assessment endpoints may have more than one primary pathway that link a Project component or activity to an interaction with the environment and a subsequent effect on a VC. For example, the pathways for effects on the ability of plant populations and communities to remain self-sustaining and ecologically effective could include alteration of water quality, soil quality, and changes to vegetation quantity and quality.

The residual effects analysis is completed for the Application Case and the RFD Case (where applicable). The Base Case includes the cumulative effects from previous and existing developments, and is the basis for the evaluation of potential changes of the Project (Application Case), as well as previous, existing and reasonably foreseeable future developments (RFD Case). The residual effects analysis considers the proposed environmental design features and mitigation identified in the pathways analysis (Section 6.5).

Results from the residual effects analysis are used to describe the magnitude, duration, and geographic (spatial) extent of the predicted changes to measurement indicators and residual effects on VC assessment endpoints. A strong effort is made to express the expected changes quantitatively or numerically. For example, the magnitude (intensity) of the effect may be expressed in absolute or percentage values above or below Base Case conditions or a guideline value. The duration, including reversibility, of the effect typically is described in years relative to the phases of development of the Project (e.g., construction, operations, and decommissioning and reclamation). The spatial extent of effects is typically expressed in area or distance from the Project. In addition, the direction, frequency, reversibility, probability, and context of effects are described, where applicable. Expressions such as short-term duration or moderate magnitude are not used in the residual effects analysis. These expressions applied to the classification of residual effects and determination of environmental significance, where definitions of these expressions are provided (Section 6.8).

Effects to socio-economic properties include positive and negative changes to measurement indicators such as employment, family income, community services, infrastructure, and land use. Some of these measurement indicators can be analyzed quantitatively (e.g., number of jobs created, estimated income levels, and estimated changes in traffic). Other indicators such as changes in land use are more difficult to quantify, and involve information from public engagement, literature, examples from similar projects under similar conditions, and experienced opinion. The effects analysis considers the interactions among the unique and common attributes, challenges, and opportunities related to socio-economic measurement indicators. A key aspect of the residual effects analysis is to predict the influence from the Project on the development and sustainability of socio-economic conditions in the defined assessment study area.

A detailed description of the methods used to analyze residual effects from the Project on VCs is provided in each residual effects assessment section (Sections 7.0 to 16.0). Where possible and appropriate, the analyses are quantitative, and consist of modelling results, scientific literature, government publications, effects monitoring reports, and personal communication. Information from scientific literature and special studies is valuable for understanding and making predictions about Project-specific and cumulative effects. Due to the amount and type of data available, some analyses are qualitative and include professional judgment or experienced opinion.

6.6.2 Approach to Cumulative Effects

Cumulative effects represent the sum of all natural and human-induced influences on the physical, biological, cultural, and economic components of the environment through time and across space. Some changes may be human-related, such as increasing industrial and agricultural development, and some changes may be associated with natural phenomena, such as extreme rainfall events and periodic harsh and mild winters. Where information is available, the cumulative effects assessment estimates or predicts the contribution of effects from the Project and other developments on VCs, in the context of natural changes in the system.

Not every VC requires an analysis of cumulative effects. The key is to determine if the effects from the Project and one or more previous, existing, approved, and/or reasonably foreseeable developments and activities (e.g., RFD Case) overlap (or interact) with the temporal or spatial distribution of the VC (Section 6.5). In the EIS, cumulative effects are identified, analyzed, and assessed in each residual effects assessment section (Sections 7.0 to 16.0), where applicable. The approach is the same as that used for the Project-specific effects analysis and residual effects classification and determination of significance (Section 6.6.1). If significant adverse cumulative effects are identified, then the opportunity for technically and economically feasible additional mitigation is considered and applied to the assessment.

6.7 Prediction Confidence and Uncertainty

The purpose of an EA is to predict the future conditions of the biophysical and socio-economic environments as a result of a project or development. Because the biophysical and socio-economic environments change naturally and continually through time and across space, most assessments of effects embody some degree of uncertainty. The purpose of the uncertainty sections of the EIS is to identify the key sources of uncertainty and discuss how uncertainty is addressed to increase the level of confidence that effects will not be worse than predicted. Confidence in effects analyses can be related to many elements, including the following:

- adequacy of the baseline data for providing an understanding of the existing conditions and future changes unrelated to the Project (e.g., rate and extent of future developments, climate change, or catastrophic events);
- model inputs (e.g., changes in surface water flow rates and levels over time and space);
- understanding of Project-related effects on complex ecosystems that contain interactions across different scales of time and space (e.g., how and why the Project will influence wildlife);
- limited knowledge and experience with the type of effect in the system; and
- knowledge of the effectiveness of the environmental design features and mitigation for reducing or removing effects (e.g., environmental performance of dust control methods).

Uncertainty in these elements can decrease confidence in the prediction of environmental significance. In accordance with the TOR (Appendix 2-B), assumptions for models and statistical tests, and details on models are presented and discussed within the residual effects analysis section. The intent of the review is to show that the models used are justified for use in the EA. Where possible, a strong attempt is made to reduce uncertainty in the EIS to increase the level of confidence in effect predictions, as shown in the following examples:

- using the results from several models and analyses to help reduce bias and increase precision in prediction;
- using data from effects monitoring programs and literature as inputs for models rather than strictly hypothetical or theoretical values; and
- implementing a conservative approach when information is limited so that effects are typically overestimated (e.g., defining the key input variables so that the result is a conservatively high effects prediction).

Where appropriate, uncertainty may be addressed by additional mitigation and in follow-up and monitoring programs, which would be implemented as required. Each effects assessment includes a discussion of how uncertainty is addressed, and provides a qualitative evaluation of the resulting level of confidence, which is included in the residual effects classification and determination of significance.

6.8 Residual Effects Classification and Determination of Significance

6.8.1 Residual Effects Criteria

The purpose of the residual effects classification is to describe the residual incremental and cumulative adverse effects from previous and existing developments (Base Case) and the Project (Application Case), and future developments (RFD Case, if applicable) on VCs using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment. It is difficult (and not appropriate) to provide definitions for all residual effects criteria and significance that are universally applicable to each VC. Consequently, specific definitions will be provided for each VC in each effects assessment section of the EIS (Sections 7.0 to 16.0).

Results from the residual effects classification are then used to determine the environmental significance from the Project and other developments on assessment endpoints (Section 6.2.2). To provide clarity and consistency across VCs with assessment endpoints, effects are described using the following criteria. Together, these criteria are used to describe the nature (e.g., severity or intensity of change, and the area and amount of time over which the change occurs) and type (e.g., direction of the change) of an effect on a VC.

Direction – Direction indicates whether the effect on a VC is negative or adverse (i.e., less favourable), positive (i.e., an improvement), or neutral (i.e., no change). The focus of the EA is to predict if the Project is likely to cause a significant adverse effect on the environment. Although positive changes associated with the Project are reported, neutral and positive effects are not assessed for significance for biophysical VCs. Positive effects are assessed for significance for socio-economic VCs.

Magnitude – Magnitude is a measure of the intensity of a residual effect on a VC, or the degree of change caused by the Project (and other developments, if applicable) relative to Base Case conditions, guideline values, or established threshold values (i.e., effect size). The number and definitions of scales of magnitude are specific to each VC and is often classified as negligible, low, moderate, and high. Where possible, magnitude is reported in absolute and relative terms. Important context for classifying magnitude for VCs is derived from the geographic extent and duration of the effect. For example, if 20 percent (%) of habitat is altered for a fish or wildlife VC, is this over a geographic extent of 100 hectares (ha) (1 square kilometre [km^2]) or 10,000 ha (100 km^2)? Does the habitat loss last for a season, 10 years, or 100 years? Answering these questions can assist in determining whether a 20% habitat loss represents a low, moderate, or high magnitude effect on the VC population.

Geographic Extent – Geographic extent refers to the spatial extent of the area affected (e.g., distance covered or range), and is different from the spatial boundary (i.e., effects study area) for the effects analysis. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution and movement of VCs (Section 6.3.1). However, the geographic extent of effects can occur on a number of scales within the spatial boundary of the assessment and is VC specific. Geographic extent is categorized as local, regional, and beyond regional. Effects at the local scale are associated largely with the predicted maximum spatial extent of combined direct and indirect changes from the Project (i.e., cumulative effects that are specific to the Project). For some VCs, cumulative direct and indirect changes from the Project and other developments may also occur at the local scale. Effects at the regional scale occur within the effects study area and are associated with incremental and cumulative changes from the Project and other developments. The beyond regional scale includes cumulative residual effects from the Project and other developments that extend beyond the effects study area. The principle applied when using geographic extent to understand magnitude is that local effects from the Project are less severe than effects that extend to the regional or beyond regional scales, all other factors being equal.

Duration – Similar to magnitude and geographic extent, duration is VC-specific and defined as the amount of time from the beginning of a residual effect to when the residual effect on a VC is reversed. It is typically expressed relative to Project phases. Duration has two components, the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases) plus the time required for the effect to be reversible. Essentially, duration is a function of the length of time that VCs are exposed to Project activities and reversibility. By definition, residual effects that are short-term, medium-term, or long-term in duration are reversible.

The timing, duration of individual events, and the overall period during which the residual effect may occur are considered. Timing includes when a residual adverse effect occurs as some effects may exhibit temporal variation over the life of the Project (e.g., during breeding or spawning season and high or low point of a population cycle). Some residual effects may be reversible soon after the stressor has ceased (e.g., change in distribution of some wildlife species following the decrease in noise and activity levels after decommissioning and reclamation), while other residual effects may take longer to be reversed (e.g., change in abundance of some species on altered habitat after reclamation and re-vegetation).

In some cases, available scientific information and experienced opinion may predict that the residual effect is irreversible. Alternately, the duration of the residual effect may not be known, except that it is expected to be extremely long and well beyond the temporal boundary of the Project. Any number of factors could cause a VC to never return to a state that is unaffected by the Project. In other words, science and logic predict that the likelihood of reversibility is so low or uncertain that the residual effect is classified as irreversible.

Reversibility – After removal of the Project activity or stressor, reversibility is the likelihood that the Project will no longer influence a VC at a future predicted period. Reversibility usually has two alternatives: reversible or irreversible. The period is provided for reversibility (i.e., duration) if a residual effect is reversible. Permanent residual effects are considered irreversible.

Frequency – Frequency refers to how often a residual effect from a change to a measurement indicator will occur and is expressed as infrequent (i.e., isolated or confined to a discrete period) or frequent (i.e., occurs intermittently, but repeatedly over the assessment, or continuously over the assessment period). Frequency is explained by identifying when the source of change and residual effect occurs (e.g., once at the beginning of the Project or several times during operations). Frequency is used to describe the residual effect that is a result of a source or activity, not the frequency of the activity that causes the residual effect.

Likelihood – Likelihood is the probability of an effect occurring and is described in parallel with uncertainty. Likelihood may be influenced by a variety of factors such as the likelihood of a negative response by a VC is occurring or the likelihood of mitigation being successful. Three categories are used:

- Unlikely – residual effect from a change to a measurement indicator is possible, but unlikely (less than 10% chance of occurring);

- Likely – residual effect from a change to a measurement indicator may occur, but is not certain (10% to 80% chance of occurring); and
- Highly Likely – residual effect from a change to a measurement indicator is likely to occur or is certain (greater than 80% chance of occurring).

The specific definitions applied to the above classification criteria for each VC are based on the biophysical or socio-economic processes and properties of the VC and are included in each effects assessment section (Sections 7.0 to 16.0). Although some professional judgement or experienced opinion is inevitable in determining the scales for effects predictions, a strong effort is made to classify residual effects using scientific principles, established guidelines, established thresholds or screening values, and supporting evidence.

6.8.2 Determination of Significance

The residual effects classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of incremental and cumulative effects from the Project and other existing, approved, and reasonably foreseeable developments on VC assessment endpoints. For some VCs there may be no RFD Case and the assessment is limited to determining the significance of incremental and cumulative effects from the Project and previous and existing developments (i.e., Application Case). For those VCs that may be influenced by forecasted future developments, the assessment includes classifying and determining the significance of cumulative effects from all previous, existing, and future developments including the Project (i.e., RFD Case). The significance of the contribution of incremental effects from the Project on VCs is provided, but the evaluation is focused on determining the significance of cumulative effects on assessment endpoints of the biophysical and socio-economic environments. To be transparent, each effects assessment provides a table showing the specific definitions of effects criteria (e.g., definitions of low, moderate, and high magnitude) and environmental significance for VCs.

Magnitude is the primary criterion used to determine environmental significance, while other criteria are used as modifiers and to provide context when assigning magnitude. Geographic extent and duration provide important ecological and socio-economic context for classifying the magnitude of effects on VC assessment endpoints. For example, determining the magnitude of an effect from changes in habitat availability and connectivity on a fish or wildlife VC depends on the spatial extent (amount of area or proportion of the population) and duration of the changes (how long the population is adversely affected). Duration includes reversibility; a reversible effect from development is one that does not result in a permanent adverse effect on population processes (e.g., survival and reproduction), and ecological functions and properties (e.g., stability and resilience). Frequency and likelihood are considered as modifiers when determining significance, where applicable.

Duration is a function of resilience, which is the ability of the population to recover or bounce back from a disturbance (e.g., rate and degree of fluctuation in population abundance and distribution after a disturbance). Resilience is largely a function of demographic and behavioural life history traits such as size and number of litters or number of eggs and survival of fry, age at reproduction, inter-birth interval, age-specific survival rates, lifespan of individuals, habitat selection, and effective dispersal (e.g., probability of leaving the natal range and successfully establishing a breeding range and reproducing). The capacity or ability of individuals in a population to change and accommodate disturbance is also related to resilience. For example, some wildlife species that avoid human features in relatively undisturbed landscapes can change their behaviour to accommodate disturbance where it is more prevalent (Martin et al. 2010; Knopff 2011). Other populations may increase reproduction to compensate for mortality.

Resilience can vary with population size, stability, and the likelihood of demographic rescue from neighbouring populations. During periods of low abundance, animal and plant populations can become less resilient to natural environmental and human-related disturbances, which may reduce stability (i.e., trajectory of the population). Stable populations exhibit no long-term increasing or declining trend in abundance outside of natural fluctuations and cycles (e.g., predator-prey cycles). Resilience and stability are properties of a population that influence the amount of risk to VCs from development (Weaver et al. 1996; Turestsky et al. 2012). The duration of development-related effects may be shorter for VCs that are highly resilient and stable.

As much as possible, effects are classified and significance determined using established guidelines, thresholds or screening values, and scientific principles. Because of the uncertainty regarding the effects of development on VCs, magnitude classification is applied conservatively to increase the level of confidence that effects will not be worse than predicted. Furthermore, the determination of significance considers the key sources of uncertainty in the effects analysis, the management of uncertainties, and the correspondent level of confidence in effects predictions (Section 6.7).

The evaluation of significance for biophysical VCs considers the entire set of primary pathways that influence the VC assessment endpoint; thus, significance is not explicitly assigned to each pathway. Rather, the relative contribution of each pathway is used to determine the significance of the Project and other developments on an assessment endpoint, which represents a weight-of-evidence approach (i.e., evaluating the persuasiveness of evidence indicating that an effect is significant or not significant). For example, a pathway with a high magnitude, a large geographic extent, and a long-term duration is given more weight in determining significance relative to pathways with smaller scale effects. The relative effect from each pathway is discussed; however, pathways that are predicted to have the greatest influence on changes to assessment endpoints are assumed to contribute the most to the determination of environmental significance. This method is used to identify predicted residual adverse effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to a VC and, therefore, result in significant effects.

Classification of residual effects and determination of significance for the human environment generally follow the methods used for biophysical VCs; however, there are some differences in the selection and definition of effects criteria. The determination of significance from Project effects on the assessment endpoint for the socio-economic environment is completed on a subset of VCs and, typically, each VC is directly associated with one or more unique pathways. The evaluation of significance for each VC considers the entire set of primary pathways in the same direction (i.e., negative or positive) that influence the VC. For socio-economic VCs, direction, magnitude, geographic extent, and duration are the criteria used to classify effects and evaluate the significance of changes to assessment endpoints. The assessment of significance considers the scale of these criteria (e.g., low magnitude, regional geographic extent, and long-term duration) and professional opinion, which is based on the context of the communities involved, and the informed value and judgement of interested and affected organizations and specialists. The level of significance assesses the efficacy of the proposed mitigation (i.e., policies, practices, and investments) and benefit enhancement programs to limit negative effects and foster positive effects on the continued sustainability of long-term social and economic properties of the environment.

Details on the approach and methods for classifying residual effects and determining significance on VCs of the biophysical and socio-economic environments are provided in the applicable sections of the EIS (Sections 7.0 to 16.0).

The following is a summary of the key factors considered in the determination of environmental significance on VCs of the biophysical and socio-economic environments.

- Results from the residual effects classification of primary pathways and associated predicted changes in measurement indicators.
- Magnitude is the primary criterion used to determine significance, with geographic extent and duration providing important context for assigning magnitude. Frequency and likelihood act as modifiers, where applicable.
- The level of confidence in predicted effects, scientific and socio-economic principles (e.g., resilience and stability), scientific interpretation, and experienced opinion are included in the evaluation of determining environmental significance. Where uncertainty was high and the cumulative effect might be either significant or not significant, the assessment conservatively identified the effect as significant and provided additional follow-up actions to reduce uncertainty.

6.9 Monitoring and Follow-Up

In the EIS, monitoring programs are proposed to deal with the uncertainties associated with the effect predictions and the performance of environmental design features and mitigation. In general, monitoring is used to verify the effects predictions. Monitoring is used to identify any unanticipated effects and provide for the implementation of adaptive management to limit these effects. Typically, monitoring includes one or more of the following categories, which may be applied during the development of the Project.

- **Compliance inspections** – monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments (e.g., inspecting the installation of a silt fence, monitoring surface water quality and volumes).
- **Follow-up monitoring** – programs designed to test the accuracy of effects predictions, reduce/address uncertainties, determine the effectiveness of environmental design features, or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., monitoring groundwater for effects to groundwater quality, wildlife effects monitoring, and socio-economic monitoring). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

Follow-up programs are typically implemented when the accuracy of the determination of significance needs to be verified or the resulting residual effects cause sufficient public concern to warrant an increased effort to determine the accuracy of the predictions or test the effectiveness of mitigation and compensation. If monitoring or follow-up detects effects that are different from predicted effects, or identifies the need for improved or modified design features and mitigation, then adaptive management will be implemented. This may include increased monitoring, changes in monitoring plans, or additional mitigation.

Proposed monitoring and follow-up programs are discussed in each section of the EIS. Upon Project approval, detailed programs will be included as part of the Project's Health, Safety, Security, and Environmental Management System or other appropriate management, monitoring, or reporting programs or plans, as required.

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7.0 ATMOSPHERIC ENVIRONMENT

7.1 Introduction

7.1.1 Background

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project) located in central Saskatchewan, approximately 60 kilometres (km) north of Regina. Yancoal proposes to develop the Project, which includes solution mining and associated supporting infrastructure.

The Project is located in the Rural Municipality (R.M.) of Longlaketon (No. 219) and the R.M. of Cupar (No. 218). An existing network of municipal grid roads, provincial highways, and rail lines will provide access to the Project. The Project (including the core facilities area, 65-year mine field, and indicated resource boundary) encompasses approximately 143 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M).

7.1.2 Purpose and Scope

This section of the Environmental Impact Statement (EIS) for the Project addresses the effects from the Project on the atmospheric environment identified in the Project's Terms of Reference (TOR) approved by the Environmental Assessment Branch (EAB) of the Ministry of Environment (MOE) in May 2015 (Appendix 2-B).

The purpose of the atmospheric environment section is to meet the TOR, specifically to assess the effects from the Project on air quality and climate. The scope of this section includes an analysis of Project-related changes during construction, operation, and decommissioning and reclamation. The incremental and cumulative residual effects from the Project and other previous, existing, and reasonably foreseeable developments on the atmospheric environment are assessed.

Changes in the atmospheric environment can influence surface water quality, fish and fish habitat, soils, vegetation, wildlife, and the socio-economic environment. Therefore, results of the air quality assessment were forwarded to the following disciplines for use in their assessments:

- Surface Water Quality (Section 10.0);
- Fish and Fish Habitat (Section 11.0);
- Soils (Section 12.0);
- Vegetation (Section 13.0);
- Wildlife (Section 14.0); and
- Socio-economic Environment (Section 16.0).

7.1.3 Valued Components, Assessment Endpoints, and Measurement Indicators

The TOR identified the atmospheric environment as a valued component (VC) that should be included in the assessment of Project effects. Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by the proponent, the public, First Nations and Métis communities, and government agencies. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by the Project's development and, therefore, are used to predict the effects of the Project on all environmental components. Rationale for selection of atmospheric environment as a VC is as follows:

- sensitivity to Project-related effects;
- can be measured or described with one or more practical indicators; and
- changes to the atmospheric environment can influence other environmental and societal components.

Community and regulatory engagement, and local and traditional knowledge were key considerations for selecting VCs, but assessment endpoints for the atmospheric environment do not explicitly consider societal values. Changes in the atmospheric environment are important and must be considered to understand the full suite of potential effects of the Project (i.e., biophysical and socio-economic dimensions). Consequently, measurement indicators from the atmospheric environment section were carried forward so that effects on societal values could be appropriately captured in the section dealing specifically with those values (Section 16.0).

Assessment endpoints are qualitative expressions used to assess the significance of effects on a VC and represent the key properties of the VC that should be protected for use by future human generations (i.e., incorporate sustainability). Assessment endpoints are general statements about what is to be protected. Measurement indicators are quantitative and/or qualitative expressions of changes to the assessment endpoints. The assessment endpoint for the atmospheric environment VC is compliance with regulatory air emission guidelines and standards. The measurement indicators for the atmospheric environment VC include the following:

- carbon monoxide (CO);
- sulphur dioxide (SO_2);
- nitrogen dioxide (NO_2);
- particulate matter (PM) including:
  - particulate matter with aerodynamic diameter less than 2.5 micrometres (µm) ($PM_{2.5}$);
  - particulate matter with aerodynamic diameter less than 10 µm (PM_{10});
  - total suspended particulate matter with aerodynamic diameter less than 40 µm (TSP);
- potash (KCl); and
- greenhouse gases (GHGs) including:
  - carbon dioxide (CO_2);
  - nitrous oxide (N_2O); and
  - methane (CH_4).

7.2 Environmental Assessment Boundaries

7.2.1 Spatial Boundaries

7.2.1.1 Baseline Study Area

For the purpose of air quality dispersion modelling, the MOE delineated five zones in the province: Northern, North Central, Central, Southwestern, and Southeastern. The Project is located in the Southeastern air dispersion modelling zone, which is selected as the baseline study area (Annex I, Section 3.2) . The MOE developed the regional meteorological datasets for use in air dispersion modelling and the background concentrations of air contaminants for each zone.

7.2.1.2 Effects Study Area

A single effects study area (ESA) was selected for the atmospheric environment assessment of the Project. The ESA is expected to be large enough to capture the maximum predicted spatial extent of combined direct and indirect environmental effects from the Project on the atmospheric environment. The ESA defined for the completion of predictive modelling on changes to air quality was defined by a 50 x 50 km region centred on the core facilities area (Figure 7.2-1). The following factors influenced the ESA selection:

- anticipated location and intensity of emission sources; and
- potentially sensitive receptor locations.

7.2.2 Temporal Boundaries

Temporal boundaries for the atmospheric environment assessment were defined by the life of the Project (Section 4.0) and the existing and future cumulative effects to which the Project might contribute. The Project phases are construction, operation, and decommissioning and reclamation. Final relinquishment of the Project will occur after the completion of reclamation.

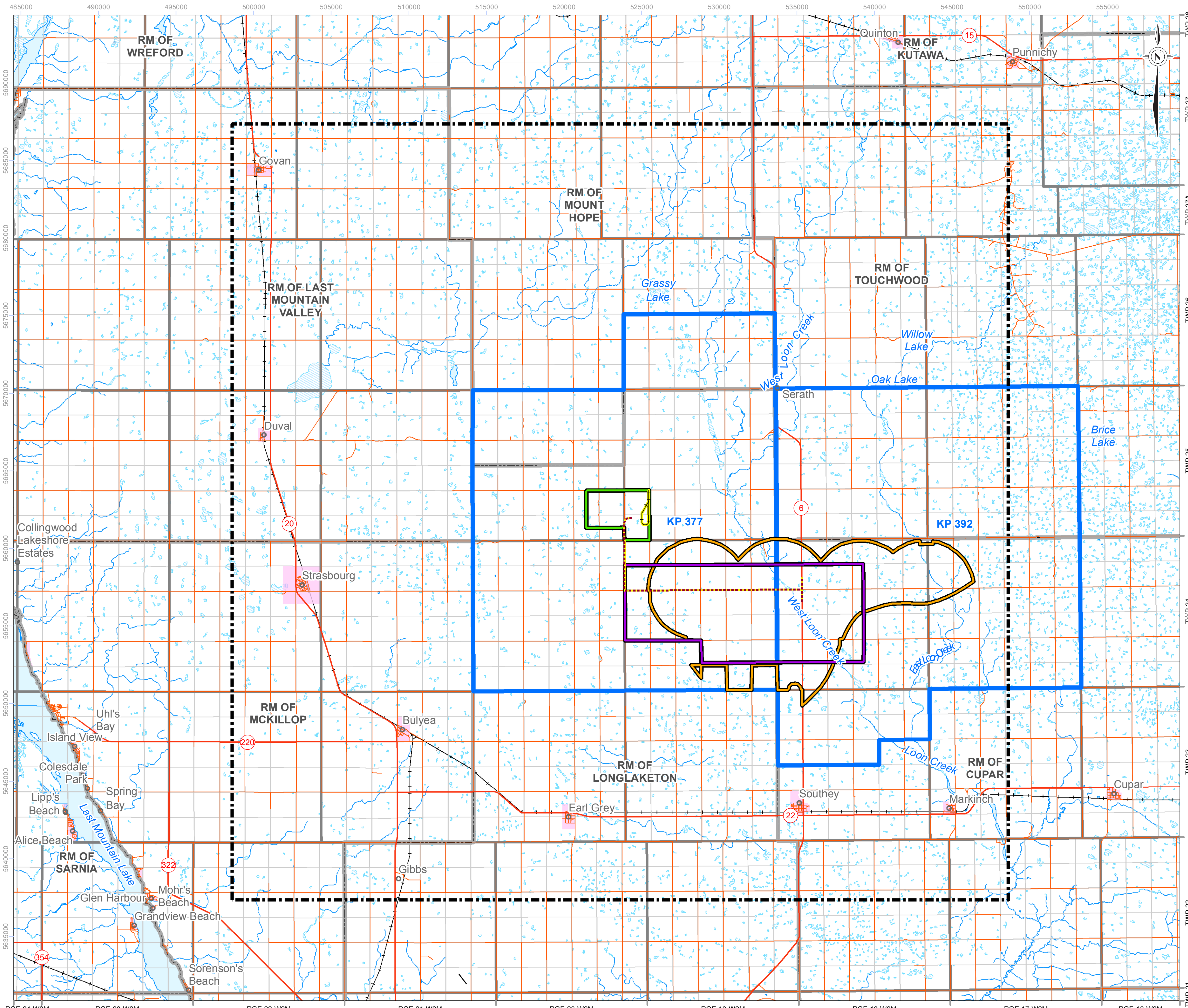
The effects analysis encompasses the Project phases as follows:

- construction (2016 to 2019);
- operations (2019 to 2119); and
- decommissioning and reclamation (2119 onward).

The above timeframes are intended to be sufficiently flexible to capture the effects of the Project on the atmospheric environment. Effects to the atmospheric environment begin during the construction phase, and continue through the operation phase and for a period of time during the completion of reclamation activities. Therefore, effects on air quality were analyzed and assessed for significance from Project construction through decommissioning and reclamation. This approach generates the maximum potential spatial and temporal extent of effects on the atmospheric environment.

7.2.2.1 Base Case

The Base Case (existing environment) represents existing conditions before application of the Project. Existing conditions include the cumulative effects from all previous and existing developments and activities.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- RURAL MUNICIPALITY BOUNDARY
- SECTION BOUNDARY
- URBAN MUNICIPALITY
- PROPOSED ACCESS ROAD
- PROPOSED RAIL LOOP
- PERMIT BOUNDARY
- 65 YEAR MINE FIELD
- CORE FACILITIES AREA
- INDICATED RESOURCE BOUNDARY
- EFFECTS STUDY AREA

REFERENCE

PERMIT BOUNDARY: POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
AIR QUALITY EFFECTS STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197		FILE No.
DESIGN			SCALE AS SHOWN REV. 2
GIS	SBM	27/05/15	FIGURE: 7.2-1
CHECK	CM	27/05/15	
REVIEW	CM	27/05/15	

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1080 - Air and Noise\12-1362-0197 - Air Quality Effects Study Area.mxd Date: 5/27/2015 8:55:05 AM

7.2.2.2 Application Case

The incremental contributions of residual effects from the Project to existing cumulative effects were assessed at the ESA scale by adding the Project to the Base Case to form the Application Case. The potential effects of the Project on regional air quality were assessed using the maximum emissions profile expected during the operations phase of the Project. The incremental contributions of the Project and the cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are predicted to evaluate changes to measurement indicators for air quality during the Application Case.

7.2.2.3 Reasonably Foreseeable Development Case

The Reasonably Foreseeable Development (RFD) Case represents the Application Case plus reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. The minimum temporal boundary for the Application Case and RFD Case is the expected lifespan of the Project that, like the Base Case, includes a range of conditions over time. The difference between the Application and RFD case is that the Application Case considers the incremental effect from the Project in isolation of potential future land use activities. The RFDs are defined as projects that:

- are currently under regulatory review or have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project, or may be induced by the Project;
- have been approved but not yet developed; or
- have the potential to change the Project or the effects predictions.

The reasonably foreseeable developments identified in Section 6.0 include the supporting infrastructure required for the Project, the Muskowekwan Potash Mine Project and the Vale Kronau Potash Project. Supporting infrastructure will include a water supply pipeline, an overhead transmission line, a natural gas supply pipeline, telecommunication services, and a railway line. Once final routing options for this supporting infrastructure have been determined, screening level assessments will be completed by each of the utility providers. The Muskowekwan Potash Mine Project, is located approximately 52 km to the northeast of the Project and is outside of the ESA. The Vale Kronau Potash Project, is located approximately 71 km south of the Project and is outside of the ESA. Attributing regional changes to air quality from individual facilities, such as potash mines, is typically not possible. Regional air quality monitoring is performed by the Saskatchewan Air Shed Association. As a result, analysis of an RFD case has not been included in the Atmospheric Environment section of this EIS.

7.3 Existing Environment

The purpose of this section is to describe the existing environment (Base Case) within the ESA as a basis to assess the potential Project-specific effects on the atmospheric environment. The detailed methods and results for baseline data collection are located in the Atmospheric and Acoustic Baseline Report (Annex I, Section 3.0).

7.3.1 Methods

The Saskatchewan Air Quality Modelling Guideline (AQMG) (MOE 2012) provides a summary of the background concentrations of criteria air contaminants that are to be used in air dispersion modeling in Saskatchewan.

Background concentrations of CO, NO_2, SO_2, and PM are provided in the AQMG. There are three classes of particulate matter, including $PM_{2.5}$, PM_{10}, and TSP. The Saskatchewan Air Quality Modelling Guideline (MOE 2012) recommends that:

- for refined modelling for 1-h and 24-h averaging periods, the background concentrations should be based on the 90th percentile value from the cumulative frequency distribution of the background monitoring data; and
- for the annual averaging period, the 50th percentile value from the cumulative frequency distribution of the background monitoring data should be used.

7.3.2 Results

The Project is located within the southeastern air quality modelling zone. The regional background air contaminant concentrations for this air zone are summarized in Table 7.3-1. The 90th percentile of 1-h CO concentrations is 687 micrograms per cubic metre (µg/m^3). The same concentration was used for the 8-h averaging period. The 1-h (90th), 24-h (90th), and annual (50th) background concentrations of NO_2 are 41.4, 37.6, and 18.8 µg/m^3, respectively. The 90th percentile of 24-h average $PM_{2.5}$ is 8.3 µg/m^3 which is 30% of the ambient standard (28 µg/m^3). The 90th percentile of 24-h PM_{10} is 36.3 µg/m^3 which represents 73% of the ambient standard (50 µg/m^3).

No background data are available for KCl deposition. Therefore the background deposition rate was assumed to be zero. The TSP background concentrations were not available from the air quality modelling guideline. The 24-hr PM_{10} background concentration was used as 24-h TSP background concentrations. One half of the 24-h annual PM_{10} value was assumed to represent the annual background concentration of TSP.

Table 7.3-1: Air Quality Baseline for the Project

Air Contaminant	Averaging Period	Concentrations	
		ppm	µg/m^3
Carbon Monoxide (CO)	1-h	0.6	687
	8-h	0.6	687
Nitrogen Dioxide (NO_2)	1-h	0.022	41.4
	24-h	0.02	37.64
	Annual	0.01	18.82
Sulphur Dioxide (SO_2)	1-h	0.001	2.62
	24-h	0.001	2.62
	Annual	0.000	0
Fine Particulate Matter ($PM_{2.5}$)	24-h	n/a	8.3
	Annual	n/a	3.7
Particulate Matter (PM_{10})	24-h	n/a	36.3
Total Suspended Particulate Matter (TSP)	24-h	n/a	36.3
	Annual	n/a	18.2

ppm = parts per million; µg/m^3 = microgram per cubic metre; h = hour; n/a = not applicable; $PM_{2.5}$ = particulate matter with aerodynamic diameter less than 2.5 micrometres; PM_{10} = particulate matter with aerodynamic diameter less than 10 micrometres; TSP = total suspended particulate matter.

7.4 Pathways Analysis

7.4.1 Methods

Pathways analysis identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects (after mitigation) on the atmospheric environment. The first part of the pathways analysis is to identify all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on the VC. Potential pathways through which the Project could affect the atmospheric environment were identified from a number of sources including the following:

- a review of the Project Description (Section 4.0) and scoping of potential effects by the environmental and engineering teams for the Project;
- information obtained from community engagement sessions (Section 5.0);
- scientific knowledge and experience with other potash mines in Saskatchewan; and
- consideration of potential effects identified from the TOR.

For an effect to occur there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a correspondent effect on the VC.

Project activity → change in environment → effect on VC

A key aspect of the pathway analysis is to identify environmental design features and mitigation that might reduce or eliminate potential effects of the Project on the atmospheric environment. Mitigation has been developed for the Project according to the following hierarchy proposed by the MOE (2014):

- avoidance;
- minimize (limit);
- restoration; and
- compensation.

Environmental design features include engineering design elements, environmental best practices, management policies and procedures, and spill response and emergency contingency plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects from the Project on the atmospheric environment. Pathways are determined to be primary, secondary (minor), or as having no linkage, using scientific, local and traditional knowledge, logic, experience with similar developments, and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- **No linkage** – analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on the atmospheric environment relative to the Base Case or guideline values; or
- **Secondary** – pathway could result in a measurable minor environmental change, but would have a negligible residual effect on the atmospheric environment relative to the Base Case or guideline values and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect; or
- **Primary** – pathway is likely to result in environmental change that could contribute to residual effects on the atmospheric environment relative to the Base Case or guideline values.

Pathways with no linkage to the atmospheric environment are not assessed further because implementation of environmental design features or mitigation will remove the pathway and result in no measureable change to the atmospheric environment. Pathways that are assessed to be secondary and demonstrated to have a negligible residual effect on the atmospheric environment through simple qualitative or semi-quantitative evaluation of the pathway are not advanced for further assessment. In summary, pathways determined to have no linkage to the atmospheric environment or those that are considered secondary are not expected to result in environmentally significant effects for compliance with regulatory air emission guidelines and standards. Primary pathways require further evaluation through more detailed quantitative and qualitative effects analysis (Section 7.5).

7.4.2 Results

Project components and activities, effects pathways and environmental design features and mitigation are summarized in Table 7.4-1. Classification of effects pathways (i.e., no linkage, secondary and primary) to the atmospheric environment is summarized in Table 7.4-1, and detailed descriptions are provided in the subsequent sections.

7.4.2.1 Pathways with No Linkage

A pathway may have no linkage to environmental effects if the activity does not occur, or if the pathway is removed by mitigation or environmental design features so that the Project results in no measurable change in measurement indicators. Subsequently, no residual effects on the atmospheric environment are expected. The pathways described in the following bullets have no linkage to air quality or climate and will not be carried forward in the assessment.

- **Long-term dust emissions from the tailings management area can cause changes to air quality.**

Solution potash mining produces waste salt (i.e., sodium chloride [NaCl] tailings) as a by-product of the potash refinement process. The waste salt tailings generated at the mine will be stored in the salt storage area in the tailings management area (TMA). The volume of tailings produced by the solution mining method used by the Project is expected to be lower than conventional underground mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because KCl is preferentially removed from the caverns.

Table 7.4-1: Potential Pathways for Effects on Atmospheric Environment

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
General construction, operations, and decommissioning and reclamation activities	Air and dust emissions from the Project can cause changes to air quality.	■ Compliance with regulatory emission requirements. ■ Dryer burners will be high efficiency, low NO_x burners to limit the amount of NO_x present in the exhaust stream. ■ Baghouses will be installed throughout the drying process area and dust collected in these baghouses will be conveyed back to the compactors. ■ A dustless chute and loading system will be installed in the product storage area to reduce dust generation in the storage and load-out. ■ The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment. ■ An Erosion and Sediment Control Plan will be implemented during all phases of the Project to limit dust production, and subsequent deposition on surrounding areas, and to limit erosion of exposed soils. ■ Dust-producing components of the potash refinement process (i.e., dryers, compaction circuit) will have controls to recover and return dust to the circuit. ■ Wet scrubbers will be used to clean the air of dust particles from off-gases from the product dryers. ■ Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. ■ Enforced speed limits will assist in reducing production of fugitive road dust. ■ Operating procedures will be developed to reduce dust generation from the tailings management area over the long-term. ■ The cyclone exhaust will be treated in high-energy scrubbers operating at a high-pressure drop.	Primary
	Greenhouse gas emissions from the Project can contribute to climate change.		Primary
	Long-term dust emissions from the tailings management area can cause changes to air quality.		No Linkage
Accidents, malfunctions, and unplanned events	Failure of air emission control systems can cause changes to air quality.	■ The environmental performance of air emissions control systems will be monitored on an on-going basis and will provide input into adaptive management. ■ Preventative maintenance will be completed regularly to confirm that emissions systems are functioning as designed.	Secondary
	Air emissions from a fire caused by Project activities can cause changes to air quality.	■ Site-specific response plans and mitigation for fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response Plan. ■ Fire safety measures and response will be reviewed with the R.M.s of Longlaketon and Cupar. ■ Personnel will be trained in fire prevention and response procedures. ■ Firefighting equipment will be available on site. ■ Inspections of the plant will be completed to identify potential fire hazards. ■ A fire suppression system will be activated during all phases of the Project. ■ Water will be stored on-site in the freshwater pond for the fire suppression system.	No Linkage

NO_x = oxides of nitrogen

The waste salt product that is precipitated during processing is removed from the process circuit as slurry and discharged to the TMA through a slurry pipeline. A solid crust forms over the outer layer of the salt pile as the slurry dries. The formation of a rigid crust over the pile tends to inhibit the production of fugitive dust due to wind erosion. Monitoring programs for the waste salt storage area will be incorporated into the design and will include monitoring pile stability and related dust production. Operating procedures will be developed to limit dust emissions from the TMA. Because of the crust formation on the outer layer of the waste pile and the implementation of operating procedures and monitoring programs for the salt storage area, long-term dust emissions from the TMA are not predicted to result in measureable changes to air quality relative to Base Case conditions or applicable air quality criteria.

- **Air emissions from a fire caused by Project activities can cause changes to air quality.**

Fire that is cause by Project activities could affect the atmospheric environment by causing temporary changes to air quality. Site-specific response plans and mitigation regarding fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response Plan. Fire safety measures and response will be developed in conjunction with local and regional first responders and applicable regulatory agencies, and will be reviewed with the R.M. of Longlaketon and the R.M. of Cupar. On-site personnel will be trained in established fire prevention and response procedures; appropriate firefighting equipment will be available on-site so trained personnel can respond promptly.

Regular inspections of the process plant will be completed to identify potential fire hazards; any necessary repairs or maintenance will be performed as soon as possible following identification. A fire suppression system will be operational during all phases of the Project and its functionality will be regularly monitored. Water will be stored on-site in the raw water pond to provide water, as needed, for the fire suppression system. The implementation of the above mentioned mitigations is predicted to prevent and suppress fires caused by the Project, and not result in measureable changes to air quality relative to Base Case conditions. Therefore, this pathway was determined to have no linkage to effects on the atmospheric environment.

7.4.2.2 Secondary Pathways

In some cases, both a source and a pathway exist, but because the change caused by the Project is anticipated to be minor relative to Base Case or guideline values, it is expected to have a negligible residual effect on air quality or climate. The pathway described in the following bullet is expected to be secondary and will not be carried forward in the assessment.

- **Failure of air emission control systems can cause changes to air quality.**

Air emission control systems have the potential to fail, which may result in short-term reductions in air quality. The environmental performance of air emission control systems will be monitored on an ongoing basis and preventative maintenance will be completed regularly to confirm that emissions systems are functioning as designed. In the event the air emission control system fails, it is predicted there would be minor and short-term change to air quality relative to Base Case conditions. Consequently, this pathway was determined to have negligible residual effects on the atmospheric environment.

7.4.2.3 Primary Pathways

The following primary pathways are assessed in detail in the residual effects analysis.

- **Air and dust emissions from the Project can cause changes to air quality; and**
- **Greenhouse gas emissions from the Project can contribute to climate change.**

7.5 Residual Effects Analysis

7.5.1 Methods

7.5.1.1 Air Quality Modelling

The air quality portion of the assessment was completed using the AERMOD model, which is a plume dispersion model developed by the United States Environmental Protection Agency (US EPA 2004). The AERMOD model was selected for the air quality assessment because it has been previously accepted in many jurisdictions in Canada and the United States, including Saskatchewan. In addition, this dispersion model is capable of local scale modelling of less than 50 km. A description of the model selection and the required input parameters is presented in Appendix 7-A.

The atmospheric environment assessment is focused on predicting the change in air quality during the Application Case. Changes to ambient air concentrations during Project operations were selected for modelling, because Project operations are expected to have the longest duration for residual effects on the atmospheric environment (i.e., 100 years). This represents the maximum emissions profile expected during the Project and the largest extent of effects on the atmospheric environment. Activities during construction and the initial stage of decommissioning and reclamation occur over a shorter period relative to operations; therefore, residual effects during these phases are discussed qualitatively. The effects analysis results are considered to represent a conservative estimate of the residual effects on the atmospheric environment (i.e., effects are likely overestimated).

The air quality assessment for Project operations was completed by:

- establishing the existing (Base Case) air quality concentrations;
- estimating the air emissions and dust deposition from the Project;
- predicting the cumulative changes to air quality from the Project, existing, and previous developments; and
- comparing the predictions to existing federal and provincial air quality criteria.

Buildings or other solid structures may affect the flow of air in the vicinity of an emissions source and cause eddies to form on the downwind side of the building. As such, structures at the process plant were incorporated into the AERMOD dispersion modelling (Appendix 7-A). To aid in the interpretation of the dispersion modelling results, they are presented in a tabular format that allows for comparison between the Base Case and Application Case and between the predictions and relevant air quality standards. In addition, isopleth maps showing the 1-h, 24-h, and annual maximum predictions for Application Case were included in the assessment. For clarity, the isopleth maps for most compounds present contour levels for 100%, 50%, and 25% of the applicable air quality standards.

7.5.1.2 Air Quality Receptors

Ground-level concentrations are modelled at selected geographical locations (i.e., receptor grid points) within the air quality ESA. The receptor grid is based on the following recommendations from the AQMG:

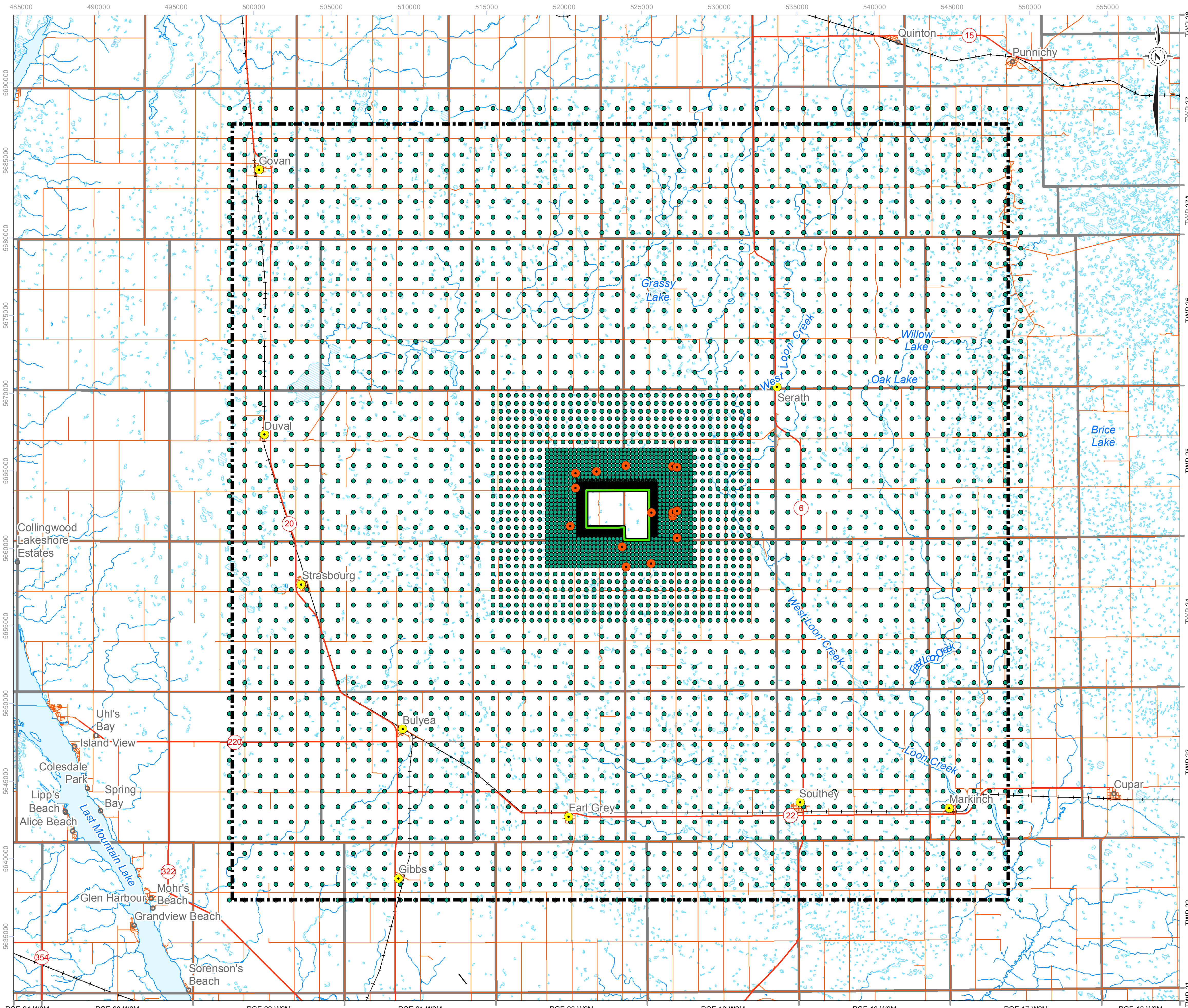
- 20-m receptor spacing in the general area of maximum impact and the property boundary;
- 50-m receptor spacing within 0.5 km from the emissions sources;
- 250--m receptor spacing within 2 km from the emissions sources;
- 500-m receptor spacing within 5 km from the sources of interest; and
- 1,000-m receptor spacing beyond 5 km from the sources of interest.

These receptor locations are illustrated along with the ESA boundary on Figure 7.5-1. The 1-km spaced receptors were extended slightly beyond the edge of the air quality ESA. In addition, maximum ground-level concentrations were predicted at receptors of special interest, such as nearby communities that may be sensitive to changes in air quality resulting from the Project. The community receptors surrounding the Project site are shown on Figure 7.5-1.

7.5.1.3 Ambient Air Quality Standards

A range of effects can result from air emissions introduced into the atmosphere by industrial activities. The emissions can have direct and indirect effects on humans, animals, vegetation, soil and water. For these reasons, federal and provincial environmental regulatory agencies have established maximum ambient air quality standards.

The air quality modelling was completed in a manner consistent with AQMG (MOE 2012). The AQMG requires results from air quality modelling to be compared to Saskatchewan's Ambient Air Quality Standards (SAAQS) as regulated by Saskatchewan's *The Clean Air Act* (1986-87-88) and *The Clean Air Regulations* (1986-87-88). In addition, revised SAAQS come into force with the proclamation of the new Saskatchewan Environmental Code (SEC) (MOE 2015). The industrial air chapter in the environment code will come into force on June 1, 2015. The new SAAQS for particulate matter smaller than 2.5 micrometres in aerodynamic diameter ($PM_{2.5}$) are not consistent with the new Canadian Ambient Air Quality Standards (CAAQS) (CCME 2013). The CAAQS include more stringent air quality criteria for $PM_{2.5}$ in 2015 and 2020. The 2015 CAAQS of $PM_{2.5}$ were used to determine the $PM_{2.5}$ compliance in this assessment. Table 7.5-1 provides a summary of the relevant air quality criteria for the compounds assessed during air quality modelling.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA / FENCE LINE
- EFFECTS STUDY AREA

RECEPTOR BY TYPE

- COMMUNITY
- RESIDENCE
- GRID

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT

YANCOAL SOUTHEY PROJECT

TITLE

LOCATION OF GRID RECEPTORS AND COMMUNITY RECEPTORS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 1
GIS	SBM	27/05/15	FIGURE: 7.5-1	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1080 - Air and Noise\12-1362-0197 - Location of Grid and Community Receptors.mxd Date: 5/27/2015 9:07:37 AM

Table 7.5-1: Saskatchewan and Canadian Air Quality Criteria

Parameter	Saskatchewan Ambient Air Quality Standards[a]	Canadian Ambient Air Quality Standards[b]
SO_2 (µg/m³)		
1-h	450	—
24-h	125	—
Annual	20	—
NO_2 (µg/m³)		
1-h	300	—
24-h	200	—
Annual	45	—
CO (µg/m³)		
1-h	15,000	—
8-h	6,000	—
TSP (µg/m³)		
24-h	100	—
Annual	60	—
PM_{10} (µg/m³)		
24-h	50	
$PM_{2.5}$ (µg/m³)		
24-h	30	28[c] 27[d]
Annual	15	10[e], 8.8[f]
KCl as K^+ or Cl^-[g] (mg/cm²)		
Monthly	0.15	

[a] New Saskatchewan Ambient Air Quality Standards.

[b] Source: CCME 2013.

[c] 2015 achievement is based on the 98th percentile ambient measurement annually, averaged over 3 consecutive years (CCME 2013).

[d] 2020 achievement is based on the 98th percentile ambient measurement annually, averaged over 3 consecutive years (CCME 2013).

[e] 2015 achievement is based on 3-year average of the annual average concentrations (CCME 2013).

[f] 2020 achievement is based on 3-year average of the annual average concentrations (CCME 2013).

[g] The Saskatchewan Clean Air Regulations allows the potash (KCl) deposition threshold (0.15 mg/cm²) to be used in the form of potassium (K^+) or of chloride (Cl^-).

SO_2 = sulphur dioxide; NO_2 = nitrogen dioxide; CO = carbon monoxide; $PM_{2.5}$ = particulate matter with aerodynamic diameter less than 2.5 micrometres; PM_{10} = particulate matter with aerodynamic diameter less than 10 micrometres; TSP = total suspended particulate matter; "—" = no criteria are available; µg/m³: microgram per cubic metre; h = hour; mg/cm^2: milligram per square centimetre

7.5.1.4 Emission Limits

In addition to ambient air quality objectives and standards, regulatory agencies have developed criteria designed to place emission limits on specific types of sources.

The first emissions criteria are the National Emission Guidelines for Commercial/Industrial Boiler and Heater Sources published by the Canadian Council of Ministers of the Environment (CCME 1998). This CCME directive provides oxides of nitrogen (NO_x) and CO guidelines for industrial boilers and heaters, including dryers, as presented in Table 7.5-2. The multi-sector air pollutants regulation from The Federal Government have set new NO_x standards for industrial boilers and heaters with rated capacity greater than 10.5 gigajoules input energy per hour (GJ/h). These emissions regulations are summarized in Tables 7.5-3 and 7.5-4.

Table 7.5-2: Canadian Council of Ministers of the Environment Emission Guidelines for Industrial Boilers and Heaters

Parameter	Fuel Type	CCME Emission Limits [g/GJ][a]	
		10.5 to 105 GJ/h[b]	>105 GJ/h[b]
NO_X	gaseous fuel	26	40
	distillate oil	40	50
	residual oil (<0.35% nitrogen)	90	90
	residual oil (>0.35% nitrogen)	110	125
CO	all fuels	125	125

Source: CCME 1998.

[a] The CCME emission limits are given in units of grams per gigajoule of energy input (g/GJ).

[b] Boiler capacities are based on the power input in units of gigajoules per hour (GJ/h).

NO_x = oxides of nitrogen; % = percent; g/GJ = gram per gigajoule; GJ/h: gigajoule per hour; < = less than; > = greater than.

Table 7.5-3: New Federal Regulations for NO_x Emission Limits for Boilers

Fuel Type	Efficiency	NO_x Emission Limit [g/GJ]
Natural gas	<80%	16
	80% - 90%	Equation 1[a]
	>90%	18
Alternative gaseous fuel	<80%	20.8
	80% - 90%	Equation 2[a]
	>90%	23

Source: Government of Canada 2015.

[a] these equations are defined below.

NO_x = oxides of nitrogen; % = percent; g/GJ = gram per gigajoule; < = less than; > = greater than.

Table 7.5-4: New Federal Regulations for NO_x Emission Limits for Heaters

Fuel Type	Air Preheat	NO_x Emission Limit [g/GJ]
Natural gas	none	16
	0 – 150ºC	Equation 3[a]
	>150ºC	19
Alternative gaseous fuel	None	20.8
	0 – 165ºC	Equation 4[a]
	>165ºC	25

Source: Government of Canada 2015.

[a] these equations are defined below.

NO_x = oxides of nitrogen; % = percent; ºC = degrees Celsius; g/GJ = gram per gigajoule; < = less than; > = greater than.

The equations referenced in Tables 7.5-3 and 7.5-4 are as follows:

$$Limit_{NO_x}(g/GJi) = 16 + (E - 80)/5 \quad Equation\ 1$$

$$Limit_{NO_x}(g/GJi) = 20.8 + (E - 80)/4.54 \quad Equation\ 2$$

$$Limit_{NO_x}(g/GJi) = 16 \times (7 \times 10^{-6}T^2 + 2 \times 10^{-4}T + 1) \quad Equation\ 3$$

$$Limit_{NO_x}(g/GJi) = 20.8 \times (7 \times 10^{-6}T^2 + 2 \times 10^{-4}T + 1) \quad Equation\ 4$$

where: E is the thermal efficiency of the boiler;

T is the number of degrees, expressed in degrees Celsius (°C) above ambient air temperature of the preheated air.

In addition to these emission limits, boilers with a capacity greater than 262.5 GJ/h will be required to emit less than 13 g/GJ regardless of whether they combust natural gas or alternative gaseous fuel, and regardless of their efficiency. Heaters with a capacity greater than 262.6 GJ/h will be required to emit less than 16 g/GJ regardless of whether they combust natural gas or alternative gaseous fuel, and regardless of the amount of air preheat.

The second relevant emissions criteria is the *Potash Refining Air Emissions Regulations* (1983), which limits the discharge of particulate matter into the ambient air from any product drying process of a new plant to 0.57 grams per dry standard cubic metre. Standard conditions are defined by the regulation as a temperature of 25°C and gas pressure of 760 millimetres of mercury (mm Hg). The *Potash Refining Air Emissions Regulations* are to be repealed following the proclamation of the SEC, but will continue to be regulated under the SEC's Industrial Source (Air Quality) Chapter (MOE 2015, Chapter E.1.2).

7.5.1.5 Greenhouse Gases Emissions

If the Project emits more than 50,000 tonnes of carbon dioxide equivalents (CO_{2e}) per year, the Project will be required to report GHG emissions under Environment Canada's Greenhouse Gas Emissions Reporting Program (Environment Canada 2015). Under Saskatchewan's *The Management and Reduction of Greenhouse Gases Act* (MRGGA 2009), the Project will be subject to GHG reporting if annual GHG emissions exceed 25,000 tonnes of CO_{2e} per year, and may be subject to regulation if annual GHG emissions exceed 50,000 tonnes (regulation threshold) of CO_{2e} per year. Currently, it is not known when the Saskatchewan MRGGA will come into effect.

The Project's GHG emissions are mainly from the combustion of fossil fuels (e.g., natural gas and diesel). The primary sources of GHG emissions from Project operations include:

- four natural gas fired boilers;
- two fluid bed dryers and one glazing dryer equipped with dust collectors;
- exhaust from three line-haul locomotives; and
- mobile equipment exhaust.

The GHG emissions from the Project were estimated from the predicted fuel consumptions and emission factors. The assumptions made for the GHG emissions inventory and the emission factors are described in detail in Appendix 7-B.

7.5.2 Results

7.5.2.1 Construction and Decommissioning and Reclamation

The potential sources of emissions during Project construction are the exhaust emissions from the diesel-fired construction equipment, such as excavators, dozers, cranes, frontend loaders, forklifts and power generators, and fugitive dust generated by vehicles. Lower overall air emissions are anticipated during Project construction relative to Project operations since most of the air emission sources from the core facilities area (e.g., boilers, heaters and dryers) would not be operational during the construction period. While mobile equipment-generated exhaust emissions and associated road dust emissions are expected to be greater during construction, these sources are expected to be relatively minor in comparison to emission sources from the core facilities area during operations. Therefore changes to air quality during construction are not anticipated to exceed applicable air quality criteria.

The potential sources of emissions from the Project during decommissioning and reclamation are similar to those during construction; however, decommissioning and reclamation activities are expected to require less equipment and be of a lower overall intensity than construction activities. Decommissioning and reclamation air emissions include exhaust emissions and fugitive dust. Changes to air quality during decommissioning and reclamation activities are not anticipated to exceed applicable air quality criteria.

7.5.2.2 Operations

Project operations considered in the air quality assessment includes the core facilities area and the potash delivery infrastructure. The air quality prediction results were based on design data and assumptions available at the time of the assessment. The primary sources of emissions from Project operations include:

- four natural gas fired boilers with total energy input of 2,173 GJ/h;
- two natural gas fired fluid bed dryers and one glazing dryer equipped with dust collectors with total energy input of 95 GJ/h;
- one compaction dust collector stack;
- one load out dust collector stack;
- exhaust from three line-haul locomotives;
- cooling towers;
- mobile equipment exhaust; and
- mobile equipment road dust.

For the purpose of the air quality assessment, the combustion equipment was assumed to operate at maximum capacity to assess the highest possible emission rates. Emission calculation methods and assumptions used in quantifying the emissions are provided in Appendix 7-C. A summary of the estimated Project emissions included in the air quality assessment is presented in Table 7.5-5. The following sections present the predicted NO_2, CO, SO_2, $PM_{2.5}$, PM_{10}, and TSP concentrations, and KCl deposition results from the AERMOD model, as well as the greenhouse gas emissions from the Project's operation phase. For each compound, the Project only maximum model predicted concentration refers to the following:

- For 1-h predictions, the maximum concentrations represent the maximum ninth highest concentration over the 5-year simulation;
- For 8-h predictions, the maximum concentrations represent the maximum fifth highest concentration over the 5-year simulation;
- For the 24-h (daily) predictions of $PM_{2.5}$, the maximum concentrations represent the maximum 98^{th} percentile of model predicted concentration over the 5-year simulation;
- For the 24-h (daily), predictions of all other pollutants, the maximum concentrations represent the maximum second highest concentration over 5-year simulation;
- For averaging times longer than 24 h, no modeled concentrations are eliminated from the maximum value. The maximum concentrations represent the maximum first highest concentration over the 5-year simulation.

The maximum predicted concentrations for the Application Case referred to the sum of maximum model predicted concentrations from the Project only and the background concentrations (i.e., Base Case). The Application Case maximum predicted concentrations are compared to the SAAQS according to AQMG to determine compliance.

Table 7.5-5: Summary of Air Emissions from the Project

Sources	TSP			PM_{10}			$PM_{2.5}$			NO_X			CO			SO_2			KCl		
	(kg/h)	(kg/day)	(tonnes/yr)	(kg/h)	(kg/day)	(tonnes/yr)	(kg/h)	(kg/day)	(tonnes/yr)	(kg/h)	(kg/day)	(tonnes/yr)	(kg/h)	(kg/day)	(tonnes/yr)	(kg/h)	(kg/day)	(tonnes/yr)	(kg/h)	(kg/day)	(tonnes/yr)
Natural Gas Boiler - Stack 1	2.1	50.6	17.3	2.1	50.6	17.3	2.1	50.6	17.3	7.1	169.5	58.0	23.3	559.2	191.3	0.8	20.1	6.9	--	--	--
Natural Gas Boiler - Stack 2	2.1	50.6	17.3	2.1	50.6	17.3	2.1	50.6	17.3	7.1	169.5	58.0	23.3	559.2	191.3	0.8	20.1	6.9	--	--	--
Natural Gas Boiler - Stack 3	2.1	50.6	17.3	2.1	50.6	17.3	2.1	50.6	17.3	7.1	169.5	58.0	23.3	559.2	191.3	0.8	20.1	6.9	--	--	--
Natural Gas Boiler - Stack 4	2.1	50.6	17.3	2.1	50.6	17.3	2.1	50.6	17.3	7.1	169.5	58.0	23.3	559.2	191.3	0.8	20.1	6.9	--	--	--
Product Dryer A Scrubber	6.2	148.6	50.8	6.2	148.6	50.8	6.2	148.6	50.8	0.5	12.2	4.2	1.4	32.6	11.1	0.0	1.2	0.4	5.8	138.3	47.3
Product Dryer B Scrubber	6.2	148.6	50.8	6.2	148.6	50.8	6.2	148.6	50.8	0.5	12.2	4.2	1.4	32.6	11.1	0.0	1.2	0.4	5.8	138.3	47.3
Glazing Baghouse	3.3	79.2	27.1	3.3	79.2	27.1	3.3	79.2	27.1	0.5	12.2	4.2	1.4	32.6	11.1	0.0	1.2	0.4	3.0	72.3	24.7
Cooling Tower	0.0	0.7	0.2	0.0	0.6	0.2	0.0	0.4	0.1	--	--	--	--	--	--	--	--	--	--	--	--
Glazing Baghouse	3.3	79.2	27.1	3.3	79.2	27.1	3.3	79.2	27.1	--	--	--	--	--	--	--	--	--	3.1	75.2	25.7
Dust Control Baghouse	2.3	54.2	18.6	2.3	54.2	18.6	2.3	54.2	18.6	--	--	--	--	--	--	--	--	--	2.1	51.5	17.6
Loadout Baghouse	1.5	36.2	12.4	1.5	36.2	12.4	1.5	36.2	12.4	--	--	--	--	--	--	--	--	--	1.4	34.4	11.8
Locomotive Emissions	0.4	0.8	0.1	0.4	0.8	0.1	0.4	0.8	0.1	16.6	31.2	4.7	4.3	8.1	1.2	0.1	0.2	0.0	0.0	0.0	0.0
On-Road Vehicle Exhaust	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.4	1.0	0.3	0.0	0.0	0.0	--	--	--
Off-road Vehicle Exhaust	0.2	1.2	0.3	0.2	1.2	0.3	0.2	1.2	0.3	2.0	12.8	3.2	1.4	8.1	2.1	0.0	0.0	0.0	--	--	--
Vehicle Paved Road Dust	0.1	0.3	0.1	0.0	0.1	0.0	0.0	0.0	0.0	--	--	--	--	--	--	--	--	--	--	--	--
Vehicle Unpaved Road Dust	0.3	2.0	0.5	0.1	0.5	0.1	0.0	0.1	0.0	--	--	--	--	--	--	--	--	--	--	--	--
Total	**32.2**	**753.6**	**257.2**	**31.9**	**751.7**	**256.8**	**31.8**	**750.9**	**256.6**	**48.4**	**758.5**	**252.3**	**103.3**	**2351.8**	**802.1**	**3.6**	**84.1**	**28.7**	**21.3**	**510.0**	**174.4**

TSP = total suspended particulate; NO_x = oxides of nitrogen; CO = carbon monoxide; SO_2 = sulphur dioxide; KCl = potash; $PM_{2.5}$ = particulate matter with aerodynamic diameter less than 2.5 micrometres; PM_{10} = particulate matter with aerodynamic diameter less than 10 micrometres; TSP = total suspended particulate matter; kg/h = kilograms per hour; kg/day = kilograms per day; tonnes/yr = tonnes per year; " – " = no data.

7.5.2.2.1 Carbon Monoxide Predictions

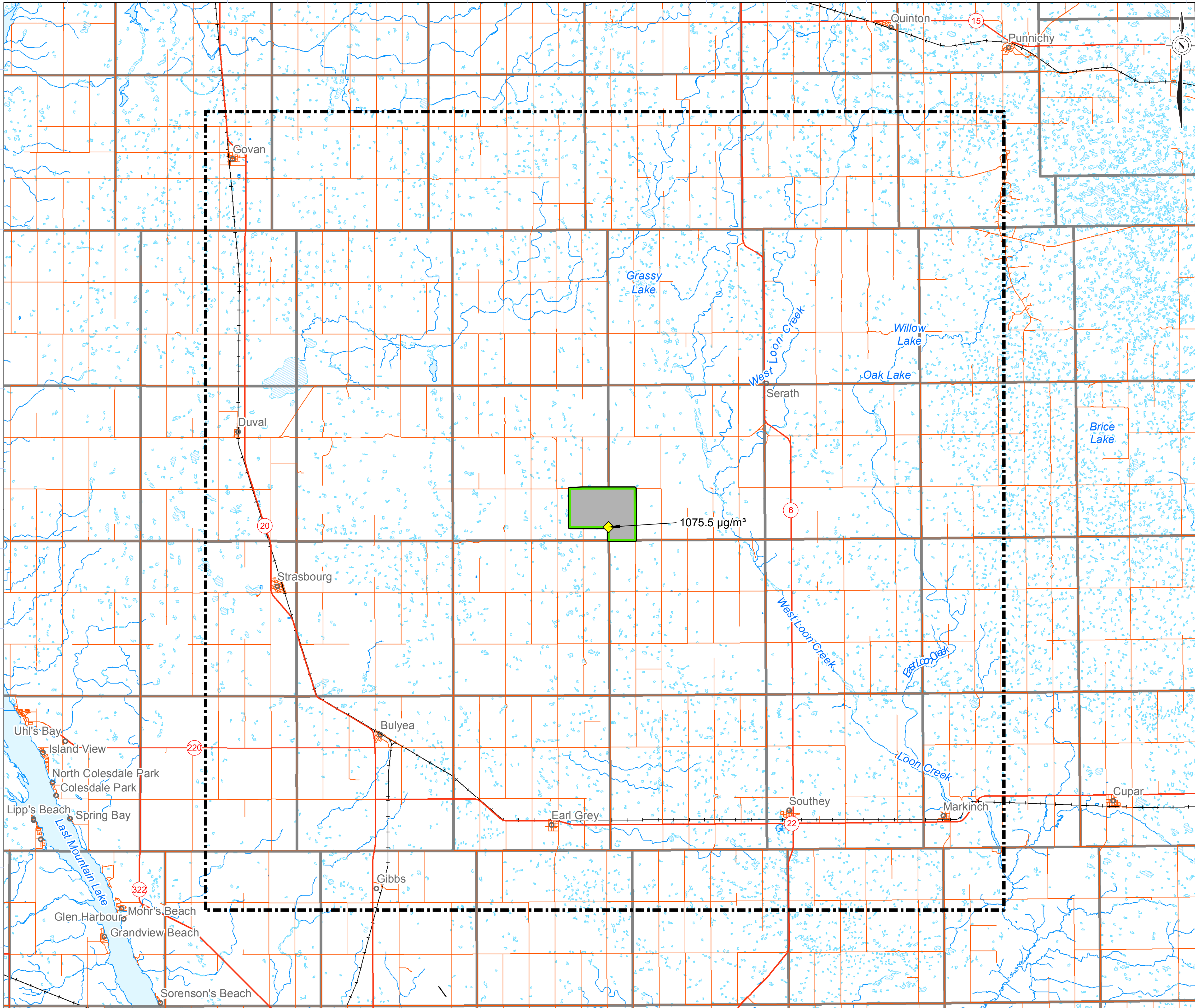
The Base Case and Application Case maximum 1-h and 8-h ground-level CO predicted concentrations are presented in Table 7.5-6 and graphically on Figures 7.5-2 and 7.5-3. The results indicate that the Application Case maximum 1-h and 8-h CO predictions outside of the core facilities area are below the SAAQS. The changes of CO 1-h and 8-h concentrations from the Project were 388.6 µg/m³ and 286.8 µg/m³, respectively. The 1-h and 8-h maximum concentrations occur at the southern edge of the core facilities area.

Table 7.5-6: Comparison of Carbon Monoxide Concentrations during the Base Case and Application Case

Averaging Period	Criteria (Ambient Air Quality Standards)[a]	Maximum Predicted Concentrations (µg/m³)		
		Base Case	Application Case	Change
1-h	15,000	687.0	1,075.5	388.6
8-h	6,000	687.0	973.7	286.8

[a] Saskatchewan Ambient Air Quality Standards (Government of Saskatchewan 2015)

CO = carbon monoxide; µg/m³ = microgram per cubic metre; h = hours



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 3,750 (BLANK)
- 3,750 to < 7,500
- 7,500 to < 15,000
- ≥ 15,000

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
APPLICATION CASE MAXIMUM PREDICTED 1-HOUR CARBON MONOXIDE CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15		
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

FIGURE: 7.5-2

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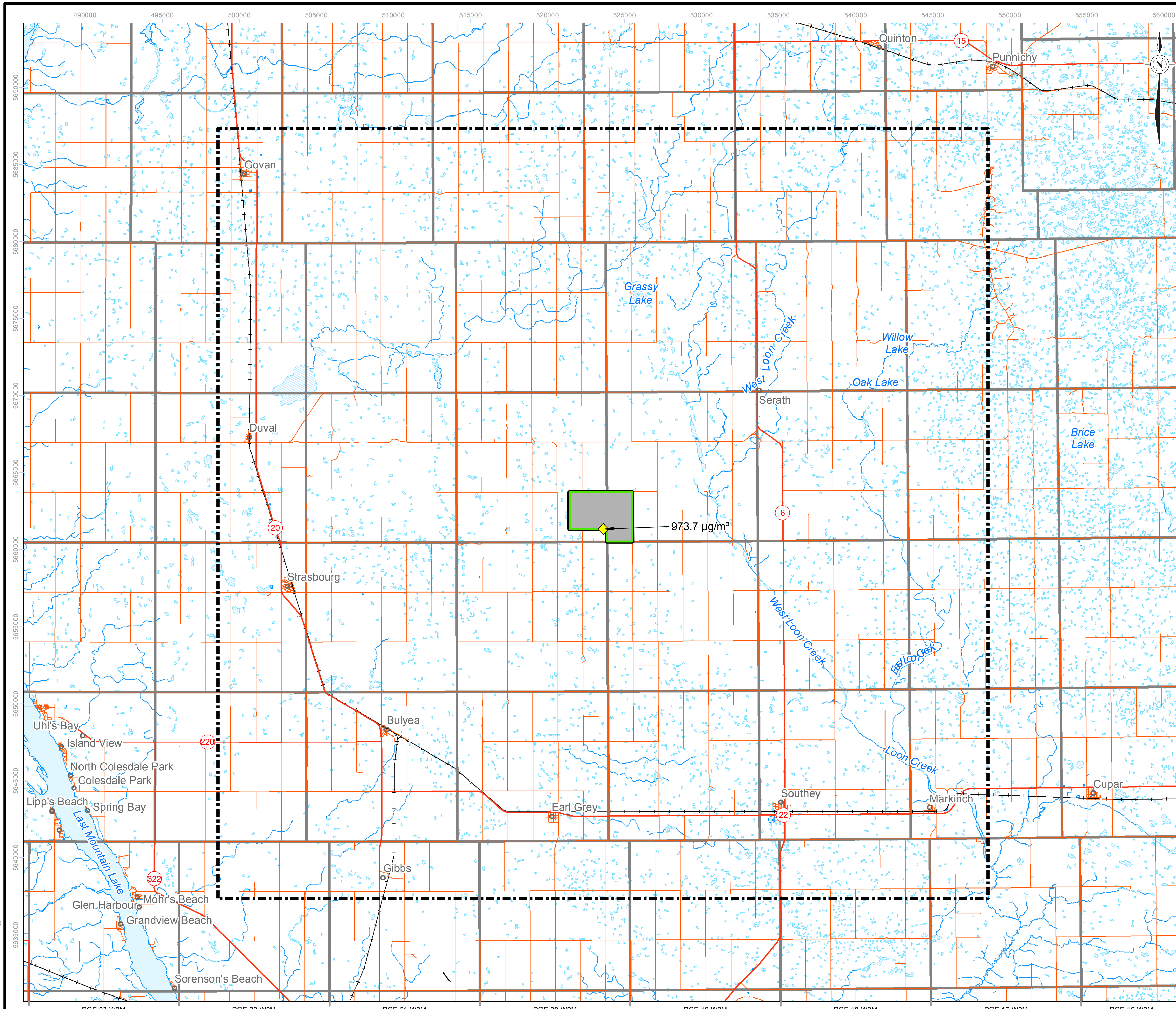

LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 1,500 (BLANK)
- 1,500 to < 3,000
- 3,000 to < 6,000
- ≥ 6,000

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT
YANCOAL SOUTHEY PROJECT

TITLE
APPLICATION CASE MAXIMUM PREDICTED 8-HOUR CARBON MONOXIDE CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197		FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15	FIGURE: 7.5-3	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

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The Application Case maximum predicted 1-h and 8-h CO concentrations at the selected receptors are listed in Table 7.5-7. The maximum predicted CO concentrations at the selected receptors are all below the SAAQS.

Table 7.5-7: Application Case Maximum Predicted Carbon Monoxide Concentrations at Selected Receptors

Receptor	1-h Maximum Predicted Concentrations (µg/m^3)	8-h Maximum Predicted Concentrations (µg/m^3)
Residence 1	851.4	715.4
Residence 2	814.5	715.6
Residence 3	802.3	711.1
Residence 4	796.0	711.5
Residence 5	792.9	710.4
Residence 6	800.3	714.5
Residence 7	758.8	700.2
Residence 8	880.3	730.6
Residence 9	794.0	708.5
Residence 10	797.8	715.9
Residence 11	792.5	713.3
Residence 12	832.5	710.3
Residence 13	829.2	711.2
Residence 14	816.8	712.2
Residence 15	879.9	743.7
Bulyea	693.6	688.2
Earl Grey	693.7	688.2
Southey	693.1	688.6
Markinch	692.9	688.5
Gibbs	692.6	688.0
Strasbourg	693.1	688.3
Duval	692.7	688.5
Govan	691.7	688.2
Serath	708.6	690.7

h = hour; µg/m^3 = micrograms per cubic metre.

7.5.2.2.2 Nitrogen Dioxide Predictions

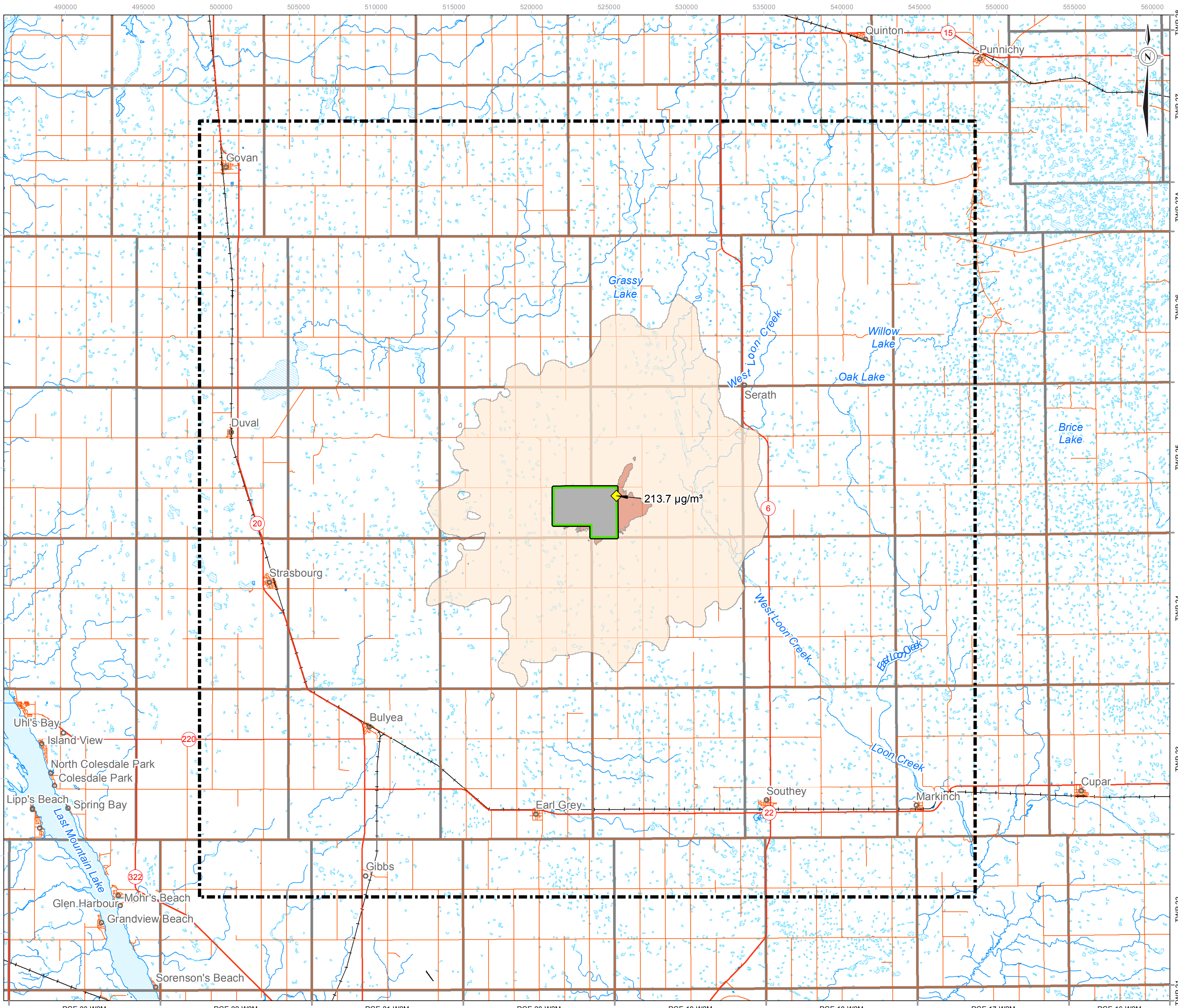
The Base Case and Application Case maximum 1-h, 24-h, and annual ground-level NO_2 concentrations are presented in Table 7.5-8 and graphically on Figures 7.5-4, 7.5-5, and 7.5-6. The results indicate that the maximum 1-h, 24-h, and annual NO_2 predictions outside of the core facilities area are below the SAAQS. The 1-h maximum concentration occurs in the east-northeast of the core facilities area, while the 24-h and annual maximum concentrations occur south and east-northeast of the core facilities area, respectively.

Table 7.5-8: Comparison of Nitrogen Dioxide Concentrations during the Base Case and Application Case

Averaging Period	Criteria (Ambient Air Quality Standards)[(a)]	Maximum Predicted Concentrations (µg/m³)		
		Base Case	Application Case	Change
1-h	300	41.4	213.7	172.3
24-h	200	37.6	93.3	55.7
Annual	45	18.8	21.1	2.3

(a) Saskatchewan Ambient Air Quality Standards (Government of Saskatchewan 2015)

µg/m³ = micrograms per cubic metre; h = hour



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 75 (BLANK)
- 75 to < 150
- 150 to < 300
- ≥ 300

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
APPLICATION CASE MAXIMUM PREDICTED 1-HOUR NITROGEN DIOXIDE CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15	FIGURE: 7.5-4	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

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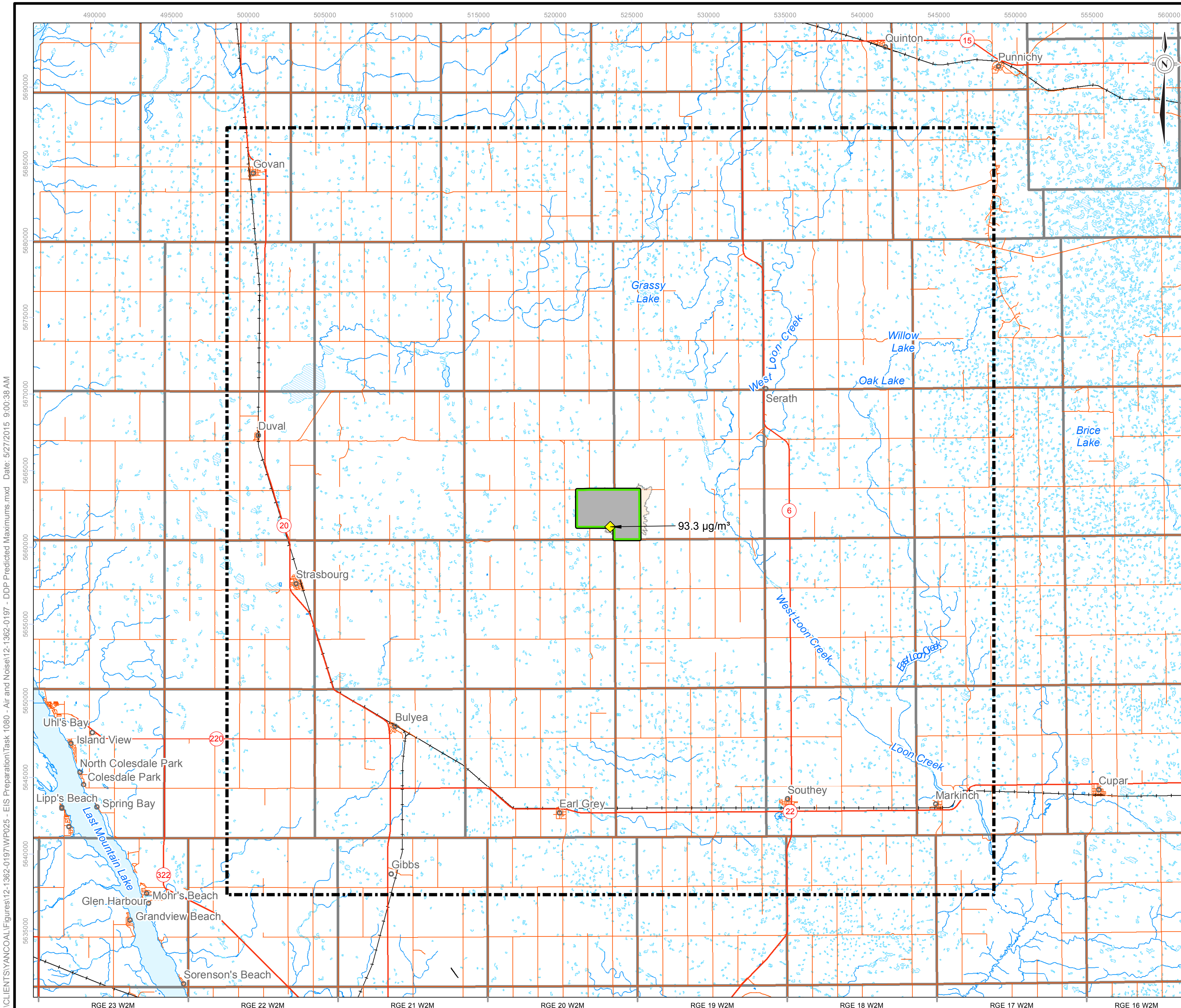


LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 50 (BLANK)
- 50 to < 100
- 100 to < 200
- ≥ 200

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

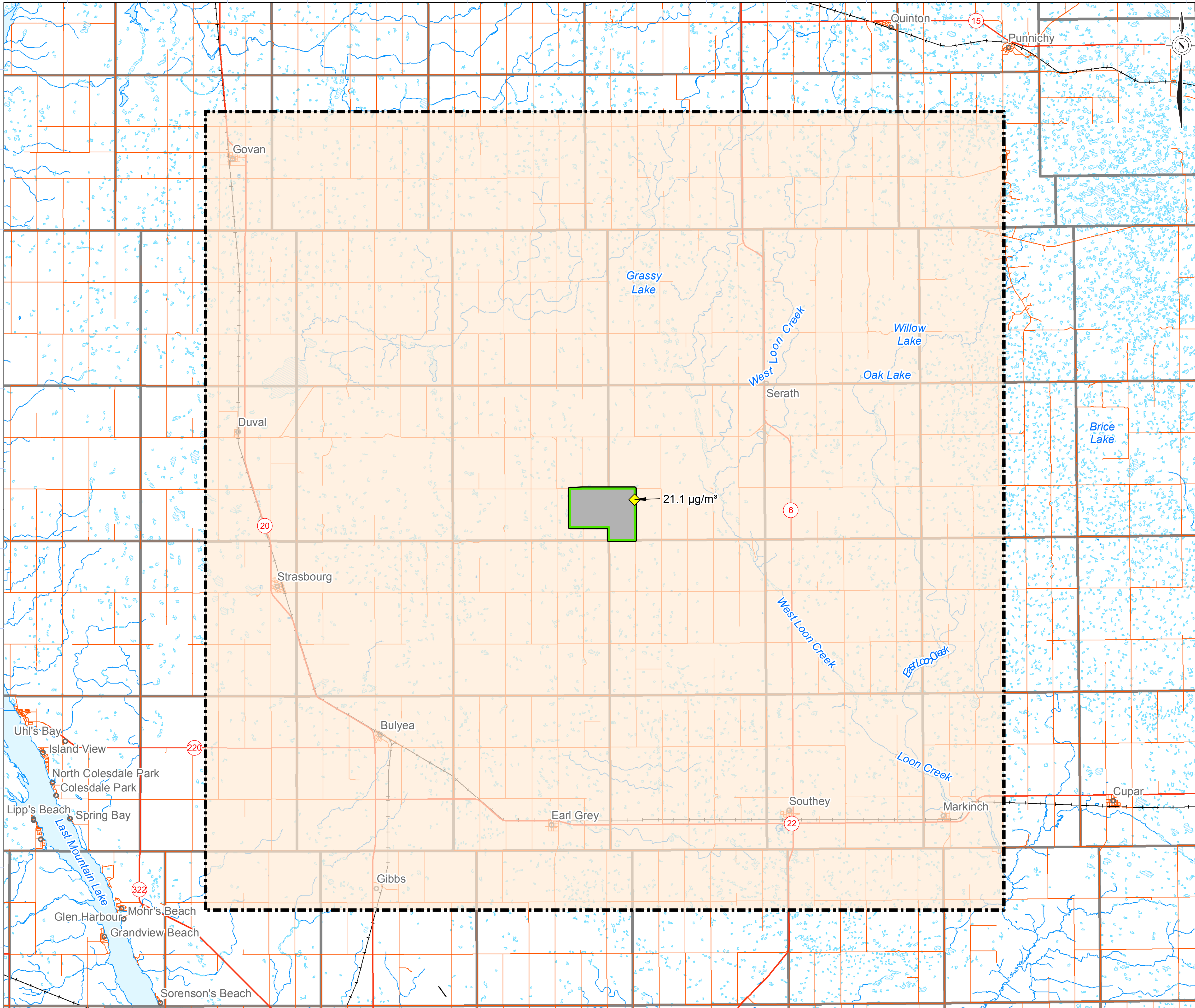
5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
APPLICATION CASE MAXIMUM PREDICTED 24-HOUR NITROGEN DIOXIDE CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	ZY	24/02/15	SCALE AS SHOWN REV. 3
GIS	SBM	27/05/15	**FIGURE: 7.5-5**
CHECK	CM	27/05/15	
REVIEW	CM	27/05/15	



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 11.25 (BLANK)
- 11.25 to < 22.5
- 22.5 to < 45
- ≥ 45

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT

YANCOAL 兖煤加拿大资源有限公司

YANCOAL SOUTHEY PROJECT

TITLE

APPLICATION CASE MAXIMUM PREDICTED ANNUAL NITROGEN DIOXIDE CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197		FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15	FIGURE: 7.5-6	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

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Table 7.5-9 lists the Application Case maximum predicted NO_2 concentrations at the selected receptors. The maximum predicted 1-h, 24-h, and annual NO_2 concentrations are all below the respective ambient standards.

Table 7.5-9: Application Case Maximum Predicted Nitrogen Dioxide Concentrations at Selected Receptors

Receptor	Maximum predicted 1-h concentrations (µg/m^3)	Maximum predicted 24-h concentrations (µg/m^3)	Maximum predicted annual concentrations (µg/m^3)
Residence 1	104.6	43.7	19.2
Residence 2	100.2	42.7	19.1
Residence 3	131.5	43.6	19.1
Residence 4	125.4	45.7	19.1
Residence 5	101.4	42.0	19.1
Residence 6	107.2	42.7	19.2
Residence 7	109.8	41.0	18.9
Residence 8	142.2	47.4	19.2
Residence 9	111.0	42.6	19.0
Residence 10	98.1	43.7	19.1
Residence 11	124.9	43.0	19.3
Residence 12	157.8	42.9	19.2
Residence 13	158.0	44.7	19.2
Residence 14	158.0	44.5	19.2
Residence 15	167.0	54.5	20.4
Bulyea	51.0	38.0	18.8
Earl Grey	51.6	37.9	18.8
Southey	50.5	38.1	18.8
Markinch	49.6	37.9	18.8
Gibbs	55.5	37.9	18.8
Strasbourg	55.2	37.9	18.8
Duval	51.0	37.9	18.8
Govan	49.3	37.8	18.8
Serath	65.0	38.5	18.9

h = hour; µg/m^3 = micrograms per cubic metre.

7.5.2.2.3 Sulphur Dioxide Predictions

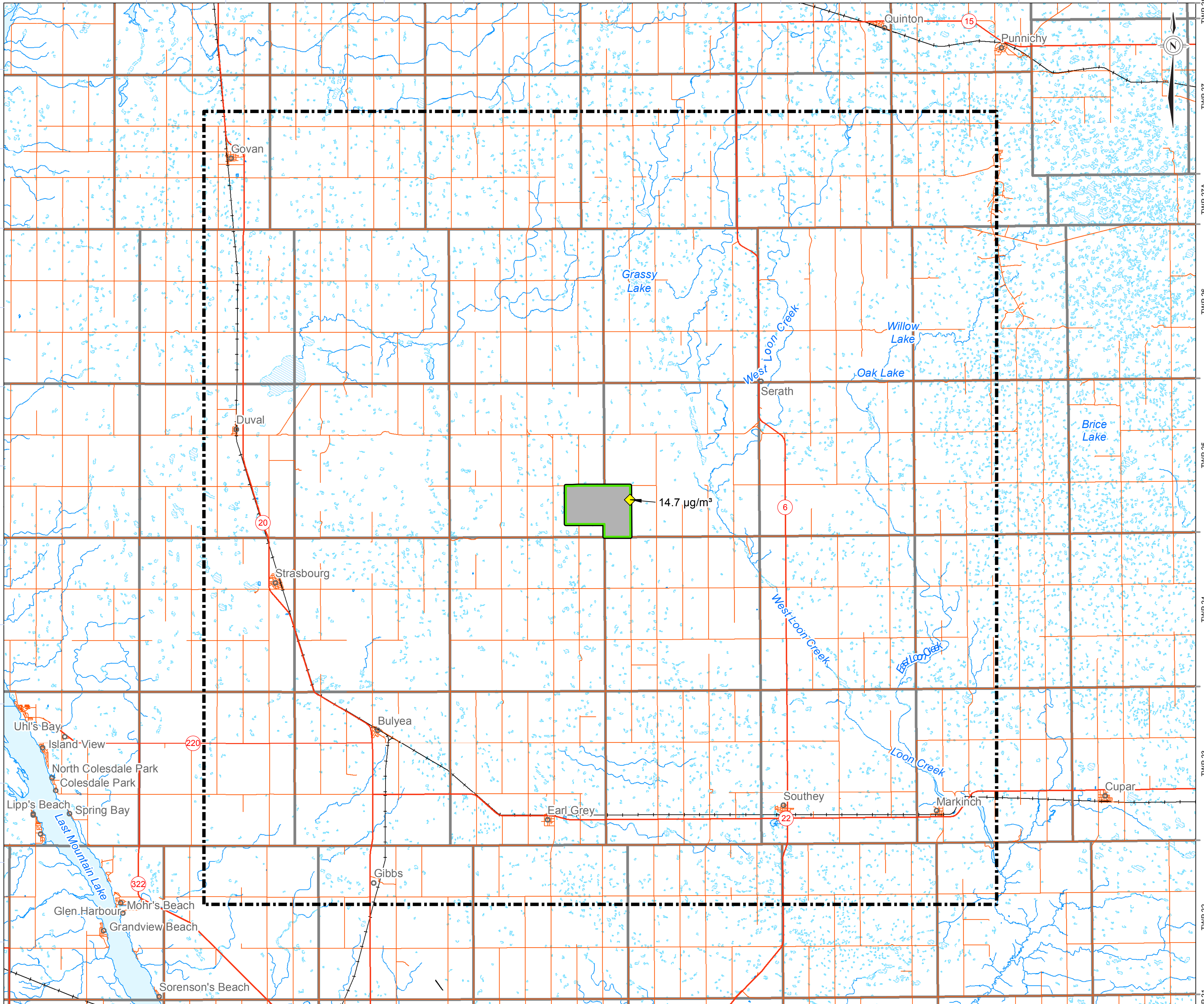
The Base Case and Application Case maximum 1-h, 24-h, and annual ground-level SO_2 concentrations resulting from Project operations are presented in Table 7.5-10 and graphically on Figures 7.5-7, 7.5-8, and 7.5-9. The results indicate that the Application Case maximum 1-h, 24-h, and annual SO_2 predictions outside of the core facilities area are below the SAAQS. The 1-h and 24-h maximum concentrations occur east-northeast of the core facilities area and the annual maximum concentration occurs east-southeast of the core facilities area.

Table 7.5-10: Comparison of Sulphur Dioxide Concentrations During the Base Case and Application Case

Averaging Period	Criteria (Ambient Air Quality Standards)[(a)]	Maximum Predicted Concentrations (µg/m³)		
		Base Case	Application Case	Change
1-h	450	2.6	14.7	12.1
24-h	125	2.6	4.5	1.9
Annual	20	0	0.2	0.2

(a) Saskatchewan Ambient Air Quality Standards (Government of Saskatchewan 2015).

h = hour; µg/m³ = micrograms per cubic metre.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 112.5 (BLANK)
- 112.5 to < 225
- 225 to < 450
- ≥ 450

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT

YANCOAL
SOUTHEY PROJECT

TITLE

APPLICATION CASE MAXIMUM PREDICTED 1-HOUR SULPHUR DIOXIDE CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	ZY	24/02/15	SCALE AS SHOWN REV. 3
GIS	SBM	27/05/15	FIGURE: 7.5-7
CHECK	CM	27/05/15	
REVIEW	CM	27/05/15	

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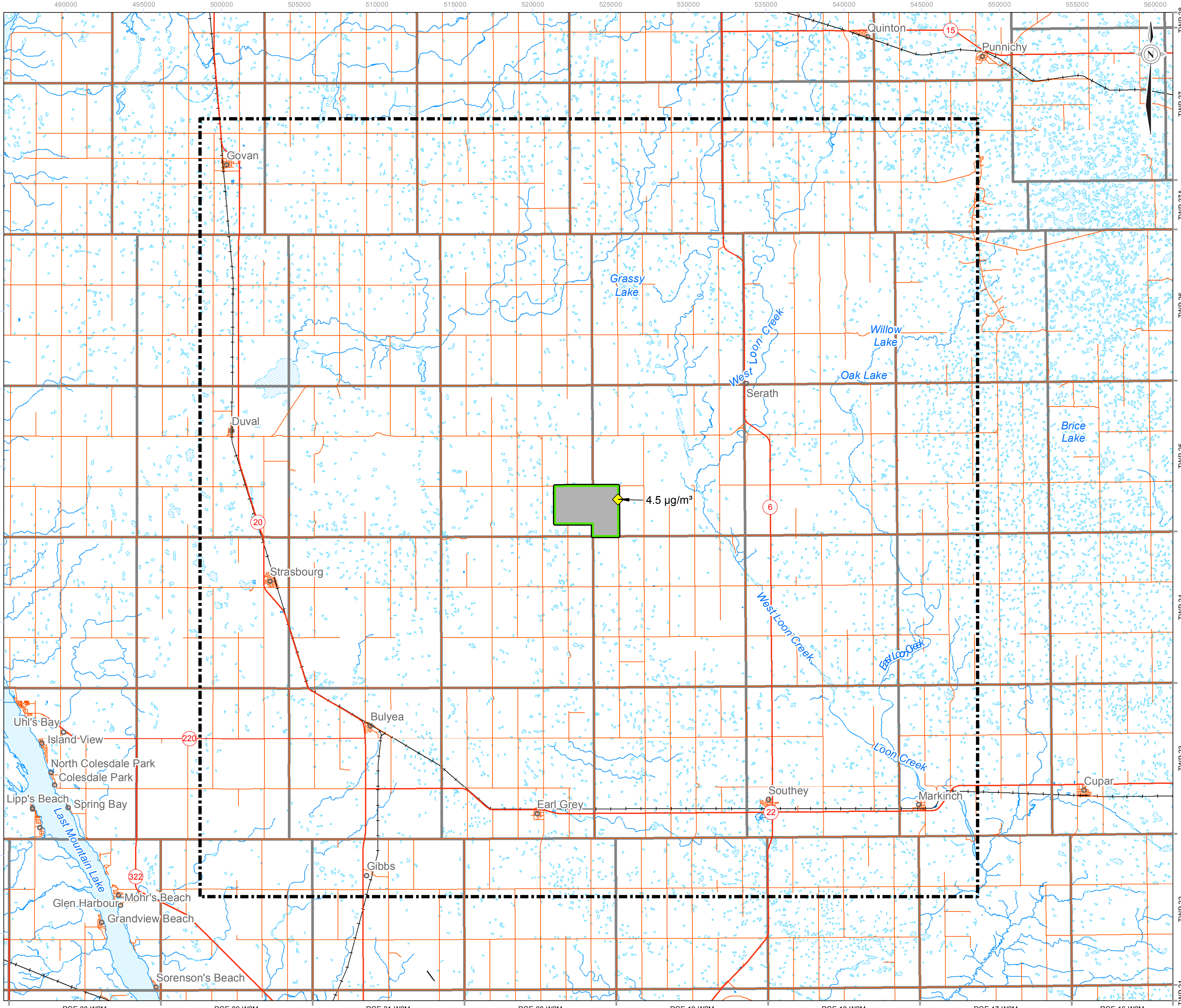

LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 31.25 (BLANK)
- 31.25 to < 62.5
- 62.5 to < 125
- ≥ 125

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
APPLICATION CASE MAXIMUM PREDICTED 24-HOUR SULPHUR DIOXIDE CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197		FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15	FIGURE: 7.5-8	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

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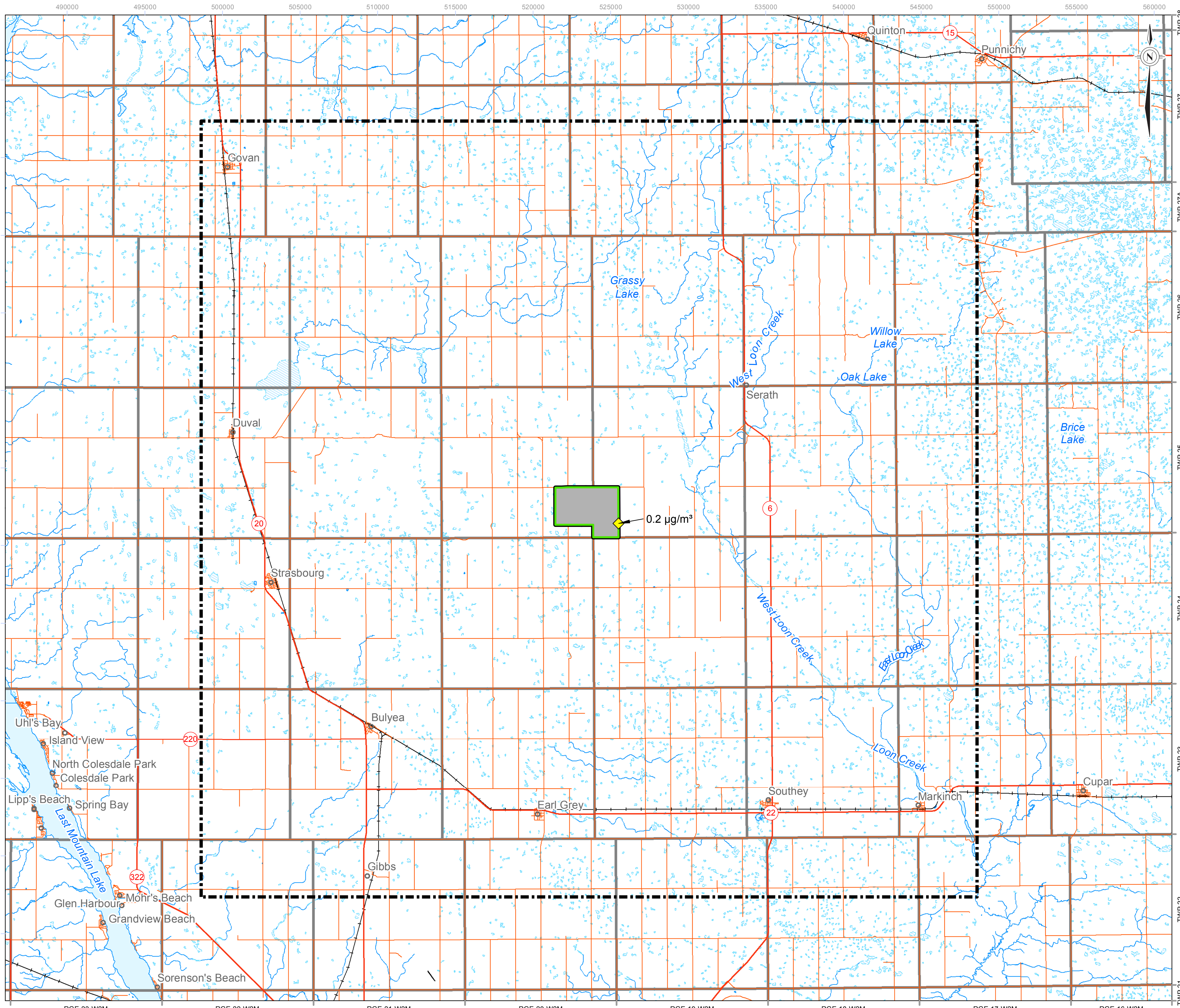


LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 5 (BLANK)
- 5 to < 10
- 10 to < 20
- ≥ 20

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
APPLICATION CASE MAXIMUM PREDICTED ANNUAL SULPHUR DIOXIDE CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197
DESIGN	ZY	24/02/15
GIS	SBM	27/05/15
CHECK	CM	27/05/15
REVIEW	CM	27/05/15

FILE No.
SCALE AS SHOWN REV. 3

FIGURE: 7.5-9

The Application Case maximum predicted 1-h, 24-h, and annual concentrations at the selected receptors are listed in Table 7.5-11. The maximum predicted SO_2 concentrations of all averaging periods at the selected receptors are all below the respective SAAQS.

Table 7.5-11: Application Case Maximum Predicted Sulphur Dioxide Concentrations at Selected Receptors

Receptor	1-h Maximum Predicted Concentrations (µg/m^3)	24-h Maximum Predicted Concentrations (µg/m^3)	Annual Maximum Predicted Concentrations (µg/m^3)
Residence 1	8.3	3.3	0.0
Residence 2	7.2	3.2	0.0
Residence 3	6.6	3.1	0.0
Residence 4	6.4	3.3	0.0
Residence 5	6.3	3.1	0.0
Residence 6	6.6	3.1	0.0
Residence 7	4.7	2.8	0.0
Residence 8	9.1	3.7	0.0
Residence 9	6.4	3.1	0.0
Residence 10	6.1	3.1	0.0
Residence 11	6.2	3.2	0.1
Residence 12	7.1	3.1	0.0
Residence 13	6.9	3.1	0.0
Residence 14	6.7	3.1	0.0
Residence 15	8.8	4.2	0.1
Bulyea	2.8	2.6	0.0
Earl Grey	2.8	2.6	0.0
Southey	2.8	2.7	0.0
Markinch	2.8	2.7	0.0
Gibbs	2.8	2.6	0.0
Strasbourg	2.8	2.6	0.0
Duval	2.8	2.7	0.0
Govan	2.8	2.6	0.0
Serath	3.3	2.7	0.0

h = hour; µg/m^3 = micrograms per cubic metre.

7.5.2.2.4 $PM_{2.5}$ Predictions

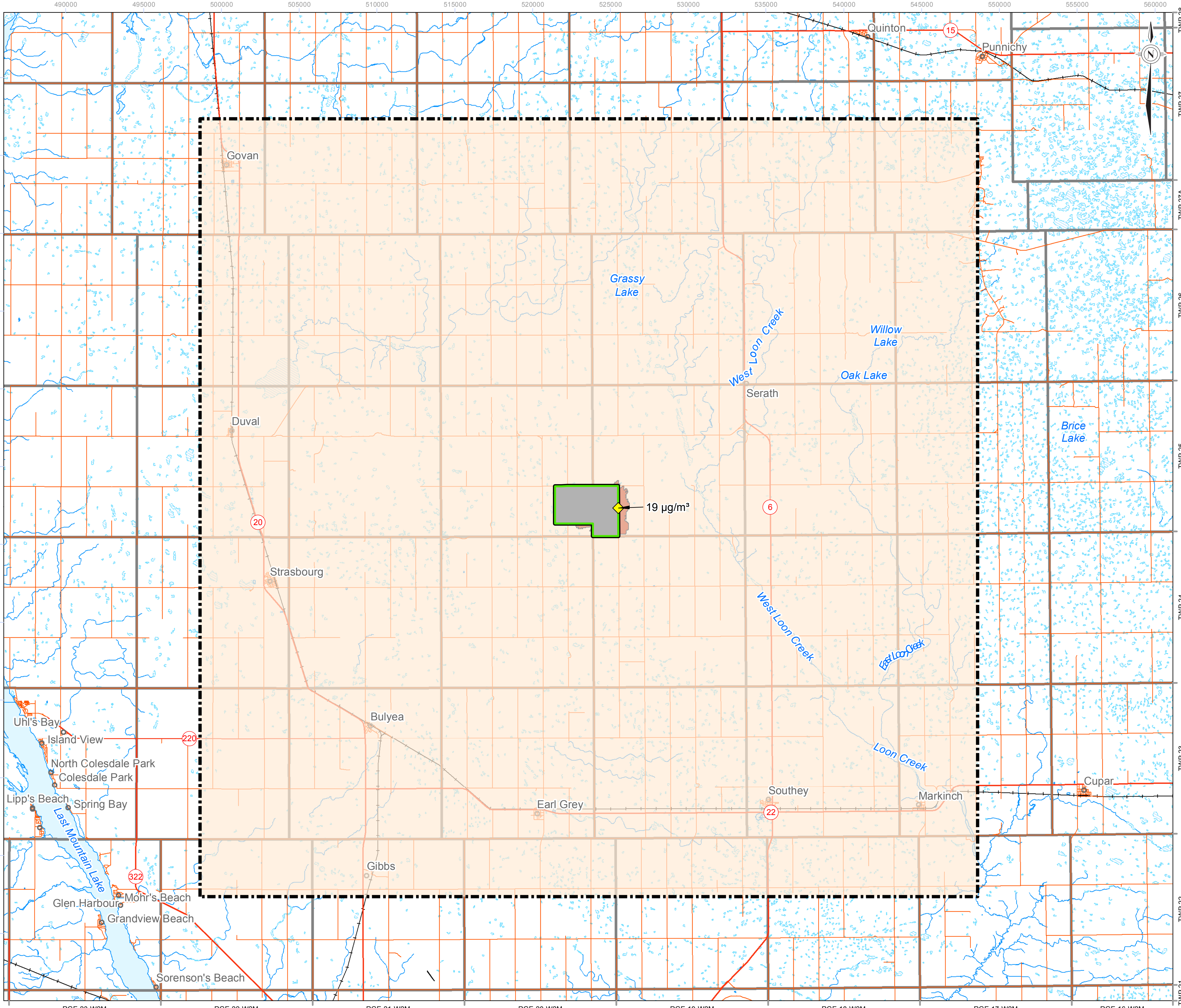
The Base Case and Application Case maximum 24-h and annual ground-level $PM_{2.5}$ concentrations resulting from the operation of the Project are presented in Table 7.5-12 and graphically on Figures 7.5-10 and 7.5-11. The results indicate that the Application Case maximum 24-h and annual $PM_{2.5}$ predictions outside of the core facilities area are below the SAAQS. The 24-h and annual maximum predicted concentrations changes due to the Project are 10.7 µg/m³ and 2.3 µg/m³, respectively. The Application Case 24-h maximum concentration occurs east of the core facilities area, while the annual maximum concentration occurs southeast of the core facilities area.

Table 7.5-12: Comparison of $PM_{2.5}$ Concentrations during the Base Case and Application Case

Averaging Period	Criteria (Ambient Air Quality Standards)[(a)]	Maximum Predicted Concentrations (µg/m³)		
		Base Case	Application Case	Change
24-hr	28	8.3	19.0	10.7
Annual	10	3.7	6.0	2.3

(a) Canadian Ambient Air Quality Standards (CCME 2013)

$PM_{2.5}$ = particulate matter with aerodynamic diameter less than 2.5 micrometres; h = hour; µg/m³ = micrograms per cubic metre



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 7 (BLANK)
- 7 to < 14
- 14 to < 28
- ≥ 28

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT

YANCOAL
SOUTHEY PROJECT

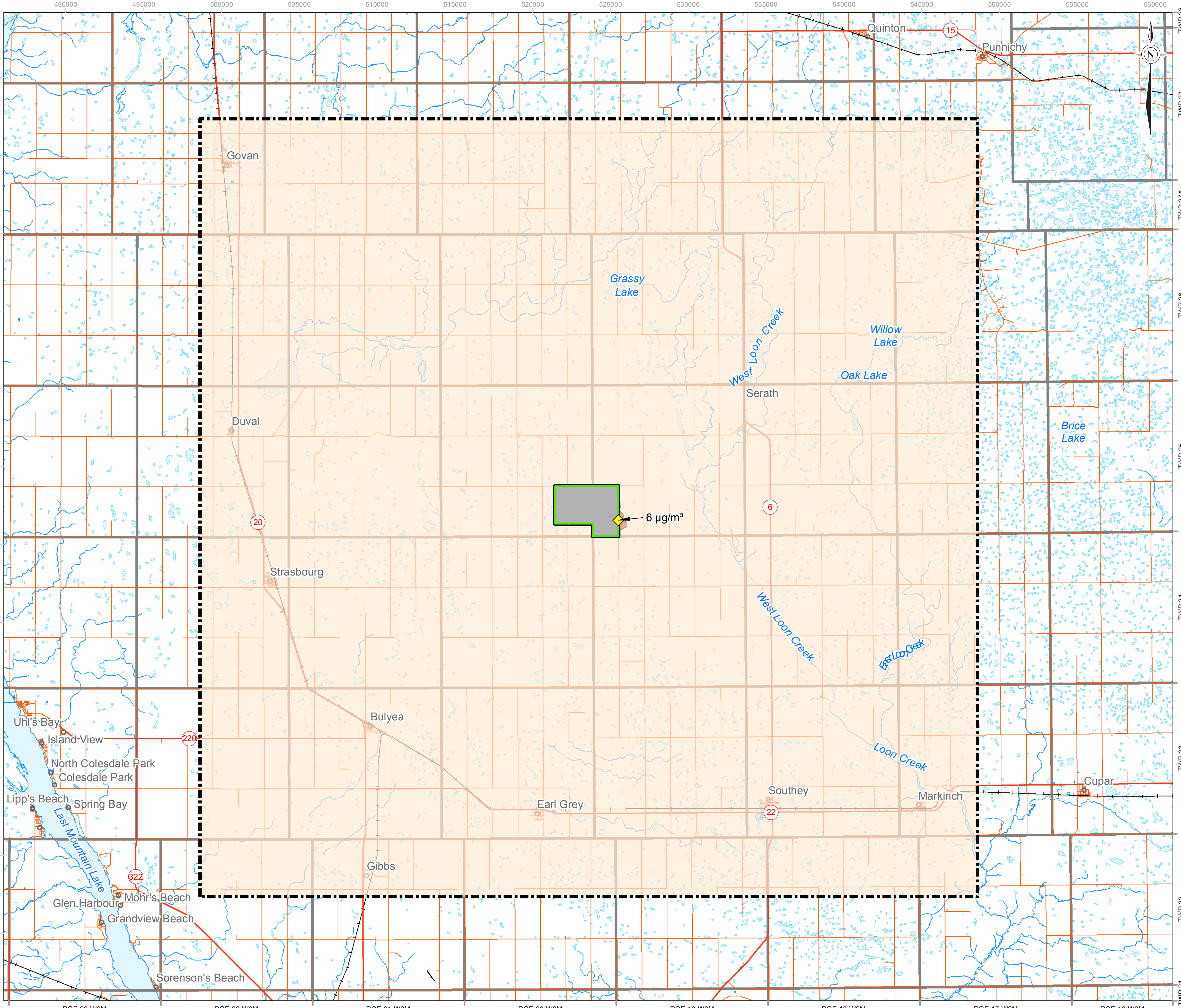
TITLE

APPLICATION CASE MAXIMUM PREDICTED 24-HOUR $PM_{2.5}$ CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	ZY	24/02/15	SCALE AS SHOWN REV. 3
GIS	SBM	27/05/15	**FIGURE: 7.5-10**
CHECK	CM	27/05/15	
REVIEW	CM	27/05/15	

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1080 - Air and Noise\12-1362-0197 - DDP Predicted Maximums.mxd Date: 5/27/2015 9:02:10 AM



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LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 2.5 (BLANK)
- 2.5 to < 5
- 5 to < 10
- ≥ 10

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5

SCALE 1:250,000 KILOMETRES

PROJECT

YANCOAL

YANCOAL SOUTHEY PROJECT

TITLE

APPLICATION CASE MAXIMUM PREDICTED ANNUAL $PM_{2.5}$ CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15	FIGURE: 7.5-11	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

Table 7.5-13 lists the Application Case maximum predicted 24-h and annual $PM_{2.5}$ concentrations at the selected receptors. The 24-h and annual $PM_{2.5}$ concentrations at the selected receptors are all below the respective ambient air quality standards.

Table 7.5-13: Maximum Predicted $PM_{2.5}$ Concentrations at Selected Receptors

Receptor	24-h Maximum Predicted Concentrations (µg/m³)	Annual Maximum Predicted Concentrations (µg/m³)
Residence 1	13.5	4.0
Residence 2	13.2	4.0
Residence 3	12.3	4.0
Residence 4	13.9	4.0
Residence 5	11.8	4.0
Residence 6	12.1	4.1
Residence 7	9.9	3.8
Residence 8	17.2	4.1
Residence 9	12.9	3.9
Residence 10	12.7	4.0
Residence 11	13.6	4.2
Residence 12	13.2	4.2
Residence 13	12.7	4.1
Residence 14	12.7	4.1
Residence 15	21.8	5.0
Bulyea	8.5	3.7
Earl Grey	8.5	3.7
Southey	8.6	3.7
Markinch	8.7	3.7
Gibbs	8.5	3.7
Strasbourg	8.5	3.7
Duval	8.6	3.7
Govan	8.5	3.7
Serath	9.1	3.8

$PM_{2.5}$ = particulate matter with aerodynamic diameter less than 2.5 micrometres; h = hour; µg/m³ = micrograms per cubic metre

7.5.2.2.5 PM_{10} Predictions

The Base Case and Application Case maximum 24-h PM_{10} concentrations are presented in Table 7.5-14 and graphically on Figure 7.5-12. The results indicate that the Application Case maximum 24-h PM_{10} prediction outside of the core facilities area (53.4 µg/m³) is above the SAAQS of 50 µg/m³. However, the background concentration (Base Case) of PM_{10} is 36.3 µg/m³, which represents 72.6% of the ambient air quality standard. The background concentration of PM_{10} listed in the AQMG was measured at an air quality monitoring station in the City of Regina (population [pop.] 180,000); there are no rural PM_{10} measurements available from the MOE.

Table 7.5-14: Comparison of PM_{10} Concentrations during the Base Case and Application Case

Averaging Period	Criteria (Ambient Air Quality Standards)[(a)]	Maximum Predicted Concentrations (µg/m³)			Occurrences above SAAQS (days)[(b)]	Areal extent above SAAQS (ha)[(c)]
		Base Case	Application Case	Change		
24-h	50	36.3	53.4	17.1	3	0.19

(a) Saskatchewan Ambient Air Quality Standards (Government of Saskatchewan 2015)

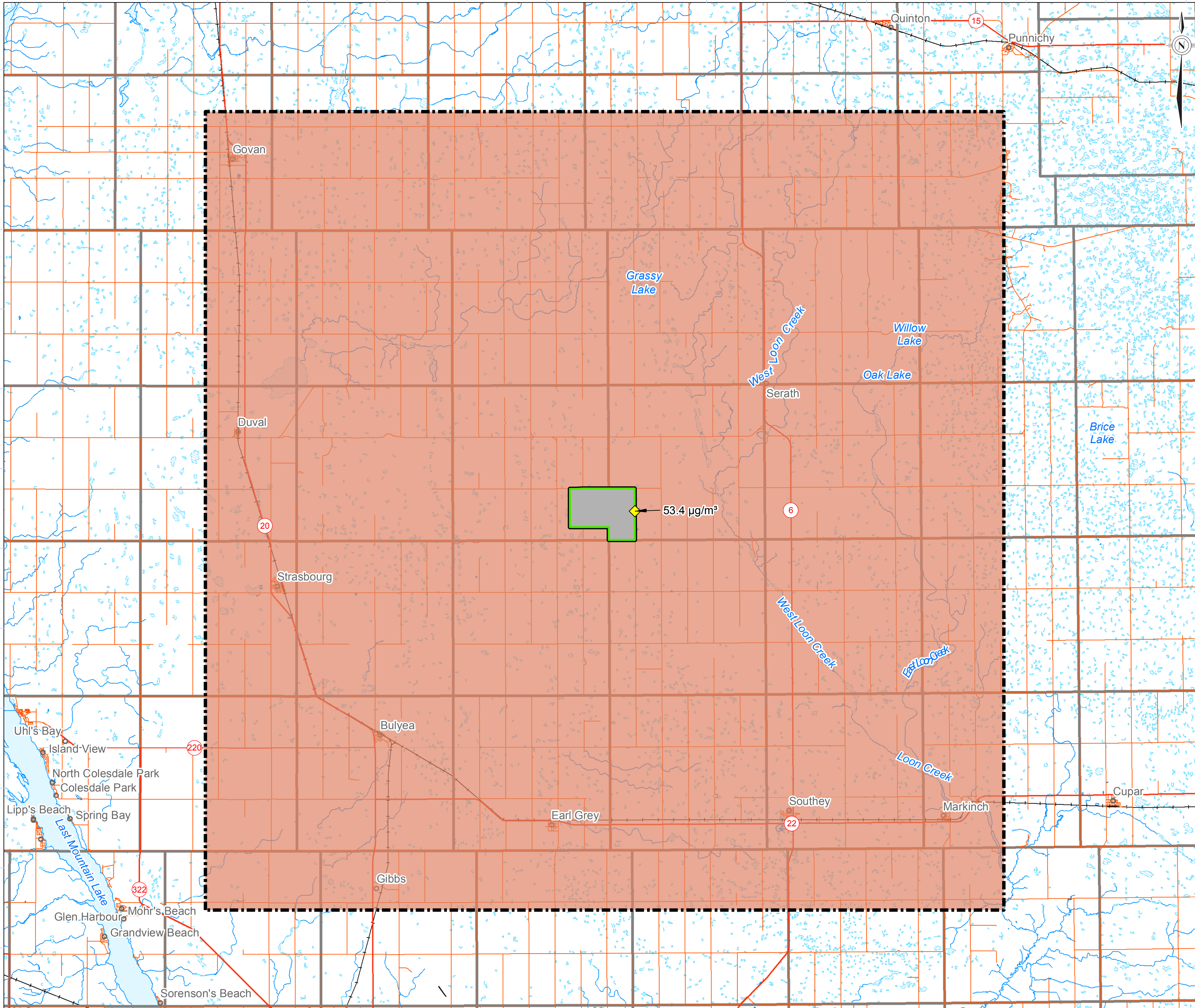
(b) Occurrence refers to averaged days of maximum predicted PM_{10} concentrations exceeding of Saskatchewan Ambient Air Quality Standard (SAAQS) during the modelling years (2003 to 2007);

(c) Areal extend above SAAQS is based on the application maximum predicted concentrations outside the core facility area

PM_{10} = particulate matter with aerodynamic diameter less than 10 micrometres; ha = hectares; h = hours; µg/m³ = micrograms per cubic metre.

Urban areas typically have higher particulate matter concentrations than rural areas. For example, the 90th percentile PM_{10} concentration measured at Fargo, North Dakota (pop. 115,000) is 25 µg/m³. The United States Interagency Monitoring of Protected Visual Environments network (IMPROVE 2015) monitors PM_{10} concentrations at four rural sites in Montana and North Dakota, including Fort Peck, Montana, Medicine Lake, Montana, Lostwood, North Dakota, and Theo Roosevelt, North Dakota. At these rural locations, the 90th percentile PM_{10} concentrations are 16, 19, 19 and 18 µg/m³ (pooled average 17.9 µg/m³) This supports the conclusion that the Saskatchewan AQMG background PM_{10} concentration value of 36.3 µg/m³ is likely higher than the actual background concentrations at the rural Project site.

The 24-h maximum predicted concentrations change resulting from the Project is 17.1 µg/m³. The Application Case 24-h maximum concentration occurs east of the core facilities area. Further analyses show that the averaged days of Application Case maximum predicted PM_{10} concentrations exceeding of SAAQS are 3 days during the modelling years (2003 to 2007). The areal extent above SAAQS for the Application Case is 0.19 ha. This result assumes a background PM_{10} concentration of 36.3 µg/m³. Using a rural background PM_{10} concentration of 17.9 µg/m³ results in a maximum predicted concentration of 35 µg/m³, this maximum predicted concentration is below the SAAQS.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 12.5 (BLANK)
- 12.5 to < 25
- 25 to < 50
- ≥ 50

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT
YANCOAL SOUTHEY PROJECT

TITLE
APPLICATION CASE MAXIMUM PREDICTED 24-HOUR PM_{10} CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15	**FIGURE: 7.5-12**	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

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Table 7-5-15 lists the Application Case maximum predicted 24-h PM_{10} concentrations at the selected receptors. The 24-h concentrations at the selected receptors are all below the respective ambient air quality standards assuming a background PM_{10} concentration of 36.3 µg/m³.

Table 7.5-15: Application Case Maximum Predicted 24-hour PM_{10} Concentrations at Selected Receptors

Receptor	24-h Maximum Predicted Concentrations (µg/m³)
Residence 1	41.5
Residence 2	41.2
Residence 3	40.3
Residence 4	41.9
Residence 5	39.8
Residence 6	40.1
Residence 7	37.9
Residence 8	45.2
Residence 9	40.9
Residence 10	40.7
Residence 11	41.6
Residence 12	41.2
Residence 13	40.7
Residence 14	40.7
Residence 15	49.8
Bulyea	36.5
Earl Grey	36.5
Southey	36.6
Markinch	36.7
Gibbs	36.5
Strasbourg	36.5
Duval	36.6
Govan	36.5
Serath	37.1

PM_{10}= particulate matter with aerodynamic diameter less than 10 micrometres; h = hour; µg/m³ = micrograms per cubic metre.

7.5.2.2.6 Total Suspended Particulate Matter Predictions

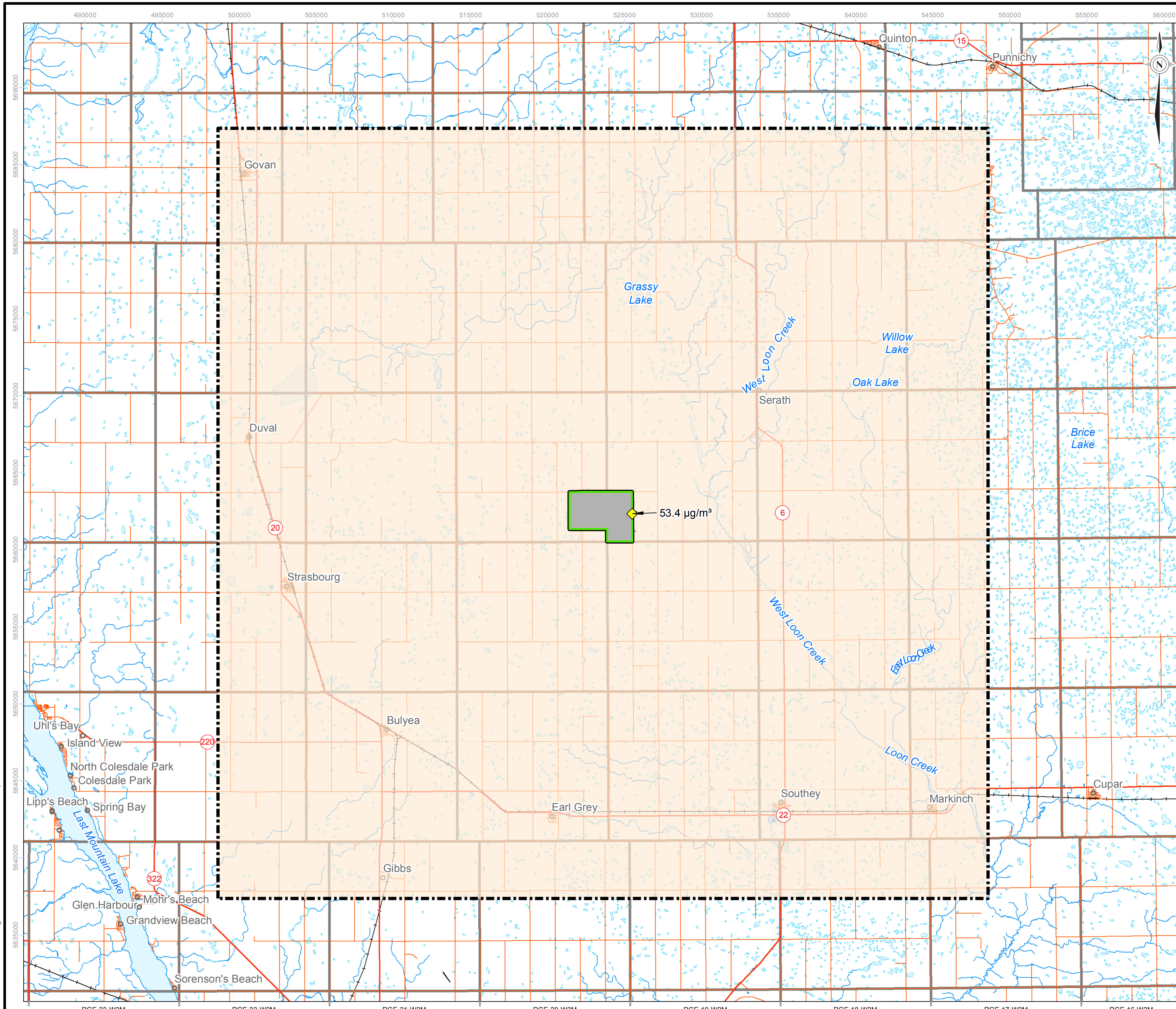
The Base Case and Application Case maximum 24-h and annual ground-level TSP concentrations resulting from the operation of the Project are presented in Table 7.5-16 and graphically on Figures 7.5-13 and 7.5-14. The results indicate that the Application Case maximum 24-h and annual TSP predictions outside of the core facilities area are below the respective ambient air quality standards. The 24-h and annual maximum predicted concentrations changes due to the Project are 17.1 µg/m³ and 2.3 µg/m³, respectively. The 24-h maximum concentration occurs in the east direction on the Project boundary, while the annual maximum concentration occurs in the east-southeast direction on the Project boundary.

Table 7.5-16: Comparison of Total Suspended Particulate Matter Concentrations during the Base Case and Application Case

Averaging Period	Criteria (Ambient Air Quality Standards)[(a)]	Maximum Predicted Concentrations (µg/m³)		
		Base Case	Application Case	Change
24-hour	100	36.3	53.4	17.1
annual	60	18.2	20.5	2.3

(a) Saskatchewan Ambient Air Quality Standards (Government of Saskatchewan 2015)

h = hour; µg/m³ = micrograms per cubic metre



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 25 (BLANK)
- 25 to < 50
- 50 to < 100
- ≥ 100

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT
YANCOAL
SOUTHEY PROJECT

TITLE
APPLICATION CASE MAXIMUM PREDICTED 24-HOUR TOTAL SUSPENDED PARTICULATE MATTER CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15	FIGURE: 7.5-13	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

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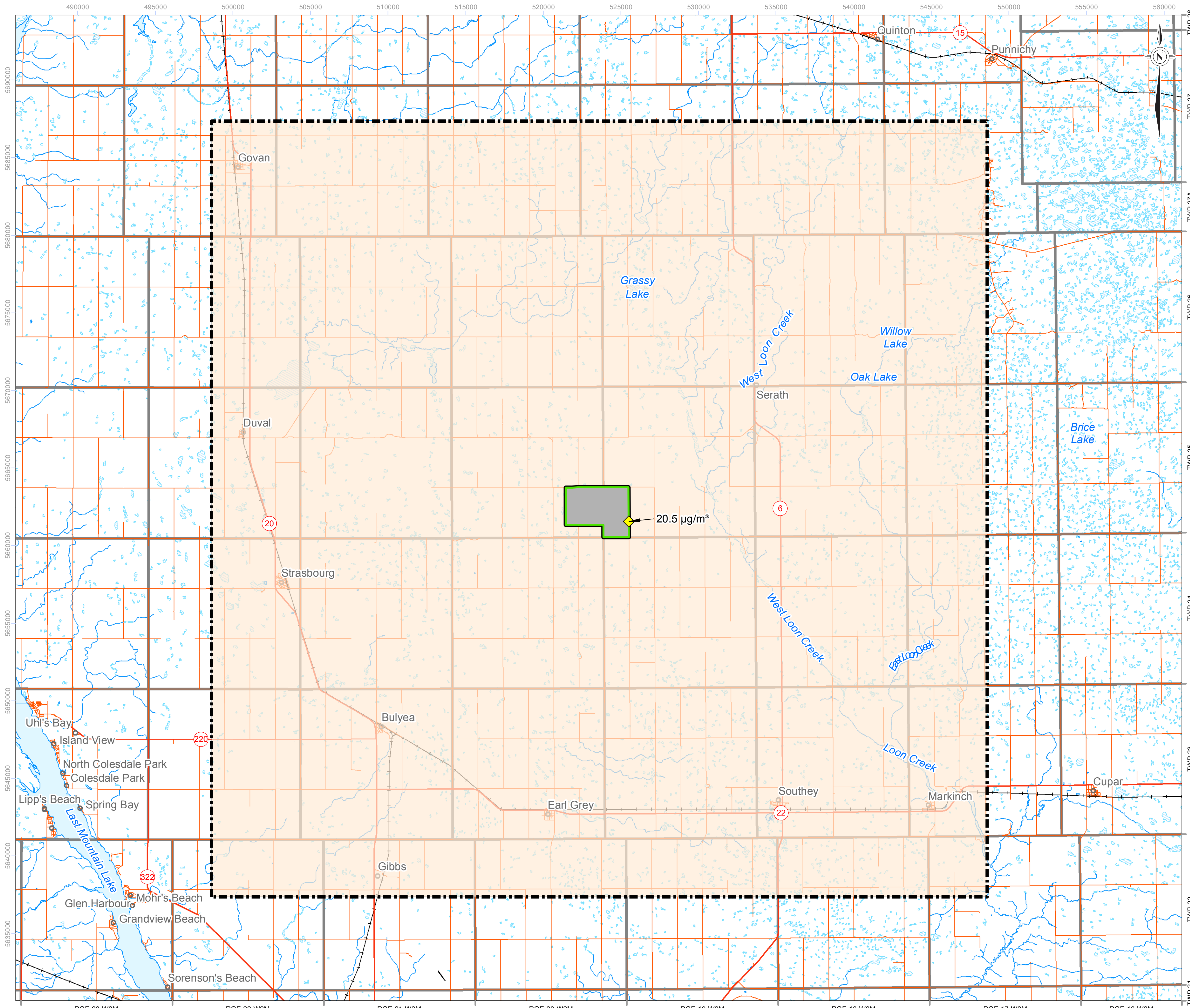

LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (µg/m³)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 15 (BLANK)
- 15 to < 30
- 30 to < 60
- ≥ 60

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT

YANCOAL
SOUTHEY PROJECT

TITLE

APPLICATION CASE MAXIMUM PREDICTED ANNUAL TOTAL SUSPENDED PARTICULATE MATTER CONCENTRATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15	**FIGURE: 7.5-14**	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

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Table7.5-17 lists the Application Case maximum predicted 24-h and annual TSP concentrations at the selected receptors. The 24-h and annual TSP concentrations at the selected receptors are all below the respective ambient air quality standards.

Table 7.5-17: Application Case Maximum Predicted Total Suspended Particulate Matter Concentrations at Selected Receptors

Receptor	24-h Maximum Predicted Concentrations (µg/m^3)	Annual Maximum Predicted Concentrations (µg/m^3)
Residence 1	41.5	18.5
Residence 2	41.2	18.5
Residence 3	40.4	18.5
Residence 4	41.9	18.5
Residence 5	39.8	18.5
Residence 6	40.1	18.6
Residence 7	37.9	18.3
Residence 8	45.2	18.6
Residence 9	40.9	18.4
Residence 10	40.7	18.5
Residence 11	41.6	18.7
Residence 12	41.2	18.7
Residence 13	40.7	18.6
Residence 14	40.7	18.6
Residence 15	49.8	19.5
Bulyea	36.5	18.2
Earl Grey	36.5	18.2
Southey	36.6	18.2
Markinch	36.7	18.2
Gibbs	36.5	18.2
Strasbourg	36.5	18.2
Duval	36.6	18.2
Govan	36.5	18.2
Serath	37.1	18.3

h = hour; µg/m^3 = micrograms per cubic metre.

7.5.2.2.7 Potash Deposition

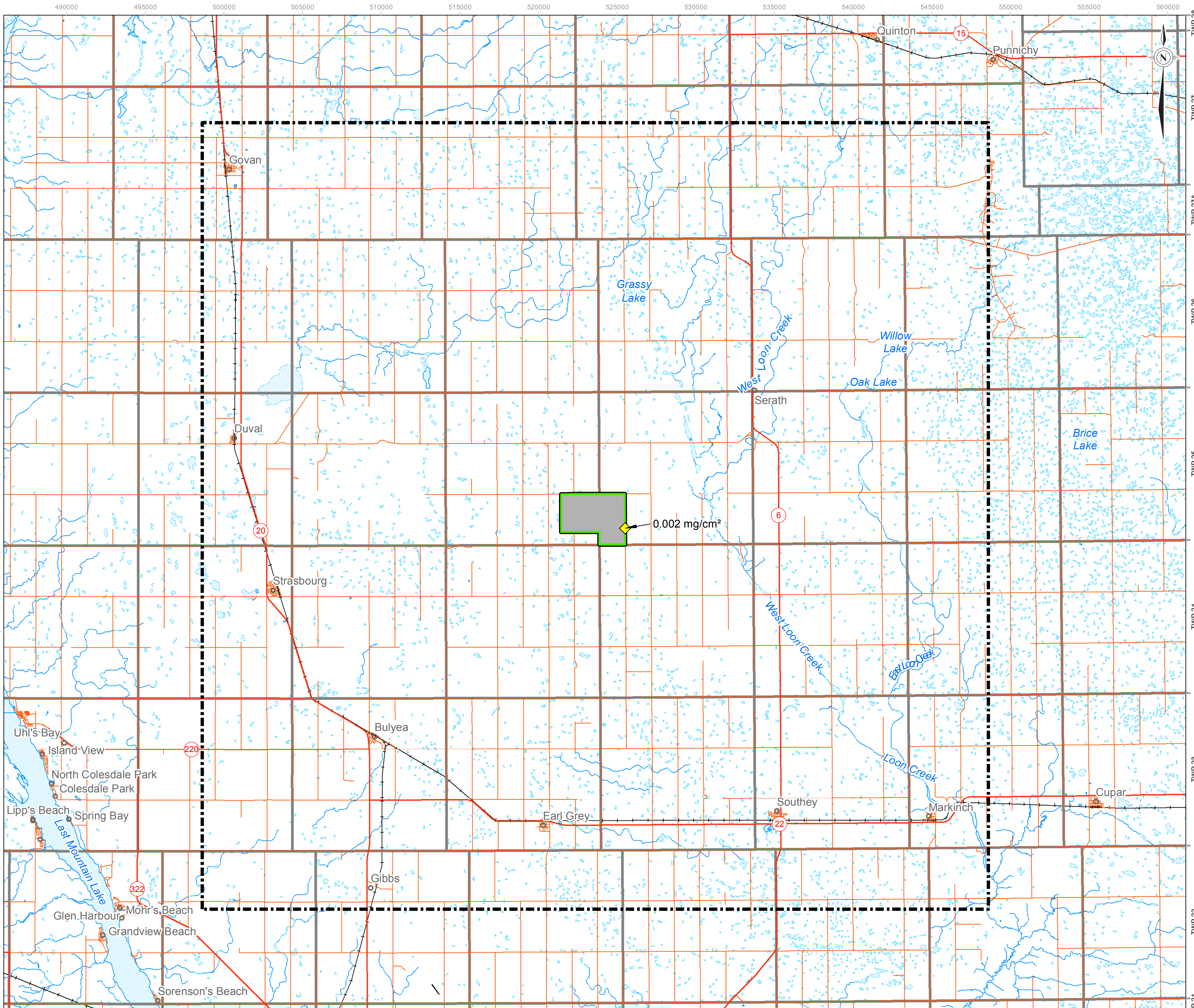
The monthly KCl depositions resulting from operation of the Project are presented in Table 7.5-18 and graphically on Figures 7.5-15, 7.5-16, and 7.5-17. The results indicate that the Application Case monthly KCl predictions outside of the core facilities area are below the air quality standards. The maximum predicted depositions of KCl, KCl as K^+, and KCl as Cl^- are 0.002, 0.001, and 0.001 milligrams per square centimetre per month (mg/cm²/month), respectively. The maximum KCl deposition occurs southeast of the core facilities area.

Table 7.5-18: Comparison of Potash Deposition during the Base Case and Application Case

KCl(mg/cm²/month)	Criteria (Ambient Air Quality Standards)[a]	Maximum Predicted Monthly Deposition		
		Base Case	Application Case	Change
Maximum KCl Deposition	0.15	0	0.002	0.002
Maximum KCl Deposition as K^+		0	0.001	0.001
Maximum KCl Deposition as Cl^-		0	0.001	0.001

[a] *The Clean Air Regulations.* 1986-87-88

KCl = potash; K^+ = potassium; Cl^- = chloride; mg/cm²/month = milligrams per square centimetre per month.



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LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (mg/m²)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 0.0375 (BLANK)
- 0.0375 to < 0.075
- 0.075 to < 0.15
- ≥ 0.15

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT

YANCOAL

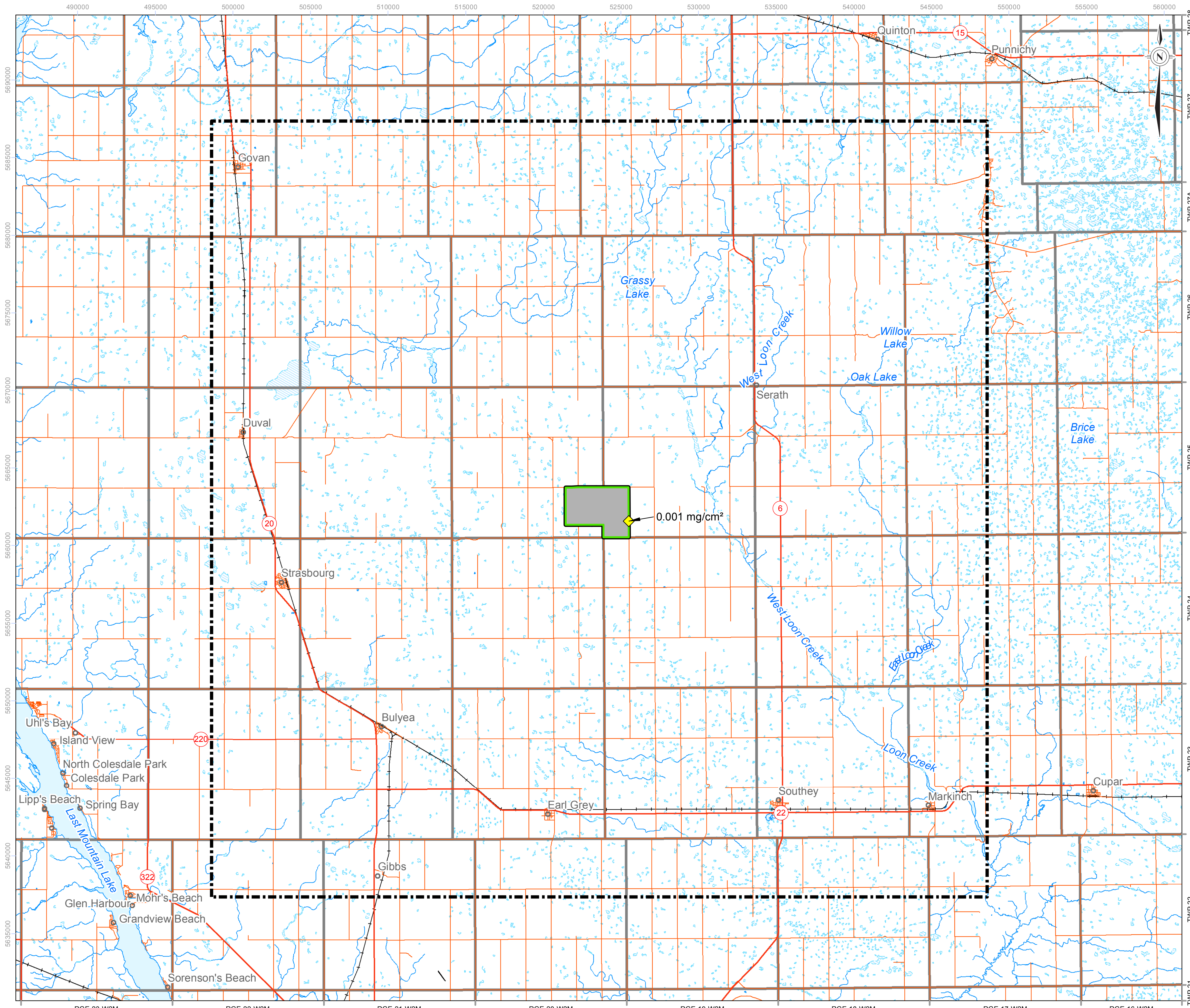
YANCOAL SOUTHEY PROJECT

TITLE

APPLICATION CASE MAXIMUM PREDICTED MONTHLY POTASSIUM CHLORIDE DEPOSITIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15	**FIGURE: 7.5-15**	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (mg/m²)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 0.0375 (BLANK)
- 0.0375 to < 0.075
- 0.075 to < 0.15
- ≥ 0.15

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
APPLICATION CASE MAXIMUM PREDICTED MONTHLY POTASSIUM DEPOSITIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15	**FIGURE: 7.5-16**	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

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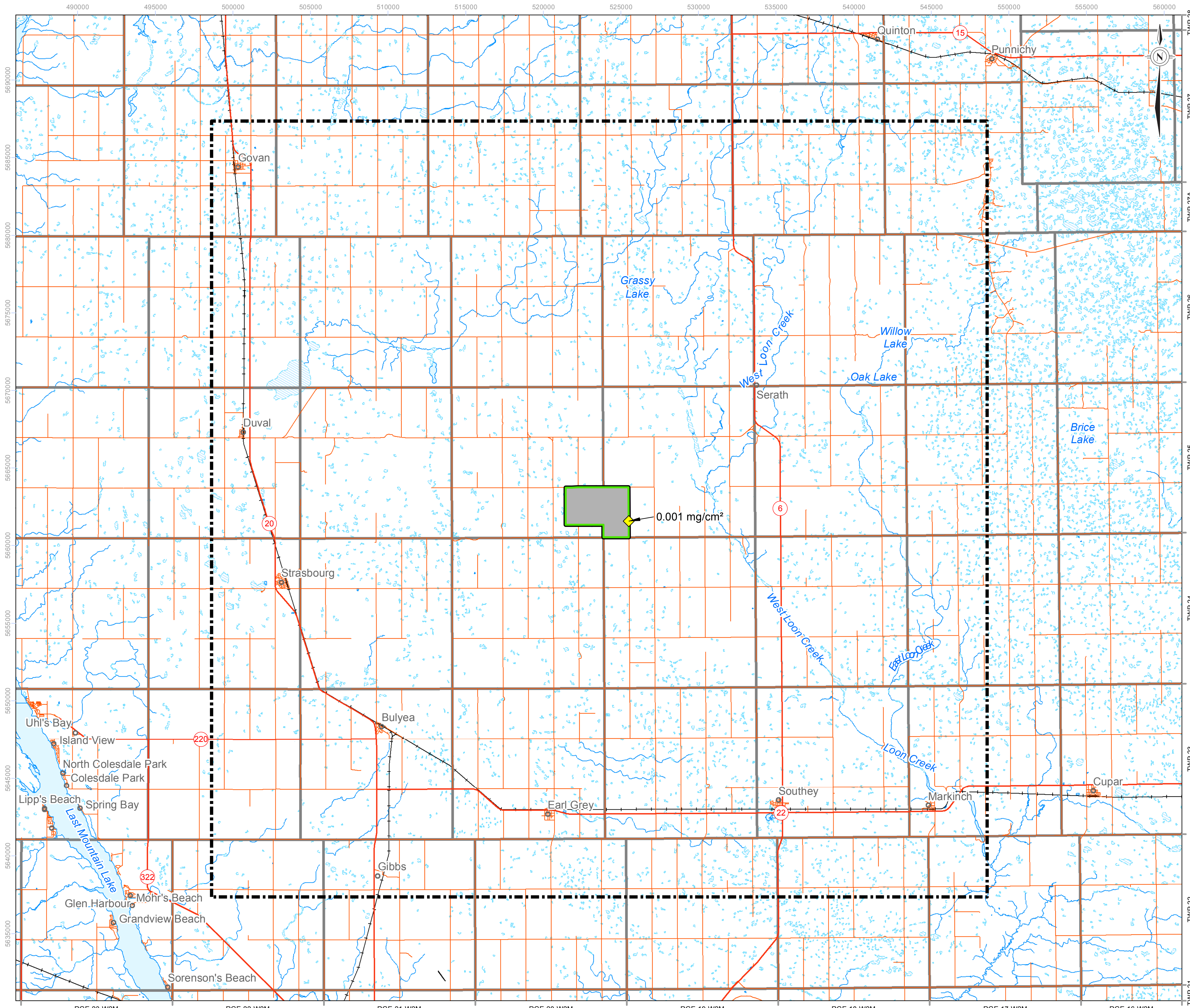

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LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- CORE FACILITIES AREA
- EFFECTS STUDY AREA

CONCENTRATION (mg/m²)

- MAXIMUM POINT OF IMPINGEMENT
- 0 to < 0.0375 (BLANK)
- 0.0375 to < 0.075
- 0.075 to < 0.15
- ≥ 0.15

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT
YANCOAL SOUTHEY PROJECT

TITLE
APPLICATION CASE MAXIMUM PREDICTED MONTHLY CHLORIDE DEPOSITIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	ZY	24/02/15	SCALE AS SHOWN	REV. 3
GIS	SBM	27/05/15	**FIGURE: 7.5-17**	
CHECK	CM	27/05/15		
REVIEW	CM	27/05/15		

Table 7.5-19 lists the Application Case maximum predicted KCl depositions at the selected receptors. The KCl deposition as K^+ and Cl^- are listed in the table. It shows that the maximum monthly depositions of KCl are below the ambient air quality standard at all selected receptors.

Table 7.5-19: Application Case Maximum Predicted Potash Deposition at the Selected Receptors

Report Name	Maximum Monthly KCl Deposition (mg/cm²/month)	Maximum Monthly KCl Deposition as K^+ (mg/cm²/month)	Maximum Monthly KCl Deposition as Cl^- (mg/cm²/month)
Residence 1	0.0002	0.0001	0.0001
Residence 2	0.0002	0.0001	0.0001
Residence 3	0.0002	0.0001	0.0001
Residence 4	0.0002	0.0001	0.0001
Residence 5	0.0001	0.0001	0.0001
Residence 6	0.0002	0.0001	0.0001
Residence 7	0.0001	0.0001	0.0001
Residence 8	0.0003	0.0002	0.0002
Residence 9	0.0002	0.0001	0.0001
Residence 10	0.0002	0.0001	0.0001
Residence 11	0.0002	0.0001	0.0001
Residence 12	0.0003	0.0001	0.0001
Residence 13	0.0003	0.0001	0.0001
Residence 14	0.0002	0.0001	0.0001
Residence 15	0.0009	0.0005	0.0004
Bulyea	0.0000	0.0000	0.0000
Earl Grey	0.0000	0.0000	0.0000
Southey	0.0000	0.0000	0.0000
Markinch	0.0000	0.0000	0.0000
Gibbs	0.0000	0.0000	0.0000
Strasbourg	0.0000	0.0000	0.0000
Duval	0.0000	0.0000	0.0000
Govan	0.0000	0.0000	0.0000
Serath	0.0000	0.0000	0.0000

KCl = potash; K^+ = potassium; Cl^- = chloride; mg/cm²/month = milligrams per square centimetre per month.

7.5.2.2.8 Greenhouse Gas Emissions

Table 7.5-20 summarizes the predictions of GHG emissions for the Project. Total emissions based on operating at full capacity for 94% of the time annually are 1.09 million tonnes (MT) of carbon dioxide equivalents ($CO_{2\ eq}$) annually. The dominant sources of GHG emissions are the four large natural gas boilers (i.e., approximately 96%).

Saskatchewan's greenhouse gas emissions were 74.8 MT of $CO_{2\ eq}$ in 2012; according to Environment Canada the national total emissions are 699 MT of $CO_{2\ eq.}$ The Project will contribute 1.4% to the total greenhouse gas emissions in Saskatchewan based on the 2012 data. The Project-related greenhouse gas emission is 0.16% of the total national GHGs emissions in 2012.

Facilities emitting greater than 50,000 tonnes of $CO_{2\ eq}$ per year are required to report their emissions to Environment Canada's Greenhouse Gas Emissions Reporting Program (Environment Canada 2014). Based on this requirement, the Project will be required to report its GHG emissions to Environment Canada annually. Facilities in Saskatchewan emitting greater than 50,000 tonnes of $CO_{2\ eq}$ per year are to be subject to regulation under the proposed MRGGA. The regulated emitters will be required to reduce annual GHG emissions to meet the provincial target.

Based on the above regulatory requirements, the Project's GHG emissions will be subject to GHG reporting and regulation by the MOE. However, the timeline for enforcement of the *Act*, and details of the enforcement of the MRGGA have not been finalized or published by the MOE.

Table 7.5-20: Greenhouse Gas Emissions Summary

Sources		CO_2 (tonnes/yr)	N_2O (tonnes/yr)	CH_4 (tonnes/yr)	$CO_{2\ eq}$ (tonnes/yr)
Natural Gas Boilers					
Boiler 1	Natural Gas Boiler - Stack 1	258,987.48	4.70	5.27	260,518.50
Boiler 2	Natural Gas Boiler - Stack 2	258,987.48	4.70	5.27	260,518.50
Boiler 3	Natural Gas Boiler - Stack 3	258,987.48	4.70	5.27	260,518.50
Boiler 4	Natural Gas Boiler - Stack 4	258,987.48	4.70	5.27	260,518.50
Natural Gas Dryers					
Dryer 1	Fluid Bed Dryer 1 Natural Gas Combustion	15,096.68	0.27	0.31	15,185.92
Dryer 2	Fluid Bed Dryer 2 Natural Gas Combustion	15,096.68	0.27	0.31	15,185.92
Dryer 3	Glazing Dryer Natural Gas Combustion	15,096.68	0.27	0.31	15,185.92
Diesel Locomotive					
Locomotive	Diesel combustion from locomotive engines	509.02	0.03	0.21	531.06
Diesel and Gasoline Vehicle Emission					
Total Vehicle Emission	On-road and off-road vehicle emissions	--	--	--	995.12
Total GHG emission					
Total	**Total GHG emission from all sources onsite**	**1,081,748.98**	**19.63**	**22.19**	**1,089,157.94**

CO_2 = carbon dioxide; N_2O = nitrous oxide; CH_4 = methane; $CO_{2\ eq}$ = carbon dioxide equivalents; GHG = Greenhouse Gas; "--" = emissions are not calculated for each compound; tonnes/yr = tonnes per year.

7.6 Prediction Confidence and Uncertainty

Air dispersion models are used primarily to estimate the changes in ambient air quality from Project emissions. The accuracy of these predictions depends on factors such as quality and certainty of the emission quantification, the terrain data, and the meteorological data.

The AERMOD model is an approved dispersion model that was selected for completing the dispersion modelling to reduce uncertainty. Terrain data can influence air quality predictions; however, the Project site has very little variation in elevation and terrain should have a negligible influence on model predictions. A five-year meteorological dataset (2003 to 2007) provided by MOE was used in the dispersion modelling and is anticipated to capture the variations in regional weather conditions for the Project site. To increase confidence that the residual effects are not underestimated, the maximum of the five-year ground-level concentrations were compared to the applicable standards and objectives to determine Project compliance. The above approach occasionally can result in high predicted ground-level concentrations due to transient and rare meteorological events. Therefore, specific guidelines in the Saskatchewan air quality modelling guideline were followed when using multi-year meteorological data.

The intensity and location of emission sources can influence modelled results. The maximum hourly, daily, monthly, and annual emissions from Project operations were modelled to assess the maximum air quality effects from the Project. The air quality modelling conservatively assumed that the maximum emission profile for each source occurs instantaneously. The emissions intensities for some of the pollutants were provided by the engineering design team, while others were calculated using US EPA emission factors, CCME guidelines, and the multi-sectors air pollution regulations. When specific Project process information was not available, conservative assumptions were made. These procedures are anticipated to result in a conservative assessment of changes in ambient air quality from the Project and increase confidence that the residual effects are not greater than predicted.

7.7 Residual Effects Classification and Determination of Significance

7.7.1 Methods

7.7.1.1 Residual Effects Criteria

The purpose of the residual effects classification is to describe the residual incremental and cumulative adverse effects from previous and existing developments and the Project (Application Case) on the atmospheric environment VC using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment.

Results from the residual effects classification are then used to determine the environmental significance from the Project and other developments on the assessment endpoint for the atmospheric environment (i.e., compliance with regulatory standards). Effects are described using the criteria defined in Table 7.7-1 and reflect the effects criteria provided in the TOR (Appendix 2-B). Together, these criteria are used to describe the nature (e.g., severity or intensity of change, and the area and amount of time over which the change occurs) and type (e.g., direction of the change) of an effect on a VC. The focus of the EIS is to predict whether the Project is likely to cause a significant adverse (i.e., negative) effect on the environment. Therefore, positive effects are not assessed for significance.

Table 7.7-1: Definitions of Residual Effects Criteria Used to Evaluate Significance for the Atmospheric Environment

Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Negligible to Low: No measureable change in air quality or the change is predicted to be less than the applicable criteria. GHG emission is below 1% of the provincial emission. **Moderate:** Change in air quality is predicted to be above applicable criteria and is less than 2 standard deviations from Base Case conditions. GHG emission is below 1% of the national total emission. **High:** Change in air quality is predicted to be above applicable criteria and is greater than 2 standard deviations from Base Case conditions. GHG emission is above 1% of the national total emission.	**Local:** Predicted maximum spatial extent of direct and indirect effects from changes to measurement indicators due to a project or activity. **Regional:** Residual effects from changes to measurement indicator due to a project or activity exceed the local scale and can include cumulative effects from other developments in the effects study area. **Beyond Regional:** Residual cumulative effects from changes to measurement indicator due to a number of developments extend beyond the effects study area.	**Short-term:** Residual effect from change to measurement indicator is reversible at end of construction of Project. **Medium-term:** Residual effect from change to measurement indicator is reversible at end of operations of Project. **Long-term:** Residual effect from change to measurement indicator is reversible within a defined length of time past closure of a Project. **Permanent:** Residual effect from change to measurement indicator is irreversible.	**Infrequent:** Residual effect from change to measurement indicator is confined to a specific discrete event. **Frequent:** Residual effect from change to measurement indicator occurs intermittently over the life of the Project. **Continuous:** Residual effect from change to measurement indicator occurs continuously.	**Reversible:** Residual effect from change to measurement indicator is reversible within a time period that can be identified when a development or activity no longer influences air quality. **Irreversible:** Residual effect from change to measurement indicator is predicted to influence air quality indefinitely (i.e., duration of effect is permanent).	**Unlikely:** Residual effect from change to measurement indicator is possible but unlikely (less than 10% chance of occurrence). **Likely:** Residual effect from change to measurement indicator may occur, but is not certain (10% to 80% chance of occurring. **Highly Likely:** Residual effect from change to measurement indicator is likely to occur or is certain (greater than 80% chance of occurring).

GHG = greenhouse gases; % = percent

Magnitude – Magnitude is a measure of the intensity of an effect on a VC, or the degree of change caused by the Project relative to Base Case conditions, guideline, or established threshold values. Magnitude is specific to each VC and is classified into three scales: negligible to low, moderate, and high. For the atmospheric environment, magnitude is a function of numerical changes in measurement indicators (e.g., numerical changes in annual ground-level NO_2 concentrations). The evaluation of magnitude is based on the predicted change from application of the Project with respect to Base Case conditions and the applicable air quality standards. For example, a negligible to low magnitude would be assigned if the change in the measurement indicators for air quality is predicted to be less than the applicable criteria. A high magnitude would be assigned if the change in the measurement indicators for air quality is predicted to be above applicable criteria and is greater than 2 standard deviations from Base Case conditions.

Determining the magnitude of potential effects on climate change is subjective as there are no specific thresholds or criteria that define whether an effect is expected to occur. Instead, potential effects on climate change typically are assessed quantitatively through comparison of Project-related emissions of greenhouse gases to total federal and provincial/territorial GHG emission levels. For example, a low magnitude would be assigned if the predicted GHG emission is below 1% of the provincial emission, and high magnitude when the GHG emission is above 1% of the national total emission.

Geographic Extent – Geographic extent refers to the spatial extent of the area affected and is different from the spatial boundary (i.e., ESA) for the effects analysis. The study area for the effects analysis represents the maximum area used for the assessment (Section 7.2.1). However, the geographic extent of effects can occur on a number of scales within the spatial boundary of the assessment and is VC-specific. Effects at the local scale are largely associated with the predicted maximum spatial extent of combined direct and indirect changes from the Project (i.e., cumulative effects that are specific to the Project). Effects at the regional scale occur within the ESA, and are associated with incremental and cumulative changes from the Project and other developments. The beyond regional scale includes cumulative residual effects from the Project and other developments that extend beyond the ESA.

Duration – Duration is VC-specific and defined as the amount of time from the beginning of a residual effect to when the residual effect on the atmospheric environment is reversed. It is usually expressed relative to Project phases (usually in years). Duration has two components, the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases), plus the time required for the effect to be reversible. Essentially, duration is a function of the length of time that VCs are exposed to Project activities and reversibility of the effect. By definition, residual effects that are short-term, medium-term, or long-term in duration are reversible.

7.7.1.2 Determination of Significance

The classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of incremental and cumulative effects from the Project and other existing and approved developments on the assessment endpoint for the atmospheric environment. The evaluation is focused on determining the significance of cumulative effects on compliance with regulatory emission guidelines and standards.

Magnitude is the primary criterion used to determine environmental significance, while other criteria are used as modifiers and to provide context when assigning magnitude. Geographic extent and duration provide important context for classifying the magnitude of effects on atmospheric environment assessment endpoints. Frequency and likelihood are considered as modifiers when determining significance, where applicable.

The evaluation of significance for the atmospheric environment considers the entire set of primary pathways that influence the assessment endpoint; thus, significance is not explicitly assigned to each pathway. Rather, the relative contribution of each pathway is used to determine the significance of the Project and other developments on the assessment endpoint, which represents a weight of evidence approach (i.e., evaluating the persuasiveness of evidence indicating that an effect is significant or not significant). For example, a pathway with a high magnitude, a large geographic extent, and a long-term duration is given more weight in determining significance relative to pathways with smaller scale effects. The relative effect from each pathway is discussed; however, pathways that are predicted to have the greatest influence on changes to the assessment endpoint are assumed to contribute the most to the determination of environmental significance.

The determination of environmental significance on the atmospheric environment considered the following key factors.

- Results from the residual effect classification of primary pathways and associated predicted changes in measurement indicators.
- Magnitude is the primary criterion used to determine significance with geographic extent and duration providing important context for assigning magnitude. Frequency and likelihood act as modifiers for determining significance, where applicable.
- The level of confidence in predicted effects, established guidelines and standards, and experienced opinion are included in the evaluation of determining environmental significance.

This method is used to identify predicted residual adverse effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to the atmospheric environment, and therefore, result in significant effects. The following definitions are used for predicting the significance of effects on compliance with regulatory air emission guidelines and standards.

Not significant – The predicted change in air quality is below applicable standards or is less than 2 standard deviations from Base Case conditions. Greenhouse gas emissions are below 1% of the national total GHG emission.

Significant – The predicted change in air quality is above applicable criteria and is greater than 2 standard deviations from Base Case conditions. Greenhouse gas emissions are above 1% of the national total GHG emission. High magnitude and irreversible changes at the local to regional scale would be considered significant.

7.7.2 Results

A summary of the residual effects classification and predicted significance on the atmospheric environment is provided in Table 7.7-2.

Table 7.7-2: Summary of Residual Effects Classification of Primary Pathways and Predicted Significance of Cumulative Effects on Atmospheric Environment

Pathway	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Significance for Assessment Endpoint
Air emissions and dust deposition cause changes to air quality	Negligible to low	Regional	Medium-term	Continuous	Reversible	Highly likely	Not significant
Greenhouse gas emissions from the Project can contribute to climate change	Moderate	Beyond Regional	Long-term	Continuous	Reversible	Highly likely	

Lower overall emissions are anticipated during Project construction relative to operations as most of the emission sources from the core facilities area would not be operational during the construction period. While mobile equipment-generated exhaust emissions and associated road dust emissions are expected to be greater during construction, these sources of emissions are expected to be relatively minor in comparison to emission sources from the core facilities area during operations. The potential sources of emissions from Project decommissioning and reclamation are similar to those during construction; however, decommissioning and reclamation are expected to require less equipment and effort, and therefore less emissions intensity. Dust emissions from the Project are not expected to result in measureable residual effects on the atmospheric environment (negligible to low magnitude).

The air quality assessment for operations considered how Project emissions affect local air quality by conducting dispersion modelling. The predicted ground-level concentrations were compared to the SAAQS or other criteria, as applicable. The Project will result in an increase in emissions of NO_2, SO_2, CO, $PM_{2.5}$, PM_{10}, TSP, and KCl. The dispersion modelling results show that the Project-related increase in NO_2, SO_2, CO, $PM_{2.5}$, PM_{10}, TSP concentrations, and KCl deposition are limited to the ESA. The extent of Application Case concentrations of NO_2, NO_2, CO, $PM_{2.5}$, TSP, and deposition of KCl are in compliance with the applicable criteria outside of the core facilities area and at all community receptors.

The Application Case maximum predicted PM_{10} concentrations exceed the ambient air quality standard for an average of 3 days during the modelling years (2003 to 2007) over an area of 0.19 ha. However, concentrations of PM_{10} above the SAAQS result from the high Base Case (i.e., background) concentrations prescribed for use in the Saskatchewan AQMG. The Base Case concentration of PM_{10} used in the assessment is 36.3 µg/m³. This prescribed AQMG value was derived from urban measurements; there is no rural PM_{10} background concentration data available from the Saskatchewan MOE. High-quality measurements in rural North Dakota and Montana indicate background concentrations of PM_{10} are approximately 17.9 µg/m³; a value that does not result in a maximum plus background PM_{10} concentration that would exceed the SAAQS for the Application Case.

The magnitude of the predicted concentrations is negligible to low and regional in geographic extent. The changes to air quality will mostly be reversed at the conclusion of Project operations and will be completely reversed following decommissioning and reclamation because air emissions and effects cease when Project activities are completed.

The Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment states: "…the contribution of an individual project to climate change cannot be measured" (FTPCCCEA 2003). This assessment has determined that greenhouse gas emissions from the Project represent a 1.08% increase in the provincial total emissions and 0.16% increase in national total emissions. The magnitude of these GHG emissions is moderate. While the effect of the Project's GHG emissions on climate may not be quantifiable, they are reversible in the long-term (i.e., decades) following completion of decommissioning and reclamation of the Project. Overall, effects to air quality were classified as not significant.

7.8 Monitoring and Follow-up

Typically, monitoring includes compliance monitoring and follow-up, which may be applied during the development of the Project. These programs form part of the environmental management system for the Project. Adaptive management will be implemented if monitoring or follow-up detects effects that are different from predicted effects or the need for improved or modified design features and mitigation. This may include increased monitoring, changes in monitoring plans, and additional mitigation.

Compliance monitoring involves monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments.

Follow-up programs are designed to test the accuracy of effects predictions, reduce/address uncertainties, determine the effectiveness of environmental design features, and/or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., monitoring of downstream lakes for aquatic effects, wildlife effects monitoring, and socio-economic monitoring). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

The Environmental Protection Plan implemented for the Project will be managed on site by qualified personnel. Current monitoring for the atmospheric environment includes continuous measurements of basic meteorological and air quality parameters. The meteorological sensors measure temperature, relative humidity, wind speed, wind direction, and solar radiation; air quality measurements include NO_x (NO and NO_2), TSP, and $PM_{2.5}$.

7.9 Summary and Conclusions

The potential environmental effect of the Project on the atmospheric environment was assessed using an air quality modelling approach. The assessment employed the MOE approved AERMOD air quality model and was conducted in accordance with the Saskatchewan Air Quality Modelling Guidelines. The air emissions during construction and decommissioning and reclamation were determined to be less than during operations in emission intensity and in duration. Therefore, the air quality assessment focused on the Project's operations. The air quality assessment for Project operations was completed by comparing the Project's predicted cumulative changes to air quality and the Base Case conditions to applicable ambient air quality standards.

The modelling results show that other than ground-level 24-h PM_{10} concentrations, Application Case maximum predicted NO_2, SO_2, CO, $PM_{2.5,}$ and TSP concentrations, and KCl deposition for all averaging periods complies with their respective ambient air quality standards. The magnitude of the changes to air quality is negligible to low and are regional in geographic extent. The Project's greenhouse gas emissions result in an approximately 1% increase in total provincial emissions and 0.16% increase in total national emissions. It is concluded that the Project's cumulative effects on the atmospheric environment are not significant.

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7.11 Glossary

Term	Description
AERMOD	A steady-state dispersion model designed for short-range (i.e., up to 50 kilometres) dispersion of air pollutant emissions from stationary industrial sources.
Air Emission	Release of pollutants into the atmosphere from stationary sources and mobile equipment.
Air Quality	Air quality describes the concentration of air pollutants in the air.
Air Quality Modelling	Mathematical simulation of how air pollutants disperse in the ambient atmosphere.
Ambient	The conditions surrounding an organism or area.
Atmospheric Environment	The envelope of air surrounding the Earth, including its interfaces and interactions with the Earth's solid or liquid surface.
Baghouse	An air pollution control device that reduces particulate emissions prior to their release into the ambient atmospheric environment.
Best Practice	Method or procedure that is accepted by industry as being effective, practical and reliable in maintaining quality, and meeting Project objectives and regulatory requirements.
Biophysical	An interdisciplinary science using methods of, and theories from, physics to study biological systems.
Climate Change	A long-term shift in weather patterns.
Deposition	The process by which gas or particles collect or deposit themselves on solid sufaces, decreasing the concentration of gas or particles in the air.
Greenhouse Gas	A gas that contributes to the greenhouse effect by absorbing infrared radiation (e.g., carbon dioxide and chlorofluorocarbons).
Socio-economic	The social science that studies how economic activity affects social processes.
TSP	Particulates with aerodynamic diameter up to 40 micrometres.

8.0 HYDROGEOLOGY

8.1 Introduction

8.1.1 Background

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project) located in central Saskatchewan, approximately 60 kilometres (km) north of Regina. Yancoal proposes to develop the Project, which includes solution mining and associated supporting infrastructure.

The Project is located in the Rural Municipality (R.M.) of Longlaketon (No. 219) and the R.M. of Cupar (No. 218). An existing network of municipal grid roads, provincial highways, and rail lines will provide access to the Project. The Project (including the core facilities area, 65-year mine field, and indicated resource boundary) encompasses approximately 143 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M).

8.1.2 Purpose and Scope

This section of the Environmental Impact Statement (EIS) for the Project addresses the effects on hydrogeology identified in the Terms of Reference (TOR) approved by the Environmental Assessment Branch (EAB) of the Ministry of Environment (MOE) in May 2015 (Appendix 2-B).

The purpose of this section is to meet the TOR, specifically to assess the effects from the Project on groundwater. The scope of this section includes an analysis of Project-related changes during construction, operation, and decommissioning and reclamation. The incremental and cumulative residual effects from the Project and other previous, existing, and reasonably foreseeable developments on hydrogeology are assessed.

Strong relationships exist between the quality and quantity of groundwater and components of the surface water and terrestrial environments, and the people that use these resources. As such, related assessments are provided in the following sections:

- Hydrology (Section 9.0);
- Surface Water Quality (Section 10.0);
- Fish and Fish Habitat (Section 11.0);
- Soils (Section 12.0);
- Vegetation (Section 13.0);
- Wildlife (Section 14.0); and
- Socio-economic Environment (Section 16.0).

8.1.3 Valued Components, Assessment Endpoints, and Measurement Indicators

The TOR identified groundwater as a valued component (VC) that should be included in the assessment of effects on hydrogeology. Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by the proponent, the public, First Nations and Métis communities, and government agencies. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development and, therefore, are used to predict the effects of the Project on all environmental components. Rationale for selection of hydrogeology as a VC is as follows:

- sensitivity to Project-related effects;
- can be measured or described with one or more practical indicators; and
- changes to hydrogeology can influence other aquatic, terrestrial, and societal components.

Community and regulatory engagement, and local and traditional knowledge were key considerations for selecting VCs, but assessment endpoints for groundwater do not explicitly consider societal values, such as continued opportunity for the human use of groundwater. Changes in groundwater are important and must be considered to understand the full suite of potential effects of the Project (i.e., both human and ecological dimensions). Consequently, measurement indicators from the hydrogeology section were carried forward so that effects on societal values could be appropriately captured in the sections dealing specifically with those values (Section 16.0).

Assessment endpoints are qualitative expressions used to assess the significance of effects on a VC and represent the key properties of the VC that should be protected for use by future human generations (i.e., incorporate sustainability). Assessment endpoints are general statements about what is to be protected. Measurement indicators are quantitative and/or qualitative expressions of changes to the assessment endpoints. The assessment endpoint for the hydrogeology VC is continued suitability of groundwater for human use. The measurement indicators include the following:

- groundwater chemistry;
- groundwater levels; and
- vertical and horizontal migration.

8.2 Environmental Assessment Boundaries

8.2.1 Spatial Boundaries

8.2.1.1 Baseline and Effects Study Areas

To quantify baseline conditions, baseline study areas were defined for hydrogeology and included a regional study area (RSA) and local study area (LSA).

The RSA was defined at a scale to encompass Townships 20 to 31 and within Ranges 11 to 24 W2M. The area includes predominate surficial features such as Last Mountain Lake and the Qu'Appelle Valley (Figure 8.2-1). The northern and eastern boundaries were selected to approximately parallel the watershed boundaries of Quill Lakes and Assiniboine River, which represent flow divides. The western and southern boundaries were selected to coincide with Last Mountain Lake and the Qu'Appelle Valley, respectively. These features represent zones of groundwater discharge. Hydrologic and hydrogeologic systems will operate independently west and south of these natural barriers. The scale of the RSA was set large enough so that any modeling boundary conditions are unlikely to affect the subsequent development of a local scale groundwater flow model within the KP377 and KP392 permit areas.

The LSA is mainly focused on KP377 and KP392 permit areas and encompasses Townships 23 to 26, Ranges 16 to 21 W2M (Figure 8.2-1). The ground surface within the KP377 and KP392 permit areas is mainly a ridged moraine formation that generally drains to the west and south with water collecting in the Last Mountain Lake area and in the Qu'Appelle Valley. A detailed study was conducted in the LSA providing definition of an area in relative close proximity to the core facilities area. The hydrogeology effects study areas (ESA) is the same boundary as the LSA (Figure 8.2-1).

8.2.2 Temporal Boundaries

Temporal boundaries for the hydrogeology assessment were defined by the life of the Project (Section 4.0) and the existing and future cumulative effects to which the Project might contribute. The Project phases are construction, operation, and decommissioning and reclamation. Final relinquishment of the Project will occur after the completion of reclamation.

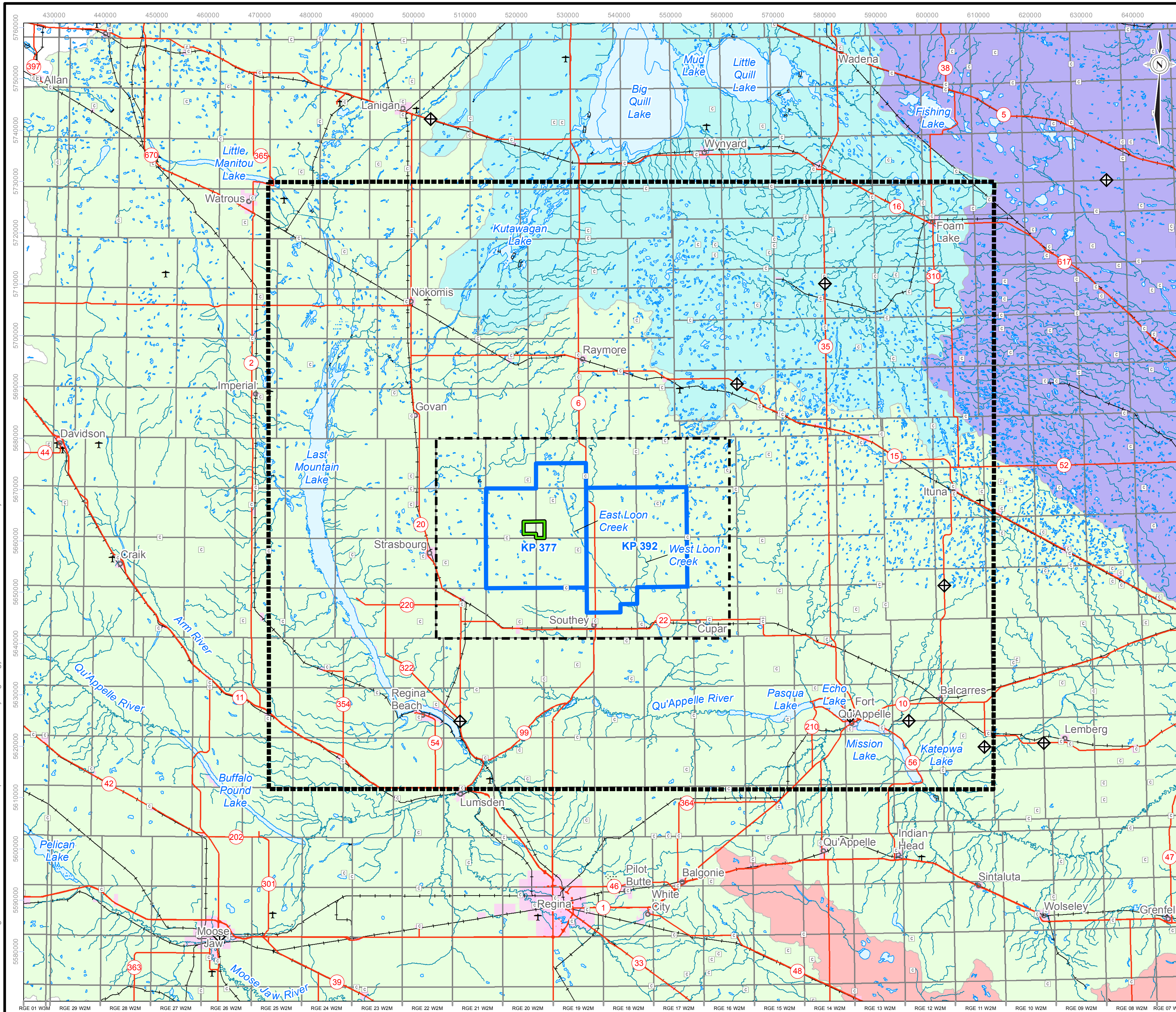
The effects analysis encompasses the Project phases as follows:

- construction (2016 to 2019);
- operations (2019 to 2119); and,
- decommissioning and reclamation (2119 onward).

The above timeframes are intended to be sufficiently flexible to capture the effects of the Project on the hydrogeology VC. Effects on hydrogeology begin during the construction phase and continue through the decommissioning and reclamation phase (unless determined to be permanent). Therefore, effects on hydrogeology were analyzed from Project construction through decommissioning and reclamation. This approach generates the maximum potential spatial and temporal extent of effects on groundwater.

8.2.2.1 Base Case

The Base Case (existing environment) represents existing conditions before application of the Project. Existing conditions include the cumulative effects from all previous and existing developments and activities.



G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1085 - Hydrogeology\12-1362-0197 - Baseline and Effects Study Area.mxd Date: 5/27/2015 3:15:28 PM

LEGEND

- COMMUNITY
- HISTORIC SITE/POINT OF INTEREST
- CEMETERY
- HIGHWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- PERMIT BOUNDARY
- CORE FACILITIES AREA
- REGIONAL STUDY AREA
- LOCAL AND EFFECTS STUDY AREA
- ASSINIBOINE RIVER BASIN
- QU'APPELLE RIVER BASIN
- QUILL LAKES BASIN
- SOURIS RIVER BASIN

REFERENCE

WATERSHED BASINS OBTAINED FROM PFRA/AGRICULTURE AND AGRI-FOOD CANADA
POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
CANVEC © NATURAL RESOURCES CANADA
NTS MAPSHEET: 62L/M, 72I/J/O/P
NAD83 UTM ZONE 13

15 0 15
SCALE 1:750,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
LOCATION OF THE HYDROGEOLOGY BASELINE AND EFFECTS STUDY AREAS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	CH	13/05/14	SCALE AS SHOWN REV. 0
GIS	LMS	27/05/15	FIGURE:
CHECK	CK	27/05/15	8.2-1
REVIEW	MAT	27/05/15	

8.2.2.2 Application Case

The incremental contributions of residual effects from the Project to existing cumulative effects were assessed by adding the Project to the Base Case to form the Application Case. Maximum effects on groundwater are expected to occur during the operations and decommissioning phases of the Project. The incremental contributions of the Project and the cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are predicted in order to evaluate changes to measurement indicators for hydrogeology during the Application Case.

8.2.2.3 Reasonably Foreseeable Development Case

The Reasonably Foreseeable Development (RFD) Case represents the Application Case plus reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. The minimum temporal boundary for the Application Case and RFD Case is the expected lifespan of the Project that, like the Base Case, includes a range of conditions over time. The difference between the Application and RFD Case is that the Application Case considers the incremental effect from the Project in isolation of potential future land use activities. The RFDs are defined as projects that:

- are currently under regulatory review or have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project or may be induced by the Project;
- have been approved but not yet developed; or
- have the potential to change the Project or the effects predictions.

The reasonably foreseeable developments identified in Section 6.0 include the supporting infrastructure required for the Project, the Muskowekwan Potash Mine Project and the Vale Kronau Project. Supporting infrastructure will include a water supply pipeline, an overhead transmission line, a natural gas supply pipeline, telecommunication services, and a railway line. Screening assessment reports will be completed by each of the utility providers, once the final routing options are determined; the final routing options are not known at this time. The Muskowekwan Potash Mine Project is located about 52 km northeast of the Project and the Vale Kronau Project is located approximately 71 km south of the Project; both are outside the ESA. Effects on groundwater from the development of the Muskowekwan Potash Mine Project and the Vale Kronau Project are not expected to overlap with effects on groundwater in the ESA. Therefore, the RFD Case is not included in this section of the EIS.

8.3 Existing Environment

The purpose of this section is to describe the existing environment (Base Case) for hydrogeology within the ESA as a basis to assess the potential Project-specific effects on groundwater. The detailed methods and results for baseline data collection are located in the Hydrogeology Baseline Report (Annex II, Section 4.0).

The groundwater flow system acts as a link between the atmospheric, terrestrial, and aquatic environments. Infiltration of precipitation from upland surface water bodies to the subsurface results in groundwater recharge and induces flow through water-bearing geologic units, ultimately discharging in topographically low-lying areas often coincident with surface watercourses.

The geologic units within the ESA can be grouped as hydrostratigraphic units of aquifers and aquitards. An aquifer is composed of sediments that are sufficiently permeable to supply economic quantities of water. An aquitard refers to low permeability deposits that act as a confining layer, which is capable of storing water and transporting it from one aquifer to another, but is not capable of supplying useable quantities of water (Fetter 2001). A hydrostratigraphic unit has considerable lateral extent and is connected to the hydrological system through groundwater recharge and discharge.

8.3.1 Methods

Characterization of site geology provides the framework for defining potential interactions between the Project and the subsurface environment. Studies were undertaken to define the presence and spatial extent of geological units within the RSA. Methods included review of existing reports on the geology of the area, compilation of historical borehole data within the RSA, and an airborne geophysical survey of the ESA. Intrusive investigations were undertaken within the ESA, which included geotechnical and stratigraphic drilling, down-hole geophysical wireline logging, analytical soil testing, and geotechnical soil index testing. Detailed descriptions of methods are presented in Annex II (Section 4.0).

Borehole stratigraphy was interpreted from soil lithology, analytical testing data, geotechnical index testing data, and down-hole geophysical data. Interpreted borehole stratigraphy developed from current and historical data were compiled into a geological model of the ESA. The model serves as the central repository for all geological data used to characterize sub-surface conditions.

The commercially available software package RockWorks was used to create a three-dimensional (3-D) model of site stratigraphy by interpolating stratigraphic data between boreholes to produce a surface for each stratigraphic unit. These surfaces were then layered to produce a 3-D representation of the stratigraphy of the ESA. Isopachs of stratigraphic layers, cross-sections, and surface contours can all be generated by RockWorks using this 3-D model. The geological model forms the basis for development of groundwater flow models of the ESA.

Studies were undertaken to classify geologic units according to their role in the hydrogeological system as aquifers or aquitards. This entailed a review of existing literature related to the hydrogeology of the ESA, compilation of historical hydrogeological data, hydraulic testing of geologic units, and collection of baseline groundwater hydraulic head and chemistry data. The above information was used in conjunction with the extents of hydrostratigraphic units provided in the geological model as the basis for the development of a conceptual hydrogeological model.

A numerical groundwater flow model was developed based on the site geology and conceptual hydrogeological model and calibrated to observed conditions as a means of interpretation of the groundwater flow system. Geological and hydrogeological site characterization form the basis for the subsequent development of a solute transport model that will be integral to the design of key waste management facilities and the assessment of the groundwater flow pathways in connection with the Project.

8.3.2 Results

The near-surface geology of southern Saskatchewan is the result of multiple glacial advances and retreats occurring from approximately 20,000 to 14,000 years ago, resulting in a blanket of glacial drift over much of the bedrock surface. Drift deposits consist of till interbedded with stratified deposits of silt, sand, and gravel and can be present at thickness up to 300 metres (m) (Maathuis 1992). The Surficial Stratified Deposits (SSD) were mainly deposited by postglacial streams and lakes. The texture of the SSD grades progressively from sand and gravel in the apex of the deltas to clay in the deeper parts of the basins (Simpson 2004). In general, the stratified deposits form aquifers, which are isolated by the till and clay-shale units and act as confining strata (i.e., aquitards). The generalized stratigraphy and hydrostratigraphy are presented in Figure 8.3-1.

Thick Cretaceous age deposits of highly over-consolidated silt and clay shale comprise the underlying bedrock throughout the region. The extent of these shale deposits is great and they are considered a reliable geological datum (Saskatchewan Agriculture 1986). Due to the thickness and low permeability of these shales, the top boundary is taken to be the base of regional groundwater near surface flow systems (Maathuis and van der Kamp 1988). The outcropping of these shale deposits is minimal and is associated with river valleys and other erosional features. The cretaceous bedrock surface within the ESA is presented in Figure 8.3-2.

Bedrock of the Cretaceous-aged Lower and Upper Colorado Groups consist almost entirely of shale deposits with some minor sandstone, siltstone, and conglomerate deposits. The Cretaceous-aged Montana Group contains the top-most sequence of shale and sandstones continuing upwards to the base of the Quaternary/Tertiary deposits. In the ESA, these consist of the Lea Park Formation, Judith River Formation, and the Bearpaw Formation, in ascending order. The Lea Park and Bearpaw Formations are lithologically identical shale deposits, separated by the fine-grained sandstone and siltstone of the Judith River Formation. In eastern Saskatchewan, where the Judith River Formation pinches out, the Lea Park and Bearpaw Formations are referred to collectively as the Pierre Shale.

Several processes altered the bedrock topography (Simpson 2004). These included preglacial erosion and deposition, glacial fluvial and glacial erosion, and collapse. Preglacial rivers flowing from the Rocky Mountains eastward across Saskatchewan created channel features within the bedrock surface. Glacial action and meltwater created moraine features and glaciofluvial meltwater channels, especially within the Qu'Appelle Valley.

The near surface sediments in southern Saskatchewan consist of multiple layers of Quaternary stratified drift underlain by Tertiary/Quaternary fluvial deposits. The fluvial deposits of the Empress Group that are overlying the bedrock were encountered in the ESA. Above this, in ascending order are the glacial "drift" deposits of the Sutherland Group followed by the Saskatoon Group. Each group has distinct geological compositions and geographic extents. The Empress Group, Sutherland Group, and Saskatoon Group appear to be contiguous across the ESA. Borehole locations within the ESA are presented on Figure 8.3-3 and stratigraphic sections are presented on Figures 8.3-4 and 8.3-8.

The ground surface in the RSA is a mixture of glacial lacustrine, glacial fluvial, and moraine features. The major drainage features of the RSA and ESA are Last Mountain Lake Basin in the northwest and East Loon Creek and West Loon Creek flowing to the Qu'Appelle Valley. The ground surface topography within the RSA is shown on Figure 8.3-9.

Period	Composite Stratigraphy			Lithology	Hydrostratigraphic Unit	
Quaternary	Alluvium/Colluvium			clay, silt and sand	Aquifer/Aquitard	
	Surficial Stratified Deposits			Sand & Gravel	Aquifer	Surficial Sand Aquifer
	Saskatoon Group	Battleford Formation		till	Aquitard	Saskatoon Group Aquifer/Aquitard
				sand and gravel	Aquifer	
		Floral Formation	Upper Floral Till	till	Aquitard	
			Riddell Member	sand and gravel	Aquifer	
			Lower Floral Till	till	Aquitard	
				sand and gravel	Aquifer	Intertill Aquifer
	Sutherland Group	Warman Formation		till	Aquitard	Sutherland Group Aquifer/Aquitard
				sand and gravel	Aquifer	
		Dundurn Formation		till	Aquitard	
				sand and gravel	Aquifer	
		Mennon Formation		till	Aquitard	
	Empress Group			sand and gravel	Empress Group Aquifer	Empress Group Aquifer
Tertiary	Wynyard Formation			sand and gravel	Aquifer	Tertiary Aquifer "Wynyard Aquifer"
Cretaceous	Montana Group	Pierre Shale		clay and silt	Aquitard	
			Bearpaw Sands/ Ardkenneth Mb		Aquifer	Bearpaw Sand Aquifer
			Bearpaw Formation	clay and silt	Aquitard	
			Judith River Formation	silt and sand	Aquifer	Judith River Aquifer
	Upper Colorado Group	Lea Park Formation & Upper Colorado Group		clay	Aquitard	
	Lower Colorado Group/Ashville Formation			clay	Aquitard	
	Mannville Group/Swan River Formation			sand	Aquifer	Blairmore

REFERENCE

SIMPSON, M.A. 1998. GEOLOGY AND HYDROSTRATIGRAPHY OF THE ROSETOWN AREA (72O), SASKATCHEWAN. SASKATCHEWAN RESEARCH COUNCIL TECHNICAL REPORT. PUBLICATION NO.10416-2C98

SIMPSON, M.A. 2000. GEOLOGY AND HYDROSTRATIGRAPHY OF THE WYNYARD AREA (72P), SASKATCHEWAN. SASKATCHEWAN RESEARCH COUNCIL TECHNICAL REPORT. PUBLICATION NO.10416-1C00

PROJECT

YANCOAL 兖煤加拿大资源有限公司

YANCOAL SOUTHEY PROJECT

TITLE

TYPICAL HYDROSTRATIGRAPHIC COLUMN

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197		FILE No.	
DESIGN	CH	09/07/13	SCALE AS SHOWN	REV. 0
CADD	MKH	22/04/15	FIGURE: 8.3-1	
CHECK	CK	27/05/15		
REVIEW	MAT	27/05/15		

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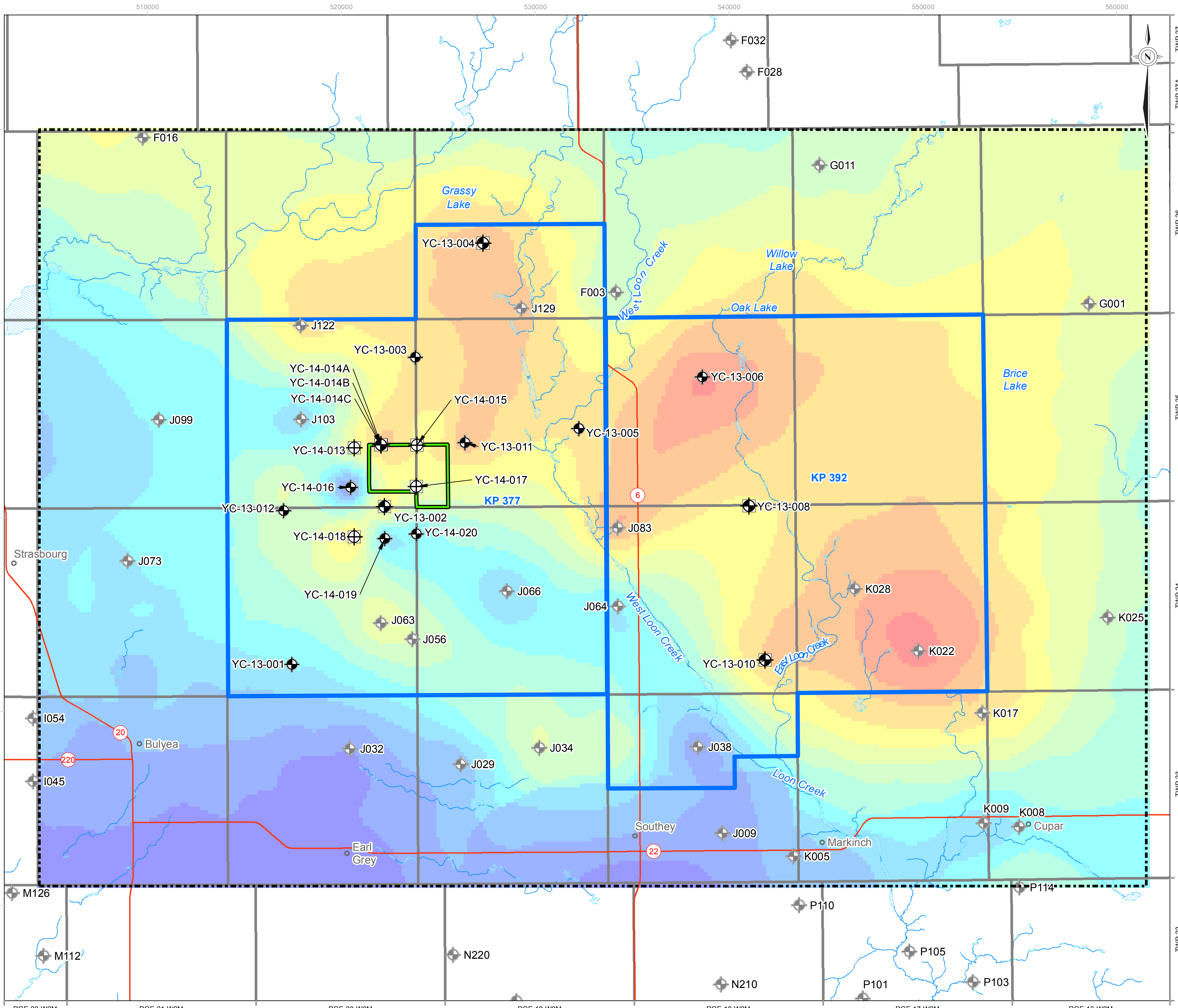


LEGEND

- COMMUNITY
- HIGHWAY
- TOWNSHIP AND RANGE BOUNDARY
- EFFECTS STUDY AREA
- PERMIT BOUNDARY
- CORE FACILITIES AREA
- BOREHOLE LOCATION
- BOREHOLE WITH STAND PIPE PIEZOMETER
- BOREHOLE WITH VIBRATING WIRE PIEZOMETER
- HISTORIC BOREHOLE

ELEVATION (mASL)

- 355 - 360
- 361 - 370
- 371 - 380
- 381 - 390
- 391 - 400
- 401 - 410
- 411 - 420
- 421 - 430
- 431 - 440
- 441 - 450
- 451 - 460
- 461 - 470
- 471 - 480

REFERENCE

POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
NAD83 UTM ZONE 13

4 0 4
SCALE 1:200,000 KILOMETRES

PROJECT

YANCOAL SOUTHEY PROJECT

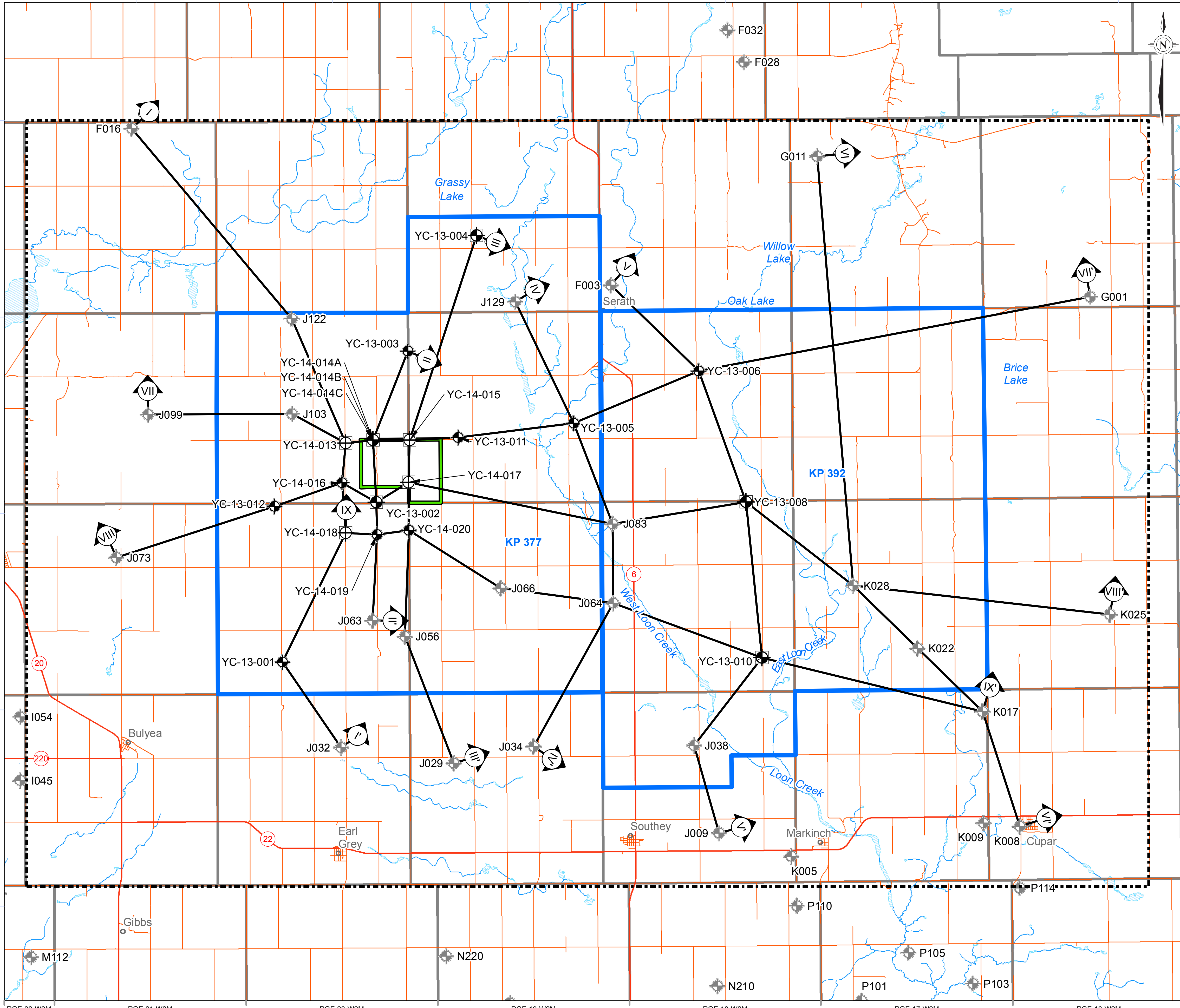
TITLE

EFFECTS STUDY AREA
CRETACEOUS BEDROCK SURFACE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	CH	12/05/14	SCALE AS SHOWN REV. 0
GIS	SM/LR	22/04/15	**FIGURE: 8.3-2**
CHECK	CK	27/05/15	
REVIEW	MAT	27/05/15	

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1085 - Hydrogeology\12-1362-0197 - ESA Cretaceous Bedrock Surface.mxd Date: 5/27/2015 3:26:12 PM



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- EFFECTS STUDY AREA
- PERMIT BOUNDARY
- CORE FACILITIES AREA
- BOREHOLE LOCATION
- BOREHOLE WITH STAND PIPE PIEZOMETER
- BOREHOLE WITH VIBRATING WIRE PIEZOMETER
- HISTORIC BOREHOLE
- CROSS SECTION

REFERENCE

POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
NAD83 UTM ZONE 13

4 0 4
SCALE 1:200,000 KILOMETRES

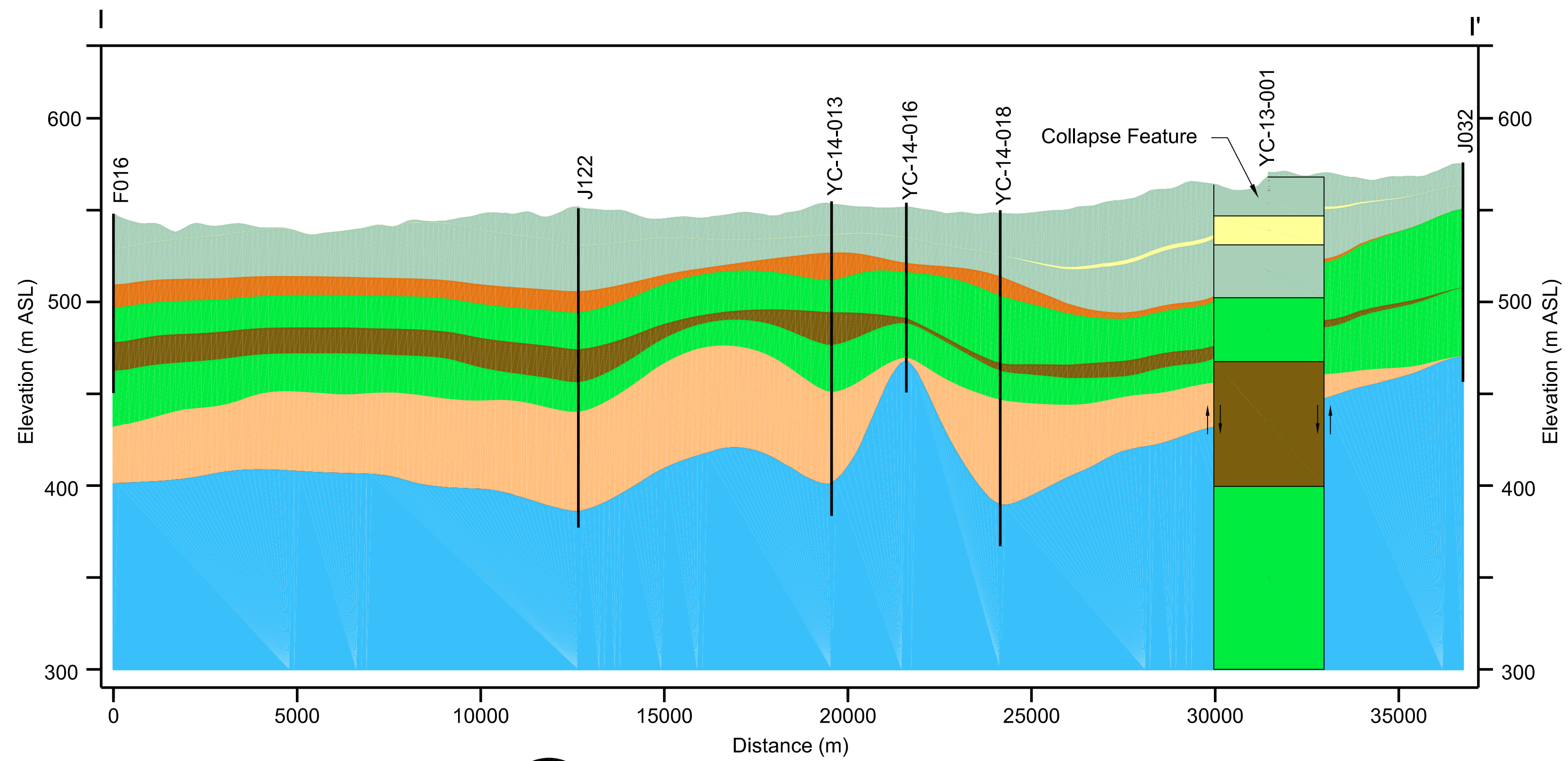
PROJECT
YANCOAL
SOUTHEY PROJECT

TITLE
EFFECTS STUDY AREA
BOREHOLE LOCATION PLAN

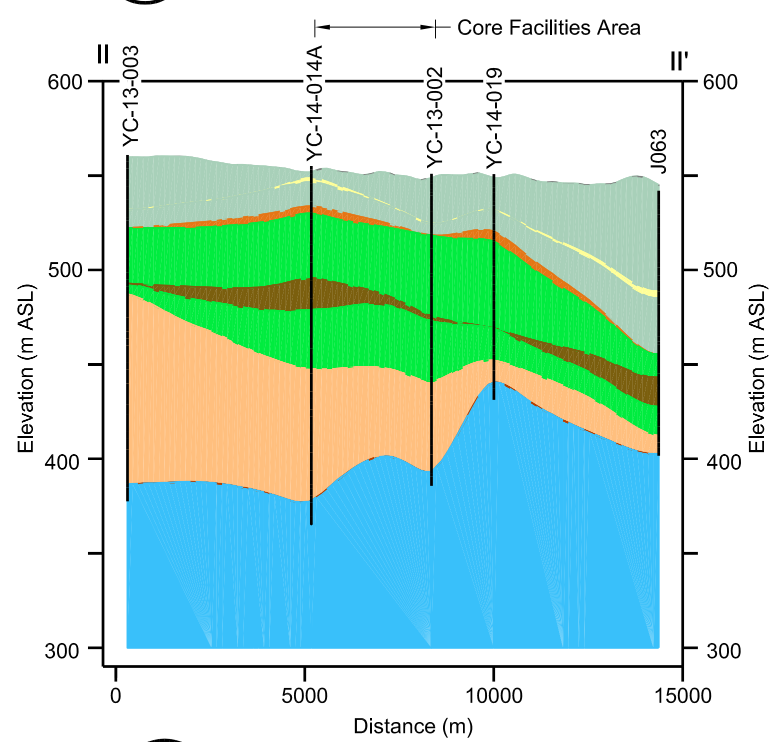
Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	CH	12/05/14	SCALE AS SHOWN	REV. 0
GIS	SM/LR	22/04/15	**FIGURE: 8.3-3**	
CHECK	CK	27/05/15		
REVIEW	MAT	27/05/15		

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1085 - Hydrogeology\12-1362-0197 - ESA Borehole Location Plan.mxd Date: 5/27/2015 3:24:52 PM



I
-
CROSS SECTION I-I'



II
-
CROSS SECTION II-II'

LEGEND

BOREHOLE LOCATION

STRATIGRAPHIC COLOUR LEGEND

- ALLUVIUM
- SASKATOON GROUP TILL
- SASKATOON GROUP AQUIFER
- INTERTILL AQUIFER
- SUTHERLAND GROUP TILL
- SUTHERLAND GROUP AQUIFER
- EMPRESS GROUP
- BEARPAW FORMATION

NOTE

DATA CONCERNING VARIOUS STRATA HAS BEEN OBTAINED AT BOREHOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE BOREHOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND MAY VARY FROM THAT SHOWN. FOR DETAILED STRATIGRAPHY OF EACH BOREHOLE LOCATION REFER TO THE RECORD OF BOREHOLE SHEETS.
ALL ELEVATIONS SHOWN IN m ASL (metres ABOVE SEA LEVEL)

REFERENCE

COLOURS BASED ON STANDARD COLOURS IN "GEOLOGICAL SITE CHARACTERIZATION GUIDELINES" BY E.K. SAUER AND E.A. CHRISTIANSEN (1996).

VERTICAL 100 0 100
SCALE 1:4,000 METRES

HORIZONTAL 5 0 5
SCALE 1:200,000 KILOMETRES

PROJECT
YANCOAL
SOUTHEY PROJECT

TITLE
EFFECTS STUDY AREA
CROSS SECTIONS I-I' AND II-II'

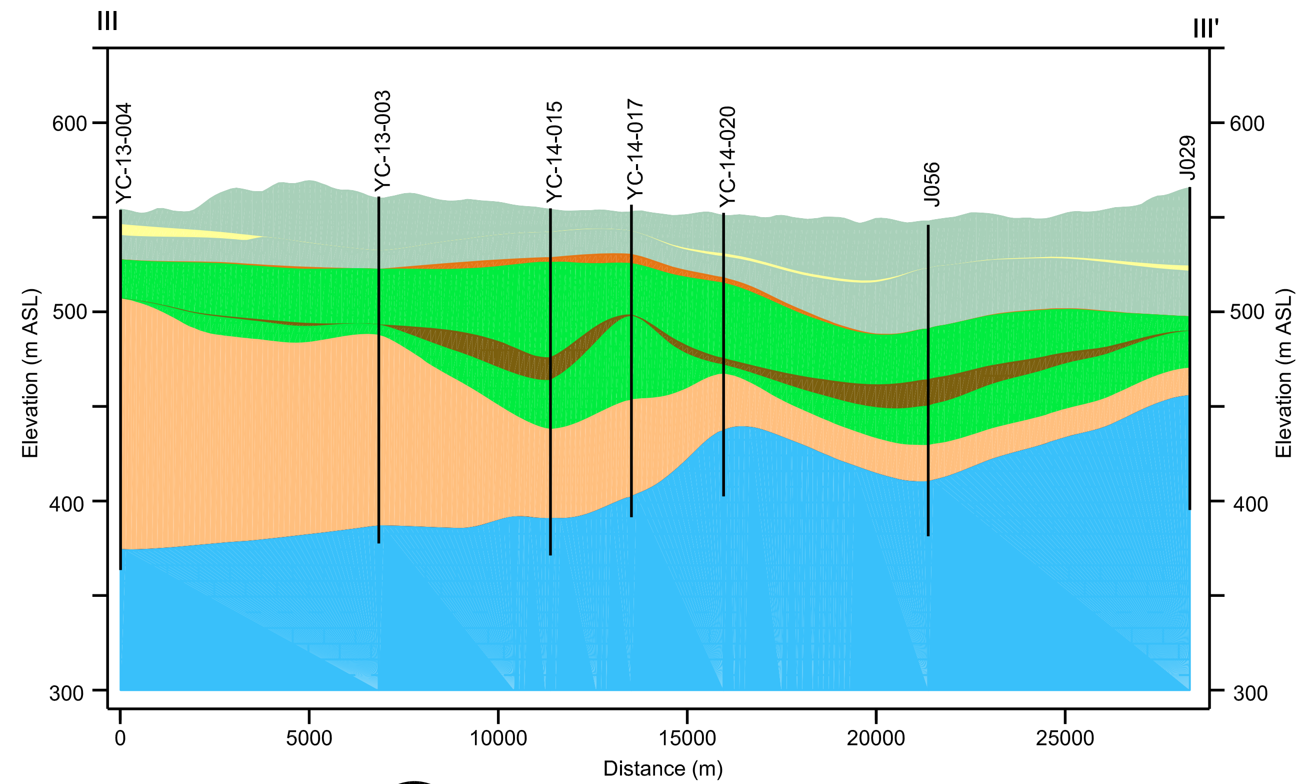
Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197	
DESIGN	CH	12/05/14
CADD	MKH	22/04/15
CHECK	CK	27/05/15
REVIEW	MAT	27/05/15

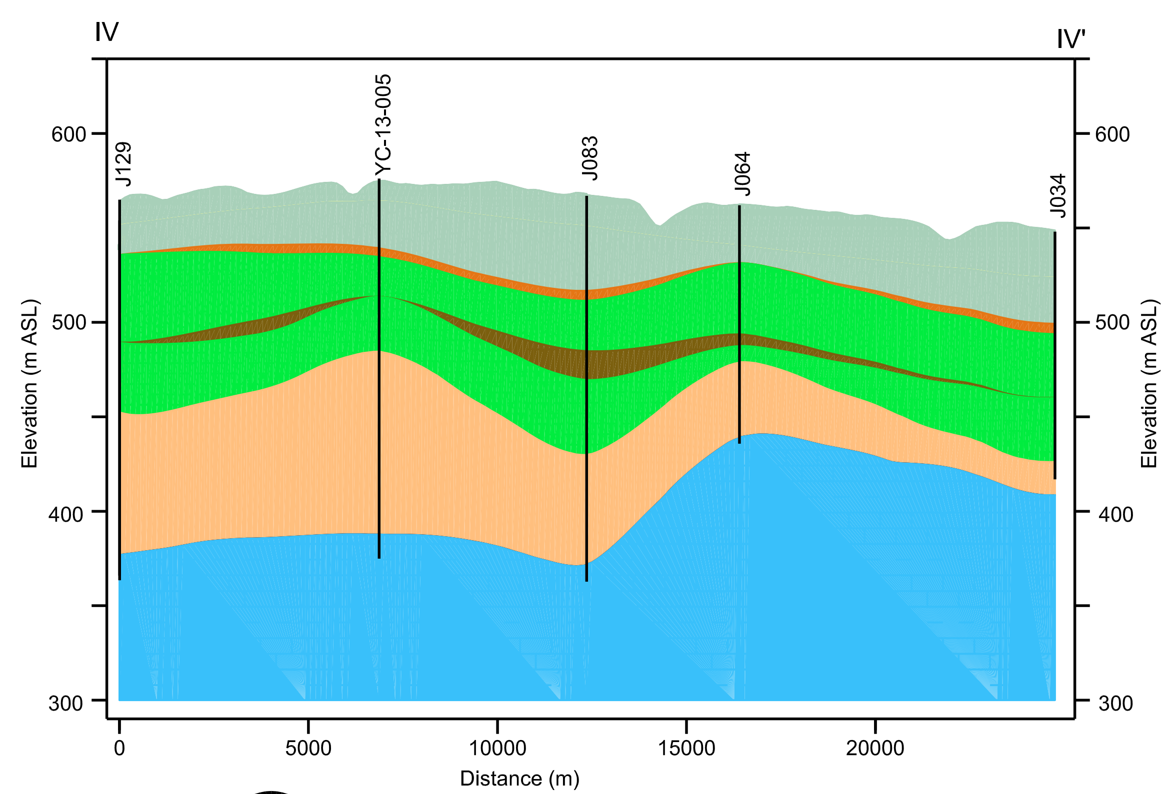
FILE No.
SCALE AS SHOWN REV. 0

FIGURE: 8.3-4

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1085 - Hydrogeology\12-1362-0197 - ESA Stratigraphic Sections.dwg 5/27/2015 3:25 PM



III - CROSS SECTION III-III'



IV - CROSS SECTION IV-IV'

LEGEND

BOREHOLE LOCATION

STRATIGRAPHIC COLOUR LEGEND

- ALLUVIUM
- SASKATOON GROUP TILL
- SASKATOON GROUP AQUIFER
- INTERTILL AQUIFER
- SUTHERLAND GROUP TILL
- SUTHERLAND GROUP AQUIFER
- EMPRESS GROUP
- BEARPAW FORMATION

NOTE

DATA CONCERNING VARIOUS STRATA HAS BEEN OBTAINED AT BOREHOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE BOREHOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND MAY VARY FROM THAT SHOWN. FOR DETAILED STRATIGRAPHY OF EACH BOREHOLE LOCATION REFER TO THE RECORD OF BOREHOLE SHEETS.
ALL ELEVATIONS SHOWN IN m ASL (metres ABOVE SEA LEVEL)

REFERENCE

COLOURS BASED ON STANDARD COLOURS IN "GEOLOGICAL SITE CHARACTERIZATION GUIDELINES" BY E.K. SAUER AND E.A. CHRISTIANSEN (1996).

VERTICAL 100 0 100 SCALE 1:4,000 METRES

HORIZONTAL 5 0 5 SCALE 1:200,000 KILOMETRES

PROJECT

YANCOAL

YANCOAL SOUTHEY PROJECT

TITLE

EFFECTS STUDY AREA CROSS SECTIONS III-III' AND IV-IV'

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	CH	12/05/14	SCALE AS SHOWN REV. 0
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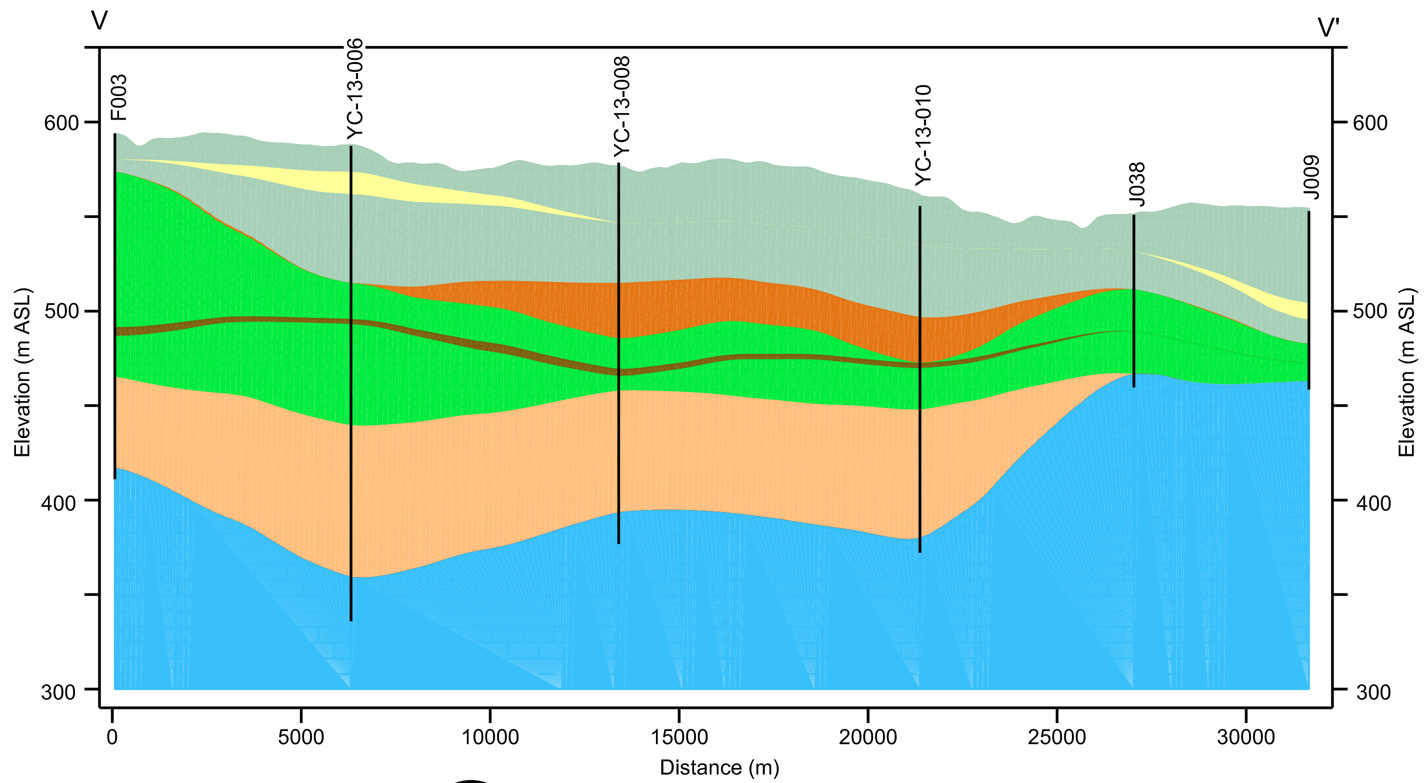
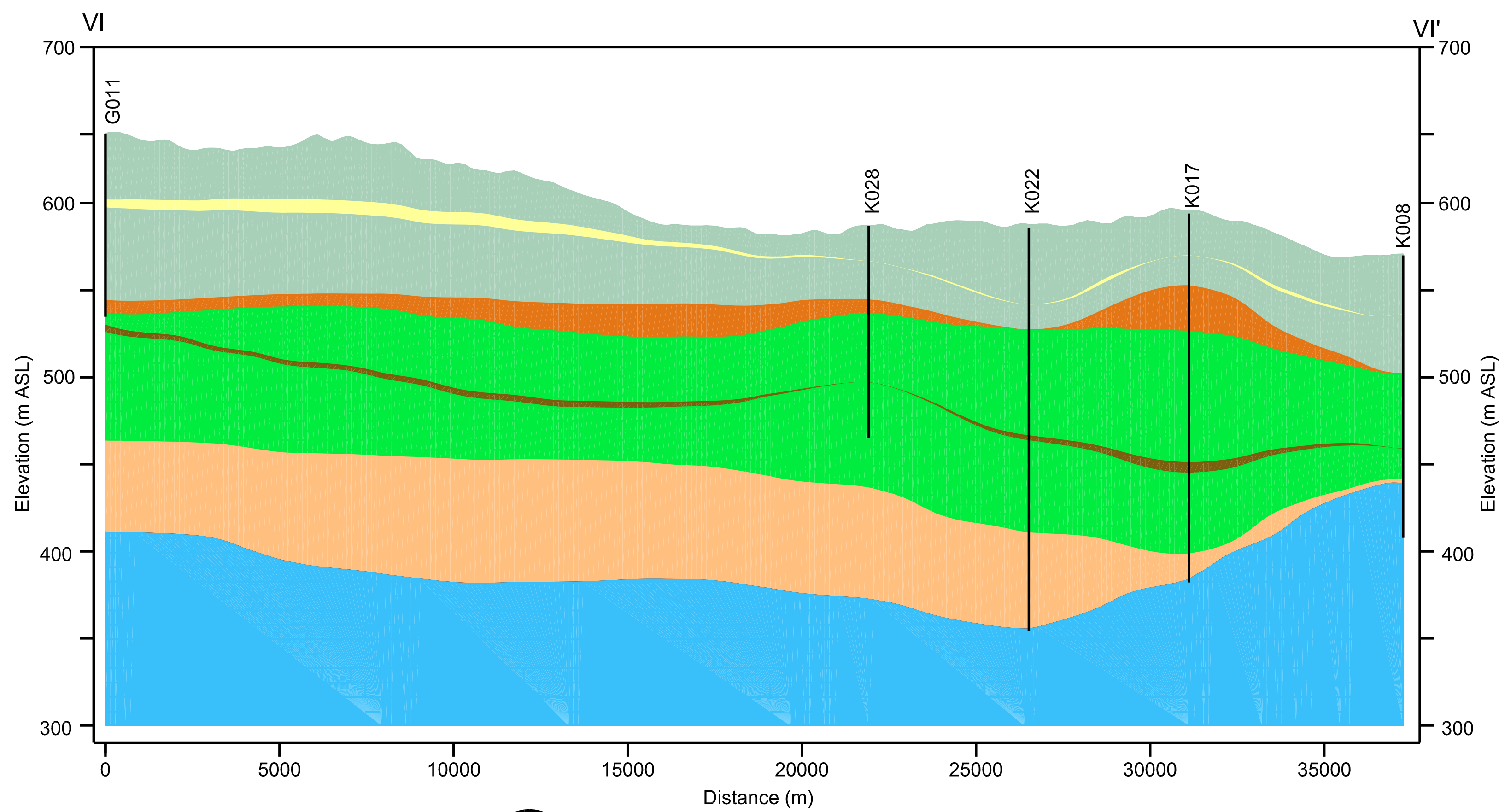


V
-
CROSS SECTION V-V'



VI
-
CROSS SECTION VI-VI'

LEGEND

BOREHOLE LOCATION

STRATIGRAPHIC COLOUR LEGEND

- ALLUVIUM
- SASKATOON GROUP TILL
- SASKATOON GROUP AQUIFER
- INTERTILL AQUIFER
- SUTHERLAND GROUP TILL
- SUTHERLAND GROUP AQUIFER
- EMPRESS GROUP
- BEARPAW FORMATION

NOTE

DATA CONCERNING VARIOUS STRATA HAS BEEN OBTAINED AT BOREHOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE BOREHOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND MAY VARY FROM THAT SHOWN. FOR DETAILED STRATIGRAPHY OF EACH BOREHOLE LOCATION REFER TO THE RECORD OF BOREHOLE SHEETS.
ALL ELEVATIONS SHOWN IN m ASL (metres ABOVE SEA LEVEL)

REFERENCE

COLOURS BASED ON STANDARD COLOURS IN "GEOLOGICAL SITE CHARACTERIZATION GUIDELINES" BY E.K. SAUER AND E.A. CHRISTIANSEN (1996).

VERTICAL 100 0 100
SCALE 1:4,000 METRES

HORIZONTAL 5 0 5
SCALE 1:200,000 KILOMETRES

PROJECT
YANCOAL
SOUTHEY PROJECT

TITLE
EFFECTS STUDY AREA
CROSS SECTIONS V-V' AND VI-VI'

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	CH	12/05/14	SCALE AS SHOWN	REV. 0
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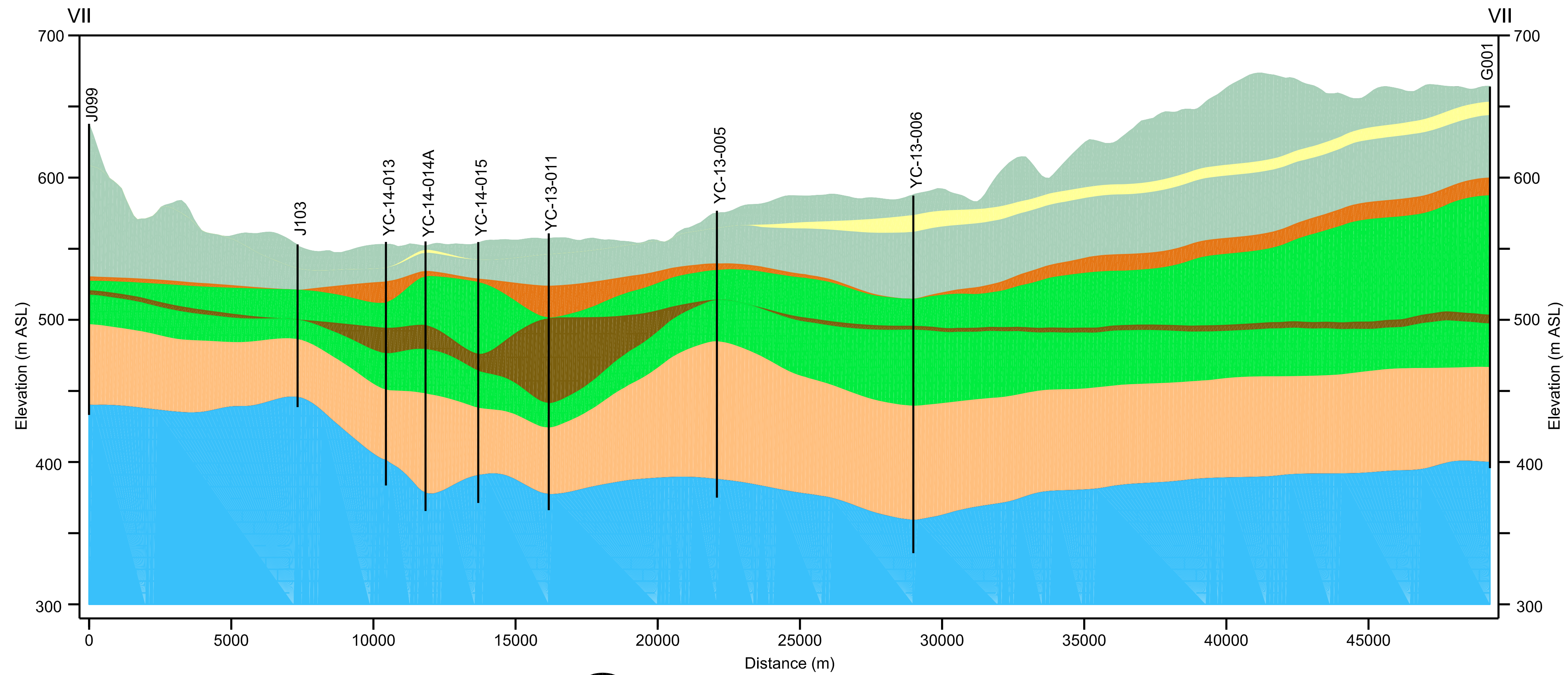
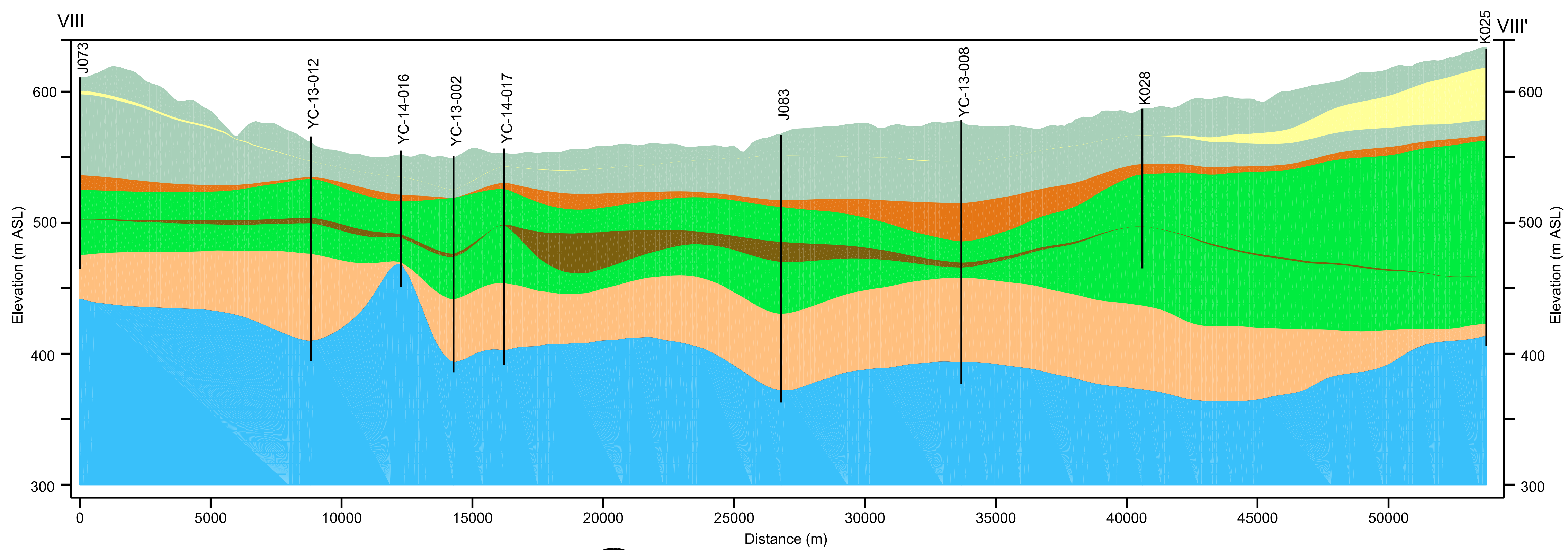


VII
-
CROSS SECTION VII-VII'



VIII
-
CROSS SECTION VIII-VIII'

LEGEND

BOREHOLE LOCATION

STRATIGRAPHIC COLOUR LEGEND

- ALLUVIUM
- SASKATOON GROUP TILL
- SASKATOON GROUP AQUIFER
- INTERTILL AQUIFER
- SUTHERLAND GROUP TILL
- SUTHERLAND GROUP AQUIFER
- EMPRESS GROUP
- BEARPAW FORMATION

NOTE

DATA CONCERNING VARIOUS STRATA HAS BEEN OBTAINED AT BOREHOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE BOREHOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND MAY VARY FROM THAT SHOWN. FOR DETAILED STRATIGRAPHY OF EACH BOREHOLE LOCATION REFER TO THE RECORD OF BOREHOLE SHEETS.
ALL ELEVATIONS SHOWN IN m ASL (metres ABOVE SEA LEVEL)

REFERENCE

COLOURS BASED ON STANDARD COLOURS IN "GEOLOGICAL SITE CHARACTERIZATION GUIDELINES" BY E.K. SAUER AND E.A. CHRISTIANSEN (1996).

VERTICAL 100 0 100 SCALE 1:4,000 METRES

HORIZONTAL 5 0 5 SCALE 1:200,000 KILOMETRES

PROJECT

YANCOAL SOUTHEY PROJECT

TITLE

EFFECTS STUDY AREA CROSS SECTIONS VII-VII' AND VIII-VIII'

Golder Associates Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	CH	12/05/14	SCALE AS SHOWN REV. 0
CADD	MKH	22/04/15	
CHECK	CK	27/05/15	**FIGURE: 8.3-7**
REVIEW	MAT	27/05/15	

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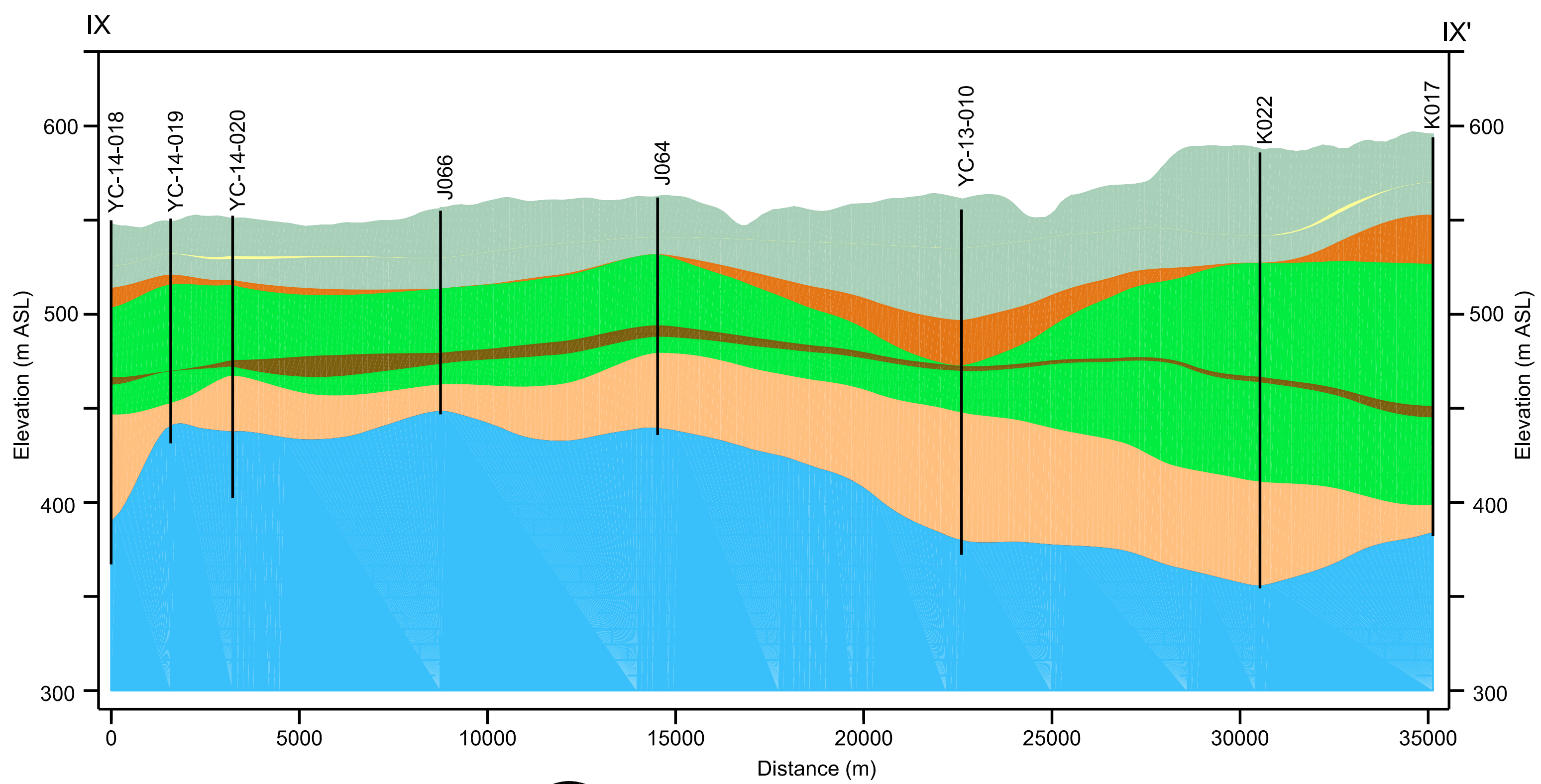

IX
-
CROSS SECTION IX-IX'

LEGEND

BOREHOLE LOCATION

STRATIGRAPHIC COLOUR LEGEND

- ALLUVIUM
- SASKATOON GROUP TILL
- SASKATOON GROUP AQUIFER
- INTERTILL AQUIFER
- SUTHERLAND GROUP TILL
- SUTHERLAND GROUP AQUIFER
- EMPRESS GROUP
- BEARPAW FORMATION

NOTE

DATA CONCERNING VARIOUS STRATA HAS BEEN OBTAINED AT BOREHOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN THE BOREHOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND MAY VARY FROM THAT SHOWN. FOR DETAILED STRATIGRAPHY OF EACH BOREHOLE LOCATION REFER TO THE RECORD OF BOREHOLE SHEETS.
ALL ELEVATIONS SHOWN IN m ASL (metres ABOVE SEA LEVEL)

REFERENCE

COLOURS BASED ON STANDARD COLOURS IN "GEOLOGICAL SITE CHARACTERIZATION GUIDELINES" BY E.K. SAUER AND E.A. CHRISTIANSEN (1996).

VERTICAL 100 0 100
SCALE 1:4,000 METRES

HORIZONTAL 5 0 5
SCALE 1:200,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
EFFECTS STUDY AREA CROSS SECTION IX-IX'

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	CH	12/05/14	SCALE AS SHOWN	REV. 0
CADD	MKH	22/04/15	FIGURE: 8.3-8	
CHECK	CK	27/05/15		
REVIEW	MAT	27/05/15		

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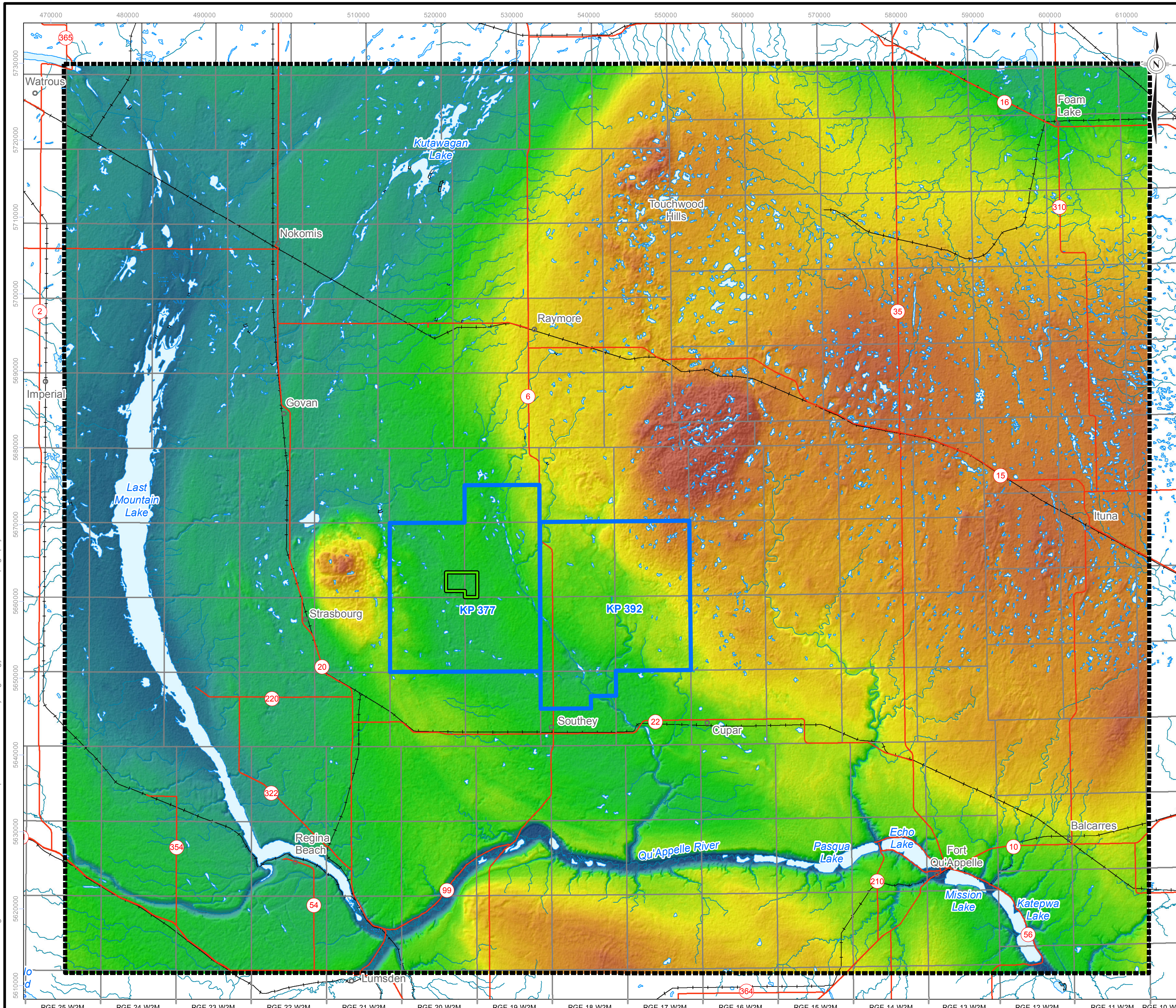

LEGEND

- COMMUNITY
- HIGHWAY
- TOWNSHIP AND RANGE BOUNDARY
- PERMIT BOUNDARY
- REGIONAL STUDY AREA
- CORE FACILITIES AREA

ELEVATION (mASL)
HIGH : 760
LOW : 260

REFERENCE

POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
CANVEC © NATURAL RESOURCES CANADA, 2012
NASA SHUTTLE TOPOGRAPHY MISSION (SRTM)
NTS MAPSHEET: 62L/M, 72I/J/O/P
NAD83 UTM ZONE 13

10 0 10
SCALE 1:500,000 KILOMETRES

PROJECT
YANCOAL SOUTHEY PROJECT

TITLE
REGIONAL STUDY AREA TOPOGRAPHY

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197		FILE No.	
DESIGN	CH	12/05/14	SCALE AS SHOWN	REV. 0
GIS	LMS	27/05/15	FIGURE: 8.3-9	
CHECK	CK	27/05/15		
REVIEW	MAT	27/05/15		

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In the ESA, aquifers may be composed of poorly sorted or well-sorted gravel and/or sand, and aquitards may be composed of glacial till, lacustrine silt, and clay deposits, or marine silt and clay bedrock deposits. Hydrogeology in the ESA involves the interactions among surficial sands and gravels, inter- and intra- till granular sediments and preglacial valley fills. Intertill granular sediments are those present between the till units of the Saskatoon and Sutherland Groups. Intratill granular sediments are within the Saskatoon and Sutherland Group till units.

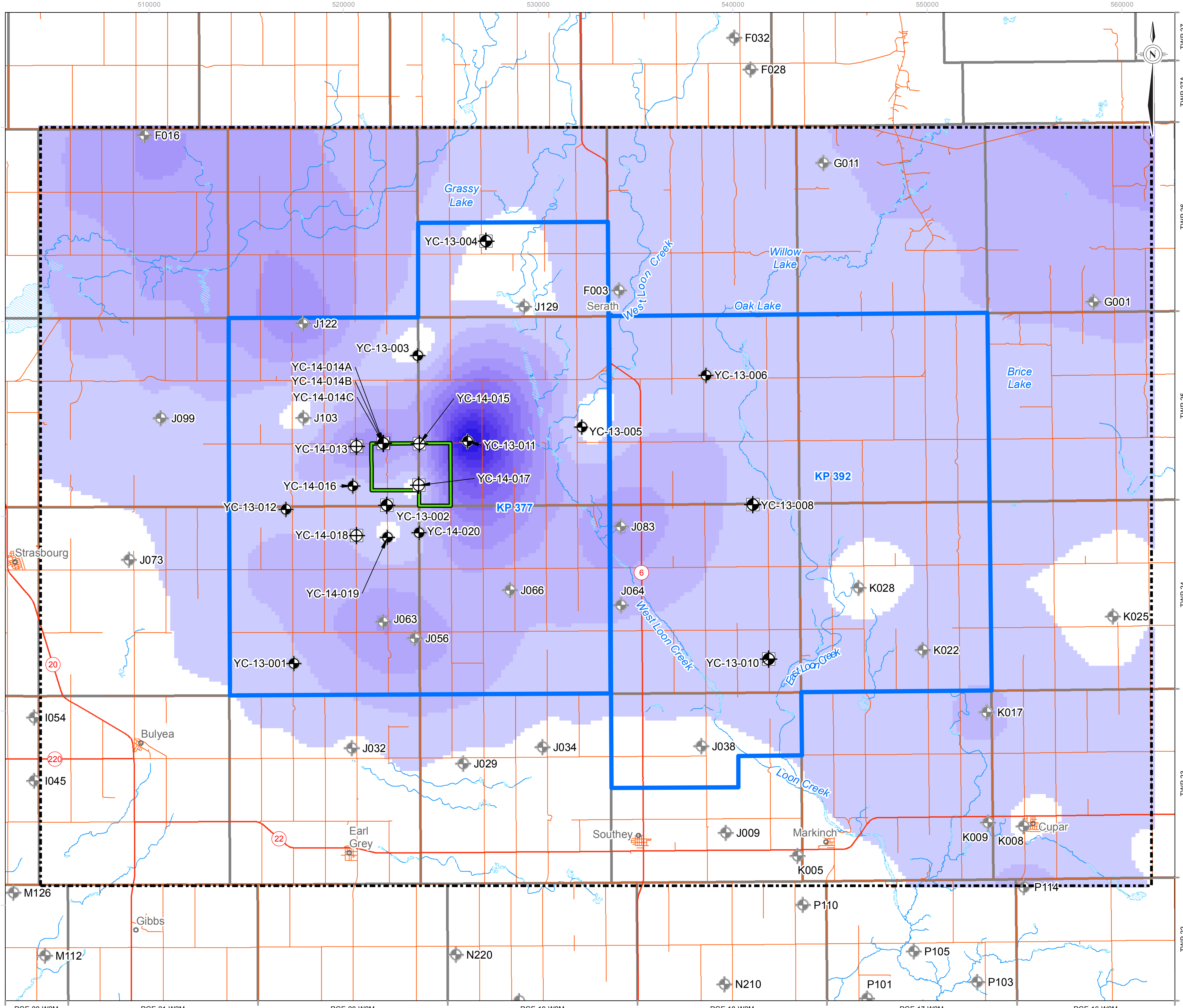
The main aquitards in the RSA are the clayey tills of the Saskatoon and Sutherland Groups that confine the stratified intertill and intratill sand and gravel deposits; the clay shale of the Bearpaw Formation or Pierre Shale that act to confine the lower surface of the Empress Group stratified sand and gravel deposits where present, as well as the clay of the Lea Park Formation which confines the Judith River Formation silts and sands.

In ascending order, the aquifers identified in the ESA include:

- Judith River Formation;
- Tertiary Wynyard Formation;
- Empress Group;
- Sutherland Group sands;
- Intertill Sands;
- Saskatoon Group sands;
- SSD Sand; and
- Alluvium.

The Hatfield Valley aquifer is the most significant groundwater resource of the Empress Group and has resulted from the infilling with fluvial deposits of an expansive bedrock valley that runs southeast from the Alberta to Manitoba borders through central Saskatchewan. The Hatfield Valley aquifer directly underlies the KP377 permit area, and underlies all but the southeastern portion of the KP392 permit area, and averages 30 km in width. The sediments that comprise the Hatfield Valley aquifer are medium to medium-coarse sand and gravels with minor amounts of silt and clay. The Empress Group aquifer is the most used source of groundwater in the ESA.

Sutherland Group aquifer is located within the tills of the Sutherland Group as stratified sand and silt beds. The Sutherland Group aquifer is found from 60 to 110 metres below ground surface (m BGS) and underlies much of the KP377 and KP392 permit areas. An isopach of the Sutherland Group aquifer is shown on Figure 8.3-10.



G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1085 - Hydrogeology\12-1362-0197 - ESA Sutherland Group Aquifer Isopach.mxd Date: 5/27/2015 3:33:11 PM

LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- EFFECTS STUDY AREA
- PERMIT BOUNDARY
- CORE FACILITIES AREA
- BOREHOLE LOCATION
- BOREHOLE WITH STAND PIPE PIEZOMETER
- BOREHOLE WITH VIBRATING WIRE PIEZOMETER
- HISTORIC BOREHOLE

THICKNESS (m)

- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 35
- 36 - 40
- 41 - 45
- 46 - 50
- 51 - 55
- 56 - 60
- 61 - 65

REFERENCE

POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
ISOPACH DATA, GOLDER GEOLOGICAL MODEL, 2014
NAD83 UTM ZONE 13

4 0 4
SCALE 1:200,000 KILOMETRES

PROJECT
YANCOAL
SOUTHEY PROJECT

TITLE
EFFECTS STUDY AREA
SUTHERLAND GROUP AQUIFER ISOPACH

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	CH	13/05/14	SCALE AS SHOWN	REV. 0
GIS	SM/LS	22/04/15	**FIGURE: 8.3-10**	
CHECK	CK	27/05/15		
REVIEW	MAT	27/05/15		

Where present, the Intertill aquifer overlies the Sutherland Group till. The Intertill Aquifer has been encountered in and around the KP377 and KP392 permit areas at depths ranging from 20 m to 65 m BGS. An isopach of the Intertill aquifer is shown on Figure 8.3-11.

Saskatoon Group aquifers refer to sand and gravel deposits located within the Saskatoon Group till. These aquifer systems are present as isolated deposits within the KP377 and KP392 permit areas at depths ranging from 5 m to 30 m BGS. An isopach of the Saskatoon Group aquifer is shown on Figure 8.3-12.

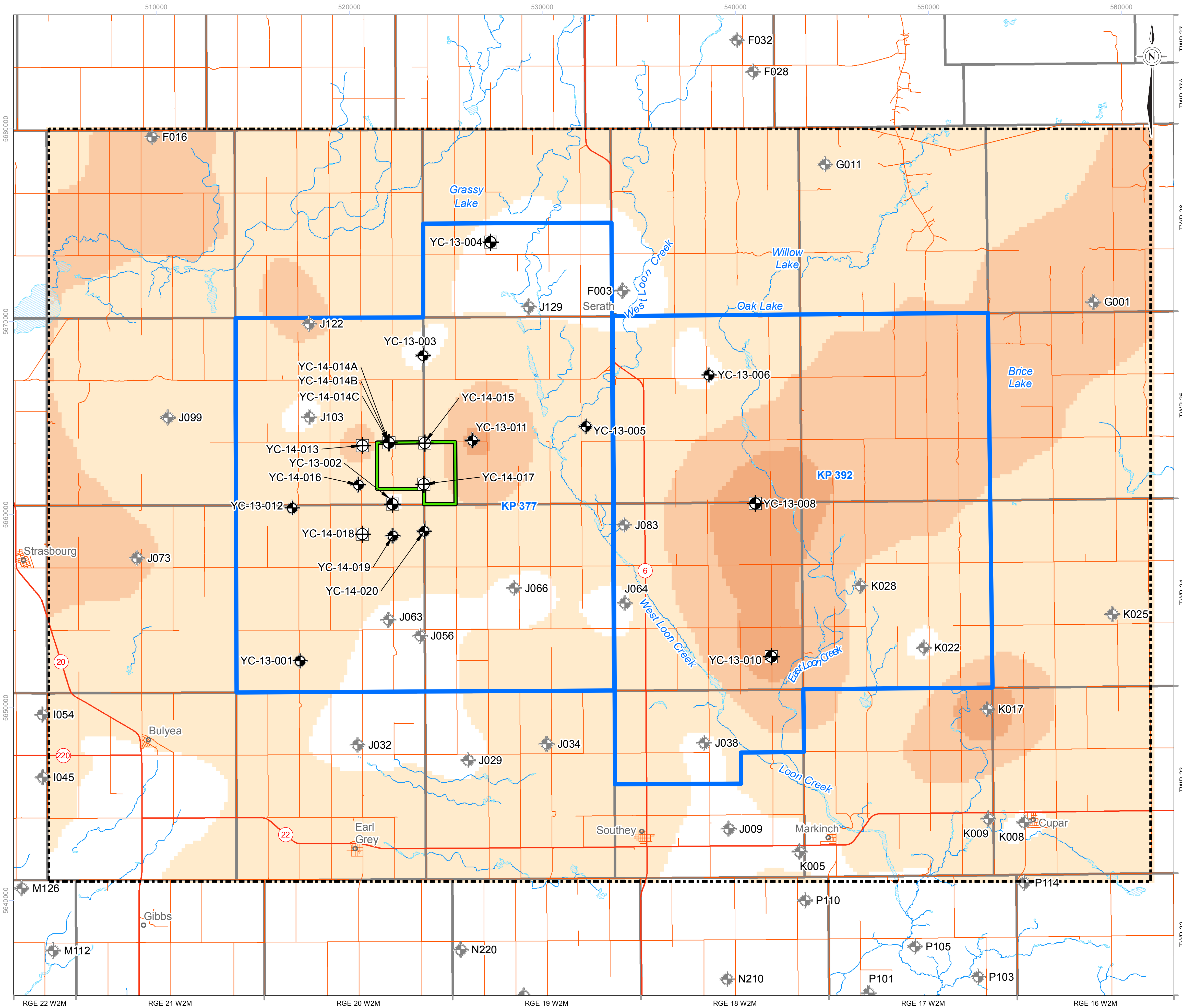
8.3.2.1 Groundwater Chemistry

The results of groundwater chemical analyses are provided in Annex II, Section 4.0, along with quality guidelines based on Health Canada *Guidelines for Canadian Drinking Water Quality* and Canadian Council of Ministers of the Environment *Water Quality Guidelines for the Protection of Agriculture, Irrigation Criteria*.

The groundwater sample collected from the Empress Group exceeds the applicable drinking water and irrigation guidelines or has elevated levels of sodium, sulphate, total dissolved solids, iron, and manganese. The sample collected from the Intertill aquifer exceeds the applicable drinking water and irrigation guidelines or has elevated levels of sulphate, total dissolved solids, iron, manganese, and uranium.

Another way to assess the chemical composition of groundwater is to use a Piper plot. Piper plots use milliequivalent data based on the number of charge units of each chemical species. This is opposed to the weight-based data used when referring to milligrams per litre (mg/L). The relative contributions of each species of negative (anion) and positive (cation) major ions are plotted on the triangles at the lower portion of the diagram. Each triangle apex represents a 100% milliequivalent concentration of that species for either the cations or anions. The contributions of different positive ions (cations) to the positively charged portion of a sample are shown on the lower left triangle. The contributions of different negative ions (anions) to the negatively charged portion of a sample are shown on the lower right triangle. The points plotted on these smaller triangles are projected to the diamond shape in the centre. Points representing fresh water will typically plot near the centre-left apex of the diamond, while water that is more saline will typically plot near the centre-right apex of the diamond. As fresh water becomes more saline along a flow path, water samples will generally plot along a curved path from freshwater to more saline.

A Piper plot for the groundwater quality of the Intertill and Empress aquifers is shown on Figure 8.3-13. The standpipe piezometer installed in the Intertill aquifer has a composition of calcium sulphate, while the Empress aquifer has a composition of sodium–potassium/sulphate. This likely is due to dissolution of minerals such as gypsum, dolomite, mirabilite, and epsomite as groundwater moves along its flow path. For comparison, published typical groundwater chemistry for Saskatoon Group Aquifer and Empress Aquifer (Norman 2011) is presented along with typical ranges for fresh water and brine on Figure 8.3-13. Both results for groundwater chemistry are as expected for each aquifer.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- EFFECTS STUDY AREA
- PERMIT BOUNDARY
- CORE FACILITIES AREA
- BOREHOLE LOCATION
- BOREHOLE WITH STAND PIPE PIEZOMETER
- BOREHOLE WITH VIBRATING WIRE PIEZOMETER
- HISTORIC BOREHOLE

THICKNESS (m)

- 1 - 10
- 11 - 20
- 21 - 30

REFERENCE

POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
ISOPACH DATA, GOLDER GEOLOGICAL MODEL, 2014
NAD83 UTM ZONE 13

4 0 4
SCALE 1:200,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
EFFECTS STUDY AREA
INTERTILL AQUIFER ISOPACH

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	CH	13/05/14	SCALE AS SHOWN REV. 0
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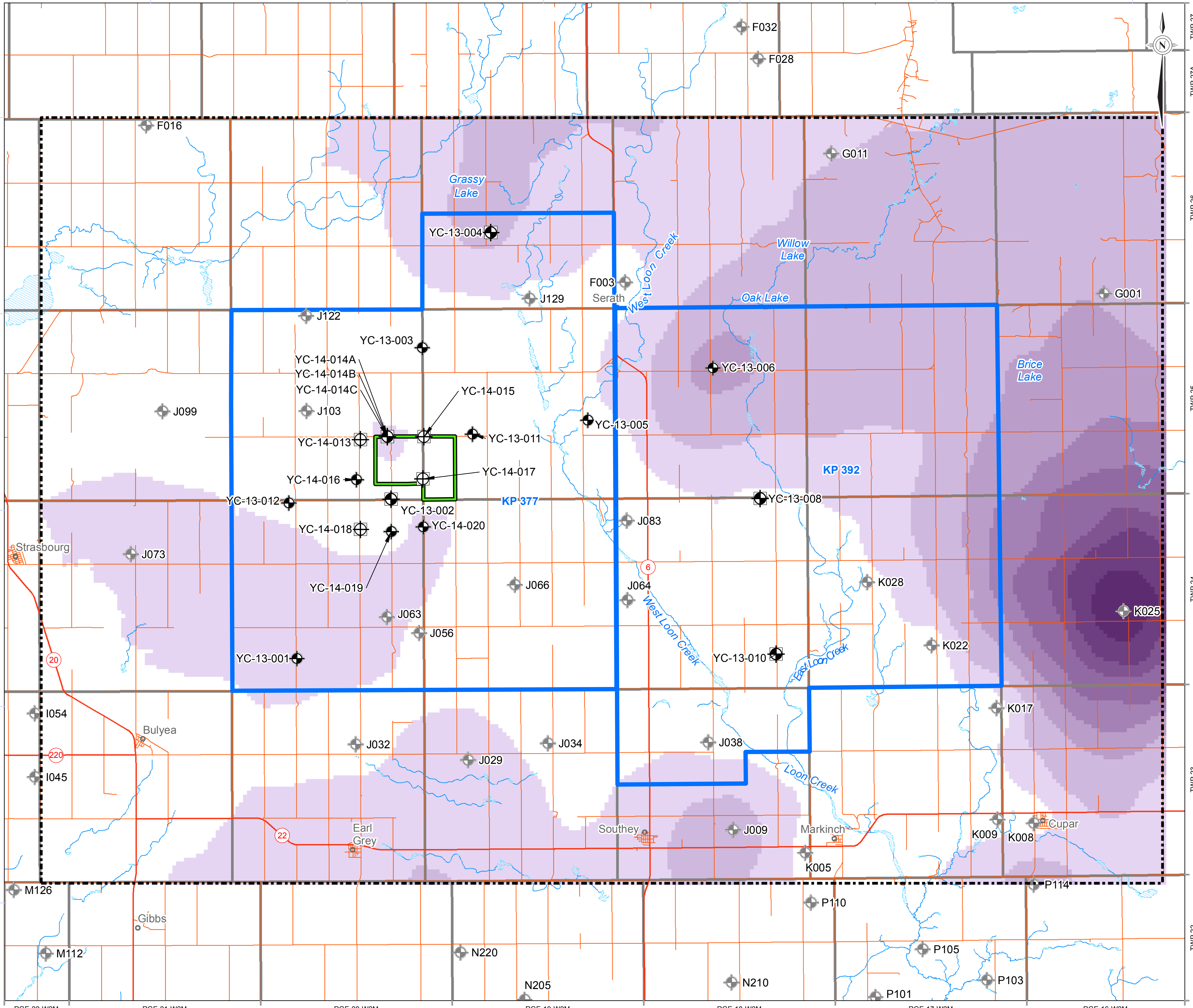
CHECK	CK	13/01/16	
REVIEW	MAT	13/01/16	



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- EFFECTS STUDY AREA
- PERMIT BOUNDARY
- CORE FACILITIES AREA
- BOREHOLE LOCATION
- BOREHOLE WITH STAND PIPE PIEZOMETER
- BOREHOLE WITH VIBRATING WIRE PIEZOMETER
- HISTORIC BOREHOLE

THICKNESS (m)

- 1 - 5
- 6 - 10
- 11 - 15
- 16 - 20
- 21 - 25
- 26 - 30
- 31 - 35
- 36 - 40

REFERENCE

POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
ISOPACH DATA, GOLDER GEOLOGICAL MODEL, 2014
NAD83 UTM ZONE 13

4 0 4
SCALE 1:200,000 KILOMETRES

PROJECT

YANCOAL SOUTHEY PROJECT

TITLE

EFFECTS STUDY AREA SASKATOON GROUP AQUIFER ISOPACH

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	CH	13/05/14	SCALE AS SHOWN	REV. 0
GIS	SM/LS	22/04/15	FIGURE: 8.3-12	
CHECK	CK	27/05/15		
REVIEW	MAT	27/05/15		

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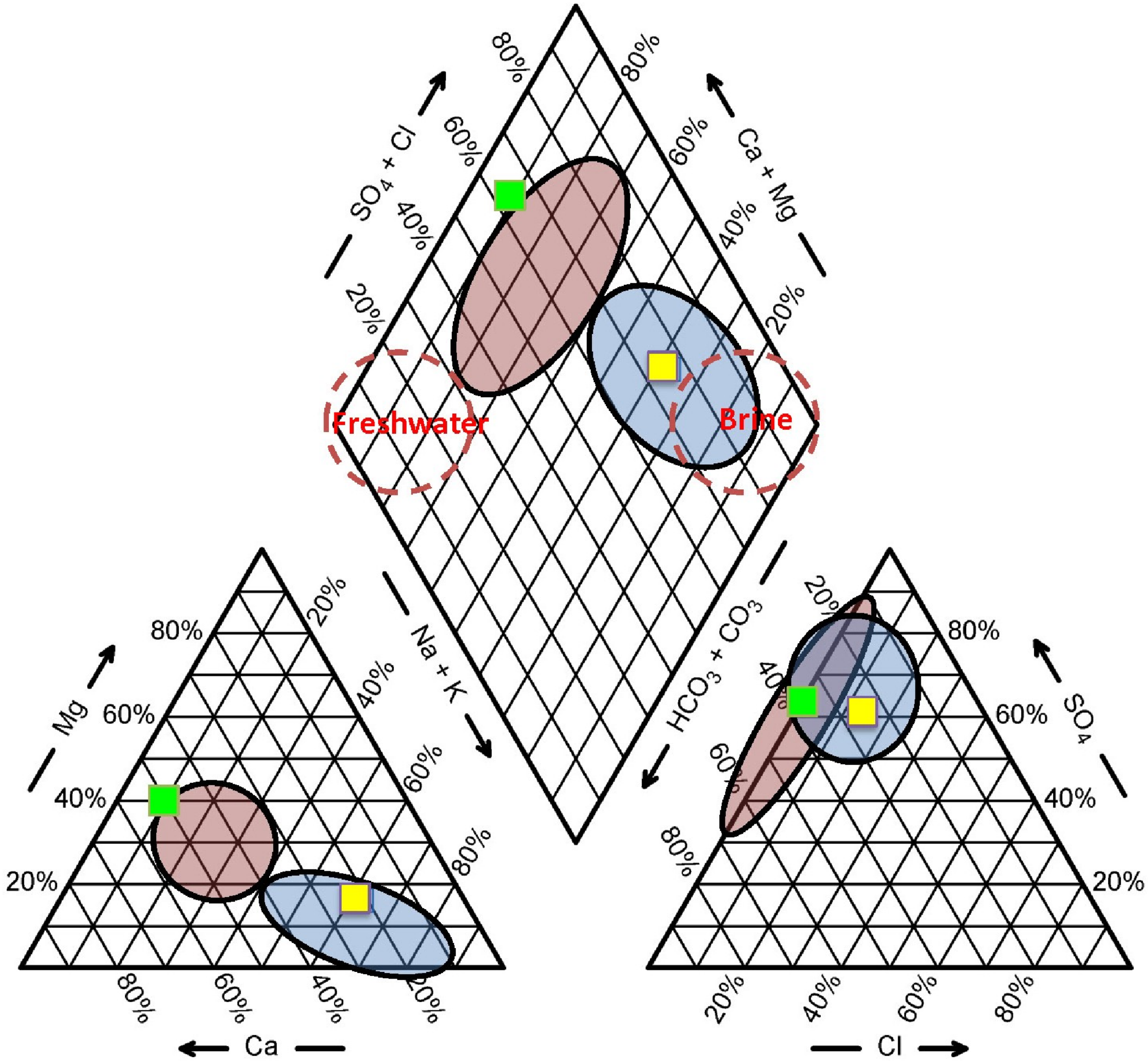
G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1085 - Hydrogeology\12-1362-0197 - ESA Major Ions in Groundwater Piper Plot.mxd



LEGEND

- YC-14-014A – Empress Aquifer
- YC-14-014C – Intertill Aquifer
- Typical Groundwater Chemistry Results of the Empress Aquifer
- Typical Groundwater Chemistry Results of the Saskatoon Group Aquifer

REFERENCE

NORMAN, R. 2011. HYDROGEOLOGY MAPPING OF NTS MAPSHEET SASKATOON 73B SASKWATERSHED REPORT #M1890-1030109

PROJECT

YANCOAL 兖煤加拿大资源有限公司

YANCOAL SOUTHEY PROJECT

TITLE

EFFECTS STUDY AREA MAJOR IONS IN GROUNDWATER PIPER PLOT

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197
DESIGN	CH	27/05/15
GIS	SM/LS	27/05/15
CHECK	CK	27/05/15
REVIEW	MAT	27/05/15

FILE No.

SCALE AS SHOWN | REV. 0

FIGURE: 8.3-13

8.3.2.2 Groundwater Flow

Regional topography exerts a controlling influence on the general direction of deep groundwater flow. Within upland areas the ground moraine is generally internally drained, with surface water collecting in small, isolated shallow depressions and then either infiltrating into the ground surface or evaporating. The areas of eroded moraine have improved drainage, with small, poorly incised creeks directing flow toward Last Mountain Lake to the west and the Qu'Appelle Valley to the south of the moraine. The northeastern portion of the RSA drains into the Quill Lakes and Assiniboine River watersheds. The Empress Group Formation is the largest continuous aquifer within the region. Much of the Empress group lies within the Hatfield Valley Aquifer system's main thalweg that runs from the northwest to the southeast within the RSA. The Empress Group pinches out in the northeastern corner of the RSA, where the Tertiary Wynyard Formation is present, and toward the southwest. The Empress Group aquifer and Hatfield Valley in the RSA have large flow and connectivity throughout the province. It is thought that the Judith River Formation has connectivity with the Hatfield Valley where separation of the two by the Bearpaw Formation is absent (Simpson 2000).

Hydraulic head measurements were taken from all available boreholes within the RSA and are shown in Annex II (Section 4.3.1.4). Vertical gradients are downward, indicating groundwater ultimately recharges to the Empress Group.

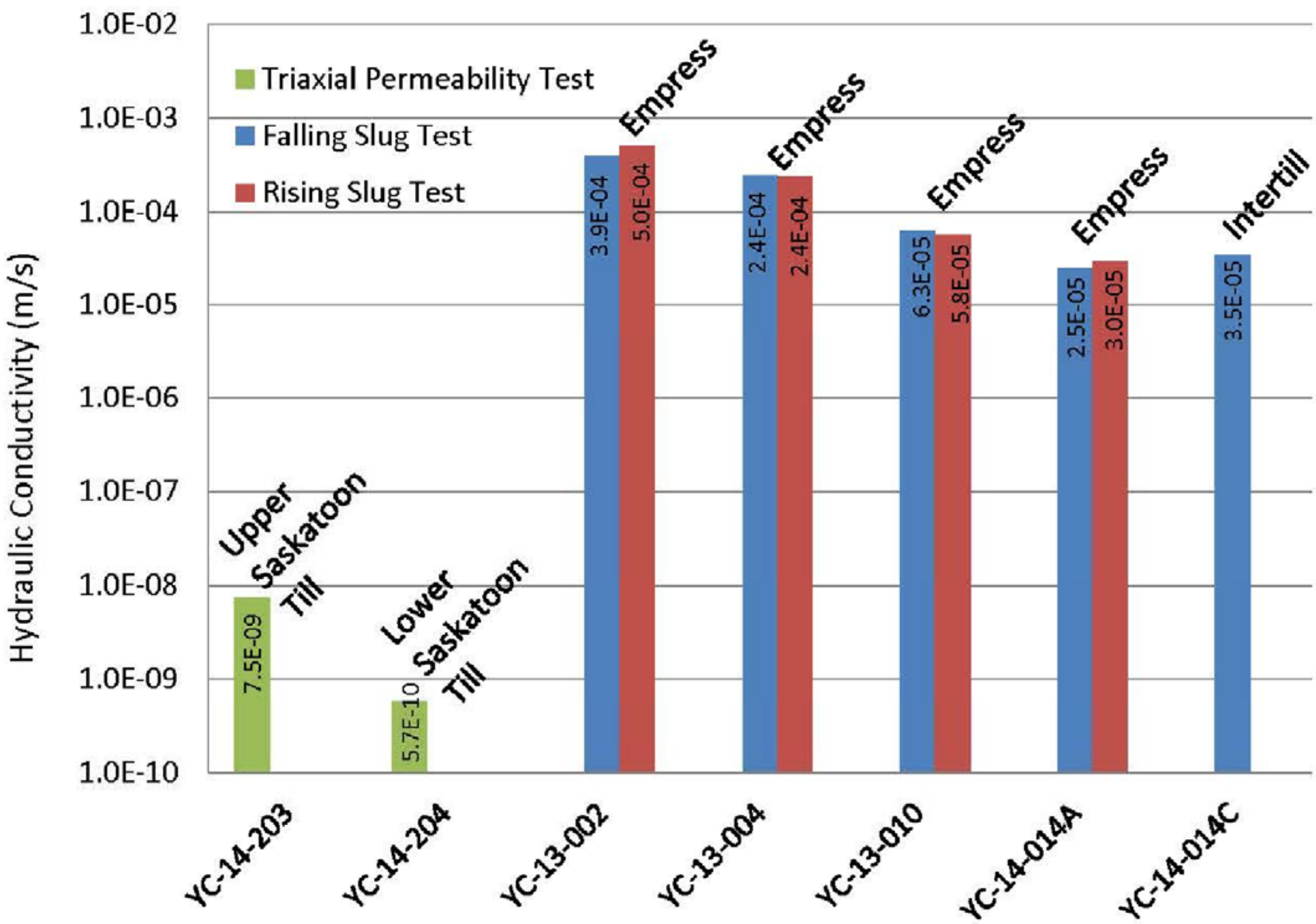
8.3.2.3 Hydraulic Testing

The hydraulic conductivities of the hydrostratigraphic units were determined from response testing (slug tests) and laboratory triaxial permeability testing. The results of the hydraulic head testing are presented on Figure 8.3-14.

Falling head and rising head response testing data was used to determine hydraulic conductivities for the Intertill and Empress Group aquifer. Hydraulic conductivity values for the Intertill aquifer were in the magnitude of 1×10^{-5} metres per second (m/s). Hydraulic conductivity values determined for the Empress Group were in the magnitude of 1×10^{-4} to 1×10^{-5} m/s.

Triaxial hydraulic conductivity testing results on the Saskatoon Group till were 7.5×10^{-9} m/s (Upper Saskatoon Group) and 5.7×10^{-10} m/s (Lower Saskatoon Group). These hydraulic conductivity values generally agree with those published for typical Saskatchewan tills (Maathuis and van der Kamp 1994).

Hydraulic Conductivity Summary



PROJECT

YANCOAL 兖煤加拿大资源有限公司

YANCOAL
SOUTHEY PROJECT

TITLE

HYDRAULIC CONDUCTIVITY SUMMARY

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	CH	17/04/14	SCALE AS SHOWN	REV. 0
CADD	MKH	22/04/15	**FIGURE: 8.3-14**	
CHECK	CK	27/05/15		
REVIEW	MAT	27/05/15		

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8.3.2.4 Groundwater Flow Model

Two groundwater models were constructed for the Project; one to evaluate the groundwater flow system on a regional scale and one focused on the area surrounding the core facilities area to provide increased resolution of local-scale hydrogeologic conditions beneath the site.

The regional model was constructed to provide a general understanding and approximation of the regional groundwater flow patterns, as well as to provide boundary conditions and hydraulic property estimates for the local model. The local model includes increased refinement in the geologic conditions surrounding the Project site and allows for the simulation of local-scale groundwater flow patterns to identify potential seepage pathways from the core facilities area.

The numerical groundwater models are based on the conceptual models as outlined in Annex II, Section 4.0. The stratigraphy described in Annex II provides the basic layer structure for the models and identifies available hydraulic conductivity data and estimates considered in assigning initial model parameter values.

The groundwater flow models developed for the Project are outlined in Annex II, Section 4.0, including the numerical groundwater flow code employed, the assigned hydrogeological parameters and boundary conditions, and the results of the model calibration. A summary of model assumptions and limitations associated with the groundwater flow models is also provided. The calibrated regional and local scale groundwater flow models reasonably reproduce the observed groundwater elevations and the general flow patterns expected in the area. Based on this, the local scale model is considered a useful tool to assist with understanding the potential directions of groundwater flow in and around Project facilities.

8.4 Pathways Analysis

8.4.1 Methods

Pathways analysis identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects (after mitigation) on groundwater. The first part of the analysis is to identify all potential effects pathways for the Project. Each pathway initially is considered to have a linkage to potential effects on the VC. Potential pathways through which the Project could affect groundwater were identified from a number of sources including:

- a review of the Project Description (Section 4.0) and scoping of potential effects by the environmental and engineering teams for the Project;
- information obtained from community engagement sessions (Section 5.0);
- scientific knowledge and experience with other potash mines in Saskatchewan; and
- consideration of potential effects identified from the TOR.

For an effect to occur there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a correspondent effect on the VC.

Project activity → change in environment → effect on VC

A key aspect of the pathways analysis is to identify environmental design features and mitigation that might reduce or eliminate potential effects of the Project to groundwater. Mitigation has been developed for the Project according to the following hierarchy proposed by the MOE (2014):

- avoidance;
- minimize (limit);
- restoration; and
- compensation.

Environmental design features include engineering design elements, environmental best practices, management policies and procedures, and spill response and control, and emergency contingency plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening level analysis was used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on groundwater. Pathways are determined as having no linkage, or to be secondary (minor) or primary, using scientific, local and traditional knowledge, logic, experience with similar developments, and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- **No linkage** – analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on groundwater relative to the Base Case or guideline values; or
- **Secondary** – pathway could result in a measurable minor environmental change, but would have a negligible residual effect on groundwater relative to the Base Case or guideline values and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect; or
- **Primary** – pathway is likely to result in environmental change that could contribute to residual effects on groundwater relative to the Base Case or guideline values.

Pathways with no linkage to groundwater are not assessed further because implementation of environmental design features or mitigation will remove the pathway and result in no measureable change to groundwater. Pathways that are assessed to be secondary and demonstrated to have a negligible residual effect on groundwater through simple qualitative or semi-quantitative evaluation of the pathway are not advanced for further assessment. In summary, pathways determined to have no linkage to groundwater or those that are considered secondary are not expected to result in environmentally significant effects for continued suitability of groundwater for human use. Primary pathways require further evaluation through more detailed quantitative and qualitative effects analysis (Section 8.5).

8.4.2 Results

Project components and activities, effects pathways and environmental design features and mitigation are summarized in Table 8.4-1. Classification of effects pathways (i.e., no linkage, secondary and primary) to groundwater resources is also summarized in Table 8.4-1 and detailed descriptions are provided in the subsequent sections.

8.4.2.1 Pathways with No Linkage

A pathway may have no linkage to environmental effects if the activity does not occur, or if the pathway is removed by mitigation or environmental design features so that the Project results in no measurable change in measurement indicators. Subsequently, no residual effect on groundwater is expected. The pathways described in the following bullets have no linkage to groundwater and will not be carried forward in the assessment.

- **Air and dust emissions and subsequent deposition can cause changes to the chemical properties of surface water and soils, which can affect groundwater quality.**

Construction and operation of the Project will generate air emissions such as nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter (particulate matter with aerodynamic diameter less than 2.5 micrometre (µm) [$PM_{2.5}$] particulate matter with aerodynamic diameter less than 10 µm [PM_{10}] and total suspended particulates [TSP]), and potassium chloride (KCl) can result from industrial processes, road travel, vehicle and facility exhaust, conveyor systems, and other activities occurring on-site. Increased atmospheric deposition from dust and air emissions generated by the Project may alter the chemical characteristics of local soil and surface waterbodies, which subsequently can influence groundwater quality.

Air quality modelling was completed to predict the ground-level concentrations associated with Project emissions (Section 7.5). Air quality modelling was completed using the maximum emissions profile expected during the operations phase of the Project. The cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are predicted in order to evaluate changes to measurement indicators for air quality during the Application Case. This provides the maximum potential effects from the Project. Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates. The dispersion modelling results show that the Project-related increase in NO_2, SO_2, are limited to the atmospheric environment ESA and $PM_{2.5}$, PM_{10}, TSP concentrations, and KCl deposition are limited to the immediate vicinity of the Project (Section 7.5). The extent of Application Case concentrations of NO_2, SO_2, CO, $PM_{2.5}$, TSP, and deposition of KCl are in compliance with the applicable criteria outside of the core facilities area and at all community receptors. Lower emissions are anticipated from Project construction and decommissioning relative to operations as most of the emission sources from the core facilities area would not be operational during construction and decommissioning.

Table 8.4-1: Potential Pathways for Effects on Groundwater

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
General construction, operations, and decommissioning and reclamation activities	Air and dust emissions and subsequent deposition can cause changes to the chemical properties of surface water and soils, which can affect groundwater quality.	■ Compliance with regulatory emission requirements. ■ Dryer burners will be high efficiency, low NO_x burners to limit the amount of NO_x present in the exhaust stream. ■ Baghouses will be installed throughout the dry process area and dust collected in these baghouses will be conveyed back to the compactors. ■ A dustless chute and loading system will be installed in the product storage area to reduce dust generation in the storage and load-out. ■ The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment. ■ An Erosion and Sediment Control Plan will be implemented during all phases of the Project to limit dust production, and subsequent deposition on surrounding areas, and to limit erosion of exposed soils. ■ Dust-producing components of the potash refinement process (i.e., dryers, compaction circuit) will have controls to recover and return dust to the circuit. ■ Wet scrubbers will be used to clean the air of dust particles from off-gases from the product dryers. ■ Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. ■ Enforced speed limits will assist in reducing production of dust. ■ Operating procedures will be developed to reduce dust generation from the TMA over the long-term. ■ The cyclone exhaust will be treated in high-energy scrubbers operating at a high-pressure drop.	No Linkage
Solution Mining	Ground subsidence caused by solution mining can cause changes to terrain and can alter groundwater flow patterns.	■ Unmined pillars will be left between the caverns to increase stability during mining and reduce the potential for subsidence. ■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence and will provide input into adaptive management. ■ Subsidence will be non-disruptive. Disruptive subsidence, such as the formation of sinkholes, is not expected to occur. ■ Subsidence will be gradual and ultimate (maximum) subsidence (i.e., final, steady state) will not occur for centuries. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface developments.	Secondary
Tailings Management Area	Vertical and lateral migration of brine from the tailings management area can cause changes to groundwater quality.	■ The location of the TMA was selected based on site-specific geologic and hydrogeologic studies completed to identify an appropriate foundation for the TMA, which provides natural containment of brine material. ■ The TMA will be located over soils that are known to provide natural retention of brine solutions and offer protection against seepage into nearby ground and surface water resources. ■ Brine reclaim ponds will be designed to provide containment of brine under normal and extreme (i.e., storm) conditions over the life of the mine. ■ A perimeter dyke will be constructed around the TMA to contain waste salt and decanted brine. ■ Excess brine reclaimed from the TMA will be disposed of by deep well injection, a proven practice used to manage brine and prevent release to surface waters and fresh-water aquifers. ■ A containment system will be designed to control deep migration of brine from the TMA to underlying aquifers and horizontal migration of brine, as required. ■ A Waste Salt Management Plan for the TMA will be incorporated into the detailed design. ■ The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan and adaptive management will be implemented, if required. ■ A Decommissioning and Reclamation Plan will be developed and will incorporate new technologies as they become available to reduce the length of the decommissioning period and the associated duration of salt storage at surface.	Primary
	Long-term brine migration from the tailings management area can alter groundwater quality.		Primary
	Deep well injection of brine can disrupt or change sub-surface and deep groundwater flow, levels, and quality.	■ An evaluation of the capacity of potential deep injection horizons has been conducted identifying the Winnipeg Formation and the Deadwood Formation to be suitable for brine disposal.	No Linkage

Table 8.4-1: Potential Pathways for Effects on Groundwater

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Accidents, malfunctions, and unplanned events	Spills (e.g., waste oil, petroleum products, reagents, potash product, Project equipment leaks, vehicle accidents, and wash-down) can cause changes to surface water quality and affect groundwater quality.	■ Instruction will be provided to employees as part of the Health, Safety, Security, and Environmental Management System; training will be provided to all employees on transportation of dangerous goods, as well as on spill reduction, control, and clean up procedures. ■ Basic, core, and specific training of workers as part of the Health, Safety, Security, and Environmental Management System. ■ An Emergency Response Team will be formed on-site and members will be trained to implement the Emergency Response Plan. ■ Spills will be promptly reported and managed according to procedures identified in the Spill Response and Control Plan. ■ Chemical spill containment will be incorporated into the plant design to mitigate environmental effects from spills (i.e., installation of concrete floors, drains, and sump mechanisms). ■ Smaller fuel dispensing tanks will be double-walled, and all dispensing will be performed over concrete containment slabs. ■ Reagent tanks and larger fuel tanks will be located inside a bermed, lined storage compound. ■ Liquid, solid spills, and wash-down within the processing facilities will be contained within the mill facility (e.g., door curbs, sloped floors, and sumps) or engineered site area. ■ Diesel and gasoline will be stored in accordance with applicable regulations. ■ On-site storage facilities for hazardous substances and waste dangerous goods will be designed to meet regulatory requirements. ■ Domestic and recyclable waste dangerous goods will be stored in appropriate containers until shipped off site to an approved facility. ■ Spill response material will be located throughout the site in designated areas, where fuel and chemicals are stored, and in company vehicles. ■ Best practices will be adopted within the Waste Management Plan for proper handling and storage of waste dangerous goods. ■ Salvageable product from centrifuging, drying, screening, and compaction will be recycled back to the process. ■ Construction equipment will be regularly inspected and maintained. ■ To limit the occurrence of vehicular accidents, training for equipment operators will be implemented as part of the Health, Safety, Security, and Environmental Management System. ■ Equipment will be inspected for leaks and repaired prior to entry into the Project area and routinely inspected throughout the duration of the Project. ■ Daily vehicle inspections will be required, and a preventative maintenance program will be implemented for all vehicles used on-site. ■ Speed limits will be enforced. ■ Timely snow removal and sanding will occur on site access roads during winter to improve traction.	No Linkage
	Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to groundwater quality.	■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ Brine will be transported by steel pipeline lined with high-density polyethylene, which provides additional pipe flexibility and resistance to corrosion. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface developments. ■ Unmined pillars will be left between the caverns to increase stability during mining and reduce the potential for subsidence. ■ As part of the Environmental Protection Plan, regular monitoring of pipelines will be carried out to limit the potential for leaks and allow for early detection and management of spills. ■ Piping and valve arrangements will be routed so that each cavern works independently from the others at difference stages of cavern development and production. ■ During the detailed design stage, additional spill response and mitigation will be included in the Emergency Response Plan.	No Linkage
	Slope failure of the waste salt storage pile can cause translocation of waste salts and change surface water quality, which can affect groundwater quality.	■ Salt pile side slopes of 4H:1V were applied to the TMA layout, which were found to provide stable slope configuration based on preliminary slope stability analysis. ■ The final configuration of salt pile slopes will be refined based on subsequent analyses calibrated to pore-water pressure and slope movement data obtained during the initial development of the waste salt pile. ■ Regular inspections of the TMA. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan.	No Linkage

Table 8.4-1: Potential Pathways for Effects on Groundwater

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Accidents, malfunctions, and unplanned events (continued)	Failure of the brine containment pond and resulting brine leakage can cause changes to surface water quality, which can affect groundwater quality.	■ The brine reclaim pond will provide adequate storage to accommodate storage of process streams under normal and extreme operating conditions and design storm events. ■ Sufficient freeboard will be provided to account for wind induced set-up and wave run-up on the sides of the pond slopes. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan. ■ Maximum operating levels will be developed to provide adequate storage volumes for the design storm event (300 mm in 24 hours). ■ Containment berms and dykes will be constructed around the tailings management area to contain salt tailings and decanted brine, as well as to divert surface water. ■ Containment dykes will be keyed into surficial materials as necessary. ■ Brine levels will be monitored and excess brine will be injected into deep well injection zones after mining is complete. Sub-surface brine migration will be monitored and groundwater wells will be monitored to confirm the adequacy of the brine containment pond. ■ In the event of high flows due to precipitation events, additional flow capacity from the collection ditch to the reclaim pond would be provided by an overflow spillway in the embankment. ■ The brine reclaim pond will be monitored regularly; monitoring results will provide input into adaptive management.	No Linkage

TMA = tailings management area; mm = millimetres; NO_x = oxides of nitrogen.

Various dust-producing components of the potash refinement process (i.e., dryers or compaction circuit) will have controls to recover and return dust to the circuit. The process plant will use cyclones, baghouses, and wet scrubbers to reduce air and dust emissions so that an acceptable working environment is achieved and government standards are met. The dryer burners will be high efficiency, oxides of nitrogen (NO_x) burners to limit the amount of NO_x present in the exhaust stream. Several vent pick-up inlets will be provided for collecting dust at all critical transfer points and from dryer exhausts. Dust control systems will discharge to proven scrubber systems in areas where ore is handled (e.g., product screening, storage, and loadout). Particulate matter in the form of dust will be controlled and all conveyors between buildings will be enclosed. Compliance with regulatory stack emissions and ambient air quality standards will be maintained throughout construction and operation of the Project. Any required or scheduled maintenance of equipment will be performed as needed to meet federal and provincial air emissions standards. The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment. Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. Enforced speed limits will assist in reducing production of dust from roadways. Finally, erosion control practices will be implemented during construction and operation of the Project to limit dust production.

Air and dust emissions and subsequent deposition are expected to result in minor and local changes to the chemical properties of surface water and soils relative to Base Case conditions. The minor changes to surface water and soil quality are not anticipated to cause measurable changes to groundwater chemistry. Consequently, this pathway was determined to have no linkage to effects on groundwater.

- **Deep well injection of brine can disrupt or change sub-surface and deep groundwater flow, levels, and quality.**

Brine will be disposed of through deep-well injection during the Project to reduce the amount of brine stored in the TMA. Changes to sub-surface and deep groundwater from deep well injection of excess brine may potentially alter local groundwater flows and quality. Disruption in groundwater flow may adversely affect water levels in wetlands by changing recharge and discharge areas and rates (Chen and Hu 2004). Deep well injection of excess brine is a proven practice used to manage brine and prevent release to surface waters. An assessment of target zones for brine disposal has been completed to allow selection of formations with adequate capacity to accept waste brine solution from the Project and sufficient separation from overlying fresh-water aquifers to provide adequate containment of brine (Appendix 4-A). The disposal formations were found to be separated from fresh water resources and have multiple intervening low permeability layers, which provide adequate containment of the brine. The target formations were found to have very large capacity, considering thickness and lateral extent. Therefore, no measureable changes to sub-surface and deep groundwater flows, levels, and quality from Base Case conditions are expected. Subsequently, this pathway was determined to have no linkage to effects on groundwater.

- **Spills (e.g., waste oil, petroleum products, reagents, potash product, Project equipment leaks, vehicle accidents, and wash-down) can cause changes to surface water quality and affect groundwater quality.**
- **Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to groundwater quality.**

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks in order to limit the effects of spills and leaks on groundwater quality. Pipelines will be used to transport water, brine solution and potash product within the Project footprint. Pipelines will be constructed of standard carbon steel and lined with high-density polyethylene. Pipelines will be installed underground at a depth that will reduce the possibility of damage from frost and surface activities (e.g., farming), and will be monitored for pressure and flow using flow meters. Double-walled pipe for secondary containment will be used in critical crossing areas (i.e., based on site-specific analysis to meet environmental conditions). All pipelines will be insulated to maintain the required temperature for the process with the exception of the early brine return pipelines. Trains and vehicles will transport chemicals, potash product, and other reagents on and off-site.

An Emergency Response Plan will be developed as part of the Health, Safety, Security, and Environmental Management System to provide rapid and competent response to incidents that may occur during the Project. Aspects of this plan include instructions and procedures for quick detection, control, and management of spills occurring on site (e.g., Spill Response and Control Plan). Other mitigation will include a leak detection system for mining area pipelines, which will consist of monitoring and appropriate pipe isolation to limit potential leaks and for early detection. Leak detection and monitoring of pipelines will be based on flow and pressure measurements at points along the pipeline. In addition to the pipeline monitoring program, liquid spills and wash-down occurring within the potash processing facilities will be contained within the mill facility or the engineered site area, and salvageable product spills will be recycled into the process feed.

If a spill originates in the tank farm, the hazardous substance will be pumped and properly disposed of off-site. The tank farm will be designed to include an adequately sized containment berm for containing potential leaks or spillage. Storage facilities for hazardous wastes will meet regulatory requirements, and site personnel will be trained on spill reduction, control, and clean-up procedures. Employees will receive spill response training, and appropriate spill response materials (e.g., absorbent pads or booms) and equipment will be located at strategic locations on-site. Disposal of all hazardous materials such as waste chemicals, hydrocarbons, reagents, and petroleum products will be handled by a licensed contractor and will be hauled off-site to an approved facility. Waste products from the Project (e.g., hazardous waste, domestic waste, or recyclable waste) will be stored and disposed of following procedures prescribed by federal and provincial legislation.

Implementation of the above-mentioned environmental design features are expected to reduce the likelihood and extent of spills and leaks occurring on-site and along transportation corridors, resulting in no measureable changes to groundwater quality relative to Base Case conditions. Therefore, these pathways are determined to have no linkage to effects on groundwater.

- **Slope failure of the waste salt storage pile can cause translocation of waste salts and change surface water quality, which can affect groundwater quality.**

The volume of tailings produced by the solution mining method for the Project is expected to be lower than conventional underground potash mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only KCl is removed from the caverns during this mining phase.

Salt tailings stockpile stability is governed primarily by the salt pile height, shear strength of the underlying soils, and the degree to which soil pore water pressures are generated in response to the surcharge load of the stockpile. Detailed slope stability analysis for the salt pile will be completed to determine the optimal salt pile height for the Project. The final design of the waste salt storage area will provide for flexibility to expand the storage area in stages through modifications to the footprint or increasing the salt pile height should additional storage be required.

The probability of slope failure of the waste salt storage pile will be limited by the implementation of operating procedures and monitoring programs for the salt storage area. Salt pile stability monitoring will be incorporated into the design. As such, no measurable changes to groundwater quality are predicted. This pathway was determined to have no linkage to effects on groundwater.

- **Failure of the brine containment pond and resulting brine leakage can cause changes to surface water quality, which can affect groundwater quality.**

The TMA will consist of the Stage I and Stage II salt storage areas, the Stage I and Stage II brine reclaim ponds, sewage lagoon, and surface diversion works. The TMA will be in operation during the life of the Project, and following decommissioning and reclamation of the mine. Brine is primarily composed of soluble salts (sodium chloride [NaCl], with smaller amounts of KCl) and other insoluble materials (e.g., metals) (Tallin et al. 1990). A leak resulting from failure of the brine reclaim pond could cause changes to surface water quality and affect groundwater quality.

The brine reclaim pond will provide adequate storage to accommodate storage of process streams under normal and extreme operating conditions and design storm events. Sufficient freeboard will be provided to account for wind induced set-up and wave run-up on the sides of the pond slopes. In the event of high flows due to precipitation events, additional flow capacity from the collection ditch to the reclaim pond would be provided by an overflow spillway in the embankment. Containment berms and dykes will be constructed around the TMA to contain decanted brine. The containment system will be designed to accommodate high flows due to precipitation events. Additional flow capacity from the collection ditch to the reclaim pond would be provided by an overflow spillway in the embankment. The environmental performance of the brine reclaim pond will be monitored over the life of the Project as part of the Waste Salt Management Plan.

Implementation of the above-mentioned environmental design features, mitigation, and monitoring programs are expected to reduce the potential for failure of the brine containment pond. Therefore, no measurable changes to groundwater quality are expected. Consequently, this pathway was determined to have no linkage to effects on groundwater.

8.4.2.2 Secondary Pathways

In some cases, both a source and a pathway exist but, because the change caused by the Project is anticipated to be minor relative to Base Case or guideline values, it is expected to have a negligible residual effect on groundwater. The pathways described in the following bullets are expected to be secondary and will not be carried forward in the assessment.

- **Ground subsidence caused by solution mining can cause changes to terrain and can alter groundwater flow patterns.**

The assessment considers the final land surface configuration that would ultimately result following the completion of the 65-year mine plan when the caverns have totally closed and no further settlement related to mining is expected. Actual topographic changes are dynamic and can be expected to commence once mining begins, and the spatial extent and magnitude will be directly related to the mining plan. However, the process is very gradual and the final topography may require hundreds of years to develop fully. The final state of topography is assumed as the worst-case scenario for predicting the maximum spatial extent and magnitude of subsidence.

Deep and shallow flow components comprise the overall groundwater flow system. In general, groundwater flow patterns are governed by topography with recharge occurring in highlands and discharge in low-lying areas. Localized topographic features govern the shallow flow regime and regional topography exerts a controlling influence on the general direction of deep groundwater flow. Therefore, changes in topography due to ultimate subsidence may result in changes to groundwater flow patterns.

Predicted subsidence values range up to approximately -6.7 m towards the central portion of the mining area. The gradient of surface subsidence would be gradual, with slightly steeper slopes near the mine boundary. The expected maximum gradient is approximately 3.9 metres per kilometre (m/km). This result may have a localized effect on shallow groundwater flow patterns, but will not have a measurable effect on regional (deep) groundwater flow patterns. The near-surface expression of subsidence will occur at a slow rate (i.e., over centuries); exhibiting plastic deformation in the horizons containing groundwater resources (Tertiary and Quaternary age sediments).

Effects of subsidence will be mitigated by applying environmental design features and specialized techniques for solution mining. For example, pillars of unmined material will be left between the mine caverns to isolate the caverns, to increase stability during mining, and reduce potential subsidence. The cavern layout will be refined as additional modeling is completed to optimize potash recovery and to limit the potential effects of subsidence on surface topography. Secondary mining techniques that reduce the amount of material removed from the mine cavern will be employed after development of primary caverns wherever possible. Extraction ratios will be controlled to limit strain on the overlying environment.

Sinkholes or disruptive subsidence features are not expected because of the depth to the caverns developed by mining activities, the limited vertical extent of cavern development, the low extraction ratio, and favorable overlying stratigraphy. Strain within the Quaternary age deposits will be low due to the relatively small gradients characterizing the surface expression of subsidence and, therefore, near-surface deformation is not expected to affect the continuity of fresh-water aquifers.

Long-term changes are not anticipated to be obvious and domestic activities should adjust to the changes over time. Because subsidence will occur very gradually, no acute, adverse effects on groundwater quantity is predicted. Although minor changes in groundwater quantity are predicted, this pathway was determined to have a negligible residual effect on groundwater.

8.4.2.3 Primary Pathways

The following primary pathways are assessed in detail in the residual effects analysis.

- **Vertical and lateral migration of brine from the tailings management area can cause changes to groundwater quality.**
- **Long-term brine migration from the tailings management area can alter groundwater quality.**

8.5 Residual Effects Analysis

The residual effects analysis is focused on thoroughly evaluating the primary pathways associated with the Project and other developments on groundwater. The residual effects assessment is completed by calculating and estimating changes to the measurement indicators that are relevant to the primary pathways, which includes groundwater chemistry.

8.5.1 Effects on Groundwater

8.5.1.1 Methods

The potential for migration of brine from the TMA to groundwater aquifers exists during the operating and decommissioning phases of the Project. The stratigraphy of soils in and around the TMA, and their hydrogeological properties were determined through extensive site characterization studies. Site characterization results were used in the core facilities area selection process to determine an optimal TMA location taking into account operational requirements, social considerations, and geological conditions with preference for clay-rich soils that would mitigate the vertical migration of brine from the TMA. Solute transport simulations were completed to assess vertical migration of brine from the TMA. Methods and results of transport modelling are presented in detail in Appendix 8-A. Solute transport analyses used field and laboratory data collected during site characterization studies, and considered the proposed site layout in relation to geologic units which have been identified underlying the core facilities area. The results of field investigations and interpretation of hydrogeologic conditions near the TMA, on which the analyses were based, are presented in detail in Annex II, Section 4.0.

A 3-D groundwater flow model of the ESA was created and calibrated to baseline hydraulic head data. The details of model development and simulation results are presented in Annex II, Section 4.0. A particle tracking analysis was conducted to identify the fate of groundwater flow from the TMA. Particles were released within the local scale groundwater flow model at the ground surface within boundaries of the proposed TMA. The particles were forward tracked in the direction of groundwater flow, and effectively represent the theoretical migration of a conservative solute (i.e., no attenuation processes in transport) following its introduction to the groundwater table.

8.5.1.2 Results

The TMA will be situated on glacial moraine deposits comprised primarily of clay till deposits, which are underlain by an aquifer at depth in certain locations. The particle tracking analysis indicated that the dominant seepage path from the TMA is vertical through glacial till confining layers, then lateral through zones of enhanced permeability through one of the Saskatoon Group Aquifer or the Intertill Aquifer sand and gravel deposits (Figure 8.5-1). In addition, shallow lateral flow may be expected locally around the periphery of the TMA where, if present, surficial stratified deposits or fractured and oxidized clay zones may provide a preferential seepage path, large horizontal hydraulic head gradients exist due to mounding of the brine within the salt pile.

Design features will be implemented to prevent lateral long-term seepage of brine from the TMA and may include the construction of bentonite-amended cutoff walls or recovery wells. The cutoff walls may be used to effectively isolate a brine plume from preferential groundwater flow zones. The recovery wells may be used to locally reverse hydraulic gradients beneath the TMA, such that hydraulic containment of a brine plume could be maintained. These design features provide two lines of defense against the release of brine from the TMA and may be used to contain brine along both deep and shallow seepage paths. The predicted 1,000-year particle pathlines and groundwater flow directions from beneath the TMA footprint with the addition of a wall boundary and groundwater pumping system is shown in Figure 8.5-2. Analysis of the brine containment option suggests that containment of the groundwater within the TMA footprint requires the construction of a barrier wall along with a groundwater pumping/collection system. Monitoring of groundwater elevations and groundwater quality within and outside the barrier wall will be required during pumping operations to optimize pumping rates and confirm brine capture within the TMA footprint.

A solute transport analysis was completed to determine the time required for the brine plume to advance through the clay-rich deposits and arrive at underlying aquifers/enhanced permeability zones (Appendix 8-A). Geological conditions indicate the presence of two shallow sand aquifers below the core facilities area. The core facilities area is underlain by silty clay till aquitard that ranges from approximately 6 to 25 m in thickness. The Saskatoon Group aquifer and the Intertill aquifer are the most permeable units below the core facilities area and, therefore, represent a potential conduit for brine migration away from the TMA.

Analysis results predict first arrival of the brine plume at the Saskatoon Group Aquifer approximately four years after the start of waste salt deposition, while the sensitivity analysis showed that, considering uncertainty in soil properties, break through times ranging from less than one year to 25 years could be possible. Given uncertainty inherent in predicted values, the timing of implementation of containment infrastructure in areas where the Saskatoon group aquifer is present should be based on additional site characterization at the detailed design stage of the Project, and results of monitoring plume development during the initial stages of operations.

The first arrival of the brine plume at the Intertill Aquifer was predicted to occur approximately 400 years after the start of waste salt deposition, while the sensitivity analysis showed that, considering uncertainty in soil properties, break through times ranging from 50 years to 1,600 years could be possible. Based on the results, implementation of containment infrastructure to the depth of the Intertill Aquifer can be deferred into the future and implemented based on the results of monitoring plume development.

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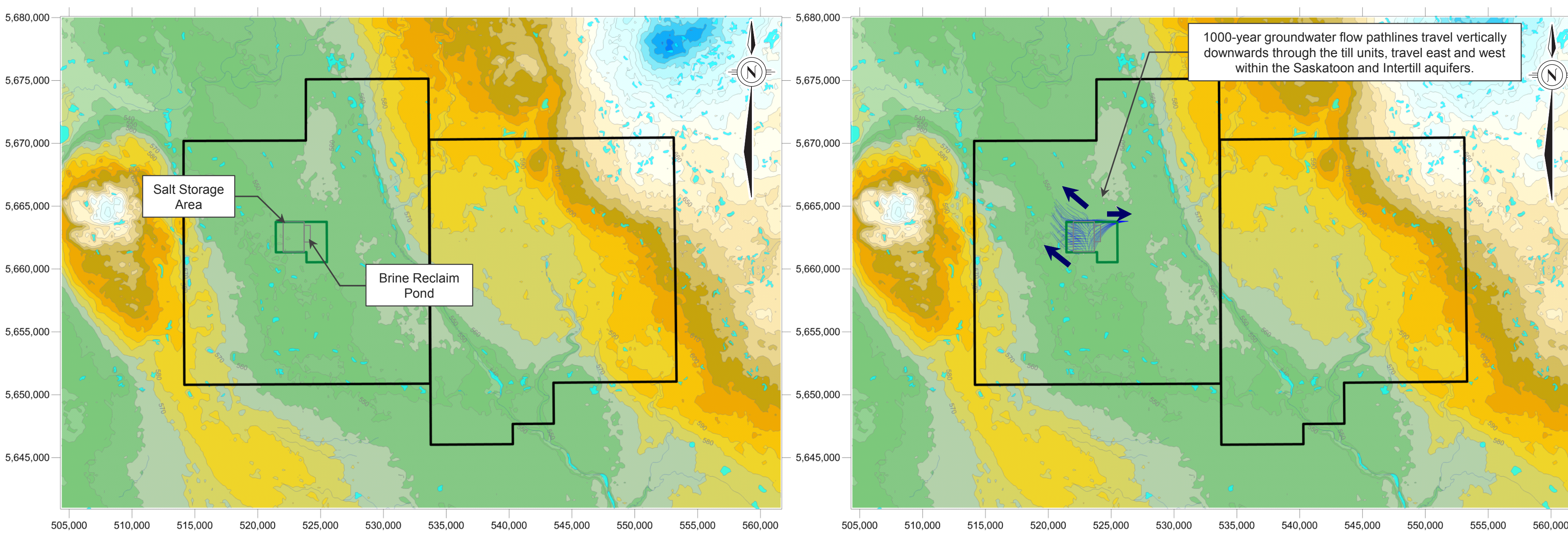

LEGEND

- PARTICLE PATHLINE
- SURFACE WATERCOURSE/WATERBODY
- PERMIT BOUNDARY
- CORE FACILITIES AREA
- DIRECTION OF GROUNDWATER FLOW

NOTE

1. THE PARTICLE PATHLINES SHOWN REPRESENT STEADY-STATE PARTICLE TRAVEL RESULTING FROM STEADY-STATE GROUNDWATER FLOW CONDITIONS, THEIR THREE-DIMENSIONAL DIRECTION PROJECTED TO SURFACE ON A TWO-DIMENSIONAL PLANE.
2. CONTOURS SHOWN REPRESENT THE SURFACE TOPOGRAPHY AT A 10 METRE CONTOUR INTERVAL.

PROJECT

YANCOAL SOUTHEY PROJECT

TITLE

PROPOSED CORE FACILITIES BOUNDARY CONDITIONS AND 1000-YEAR PARTICLE PATHLINES LOCAL MODEL

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	JR	01/05/14	SCALE AS SHOWN REV. 0
GIS	SM/LS	22/04/15	FIGURE: 8.5-1
CHECK	CK	27/05/15	
REVIEW	MAT	27/05/15	

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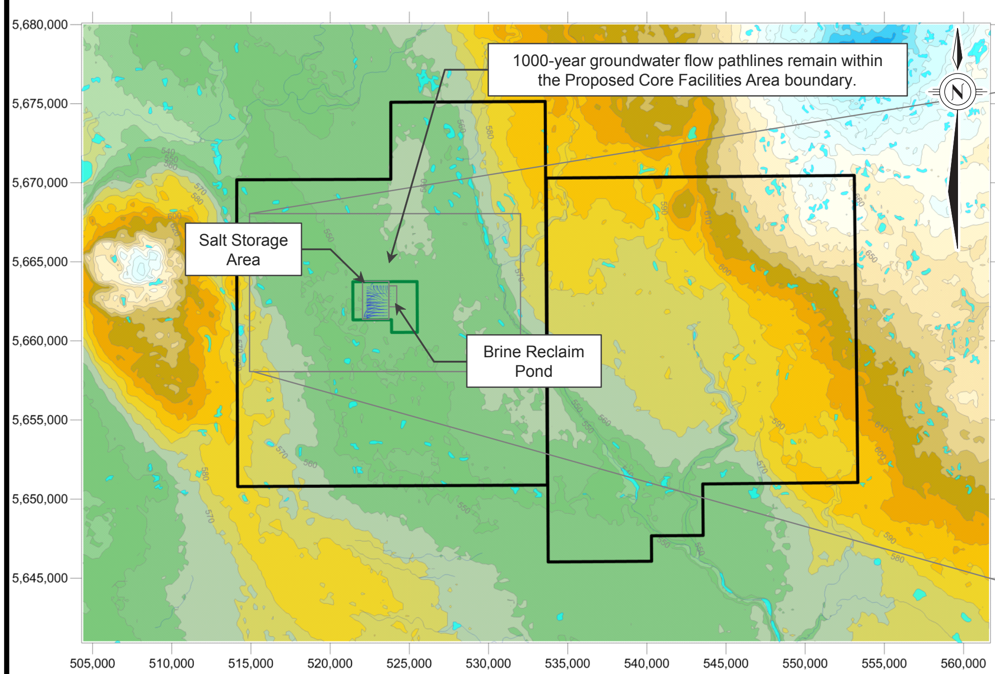

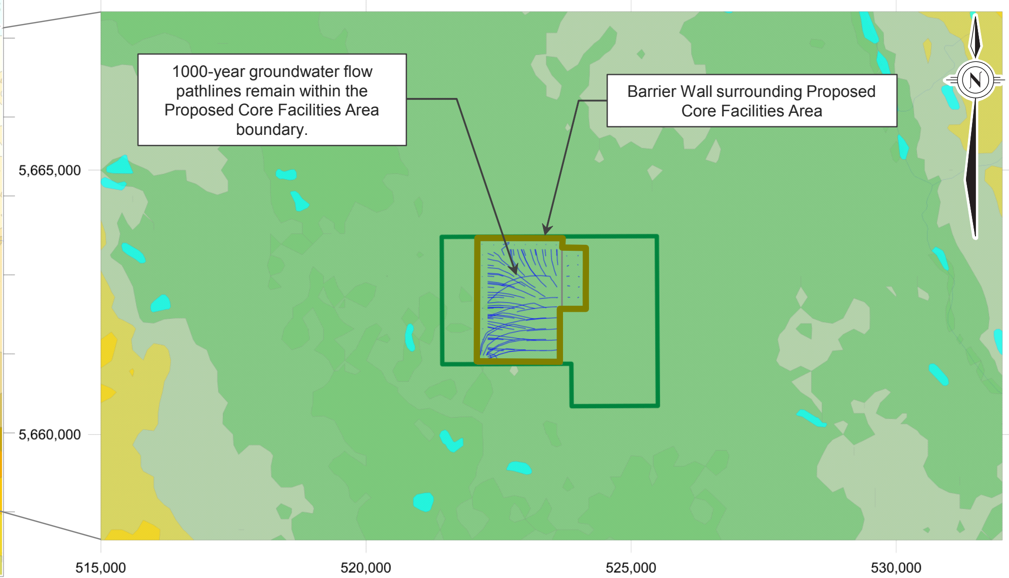

LEGEND

- PARTICLE PATHLINE
- SURFACE WATERCOURSE/WATERBODY
- BARRIER WALL
- PERMIT BOUNDARY
- CORE FACILITIES AREA

NOTE

1. THE PARTICLE PATHLINES SHOWN REPRESENT 1000-YEAR PARTICLE TRAVEL RESULTING FROM STEADY-STATE GROUNDWATER FLOW CONDITIONS, THEIR THREE-DIMENSIONAL DIRECTION PROJECTED TO SURFACE ON A TWO-DIMENSIONAL PLANE.
2. CONTOURS SHOWN REPRESENT THE SURFACE TOPOGRAPHY AT A 10 METRE CONTOUR INTERVAL.

PROJECT

YANCOAL SOUTHEY PROJECT

TITLE

1000-YEAR PARTICLE PATHLINES WITH GROUNDWATER CONTAINMENT BARRIER WALL LOCAL MODEL

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	JR	01/05/14	SCALE AS SHOWN	REV. 0
GIS	SM/LS	22/04/15	FIGURE: 8.5-2	
CHECK	CK	14/04/15		
REVIEW	MAT	27/05/15		

A monitoring program for the TMA will be implemented at the start of operations. Monitoring results will be used to track plume development and assess the need for and subsequent performance of containment infrastructure. Should monitoring indicate unsatisfactory performance of containment infrastructures, further mitigation may be undertaken to contain brine within the TMA footprint. Considering the application of design features (containment infrastructure) and the ability to monitor plume development during operations and adapt mitigation strategies, long-term changes to groundwater quality are only expected to occur within the footprint of the TMA.

8.6 Prediction Confidence and Uncertainty

Primary areas of uncertainty related to prediction of effects on the groundwater system include stratigraphic heterogeneity, continuity between hydrostratigraphic units, and hydraulic properties of geologic units. These uncertainties are addressed through sensitivity runs conducted during modelling exercises, which identifies critical parameters and provide a range of possible results, given uncertainties related to input parameters. The sensitivity analyses are used to define upper and lower bound predictions, which have been discussed with predictive results. As the Project moves into subsequent stages of site characterization, definition and operational monitoring, additional data may be used to reduce uncertainty and constrain effects prediction further within the range provided herein.

8.7 Residual Effects Classification and Determination of Significance

8.7.1 Methods

8.7.1.1 Residual Effects Criteria

The purpose of the residual effects classification is to describe the residual incremental and cumulative adverse effects from previous and existing developments and the Project (Application Case) on groundwater using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment.

Results from the residual effects classification are then used to determine the environmental significance from the Project and other developments on the assessment endpoint for hydrogeology (i.e., continued suitability of groundwater for human use). Effects are described using the criteria defined in Table 8.7-1, and reflect the effects criteria provided in the TOR (Appendix 2-B). Together, these criteria are used to describe the nature (e.g., severity or intensity of change, and the area and amount of time over which the change occurs) and type (e.g., direction of the change) of an effect on a VC. The focus of the EIS is to predict whether the Project is likely to cause a significant adverse (i.e., negative) effect on the environment; positive effects are not assessed for significance.

Magnitude –Magnitude is a measure of the intensity of a residual effect, or the degree of change caused by the Project relative to Base Case conditions or a guideline value. It is classified into three scales: negligible to low, moderate, and high. The scale of magnitude is defined differently for changes in groundwater quality and quantity. For changes to groundwater quality, a classification of negligible to low magnitude means no measureable change in groundwater quality or a minor predicted change in groundwater quality (i.e., less than one standard deviation from Base Case conditions). A moderate magnitude residual effect involves a predicted change in groundwater quality (i.e., less than two standard deviations from baseline conditions), with quality remaining suitable for present use based on applicable water quality criteria. A high magnitude effect is defined as a predicted change in groundwater quality (i.e., greater than two standard deviations from Base Case conditions), with quality no longer suitable for present use based on applicable water quality criteria.

Table 8.7-1: Definitions of Residual Effects Criteria Used to Evaluate Significance for Groundwater

Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Negligible to Low: Minor predicted change in groundwater quality and available yield meets current demand. **Moderate:** Predicted change in groundwater quality however remains suitable for present use and alternate sources are available to meet current demand. **High:** Predicted groundwater quality is not suitable for current use, available yield does not meet current demand and no alternate sources are available.	**Local:** Predicted maximum spatial extent of direct and indirect effects from changes to measurement indicators due to a project or activity. **Regional:** Residual effects from changes to measurement indicator due to a project or activity exceed the local scale and can include cumulative effects from other developments in the effects study area. **Beyond Regional:** Residual cumulative effects from changes to measurement indicator due to a number of developments extend beyond the effects study area.	**Short-term:** Residual effect from change to measurement indicator is reversible at end of construction of Project. **Medium-term:** Residual effect from change to measurement indicator is reversible at end of operations of Project. **Long-term:** Residual effect from change to measurement indicator is reversible within a defined length of time past closure of Project. **Permanent:** Residual effect from change to measurement indicator is irreversible.	**Infrequent:** Residual effect from change to measurement indicator is confined to a specific discrete event. **Frequent:** Residual effect from change to measurement indicator occurs intermittently over the life of the Project. **Continuous:** Residual effect from change to measurement indicator occurs continuously.	**Reversible:** Residual effect from change to measurement indicator is reversible within a period that can be identified when a development or activity no longer influences groundwater. **Irreversible:** Residual effect from change to measurement indicator is predicted to influence groundwater indefinitely (duration is permanent or unknown).	**Unlikely:** Residual effect from change to measurement indicator is possible but unlikely (less than 10% chance of occurrence). **Likely:** Residual effect from change to measurement indicator may occur, but is not certain (10% to 80% chance of occurring). **Highly Likely:** Residual effect from change to measurement indicator is likely to occur or is certain (greater than 80% chance of occurring).

% = percent.

For groundwater quantity, a classification of negligible to low magnitude means no measurable change in groundwater quantity or a minor change in available aquifer yield, with available yield capable of meeting current demand. For a moderate magnitude effect, aquifer yield is predicted not to meet current demand; however, alternate groundwater sources are available. A high magnitude effect is defined as occurring when aquifer yield is no longer able to meet current demand and no suitable alternate groundwater source is available.

Geographic Extent – Geographic extent refers to the spatial extent of the area affected and is different from the spatial boundary (i.e., ESA) for the effects analysis. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution of the VC (Section 8.2.1). However, the geographic extent of effects can occur on a number of scales within the spatial boundary of the assessment and is VC-specific. Effects at the local scale are largely associated with the predicted maximum spatial extent of combined direct and indirect changes from the Project (i.e., cumulative effects that are specific to the Project). Effects at the regional scale occur within the ESA, and are associated with incremental and cumulative changes from the Project and other developments. The beyond regional scale includes cumulative residual effects from the Project and other developments that extend beyond the ESA. The principle applied when using geographic extent to understand magnitude is that local effects from the Project are less severe than effects that extend to the regional or beyond regional scales, all other factors being equal.

Duration –Duration is VC-specific and defined as the amount of time from the beginning of a residual effect to when the effect on a VC is reversed. It is usually expressed relative to Project phases (usually in years). Duration has two components; the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases), plus the time required for the effect to be reversible. Essentially, duration is a function of the length of time that VCs are exposed to Project activities and reversibility of the effect. By definition, residual effects that are short-term, medium-term, or long-term in duration are reversible.

In some cases, available scientific information and experienced opinion may predict that the residual effect is irreversible. Alternately, the duration of the residual effect may not be known, except that it is expected to be extremely long and well beyond the temporal boundary of the Project. Any number of factors could cause a VC to never return to a state that is unaffected by the Project. In other words, science and logic predict that the likelihood of reversibility is so low or uncertain that the residual effect is classified as irreversible.

8.7.1.2 Determination of Significance

The classification of primary pathways and the associated predicted changes in measurement indicators provides the foundation for determining the significance of incremental and cumulative effects from the Project and other existing and approved developments on the assessment endpoint for groundwater. The evaluation is focused on determining the significance of cumulative effects on continued suitability of groundwater for human use.

Magnitude is the primary criterion used to determine environmental significance, while other criteria are used as modifiers and to provide context when assigning magnitude. Geographic extent and duration provide important context for classifying the magnitude of an effect on the groundwater assessment endpoint. For example, determining the magnitude of an effect from changes in the groundwater levels on the hydrogeology VC depends on the spatial extent and duration of the changes. Duration includes reversibility; a reversible effect from a development is one that does not result in a permanent adverse effect on hydrogeological functions and properties. Frequency and likelihood are also considered as modifiers when determining significance, where applicable.

The evaluation of significance for groundwater considers the entire set of primary pathways that influence the assessment endpoint; thus, significance is not explicitly assigned to each pathway. Rather, the relative contribution of each pathway is used to determine the significance of the Project and other developments on the assessment endpoint, which represents a weight of evidence approach (i.e., evaluating the persuasiveness of evidence indicating that an effect is significant or not significant). For example, a pathway with a high magnitude, a regional geographic extent, and a long-term duration is given more weight in determining significance relative to pathways with smaller scale effects. The relative effect from each pathway is discussed; however, pathways that are predicted to have the greatest influence on changes to the assessment endpoint are assumed to contribute the most to the determination of environmental significance.

The determination of environmental significance on groundwater considered the following key factors:

- Results from the residual effect classification of primary pathways and associated predicted changes in measurement indicators.
- Magnitude is the primary criterion used to determine significance with geographic extent and duration providing important context for assigning magnitude. Frequency and likelihood act as modifiers for determining significance, where applicable.
- The level of confidence in predicted effects, established guidelines and standards, and experienced opinion are also included in the evaluation of determining environmental significance.

This method is used to identify predicted residual adverse effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to groundwater, and therefore, result in significant effects. The following definitions are used for predicting the significance of effects on the continued suitability of groundwater for human use.

Not significant – A residual effect on groundwater that is not significant results in available groundwater yield that is still able to meet current demand from current or suitable alternate sources or a change in groundwater quality, which is still suitable for present use, based on applicable water quality criteria. Changes resulting from the Project are not measurable at the regional scale and are reversible

Significant – A significant residual effect on groundwater is a result of a change in groundwater quantity so that it is no longer able to meet current demand and no suitable alternate source is available, or is a result of a change in groundwater quality so it is no longer suitable for present use based on applicable water quality criteria. Changes from the Project are measurable at the regional scale, and will permanently affect the suitability of groundwater for human use.

8.7.2 Results

The location of the TMA was selected based on site-specific geologic studies conducted to identify an appropriate foundation for the TMA, which provides natural containment of brine material. This natural containment, together with other Project environmental design features is expected to contain the vertical and lateral movement of brine along both deep and shallow seepage paths during operations and in the long-term (i.e., local in spatial extent). Design features will be implemented to prevent lateral long-term seepage of brine from the TMA and may include the construction of bentonite-amended cutoff walls or recovery wells. The cutoff walls may be used to effectively isolate a brine plume from preferential groundwater flow zones. The recovery wells may be used to locally reverse hydraulic gradients beneath the TMA, such that hydraulic containment of a brine plume could be maintained. These design features provide two lines of defense against the release of brine from the TMA and may be used to contain brine along both deep and shallow seepage paths (i.e., negligible to low magnitude).

The results of the solute transport analysis predict first arrival of the brine plume could range from less than 1 year to more than 1,600 years after the start of waste salt deposition depending on the depth to aquifers present at a given location, taking into account uncertainty in soil properties. These results indicate that the timing of implementation of containment infrastructure should be based on additional site characterization at the detailed design stage of the Project and results of monitoring plume development during the initial stages of operations.

A monitoring program for the TMA will be implemented at the start of operations. Monitoring results will be used to track plume development and assess the performance of containment infrastructure. Should monitoring indicate unsatisfactory performance of containment infrastructures, further mitigation may be undertaken to contain brine within the TMA footprint. Therefore, the residual effect on groundwater quality from vertical and lateral brine migration from the Project during operations and in the long-term is negligible to low in magnitude and local in geographic extent (Table 8.7-2).

Uncertainty related to containment of brine migration from the TMA is primarily related to the spatial distribution and continuity of coarse-grained stratified sediments, and the hydraulic conductivity of confining clay till deposits. Inputs to solute transport analyses were selected based on the results of field and laboratory testing and engineering judgment, yielding analysis results which may be considered to represent a best estimate of brine migration rates. Sensitivity analyses were completed as a means of defining a reasonable upper bound rate of brine migration from the TMA. For the purposes of this assessment, it has been assumed that aquifer units encountered within the core facilities area are continuous with the corresponding aquifers known to exist adjacent to the core facilities area. Investigations will be undertaken in subsequent design phases of the TMA infrastructure to delineate the spatial distribution of stratified deposits beneath the TMA and examine the continuity with adjacent aquifer systems. Monitoring for the TMA will be completed to track the performance of containment infrastructure which will allow for an adaptive management approach to implementation of additional mitigation, if required. Overall, the changes to groundwater from the Project are predicted to have no significant effect on the continued suitability of groundwater for human use.

A summary of the effects classification and prediction of significance on the groundwater assessment endpoints are provided in Table 8.7-2.

Table 8.7-2: Summary of Residual Effects Classification of Primary Pathways and Predicted Significance of Cumulative Effects on Groundwater

Pathway	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Significance for Assessment Endpoint
Vertical and lateral migration of brine from the TMA may cause changes to groundwater quality.	Negligible to low	Local	Permanent	Continuous	Irreversible	High	Not significant
Long-term migration of brine from the TMA may cause changes to groundwater quality.	Negligible to low	Local	Permanent	Continuous	Irreversible	High	

TMA = tailings management area.

8.8 Monitoring and Follow-up

Typically, monitoring includes one or more of the following categories, which may be applied during the development of the Project:

- **Compliance monitoring** – monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments (e.g., inspecting the installation and effectiveness of a silt fence).
- **Follow-up monitoring** – programs designed to test the accuracy of effects predictions, reduce/address uncertainties, determine the effectiveness of environmental design features, and/or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., monitoring of downstream lakes for aquatic effects, wildlife effects monitoring, and socio-economic monitoring). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

Follow-up programs are typically implemented when the accuracy of the determination of significance needs to be verified or the resulting residual effects cause sufficient public concern to warrant an increased effort to determine the accuracy of the predictions or test the effectiveness of mitigation and compensation. These programs form part of the environmental management system for the Project. If monitoring or follow-up detect effects that are different from predicted effects, or the need for improved or modified design features and mitigation, adaptive management will be implemented. This may include increased monitoring, changes in monitoring programs, and additional mitigation. Monitoring for groundwater will involve:

- down-hole geophysical electromagnetic logging (e.g., EM39);
- terrain conductivity surveys (e.g., EM31);
- groundwater chemistry;

- groundwater hydraulic head; and
- TMA salt pile stability.

Monitoring data will provide the basis for evaluating the effectiveness of brine containment within the TMA and will provide timely feedback required to implement additional mitigation, if required. The details of the monitoring program, as well as various threshold criteria for implementation of mitigation, will be determined in the detailed design in support of licensing the Project. As a guiding principle, monitoring station locations and monitoring frequencies will be selected to provide a data record sufficient to evaluate the development of plumes associated with the TMA and assess the effectiveness of containment infrastructure. Threshold criteria will be selected so that further mitigation may be implemented in a timely manner to contain brine within the TMA footprint, and thus mitigate effects on the surrounding subsurface environment should it be required. Brine migration rates are predicted to occur at a rate on the order of centimetres per year; therefore, conventional monitoring practices employed by the potash mining industry are expected to be adequate to assess the timing for implementation of engineering controls or mitigation measures.

8.9 Summary and Conclusions

The potential environmental effects of the Project to hydrogeology were assessed using groundwater flow and solute transport models. The results of the solute transport analysis provide an estimate and reasonable bounds of potential effects, taking into account uncertainty in site geology and soil properties. These results indicate that implementation of environmental design features such as containment infrastructure (e.g., cutoff walls and recovery wells) should be based on additional site characterization at the detailed design stage of the Project and results of groundwater monitoring during the initial stages of operations. These design features provide two lines of defense against the release of brine from the TMA and may be used to contain brine along both deep and shallow seepage paths. A monitoring program for the TMA will be implemented at the start of operations. Monitoring results will be used to track plume development and assess the performance of containment infrastructure. Should monitoring indicate unsatisfactory performance of containment infrastructures, further mitigation will be undertaken to contain brine within the TMA footprint.

Considering the application of environmental design features (i.e., containment infrastructure) and the ability to monitor plume development during operations and adapt mitigation strategies, long term changes to groundwater quality are expected to occur only within the footprint of the TMA. The residual effect on groundwater quality from vertical and lateral brine migration from the Project is negligible to low in magnitude and local in geographic extent. Overall, changes to groundwater from the Project are predicted to have no significant effect on the continued suitability of groundwater for human use.

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8.11 Glossary

Term	Description
Alluvial	Refers to sediments deposited in water.
Aquifer	Rock or sediment geologic unit, or portion of, that is saturated and sufficiently permeable to yield significant quantities of water to wells or springs.
Aquitard	A low-permeability unit that can store groundwater and transmit it slowly from one aquifer to another.
Bedrock	Refers to all sediments older than Quaternary (glacial) deposits.
Best Practice	Method or procedure that is accepted by industry as being effective, practical and reliable in maintaining quality, and meeting Project objectives and regulatory requirements.
Brine	A concentrated solution of inorganic salts.
Calcareous	Soil containing sufficient calcium carbonate, often with magnesium carbonate, to effervesce visibly when treated with cold 0.1N hydrochloric acid.
Clay	Fine-grained sediment (typically <5 µm) that contains clay minerals, has plasticity, and is cohesive.
Cretaceous	The geologic period and system from approximately 145 to 65 million years ago. In the geologic timescale, the Cretaceous follows on the Jurassic period and is followed by the Paleocene period of the Cenozoic era. It is the youngest period of the Mesozoic era. The end of the Cretaceous defines the boundary between the Mesozoic and Cenozoic eras.
Drift	A general term applied to all material (clay, silt, sand, gravel, and boulders) transported by a glacier and deposited directly by or from the ice, or by glacial melt water.
Erosion	The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. Detachment and movement of soil or rock by water, wind, ice, or gravity.
Fluvial	Refers to sediments deposited by a stream.
Formation	The basic lithostratigraphic unit in the local classification of geologic units characterized by some degree of internal lithologic homogeneity or distinctive lithology that is mappable at Earth's surface or traceable in the subsurface. Formations may be combined into groups or subdivided into members.
Glacial Till	Unstratified soil deposited by a glacier; consists of sand and clay and gravel and boulders mixed together.
Gravel	Coarse alluvial sediments, containing mostly particles larger than 5 millimetres.
Hydrostratigraphy	A geologic framework consisting of a body of rock or sediment having considerable lateral extent and composing a reasonably distinct hydrologic system.
Lacustrine	Refers to sediments deposited by a lake.
Lithology	Description and classification of the mineralogy, grain size, texture, and other physical properties of granular soil, sediment, or rock.
Local study area (LSA)	The area where direct effects and small-scale indirect effects from the Project are expected to occur. Occurs within the RSA.
Quaternary	The latter period of the Cenozoic Era of geologic time, extending from the end of the Tertiary Period (about 1.6 million years ago) to the present and comprising two epochs, the Pleistocene (Ice Age) and Holocene (Recent).
Reclamation	The process of reconverting disturbed land to its former or other productive uses.
Regional study area (RSA)	A broad area defined for the description of groundwater conditions generally centred on the Project and surroundings, and including areas where indirect effects of the Project might be expected to occur. Includes the LSA.

9.0 HYDROLOGY

9.1 Introduction

9.1.1 Background

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project) located in central Saskatchewan, approximately 60 kilometres (km) north of Regina. Yancoal proposes to develop the Project, which includes solution mining and associated supporting infrastructure.

The Project is located in the Rural Municipality (R.M.) of Longlaketon (No. 219) and the R.M. of Cupar (No. 218). An existing network of municipal grid roads, provincial highways, and rail lines will provide access to the Project. The Project (including the core facilities area, 65-year mine field, and indicated resource boundary) encompasses approximately 143 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M).

9.1.2 Purpose and Scope

This section of the Environmental Impact Statement (EIS) for the Project addresses the effects on the surface water environment identified in the Terms of Reference (TOR) approved by the Environmental Assessment Branch (EAB) of the Ministry of Environment (MOE) in May 2015 (Appendix 2-B).

The purpose of this section of the EIS is to meet the TOR, specifically to assess the effects from the Project on hydrology. The scope of the hydrology section includes an analysis of Project-related changes during construction, operation, and decommissioning and reclamation. The incremental and cumulative residual effects from the Project and other previous, existing, and reasonably foreseeable developments on hydrology are assessed.

Strong relationships exist between hydrology and the surface water quality, fish and fish habitat components of the environment. Changes in hydrology can also influence soils, vegetation, wildlife and the socio-economic environments. As such, related assessments are provided in the following sections:

- Hydrogeology (Section 8.0);
- Surface Water Quality (Section 10.0);
- Fish and Fish Habitat (Section 11.0);
- Soils (Section 12.0);
- Vegetation (Section 13.0);
- Wildlife (Section 14.0);
- Heritage Resources (Section 15.0); and
- Socio-economic Environment (Section 16.0).

9.1.3 Valued Components, Assessment Endpoints, and Measurement Indicators

The TOR identified hydrology as a valued component (VC) that should be included in the assessment of Project effects. Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by the proponent, the public, First Nations and Métis communities, and government agencies. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development and, therefore, are used to predict the effects of the Project on all environmental components. Rationale for selection of hydrology as a VC is as follows.

- The hydrologic environment is sensitive to Project-related effects.
- The hydrologic environment can be measured or described with one or more practical indicators.
- Surface water availability is a concern identified through engagement with the public, First Nations and Métis communities, and regulatory agencies.
- The movement, and spatial and temporal distribution of surface water (i.e., hydrology), is intrinsically linked with water quality and fish habitat; therefore quantifying the Project effects on hydrology assists in assessment of these VCs.

Community and regulatory engagement, and local and traditional knowledge were key considerations for selecting the hydrology VC, but assessment endpoints for the hydrology VC do not explicitly consider societal values, such as the response of people to changes in surface water quantity that is related to quality of life. Changes in hydrology are important and must be considered to understand all of the potential effects of the Project (i.e., both human and ecological dimensions). Consequently, measurement indicators from the hydrology section were carried forward so that effects on societal values could be appropriately captured in the sections dealing specifically with those values (Section 16.0).

Assessment endpoints are qualitative expressions used to assess the significance of effects on a VC and represent the key properties of the VC that should be protected for use by future human generations (i.e., incorporate sustainability). Assessment endpoints are general statements about what is to be protected. Measurement indicators are quantitative and/or qualitative expressions of changes to the assessment endpoints. The assessment endpoint for the hydrology VC is availability of surface water quantity for human use and ecosystems. The measurement indicators for hydrology (including geomorphological changes) include the following:

- spatial distribution of water including the spatial extent and location of waterbodies, runoff pathways, and streams;
- temporal distribution of water including changes in water levels and flows through time;
- drainage boundaries; and
- stream channel gradients.

9.2 Environmental Assessment Boundaries

9.2.1 Spatial Boundaries

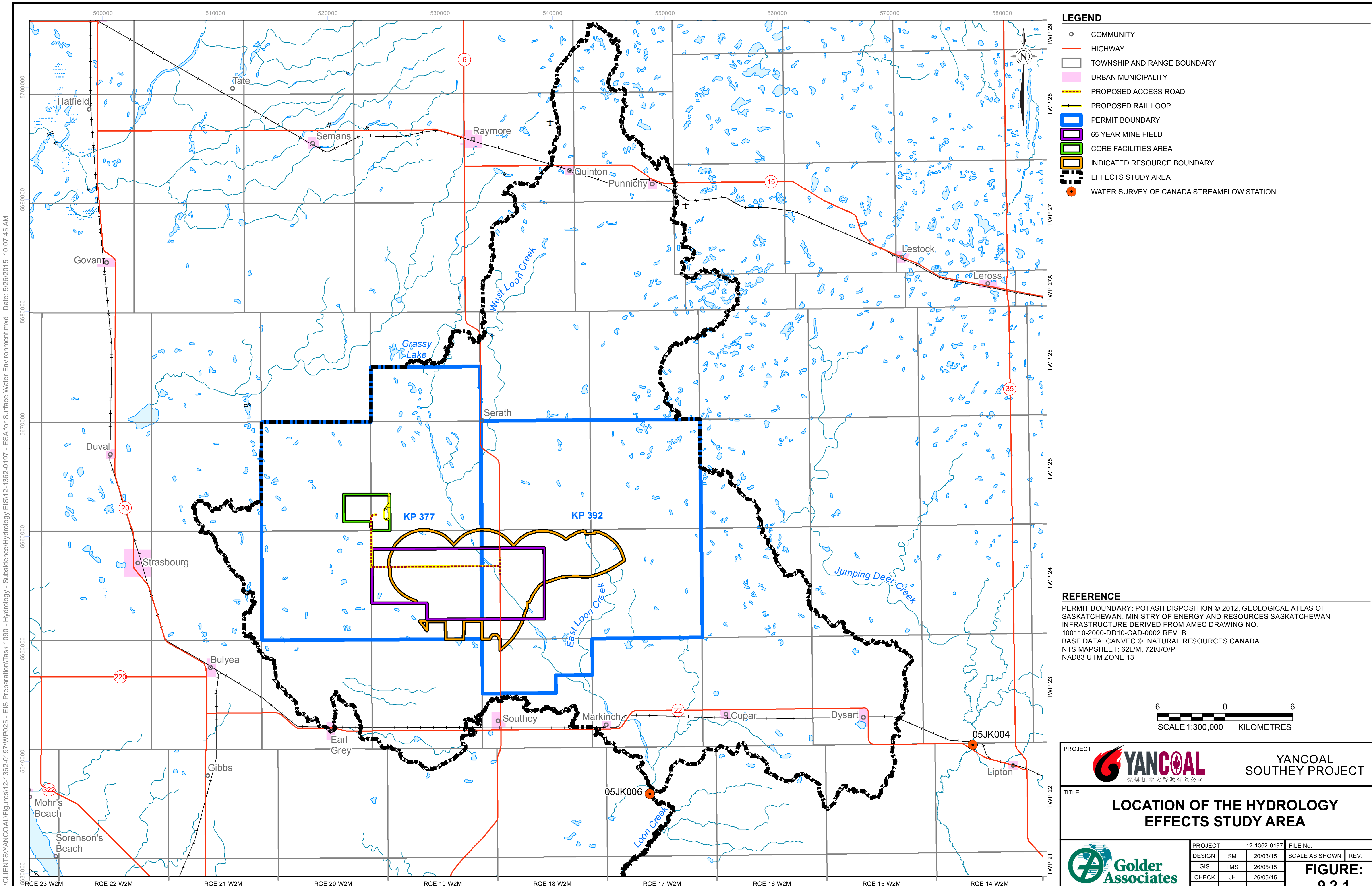
The Project occurs on the Strasbourg Plain (K15) Landscape Area of the Moist Mixed Grassland Ecoregion. The area is characterized by a combination of prairie, woodland and shrub land with hummocky landscapes where wetlands occur in lower areas and grassland and agriculture occupy the upper slopes (Acton et al. 1998). The region has a sub-humid continental climate characterized by warm summer and cold, dry winters. Approximately 79 percent (%) of the mean annual precipitation falls as rain, while the remaining 21% occurs as snowfall. The mean annual temperature is 3.1 degrees Celsius (°C) with temperatures likely to be below zero from November to March (Environment Canada 2014).

The Project permit boundary is within the Qu'Appelle River basin, Saskatchewan. Last Mountain Lake is located approximately 40 km west of the Project and the Qu'Appelle River is located about 30 km south. Most of the KP377 and KP392 permit areas are located within the Loon Creek drainage, but small peripheral areas are in the headwaters of the Last Mountain Lake and Jumping Deer Creek drainages, all of them flowing south to the Qu'Appelle River.

9.2.1.1 Baseline and Effects Study Areas

To quantify baseline conditions for hydrology, baseline study areas were defined for the surface water environment and included a regional study area (RSA) and local study area (LSA) (Annex III; Section 3.0). The RSA was defined by the maximum expected spatial extent of direct and indirect effects from the Project. The LSA was defined by the maximum expected spatial extent of the Project's direct effects.

To assess Project related effects on the surface water environment, an effects study area (ESA) was delineated for hydrology. One of the key indicators for measuring potential effects on hydrology is the spatial distribution and movement of surface water. Therefore, the 1,959-km^2 ESA extends to the boundaries of the drainage basins interacting with the Project (i.e., the ESA includes the Loon Creek basin downstream to the Water Survey of Canada hydrometric station 05JK006 near Markinch). Station 05JK006 is located about 16 km upstream of the Qu'Appelle River. Streamflow from the West and East Loon creek sub-basins and from a tributary near Cupar, Saskatchewan make up most of the flows to Loon Creek at Station 05JK006 (Figure 9.2-1). The ESA includes the Project footprint and the areas potentially affected by subsidence up to the confluence of West and East Loon creeks (Figure 9.2-1).


LEGEND
COMMUNITY
HIGHWAY
TOWNSHIP AND RANGE BOUNDARY
URBAN MUNICIPALITY
PROPOSED ACCESS ROAD
PROPOSED RAIL LOOP
PERMIT BOUNDARY
65 YEAR MINE FIELD
CORE FACILITIES AREA
INDICATED RESOURCE BOUNDARY
EFFECTS STUDY AREA
WATER SURVEY OF CANADA STREAMFLOW STATION
REFERENCE
PERMIT BOUNDARY: POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NTS MAPSHEET: 62L/M, 72I/J/O/P
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Quinton
Punnichy
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Govan
Grassy Lake
West Loon Creek
Serath
Duval
KP 377
KP 392
Strasbourg
Jumping Deer Creek
East Loon Creek
Bulyea
Southey
Markinch
Cupar
Dysart
Earl Grey
Gibbs
05JK004
05JK006
Lipton
Loon Creek
Mohr's Beach
Sorenson's Beach
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RGE 14 W2M
TWP 29
TWP 28
TWP 27
TWP 27A
TWP 26
TWP 25
TWP 24
TWP 23
TWP 22
TWP 21
PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT
TITLE
LOCATION OF THE HYDROLOGY EFFECTS STUDY AREA
Golder Associates
Saskatoon, Saskatchewan
PROJECT 12-1362-0197
DESIGN SM 20/03/15
GIS LMS 26/05/15
CHECK JH 26/05/15
REVIEW BT 26/05/15
FILE No.
SCALE AS SHOWN
REV. 0
FIGURE: 9.2-1
G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1090 - Hydrology - Subsidence\Hydrology EIS\12-1362-0197 - ESA for Surface Water Environment.mxd Date: 5/26/2015 10:07:45 AM

9.2.2 Temporal Boundaries

Temporal boundaries for the hydrology assessment were defined by the life of the Project (Section 4.0) and the existing and future cumulative effects to which the Project might contribute. The Project phases are construction, operation, and decommissioning and reclamation. Final relinquishment of the Project will occur after the completion of reclamation.

The effects analysis encompasses the Project phases as follows:

- construction (2016 to 2019);
- operations (2019 to 2119); and
- decommissioning and reclamation (2119 onward).

The above timeframes are intended to be sufficiently flexible to capture the effects of the Project on the hydrology VC. Effects on hydrology begin during the construction phase and continue through the decommissioning and reclamation phase (unless determined to be permanent). In this section of the EIS, the operations phase is considered in two stages, operations stage 1 (2019 to 2084) and operations stage 2 (2085 to 2119). Effects on topography and hydrology are focused on predicted subsidence for the 65-year mine plan (i.e., operations stage 1). The periods following operations stage 1 (i.e., operations stage 2 and decommissioning and reclamation phase) are discussed qualitatively in the effects assessment. This approach generates the maximum potential effects on the spatial and temporal distribution of water, which provides confident and ecologically relevant effects predictions.

9.2.2.1 Base Case

The Base Case (existing environment) represents existing conditions before application of the Project. Previous and existing developments and activities include roads, communities, water use, and agricultural activities. Consequently, the Base Case represents the cumulative outcome of all previous and existing developments and activities.

9.2.2.2 Application Case

The incremental contributions of residual effects from the Project on existing cumulative effects were assessed by adding the Project to the Base Case to form the Application Case. There are two periods during the Project that are expected to contribute to a maximum effect on surface water hydrology: the period when the maximum extent of the Project footprint would be isolated from the existing hydrology system (i.e., this would be reached in an early stage of the operation period) and the period when the settlement due to mine subsidence would be the maximum expected (i.e., this would be reached many years after decommissioning and reclamation). Changes to measurement indicators for hydrology were predicted and incremental contributions of the Project and cumulative effects of the Project, plus previous and existing developments and activities are evaluated.

9.2.2.3 Reasonably Foreseeable Development Case

The Reasonably Foreseeable Development (RFD) Case represents the Application Case plus reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. The minimum temporal boundary for the

Application Case and RFD Case is the expected lifespan of the Project that, like the Base Case, includes a range of conditions over time. The difference between the Application and RFD Case is that the Application Case considers the incremental effects from the Project in isolation of potential future land use activities. The RFDs are defined as projects that:

- are currently under regulatory review or that have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project or may be induced by the Project;
- have been approved but not yet developed; or
- have the potential to change the Project or the effects predictions.

The reasonably foreseeable developments identified in Section 6.0 include the supporting infrastructure required for the Project, the Muskowekwan Potash Mine Project, and the Vale Kronau Project. Supporting infrastructure will include a water supply pipeline, an overhead transmission line, a natural gas supply pipeline, telecommunication services, and a railway line. Screening assessment reports will be completed by each of the utility providers once the final routing options are determined. Most of the preferred routes for the supporting infrastructure are not known at this time. Therefore, the supporting infrastructure for the Project will not be assessed as an RFD for hydrology.

Process and non-potable water for the Project will be extracted from Buffalo Pound Lake and supplied by infrastructure to be constructed and operated by Saskatchewan Water Corporation (SaskWater). A surface water rights licence for the Project was obtained in June 2013 for an annual industrial water use allocation of up to 13,000 cubic decametres per year (dam^3). Continuation of this licence is subject to completion of the environmental assessment and regulatory approval and other conditions specified by the Water Security Agency (WSA). Use of water from Buffalo Pound Lake and the regional water supply system may require additional diversion of water from Lake Diefenbaker to the Upper Qu'Appelle River, which may reduce flows through the Gardiner Dam along the South Saskatchewan River system. Regional changes to hydrology due to the Buffalo Pound Regional Non-Potable Water Supply System Yancoal Pipeline will be assessed in a separate assessment and approved by WSA prior to construction. Changes to regional hydrology would occur within the South Saskatchewan River Basin and along the Qu'Appelle River. These effects are not expected to overlap with effects on hydrology in the ESA and, therefore, will not be assessed as an RFD for hydrology.

The proposed Muskowekwan Potash Mine Project is located approximately 52 km northeast of the Project; and the Vale Kronau Project is located approximately 71 km south of the Project. The effects on hydrology from development of the Muskowekwan Potash Mine Project and the Vale Kronau Project are not expected to overlap with effects on hydrology within the ESA, as they are located in different watersheds. Therefore, these projects will not be assessed as an RFD for hydrology.

9.3 Existing Environment

The purpose of this section is to describe the existing environment (Base Case) within the ESA as a basis to assess the potential Project-specific effects on hydrology. The detailed methods and results for baseline data collection are provided in the Surface Water Environment Baseline Report (Annex III, Section 3.0).

9.3.1 Sources of Information

The existing environment description is based on the baseline field data and on the long-term hydrologic records available from Environment Canada. Baseline data were collected during multiple field visits in 2013, during the spring freshet (i.e., late April to mid-May) and in the summer and fall (i.e., mid-July, mid-August, and early November). Water level recorders and rain gauge were installed during the entire 2013 open water season and streamflow data was measured at several locations during the open water period. Topographic data was collected using a Light Detection and Ranging (LiDAR) survey in September 2013. Long-term historical climate records are available from Duval Station (ID 4012300) located approximately 25 km from the Project, Regina International Airport station (ID 4016560), and Regina Gilmour (ID 4016651) stations, located approximately 60 km from the Project. The most recent climate normals are provided by Environment Canada (2014).

9.3.2 Topography and Drainage

Surface elevations in the permit boundaries (KP377 and KP392) range from about 670 metres above sea level (masl) in the upland areas along the edge of the Little Touchwood Hills to 532 masl in the low-lying areas west of West Loon Creek and along local streams. The area is characterized by numerous wetlands or potholes typical of the prairie pothole region that contains glacial till with gently rolling hills and a few stream valleys. Prairie wetlands store water above and below the ground surface. Water stored in wetlands is usually lost to evapotranspiration with a much smaller volume lost to flows downstream.

Most of the study area is located within the Loon Creek drainage. The main tributaries of Loon Creek, including West Loon Creek (1,018 km^2) and East Loon Creek (517 km^2), join together to form Loon Creek near the town of Markinch, and this stream flows south into the Qu'Appelle River. Both West and East Loon creeks have well-defined stream channels and stream valleys. The northwest portion of KP377 drains towards Last Mountain Lake; however, in most years the runoff is likely stored within an unnamed waterbody near Duval, Saskatchewan. The southwest portion of KP377 has poorly defined runoff pathways and collects runoff from an area of approximately 453 square kilometres (km^2), including the proposed core facilities area and a portion of the mining plan area; this area would likely contribute to Loon Creek during wet years. Another tributary of Loon Creek (342 km^2) is located in the southeast portion of KP392 near the town of Cupar, Saskatchewan. This tributary receives treated effluent from the town sewage lagoon system during the spring and fall.

9.3.3 Climate and Hydrology

Average annual adjusted precipitation for the Regina Airport station was 451 millimetres (mm) with 326 mm occurring as rainfall for the years 1898 to 2007 (Environment Canada 2015). Precipitation data are adjusted to consider gauge under-catch, evaporation, and other losses. The average, maximum, and minimum historical parameters of gross evaporation, based on the period 1911 to 2008, was 939 mm, 1,311 mm, and 721 mm, respectively (Bell 2009, pers. comm.). In 2013, gross evaporation calculated using the modified-Meyer method was 815 mm, which is slightly below average.

The mean annual temperature is 3.1°C and average monthly air temperatures are below zero from November to March. Streams and waterbodies in the region are usually ice-free by late March or April and surface waterbodies start to freeze over in November. Streamflow either ceases in the smaller streams or is much reduced in the larger streams from November through March. Spring snowmelt runoff is the main source of water to local wetlands and streams and replenishes soil moisture.

According to the WSA (2014), the winter of 2012 to 2013 had an above-average snow water equivalent of 159 mm. From November 2012 to October 2013, the total precipitation was 437 mm at the station near Duval, Saskatchewan, while rainfall amounts recorded at weather stations near or in the ESA were quite variable.

9.3.4 Streamflow

Streamflow in Loon Creek was measured near Markinch, Saskatchewan at hydrometric Station 05JK006. This is the only hydrometric station within the ESA. The Loon Creek station was active from 1944 to 1954. Jumping Deer Creek streamflow is currently measured near Lipton, Saskatchewan at Station 05JK004. Jumping Deer Creek drains an adjacent and similar sized watershed with similar topography, land use, and surficial geology as that occurring in the Loon Creek watershed. Therefore, this station was selected as the most suitable station for characterizing the flood regime for the small drainages within the Loon Creek basin. The flood magnitude and frequency of the temporary streamflow stations was calculated based on their effective drainage areas using Jumping Deer Creek as the reference station (SaskWater 1993). The Jumping Deer Creek hydrometric station 05JK004 has been active since 1941 and is located approximately 30 km east of the Loon Creek station.

To characterize the temporal distribution of streamflow in the ESA, historical mean monthly flows from the decade of records available at Loon Creek (Station 05JK006) and 73 years of records at Jumping Deer Creek (Station 05JK004) are illustrated on Figure 9.3-1. According to Figure 9.3-1, peak flows most often occur in April due to the spring snowmelt freshet, with flows tapering off for the rest of the year.

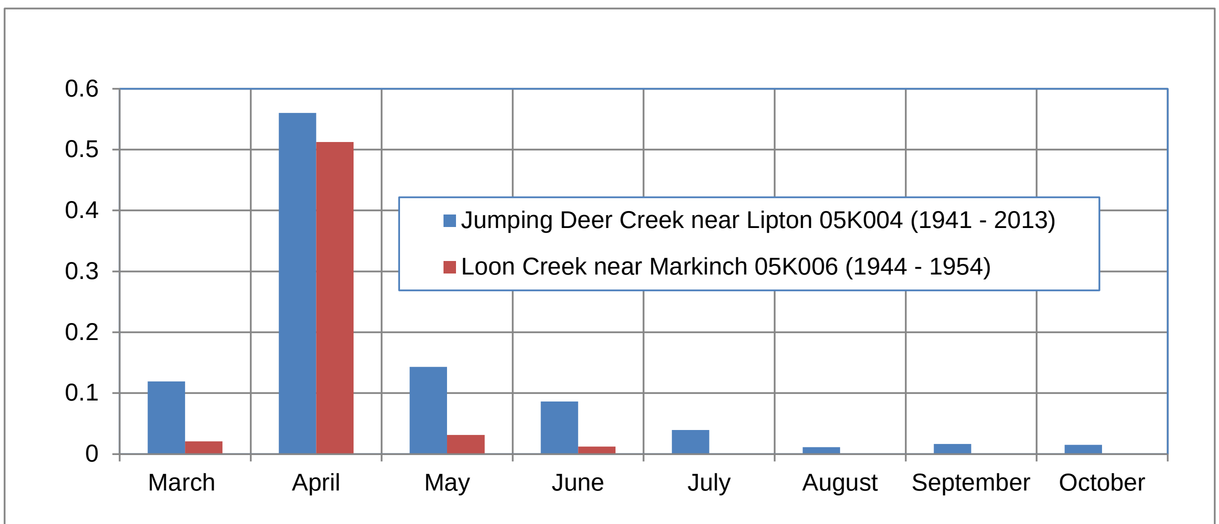


Figure 9.3-1: Monthly Mean Discharge (m^3/s) for Jumping Deer Creek and Loon Creek

Flow duration curves for Jumping Deer Creek were created for each month from March to October based on all available daily records (Figure 9.3-2). Flow duration curves illustrate the relationship between discharge and the percentage of time that it is exceeded. For example, Figure 9.3-2 indicated that in April, a discharge of 0.1 cubic metres per second (m^3/s) is exceeded 50% of the time. April flows are usually the highest, as snowmelt runoff occurs most often during April, although occasionally peak flows have occurred in late March or early May. Flows in summer and fall are usually much lower, dropping off to zero in most years. However, even in April there are years in the record with no measurable flow at Jumping Deer Creek.

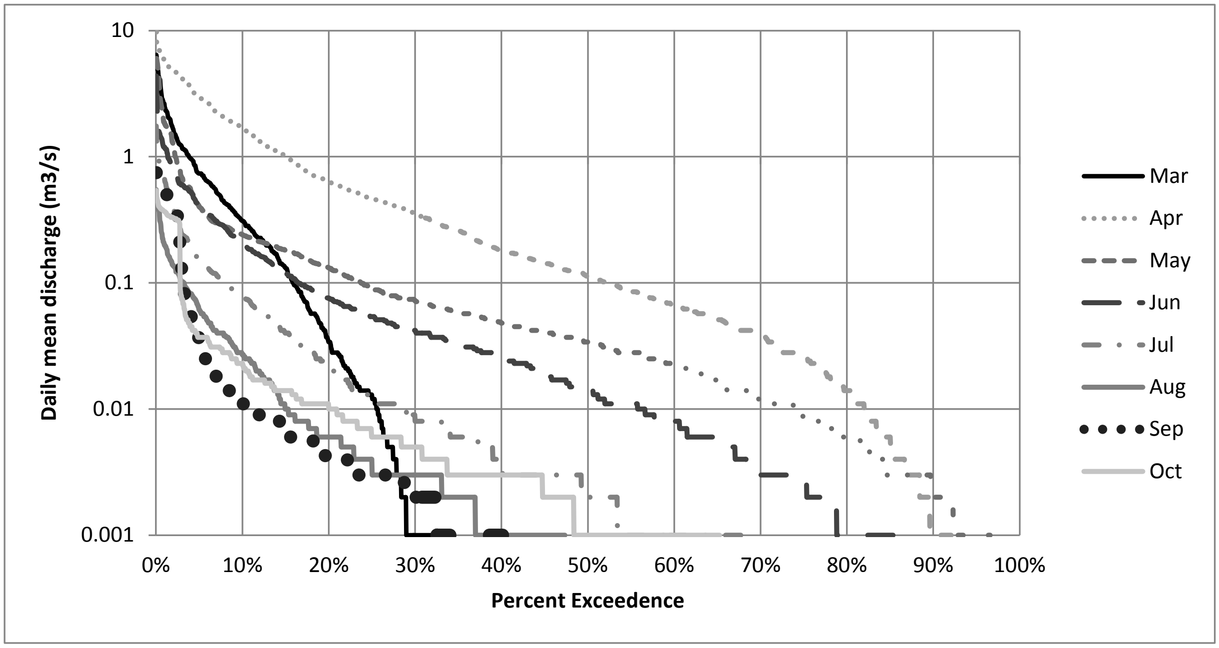


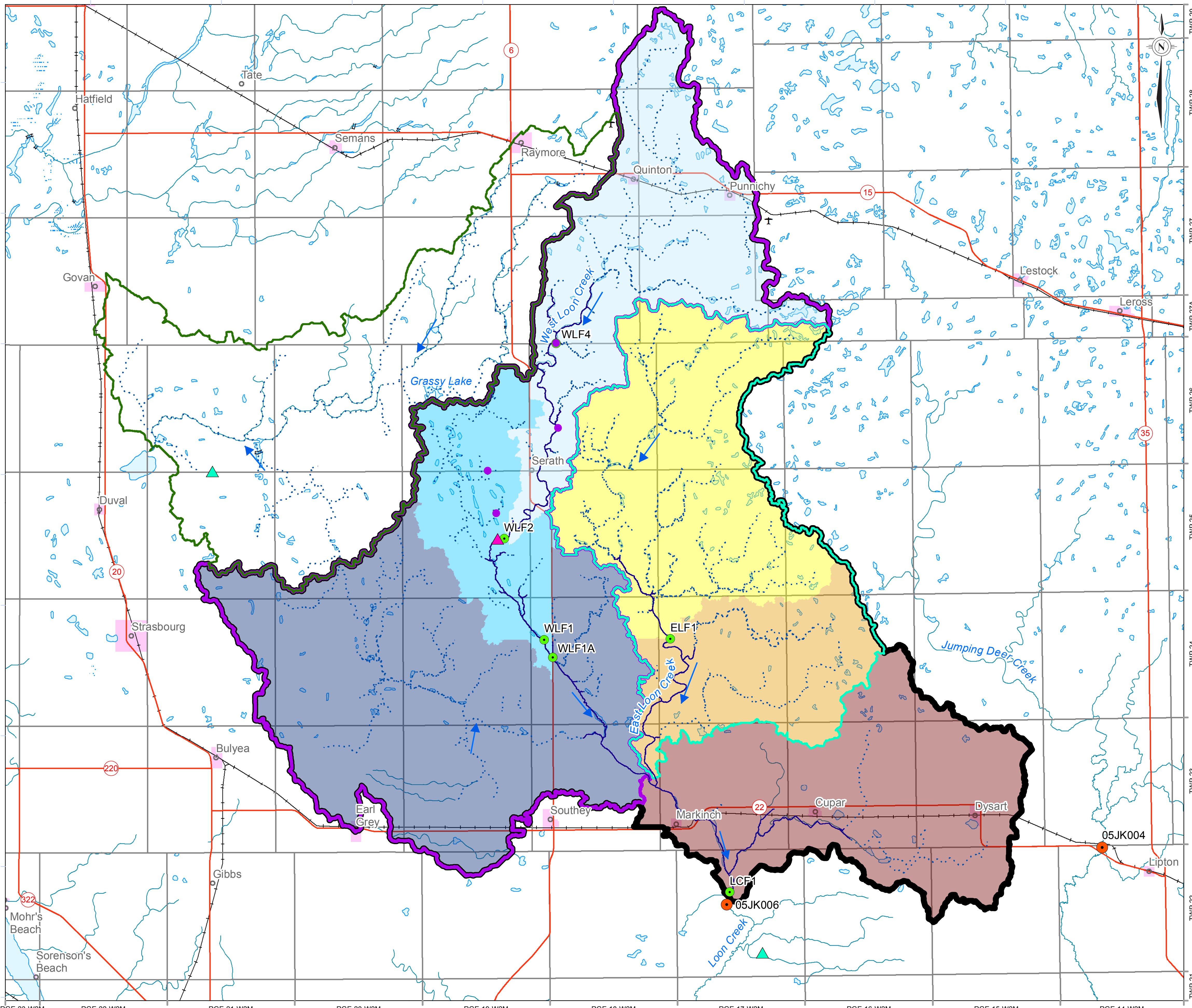
Figure 9.3-2: Daily Mean Flow Duration Curves for Jumping Deer Creek

During the 2013 hydrology baseline field program, five temporary streamflow stations were installed within Loon Creek basin. Station locations, drainage areas, and periods of record are provided in Table 9.3-1 and locations are illustrated on Figure 9.3-3. The effective drainage area for a median runoff year was estimated for the smaller sub-basins using the published map of effective drainage areas for Loon Creek basin (AAFC 2005) and modified using field observations and LiDAR data.

Table 9.3-1: Streamflow Monitoring Locations with Continuous Water Level Records in 2013

Station Identifier	Sub-basin	Location UTM NAD83	Record Length	GDA Area (km^2)[(a)]	EDA Area (km^2) [(a)]
LCF1	Loon Creek	13U 548898 5638030	April 29 to November 5	1,877	130
ELF1	East Loon Creek	13U 544352 5657411	April 28 to November 5	342	5.25
WLF1A	West Loon Creek	13U 535335 5655999	April 26 to November 5	469	41.4
WLF1B	West Loon Creek	13U 534694 5657354	May 3 to November 5	467	39.2
WLF2	West Loon Creek	13U 532008 5665332	April 28 to November 5	320	23.8

[(a)] GDA = gross drainage area, EDA = effective drainage area; these are described further in Annex III, Section 3.0.
km^2 = square kilometres; UTM = Universal Transverse Mercator; NAD83 = North American Datum of 1983.



G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1090 - Hydrology - Subsidence\Hydrology EIS\12-1362-0197 - Local Hydrological Features.mxd Date: 5/26/2015 10:11:05 AM

LEGEND

- COMMUNITY
- HIGHWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- CONTINUOUS STREAMFLOW STATION LOCATION
- DISCHARGE STATION
- 2013 GOLDER WEATHER STATION
- ENVIRONMENT CANADA CLIMATE STATION
- WATER SURVEY OF CANADA STREAMFLOW STATION
- EFFECTIVE DRAINAGE CHANNEL
- INTERMITTENT CHANNEL
- FLOW DIRECTION
- EAST LOON CREEK SUB-BASIN
- WEST LOON CREEK SUB-BASIN
- UNNAMED LAKE NEAR DUVAL SUB-BASIN
- LOON CREEK (AT LCF1) SUB-BASIN

STREAMFLOW STATION SUB-BASIN

- EAST LOON CREEK (AT ELF1)
- EAST LOON CREEK (AT CONFLUENCE)
- LOON CREEK (AT LCF1)
- WEST LOON CREEK (AT CONFLUENCE)
- WEST LOON CREEK (AT WLF1A)
- WEST LOON CREEK (AT WLF2)

REFERENCE

WATER WELL ALLOCATIONS: SASKATCHEWAN WATERSHED AUTHORITY, 2013
WATERSHEDS AND CHANNELS WERE DERIVED FROM A COMBINATION OF 2M LIDAR AND CDED DATA.
CANVEC © NATURAL RESOURCES CANADA
NTS MAPSHEET: 62L/M, 72I/J/O/P
NAD83 UTM ZONE 13

6 0 6
SCALE 1:300,000 KILOMETRES

PROJECT
YANCOAL SOUTHEY PROJECT

TITLE
LOCAL HYDROLOGICAL FEATURES

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	SM	20/03/15	SCALE AS SHOWN	REV. 0
GIS	LMS	26/05/15	FIGURE: 9.3-3	
CHECK	JH	26/05/15		
REVIEW	BT	26/05/15		

Water levels were monitored continuously at the five streamflow stations over the 2013 open-water season. Stage and discharge rating curves were developed during several field visits during spring and summer of 2013 in order to calculate streamflow. Daily mean discharge for the stations in 2013 is provided on Figure 9.3-4. Spring snowmelt was late in 2013, starting in the last week of April. The streamflow hydrographs indicate the freshet lasted from one to two weeks for East and West Loon creeks and lasted until mid-May at the Loon Creek station LCF1. An average runoff was predicted for spring 2013 based on dry soil conditions and above average accumulated snow pack (WSA 2014) peak flows at Jumping Deer Creek were close to its 2-year flood value.

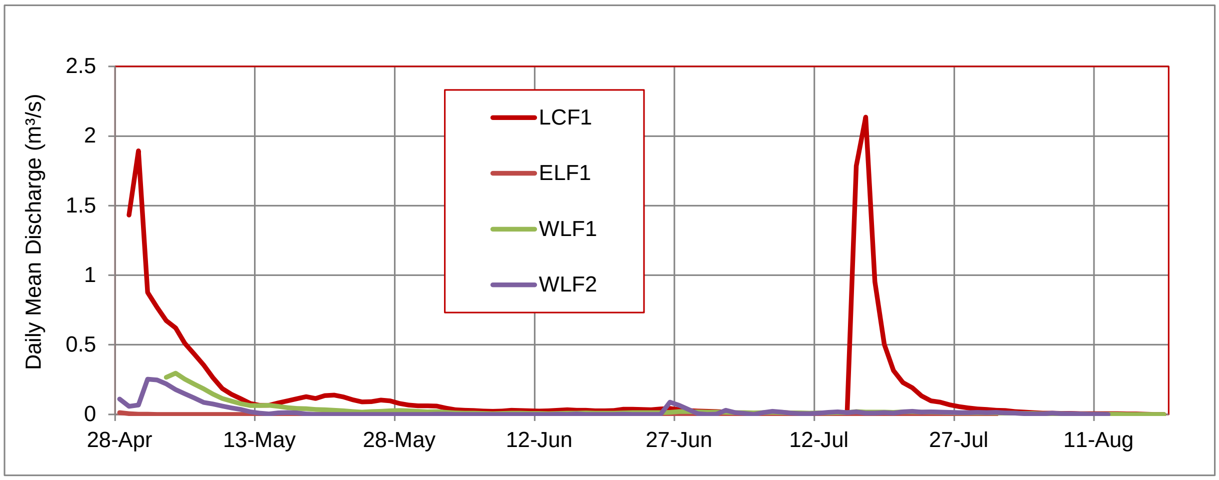


Figure 9.3-4: Daily Mean Discharge for Temporary Streamflow Stations

Spring streamflow at Loon Creek station LCF1 was also close to normal in 2013, but peak flows for the small sub-basins upstream seemed to be below normal based on their effective drainage areas (Annex III, Section 3.0). In particular, flows measured in East Loon Creek were very low at the monitoring station ELF1. Local landowners indicated that East Loon Creek flows at the confluence with West Loon Creek were very low during the freshet while West Loon Creek flows seemed normal. Spring runoff volumes between the start of the freshet in late April 2013 and May 15, 2013 were 2.1 dam^3 for ELF1, 151 dam^3 for WLF2, 164 dam^3 for WLF1 farther downstream, and 740 for Loon Creek station LCF1. In comparison, total annual runoff in 2013 was 2.3 dam^3 for ELF1, 212 dam^3 for WLF2, 278 dam^3 for WLF1 farther downstream, and 1,560 dam^3 for Loon Creek station LCF1.

An average annual unit-runoff value of 0.0008 cubic metres per second per square kilometre ($m^3/s/km^2$) was estimated from daily streamflow records for the Jumping Deer Creek station (05JK004) for the years from 1941 to 2013. This unit-runoff value was based on the effective drainage area for Jumping Deer Creek and is supported by the flow measurements at the five temporary Loon Creek tributary stations during the 2013 open-water season. Jumping Deer Creek has records from March to November with the highest unit-runoff value of 0.0036 $m^3/s/km^2$ occurring in April. An average annual unit-area runoff volume of 19,008 (cubic metres per square kilometre [m^3/km^2]) based on the open-water season is used for this assessment.

9.3.5 Spatial Extent of Wetlands and Depressions

The spatial extent of wetlands and depressions in the ESA is expected to change over the long-term with ground subsidence. To establish the baseline condition, a digital elevation model (DEM) was created for the ESA using the LiDAR data obtained in September 2013. To visualize the physical capacity for storing water on the ground surface within the ESA, a 100-mm rainfall event (which approximates a 1:100 year rainfall event) was added to the DEM surface using the Wetland DEM Ponding Model (WDPM) (Shook et al. 2014). Once the rainfall depth is added, wetlands, depressions, and stream channels are filled to a water level that permits water to move by gravity and drain to low-lying areas or downstream. The model does not account for soil and groundwater storage below the surface, thus the extent of ponding is conservative and would only represent near-saturated ground conditions.

Results from the ponding model are provided on Figure 9.3-5 for the area within the ESA that may be affected by subsidence in the future (Appendix 9-A). Results show the numerous wetlands and depressions that currently exist in the uplands as well as the West Loon Creek stream valley that flows to the southeast. Most of the ESA appears to be poorly drained even during a 100-mm rainfall event. There appears to be no continuous runoff pathway draining the "non-contributing" area west of West Loon Creek. The water retained in these wetlands and depressions greatly reduces the amount of surface runoff that can reach stream channels farther downstream, including West Loon Creek and Loon Creek.

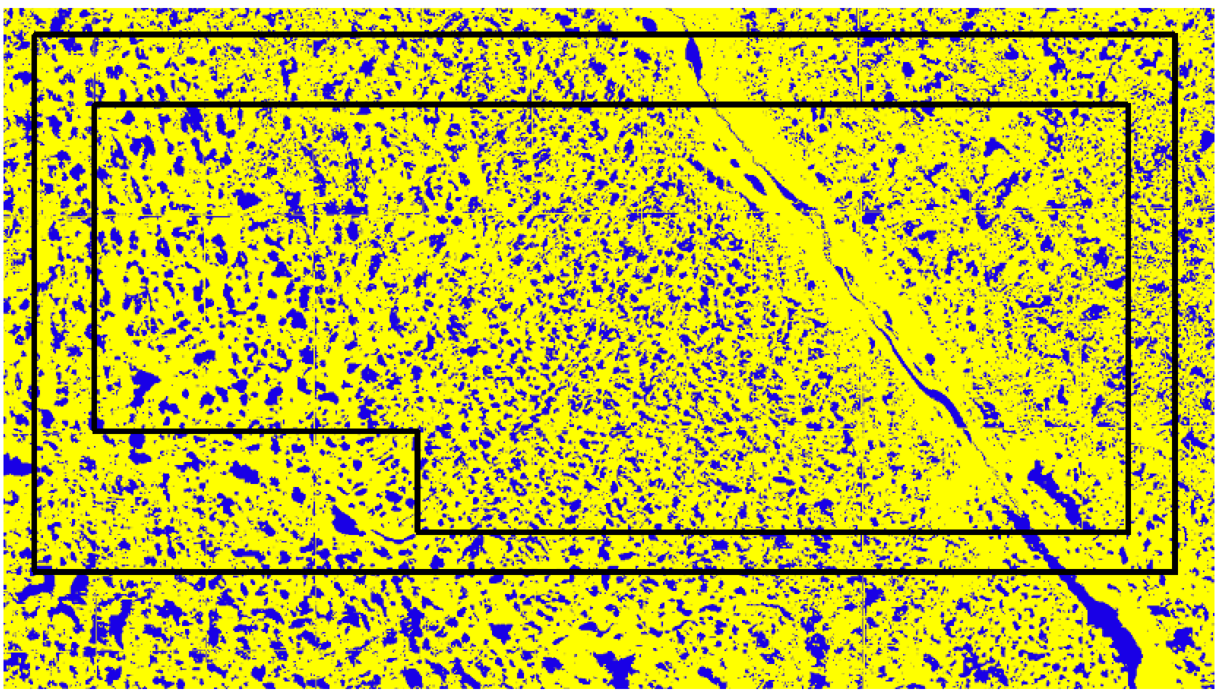


Figure 9.3-5: Distribution of Runoff from a 100-millimetre Rainfall Event for Existing Conditions

9.4 Pathways Analysis

9.4.1 Methods

Pathways analysis identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects on hydrology after mitigation. The first part of the analysis is to identify all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on the VC. Potential pathways through which the Project could affect hydrology were identified from a number of sources including:

- a review of the Project Description and scoping of potential effects by the Project's environmental and engineering teams;
- information obtained from community engagement sessions (Section 5.0);
- scientific knowledge and experience with other potash mines in Saskatchewan; and,
- consideration of potential effects identified from the TOR.

For an effect to occur there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a correspondent effect on the VC.

Project activity → change in environment → effect on VC

A key aspect of the pathway analysis is to identify environmental design features and mitigation that might reduce or eliminate potential effects of the Project to hydrology. Mitigation has been developed for the Project according to the following hierarchy proposed by the MOE (2014):

- avoidance;
- minimize (limit);
- restoration; and
- compensation.

Environmental design features include engineering design elements, environmental best practices, management policies and procedures, and spill response and emergency contingency plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams in order to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on hydrology. Pathways are determined to be primary, secondary (minor), or as having no linkage, using scientific, local and traditional knowledge, logic, experience with similar developments, and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- **No linkage** – analysis of the potential pathway reveals that there is no linkage, or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on hydrology relative to the Base Case or guideline values; or

- **Secondary** – pathway could result in a measurable minor environmental change, but would have a negligible residual effect on hydrology relative to the Base Case or guideline values and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect; or
- **Primary** – pathway is likely to result in environmental change that could contribute to residual effects on hydrology relative to the Base Case or guideline values.

Pathways with no linkage to hydrology are not assessed further because the implementation of environmental design features or mitigation will remove the pathway and result in no measureable change to hydrology. Pathways that are assessed to be secondary and demonstrated to have a negligible residual effect on hydrology through simple qualitative or semi-quantitative evaluation of the pathway are not advanced for further assessment. In summary, pathways determined to have no linkage to hydrology or those that are considered secondary are not expected to result in environmentally significant effects for the availability of surface water quantity for human use and ecosystems. Primary pathways require further evaluation through more detailed quantitative and qualitative effects analysis.

9.4.2 Results

Project components and activities, effects pathways and environmental design features and mitigation are summarized in Table 9-4.1. Classification of effects pathways (i.e., no linkage, secondary, and primary) on hydrology is summarized in Table 9-4.1 and detailed descriptions are provided in the subsequent sections.

9.4.2.1 Pathways with No Linkage

A pathway may have no linkage to environmental effects if the activity does not occur, or if the pathway is removed by mitigation or environmental design features so that the Project results in no measurable change in measurement indicators. Subsequently, no residual effect on hydrology is expected. The pathways described in the following bullets have no linkage to hydrology and will not be carried forward in the assessment.

- **Deep well injection of brine can disrupt or change sub-surface and deep groundwater flow and levels and may affect local surface water flows and levels.**

The design and location of the Project is based on extensive site-specific hydrogeological investigations completed during Project development. Methods used in the solution mining process will maintain stability of shallow and deep groundwater aquifers. In addition, an evaluation of the capacity of potential deep injection horizons has been conducted identifying the Winnipeg Formation and the Deadwood Formation to be suitable for brine disposal. The Winnipeg and Deadwood Formations are considered the best target for brine disposal because there is a large storage capacity in these formations, the formations are well isolated from overlying freshwater aquifers, and the formations are distant from recharge and discharge areas (Appendix 4-A). No changes to sub-surface and deep groundwater flow and levels are predicted. Therefore, this pathway was determined to have no linkage to effects on hydrology.

Table 9.4-1: Potential Pathways for Effects on Hydrology

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Physical Disturbance from the Project Footprint	Changes in local flows, drainage patterns (spatial distribution), and drainage areas due to the exclusion of the core facilities area from the natural drainage system.	■ The compact layout of the core facilities area will limit the area that is disturbed by construction. ■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance. ■ Progressive reclamation of well pads will occur where applicable (e.g., progressive pad site reclamation). ■ Existing public roads will be used where possible to provide access to the mine well field area and to reduce the amount of new road construction required for the Project. ■ All on-site roads will be removed during decommissioning. ■ Mine well field pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible. ■ Where practical, natural drainage patterns will not be altered and semi-permanent and permanent wetlands will be avoided. ■ Culverts will be installed along site access roads, as necessary, to maintain natural drainage. ■ A Water Management Plan will be incorporated at the detailed design stage, and provide input into adaptive management.	Primary
Solution Mining	Ground subsidence caused by solution mining can change local flows, drainage patterns (spatial distribution), drainage area boundaries, and stream channel and waterbody morphology.	■ Unmined pillars will be left between the mine caverns to increase stability during mining and reduce potential subsidence. ■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence and will provide input into adaptive management. ■ Subsidence will be gradual and ultimate subsidence (i.e., final, steady state) will not occur for centuries. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface developments.	Primary

Table 9.4-1: Potential Pathways for Effects on Hydrology

Project Component/Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Tailings Management Area	Deep well injection of brine can disrupt or change sub-surface and deep groundwater flow and levels and may affect local surface water flows and levels.	■ An evaluation of the capacity of potential deep injection horizons has been conducted identifying the Winnipeg Formation and the Deadwood Formation to be suitable for brine disposal. ■ There will be no interaction between the brine disposal formations and surface water in this region. Deep well injection is a proven practice used to manage brine and prevent release to surface waters and fresh-water aquifers.	No Linkage
Water Management	Site run-off from the core facilities area can affect surface flows and water levels.	■ The TMA will be located over soils that are known to provide natural retention of brine solutions and offer protection against seepage into nearby ground and surface water resources. ■ The TMA location was selected based on site-specific geologic and hydrogeologic studies completed to identify an appropriate foundation for the TMA, which provides natural containment of brine material. ■ Surface water diversion channels along the perimeter of the core facilities area including the TMA will be designed to collect and redirect external drainage. A Water Management Plan will be incorporated at the detailed design stage. ■ The surface water diversions will be designed to convey the runoff associated with the 300 mm 24-hour design rainstorm event. ■ Waste salt and decanted brine within the TMA will be contained using a perimeter dyke, and excess brine will be directed to the brine reclaim pond to be reused within the process and ultimately disposed of via deep injection wells. The brine reclaim pond will maintain sufficient capacity to contain storage of process water under normal and extreme operating conditions and design storm events. Maximum operating levels will provide sufficient storage for the 300 mm 24-hour design storm event, and sufficient freeboard to account for wave run-up and wind set-up against the sides of the ponds. ■ A containment system will be designed to control deep migration of brine from the TMA to underlying aquifers and lateral migration of brine, as required.	No Linkage

TMA = tailings management area; mm = millimetres.

- **Site run-off from the core facilities area can affect surface flows and water levels.**

Surface water will be contained within the core facilities area without any interaction with the surrounding natural drainage system. Management of runoff within the core facilities area, mine well field areas, and new roads will be included in a Water Management Plan. The existing road network, which is reasonably well developed in the area, is currently used to access cultivated areas, and communities, near the Project. To the extent possible, existing infrastructure and utility corridors will be used to limit disturbance to local flows, drainage patterns, and drainage areas in the ESA. New road sections that will be constructed on site in association with the Project will have adequately designed cross-drainage structures to maintain the natural flow paths.

Several environmental design features will be implemented to prevent water release from the core facilities area entering the receiving environment. A Water Management Plan will be developed and infrastructure will be constructed to store on-site runoff, as well as divert freshwater runoff around the core facilities area. The diversion channels for the TMA will be designed to accommodate a rainstorm event of 300 mm over 24 hours (Section 4.6.2). This will effectively isolate the core facilities area from the surrounding drainage. Runoff within the TMA will be redirected to the brine reclaim pond for temporary storage prior to deep well injection. Inspection and maintenance procedures for infrastructure will be outlined in the Water Management Plan.

The main access to the Project will be from Highway 6 westward onto rural grid road 731 for about 5.6 km and then northward onto an existing secondary grid road. Enhancements required in these roads will be completed following Ministry of Highways guidelines. Existing roads will be used to access the well pads to the extent possible, to reduce surface disturbance.

Implementation of environmental design features and mitigation is expected to result in small changes in runoff pathways, but with no detectable changes in surface runoff or water levels adjacent to the Project. Subsequently, this pathway was determined to have no linkage to effects on hydrology.

9.4.2.2 Secondary Pathways

No pathways were identified as having secondary linkages to hydrology (Table 9.4-1).

9.4.2.3 Primary Pathways

The following primary pathways are assessed in detail in the residual effects analysis.

- **Changes in local flows, drainage patterns (spatial distribution), and drainage areas due to the exclusion of the core facilities area from the natural drainage system.**
- **Ground subsidence caused by solution mining can change local flows, drainage patterns (spatial distribution), drainage area boundaries, and stream channel and waterbody morphology.**

9.5 Residual Effects Analysis

The residual effects analysis is focused on thoroughly evaluating the primary pathways associated with the Project and other developments on the hydrology VC. The residual effects assessment is completed by calculating and estimating changes to the measurement indicators of hydrology that are relevant to the primary pathways. These measurement indicators are:

- spatial distribution of water including the spatial extent and location of waterbodies, runoff pathways, and streams;

- temporal distribution of water including changes in water levels and flows through time;
- drainage boundaries; and
- stream channel gradients.

The two activities expected to have measurable residual effects on the hydrology VC are the physical disturbance from construction of the Project and solution mining activities.

Surface runoff within the core facilities area will be collected for use in mill processes and finally disposed of through deep well injection. Runoff pathways that naturally flow throughout the core facilities area will be intercepted by the diversion channels. These channels will be routed back into the pre-existing natural channels farther downstream, whenever possible. By managing the water inside the core facilities area, a portion of the drainage area that contributes runoff in the absence of the Project, will no longer contribute to streamflow and the effective drainage area in the ESA will be reduced.

Physical disturbance is also expected from the mine well field area and new access roads and pipelines that are associated with well pads. The location of individual well pads, their access roads, and pipeline corridors may disrupt runoff pathways. The size of the individual well pad areas is approximately 18,000 square metres (m^2)(i.e., 100 metres [m] by 180 m) and the length of their access roads and pipeline corridors will vary with the distance from local roads, and the core facilities area, respectively.

Settlement of the ground surface due to mining activities modifies topography and, consequently, has effects on drainage patterns within the subsidence area and possibly downstream of the area. Potential effects could be reflected by changes in the spatial and temporal distribution, and in the quantity of surface water.

Evaluation of residual effects on hydrology is based on a comparison between the Base Case, (i.e., existing conditions) and the Application Case. Existing hydrology conditions were obtained from several sources such as past reports, historical datasets, LiDAR topography, and field data collection (Section 9.3). A review of existing hydrology, focusing on its temporal and spatial distribution within the ESA, is based on data from Water Survey of Canada stations in the region. LiDAR and geographical information system (GIS) tools were used for defining drainage boundaries and runoff pathways in the ESA, complemented with information available from the National Topography System (NTS) and ground reconnaissance. Hydrology following the Project (i.e., the Application Case) was obtained after applying ground subsidence and the isolation of areas required for the operation of Project.

The residual effects on hydrology are addressed according to the two main Project-related influences that physically alter the drainage areas:

- residual effects due to isolation of the core facilities area from the natural hydrology system; and
- residual effects associated with the final state of the topography due to subsidence.

A quantification of the extent of the areas where the physical changes in terrain are expected to occur is done prior to addressing residual effects on hydrology. For hydrology, this area is defined as the area directly affected by ground subsidence, plus the area required for the operation of the Project if outside of the subsidence area.

9.5.1 Residual Effects Due to the Isolation of the Core Facilities Area from the Natural Drainage System

9.5.1.1 Methods

During operations, the core facilities area will be isolated from the natural drainage system by surface water diversions. The diversion channel will be an engineered design that will increase drainage efficiency around the core facilities area. Following decommissioning and reclamation, much of the drainage area existing in the core facilities area will be reclaimed and the pre-development drainage paths can be re-established; however, the area within the TMA will remain isolated from the drainage. Therefore, after decommissioning and reclamation the change in local flows, drainage patterns, and drainage areas due to exclusion of the TMA will be permanent.

During operations, the annual runoff volume is reduced in one area within the ESA. This is calculated by subtracting the expected annual runoff volume for the core facilities area. Following decommissioning and reclamation (i.e., after operations) the reduction of annual runoff volume from areas not reclaimed is maintained. The annual runoff volume is estimated based on the unit-runoff volume for the Jumping Deer Creek streamflow station. The average unit-area runoff was derived from historical flow records for Jumping Deer Creek, which is an adjacent watershed with similar topography and flow characteristics as the Loon Creek basin.

9.5.1.2 Results

The exclusion of the core facilities area from the existing drainage area has a direct residual effect on the hydrologic system. The effect is related to the decrease in runoff reporting downstream of the core facilities area to the local runoff pathways and natural depressions. An average annual unit-runoff volume of 19,008 m^3/km^2 based on an effective drainage area was estimated for drainage areas within the ESA (Section 9.3.4), and this unit value is used to quantify the reduction of annual runoff downstream of the core facilities area.

The core facilities area is estimated to be 11 km^2 and makes up about 2.3% of the total basin area of about 470 km^2 contributing to West Loon Creek. The reduction in the annual flow volume contributed from this sub-basin is estimated to be 190,080 cubic metres per year (m^3/yr). This translates to an average flow rate of about 6 litres per second (L/s). The reduction in runoff volume would only rarely affect inflows to West Loon Creek. Most years, this intermittently flowing tributary does not contribute runoff to the main channel of West Loon Creek.

During decommissioning and reclamation activities, the potash processing and storage facilities, along with ancillary buildings, will be dismantled and moved to an approved disposal site. Within the TMA, the salt storage areas and the brine reclaim ponds would remain for several hundred years until the salt pile is dissolved and the brine is disposed of by deep well injection. Runoff within the core facilities area will be re-established during decommissioning and reclamation, with the exception of the TMA. In summary, following decommissioning and reclamation, most of the drainage area existing in the core facilities area will be reclaimed. According to the available information related to the TMA, 4.2 km^2 can be re-established into the natural hydrology system, while the remaining 5.2 km^2 would not be reclaimed. The average annual residual reduction in flows to the low-lying area south of the core facilities area is therefore estimated to be about 98,842 m^3, which corresponds to 1.1% of the total contributing area.

The exclusion of individual well pad areas from the natural drainage system may affect local flows and drainage patterns in the ESA, and the mine well field area is primarily located in the same sub-basin (i.e., West Tributary of West Loon Creek) as the TMA, which rarely flows to West Loon Creek. Progressive reclamation of well pads will occur during operations, and for this assessment it was assumed that up to 19 well pads would be active at one time during operations, which may overestimate the effects on hydrology. The size of the individual well pad areas is approximately 18,000 m^2 (i.e., 100 by 180 m) and the length of their access roads and pipeline corridors will vary with the distance from local roads, and the core facilities area, respectively. A total area of up to 342,000 m^2 (or 0.3 km^2) would be isolated from the natural drainage of the West Tributary of West Loon Creek. The cumulative reduction in drainage area size for the West Tributary of West Loon Creek is estimated to be about 0.07%, which would reduce average annual unit-runoff volume by 6,500 m^3/yr. This would not cause a measurable change in flows in the sub-basin.

9.5.2 Alterations to Drainage Patterns and Boundaries from Ground Subsidence

9.5.2.1 Methods

Most of the residual effects on surface water are related to the predicted ultimate subsidence of the land surface overlying the mine well field and adjacent areas. The ultimate subsidence results in topographic variation on the ground subsidence area that would induce changes in the hydrological features. The effects on hydrology from ground subsidence associated with the 65-year mine plan for the Project are described in Appendix 9-A. Effects on hydrology were evaluated by comparing two topographic scenarios.

- Base Case - considers the existing hydrological conditions related to the current topography, including all hydrology features within the subsidence area (i.e., drainage area boundaries, drainage pathways, and wetlands).
- Application Case (Post-subsidence scenario) - considers hydrological adjustments in response to topographic changes resulting from the predicted ultimate subsidence.

Surface hydrology, including drainage areas and flow pathways (i.e., watercourses), is defined for both scenarios and the changes are analyzed. Changes of the hydrological features are quantified by the increase and/or decrease in particular drainage basin boundaries, the runoff pathways realignment, increase, and/or decrease of stream channel gradients, and increase and/or decrease in volumes of storage areas.

For the Base Case, a GIS application, Global Mapper, was used to create a DEM based on LiDAR topographic data obtained in 2013. For post-subsidence topographic conditions (i.e., the Application Case), the LiDAR data was modified by lowering the topography according to the magnitude and spatial extent of the ultimate subsidence predicted by Agapito (2014a, b). The result is a modified DEM that is used for the subsequent hydrological analysis. Minor adjustments to both the existing and post-subsidence DEMs were undertaken to digitally set the invert of the existing culverts providing continuity of flow where streams and flow pathways intersect roads.

Surface hydrology including drainage areas and flow pathways (i.e., watercourses) associated with existing and post-subsidence topographic conditions was defined using the GIS application “Green Kenue” (NRC 2012).

To address residual effects on hydrology, both the existing and ultimate subsidence DEMs were assessed to define drainage areas and runoff pathways, stream channel slopes and the spatial extent of depressions or wetland formations. To evaluate the changes in wetland storage due to subsidence, the spatial extent of depressions and wetlands before and after ultimate subsidence were compared using the WDPM model (Shook et al. 2014). A full discussion and presentation of the project ground subsidence effect on hydrology based on the 65-year mine plan is provided in Appendix 9-A. The following sections provide a summary of the assessment required to quantify the residual effects on hydrology for both the 65-year mine plan and a qualitative assessment of the mine well field areas, well pads, access roads, and pipeline corridors.

9.5.2.2 Results

9.5.2.2.1 Predicted Ultimate Subsidence

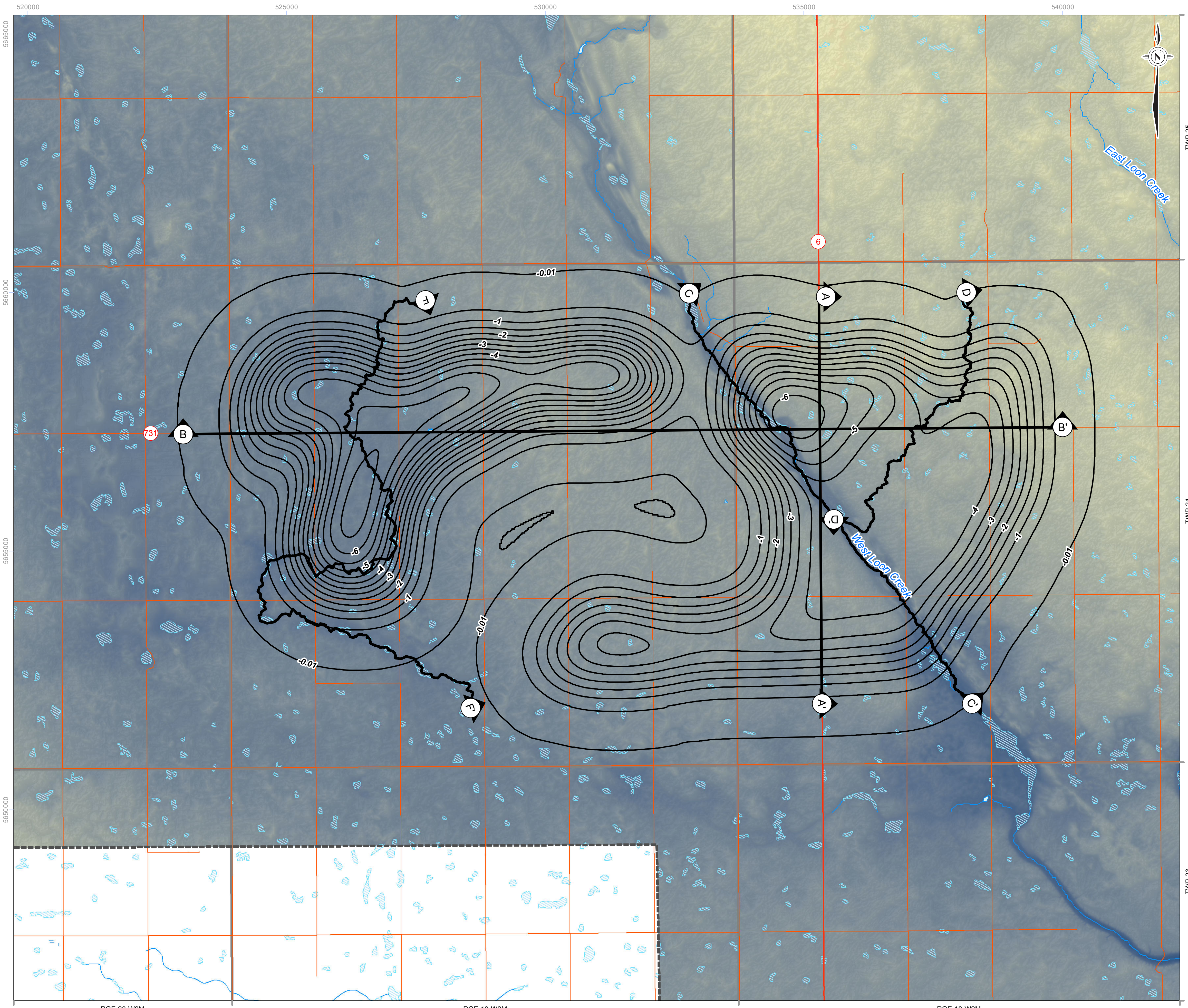
Ground subsidence has a direct effect on the topographic features within the areas overlying the 65-year mine field area. The underground caverns begin to close gradually as mining is completed due to the pressure exerted by the overlying material. Over the long-term, this closure translates to the surface resulting in a subsided area. The process is gradual and may require several hundred years to develop fully after mining is completed. The final state of topography associated with ultimate subsidence is used as the worst-case scenario for predicting the residual effects on hydrology from subsidence.

The predicted ultimate subsidence was evaluated by Agapito (2014a, b) and is provided in Appendix 9-A. The area affected by surface subsidence would extend over a distance of approximately 17 km from west to east, and about 8 km from north to south (Appendix 9-A). A maximum vertical topographic displacement of 6.7 m was estimated and is expected to occur in the western section of the 65-year mine field area. Most of the area affected by subsidence occurs in the West Loon Creek sub-basin.

Contour lines of ultimate subsidence values are superimposed on the existing topography to illustrate the location and magnitude of subsidence and to identify the areas where subsidence steepens or flattens the existing gradient (Figure 9.5-1). Topographic slopes would increase in areas where settlement gradients and existing topography gradients are in the same direction. Alternatively, topographic slope would decrease in areas where settlement gradients and existing topography gradients are opposed. Surface subsidence is expected to extend approximately 1.3 km outside the 65-year mine field (i.e., the assessed area). The gradient of surface subsidence at the boundary of the mine well field area would be gradual. In areas with steeper subsidence gradients, settlement would increase from 0.5 to 6.7 m of subsidence over a distance of approximately 1.6 km (i.e., an average of about 3.9 m per km [1/256 metres per metre (m/m)], but maximum gradients are expected to be around 5.0 m per km [1/200 m/m]).

9.5.2.2.2 Changes in Stream Channel Slope

For the 65-year mine field West Loon Creek is the main stream affected by ground subsidence along with two other smaller tributaries. Three channels located in the mine well field area were selected for the analysis: West Loon Creek, a tributary of West Loon Creek draining from the east, and a tributary of West Loon Creek draining from the west. Sections of these channels occur within the area of ultimate subsidence. Alignments for these channels are shown on Figure 9.5-1. West Loon Creek channel section is shown as C to C’ and the western and eastern tributaries are shown as section F to F’ and section D to D’, respectively.



LEGEND

- HIGHWAY
- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- PROFILE LINE
- SUBSIDENCE CONTOUR (0.5 METRE INTERVAL)
- LIDAR EXTENT

ELEVATION (masl)

HIGH : 688.32

LOW : 530.33

REFERENCE

ELEVATION SURFACE DERIVED FROM LIDAR PROVIDED BY LSI
CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

1.5 0 1.5

SCALE 1:75,000 KILOMETRES

PROJECT

YANCOAL SOUTHEY PROJECT

TITLE

PREDICTED CHANGES IN SURFACE ELEVATIONS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	SM	20/03/15	SCALE AS SHOWN	REV. 0
GIS	LMS	26/05/15	**FIGURE: 9.5-1**	
CHECK	JH	26/05/15		
REVIEW	BT	26/05/15		

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1090 - Hydrology - Subsidence\Hydrology EIS\12-1362-0197 - Predicted Changes in Surface Elevations.mxd Date: 5/26/2015 10:13:53 AM

West Loon Creek

The existing and predicted post-subsidence stream channel invert profiles for West Loon Creek from C to C' (Figure 9.5-1), are shown on Figure 9.5-2. For reference, this figure includes the location of Highway 6 and grid road 731 crossings. Due to subsidence, the channel gradient will increase along the north section of the stream beginning near 1 km and extending to 4 km. The channel gradient generally is unchanged between 5.5 and 8 km and would decrease or even reverse in the lower sections from 3.8 to 5.5 km and 8 to 10 km.

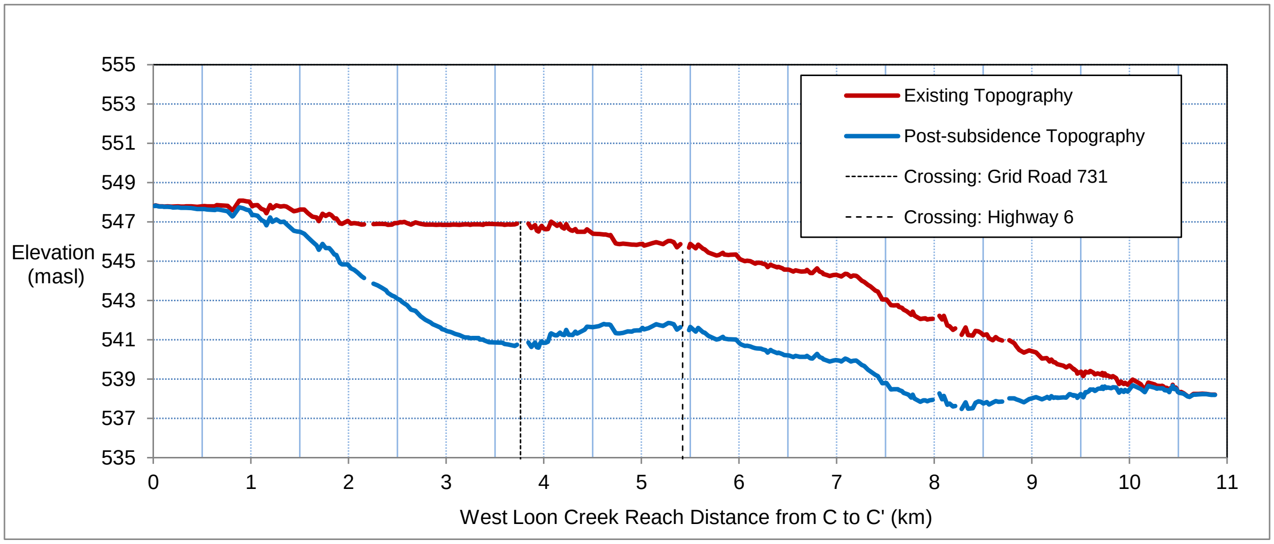


Figure 9.5-2: West Loon Creek Section C to C'

Subsidence is predicted to exceed 6 m in some sections of West Loon Creek channel near the grid road 731 crossing. Channel slope, in percentage (%), for selected locations calculated from distances of approximately one km is provided on Figure 9.5-3. The maximum change in channel average gradient is expected to occur between 2 km and 3 km, where the gradient steepens from approximately 0.2 metres per kilometres (m/km) to 3.3 m/km. Changes to average channel slopes range from 0 to 3 m/km.

Potential for some shallow ponding occurs between 3.8 km and 5.5 km and between 9 and 10 km sections, but downstream drainage could still occur. The pond section near 4 km would need to reach a headwater of about 1.3 m for the flow to continue downstream by gravity; the length of channel affected is approximately 1.7 km. The pond section near 9 km would need to be ponded to a depth of 1.2 m prior to flow continuing downstream; a 2 km length would be affected (Figure 9.5-4).

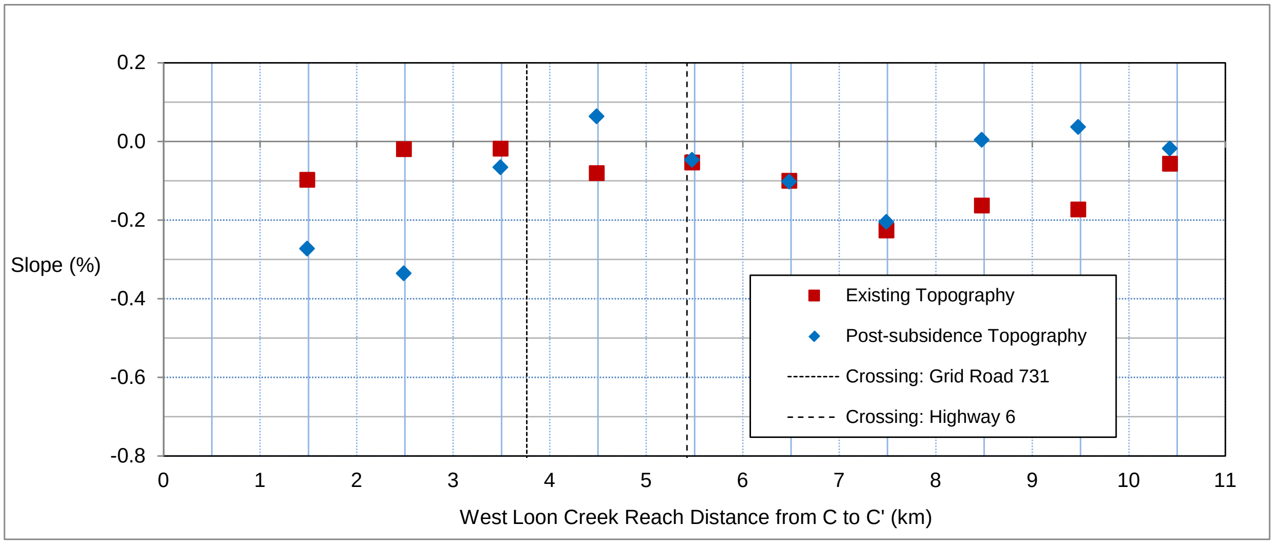


Figure 9.5-3: Changes in Percent Slope along West Loon Creek Channel along Section C to C'

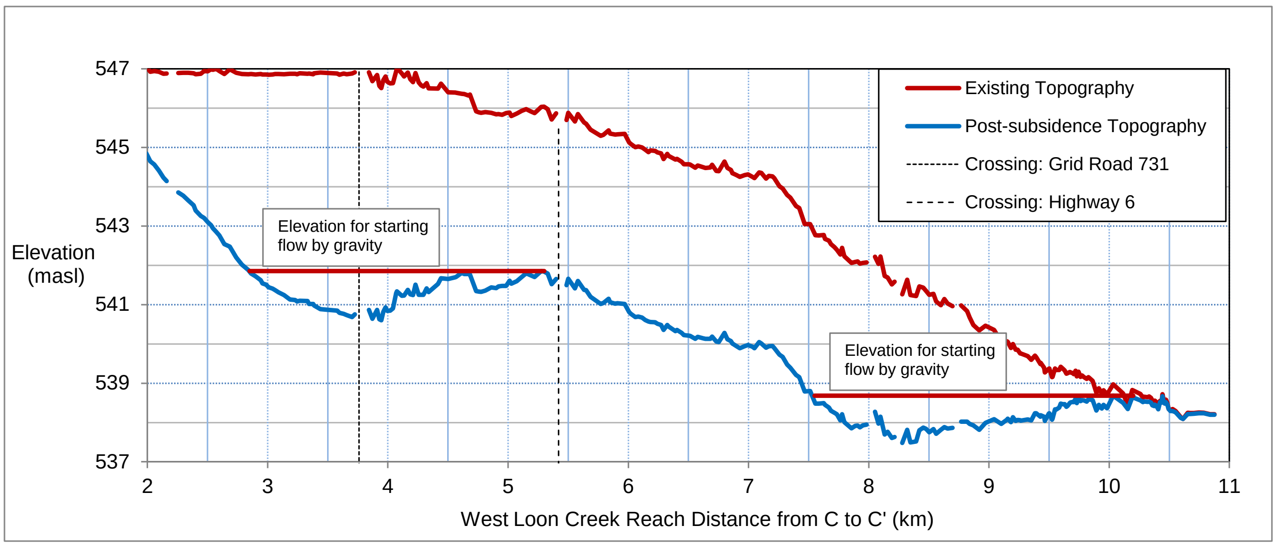


Figure 9.5-4: New Depressions along West Loon Creek That May Form Following Subsidence (4 to 9 Kilometres)

East Tributary of West Loon Creek

An east tributary of West Loon Creek crosses through the mine well field area where ultimate subsidence will be up to 4.0 m. Profiles for the existing and post-subsidence channel slope along this tributary, extending downstream to the confluence into West Loon Creek channel are provided on Figure 9.5-5, and represent section D to D' as shown on Figure 9.5-1. For reference, the grid road 731 crossing and the West Loon Creek confluence location are shown. The existing channel is poorly drained with many depressions that need to be filled with water and overtopped to allow flow to continue downstream. For example, between 3 km and 4.5 km near the grid road 731 crossing, a ponding depth of 2 m is required under existing conditions for the flow to continue downstream; the same conditions would remain following subsidence.

Channel slopes are provided on Figure 9.5-6 at 1-km intervals along the channel. An increase in channel slope would occur in the first 3.5 km of the channel section. The greatest change in the slope occurs about 2.5 km upstream of the grid road 731 crossing where the channel gradient would increase from about 4.6 to 5.8 m/km. The existing channel seems poorly drained; a condition that would likely improve slightly following subsidence. Despite the effect of subsidence, the existing channel slope is largely maintained over most of the length of the tributary.

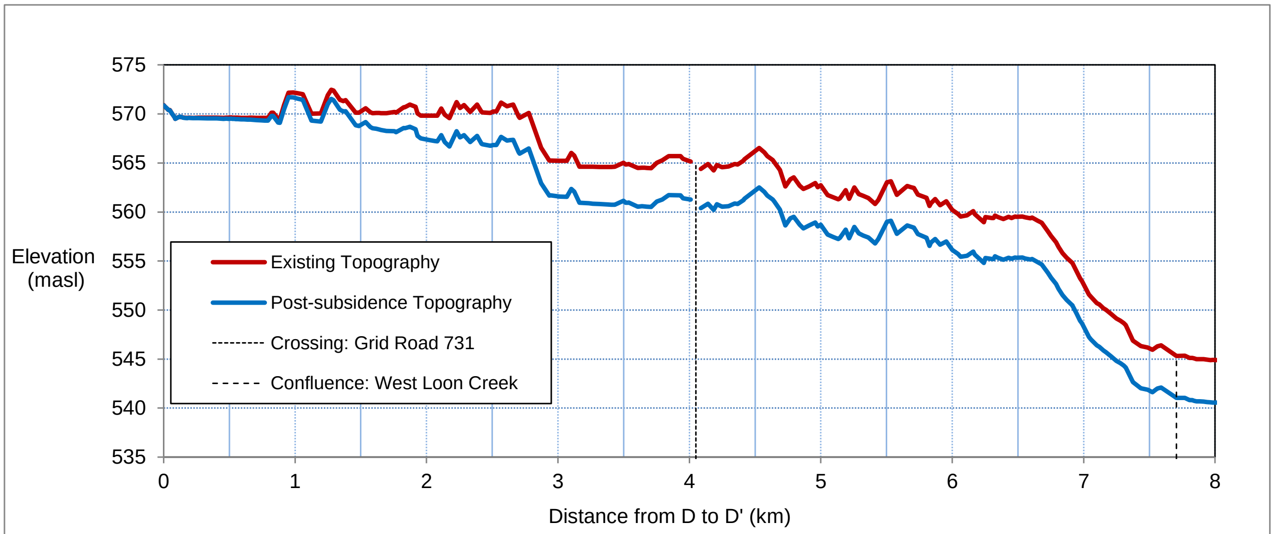


Figure 9.5-5: East Tributary of West Loon Creek Section D to D'

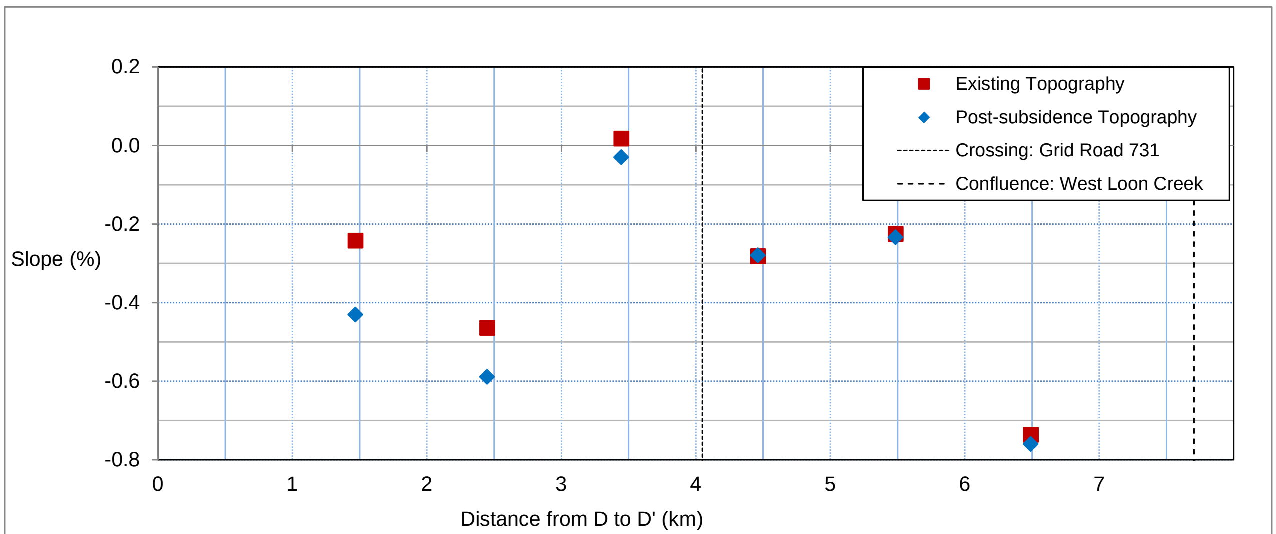


Figure 9.5-6: Changes in Percent Slope along the East Tributary of West Loon Creek Channel Section D to D'

West Tributary of West Loon Creek

The drainage area occurring in the western section of the mine well field area is poorly drained with intermittent flow pathways, numerous wetlands, and depressions. No permanent streams are shown on 1:50,000 scale NTS maps. A preferred runoff pathway delineated based on LiDAR is illustrated on Figure 9.5-1 as section F to F'. As stated in a previous section, in very wet conditions, this area may contribute runoff to West Loon Creek, at a location south of the mine well field area. In normal climate conditions, runoff in this area is likely stored on the landscape in the many depressions and wetlands that occur in the sub-basin.

Existing and post-subsidence elevations along section F to F' are plotted on Figure 9.5-7. For reference, this figure includes the grid road 731 crossing location. The stream along F to F' would experience the greatest subsidence of up to 6.6 m in a section east of grid road 731. From north to south the maximum change is about 5.5 km downstream (south) along the runoff pathway; after this point subsidence is smaller with no predicted change in elevation beyond 11.5 km. Channel slope, in percentage (%), for selected locations calculated from distances of approximately 1.0 km are provided on Figure 9.5-8.

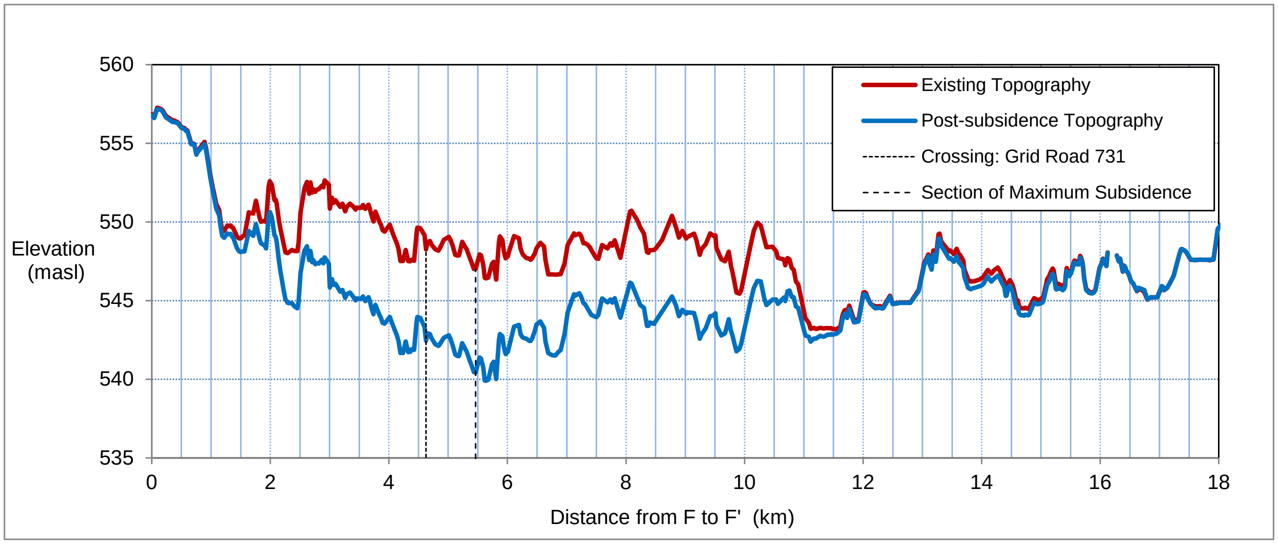


Figure 9.5-7: West Tributary of West Loon Creek Section F to F'

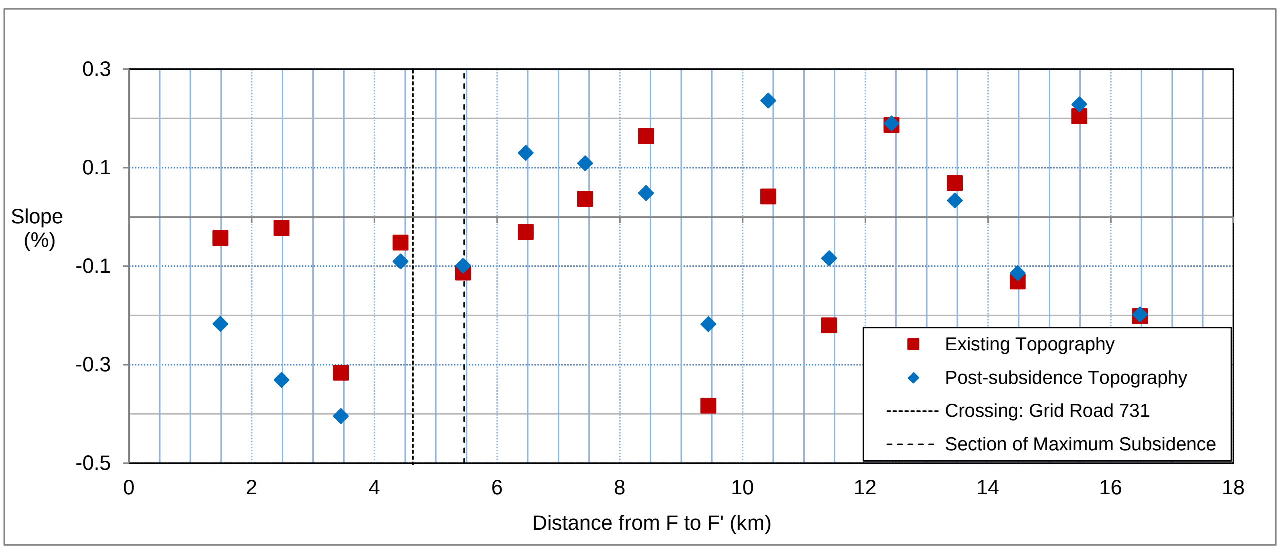


Figure 9.5-8: Changes in Percent Slope along West Tributary of West Loon Creek Section F to F'

For existing conditions along the flow pathway, section F to F' two channel sections would accumulate runoff during the spring freshet or after an extreme rainfall event from 3.8 to 8.0 km and from 10.4 km to the south boundary of the mine well field area (Figure 9.5-9). Following subsidence, these two pond sections may combine into one larger depression from 2.2 km to the south boundary of the mine well field area. The maximum subsidence along this section may be up to 9.0 m (Figure 9.5-10). In the long-term, there may be gradual subsidence of the existing grid roads crossing the stream valleys that may increase ponding or backwatering at the crossings.

While changes in topographic controls suggest that there would be increased opportunities for ponding, the actual extent or frequency of ponding will be largely dependent on climatic conditions that support elevated runoff levels and subsequent accumulations of water in low-lying areas. In normal or dry periods, there may be little change to the occurrence of stored water on the landscape.

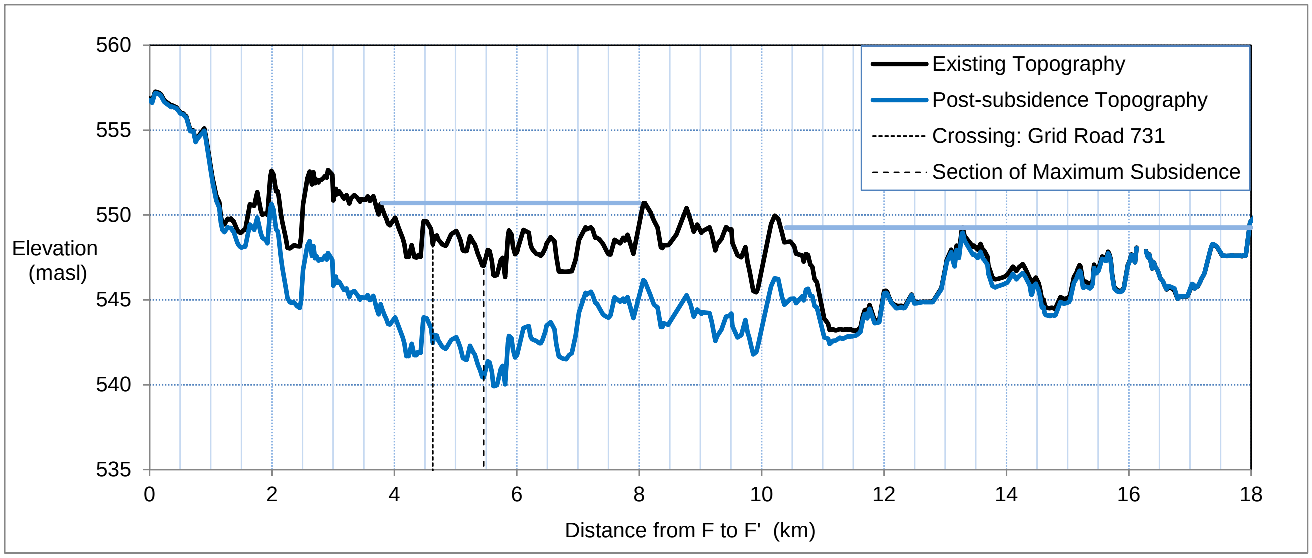


Figure 9.5-9: Depressions along the West Tributary of West Loon Creek for Section F to F'

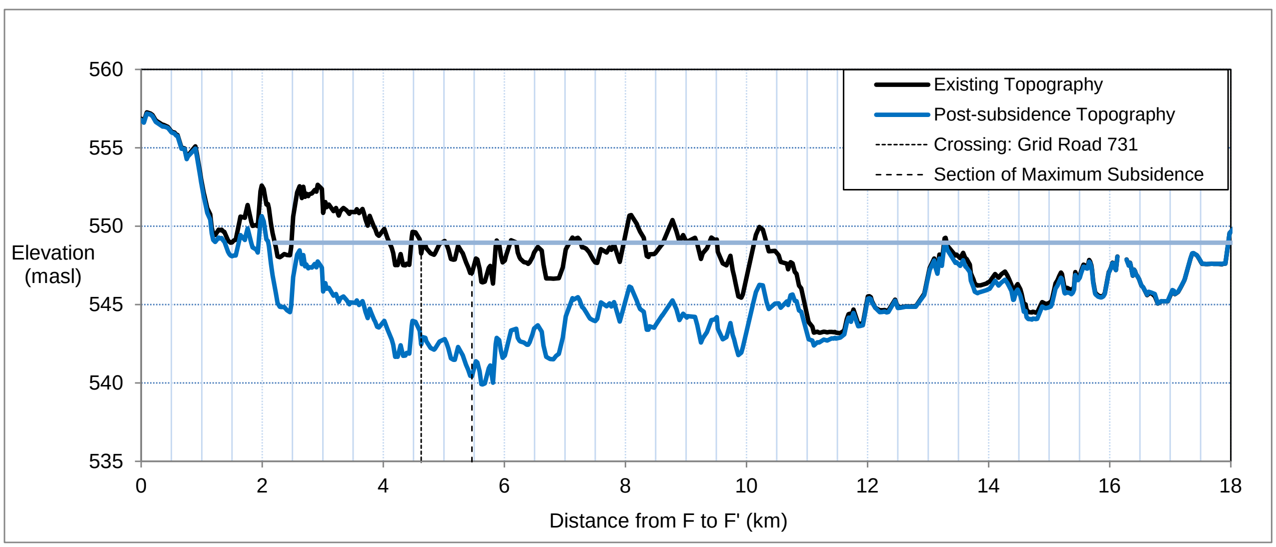


Figure 9.5-10: New Depressions That May Form Following Subsidence along Section F to F' of the West Tributary of West Loon Creek

9.5.2.2.3 Changes in Drainage Boundaries

Topographic adjustments due to subsidence can cause drainage area boundaries to shift, increasing or decreasing contributing areas in adjacent watersheds. Four drainage outlets were selected within the area affected by subsidence where drainage area boundary adjustments are most apparent. The outlets and drainage boundaries for existing and post-subsidence topographic conditions are illustrated (Figure 9.5-11). The brown line indicates the existing drainage area boundary, while the green line indicates the post-subsidence drainage area boundary. In the locations that the two lines overlay one another, no change is expected.

Outlet 2 is located upstream of Outlet 1, and both occur along West Loon Creek main channel. Outlets 3 and 4 occur in the West Basin of West Loon Creek and currently do not have well-defined runoff pathways (Figure 9.3-3). Outlet 4 would drain east through Outlet 3 towards West Loon Creek under very wet conditions or during wet periods.

According to Figure 9.5-11, a shift in some smaller drainage area boundaries in the central section of the mine well field area is likely. Overall, little change occurs in drainage area reporting to West Loon Creek since the drainage area boundary adjustments are localized. No changes to the gross or effective drainage area of West Loon Creek at the confluence with East Loon Creek are predicted.

The changes associated with the four selected drainage outlets are summarized in Table 9.5-1. All drainage areas increase in size following subsidence. The largest change occurs at Outlet 4; an additional 9.2 km² would contribute to the poorly drained area further downstream, but the total drainage area of the West Basin of West Loon Creek will not change, and therefore no changes in flows are expected for West Loon Creek. Only local changes in flows and flow patterns are predicted.

Table 9.5-1: Changes in Effective Local Drainage Areas due to Ground Subsidence

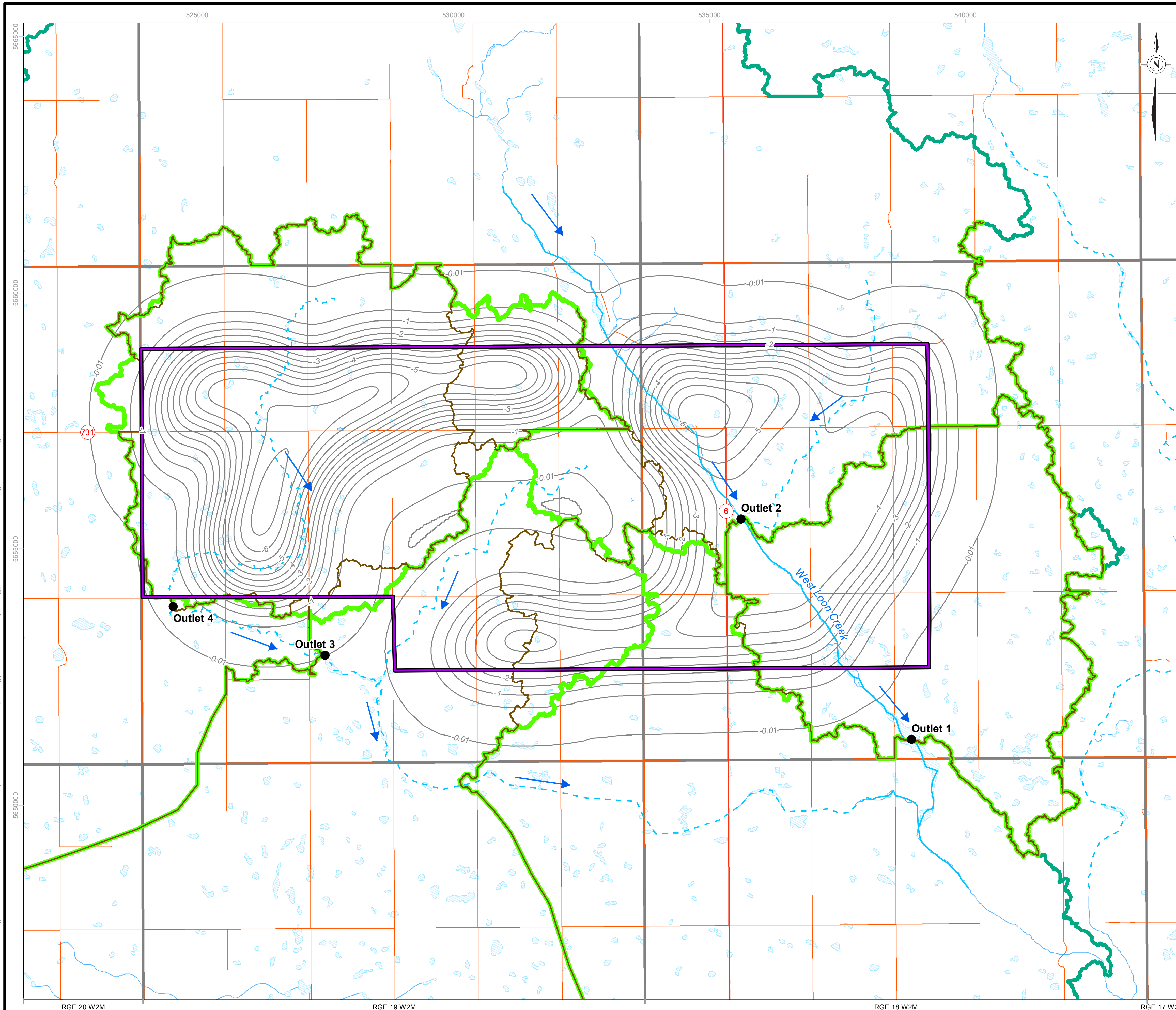
Outlet	Drainage Area for Existing Conditions (km²)	Drainage Area for Post-subsidence Conditions (km²)	Change (km²)	Change (%)
1	525.7	530.9	5.2	1.0
2	488.3	493.4	5.1	1.0
3	128.5	129.0	0.5	0.4
4	40.8	50	9.2	22.5

km² = square kilometres; % = percent.

9.5.2.2.4 Changes in Water Storage in Streams and Wetlands

The spatial distribution of water stored on the landscape may change in some areas due to differential settlement and subsidence. However, shifts in the spatial distribution of depressions and wetlands may not be apparent except during wet periods, or following large rainfall or snowmelt-runoff events. Changes in total water storage in selected sub-basins are considered.

To assess the change in spatial distribution of surface water storage for the existing and post-subsidence scenarios, a large rainfall event was artificially distributed over the landscape using the WDPM (Shook et al. 2014). The analysis provides an indication of the changes in the spatial extent of wetlands and depressions due to subsidence. A large rainfall event is used to more easily visualize the effect of subsidence, which is added to the DEM surfaces. Rainfall is redistributed by the model into low-lying depressions, ditches, wetlands, and stream floodplains. Depressions drain downstream by gravity after they are filled.



LEGEND

- HIGHWAY
- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- 65 YEAR MINE FIELD
- OUTLET
- CHANNEL
- INTERMITTENT CHANNEL
- DRAINAGE BOUNDARY FOR EXISTING TOPOGRAPHY
- DRAINAGE BOUNDARY FOR POST-SUBSIDENCE TOPOGRAPHY
- SUBSIDENCE CONTOUR (0.5 METRE INTERVAL)
- WEST LOON CREEK SUB-BASIN

REFERENCE

POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

1.5 0 1.5
SCALE 1:75,000 KILOMETRES

PROJECT
YANCOAL 兖煤加拿大资源有限公司
YANCOAL SOUTHEY PROJECT

TITLE
CHANGES IN DRAINAGE AREA BOUNDARIES

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	SM/JH	20/03/15	SCALE AS SHOWN	REV. 0
GIS	LMS	18/01/16	FIGURE: 9.5-11	
CHECK	GM	18/01/16		
REVIEW	GM	18/01/16		

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For the assessment, a 300-mm and a 100-mm rainfall event were distributed over the DEM surfaces for the area of about 300 km^2 likely to be effected by ground subsidence. Subsidence effects are calculated as the increase/decrease in stored water volume. Initial conditions for areas likely to pond water correspond to the conditions of the day the LiDAR was obtained. The model does not account for losses due to infiltration or groundwater during or after a rainfall event. However, the results identify the areas that are vulnerable to flooding based on topography. Results of the spatial distribution of the 300-mm rain event are provided on Figure 9.5-12. In this figure, the blue-shaded areas show potential ponding for existing topography, the orange-shaded areas show the potential ponding following subsidence conditions and brown-shaded areas show potential ponding for both existing and post-subsidence topography.

According to these results, depressions located in subsidence areas are likely to tilt in the direction of slope change. When the entire depression tilts towards its existing outlet, a reduction in the storage capacity is likely and vice versa. Areas with reduced ponding appear along the west and north sides of the 65-year mine field area. In contrast, increased ponding tends to coincide with the areas with the greatest subsidence (highlighted in orange), and includes an area within the West Loon Creek valley.

Results obtained with the WDPM model are consistent with the other results focused on changes in stream channel gradients along West Loon Creek. The potential increase in storage along the main West Loon Creek channel would occur along a reach of about 2.5 km in length that includes the grid road 731 crossing, and in another reach of the same length near the south mine well field boundary (Figure 9.5-4).

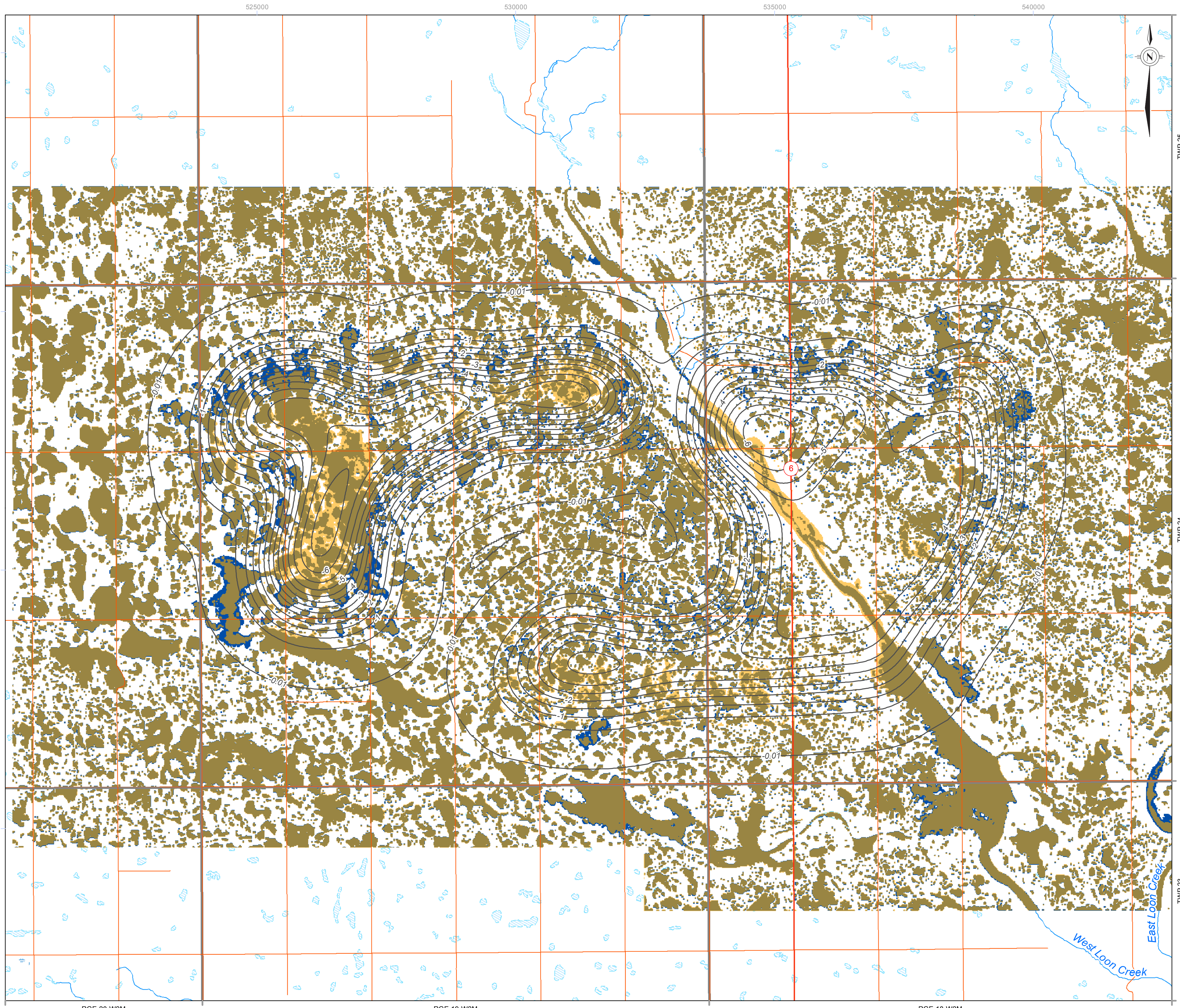
The drained volume obtained from the model after distributing the 300-mm and 100-mm rainfall events is used to estimate the change in volume of water stored on the landscape. The results are provided in Table 9.5-2. According to these results, the area contains a large number of wetlands and topographic depressions and, thus, has a large storage capacity under existing conditions. Only a small volume is drained from the area after a 100-mm rainfall event (Figure 9.5-13). This indicates that changes in runoff would be relatively minor even for a large event.

Finally, effects on hydrology due to the increase or decrease in water storage capacity have relevance only during wet periods or after large snowmelt or rainfall events. Therefore, effects on hydrology may only occur during wet periods or after high magnitude rainfall events.

Table 9.5-2: Results of the Wetland DEM Ponding Model Distribution on an Area of about 300 Square Kilometres

Volume	Under Existing Conditions	Under Post-subsidence Conditions
Rainfall Event: 300-mm		
Total Water Volume added (m^3)	89,698,185	89,698,185
Volume drained (m^3)	1,730,805	244,049
Volume Stored (m^3)	87,967,380	89,454,136
Volume Stored (%)	98.1	99.7
Rainfall Event: 100-mm		
Total Water Volume added (m^3)	29,899,395	29,899,395
Volume drained (m^3)	314,516	0
Volume Stored (m^3)	29,584,879	29,899,395
Volume Stored (%)	98.9	100

mm = millimetres; m^3 = cubic metres; % = percent.



LEGEND

- HIGHWAY
- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- SUBSIDENCE CONTOUR (0.5 METRE INTERVAL)
- RUNOFF DISTRIBUTION FOR EXISTING TOPOGRAPHY
- RUNOFF DISTRIBUTION FOR POST-SUBSIDENCE TOPOGRAPHY
- RUNOFF DISTRIBUTION FOR EXISTING AND POST-SUBSIDENCE TOPOGRAPHY

REFERENCE

CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

1.5 0 1.5
SCALE 1:75,000 KILOMETRES

PROJECT

YANCOAL SOUTHEY PROJECT

TITLE

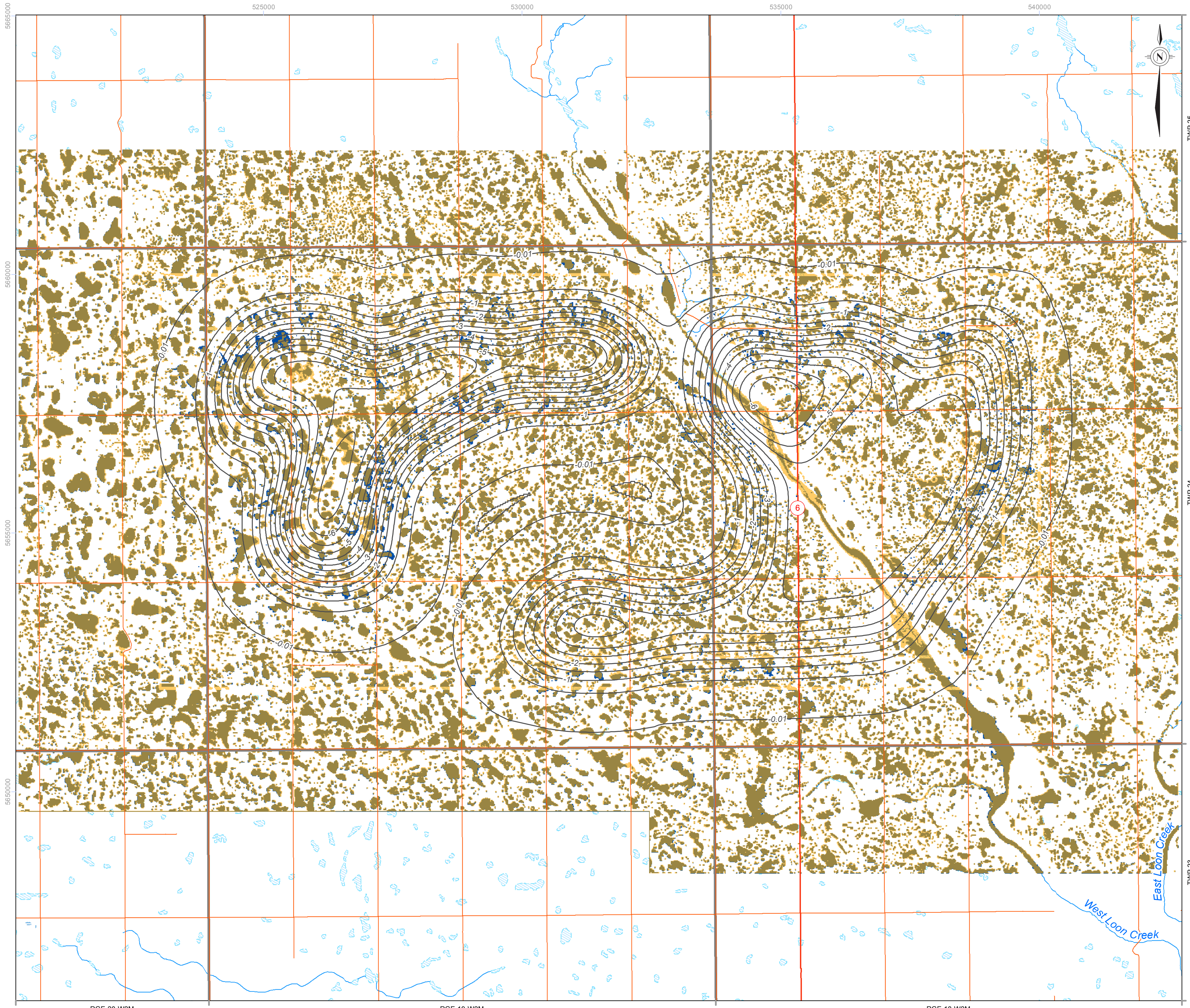
DISTRIBUTION OF RUNOFF FROM A RAINFALL EVENT OF 300 MM

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197
DESIGN	SM	20/03/15
GIS	LMS	26/05/15
CHECK	JH	26/05/15
REVIEW	BT	26/05/15

FILE No.
SCALE AS SHOWN REV. 0

FIGURE: 9.5-12



LEGEND

- HIGHWAY
- ROAD
- TOWNSHIP AND RANGE BOUNDARY
- SUBSIDENCE CONTOUR (0.5 METRE INTERVAL)
- RUNOFF DISTRIBUTION FOR EXISTING TOPOGRAPHY
- RUNOFF DISTRIBUTION FOR POST-SUBSIDENCE TOPOGRAPHY
- RUNOFF DISTRIBUTION FOR EXISTING AND POST-SUBSIDENCE TOPOGRAPHY

REFERENCE

CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

1.5 0 1.5
SCALE 1:75,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
DISTRIBUTION OF RUNOFF FROM A RAINFALL EVENT OF 100 MM

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
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GIS	LMS	26/05/15	**FIGURE: 9.5-13**	
CHECK	JH	26/05/15		
REVIEW	BT	26/05/15		

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Potential changes in surface water storage and the spatial extent of wetlands and depressions may also occur during operations due to expansion of the mine well field area or changes to the mine plan over time. The location of individual well pads, their access roads, and pipeline corridors may disrupt runoff pathways. The size of the individual well pad areas is approximately 18,000 m^2 (i.e., 100 m by 180 m) and the length of their access roads and pipeline corridors will vary with their distance from local roads, and the core facilities area, respectively.

9.6 Prediction Confidence and Uncertainty

Technical limitations are expected to be present when predicting the response of natural systems to man-made disturbances. Random errors and lack of knowledge must be considered. The main sources of uncertainty for the hydrology assessment likely are due to sources that can be classified into three categories (Ven Te Chow et al. 1988):

- inherent uncertainty, related to the random variability (unpredictability) associated with the hydrologic process;
- model uncertainty, related to the simplification that is done when representing complex systems with mathematical equations; and
- parameter uncertainty, related to model parameterization used to represent unknown processes and/or small-scale complex processes too detailed to be incorporated into the model.

In quantifying the reduction in natural runoff from the exclusion of the core facilities area, assumptions included inferring that the climate and runoff response in the future will be similar to current conditions. Uncertainty is inherent because future climate is unknown, but the modelling of the transformation of precipitation into runoff is a complex phenomenon involving both the lack of knowledge and small-scale complex processes with no uniformity in space and time. A lack of detailed information exists for long-term plans on specific well pad locations and related infrastructure (e.g., pipelines and access roads) and plans may change during operations.

The assessment assumes that precipitation and runoff conditions that include wet and dry spells that have been observed in the past will be representative of future conditions. However, additional uncertainties occur due to the limited spatial distribution and duration of historical records or inherent error associated with the data collection itself, such as equipment precision and human errors. Uncertainty is addressed, in part, by using the longest historical flow records representative for the area. Errors associated with the data collection were reduced through quality assurance/quality control (QA/QC) measures such as using standard practices, calibrated equipment that was inspected prior to its use, and internal review.

Although LiDAR data is sufficient for evaluating the existing drainage patterns, the topography after subsidence is subject to model and parameter uncertainties. To increase the level of confidence in the subsidence evaluation, parameters are evaluated against observed subsidence values from long-term ground surface elevation surveys at operating potash mines in Saskatchewan (Agapito 2014b; Appendix 9-A). The evolution in time and in space of subsidence is uncertain due to potential changes in the mine plan and the future technical advances in solution mining that may be adopted to mitigate environmental effects of subsidence. In addition, surface drainage systems continuously undergo modification due to erosion and deposition, adding additional uncertainty to the estimation of changes to the spatial and temporal distribution of surface water from long-term ground surface changes. To be conservative, the hydrological assessment is based on maximum predicted subsidence.

For estimating the residual effects from the Project and existing and potential future developments in the ESA, the assessment relies on the acquisition of available information from responsible authorities for utilities routes that would be finalized once the Project is approved. The more complete the available information, the lower the uncertainty to estimate environmental effects.

In summary, uncertainty and confidence in the predictions of the residual effects on hydrology are addressed by:

- the use of the most acceptable baseline data for understanding current hydrologic conditions and future changes potentially not related to the Project;
- model inputs and parameters based on reasonable estimators;
- learnings from existing potash mines in Saskatchewan; and
- conservative scenarios when information is limited.

9.7 Residual Effects Classification and Determination of Significance

9.7.1 Methods

9.7.1.1 Residual Effects Criteria

The purpose of the residual effects classification is to describe the residual incremental and cumulative adverse effects from previous and existing developments and the Project (Application Case) on hydrology using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment.

Results from the residual effects classification are then used to determine the environmental significance from the Project and other developments on the assessment endpoint for hydrology (i.e., availability of surface water quantity for human use and ecosystems). Effects are described using the criteria defined in Table 9.7-1 and reflect the effects criteria provided in the TOR (Appendix 2-B). Together, these criteria are used to describe the nature (e.g., severity or intensity of change and the area and amount of time over which the change occurs) and type (e.g., direction of the change) of an effect on a VC. The focus of the EIS is to predict whether the Project is likely to cause a significant adverse (i.e., negative) effect on the environment. Therefore, positive effects are not assessed for significance.

Table 9.7-1: Definitions of Residual Effects Criteria Used to Evaluate Significance for Hydrology

Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Negligible to Low: No measurable or minor changes in spatial and temporal distribution of surface water are likely. **Moderate:** Predicted change in surface water is measurable but is within the range of the natural hydrological regime. **High:** Predicted change in surface water is measurable and is outside the range of the natural hydrological regime.	**Local:** Predicted maximum spatial extent of direct and indirect effects from changes to measurement indicators due to a project or activity. **Regional:** Residual effects from changes to measurement indicator due to a project or activity exceed the local scale and can include cumulative effects from other developments in the effects study areas. **Beyond Regional:** Residual cumulative effects from changes to measurement indicator due to a number of developments extend beyond the effects study areas.	**Short-term:** Residual effect from change to measurement indicator is reversible at end of construction of Project. **Medium-term**: Residual effect from change to measurement indicator is reversible at end of operations of Project. **Long-term:** Residual effect from change to measurement indicator is reversible within a defined length of time past closure of a Project. **Permanent:** Residual effect from change to measurement indicator is irreversible.	**Infrequent:** Residual effect from change to measurement indicator is confined to a specific discrete event. **Frequent:** Residual effect from change to measurement indicator occurs intermittently over the life of the Project. **Continuous:** Residual effect from change to measurement indicator occurs continuously.	**Reversible:** Residual effect from change to measurement indicator is reversible within a time period that can be identified when a development or activity no longer influences hydrology. **Irreversible:** Residual effect from change to measurement indicator is predicted to influence hydrology indefinitely (duration is permanent or unknown).	**Unlikely:** Residual effect from change to measurement indicator is possible but unlikely (less than 10% chance of occurrence). **Likely:** Residual effect from change to measurement indicator may occur, but is not certain (10% to 80% chance of occurring). **Highly Likely:** Residual effect from change to measurement indicator is likely to occur or is certain (greater than 80% chance of occurring).

% = percent.

Magnitude - Magnitude is a measure of the intensity of a residual effect on a VC, or the degree of change caused by the Project relative to Base Case conditions, guideline, or established threshold values (i.e., effect size). Magnitude is specific to each VC and is classified into three scales: negligible to low, moderate, and high. Changes in measurement indicators are used to predict effects on hydrology. For hydrology, the intensity of change is focused on potential modification of the temporal and spatial water distribution. The criterion of magnitude is referenced to the Base Case conditions and considered in comparison to the range of natural hydrological variability.

A negligible to low magnitude relates to changes that are easily embedded in the hydrology natural dynamics, which are minor or not measurable. For this assessment, it is considered that any change less than 5% would not be measurable within the error of conventional flow measurement equipment.

A moderate magnitude is used for those measurable changes that do not affect the water requirements for current demand year around. The water supply demands in the area are limited to soil moisture for agriculture purposes. A moderate magnitude would be defined as predicted changes greater than 5% but less than 25% of the mean annual unit-area runoff as defined by the annual historical records from Jumping Deer Creek hydrometric station (05JK004). Consequently any change lower than or equal to 25% reference to Base Case conditions will be classified as moderate, while any change in flow larger than 25% will be classified as high magnitude.

Geographic Extent - Geographic extent refers to the spatial extent of the area (or distance covered, or range) affected and is different from the spatial boundary defined for the effects analysis. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution of the VC (Section 9.2.1). However, the geographic extent of effects can occur on a number of scales within the spatial boundary of the assessment and is VC-specific. Effects at the local scale are largely associated with the predicted maximum spatial extent of combined direct and indirect changes from the Project. Effects at the regional scale occur within the ESA and are associated with incremental and cumulative changes from the Project and other developments. The beyond-regional scale includes cumulative residual effects from the Project and other developments that extend beyond the ESA. The principle applied when using geographic extent to understand magnitude is that local effects from the Project are less severe than effects that extend to the regional or beyond-regional scales, all other factors being equal.

Duration - Duration is VC-specific and defined as the amount of time from the beginning of a residual effect until the residual effect on hydrology is reversed. Typically, duration is expressed relative to Project phases (usually in years). Duration has two components, the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases), plus the time required for the effect to be reversible. Essentially, duration is a function of the length of time that VCs are exposed to Project activities and reversibility of the effect. By definition, residual effects that are short-term, medium-term, or long-term in duration are reversible.

In some cases, available scientific information and experienced opinion may predict that the residual effect is irreversible. Alternately, the duration of the residual effect may not be known, except that it is expected to be extremely long and well beyond the temporal boundary of the Project. Any number of factors could cause a VC to never return to a state that is unaffected by the Project. In other words, science and logic predict that the likelihood of reversibility is so low or uncertain that the residual effect is classified as irreversible and permanent.

9.7.1.2 Determination of Significance

The classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of incremental and cumulative effects from the Project and other existing and approved developments on the assessment endpoint for hydrology. The evaluation is focused on determining the significance of cumulative effects on the availability of surface water quantity for human use and ecosystems.

Magnitude is the primary criterion used to determine environmental significance, while other criteria are used as modifiers and to provide context when assigning magnitude. Geographic extent and duration provide important context for classifying the magnitude of effects on the hydrology assessment endpoint. For example, determining the magnitude of an effect from changes in the temporal and spatial distribution of water on the hydrology VC depends on the spatial extent and duration of the changes. Duration includes reversibility; a reversible effect from a development is one that does not result in a permanent adverse effect on hydrological functions and properties. Frequency and likelihood are considered as modifiers when determining significance, where applicable.

The evaluation of significance for hydrology considers the entire set of primary pathways that influence the assessment endpoint; thus, significance is not explicitly assigned to each pathway. Rather, the relative contribution of each pathway is used to determine the significance of the Project and other developments on the assessment endpoint, which represents a weight of evidence approach (i.e., evaluating the persuasiveness of evidence indicating that an effect is significant or not significant). For example, indicators from a pathway showing effects with high magnitude, a regional geographic extent, and a long-term duration are given more weight in determining significance relative to pathways with smaller scale effects. The relative effect from each pathway is discussed; however, pathways that are predicted to have the greatest influence on changes to the assessment endpoint are assumed to contribute the most to the determination of environmental significance.

The determination of environmental significance on hydrology considered the following key factors:

- Results from the residual effects classification of primary pathways and associated predicted changes in measurement indicators.
- Magnitude is the primary criterion used to determine significance with geographic extent and duration providing important context for assigning magnitude. Frequency and likelihood act as modifiers for determining significance, where applicable.
- The level of confidence in predicted effects, established guidelines and standards, and experienced opinion are included in the evaluation of determining environmental significance.

This method is used to identify predicted residual adverse effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to hydrology and, therefore, result in significant effects. The following definitions are used for predicting the significance of effects on the availability of surface water quantity for human use and ecosystems.

Not significant – the effects on hydrology are measureable but would not likely affect the continued availability of surface water quantity for human use and ecosystems.

Significant – the effects on hydrology are likely to result in a change in the spatial and temporal distribution of surface water to the extent they are measureable at the local and regional scale (e.g., the current water demands year round cannot be supplied and no alternate sources of water are available) and are likely to affect the continued availability of surface water quantity for human use and ecosystems.

9.7.2 Results

The exclusion of the core facilities area from the natural drainage system is predicted to produce disturbances to the existing drainage system. The core facilities area will no longer contribute runoff to natural runoff. The exclusion of the core facilities area would have an effect on runoff reporting to a low topography area downstream, but would rarely affect West Loon Creek stream flows. Therefore, the effects on flows downstream of the West Tributary of West Loon Creek are unlikely to occur. The reduction in runoff was estimated to be about 2.3% of the runoff reporting to the low topography area while the Project is in operation. Therefore, these changes are predicted to be negligible to low in magnitude.

The required channel diversion for the exclusion of the core facilities area will intercept and partly modify directions of secondary watercourses or flow pathways. These channels would cause localized changes in drainage patterns compared to Base Case conditions. However, the freshwater diversion channels will re-align runoff over a short distance, but no inter-basin transfers occur and freshwater will be reintroduced to the same watercourses it currently flows through. Residual effects are local in geographical extent. Any effects on local flow pathways and morphology would occur gradually and frequently (e.g., during peak flows during the spring freshet).

Within the core facilities area, the waste salt storage areas and the brine reclaim ponds (i.e., TMA) would remain in place for several hundred years after decommissioning and reclamation until the salt pile is dissolved and the brine disposed of by deep well injection. Thus, ground disturbance from the TMA is irreversible. For the remaining core facilities area, natural drainage patterns would be re-established following the completion of decommissioning and reclamation (i.e., medium to long-term duration). The reduction in drainage area size for the West Tributary of West Loon Creek would be permanent and estimated to be about 1.1%, but without a reduction in flow volume in West Loon Creek downstream of the Project. Consequently, the effects are predicted to be negligible to low in magnitude and local in geographic extent.

Changes in local flows, drainage patterns, and the spatial extent of wetlands and depressions may also occur during operations due to the mine well field area and the locations of the individual well pad areas, which may change over time. The location of individual well pad areas, their access roads, and pipeline corridors may disrupt runoff pathways. The size of the individual well pad areas is approximately 18,000 m^2 (i.e., 100 m by 180 m) and the length of their access roads and pipeline corridors will vary with the distance from local roads, and the core facilities area, respectively. During operations, it was estimated that up to 19 well pads could be developed at once; therefore, a total area of 342,000 m^2 (or 0.3 km^2) would be isolated from the natural drainage of the West Tributary of West Loon Creek. The cumulative reduction in drainage area size for the West Tributary of West Loon Creek is estimated to be about 0.07%, which would not measurably reduce flows to West Loon Creek, particularly as this sub-basin rarely contributes to West Loon Creek. Physical disturbance affecting hydrology will be minimized through the use of design features such as minimizing the number of well pads needed, avoiding semi-permanent and permanent wetlands, minimizing disturbance to natural drainage patterns, if possible, and use of existing utility corridors and roads. Cross-drainage structures will be installed for access roads if they intersect with flow pathways. Progressive reclamation of well pads will occur during operations. Based on this mitigation, the effects on hydrology will be negligible to low in magnitude and occur over the medium-term.

Ground subsidence is expected to affect an area that extends about 17 km from west to east and about 8 km from north to south. A maximum vertical topographic displacement of 6.7 m was predicted to occur in the western section of the mine well field area. Most of the area affected by subsidence is located within the West Loon Creek sub-basin and more than 50% occurs around a topographic low located in the West Tributary of this stream that is characterized by poor network drainage conditions likely to contribute to the main channel only under the occurrence of rare extreme precipitation, wet periods, or snowmelt events.

West Loon Creek channel will be affected by changes in gradients. The change in channel gradient is predicted to be from 0 m/km to 3 m/km. Potential exists for some shallow ponding to occur in two reaches of about 2 km length. However, downstream drainage would continue to occur after inflows fill channel depressions. Streamflow response to precipitation or snowmelt events would be delayed from its current condition and peak flows may be reduced. Soil moisture and the water table may increase due to the increased ponding in these areas and evapotranspiration losses would increase. These effects are localized and likely will have negligible to low magnitude effects on streamflow.

Storage capacity in the low topographic area west of West Loon Creek would increase due to subsidence but effects on flows downstream are predicted to be negligible to low in magnitude because the area has a large capacity for storing runoff under the Base Case conditions and only rarely transmits surface runoff to West Loon Creek. In addition, some localized changes in runoff pathways and the location and size of drainage areas are predicted to be confined to the area affected by subsidence. The potential storage capacity of the West Tributary of West Loon Creek will increase, but effects on the downstream measurement would be possible only under rare precipitation events of at least the 1:100-yr event or after extended wet periods. Based on these considerations, the affects to the hydrological regime are classified as negligible to low magnitude.

The residual effects on hydrology from subsidence are regional in geographical extent, while the magnitude is negligible to low because changes to stream channel gradients will occur gradually and the timing and magnitude of streamflow response along West Loon Creek may not measurably affect flows in Loon Creek downstream of the Project. Subsidence is a continuous process that is likely to occur beyond the temporal boundary of the assessment, and is therefore classified as permanent, but would not affect the continued availability of surface water quantity for human use and ecosystems in this area.

The incremental effects from the Project are expected to be reversible in the medium- to long-term, except for localized effects from the TMA (i.e., 5.2 km^2), which will be permanent and irreversible. Overall, the cumulative residual effects of the Project on hydrology are expected to be negligible and low in magnitude and regional in geographic extent. The incremental and cumulative changes from the Project and other developments are predicted not to have significant adverse effects on the availability of surface water quantity for human use and ecosystems. A summary of the residual effects classification and predicted significance on hydrology is provided in Table 9.7-2.

Table 9.7-2: Summary of Residual Effects Classification of Primary Pathways and Predicted Significance of Cumulative Effects on Hydrology

Pathway	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Significance for Assessment Endpoint
Changes in surface flows, drainage patterns (spatial distribution) and drainage areas from the Project footprint.	Negligible to low	Local	Medium to long-term for reclaimed areas Permanent for residual disturbance	Continuous	Reversible for reclaimed areas Irreversible for residual disturbance	Highly likely	Not significant
Ground subsidence caused by solution mining can change surface flows, drainage patterns (distribution), drainage areas, and waterbody or stream morphology.	Negligible to low	Regional	Permanent	Continuous	Irreversible	Highly likely	

9.8 Monitoring and Follow-up

Typically, monitoring includes one or more of the following categories, which may be applied during the development of the Project:

- **Compliance monitoring** – monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments.
- **Follow-up monitoring** – programs designed to test the accuracy of effects predictions, reduce or address uncertainties, determine the effectiveness of environmental design features, and/or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., monitoring of downstream lakes for aquatic effects, wildlife effects monitoring, and socio-economic monitoring). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

Follow-up programs are typically implemented when the accuracy of the determination of significance needs to be verified or the resulting residual effects cause sufficient public concern to warrant an increased effort to determine the accuracy of the predictions or test the effectiveness of mitigation and compensation. If monitoring or follow-up detects effects that are different from predicted effects, or the need for improved or modified design features and mitigation, then adaptive management will be implemented. This may include increased monitoring, changes in monitoring plans, and additional mitigation. Monitoring for hydrology is discussed below.

Continuation of the local surface water level monitoring program established in the ESA during the 2013 field program. It is advisable to continue with this monitoring program during operations and following decommissioning and reclamation. The monitoring program will be extended to include the proposed diversion channels. Diversion channels are engineering designs to convey a design storm with erosion control on place; therefore, records from this program will be useful for monitoring water quantity changes and future estimation of water volumes in the ESA.

A follow-up monitoring program will be implemented to monitor the progress of ground subsidence. The program will be designed to reduce uncertainty from the potential effects of subsidence on hydrology. Topographic elevations in the mine well field area will be surveyed regularly. A combination of three approaches may be used. The first approach involves the use of Real Time Kinematics (RTK) surveying methods more frequently, the second method involes the use of fixed pile survey monuments that would also allow for more frequesnt surveying, and the third method is be based on LiDAR airborne surveys at longer intervals. Series of survey control points would be required in the mine well field area where subsidence is predicted to occur for an easy evaluation of ground subsidence progress. Over time, changes in control point elevations would be used as indicators of the effect of subsidence on topography.

Ground subsidence due to solution mining occurs over a long period, with ultimate subsidence occurring over hundreds of years. The dynamic change in ground elevation has to be considered for future developments and infrastructure upgrades in this area. Long term monitoring of topographic changes, combined with an adaptive management approach will be used to mitigate potential effects and uncertainty related to subsidence and streamflow.

9.9 Summary and Conclusions

The Project is not expected to affect the continued availability of surface water quantity for human use and ecosystems. Four Project components or activities that would likely affect hydrology were identified and effects pathways were examined in this assessment. From the potential effects pathways, two Project components or activities were anticipated to have measurable effects on the hydrological system, and these were evaluated in more detail to determine that the changes were not significant:

- changes in local flows, drainage patterns (spatial distribution), and drainage areas due to the exclusion of the core facilities area from the natural drainage system; and
- changes in surface flows, drainage patterns (distribution), drainage areas, and waterbody or stream morphology due to ground subsidence.

The other two effects pathways were not anticipated to cause a measurable effect on hydrology considering the Project location, environmental design features and mitigation that would be in place, and the use of external water sources for the Project water supply:

- Disruption or change in sub-surface and deep groundwater flow, levels, and quality may affect local surface water flows and drainage patterns.
- Runoff within the core facilities area, mine well field areas, mine well field utility corridors, and new access roads can affect surface flows and water levels.

The application of mitigation for the Project will follow the hierarchy outlined in MOE (2014). The following guidelines and practices will be in place as part of the Project design to reduce as much as possible the potential effects from the Project on hydrology:

- The location of the Project site is in the headwaters of the West Tributary of West Loon Creek and does not intersect any major streams or lakes.
- The TMA location was selected based on site-specific soil, geologic, and hydrogeologic properties that provide an appropriate foundation and provide natural containment of brine material.
- The Project's water supply will be sourced from an external water supply source, which will be from Buffalo Pound Lake and distributed to the Project via a pipeline to be operated by SaskWater.
- The core facilities area and individual well pads will be isolated from the natural drainage system using diversion works, and berms, respectively. Semi-permanent and permanent wetlands will be avoided and existing access roads and utility corridors will be used to reduce disturbance to the natural environment and hydrology, to the extent practical. Diversion ditches will be designed to accommodate a 24-hour 300-mm rainfall event so that the core facilities area will remain isolated from the natural drainage.
- Runoff generated within the core facilities area will be managed on site and may slightly reduce the overall Project water demands as it could be reused for process and potable water supplies. Process and wastewater may also be recycled and reused to the extent practical. The brine reclaim pond on site will be designed to accommodate storage of process streams under normal and extreme operating conditions as well as a 24-hour 300-mm rainfall event; excess brine will be disposed by deep well injection methods.

- Where possible, existing infrastructure and corridors will be used to limit the extent of disturbance to natural flow paths and, where necessary, culverts and stream crossings will be installed along new access roads to retain natural runoff paths.
- Solution mining methods will reduce ground subsidence by leaving unmined pillars in between caverns to increase stability. Use of secondary mining techniques that reduce the total amount of material removed also will be used and extraction ratios will be controlled to limit strain on the overlying environment.
- Additional environmental design features including containment berms and dykes around the TMA, seepage cutoff walls to protect groundwater quality, progressive reclamation of the mine well field area, and erosion control measures will be implemented to limit losses from topsoil and overburden stockpiles.
- A Decommissioning and Reclamation Plan will be developed that will incorporate new technologies as they become available to reduce the duration of the decommissioning period.

A potential measurable environment effect will result from ground subsidence overlying the mine well field caverns. Although the maximum calculated settlements would be about 6 m, negligible to low effects are expected on the total annual runoff volume in the ESA. The water conveyance efficiency in the north portion of the affected area may increase with increased slope along runoff pathways, whereas reduced conveyance efficiency in the south section of the subsided area is anticipated. Some reversal in the topographic gradient is expected along short sections of West Loon Creek. Both indirect and direct hydrological effects would be local and only occur in certain areas within Loon Creek watershed. Subsidence will be monitored on a regular basis over the period of operation and following Project decommissioning and reclamation.

The isolation of the core facilities area (and the well pads) from the surrounding local drainages will slightly reduce runoff and irreversibly change drainage patterns in the immediate area. The effects in annual runoff volume was classified as negligible to low and was estimated to be about a 2.3% decrease of the runoff reporting to the low-topography area within the West Tributary sub-basin of West Loon Creek, and negligible for West Loon Creek during the operations phase.

At decommissioning, part of the core facilities area could be reclaimed into the natural drainage system, while the TMA (i.e., salt storage, brine reclaim pond and surface water diversion around the TMA) will continue to contain some runoff during decommissioning and reclamation. However, annual runoff volume would only be reduced by about 1.1% in an average year. Water quantity will still be available for human use and ecosystems.

Water storage capacity in low depressions (wetlands capacity) would be likely to increase, especially in the low topography area within the West Tributary of West Loon Creek sub-basin. Using modeling analysis it was determined that the storage capacity within the sub-basin is high for existing conditions. For example, after redistributing 300-mm and 100-mm (about 1:100 yr precipitation event) rainfall events, the area retained 98% and 99% of the associated water volume, respectively. Following ground subsidence, these values increased to 99% and 100% respectively. The increase of water storage in low-lying depressions is likely, but the effects are low and infrequent due to the existing high storage capacity in the area.

Overall, the cumulative residual effect of the Project on hydrology is expected to be negligible to low in magnitude and regional in geographic extent. The residual effects from the Project are predicted not to have significant adverse effects on the availability of surface water quantity for human use and ecosystems.

9.10 References

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9.11 Glossary

Term	Description
Best Practice	Method or procedure that is accepted by industry as being effective, practical and reliable in maintaining quality, and meeting Project objectives and regulatory requirements.
Channel	A geomorphic feature that represents the physical confines of a stream and consists of a streambed and banks. The channel contains most of the normal flows of water and sediment within a stream except for higher flood flows, which overtop the banks and spread over the adjacent floodplains. Channels are created and adjust over time to changes in streamflow, sediment load, stream slope, and vegetation. See also Floodplain.
Class A Meteorological Station	Station that meets World Meteorological Organization highest standards for temperature and precipitation.
Coulee	A ravine with sloping sides, often dry in the summer.
Creek	A branch or small tributary of a river.
Depression	A small low-lying area within the landscape that can store surface water
Discharge	The volume of surface water in a stream passing a given point over a unit period of time.
Drainage Basin	The land area that could contribute runoff to a river or lake at a given location. The boundaries of the drainage basin are defined by high points of land.
Effective Drainage Area	The effective drainage area can be equal to, but is usually less than, the gross drainage area (or drainage basin area) for a given location along a stream or for a waterbody. In the prairie region, this is defined as the land area that contributed runoff to a stream in a year with a 1 in 2 year peak discharge, which generally occurs during the spring freshet.
Evaporation	The change in phase of water from a liquid to a vapor state that requires energy to be used from the environment. Evaporation can occur from the soil, from the surface of vegetation, or from ponded water. See also Evapotranspiration.
Evapotranspiration	The combined processes of water loss from land and water surfaces that includes evaporation losses and losses of water from vascular plants via transpiration.
Flood plain	A geomorphic feature associated with streams that includes the area outside the main stream channel along the valley floor, which becomes inundated at high flows.
Gross Drainage Area	The gross drainage area is equal to the area of a drainage basin for a given location along a stream or for a waterbody. See also Drainage Basin.
Hydrology	The study of the movement, distribution, and quantity of water including the hydrologic cycle, water resources, and watershed water quantity issues.
Infiltration	The process of downward water movement from the soil surface that occurs by gravity. Infiltration occurs in unsaturated and saturated soils or beneath ponded areas.
Saturated (soils)	Soils are saturated when all pore space between soil particles is filled with water. This is measurable in situ using various methods if pore water pressure is equal to or greater than atmospheric pressure.
Stage	The height of water in a stream at a hydrometric station measured above a specific local or geodetic elevation, which may be measured above the gauge height of zero flow, if this is known.
Streamflow	This term is used interchangeably with discharge to describe movement of water along a stream.
Unsaturated (soils)	Soils are unsaturated when pore space between soil particles is not filled with water. This is measurable in situ using various methods if pore water pressure is greater than the atmospheric pressure.
Transpiration	The process by which moisture is carried through plants from the roots to small pores on the underside of leaves, where it changes to vapor and is lost to the atmosphere.
Wetland	Defined as natural or artificial depressions that store water in low-lying areas, which facilitate the development of characteristic soils and support vegetation types that can withstand some degree of soil saturation or flooding. Wetlands are classified based on characteristic vegetation, soil types, and the hydroperiods that water is stored within them (e.g., ranging from ephemeral wetlands that store water temporarily in wet periods to permanent wetlands that store water in both wet and dry periods).

10.0 SURFACE WATER QUALITY

10.1 Introduction

10.1.1 Background

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project) located in central Saskatchewan, approximately 60 kilometres (km) north of Regina. Yancoal proposes to develop the Project, which includes solution mining and associated supporting infrastructure.

The Project is located in the Rural Municipality (R.M.) of Longlaketon (No. 219) and the R.M. of Cupar (No. 218). An existing network of municipal grid roads, provincial highways, and rail lines will provide access to the Project. The Project (including the core facilities area, 65-year mine field, and indicated resource boundary) encompasses approximately 143 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M).

10.1.2 Purpose and Scope

This section of the Environmental Impact Statement (EIS) for the Project addresses the effects on surface water quality identified in the Terms of Reference (TOR) approved by the Environmental Assessment Branch (EAB) of the Ministry of Environment (MOE) in May 2015 (Appendix 2-B).

The purpose of this section is to meet the TOR, specifically to assess the effects from Project on surface water quality. The scope of this section includes an analysis of Project-related changes during construction, operation, and decommissioning and reclamation. The incremental and cumulative residual effects from the Project and other previous, existing, and reasonably foreseeable developments on surface water quality are assessed.

The quality of surface water is linked to the atmospheric, hydrogeology, hydrology, fish and fish habitat, soils, vegetation, and wildlife components of the environment, and the people who use these resources. As such, related assessments are provided in the following sections:

- Atmospheric Environment (Section 7.0);
- Hydrogeology (Section 8.0);
- Hydrology (Section 9.0);
- Fish and Fish Habitat (Section 11.0);
- Soils (Section 12.0);
- Vegetation (Section 13.0);
- Wildlife (Section 14.0); and
- Socio-economic Environment (Section 16.0).

10.1.3 Valued Components, Assessment Endpoints, and Measurement Indicators

The TOR identified surface water quality as a valued component (VC) that should be included in the assessment of effects on the environment. Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by the proponent, the public, First Nations and Métis communities, and government agencies. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components (VCs) have the potential to be adversely affected by Project development and, therefore, are used to predict the effects of the Project on all environmental components. Rationale for selection of surface water quality as a VC is as follows:

- is sensitive to Project-related effects (e.g., dust deposition);
- changes to surface water quality can potentially affect other components of the environment (e.g., aquatic and terrestrial organisms, human health, and traditional and non-traditional land use activities); and
- surface water quality can be measured or described with one or more practical indicators.

Community and regulatory engagement and local and traditional knowledge were key considerations for selecting the VC, but assessment endpoints for surface water quality do not explicitly consider societal values, such as continued opportunity for the human use of surface water. Changes in surface water quality must be considered to understand the full suite of potential effects of the Project (i.e., both human and ecological dimensions). Consequently, measurement indicators from the surface water quality section were carried forward so that effects on ecological and societal values could be appropriately captured in the sections dealing specifically with those values (Section 16.0).

Assessment endpoints are qualitative expressions used to assess the significance of effects on a VC and represent the key properties of the VC that should be protected for use by future human generations (i.e., incorporate sustainability). Assessment endpoints are general statements about what is to be protected. Measurement indicators are quantitative and/or qualitative expressions of changes to the assessment endpoints. The assessment endpoint for the surface water quality is continued suitability of surface water for human use. The measurement indicator is surface water quality (i.e., physical analytes and chemical properties).

10.2 Environmental Assessment Boundaries

10.2.1 Spatial Boundaries

10.2.1.1 Baseline Study Area

To quantify baseline conditions for surface water quality, baseline study areas were defined for the surface water environment and included a regional study area (RSA) and local study area (LSA) (Annex III, Section 3.0). The RSA was defined by the maximum expected spatial extent of direct and indirect effects from the Project. The LSA was defined by the maximum expected spatial extent of the Project's direct effects.

10.2.1.2 Effects Study Area

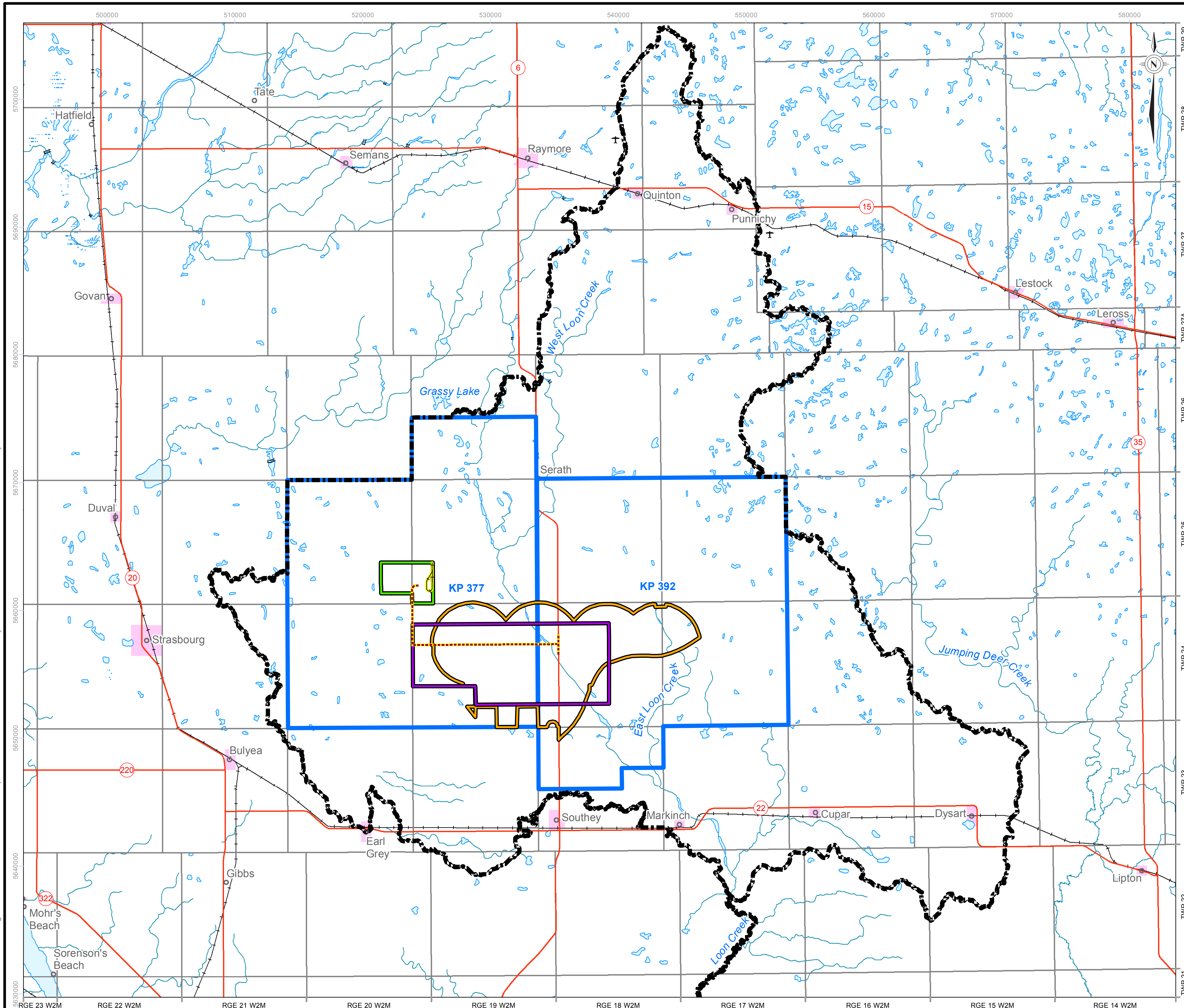
To assess Project-related effects on the surface water environment, an effects study area (ESA) was delineated for surface water quality and is approximately 1,959 km^2 (Figure 10.2-1). The ESA extends to the boundaries of the drainage basins interacting with the Project. The ESA includes both unaffected (i.e., reference) areas, as well as areas influenced by the Project. The ESA is expected to be large enough to provide an ecologically relevant and confident assessment of the direct and indirect effect on surface water quality from the Project, and the potential cumulative effects from the Project and other previous, existing, and reasonably foreseeable developments.

The ESA encompasses the Project footprint, including the core facilities area, as well as the area of potential subsidence (i.e., within the 65-year mine field). East Loon Creek, West Loon Creek, Loon Creek, and minor tributaries to these streams may be indirectly affected by air and dust emissions from the Project, which may influence the chemical properties of surface water within these systems. Therefore, the ESA includes the KP392 and KP377 permit areas, as well as the Loon Creek drainage area downstream to the Water Survey of Canada (WSC) station 05JK006. As such, the confluence of West Loon Creek and East Loon Creek is encompassed by the ESA (Figure 10.2-1).

The ESA is situated on a transitional area between the boundaries of the Moist Mixed Grassland and Aspen Parkland Ecoregions of the Prairie Ecozone in Saskatchewan (Acton et al. 1988). The west portion of the ESA is situated in the Strasbourg Plain Landscape Area within the Moist Mixed Grassland Ecoregion. The east portion of the ESA is situated in the Touchwood Hills Upland Landscape Area of the Aspen Parkland Ecogregion. The Moist Mixed Grassland Ecoregion is a broad, level plain with the occasional deep valley, such as the Qu'Appelle Valley (Flory 1980; Acton et al. 1988). The Moist Mixed Grassland is characterized by a patchy landscape of prairie, woodland, and shrubland, (Acton et al. 1998), although much of the ecoregion is now predominantly cultivated land. The Aspen Parkland Ecoregion is characterized by hummocky landscapes where woodlands or wetlands occur in lower areas associated with pot and kettle topography, and grasslands are established on the upper slopes. Much of the area has now been cultivated or is used for livestock grazing; rangelands are typically located in the scattered areas of steep or wooded terrain.

The climate in the ESA is described as a sub-humid continental climate and is characterized by warm, short summers and cold, long winters, with snow usually remaining on the ground for four to five months. Streams and waterbodies in this region are usually ice-free from late March or April until the end of October or November. Streamflow ceases in the smaller streams and is reduced in larger streams from November to March. Snow accumulates through the winter and is the main source of spring runoff to local wetlands and streams. Rainfall makes up 80 percent (%) of the total precipitation each year, with the intensity, duration, and spatial extent of rainfall events varying considerably.

There are no lakes in the ESA, but because it is located in the "prairie pothole" region there are numerous ephemeral wetlands present. Within the vicinity of the Project, streams generally flow from north to south toward the Qu'Appelle River. Most of the Project footprint is located within the Loon Creek drainage; however, the northwest portion of KP377 drains towards Last Mountain Lake. The main tributaries of Loon Creek include West Loon Creek and East Loon Creek. Both West and East Loon creeks have well-defined stream channels and stream valleys. A tributary of West Loon Creek that is referred to as "unnamed stream" has a poorly-defined stream channel and drains a large part of the ESA, including the proposed core facilities area and a portion of the mining area.



LEGEND

- COMMUNITY
- HIGHWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- PROPOSED ACCESS ROAD
- PROPOSED RAIL LOOP
- PERMIT BOUNDARY
- 65 YEAR MINE FIELD
- CORE FACILITIES AREA
- INDICATED RESOURCE BOUNDARY
- EFFECTS STUDY AREA

REFERENCE

PERMIT BOUNDARY: POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
CANVEC © NATURAL RESOURCES CANADA
NTS MAPSHEET: 62L/M, 72I/J/O/P
NAD83 UTM ZONE 13

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SCALE 1:300,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
LOCATION OF THE SURFACE WATER QUALITY EFFECTS STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	KT/BH	09/07/14	SCALE AS SHOWN	REV. 0
GIS	LMS	06/05/15	FIGURE: 10.2-1	
CHECK	AO	21/05/15		
REVIEW	BC	21/05/15		

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10.2.2 Temporal Boundaries

Temporal boundaries for the surface water quality assessment were defined by the life of the Project (Section 4.0) and the existing and future cumulative effects to which the Project might contribute. The Project phases are construction, operation, and decommissioning and reclamation. Final relinquishment of the Project will occur after the completion of reclamation.

The effects analysis encompasses the Project phases as follows:

- construction (2016 to 2019);
- operations (2019 to 2119); and
- decommissioning and reclamation (2119 onward).

The above timeframes are intended to be sufficiently flexible to capture the effects from the Project on surface water quality. Many effects of the Project will end when operation ceases or at decommissioning and reclamation (e.g., air emissions), but other effects may continue, unless determined to be permanent. Therefore, effects on surface water quality were analyzed from Project construction through decommissioning and reclamation. This approach generates the maximum potential spatial and temporal extent of effects on the continued suitability of surface water for human use, which provides confident and ecologically relevant effects predictions.

10.2.2.1 Base Case

The Base Case (existing environment) represents existing conditions before application of the Project. Previous and existing developments and activities include roads, communities, water use, and agricultural activities. Consequently, the Base Case represents the cumulative outcome of all previous and existing developments and activities.

10.2.2.2 Application Case

The incremental contributions of residual effects from the Project to existing cumulative effects were assessed at the ESA scale by adding the Project to the Base Case to form the Application Case. There are two periods during the Project that are expected to contribute to maximum effects on surface water quality:

- when dust deposition is at its maximum, which is expected to occur during the operations phase of the Project (Section 7.5.2); and,
- when settlement due to mine subsidence would be the maximum expected; this period would be reached many years after decommissioning and reclamation.

The incremental contributions of the Project and the cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are predicted to evaluate changes to the measurement indicator for surface water quality during the Application Case.

10.2.2.3 Reasonably Foreseeable Development Case

The Reasonably Foreseeable Development (RFD) Case represents the Application Case plus reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. The minimum temporal boundary for the

Application Case and RFD Case is the expected lifespan of the Project that, like the Base Case, includes a range of conditions over time. The difference between the Application and RFD case is that the Application Case considers the incremental effect from the Project in isolation of potential future land use activities. The RFDs are defined as projects that:

- are currently under regulatory review or have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project, or may be induced by the Project;
- have been approved but not yet developed; or
- have the potential to change the Project or the effects predictions.

The reasonably foreseeable developments identified in Section 6.0 include the supporting infrastructure required for the Project, the Muskowekwan Potash Mine Project, and the Vale Kronau Project. Supporting infrastructure will include a water supply pipeline, an overhead transmission line, a natural gas supply pipeline, telecommunication services, and a railway line. Screening assessment reports will be completed by each of the utility providers once the final routing options are determined. Most of the preferred routes for the supporting infrastructure are not known at this time. Therefore, the supporting infrastructure for the Project will not be assessed as an RFD for surface water quality.

The proposed Muskowekwan Potash Mine Project is located approximately 52 km northeast of the Project and the Vale Kronau Project is located approximately 71 km south of the Project; both projects are outside of the ESA. The effects on surface water quality from development of the Muskowekwan Potash Mine Project and the Vale Kronau Project are not expected to overlap with effects on surface water quality within the ESA, as they are located in different watersheds. Therefore, the RFD Case is not included in this section of the EIS.

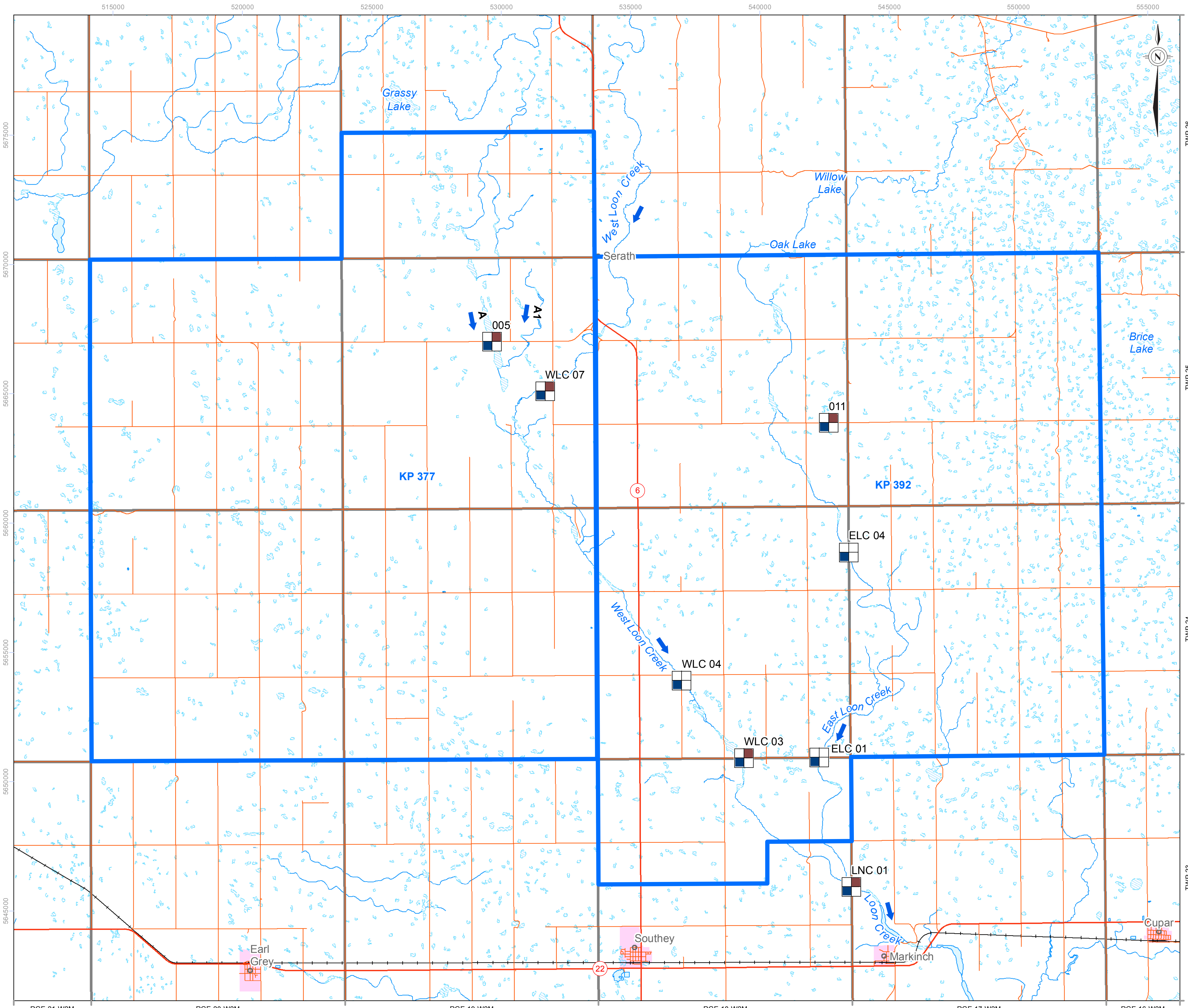
10.3 Existing Environment

The purpose of this section is to describe the existing environment for surface water quality within the ESA (Base Case) as a basis to assess the Project-specific effects on surface water quality. The detailed methods and results for baseline data collection are described in the Surface Water Environment Baseline Report (Annex III, Section 4.0).

10.3.1 Methods

Water chemistry samples were collected during the spring, summer, and fall of 2013 from one location in Loon Creek, two locations in East Loon Creek, three locations in West Loon Creek, and two land-locked waterbodies in the ESA. Sediment chemistry samples were collected from five water sampling locations in the ESA during the fall 2013 sampling session (Figure 10.3-1).

Water and sediment samples were collected according to Golder Associates Ltd. (Golder) standardized technical procedures. A calibrated YSI 600QS-O-M water quality meter was used to measure field parameters, which included temperature, specific conductivity, dissolved oxygen, and pH. Surface water quality samples were collected approximately 30 centimetres (cm) below the water surface. Sediment quality samples consisted of single samples from the top 10 to 15 cm of stream or pond bottom that were collected using an Ekman grab sampler (sampling area of 0.0232 square metres [m^2]).



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- PERMIT BOUNDARY
- 2013 SEDIMENT QUALITY SAMPLING STATION
- 2013 WATER QUALITY SAMPLING STATION

REFERENCE

POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

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SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
WATER AND SEDIMENT SAMPLING LOCATIONS IN THE EFFECTS STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	KT/BH	10/07/14	SCALE AS SHOWN	REV. 0
GIS	LMS	12/05/15	**FIGURE: 10.3-1**	
CHECK	AO	21/05/15		
REVIEW	BC	21/05/15		

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Water quality samples were submitted to an ALS Environmental Ltd. (ALS) laboratory for analysis of conventional parameters, major ions, nutrients, total metals, and dissolved metals. Sediment samples were submitted to ALS for analysis of moisture content, particle size, nutrients, and total metals.

Water quality data was evaluated by comparing concentrations of individual parameters with the following objectives and guidelines:

- water quality objectives and guidelines for the protection of fresh water aquatic life (Saskatchewan Environment 2006; CCME 2015);
- water quality objectives and guidelines for the protection of wildlife health and livestock watering (CCME 2005; Saskatchewan Environment 2006);
- water quality standards, objectives and guidelines for the protection of human health (Saskatchewan Environment 2002; Health Canada 2012a); and
- water quality objectives and guidelines for the protection of recreational use and aesthetics (Saskatchewan Environment 2006; Health Canada 2012b).

The most conservative objective or guideline for each protection type was used in the screening.

Sediment chemistry was compared to the Canadian sediment quality guidelines for the protection of aquatic life (CCME 2002). The sediment quality guidelines consist of an Interim Sediment Quality Guideline (ISQG) and a Probable Effects Level (PEL). The ISQG represents the level below which adverse effects rarely occur. The PEL represents the concentration above which adverse biological effects frequently occur.

10.3.2 Results

Water chemistry data for all waterbodies and watercourses sampled during the baseline program are summarized in Table 10.3-1. Sediment chemistry data for all waterbodies and watercourses sampled during the baseline program can be found in Annex III, Appendix III.5, Table III.5-2.

Table 10.3-1: Summary of Water Quality in Waterbodies and Watercourses of the Surface Water Quality in the Effects Study Area

Waterbody	Units	Detection Limit	Loon Creek	East Loon Creek	West Loon Creek	005	011
Total Samples			**n= 3**	**n = 2**	**n = 7**	**n = 3**	**n = 3**
Conventional Parameters							
Temperature (field)	°C	0.1	4.13 to 19.10	10.28 to 18.99	5.09 to 21.12	8.05 to 21.81	6.04 to 19.27
pH (field)	pH	0.10	8.46 to ***9.30***	8.08 to 8.93	8.02 to ***9.51***	8.64 to ***9.37***	8.02 to ***9.36***
Dissolved Oxygen (field)	mg/L	0.01	6.11 to 11.51	7.03 to 15.30	**5.33** to 12.72	9.22 to 14.72	**2.33** to 11.52
Conductivity (field)	µS/cm	1	750 to 1048	957 to 2015	942 to 1749	1566 to 2188	1102 to 1967
Conductivity (lab)	µS/cm	10	753 to 1070	892 to 2090	972 to 1820	1610 to 2290	1130 to 2030
pH (lab)	pH	0.10	8.40 to ***9.09***	7.89 to ***9.05***	7.98 to ***9.29***	8.56 to ***9.21***	7.88 to ***9.50***
Turbidity (field)	NTU	0.01	1.65 to 4.62	0.95 to 9.10	2.11 to 26.77	6.68 to 154	2.00 to 84.40
Total Alkalinity (as $CaCO_3$)	mg/L	20	274 to 397	174 to 359	232 to 543	519 to 681	305 to 415
Total Hardness (as $CaCO_3$)	mg/L	-	439 to 627	444 to 1230	486 to 935	765 to 1000	544 to 948
TDS (Calculated)	mg/L	-	511 to 741	610 to 1690	645 to 1240	1120 to 1630	753 to 1390
Total Suspended Solids	mg/L	5.0	<5.0 to 8.7	<5.0 to 25	<5.0 to 39.7	12.7 to 136.0	<5.0 to 13.4
Ions and Nutrients							
Ammonia, Total (as N)	mg/L	0.050	<0.050	**0.060 to 0.101**	<0.050 to **0.635**	**0.086 to 0.448**	0.052 to **3.90**
Bicarbonate (HCO_3)	mg/L	20	199 to 418	212 to 212	137 to 636	379 to 528	104 to 436
Carbonate (CO_3)	mg/L	10	15.6 to 122	<10 to 97.3	<10 to 95.2	51.7 to 222	<10 to 131
Chloride (Cl^-)	mg/L	1.0 to 2.0	8.9 to 12.9	6.6 to 15.3	12.3 to 30.5	26.9 to 41.6	16.4 to 35.7
Fluoride (F^-)	mg/L	0.10	<0.10 to **0.15**	<0.10 to 0.12	<0.10 to **0.14**	<0.10	<0.10
Hydroxide (OH^-)	mg/L	10	<10	<10	<10	<10	<10
Nitrate+Nitrite-N	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrate-N	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nitrite-N	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Kjeldahl Nitrogen	mg/L	0.20	1.63 to 2.01	1.67 to 4.98	1.37 to 3.72	2.62 to 11.6	2.22 to 4.03
Orthophosphate-Dissolved (as P)	mg/L	0.050	0.05 to 0.05	<0.050 to 0.404	<0.050 to 0.167	<0.050 to 0.279	<0.050
Phosphorus (P)-Total	mg/L	0.20	0.25 to 0.25	0.22 to 0.61	<0.20 to 0.38	0.78 to 1.08	<0.20 to 0.29
Cation - Anion Balance	%	-	to 0.6 to 3.8	1.2 to 3.4	to 0.9 to 3.4	to 2.2 to 0.5	to 0.6 to 1.0
Dissolved Organic Carbon	mg/L	1.0	19.6 to 27.3	18.9 to 50.3	17.5 to 33.6	23.8 to 56.3	16.5 to 30.4
Total Organic Carbon	mg/L	1.0	20.3 to 27.8	19.1 to 51.1	18.1 to 38.3	24.5 to 96.8	18.7 to 30.6

Table 10.3-1: Summary of Water Quality in Waterbodies and Watercourses of the Surface Water Quality in the Effects Study Area

Waterbody	Units	Detection Limit	Loon Creek	East Loon Creek	West Loon Creek	005	011
Total Samples			n= 3	n = 2	n = 7	n = 3	n = 3
Total Metals							
Aluminum (Al)-Total	mg/L	0.0050 to 0.010	0.0076 to 0.0935	0.0833 to **0.248**	0.0143 to **0.412**	0.015 to **0.208**	0.0430 to 0.0943
Antimony (Sb)-Total	mg/L	0.00010 to 0.00020	0.00019 to 0.00026	0.00026 to 0.00029	0.00015 to 0.00029	<0.00020 to 0.00037	0.00022 to 0.00034
Arsenic (As)-Total	mg/L	0.00010 to 0.00020	0.00289 to 0.00351	0.00356 to 0.00496	0.0023 to 0.00445	0.00257 to **0.00877**	0.00396 to **0.00536**
Barium (Ba)-Total	mg/L	0.00050 to 0.0010	0.0367 to 0.0759	0.0402 to 0.0477	0.0182 to 0.121	0.106 to 0.143	0.0172 to 0.0417
Beryllium (Be)-Total	mg/L	0.00010 to 0.00020	<0.00010	<0.00020	<0.00010 to <0.00020	<0.00020	<0.00010 to <0.00020
Bismuth (Bi)-Total	mg/L	0.00020 to 0.00040	<0.00020	<0.00040	<0.00020 to <0.00040	<0.00040	<0.00020 to <0.00040
Boron (B)-Total	mg/L	0.010 to 0.020	0.046 to 0.089	0.027 to 0.051	0.042 to 0.097	0.044 to 0.139	0.068 to 0.124
Cadmium (Cd)-Total	mg/L	0.000010 to 0.000020	<0.000010	0.000028 to 0.000029	<0.000010 to 0.000028	<0.000020	<0.000010 to <0.000020
Calcium (Ca)-Total	mg/L	0.10 to 0.20	34.4 to 83.9	47.4 to 82.6	23 to 139	30.1 to 63.0	20.0 to 41.2
Chromium (Cr)-Total	mg/L	0.00020 to 0.00040	0.0002 to 0.0002	0.0003 to 0.00042	<0.00020 to 0.00063	<0.00040 to 0.00041	<0.00020 to <0.00040
Cobalt (Co)-Total	mg/L	0.00010 to 0.00020	0.00021 to 0.00031	0.00035 to 0.00048	0.0001 to 0.00073	0.00045 to 0.00056	<0.00020 to 0.00023
Copper (Cu)-Total	mg/L	0.00050 to 0.0010	0.00054 to 0.00091	<0.0010 to 0.00295	<0.00050 to 0.00165	<0.0010	<0.00050 to <0.0010
Iron (Fe)-Total	mg/L	0.020 to 0.040	0.025 to 0.157	0.136 to **0.338**	0.028 to **0.711**	0.087 to **0.386**	0.086 to 0.154
Lead (Pb)-Total	mg/L	0.00010 to 0.00020	<0.00010	0.00011 to 0.00025	<0.00010 to 0.00041	<0.00020 to 0.00026	<0.00010 to <0.00020
Lithium (Li)-Total	mg/L	0.0020 to 0.0040	0.0474 to 0.0753	0.0523 to 0.241	0.0555 to 0.143	0.0638 to 0.162	0.0652 to 0.133
Magnesium (Mg)-Total	mg/L	0.050 to 0.10	73.6 to 104	70.1 to 250	91.1 to 190	154 to 233	118 to 209
Manganese (Mn)-Total	mg/L	0.00050 to 0.0010	0.0119 to 0.0717	0.0696 to 0.216	0.0095 to 0.258	0.228 to 0.373	0.025 to 0.207
Mercury (Hg)-Total	mg/L	0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Molybdenum (Mo)-Total	mg/L	0.00010 to 0.00020	0.0015 to 0.00476	0.00336 to 0.00549	0.00106 to 0.00637	0.00101 to 0.0012	0.0004 to 0.00081
Nickel (Ni)-Total	mg/L	0.00050 to 0.0010	0.00105 to 0.00144	0.0025 to 0.00265	0.00082 to 0.0028	<0.0010 to 0.0024	<0.0010 to 0.00112
Phosphorus (P)-Total	mg/L	0.10 to 0.20	<0.10 to 0.14	<0.20 to 0.51	0.11 to 0.38	0.78 to 1.31	<0.10 to <0.20
Potassium (K)-Total	mg/L	0.20 to 0.40	12.2 to 19.1	19.0 to 71.9	11.6 to 43.4	75.7 to 138	24.8 to 53.5
Selenium (Se)-Total	mg/L	0.00010 to 0.00020	0.00032 to 0.00041	0.00049 to **0.00154**	0.0002 to 0.00066	0.00031 to 0.00048	<0.00020 to 0.00019
Silicon (Si)-Total	mg/L	0.050 to 0.10	0.364 to 10.8	12.1 to 21.0	0.478 to 11.3	10.2 to 15.3	0.900 to 6.25
Silver (Ag)-Total	mg/L	0.000020 to 0.000040	<0.000020	<0.000040	<0.000020 to <0.000040	<0.000040	<0.000020 to <0.000040
Sodium (Na)-Total	mg/L	0.20 to 0.40	21.2 to 28.2	33.0 to 80.6	25.3 to 58.2	61.1 to 109	41.2 to 87.8
Strontium (Sr)-Total	mg/L	0.00020 to 0.00040	0.174 to 0.274	0.140 to 0.199	0.0754 to 0.391	0.214 to 0.228	0.0543 to 0.144
Thallium (Tl)-Total	mg/L	0.000050 to 0.00010	<0.000050	<0.00010	<0.000050 to <0.00010	<0.00010	<0.000050 to <0.00010
Tin (Sn)-Total	mg/L	0.00010 to 0.00020	<0.00010	<0.00020	<0.00010 to 0.00024	<0.00020	<0.00010 to <0.00020
Titanium (Ti)-Total	mg/L	0.00050 to 0.0010	0.00124 to 0.00307	0.00273 to 0.0075	0.00149 to 0.0136	<0.0010 to 0.009	0.0018 to 0.00331
Uranium (U)-Total	mg/L	0.000020 to 0.000040	0.00082 to 0.00675	0.0056 to 0.00787	0.00163 to 0.0104	0.00117 to 0.00128	0.00196 to 0.00394
Vanadium (V)-Total	mg/L	0.00010 to 0.00020	0.00101 to 0.00243	0.00116 to 0.00404	0.00037 to 0.00336	0.00086 to 0.00388	0.00069 to 0.00093
Zinc (Zn)-Total	mg/L	0.0050 to 0.010	<0.0050	0.010 to **0.0562**	<0.0050 to 0.0134	<0.010	<0.0050 to 0.0081

Table 10.3-1: Summary of Water Quality in Waterbodies and Watercourses of the Surface Water Quality in the Effects Study Area

Waterbody	Units	Detection Limit	Loon Creek	East Loon Creek	West Loon Creek	005	011
Total Samples			n= 3	n = 2	n = 7	n = 3	n = 3
Dissolved Metals							
Aluminum (Al)-Dissolved	mg/L	0.0050 to 0.010	<0.0050	<0.0050 to <0.010	<0.0050 to <0.010	<0.010	<0.0050 to <0.010
Antimony (Sb)-Dissolved	mg/L	0.00010 to 0.00020	0.00018 to 0.00025	0.00025 to 0.00035	0.00015 to 0.00028	<0.00020 to 0.00063	0.00023 to 0.00035
Arsenic (As)-Dissolved	mg/L	0.00010 to 0.00020	0.00288 to 0.00365	0.00344 to 0.00493	0.00221 to 0.00426	0.00362 to 0.00737	0.00390 to 0.00509
Barium (Ba)-Dissolved	mg/L	0.00050 to 0.0010	0.0366 to 0.0728	0.0355 to 0.0428	0.0163 to 0.1150	0.091 to 0.123	0.0158 to 0.0397
Beryllium (Be)-Dissolved	mg/L	0.00010 to 0.00020	<0.00010	<0.00010 to <0.00020	<0.00010 to <0.00020	<0.00020	<0.00010 to <0.00020
Bismuth (Bi)-Dissolved	mg/L	0.00020 to 0.00040	<0.00020	<0.00020 to <0.00040	<0.00020 to <0.00040	<0.00040	<0.00020 to <0.00040
Boron (B)-Dissolved	mg/L	0.010 to 0.020	0.047 to 0.084	0.030 to 0.046	<0.020 to 0.094	0.068 to 0.147	0.066 to 0.133
Cadmium (Cd)-Dissolved	mg/L	0.000010 to 0.000020	<0.000010	<0.000020 to 0.000022	<0.000010 to <0.000020	<0.000020	<0.000010 to <0.000020
Calcium (Ca)	mg/L	2.0	34.9 to 88.1	46.6 to 70.8	21.3 to 124	24.8 to 52.5	19.0 to 39.7
Chromium (Cr)-Dissolved	mg/L	0.00020 to 0.00040	<0.00020	<0.00020 to <0.00040	<0.00020 to <0.00040	<0.00040	<0.00020 to <0.00040
Cobalt (Co)-Dissolved	mg/L	0.00010 to 0.00020	0.00019 to 0.00026	0.00018 to 0.00035	0.00012 to 0.00046	<0.00020 to 0.0003	<0.00020 to 0.00018
Copper (Cu)-Dissolved	mg/L	0.00050 to 0.0010	<0.00050 to 0.00063	0.00239 to 0.00239	<0.00050 to 0.00109	0.0124 to 0.0124	<0.00050 to <0.0010
Iron (Fe)-Dissolved	mg/L	0.020 to 0.040	<0.020 to 0.026	<0.020 to <0.040	<0.020 to 0.055	<0.040	<0.020 to 0.037
Lead (Pb)-Dissolved	mg/L	0.00010 to 0.00020	<0.00010	<0.00010 to <0.00020	<0.00010 to <0.00020	<0.00020 to 0.00083	<0.00010 to <0.00020
Lithium (Li)-Dissolved	mg/L	0.0020 to 0.0040	0.0493 to 0.0747	0.0501 to 0.244	0.0539 to 0.1380	0.0996 to 0.173	0.0636 to 0.1470
Magnesium (Mg)	mg/L	2.0	83.9 to 118	64.8 to 271	93.7 to 216	154 to 256	108 to 226
Manganese (Mn)-Dissolved	mg/L	0.00050 to 0.0010	0.00248 to 0.0106	0.0211 to 0.0394	0.0053 to 0.0474	0.0027 to 0.187	0.00745 to 0.187
Mercury (Hg)-Dissolved	mg/L	0.000020 to 0.000040	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Molybdenum (Mo)-Dissolved	mg/L	0.00020 to 0.00040	0.00136 to 0.00488	0.0034 to 0.0049	0.00098 to 0.00606	0.00076 to 0.00151	0.00031 to 0.00111
Nickel (Ni)-Dissolved	mg/L	0.00050 to 0.0010	0.00106 to 0.00132	0.0021 to 0.00213	0.00062 to 0.00230	0.0015 to 0.0018	0.00076 to 0.00090
Phosphorus (P)-Dissolved	mg/L	0.10 to 0.20	<0.10	<0.20 to 0.49	<0.10 to 0.21	<0.20 to 0.4	<0.10 to <0.20
Phosphorus, Total Dissolved	mg/L	0.20	<0.20 to 0.25	<0.20 to 0.51	<0.20 to 0.4	<0.20 to 0.54	<0.20 to 0.22
Potassium (K)	mg/L	1.0	12.1 to 19.9	18.4 to 73.3	13.5 to 45.9	73 to 139	24.7 to 54.5
Selenium (Se)-Dissolved	mg/L	0.00010 to 0.00020	0.00031 to 0.00041	0.00046 to 0.00124	<0.00020 to 0.00065	<0.00020 to 0.00028	<0.00020 to 0.00018
Silicon (Si)-Dissolved	mg/L	0.050 to 0.10	0.076 to 10.9	10.5 to 19.3	0.397 to 10.9	8.64 to 14.6	0.685 to 5.88
Silver (Ag)-Dissolved	mg/L	0.000020 to 0.000040	<0.000020	<0.000020 to <0.000040	<0.000020 to <0.000040	<0.000040	<0.000020 to <0.000040
Sodium (Na)	mg/L	4.0	22.6 to 31.8	27.3 to 83.0	26.4 to 61.5	58 to 112	39.7 to 92.8
Strontium (Sr)-Dissolved	mg/L	0.00020 to 0.00040	0.170 to 0.312	0.148 to 0.184	0.0701 to 0.433	0.210 to 0.316	0.0535 to 0.146
Sulfur (as SO4)	mg/L	5.0	178 to 288	318 to 985	286 to 627	434 to 681	341 to 715
Thallium (Tl)-Dissolved	mg/L	0.000050 to 0.00010	<0.000050	<0.000050 to <0.00010	<0.000050 to <0.00010	<0.00010	<0.000050 to <0.00010
Tin (Sn)-Dissolved	mg/L	0.00010 to 0.00020	<0.00010	<0.00010 to <0.00020	<0.00010 to <0.00020	<0.00020	<0.00010 to <0.00020
Titanium (Ti)-Dissolved	mg/L	0.00050 to 0.0010	<0.00050	<0.00050 to <0.0010	<0.00050 to <0.0010	<0.0010	<0.00050 to <0.0010
Uranium (U)-Dissolved	mg/L	0.000020 to 0.000040	0.000810 to 0.00693	0.00451 to 0.00867	0.00156 to 0.0103	0.00117 to 0.00162	0.00185 to 0.00383

Table 10.3-1: Summary of Water Quality in Waterbodies and Watercourses of the Surface Water Quality in the Effects Study Area

Waterbody	Units	Detection Limit	Loon Creek	East Loon Creek	West Loon Creek	005	011
Total Samples			**n= 3**	**n = 2**	**n = 7**	**n = 3**	**n = 3**
Vanadium (V)-Dissolved	mg/L	0.00010 to 0.00020	0.00099 to 0.00231	0.00062 to 0.00370	0.00033 to 0.00226	0.00133 to 0.00349	0.00045 to 0.00069
Zinc (Zn)-Dissolved	mg/L	0.0050 to 0.010	<0.0050	<0.010 to 0.0362	<0.0050 to 0.007	<0.010 to 0.016	<0.0050 to <0.010
Organic Parameters							
Chlorophyll *a*	µg/L	0.10	1.24 to 11.9	4.32 to 6.15	1.98 to 82.5	14.2 to 250	1.57 to 10.6

Notes: Values are presented in the form of "(minimum to maximum)", except where minimum = maximum.
No values exceeded the guidelines for the protection of wildlife health. The most conservative of either CWQG for protection of agricultural water uses - livestock watering (CCME 2005) or SSWQO for agricultural uses - livestock watering (Saskatchewan Environment 2006) were used. Values that are in bold font indicate an exceedence of guidelines for the protection of aquatic life. The most conservative of either Canadian water quality guidelines (CWQG) for the protection of aquatic life – fresh water (CCME 2015) or Saskatchewan's surface water quality objectives (SSWQO) for the protection of aquatic life (Saskatchewan Environment 2006) were used. Values that are underlined indicate an exceedence of guidelines for the protection of human health. The most conservative of either Canadian drinking water quality guidelines (Health Canada 2012a) or Saskatchewan's drinking water quality standards and objectives (summarized) (Saskatchewan Environment 2002) were used. Values that are italicized indicate an exceedence of guidelines for the protection of recreational uses. The most conservative of either Canadian recreational water quality guidelines (Health Canada 2012b) or SSWQO for recreation and aesthetics (Saskatchewan Environment 2006) were used.

n = sample size; °C = degrees Celsius; ID = identification; DL = detection limit; µS/cm = microSiemens per centimetre; mg/L = milligrams per litre; µg/L micrograms per litre; % = percent; NTU = nephelometric turbidity units; < = less than.

10.3.2.1 Loon Creek

Field measured pH indicated that the water in Loon Creek was alkaline; this was supported by total alkalinity measurements that indicated Loon Creek is not sensitive to acidic inputs. Total dissolved solids (TDS) concentrations indicated that the water was of high ionic strength; total hardness indicated the water was very hard. Total phosphorus and total nitrogen concentrations indicated that Loon Creek was well supplied with nutrients and would likely be considered eutrophic.

Concentrations of a few parameters exceeded applicable guidelines or objectives during the baseline program (Table 10.3-1). The field measured pH ranged from being below the guidelines and objectives for the protection of aquatic life (upper limit = 9.0), recreational use (upper limit = 9.0), and the aesthetic objective for human health (upper limit = 8.5), to exceeding the guidelines and objectives with an upper value of 9.30. All samples collected from Loon Creek had TDS concentrations that exceeded the aesthetic objective value for human health (500 milligrams per litre [mg/L]), with values ranging from 511 to 741 mg/L. Fluoride concentrations exceeded the guideline for the protection of aquatic life (0.12 mg/L) with reported values ranging from less than 0.10 to 0.015 mg/L.

Total metal concentrations were either below detection limits or below applicable guidelines and objectives, with the exception of manganese. Total manganese concentrations (range 0.01169 to 0.0717 mg/L) exceeded the aesthetic objective value of 0.05 mg/L for human health.

Sediment in Loon Creek was primarily composed of silt and clay with smaller portions of fine and coarse sand. Sediment quality parameters did not exceed the ISQG or PEL.

10.3.2.2 East Loon Creek

It was not possible to collect water quality samples in all seasons due to dry conditions. Field measured pH and total alkalinity indicated the water was not sensitive to acidic inputs. Concentrations of TDS indicated that the water was of high ionic strength and total hardness indicated the water was very hard. Total phosphorus and total nitrogen concentrations indicated that East Loon Creek was well supplied with nutrients; therefore, East Loon Creek is classified as being eutrophic throughout most of the year.

Field measured pH (range 8.08 to 8.93) exceeded the aesthetic guidelines and objectives for the protection of human health. Total ammonia (as nitrogen) concentrations exceeded the temperature and pH dependent guideline/objective for the protection of aquatic life with a range of 0.060 to 0.101 mg/L. Concentrations of TDS (range 610 to 1,690 mg/L) exceeded the aesthetic objective value of 500 mg/L for human health. Total hardness concentrations ranged from 444 to 1,230 mg/L, with some values exceeding the aesthetic objective value of 800 mg/L for human health.

Values for six total metal parameters in samples from East Loon Creek exceeded guidelines or objectives. Total aluminum concentrations (range 0.0833 to 0.248 mg/L) and total iron concentrations (range 0.136 to 0.338 mg/L) exceeded the 0.1 mg/L (pH dependent) and 0.3 mg/L guidelines, respectively, for the protection of aquatic life. The total aluminum concentration also exceeded the aesthetic guideline/objective for the protection of human health (0.1 to 0.2 mg/L). Total magnesium concentrations (range 70.1 to 250 mg/L) exceeded the aesthetic objective value of 200 mg/L for human health and total manganese concentrations exceeded the aesthetic objective value of 0.05 mg/L for human health; manganese concentration ranged from 0.0696 to 0.216 mg/L.

The total selenium (range 0.00049 to 0.00154 mg/L) and zinc concentrations (range 0.010 to 0.0562 mg/L) exceeded the guidelines and objectives for the protection of aquatic life (selenium, 0.001 mg/L; zinc, 0.03 mg/L).

Sediment samples were not collected from East Loon Creek because the stream was dry during the fall sampling session when sediment samples were collected.

10.3.2.3 West Loon Creek

Field measured pH indicated that the water in West Loon Creek was alkaline. Total alkalinity indicated the water was not sensitive to acidic inputs. Measurements of TDS indicated that the water was of high ionic strength and total hardness indicated the water was very hard. Total phosphorus and total nitrogen concentrations indicated that West Loon Creek would likely be classified as eutrophic throughout the year.

The field measured pH (range 8.02 to 9.51) exceeded the guidelines/objectives for the protection of aquatic life and recreational use (pH 9.0), as well as the aesthetic guideline/objective for the protection of human health (pH 8.5). The dissolved oxygen concentration (range 5.33 to 12.72 mg/L) was below the lower limit of the guideline/objective for the protection of aquatic life (5.5 mg/L). Concentrations of TDS in each sample collected from West Loon Creek (range 645 to 1,240 mg/L) exceeded the 500 mg/L aesthetic objective for human health. Total alkalinity concentrations (232 to 543 mg/L) exceeded the aesthetic objective value of 500 mg/L for human health. Total hardness concentrations (range 486 to 935 mg/L) exceeded the 800 mg/L aesthetic objective value for human health.

Total metal concentrations were either below detection limits or below applicable guidelines and objectives, with the exception of aluminum, iron, and manganese. Total aluminum concentrations (range 0.0143 to 0.412 mg/L) exceeded the guideline/objective for the protection of aquatic life (0.1 mg/L). Total iron (0.711 mg/L) exceeded the guideline/objective for the protection of aquatic life (0.3 mg/L) and the aesthetic objective value (0.3 mg/L) for human health. Manganese concentrations exceeded the human health aesthetic objective value of 0.05 mg/L; measured concentrations ranged from 0.0095 to 0.258 mg/L.

The substrate in West Loon Creek was dominated by silt, followed by coarse sand. Sediment quality parameters did not exceed the ISQG or PEL.

10.3.2.4 Other Waterbodies

Water quality measurements and sediment samples were collected in Waterbodies 005 and 011 during the baseline program.

10.3.2.4.1 Waterbody 005

Dissolved oxygen concentrations indicated that the water in Waterbody 005 was generally well oxygenated. Field measured pH indicated that the water was alkaline and total alkalinity measurements indicated the water was not sensitive to acidic inputs. Total dissolved solids (TDS) concentrations indicated the water was of high ionic strength with total hardness indicating Waterbody 005 had very hard water. Waterbody 005 is classified as eutrophic, based on total phosphorus and total nitrogen concentrations. When taking depth measurements in the winter, the water had a strong hydrogen sulphide odour, indicating anoxic conditions under the ice.

Several parameters measured in Waterbody 005 exceeded applicable guidelines and objectives during the baseline program. The field measured pH values (range 8.64 to 9.37) exceeded the upper limit of the guideline/objective for the protection of aquatic life and recreational use (pH 9.0) and the aesthetic guidelines/objective for the protection of human health. Total alkalinity (range 519 to 681 mg/L) and TDS (range 1,120 to 1,630 mg/L) concentrations exceeded the applicable aesthetic objective value for human health (total alkalinity: 500 mg/L; TDS: 500 mg/L). Total hardness concentrations (range 765 to 1,000 mg/L) exceeded the 800 mg/L aesthetic objective value for human health. Ammonia (as nitrogen) concentrations ranged from 0.086 to 0.448 mg/L and exceeded the temperature-dependent guideline/objective for the protection of aquatic life.

Total metal concentrations in water samples were either below detection limits or below applicable guidelines/objectives, with the exception of aluminum, arsenic, iron, magnesium, and manganese. Total aluminum (range 0.015 to 0.208 mg/L), arsenic (range 0.00257 to 0.00877 mg/L), and iron (range 0.087 to 0.386 mg/L) concentrations exceeded the guidelines/objectives for the protection of aquatic life (aluminum: 0.1 mg/L; arsenic: 0.005 mg/L; iron: 0.03 mg/L). Total magnesium concentrations (range 158 to 233 mg/L) exceeded the 200 mg/L aesthetic objective value for human health. Total manganese concentrations (range 0.228 to 0.373 mg/L) exceeded the human health aesthetic objective value of 0.05 mg/L.

The substrate sample from Waterbody 005 was composed mainly of silt and coarse sand. Sediment quality parameters did not exceed the ISQG or PEL.

10.3.2.4.2 Waterbody 011

Field measured pH indicated that the water in Waterbody 011 was alkaline and not sensitive to acidic inputs. Total dissolved solids (TDS) concentrations indicated that the water was of high ionic strength, with total hardness indicating the water was very hard. Total phosphorus and total nitrogen concentrations indicated the waterbody is likely eutrophic. Water depth measurements were completed in the winter of 2013/2014; the waterbody was 0.55 metres (m) deep and frozen to the bottom, with a strong hydrogen sulphide smell in the sediment that suggested the presence of oxygen-deficient conditions.

Values for several parameters measured in Waterbody 011 exceeded guidelines or objectives during the baseline program. Dissolved oxygen concentrations (range 2.33 to 11.53 mg/L) were below the lower limit for the protection of aquatic life in some cases (5.5 mg/L). Field measured pH values (range 8.02 to 9.36) exceeded the guideline/objective for the protection of aquatic life and recreation use (pH 9.0) and the human health aesthetic objective value of 8.5. Total hardness (range 544 to 948 mg/L) and TDS concentrations (range 753 to 1,390 mg/L) exceeded applicable aesthetic guidelines and objectives for human health (total hardness: 800 mg/L; TDS: 500 mg/L).

Total metal concentrations in water samples were either below detection limits or below applicable guidelines and objectives during the baseline program, with the exception of arsenic, magnesium, and manganese. The total arsenic values ranged from 0.00396 to 0.00536 mg/L, which exceeded the guideline/objective for the protection of aquatic life (0.005 mg/L). Total magnesium (range 118 to 209 mg/L) and manganese (range 0.025 to 0.207 mg/L) concentrations exceeded their respective aesthetic objective values of 200 mg/L and 0.05 mg/L, respectively, for human health.

The substrate sample was composed mainly of silt followed by clay. Sediment quality parameters did not exceed the ISQG or PEL.

10.4 Pathways Analysis

10.4.1 Methods

Pathways analysis identifies and assesses the linkages between Project components or activities and the corresponding changes to the environment and potential residual effects (i.e., effects occurring after implementation of mitigation) on surface water quality. The first part of the analysis is to identify all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on the VC. Potential pathways through which the Project could affect surface water quality were identified from a number of sources including:

- a review of the Project Description (Section 4.0) and scoping of potential effects by the environmental and engineering teams for the Project;
- information obtained from community engagement sessions (Section 5.0);
- scientific knowledge and experience with other potash mines in Saskatchewan; and
- consideration of potential effects identified from the TOR.

For an effect to occur there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a correspondent effect on the VC.

Project activity → change in environment → effect on VC

A key aspect of pathway analysis is to identify environmental design features and mitigation that might reduce or eliminate potential effects of the Project to surface water quality. Mitigation has been developed for the Project according to the following hierarchy proposed by the MOE (2014):

- avoidance;
- minimize (limit);
- restoration; and
- compensation.

Environmental design features include engineering design elements, environmental best practices, management policies and procedures, and spill response and emergency contingency plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on surface water quality. Pathways are determined to be primary, secondary (minor), or as having no linkage, using scientific, local and traditional knowledge, logic, experience with similar developments, and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- **No linkage** – analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on surface water quality relative to the Base Case or guideline values; or
- **Secondary** – pathway could result in a measurable minor environmental change, but would have a negligible residual effect on surface water quality relative to the Base Case or guideline values, and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect; or
- **Primary** – pathway is likely to result in environmental change that could contribute to residual effects on surface water quality relative to the Base Case or guideline values.

Pathways with no linkage to surface water quality are not assessed further because implementation of environmental design features or mitigation will remove the pathway and result in no measureable change to surface water quality. Pathways that are assessed as secondary and demonstrated to have a negligible residual effect on surface water quality through simple qualitative or semi-quantitative evaluation of the pathway are also not advanced for further assessment. In summary, pathways determined to have no linkage to surface water quality or those that are considered secondary are not expected to result in environmentally significant effects for the continued suitability of surface water for human use. Primary pathways require further evaluation through more detailed quantitative and qualitative effects analysis.

10.4.2 Results

Project components and activities, effects pathways, and environmental design features and mitigation are summarized in Table 10.4-1. Classification of effects pathways (i.e., no linkage, secondary, or primary) to surface water quality also is summarized in Table 10.4-1 and detailed descriptions are provided in the subsequent sections.

Table10.4-1: Potential Pathways for Effects on Surface Water Quality

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Physical disturbance from the Project Footprint	Ground disturbance during site preparation and soil storage in stockpiles can increase erosion potential, which can affect surface water quality.	■ An Erosion and Sediment Control Plan will be developed and implemented. ■ Diversion structures to control runoff will be implemented, as needed, to divert surface runoff from exposed soils. ■ Salvaged topsoil will be stored on-site and will be kept way from surface waterbodies. ■ Erosion and sediment control measures, such as silt fences, sediment stops, and settling ponds will be implemented as necessary to prevent sediment from entering watercourses during all phases of the Project. ■ Soil storage stockpiles and exposed areas may be vegetated to protect against wind and water erosion. ■ The compact layout of the core facilities area will limit the area that is disturbed by construction. ■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance. ■ Progressive reclamation of well pads will occur where applicable. ■ Existing public roads will be used where possible to provide access to the mine well field area, reducing the amount of new road construction required for the Project. ■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible. ■ A Water Management Plan will be developed to safely manage site water, store on-site run-off and divert fresh water run-off. ■ Best practices during construction will be adopted as part of the Erosion and Sediment Control Plan for disturbed areas to reduce erosion and limit sediment transport.	No Linkage
	Changes in surface flows, drainage patterns (distribution) and drainage areas from the Project footprint can affect surface water quality.	■ The compact layout of the core facilities area will limit the area that is disturbed by construction. ■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance. ■ Progressive reclamation of well pads will occur where applicable. ■ Existing public roads will be used where possible to provide access to the mine well field area and to reduce the amount of new road construction required for the Project. ■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible. ■ Where practical, natural drainage patterns will be maintained. ■ Culverts will be installed along site access roads, as necessary, to maintain drainage. ■ A Water Management Plan will be incorporated at the detailed design stage, and provide input into adaptive management.	No Linkage
General construction, operations, and decommissioning and reclamation activities	Air and dust emissions from the Project and subsequent deposition can cause changes to the chemical properties of surface water.	■ Compliance with regulatory emission requirements. ■ Dryer burners will be high efficiency, low NO_x burners to limit the amount of NO_x present in the exhaust stream. ■ Baghouses will be installed throughout the dry process area and dust collected in these baghouses will be conveyed back to the compactors. ■ A dustless chute and loading system will be installed in the product storage area to reduce dust generation in the storage and load-out. ■ The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment. ■ An Erosion and Sediment Control Plan will be implemented during all phases of the Project to limit dust production, and subsequent deposition on surrounding areas, and to limit water erosion of exposed soils. ■ Dust-producing components of the potash refinement process (i.e., dryers, compaction circuit) will have controls to recover and return dust to the circuit. ■ Wet scrubbers will be used to clean the air of dust particles from off-gases from the product dryers. ■ Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. ■ Enforced speed limits will assist in reducing production of dust. ■ Operating procedures will be developed to reduce dust generation from the TMA over the long-term. ■ The cyclone exhaust will be treated in high-energy scrubbers operating at a high-pressure drop.	Secondary
	Long-term dust emissions from the tailings management area can cause changes to surface water quality.		No Linkage

Table10.4-1: Potential Pathways for Effects on Surface Water Quality

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Solution Mining	Ground subsidence caused by solution mining can change surface flows, drainage patterns (distribution), and drainage areas, which can affect surface water quality.	■ Unmined pillars will be left between the caverns to increase stability during mining and reduce the potential for subsidence. ■ Secondary mining techniques that reduce the amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence, and provide input into adaptive management. ■ Subsidence will be non-disruptive. Disruptive subsidence, such as the formation of sinkholes, is not expected to occur. ■ Subsidence will be gradual and ultimate (maximum) subsidence (i.e., final, steady state) will not occur for centuries. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface topography.	Secondary
Tailings Management Area	Vertical and lateral migration of brine from the tailings management area can cause changes to surface water quality.	■ The location of the TMA was selected based on site-specific geologic and hydrogeologic studies completed to identify an appropriate foundation for the TMA, which provides natural containment of brine material. ■ The TMA will be located over soils that are known to provide natural retention of brine solutions and offer protection against seepage into nearby ground and surface water resources. ■ Brine reclaim ponds will be designed to provide containment of brine under normal and extreme (i.e., storm) conditions over the life of the mine. ■ A perimeter dyke will be constructed around the TMA to contain waste salt and decanted brine. ■ Excess brine reclaimed from the TMA will be disposed of by deep well injection, a proven practice used to manage brine and prevent release to surface waters and fresh-water aquifers. ■ A containment system will be designed to control deep migration of brine from the TMA to underlying aquifers and horizontal migration of brine, as required. ■ A Waste Salt Management Plan for the TMA will be incorporated into the detailed design. ■ The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan and adaptive management will be implemented, if required. ■ A Decommissioning and Reclamation Plan will be developed and will incorporate new technologies as they become available to reduce the length of the decommissioning period and the associated duration of salt storage at surface.	No Linkage
	Long-term brine migration from the tailings management area can alter surface water quality.		No Linkage
	Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality can affect surface water quality.	■ An evaluation of the capacity of potential deep injection horizons has been conducted identifying the Winnipeg Formation and the Deadwood Formation to be suitable for brine disposal.	No Linkage
Water Management	Site run-off and associated soil erosion from the core facilities area can affect surface water quality.	■ A Water Management Plan will be designed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. ■ A diversion channel will be constructed to intercept waterflows from upland areas along the north and east borders of the core facilities area. ■ Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the core facilities area. ■ The surface water diversion will be designed to convey the runoff associated with the 300 mm 24-hour design storm event. ■ Surface water diversion channels along the perimeter of the core facilities area will be designed to collect and redirect external drainage.	No Linkage

Table10.4-1: Potential Pathways for Effects on Surface Water Quality

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Accidents, Malfunctions, and Unplanned Events	Spills (e.g., waste oil, petroleum products, reagents, potash product, project equipment leaks, vehicle accidents and wash-down) can cause changes to surface water quality.	■ Instruction will be provided to employees as part of the Health, Safety, Security, and Environmental Management System; training will be provided to all employees on transportation of dangerous goods, as well as on spill reduction, control, and clean up procedures. ■ Basic, core, and specific training of workers as part of the Health, Safety, Security, and Environmental Management System. ■ An Emergency Response Team will be formed on-site and members will be trained to implement the Emergency Response Plan. ■ Spills will be promptly reported and managed according to procedures identified in the Spill Response and Control Plan. ■ Chemical spill containment will be incorporated into the plant design to mitigate environmental effects from spills (i.e., installation of concrete floors, drains, and sump mechanisms). ■ Smaller fuel dispensing tanks will be double-walled, and all dispensing will be performed over concrete containment slabs. ■ Reagent tanks and larger fuel tanks will be located inside a bermed, lined storage compound. ■ Liquid, solid spills, and wash-down within the processing facilities will be contained within the mill facility (e.g., door curbs, sloped floors, and sumps) or engineered site area. ■ Diesel and gasoline will be stored in accordance with applicable regulations. ■ On-site storage facilities for hazardous substances and waste dangerous goods will be designed to meet regulatory requirements. ■ Domestic and recyclable waste dangerous goods will be stored in appropriate containers until shipped off site to an approved facility. ■ Spill response material will be located throughout the site in designated areas, where fuel and chemicals are stored, and in company vehicles. ■ Best practices will be adopted within the Waste Management Plan for proper handling and storage of waste dangerous goods. ■ Salvageable product from centrifuging, drying, screening, and compaction will be recycled back to the process. ■ Construction equipment will be regularly inspected and maintained. ■ To limit the occurrence of vehicular accidents, training for equipment operators will be implemented as part of the Health, Safety, Security, and Environmental Management System. ■ Equipment will be inspected for leaks and repaired prior to entry into the Project area and routinely inspected throughout the duration of the Project. ■ Daily vehicle inspections will be required, and a preventative maintenance program will be implemented for all vehicles used on-site. ■ Speed limits will be enforced. ■ Timely snow removal and sanding will occur on site access roads during winter to improve traction.	No Linkage
	Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to groundwater quality, which can affect surface water quality.	■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ Brine will be transported by steel pipeline lined with high-density polyethylene which provides additional pipe flexibility and resistance to corrosion. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface developments. ■ Unmined pillars will be left between the caverns to increase stability during mining and reduce the potential for subsidence. ■ As part of the Environmental Protection Plan, regular monitoring of pipelines will be carried out to limit the potential for leaks and allow for early detection and management of spills. ■ Piping and valve arrangements will be routed so that each cavern works independently from the others at difference stages of cavern development and production. ■ During the detailed design stage, additional spill response and mitigation will be included in the Spill Response and Control Plan.	No Linkage

Table10.4-1: Potential Pathways for Effects on Surface Water Quality

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Accidents, Malfunctions, and Unplanned Events	Slope failure of waste salt storage pile can cause translocation of waste salts and change surface water quality.	■ Salt pile side slopes of 4H:1V were applied to the TMA layout, which were found to provide stable slope configuration based on preliminary slope stability analysis. ■ The final configuration of salt pile slopes will be refined based on subsequent analyses calibrated to pore-water pressure and slope movement data obtained during the initial development of the waste salt pile. ■ Regular inspections of the TMA. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan.	No Linkage
	Failure of the brine containment pond and resulting brine leakage can cause changes to surface water quality.	■ The brine reclaim pond will provide adequate storage to accommodate storage of process streams under normal and extreme operating conditions and design storm events. ■ Sufficient freeboard will be provided to account for wind induced set-up and wave run-up on the sides of the pond slopes. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan. ■ Maximum operating levels will be developed to provide adequate storage volumes for the design storm event (300 mm in 24 hours). ■ Containment berms and dykes will be constructed around the TMA to contain salt tailings and decanted brine, as well as to divert surface water. ■ Containment dykes will be keyed into surficial materials as necessary. ■ Brine levels will be monitored and excess brine will be injected into deep well injection zones after mining is complete. Sub-surface brine migration will be monitored and groundwater wells will be monitored to confirm the adequacy of the brine containment pond. ■ In the event of high flows due to precipitation events, additional flow capacity from the collection ditch to the reclaim pond would be provided by an overflow spillway in the embankment. ■ The brine reclaim pond will be monitored regularly and will provide input into adaptive management.	No Linkage
	Deposition of air emissions from the failure of air emission control systems can result in chemical changes to the surrounding environment, and affect surface water quality.	■ The environmental performance of air emissions control systems will be monitored on an on-going basis and will support adaptive management. ■ Preventative maintenance will be completed regularly to confirm that emissions systems are functioning as designed.	No Linkage

% = percent; NO_x = oxides of nitrogen; TMA = tailings management area; mm = millimetre; R.M. = Rural Municipality.

10.4.2.1 Pathways with No Linkage

A pathway may have no linkage to environmental effects if the activity does not occur, or if the pathway is removed by mitigation or environmental design features so that the Project results in no measurable change in measurement indicators. Subsequently, no residual effect on surface water quality is expected. The pathways described in the following bullets have no linkage to surface water quality and will not be carried forward in the assessment.

- **Ground disturbance during site preparation and soil storage in stockpiles can increase erosion potential, which can affect surface water quality.**

Project construction activities, such as site clearing and soil salvage, stockpiling, and transport could increase the potential for soil erosion and subsequent movement of sediment into nearby watercourses within the ESA. Sediment entering the watercourse could affect surface water quality by altering the chemical properties of the water (e.g., increase TDS levels), which could affect the suitability of the water for supporting aquatic life. Erosion is a concern within the Project footprint during construction and operations because of the removal of the vegetation cover and the disturbance of soils. Stockpiles maintained through operations may be susceptible to erosion due to factors such as absence of vegetation, steep slopes, and desiccation.

Soils occurring in the Project footprint are predominantly rated as having moderate water erosion potential and medium wind erosion potential under Base Case conditions (Section 12.3.2.4). In areas of gullied or dissected terrain, the erosion potential would increase and where slope gradients decrease, the erosion potential will decrease. The soil erosion ratings represent the maximum erosion that would occur to exposed mineral soils with no mitigation in place. Soil erosion can be managed in a number of ways, thus limiting the potential for effects on surface water quality.

Soil erosion from site-clearing and soil salvage, stockpiling, and transport will be reduced through the use of environmental design features and mitigation. An Erosion and Sediment Control Plan, which includes the use of best practices, will be developed and implemented. The Project footprint (i.e., area of physical disruption) will be limited to the smallest reasonable size (e.g., the Project will use existing public roads for site access where possible, and as many caverns as practicable will be managed from each well pad). Additionally, areas of exposed soils will be reclaimed in the shortest practical timeframes (e.g., progressive reclamation of well pads will occur). Disturbed areas will be re-sloped to create stable landforms, and seeded to provide a vegetation cover, where required, as outlined in the Erosion and Sediment Control Plan and Decommissioning and Reclamation Plan. Sensitive areas located within or near the Project, such as streams, wetlands, natural flow pathways, and floodplains, will be protected with erosion and sedimentation control structures (e.g., silt fences, sediment stops, and settling ponds). Salvaged topsoil will be stored on-site away from surface waterbodies and revegetated as practical. Erosion control measures will be applied to topsoil and overburden stockpiles, particularly if they are to be stored for long periods. On-site runoff (i.e., runoff from exposed soil areas) that has been diverted away from nearby watercourses and natural drainages will be safely stored and managed on-site as part of a Water Management Plan that will be developed for the Project. Diversion structures will be used, as required, to divert water unaffected by site activities away from the site and into the natural hydrologic system downstream from the Project.

Implementation of the above environmental design features and mitigation is expected to reduce the potential for erosion from disturbed areas and on soil storage stockpiles and not result in measurable changes to the physical and chemical properties of surface water. Subsequently, this pathway was determined to have no linkage to effects on surface water quality.

- **Changes in surface flows, drainage patterns (distribution), and drainage areas from the Project footprint can affect surface water quality.**

Construction of Project infrastructure, including the core facilities area and required water diversions (e.g., berms, dykes, and ditches), has the potential to affect hydrology within the ESA by disrupting natural flow patterns and drainage areas. Changes in surface flows and drainage patterns could potentially change surface water quality by increasing erosion and sediment loading to watercourses.

Surface water flows, drainage patterns, and drainage areas within the Project footprint are expected to be affected by construction of the Project. The natural drainage area near the Project has already been disturbed by the existing road network used to access cultivated areas, rural homes, and communities near the Project. The Project is within an area that has poorly defined runoff pathways. During the Base Case, most of the runoff contributes to a low-lying area south of the core facilities area and it may occasionally contribute to West Loon Creek under high magnitude snowmelt and/or rainfall events (Section 9.5). The hydrology assessment predicted that the Project footprint will result in a reduction in runoff that will change the amount of water reporting to the low-lying area downstream, but would only rarely affect inflows to West Loon Creek. During decommissioning and reclamation, most the Project infrastructure will be removed, and surface water flows and drainage patterns will be reclaimed. The tailings management area (TMA) is considered permanent. The surface water flows and drainage patterns in residual footprint areas will not be reclaimed; however, no reduction in flow volume in West Loon Creek is predicted.

A Water Management Plan will be implemented to maintain streamflow quantity along natural flow pathways as much as possible. Environmental design features will be implemented to allow off-site precipitation and snow melt to remain part of the natural water cycle. The core facilities area will be limited to the smallest spatial extent required. The mine well field area access roads constructed during the Project will be designed to maintain the natural flow paths and use adequately designed cross-drainage structures (e.g., culverts), as required.

By implementing environmental design features and mitigation, it is anticipated that the Project footprint will result in minor changes to surface water flows and drainage patterns. The minor changes to surface water flows and drainage patterns are not anticipated to cause measurable changes to sediment loads in watercourses. Consequently, this pathway was determined to have no linkage to effects on surface water quality.

- **Long-term dust emissions from the tailings management area can cause local changes to surface water quality.**

Solution mining produces waste salt (i.e., sodium chloride [NaCl] tailings) as a by-product of the potash refinement process; these waste salts will be stored in the salt storage area in the TMA. Surface-storage of waste salts creates the potential for dust emissions, which may affect surface water quality within the ESA by altering the chemical properties of water. However, effects on local surface water quality are expected to be negligible following implementation of environmental design features and mitigations.

The volume of tailings produced by solution mining is expected to be lower than conventional underground mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only potassium chloride (KCl) is removed from the caverns.

The tailings that are precipitated during processing (i.e., “slurry”) are transported, in a controlled manner, to the TMA for storage. Transporting the slurry thorough a pipeline reduces the handling of the tailings and exposure to sources of erosion. A solid crust will form over the outer layer of the waste salt pile as the salt slurry dries. The formation of a rigid crust over the pile is expected to limit effects of exposure to wind and will reduce the potential for erosion. Operating procedures will be developed to limit dust emissions from the TMA. Monitoring programs for the waste salt storage area will be incorporated into the design and will include monitoring pile stability and related dust production. Due to the crusting of the outer layer of the waste salt pile and the implementation of operating procedures and monitoring programs for the salt storage area, long-term dust emissions are not expected, and are predicted to result in no measureable changes to the physical and chemical properties of surface water. Subsequently, this pathway was determined to have no linkage to effects on surface water quality.

- **Vertical and lateral migration of brine from the tailings management area can cause changes to surface water quality.**
- **Long-term brine migration from the tailings management area can alter surface water quality.**
- **Failure of the brine containment pond and resulting brine leakage can cause changes to surface water quality.**

The TMA will consist of the Stage I and Stage II salt storage areas, the Stage I and Stage II brine reclaim ponds, sewage lagoon, and surface diversion works. The TMA will be in operation during the life of the Project, and following decommissioning and reclamation of the mine. Brine is primarily composed of NaCl, with smaller amounts of KCl and other insoluble materials (e.g., metals) (Tallin et al. 1990). Vertical or lateral migration of brine into groundwater systems or directly into the surrounding environment may lead to salt accumulation and change surface water quality.

The location of the TMA was selected based on geologic and hydrogeologic studies that were completed to identify a suitable foundation that will provide natural containment for the brine material. The stratified clay and clayey tills of the Saskatoon Group are the main geological units that would mitigate the vertical migration of seepage from the TMA (Golder 2015). Soil-bentonite cut-off walls will be used to contain brine areas where shallow stratified sand and gravel deposits are present. The necessity for a deep cut-off wall extending through competent till materials will be determined based on the results of detailed site characterization. Containment berms and dykes will be constructed around the TMA to contain decanted brine. The containment system will be designed to control migration of brine from the salt storage area to underlying aquifers and control the horizontal migration of brine, as required. The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan, with monitoring results providing input for adaptive management. Further, excess brine reclaimed from the TMA will be disposed of by deep well injection, thereby reducing the volume of brine in the TMA and the potential for migrations of brine from the TMA.

Implementation of environmental design features, mitigation, and monitoring programs have shown good performance in preventing vertical and lateral seepage in similar potash projects. Consequently, these pathways were determined to have no linkage to effects on surface water quality.

- **Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality and can affect surface water quality.**

Brine will be disposed of through deep-well injection during the Project to reduce the amount of brine stored in the TMA. Injecting brine into deep wells can change sub-surface and deep groundwater flows, levels and chemistry, which could alter surface water and soil quality. Depending on the chemical composition of the brine being injected, NaCl, KCl and other insoluble materials (e.g., metals) may be introduced to groundwater (Tallin et al. 1990). Disruption in groundwater flow may adversely affect water levels in surface wetlands by changing recharge and discharge areas and rates (Chen and Hu 2004). The potential for brine injection induced changes in groundwater flow and quality to affect surface water hydrology and quality is based on the existence of a linkage between the groundwater, where the brine is injected, and the surface hydrology.

Deep well injection of excess brine is a proven practice used to manage brine and prevent release to surface waters and fresh waters aquifers. Methods used in the solution mining process will maintain stability of shallow and deep groundwater aquifers. An assessment of target zones for brine disposal was completed identifying the Winnipeg Formation and the Deadwood Formation to be suitable for brine disposal. Both formations are sufficiently isolated from the overlying fresh water aquifers, distant from recharge and discharge areas, and have the capacity to accept the waste brine solution from the Project (Appendix 4-A). Given that the formations used for deep well injection are isolated from overlying aquifers and surface water, no changes to the physical and chemical properties of surface water are expected. Therefore, this pathway was determined to have no linkage to effects on surface water quality.

- **Site runoff and associated soil erosion from the core facilities area can affect surface water quality.**

Site runoff and associated soil erosion from the core facilities area have the potential to occur during the construction, operation, and decommissioning and reclamation phases of the Project. Runoff and associated soil erosion in the core facilities area and diversion channels may transport sediment and contaminants off-site and change the physical (e.g., increased total suspended solids concentrations) and chemical properties of surface water.

Several environmental design features and mitigation measures will be implemented to prevent water release from the core facilities area entering the surrounding environment. The general site layout has been developed to use natural topography to assist site drainage to the extent practical. The topography in the area is gently sloping toward the south and slightly to the west. A diversion channel will be constructed to intercept waterflow from upland areas along the north and east borders of the core facilities area.

A Water Management Plan will be developed and infrastructure will be constructed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the facility. The surface water diversion works will be designed to accommodate runoff from a 300-mm rainstorm event over a 24-hour period.

Runoff within the TMA will be redirected to the brine reclaim pond for temporary storage prior to deep-well injection. Salt storage area internal channels (i.e., brine return channels) are designed to collect and redirect runoff originating from precipitation and brine discharges on the tailings areas to the brine reclaim pond. The

TMA will be graded to drain free brine to the brine reclaim pond by gravity. Internal salt tailings dykes and ditches may be required to direct surface flow to the collection ditch during early stages of deposition.

The brine reclaim pond will be constructed to provide containment of brine during the Project. The brine reclaim pond is designed to allow sufficient storage capacity to contain brine decant from the salt storage area during normal operations, runoff resulting from the design storm event equivalent to 300 mm over a 24-hour period (Section 4.6.2), and a 0.9-m freeboard to accommodate wind-induced setup and wave run-up on the sides of the pond slopes.

Erosion protection of the surface water diversion channel will be provided by topsoil replacement and hydro-seeding to establish grass cover within the diversion channel. A tackifier may be used to increase the temporary soil stability prior to establishment of permanent root systems.

Inspection and maintenance procedures for infrastructure will be outlined in the Water Management Plan and will provide input into adaptive management as required. Implementation of environmental design features and mitigation is expected to prevent site runoff and soil erosion from the core facilities area from entering the surrounding environment. Therefore, this pathway was determined to have no linkage to effects on surface water quality.

- **Spills (e.g., waste oil, petroleum products, reagents, potash product, Project equipment leaks, vehicle accidents, and wash-down) can cause changes to surface water quality.**
- **Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to groundwater quality, which can affect surface water quality.**

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks, and to limit effects on surface water quality. Pipelines will be used to transport water, brine solution, and potash product to and within the Project footprint. Pipelines will be constructed of standard carbon steel and lined with high-density polyethylene. Pipelines will be installed underground at a depth that will reduce the possibility of damage from frost and surface activities (e.g., farming) and will be monitored for pressure and flow using flow meters. Double-walled pipe for secondary containment will be used in critical crossing areas, based on site-specific analysis to meet environmental conditions. All pipelines will be insulated to maintain the required temperature for the process with the exception of the cold water and the early brine return pipelines. Trains and vehicles will transport chemicals, potash product, and other reagents on and off-site.

An Emergency Response Plan will be developed as part of the Health, Safety, Security, and Environmental Management System to provide rapid and competent response to incidents that may occur during the Project. Aspects of this plan include instructions and procedures for quick detection, control, and management of spills occurring on site. Other mitigation will include a leak detection system for mining-area pipelines that will consist of monitoring and appropriate pipe isolation to limit potential leaks and promote early detection. Leak detection and monitoring of pipelines will be based on flow and pressure measurements at points along the pipeline. In addition to the pipeline monitoring program, liquid spills and wash-down occurring within the potash processing facilities will be contained within the mill facility or the engineered site area; salvageable product spills will be recycled into the process feed.

If a spill originates in the tank farm, the hazardous substance will be pumped and properly disposed off-site. The tank farm will be designed to include an adequately-sized containment berm for containing potential leaks or spillage. Storage facilities for hazardous wastes will meet regulatory requirements and site personnel will be trained in spill reduction, control, and clean-up procedures. Inspections and maintenance will be completed regularly to prevent leaks from mobile equipment and vehicles. Spill response materials will be maintained at locations where hazardous materials are stored. Disposal of all hazardous materials, such as waste chemicals, hydrocarbons, reagents, and petroleum products will be handled by a licensed contractor and will be hauled off-site to an approved facility. Waste products from the Project (e.g., hazardous waste, domestic waste, or recyclable waste) will be stored and disposed of following designated procedures by federal and provincial legislation. Domestic and recyclable waste dangerous goods will be stored in appropriate containers until shipped off-site to an approved management facility for licensed disposal. A Waste Management Plan will be developed and will outline best practices for the proper handling and storage of all waste dangerous goods.

Implementation of environmental design features and mitigation are expected to reduce the likelihood and extent of spills and leaks occurring on-site and along transportation corridors resulting in no measureable changes to the physical and chemical properties of surface water. Therefore, these pathways are determined to have no linkage to effects on surface water quality.

- **Slope failure of the waste salt storage pile can cause translocation of waste salts and change surface water quality.**

Failure of the salt storage pile could allow material to enter adjacent watercourses, which could affect surface water quality. The occurrence of a slope failure is dependent on the design of the salt storage piles; slope failures are generally preventable and local in scale. The volume of tailings produced by the solution mining method for the Project is expected to be lower than conventional underground potash mining on a per-tonne of product basis because the insoluable clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only KCl is removed from the caverns during this process.

Salt tailings stockpile stability is governed primarily by the pile height, shear strength of the underlying soils, and the degree to which soil pore water pressures are generated in response to the surcharge load of the stockpile. Detailed slope stability analysis for the salt pile will be completed to determine the optimal salt pile height for the Project. The final design of the waste salt storage area will provide for flexibility to expand the storage area in stages through modifications to the footprint or increasing pile height should additional storage be required.

The probability of slope failure of the waste salt storage pile will be limited by the implementation of operating procedures and monitoring programs for the salt storage area. Pile stability monitoring will be incorporated into the design. As such, this pathway was determined to have no linkage to effects on surface water quality.

- **Deposition of air emissions from the failure of air emission control systems can result in chemical changes to the surrounding environment and affect surface water quality.**

Dust and emissions are generated during the drying and handling of potash and are managed using a combination of dust collection and suppression practices. Dust collection equipment, such as wet scrubbers, cyclones, and baghouses, are used to limit dust and emissions. The cyclone exhaust will be treated in high-energy scrubbers operating at a high-pressure drop. Wet scrubbers will be used to clean the air and rid it of dust particles associated with off-gases produced by the product dryers. The potential exists for failure of air emission control systems, which could result in short-term reductions in air quality.

Testing of emissions from stacks and discharge locations will be employed on an on-going basis to monitor the performance of the system operations. Additionally, regular maintenance of the emission control system components will be completed to reduce the potential for system failure and to confirm that the system is functioning as designed.

Preventative maintenance and monitoring of the air emissions control system is expected to limit the likelihood of system failure. The minor and short-term changes to air quality from a system failure are not anticipated to cause measurable changes to the physical and chemical properties of surface water. As such, this pathway was determined to have no linkage to effects on surface water quality.

10.4.2.2 Secondary Pathways

In some cases, both a source and a pathway exist, but because the change caused by the Project is anticipated to be minor relative to Base Case or guideline values, it is expected to have a negligible residual effect on surface water quality. The pathways described in the following bullets are expected to be secondary and will not be carried forward in the assessment.

- **Air and dust emissions from the Project and subsequent deposition can cause changes to the chemical properties of surface water.**

Construction and operation of the Project will generate air emissions such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (particulate matter with aerodynamic diameter less than 2.5 micrometres [µm] [$PM_{2.5}$], particulate matter with aerodynamic diameter less than 10 µm [PM_{10}], and total suspended particulates [TSP]) and KCl. Air emissions can result from Project activities, including the burning of fossil fuels in diesel-fired powered construction and operating equipment (e.g., trucks, earth movers, and locomotives), and natural gas-fired boilers and product dryers. Transportation routes used to access the Project are predicted to be the main source of dust ($PM_{2.5}$, PM_{10}, and TSP) due to the resuspension of soil particles. Deposition of dust, metals, acidifying compounds (i.e., SO_2 and NO_2), and other constituents has the potential to change the chemical properties of surface water in the ESA.

Air quality modelling was completed to predict the spatial extent of dust deposition and air emissions from the Project (Section 7.5). Air quality modelling was completed using the maximum emissions profile expected during the operations phase of the Project. The cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are predicted to evaluate changes to measurement indicators for air quality during the Application Case. This provides the maximum potential effects from the Project. Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates.

Environmental design features and mitigation will be incorporated into the Project design to limit air emissions and dust from the Project and will reduce changes to the physical and chemical properties of surface water (Section 7.5 and Table 10.4-1). The dryer burners will be high efficiency, low nitrogen oxide (NO_x) burners to limit the amount of NO_x present in the exhaust stream. The process plant will use cyclones, baghouses, and wet scrubbers to reduce air and dust emissions so that an acceptable working environment is achieved and government standards are met. The cyclone exhaust will be treated in high-energy scrubbers operating at a high-pressure drop. Wet scrubbers will be used to clean the air of dust particles that could result from off-gases produced by the product dryers. A dustless chute and loading system will be installed in the product storage area to reduce dust generation during storage and load-out. Dust-producing components of the potash refinement process (i.e., dryers and compaction circuit) will have controls to recover and return dust to the circuit. Baghouses will be installed throughout the dry process area and dust collected in these baghouses will be conveyed back to the compactors. All conveyors between buildings will be enclosed. Compliance with regulatory stack emissions and ambient air quality standards will be maintained throughout construction and operation of the Project.

To reduce dust generated by vehicles and equipment, paved roads will be used on site as much as possible. Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. Enforced speed limits will assist in reducing production of dust. The Project will be compliant with regulatory emission requirements (i.e., Saskatchewan Ambient Air Quality Standards [SAAQS] [Government of Saskatchewan 2015] or the Canadian Ambient Air Quality Standards [CAAQS] [CCME 2013]).

Results of the air quality modelling indicate that ground-level concentrations of SO_2 and NO_2 are not predicted to exceed SAAQS during the Application Case (Section 7.5.2). For example, the maximum 24-hour SO_2 concentration is predicted to be 4.5 micrograms per cubic metre (µg/m^3), which is below the SAAQS of 125 µg/m^3 (Section 7.5.2). The maximum 24-hour NO_2 concentration is predicted to be 49.4 µg/m^3, which is below the SAAQS of 200 µg/m^3 (Section 7.5.2).

Results of air quality modelling indicate that $PM_{2.5}$ and total suspended particulate (TSP) emissions from the Project are not predicted to exceed CAAQS and SAAQS. The maximum predicted 24-hour PM_{10} concentrations (53.4 µg/m^3) during the Application Case (Section 7.5.2) exceeded the SAAQS value of 50 µg/m^3; the maximum concentration occurs east of the mine. However, the background concentration (Base Case) of PM_{10} is 36.3 µg/m^3, which represents 72.6% of the ambient air quality standard. However, this background concentration is from the City of Regina, rather than rural Saskatchewan; no rural PM_{10} measurements are available from the MOE. The analysis shows that the averaged days during the Application Case only exceed the SAAQS for three days during the modeling years. Based on air quality monitoring data completed in rural Saskatchewan (i.e., K+S Potash Canada), analysis of rural data from Montana and North Dakota, and current monitoring from near the Project, a more appropriate background value would be 17.9 µg/m^3. Using a rural background PM_{10} concentration of 17.9 µg/m^3 results in a maximum predicted concentration of 35 µg/m^3, which is below the SAAQS.

A mass balance approach was used to assess the effects of dust deposition on water chemistry characteristics of watercourses located in the effects study area (Appendix 10-A). The water chemistry variables evaluated in the assessment included potassium and chloride. These constituents were identified in the air quality assessment as having higher than Base Case deposition rates within the ESA (Section 7.5.2). The watercourses considered in the assessment were selected based on their proximity to the dust-producing areas of the Project, and included West Loon Creek, East Loon Creek, and Loon Creek. Estimated concentrations of particulate potassium and chloride deposited per square centimetre (cm^2) per month were obtained from the air quality modelling team (Section 7.5); dust receptors used in the modelling were based on individual grid cells spread over a 50 km by 50 km area that overlapped most of the ESA. Predictions of potassium and chloride deposition, in milligrams per square centimetre per month (mg/cm^2/month) were apportioned into the effective drainage areas associated with the West Loon Creek, East Loon Creek, and Loon Creek sub-basins based on boundaries determined from a Light Detection and Ranging (LiDAR)-based digital elevation model and modelled overland flow patterns (Section 9.3.4; Figure 9.3-3). For areas within the West Loon Creek, East Loon Creek, and Loon Creek drainages that fell outside the 50 km by 50 km air quality modelling receptor grid, but within the effective drainage areas of the assessed streams, receptor points were generated and assigned deposition values based on their closest receptor within the modelling grid (Appendix 10-A).

The most realistic, conservative case for potassium and chloride deposition was evaluated to assess possible increases in potassium and chloride concentrations within selected watercourses in the ESA (Appendix 10-A). A seven month period of total accumulation was used in the mass balance model to conservatively represent the total load of particulate material that would likely accumulate in the snowpack and then flow into streams during the spring freshet. It was also assumed that the entire effective drainage area associated with each stream would contribute to runoff, and therefore potassium and chloride loads. The assessment also assumed that 100% of the potassium and chloride deposited in the effective drainage areas would be carried into the streams.

Because West Loon Creek, East Loon Creek, and Loon Creek generally flow only during the spring months, (i.e., during the period of runoff associated with spring snowmelt), the total estimated accumulation of potassium and chloride was added to the total volume of water associated with the spring freshet. Freshet volumes for each sub-basin were modelled based on the behaviour of nearby Jumping Deer Creek, which is monitored by Environment Canada. A total of three freshet flow volume scenarios were considered, including the average, 80th percentile (i.e., high), and 20th percentile (i.e., low) flow volumes.

Average, minimum, and maximum predicted deposition rates for potassium and chloride are shown in Table 10.4-2, along with the predicted changes to surface water concentrations of potassium and chloride. Average, minimum, and maximum predicted increases in potassium and chloride concentrations, relative to Base Case values, are shown in the table.

Table 10.4-2: Predicted Changes to Potassium and Chloride Concentrations in Streams Resulting from Dust Deposition during Average, High (80th Percentile), and Low (20th Percentile) Spring Flow Volume Scenarios

Watercourse	Gross Drainage Area (km^2)	Effective Drainage Area (km^2)	Predicted Dustfall Deposition Rate (mg/cm^2/month) [a]		Spring Snowmelt Flow Volume (m^3)[b]		Baseline Concentration (mg/L)[c]		Predicted Increase in Concentration (mg/L)[a]		Total Predicted Concentration (mg/L)[a,d]	
			Potassium	Chloride			Potassium	Chloride	Potassium	Chloride	Potassium	Chloride
West Loon Creek	998	55.5	0.000022 (0.000010 to 0.000040)	0.000019 (0.000010 to 0.000040)	Average Volume	197,000	21.1	15.6	0.43 (0.20 to 0.79)	0.38 (0.20 to 0.79)	21.5 (21.3 to 21.9)	16.0 (15.8 to 16.4)
					High Flow Volume	358,000			0.23 (0.11 to 0.43)	0.21 (0.11 to 0.43)	21.3 (21.2 to 21.5)	15.8 (15.7 to 16.0)
					Low Flow Volume	32,000			2.6 (1.2 to 4.9)	2.3 (1.2 to 4.9)	23.7 (22.3 to 26.0)	17.9 (16.8 to 20.5)
East Loon Creek	518	20.1	0.000010	0.000010	Average Volume	24,000	19.0	6.60	0.59	0.59	19.6	7.19
					High Flow Volume	54,000			0.26	0.26	19.3	6.86
					Low Flow Volume	4,000			3.5	3.5	22.5	10.1
Loon Creek	1,877	130	0.000016 (0.000010 to 0.000040)	0.000015 (0.000010 to 0.000040)	Average Volume	769,000	12.2	9.70	0.19 (0.12 to 0.47)	0.17 (0.12 to 0.47)	12.4 (12.3 to 12.7)	9.87 (9.82 to 10.2)
					High Flow Volume	1,317,000			0.11 (0.070 to 0.28)	0.10 (0.069 to 0.28)	12.3 (12.3 to 12.5)	9.80 (9.77 to 9.98)
					Low Flow Volume	124,000			1.2 (0.73 to 2.9)	1.1 (0.73 to 2.9)	13.4 (12.9 to 15.1)	10.8 (10.4 to 12.6)

(a) Values are presented in the form of "average (minimum to maximum)", except where average = minimum = maximum.
(b) Low and high flow volumes refer to the 20th and 80th percentile flow volumes, respectively.
(c) Baseline water quality conditions are average values for samples collected during spring (freshet) field programs associated with the Project environmental baseline surveys.
(d) Total Predicted Concentrations are based on the average values for samples collected during the spring freshet, plus the predicted increase in either potassium or chloride concentrations.
km^2 = square kilometre; mg/cm^2/month = milligrams per square centimetre per month; m^3 = cubic metre; mg/L = milligrams per litre; % = percent.

Based on the assessment in Appendix 10-A, it is anticipated that deposition of potassium and chloride will result in only very small (i.e., less than or equal to 3.5 mg/L increase in potassium or chloride concentrations) changes to surface water quality in West Loon Creek, East Loon Creek, and Loon Creek (Table 10.4-2). At average and high (i.e., 80th percentile) spring flow volumes, concentrations of potassium and chloride in West Loon Creek, East Loon Creek, and Loon Creek are expected to increase by less than 1 mg/L, relative to Base Case conditions. At low (i.e., 20th percentile) spring flow volumes, potassium and chloride concentrations in East Loon Creek are also expected to increase by approximately 1 to 3.5 mg/L relative to Base Case conditions.

The change in potassium and chloride concentrations is not considered biologically significant. Because changes are expected to be on the order of a few mg/L, total predicted surface water concentrations of potassium and chloride during the Application Case are expected to be within the natural ranges of variability for West Loon, East Loon, and Loon creeks (Table 10.3-1). It is therefore considered unlikely that deposition of potassium and chloride will adversely affect surface water quality. Salinization of watercourses is not predicted to occur, and chloride concentrations will remain well below CCME water quality guidelines for the protection of aquatic life (CCME 2015).

Overall, is anticipated that air and dust emissions and subsequent deposition from the Project will affect a relatively small area close to the core facilities area and effects will occur primarily during the spring freshet and will be minimized through implementation of mitigation measures. Results of the air modelling indicate that concentrations of SO_2, NO_2, $PM_{2.5}$, PM_{10}, and KCl are not predicted to exceed SAAQS or other applicable criteria. Based on the assessment in Appendix 10-A, it is anticipated that deposition of potassium and chloride will have only minor effects on surface water quality in West Loon Creek, East Loon Creek, and Loon Creek (Table 10.4-2). Therefore, this pathway was determined to have a negligible residual effect on surface water quality.

- **Ground subsidence caused by solution mining can change surface flows, drainage patterns (distribution), and drainage areas, which can affect surface water quality.**

Solution mining and related removal of solid, liquid, and gaseous materials from below the ground surface results in ground subsidence (i.e., terrain settling). The changes in topography (i.e., slope, gradient and terrain) resulting from subsidence can alter surface and sub-surface hydrology, drainage patterns, and drainage areas. Subsequent changes to water flow and storage could affect surface water quality. Changes to the hydrologic system in the ESA could result from alteration of topography (i.e., slopes and gradients) that can alter existing flow patterns and drainage areas, alter wetlands, and create new flow patterns and drainage areas.

The rate of ground subsidence, maximum subsidence depth, and time to reach maximum depth are based on site and mine-specific conditions (Chrzanowski et al. 1998); however, subsidence generally occurs over the long-term and may require hundreds of years to reach its maximum. Surface subsidence will depend on the specific sequence and timing of well pad development, cavern geometry, material properties of the mining horizon and overlying rock and soils, and the actual closure rate of the caverns. As a result, the potential effects due to subsidence were assessed based on ultimate (maximum) subsidence (i.e., after total cavern closure, and subsequent translation of this volume change to the ground surface), which is assumed as the worst case scenario.

The area affected by subsidence is predicted to extend over a distance of approximately 17 km from west to east and about 8 km from north to south and approximately 1.3 km outside the 65-year mine field (Appendix 9-A). Maximum settlement is predicted to occur in the western section of the 65-year mine field that lies directly over the caverns. The vertical displacement is predicted to range from 0.5 m to 6.7 m. The final gradient of surface subsidence at the boundary of the 65-year mine field is expected to be gradual from unaffected areas to the area of maximum subsidence with an average gradient of approximately 3.9 metres per kilometre (m/km). In areas of steeper subsidence gradients, settlement is predicted to increase from 0.5 m to 6.7 m over a distance of approximately 1.6 km, with maximum gradients of 5.0 m/km.

Alteration of surface topography associated with subsidence is predicted to result in small, localized changes to flow pathways and drainage areas within the West Loon Creek basin in the ESA. Changes to flow pathways are mainly predicted along the north and west edges of the 65-year mine field (Appendix 9-A). The volume of flows along major flow paths (i.e., the West Loon Creek) are predicted to be maintained, although localized alterations of flow pathways are predicted to occur and ponded sections may appear. New surface flow pathways may also occur in sections of the ESA. Alterations of smaller drainage area boundaries in the central section of the mine well field area are predicted; however, drainage is expected to continue to direct runoff to West Loon Creek. Generally, changes from subsidence to surface water flow pathways and drainage area boundaries in the ESA will be small and localized; the major flow paths (e.g., West Loon Creek) are expected to be maintained.

Subsidence is also expected to affect storage of water on the landscape in the ESA. Existing depressions and wetlands are predicted to receive more runoff in settlement areas as a result of surface subsidence. It is expected that differential settlement will cause reductions in the water storage capacity of some depressions and wetlands along the west and north sides of the mine area. In contrast, an increase in water levels is anticipated in areas with the greatest subsidence. Overall, effects of subsidence on wetlands and depressions in the ESA may include small and local changes to drainage areas, which may affect the amount of runoff arriving in wetlands and depressions.

The effects of ground subsidence could indirectly affect surface water quality by altering the topography in the ESA and, in turn, changing the direction of drainage, altering stream bed gradients, and altering the location, size, and capacity of water storage areas. For example, stream gradients may increase where streams cross areas with the greatest subsidence, which can increase flow rates and erosion of stream beds and banks. Increased erosion can lead to higher concentrations of suspended solids and other parameters. Similarly, increased water storage and submergence of previously unsubmerged soil and vegetation can lead to changes in water quality.

Effects of subsidence will be mitigated by applying environmental design features and specialized techniques for solution mining. For example, pillars of unmined material will be left between the mine caverns to isolate the caverns, to increase stability of the overlying strata, and to reduce the potential subsidence. Cavern spacing may be increased below the pipelines to reduce surface strains and to meet industry standards. Cavern layout will be refined after additional modeling is completed to optimize potash recovery and limit the potential effects of subsidence on surface topography. Secondary mining techniques that reduce the amount of material removed from the mine cavern will be employed after development of primary caverns wherever possible. Finally, extraction ratios will be controlled to limit strain on the overlying environment.

Changes to water quality from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for more than a century. Areas that become more depressional in the landscape may be expected to accumulate more snow runoff and rainfall which may create new wetland areas. Alternatively, existing wetlands may drain and become drier. Changes in stream gradients caused by subsidence will also occur gradually and take place over a long period that stream bed erosional and depositional processes are expected to remain within their natural range of variability. Because subsidence will occur very gradually, no acute, adverse effects on water quality are expected. Therefore, residual effects to surface water quality from changes from ground subsidence caused by solution mining are predicted to be negligible.

10.4.2.3 Primary Pathways

No pathways were identified as having a primary linkages to surface water quality (Table 10.4-1). As such, a residual effects analysis is not required for this section of the EIS.

10.5 Prediction Confidence and Uncertainty

Technical limitations are expected to be present when predicting the response of natural systems to man-made disturbances. Uncertainties may arise from:

- adequacy of baseline data required to understand current conditions and predictions of Project-induced effects;
- external influences not related to the Project;
- model uncertainty; and
- knowledge of the effectiveness of the mitigation for limiting effects to surface water quality.

The main source of uncertainty is related to the random variability in natural processes (e.g., runoff, discharge) and model uncertainty related to the simplification that occurs when representing complex systems with mathematical equations.

A conservative approach was used to evaluate Project effects on surface water quality. However, there is a level of uncertainty associated with the air quality modeling, mass balance equations, and hydrological data used to assess the potential effects on surface water quality. Similarly, there is uncertainty associated with the models used to assess changes to drainage patterns that could result from solution mining and ground subsidence.

For the assessment of air emissions and dust deposition, it is unclear how much of the deposited potassium and chloride will be retained in terrestrial soils and plants relative to the quantities that will enter ESA waterbodies and affect surface water quality. This uncertainty was addressed by evaluating the most realistically conservative possible case when assessing potential surface water quality effects of potassium and chloride runoff. To be conservative, it was assumed that 100% of the potassium and chloride deposited over snowpack covering the effective drainage areas of West Loon Creek, East Loon Creek, and Loon Creek would be washed into ESA streams during the spring freshet (Section 10.4.2.2). Because effects predictions were based on the most realistically conservative assessment case, it is considered likely that the true effects of the Project will not be greater than the maximum predicted effects. On this basis, it can be determined with confidence that dustfall is unlikely to result in adverse effects on water quality and its ability to support aquatic life.

The hydrological data available for use in the dustfall analyses for West Loon Creek, East Loon Creek, and Loon Creek were limited spatially and temporally. Data for Loon Creek are only available for a period of about ten years. Hydrological data collection for the Project, including measurements of flow volumes associated with the spring freshet, was completed in 2013 only. Although conditions recorded in 2013 are considered to represent an average spring freshet, the data do not adequately capture conditions representative of high or low flow years. To address the lack of temporal data within the ESA watercourses, as well as insufficient representation of high and low flow years, the most acceptable baseline data from historical records available for the area were used. Specifically, spring freshet volumes used in the mass-balance equations (Appendix 10-A) were verified and/or derived using data from Jumping Deer Creek, which is similar to ESA creeks in terms of hydrological conditions and location. Jumping Deer Creek also has a more complete flow record (i.e., 73 years) than the ESA watercourses (Section 9.3.4; Appendix 10-A).

Model uncertainty associated with dustfall and surface water quality predictions was addressed by using widely acceptable models to describe the processes under consideration. Parameter uncertainty (i.e., uncertainty related to the lack of actual knowledge of the parameter used in the equations) was addressed by examining the processes occurring at similar developments, primarily existing potash mines in Saskatchewan, and by using model inputs and parameters based on best estimators and conservative scenarios where information is limited.

In the assessment of subsidence, use of LiDAR data and Geographic Information Systems (GIS) tools reduced uncertainty in the evaluation of existing drainage patterns. The predicted topography after the terrain has subsided is subject to model and parameter uncertainties. To increase the level of confidence in the subsidence evaluation, parameters were estimated based on observed subsidence values from long-term ground surface elevation surveys at operating potash mines in Saskatchewan (see Appendix 9-A). The evolution in time of subsidence has is uncertain due to potential changes in the mine plan and the future technical advances in solution mining that may be adopted to mitigate the environmental effects of subsidence. To be conservative, the hydrological assessment is based on maximum predicted subsidence.

Uncertainty was addressed in the assessment by incorporating information from available and applicable literature, and using past experience in similar areas. Conservative estimates were used so that effects on surface water quality were not underestimated. Best practices during construction, operations, and reclamation activities will be implemented to mitigate residual effects on surface water quality.

10.6 Monitoring and Follow-up

Typically, monitoring includes one or more of the following categories, which may be applied during the development of the Project:

- **Compliance monitoring** – monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments (e.g., inspecting the installation and effectiveness of a silt fence).
- **Follow-up monitoring** – programs designed to test the accuracy of effects predictions, reduce or address uncertainties, determine the effectiveness of environmental design features, or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., monitoring of downstream lakes for aquatic effects). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

Follow-up programs are typically implemented to determine the accuracy of the predictions or test the effectiveness of environmental design features and mitigation. If monitoring or follow-up activities detect effects that are different from predicted effects, or the need for improved or modified design features and mitigation, then adaptive management will be implemented. This may include increased monitoring, changes in monitoring plans, and additional mitigation.

Monitoring for surface water quality is anticipated to include compliance monitoring; there is no follow-up monitoring program anticipated for surface water quality. Air quality (which can affect water quality) will be monitored during operations to confirm emissions standards are met (Section 7.8). Compliance inspections of environmental design features and mitigation measures (e.g., silt fences and water diversion structures) will be completed to confirm they are used and operating properly. Regular inspections will confirm the integrity of tanks, ponds, and above-ground and below-ground pipelines and detect potential leaks.

10.7 Summary and Conclusions

The Project is not expected to affect the continued suitability of surface water for human use.

Although there are no lakes present in the water quality effects study area, there are numerous ephemeral wetlands present. Within the vicinity of the Project, streams generally flow from north to south toward the Qu'Appelle River. Most of the Project footprint is located within the Loon Creek drainage; however, the northwest portion of KP377 drains towards Last Mountain Lake. The main tributaries of Loon Creek include West Loon Creek and East Look Creek. Both West and East Loon creeks have well-defined stream channels and stream valleys. A tributary of West Loon Creek that is referred to as "unnamed stream" has a poorly-defined stream channel and drains a large part of the ESA, including the proposed core facilities area and a portion of the mining area.

Water quality samples were collected during the spring, summer, and fall of 2013 from one location in Loon Creek, two locations in East Loon Creek, three locations in West Loon Creek, and two land-locked waterbodies in the study area. Water chemistry analyses for sampled watercourses showed that water quality analysis results often exceeded Saskatchewan and Canadian water quality objectives for pH, total dissolved solids, and total ammonia. Several of the East and West Loon creek samples showed exceedences of guidelines for fluoride, aluminum, iron, and manganese during the Base Case. Water quality sampling of waterbodies 005 and 011 showed that water quality analysis results often exceeded Saskatchewan and Canadian water quality objectives for pH, total hardness, total ammonia, arsenic, magnesium, and manganese, with occasional exceedances of aluminum and iron during the Base Case.

Based on the assessment, it is anticipated that deposition of potassium and chloride will result in only very small (i.e., less than or equal to 3.5 mg/L increase in potassium or chloride concentrations) changes to surface water quality in West Loon Creek, East Loon Creek, and Loon Creek. At average and high (i.e., 80th percentile) spring flow volumes, concentrations of potassium and chloride in West Loon Creek, East Loon Creek, and Loon Creek are expected to increase by less than 1 mg/L, relative to Base Case conditions. At low (i.e., 20th percentile) spring flow volumes, potassium and chloride concentrations in East Loon Creek are also expected to increase by approximately 1 to 3.5 mg/L relative to Base Case conditions.

The change in potassium and chloride concentrations is not considered biologically significant. Because changes are expected to be on the order of a few mg/L, total predicted surface water concentrations of potassium and chloride during the Application Case are expected to be within the natural range of variability for West Loon, East Loon, and Loon creeks. It is therefore considered unlikely that deposition of potassium and chloride will adversely affect surface water quality. Salinization of watercourses is not predicted to occur, and chloride concentrations will remain below the CCME water quality guidelines of 640 mg/L (short-term guideline) and 120 mg/L (long-term guideline) for the protection of aquatic life (CCME 2015).

Solution mining and related removal of solid, liquid, and gaseous materials from below the ground surface results in subsidence (i.e., terrain settling). The area affected by subsidence is predicted to extend over a distance of approximately 17 km from west to east and about 8 km from north to south and may extend approximately 1.3 km outside the 65-year mine field. Maximum settlement is predicted to occur in the western section of the 65-year mine field that lies directly over the caverns. The vertical displacement is predicted to range from 0.5 to 6.7 m. The final gradient of surface subsidence at the boundary of the 65-year mine field are expected to be gradual from unaffected areas to the area of maximum subsidence with an average gradient of approximately 3.9 metres per kilometre (m/km) and a maximum gradient of 5.0 m/km.

Changes to flow pathways are mainly predicted along the north and west edges of the 65-year mine field. The volume of flows along major flow paths (i.e., the West Loon Creek) are predicted to be maintained, although localized alterations of flow pathways are predicted to occur and ponded sections may appear. New surface flow pathways may also occur in sections of the ESA. Alterations of smaller drainage area boundaries in the central section of the mine well field are predicted; however, drainage is expected to continue to direct runoff to West Loon Creek. Generally, changes from subsidence to surface water flow pathways and drainage area boundaries in the ESA will be small and localized; the major flow paths (e.g., West Loon Creek) are expected to be maintained.

Effects of subsidence will be mitigated by applying environmental design features and specialized techniques for solution mining. For example, pillars of unmined material will be left between the mine caverns to isolate the caverns, to increase stability of the overlying strata, and to reduce the potential effects of subsidence. Cavern spacing may be increased below the pipelines to reduce surface strains and to meet industry standards. Cavern layout will be refined after additional modeling is completed to optimize potash recovery and limit the potential effects of subsidence. Secondary mining techniques that reduce the amount of material removed from the mine cavern will be employed after development of primary caverns wherever possible. Finally, extraction ratios will be controlled to limit strain on the overlying environment.

Changes to water quality from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for hundreds of years. Areas that become more depressional in the landscape may be expected to accumulate more snow runoff and rainfall which may create new wetland areas. Alternatively, existing wetlands may drain and become drier. Changes in stream gradients caused by subsidence will also occur gradually and take place over a long period that stream bed erosional and depositional processes are expected to remain within their natural range of variability. Because subsidence will occur very gradually, no acute, adverse effects on water quality are expected.

Overall, it is anticipated that through the use of environmental design features and mitigation, that the Project can be constructed, operated, and decommissioned in a manner that will result in minor changes to the physical and chemical properties of surface water, and result in negligible residual effects on surface water quality. The negligible residual effects from the Project are not likely to contribute to significant effects on the continued suitability of surface water for human use.

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10.9 Glossary

Term	Description
Alkalinity	A measure of water's capacity to neutralize an acid. Indicates the presence of carbonates, bicarbonates and hydroxides, and less significantly, borates, silicates, phosphates, and organic substances. Expressed as an equivalent of calcium carbonate. Composition is affected by pH, mineral composition, temperature, and ionic strength. Normally interpreted as a function of carbonates, bicarbonates, and hydroxides; the sum of these three components is called total alkalinity.
Acidification	The decrease of acid neutralizing capacity in water, caused by natural or anthropogenic processes. Exhibited as the lowering of pH.
Best Practice	Method or procedure that is accepted by industry as being effective, practical and reliable in maintaining quality, and meeting Project objectives and regulatory requirements.
Brine	A concentrated solution of inorganic salts.
Channel	A landform formed by fluvial processes and consisting of a channel bed and banks within which the flow of a stream is usually confined. Outside the stream channel is its flood plain which is flooded when water levels are backwatered by ice or beaver dams or during high discharge flood conditions.
Conductivity	A measure of the capacity of water to conduct an electrical current. It is the reciprocal of resistance. Provides an estimate of the total concentration of dissolved ions in the water.
Clay	Refers to the substrate particle class size that is less than 0.004 millimetres in diameter.
Creek	A branch or small tributary of a river.
Drainage area	The region of land that could contribute water to a stream or waterbody via overland or subsurface flow.
Drainage area boundary	The boundary of a drainage area for a single point on a stream or for a waterbody. Calculated using topographic data such as elevation contours or a digital elevation model. Also known as a watershed boundary.
Erosion	The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. Detachment and movement of soil or rock by water, wind, ice, or gravity.
Eutrophic	Refers to an ecosystem that is nutrient-rich (amount of nitrogen, phosphorus, and potassium).
ISQG (Interim Sediment Quality Guideline)	Recommended maximum concentration of a chemical in sediment. Intended to be protective of aquatic organisms.
Nutrients	Environmental substances (elements or compounds), such as nitrogen and phosphorus, that are necessary for the growth and developments of plants and animals.
pH	The degree of acidity (or alkalinity) of soil or solution. The pH scale is generally presented from 1 (most acidic) to 14 (most alkaline). A difference of one pH unit represents a ten-fold change in hydrogen ion concentration.
Probable Effects Level (PEL)	Concentration of a chemical in sediment above which adverse effects on aquatic organisms are likely to occur.
Sand	Refers to the substrate particle class size that is 0.063 to 2.0 millimetres in diameter.
Sediment	Solid material that is transported by, suspended in, or deposited from water. It originates mostly from disintegrated rocks but may include chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics and cause of the occurrence of sediment in streams is influenced by environmental factors (e.g., degree of slope, length of slope soil characteristics, land usage, quantity and intensity of precipitation).
Silt	Refers to the substrate particle class size that is between 0.004 and 0.063 millimetres in diameter.

Term	Description
Substrate	Refers to the material that comprises the bottom of a waterbody or watercourse, including all wetted and unwetted areas.
Total dissolved solids (TDS)	The total concentration of all dissolved compound found in a water sample.
Total suspended solids	The amount of suspended substances in a water sample. Solids, found in wastewater or in a stream, which can be removed by filtration. The origin of suspended matter may be artificial or anthropogenic wastes or natural sources such as silt.
Turbidity	An indirect measure of suspended particles, such as silt, clay, organic matter, plankton, and microscopic organisms, in water.
Waterbody	A general term that refers to ponds, bays, lakes, estuaries, and marine areas.
Watercourse	A general term that refers to riverine systems such as creeks, brooks, streams and rivers.

11.0 FISH AND FISH HABITAT

11.1 Introduction

11.1.1 Background

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project) located in central Saskatchewan, approximately 60 kilometres (km) north of Regina. Yancoal proposes to develop the Project, which includes solution mining and associated supporting infrastructure.

The Project is located in the Rural Municipality (R.M.) of Longlaketon (No. 219) and the R.M. of Cupar (No. 218). An existing network of municipal grid roads, provincial highways, and rail lines will provide access to the Project. The Project (including the core facilities area, 65-year mine field, and indicated resource boundary) encompasses approximately 143 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M).

11.1.2 Purpose and Scope

This section of the Environmental Impact Statement (EIS) for the Project addresses the effects on fish and fish habitat identified in the Project Terms of Reference (TOR) approved by the Environmental Assessment Branch (EAB) of the Saskatchewan Ministry of Environment (MOE) in May 2015 (Appendix 2-B).

The purpose of this section is to meet the TOR, specifically to assess the effects from the Project on fish and fish habitat. The scope of this section includes an analysis of Project-related changes during construction, operation, and decommissioning and reclamation. The incremental and cumulative residual effects on fish and fish habitat from the Project and other previous, existing, and reasonably foreseeable developments are assessed.

The healthy functioning of aquatic ecosystems is dependent on continual interaction among climate, air quality, the terrestrial environment, the hydrological cycle, water quality, and aquatic species. Natural and human-related disturbances can alter the timing and nature of the interactions between the physical and biological components of the aquatic environment. Changes to fish and fish habitat can influence the availability of natural resources for human use (e.g., the availability of fishing opportunities). As such, assessments related to fish and fish habitat are provided in the following sections:

- Atmospheric Environment (Section 7.0);
- Hydrogeology (Section 8.0);
- Hydrology (Section 9.0);
- Surface Water Quality (Section 10.0);
- Soils (Section 12.0);
- Vegetation (Section 13.0);
- Wildlife (Section 14.0); and
- Socio-economic Environment (Section 16.0).

11.1.3 Valued Components, Assessment Endpoints, and Measurement Indicators

The TOR identified fish and fish habitat as a valued component (VC) that should be included in the assessment of effects on the aquatic environment. Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by the proponent, the public, First Nations and Métis communities, and government agencies. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have the potential to be adversely affected by Project development and, therefore, are used to predict the effects of the Project on all environmental components. Rationale for selection of fish and fish habitat as a VC is as follows:

- represents important ecosystem processes;
- are sensitive to Project-related effects;
- fish populations provide food for wildlife and humans;
- protection of listed fish species designated by federal legislation; and
- fish and fish habitat can be measured or described with one or more practical indicators.

The fish and fish habitat assessment focuses on measurement indicators and assessment endpoints derived from ecology and conservation science. Community and regulatory engagement, and local and traditional knowledge were key considerations for selecting the fish and fish habitat VC, but assessment endpoints for fish and fish habitat do not explicitly consider societal values, such as continued opportunities for traditional and non-traditional use of fish. Societal values concerning changes in fish and fish habitat are important and must be considered to understand the full suite of potential effects of the Project (i.e., both human and ecological dimensions). Consequently, measurement indicators from the fish and fish habitat section were carried forward so that effects on societal values could be appropriately captured in the sections dealing specifically with those values (Section 16.0).

Assessment endpoints are qualitative expressions used to assess the significance of effects on a VC and represent the key properties of the VC that should be protected for use by future human generations (i.e., incorporate sustainability). Assessment endpoints are general statements about what is to be protected. Measurement indicators are quantitative and/or qualitative expressions of changes to the assessment endpoints. The assessment endpoint for fish and fish habitat is self-sustaining and ecologically effective fish populations. The measurement indicators include the following:

- spatial and temporal distribution of water;
- surface topography, drainage boundaries, waterbodies, and water pathways;
- surface water quality (i.e., physical analytes and chemical properties);
- fish habitat quantity and fragmentation;
- fish habitat quality; and
- abundance and distribution of fish species.

For each fish species, the sustainability of the population(s) depends on the quantity and quality of the habitats required for each life history stage, and on interactions with other species. While recognizing that populations can naturally fluctuate, sustainable or self-sustaining populations are defined as those with the inherent capacity to be productive when their habitats and environmental conditions permit (Randall et al. 2013); in other words, the population is not affected to the point where future recruitment is diminished.

11.2 Environmental Assessment Boundaries

11.2.1 Spatial Boundaries

11.2.1.1 Baseline Study Areas

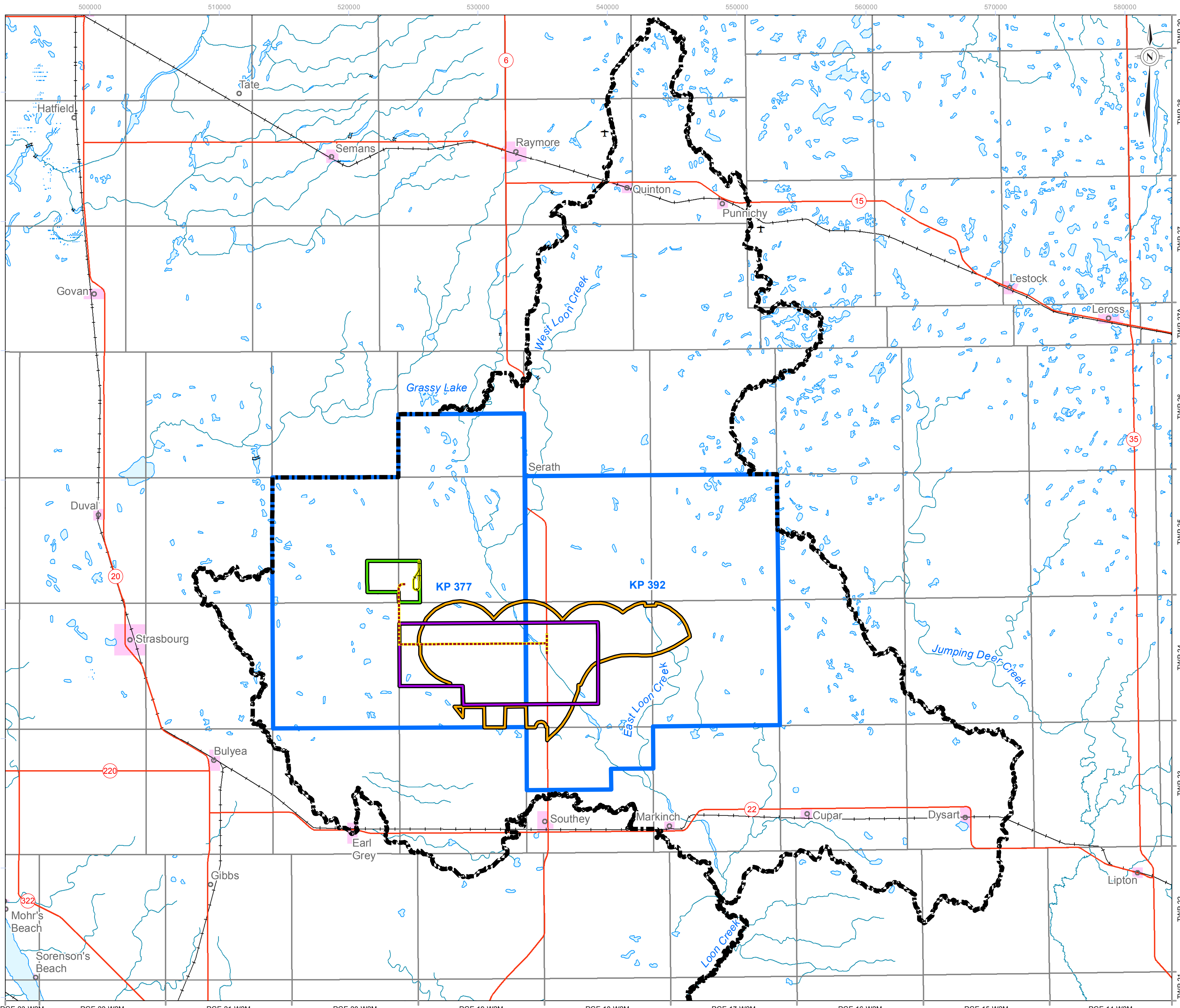
To quantify baseline conditions for fish and fish habitat, baseline study areas were defined for the surface water environment and included a regional study area (RSA) and local study area (LSA) (Annex III, Section 3.0). The RSA was defined by the maximum expected spatial extent of direct and indirect effects from the Project. The LSA was defined by the maximum expected spatial extent of the Project's direct effects.

11.2.1.2 Effects Study Area

To assess Project-related effects on the surface water environment, an effects study area (ESA) was delineated for surface water quality and is approximately 1,959 km^2 (Figure 11.2-1). The ESA extends to the boundaries of the drainage basins interacting with the Project. The ESA includes both unaffected (i.e., reference) areas, as well as areas influenced by the Project. The ESA is expected to be large enough to provide an ecologically relevant and confident assessment of the direct and indirect effects on fish and fish habitat from the Project, as well as the potential cumulative effects from the Project and other previous, existing, and reasonably foreseeable developments.

The ESA encompasses the Project footprint, including the core facilities area, as well as the area of potential subsidence (i.e., within the 65-year mine field). East Loon Creek, West Loon Creek, Loon Creek, and minor tributaries to these streams may be indirectly affected by air and dust emissions from the Project, which may influence the chemical properties of surface water, and subsequently fish and fish habitat. Therefore, the ESA includes the KP392 and KP377 permit areas, as well as the Loon Creek drainage area downstream to the Water Survey of Canada (WSC) station 05JK006. As such, the confluence of West Loon Creek and East Loon Creek is encompassed by the ESA (Figure 11.2-1).

The ESA is situated on a transitional area between the boundaries of the Moist Mixed Grassland and Aspen Parkland Ecoregions of the Prairie Ecozone in Saskatchewan (Acton et al. 1988). The west portion of the ESA is situated in the Strasbourg Plain Landscape Area within the Moist Mixed Grassland Ecoregion. The east portion of the ESA is situated in the Touchwood Hills Upland Landscape Area of the Aspen Parkland Ecoregion. The Moist Mixed Grassland Ecoregion is a broad, mostly level plain with the occasional deep valley, such as the Qu'Appelle Valley (Flory 1980; Acton et al. 1988). The Moist Mixed Grassland is characterized by a patchy landscape of prairie, woodland, and shrubland, (Acton et al. 1998); however, much of the land within the ecoregion is now predominantly cultivated land. The Aspen Parkland Ecoregion is characterized by hummocky landscapes where woodlands or wetlands occur in lower areas associated with pot and kettle topography; grasslands are established on the upper slopes. Currently, much of the area is cultivated or used for livestock grazing; rangelands are generally located in scattered areas of steep or wooded terrain.



LEGEND

- COMMUNITY
- HIGHWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- PROPOSED ACCESS ROAD
- PROPOSED RAIL LOOP
- PERMIT BOUNDARY
- 65 YEAR MINE FIELD
- CORE FACILITIES AREA
- INDICATED RESOURCE BOUNDARY
- EFFECTS STUDY AREA

REFERENCE

PERMIT BOUNDARY: POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
CANVEC © NATURAL RESOURCES CANADA
NTS MAPSHEET: 62L/M, 72I/J/O/P
NAD83 UTM ZONE 13

5 0 5
SCALE 1:300,000 KM

PROJECT

YANCOAL

YANCOAL
SOUTHEY PROJECT

TITLE

LOCATION OF THE FISH AND FISH HABITAT EFFECTS STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	KT/BH	09/07/14	SCALE AS SHOWN	REV. 0
GIS	LMS	13/03/15		
CHECK	AO	25/05/15		
REVIEW	BC	25/05/15		

FIGURE: 11.2-1

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The climate in the ESA is described as sub-humid continental climate and is characterized by warm, short summers and cold, long winters; snow usually remains on the ground for four to five months. Snow accumulated throughout the winter is the main source of spring runoff to local wetlands and streams. Streams and waterbodies in this region are usually ice-free from late March or April until the end of October or November. From November to March, streamflow ceases in the smaller streams and is reduced in larger streams. Rainfall makes up 80 percent (%) of the total precipitation each year, with the intensity, duration, and spatial extent of rainfall events varying considerably.

Streams near the proposed Project generally flow from north to south towards the Qu'Appelle River. Most of the Project footprint is located within the Loon Creek drainage; however, the northwest portion of KP377 drains towards Last Mountain Lake. The main tributaries of Loon Creek include West Loon Creek and East Loon Creek, both of which flow from north to south. West Loon and East Loon creeks have well-defined stream channels and stream valleys. A tributary of West Loon Creek that is referred to as "unnamed stream" has a poorly defined stream channel and drains a large part of the ESA, including the proposed core facilities area and a portion of the mining area. The ESA contains no lakes; however, it is located in the "prairie pothole" region where there are numerous ephemeral wetlands present.

11.2.2 Temporal Boundaries

Temporal boundaries for the fish and fish habitat assessment were defined by the life of the Project (Section 4.0) and the existing and future cumulative effects to which the Project might contribute. The Project phases are construction, operation, and decommissioning and reclamation. Final relinquishment of the Project will occur after the completion of reclamation. Many effects of the Project will end when operations cease or following decommissioning and reclamation, but effects on fish and fish habitat may continue after Project decommissioning and reclamation.

The effects analysis encompasses the Project phases as follows:

- construction (2016 to 2019);
- operations (2019 to 2119); and
- decommissioning and reclamation (2119 onward).

The above timeframes are intended to be sufficiently flexible to capture the effects of the Project on fish and fish habitat. Many effects of the Project will end when operations cease or at decommissioning and reclamation (e.g., air emissions), but other effects may continue, unless determined to be permanent (e.g., ground subsidence). Therefore, effects on fish and fish habitat were analyzed from Project construction through decommissioning and reclamation. This approach generates the maximum potential spatial and temporal extent of effects on the abundance and distribution of fish and fish habitat, which provides confident and ecologically relevant effects predictions.

11.2.2.1 Base Case

The Base Case (existing environment) represents existing conditions before application of the Project. Previous and existing developments and activities include roads, communities, water use, and agricultural activities. Consequently, the Base Case represents the cumulative outcome of all previous and existing developments and activities.

11.2.2.2 Application Case

The incremental contributions of residual effects from the Project to existing cumulative effects were assessed at the ESA scale by adding the Project to the Base Case to form the Application Case. One period during the Project is expected to contribute to maximum effects on fish and fish habitat:

- when settlement due to mine subsidence would be the maximum expected; this period would be reached many years after decommissioning and reclamation.

The incremental contributions of the Project and the cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are predicted to evaluate changes to measurement indicators for fish and fish habitat during the Application Case.

11.2.2.3 Reasonably Foreseeable Development Case

The Reasonably Foreseeable Development (RFD) Case represents the Application Case plus reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. The minimum temporal boundary for the Application Case and RFD Case is the expected lifespan of the Project that, like the Base Case, includes a range of conditions over time. The difference between the Application and RFD case is that the Application Case considers the incremental effect from the Project in isolation of potential future land use activities. The RFDs are defined as projects that:

- are currently under regulatory review or have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project, or may be induced by the Project;
- have been approved but not yet developed; or
- have the potential to change the Project or the effects predictions.

The reasonably foreseeable developments identified in Section 6.0 include the supporting infrastructure required for the Project, the Muskowekwan Potash Mine Project, and the Vale Kronau Project. Supporting infrastructure will include a water supply pipeline, an overhead transmission line, a natural gas supply pipeline, telecommunication services, and a railway line. Screening assessment reports will be completed by each of the utility providers, once the final routing options are determined. Most of the preferred routes for the supporting infrastructure are not within the ESA and the final routing options are not known at this time. Therefore, the supporting infrastructure for the Project will not be assessed as an RFD for fish and fish habitat.

The proposed Muskowekwan Potash Mine Project is located approximately 52 km northeast of the Project and the Vale Kronau Project is located approximately 71 km south of the Project. Both of these projects are located outside of the ESA. The effects on fish and fish habitat from development of the Muskowekwan Potash Mine Project and the Vale Kronau Project are not expected to overlap with effects on fish and fish habitat within the ESA, as they are located in different watersheds. Therefore, the RFD Case is not included in this section of the EIS.

11.3 Existing Environment

The purpose of this section is to describe the existing environment (Base Case) for fish and fish habitat within the ESA as a basis to assess the Project-specific effects on fish and fish habitat. The detailed methods and results for baseline data collection within the ESA are described in the Surface Water Environment Baseline Report (Annex III, Section 5.0).

11.3.1 Fish Inventory

11.3.1.1 Methods

Fish inventory surveys were completed in the ESA; assessed watercourses and waterbodies included West Loon Creek, East Loon Creek, Loon Creek, and three disconnected land-locked waterbodies (Figure 11.3-1). Non-lethal fish capture methods (i.e., minnow traps and backpack electrofishing) were used. The following information was recorded for each fishing effort:

- sampling date and time (start and end times);
- Universal Transverse Mercator (UTM) coordinates;
- number of fish captured and observed; and
- a general habitat description for the site.

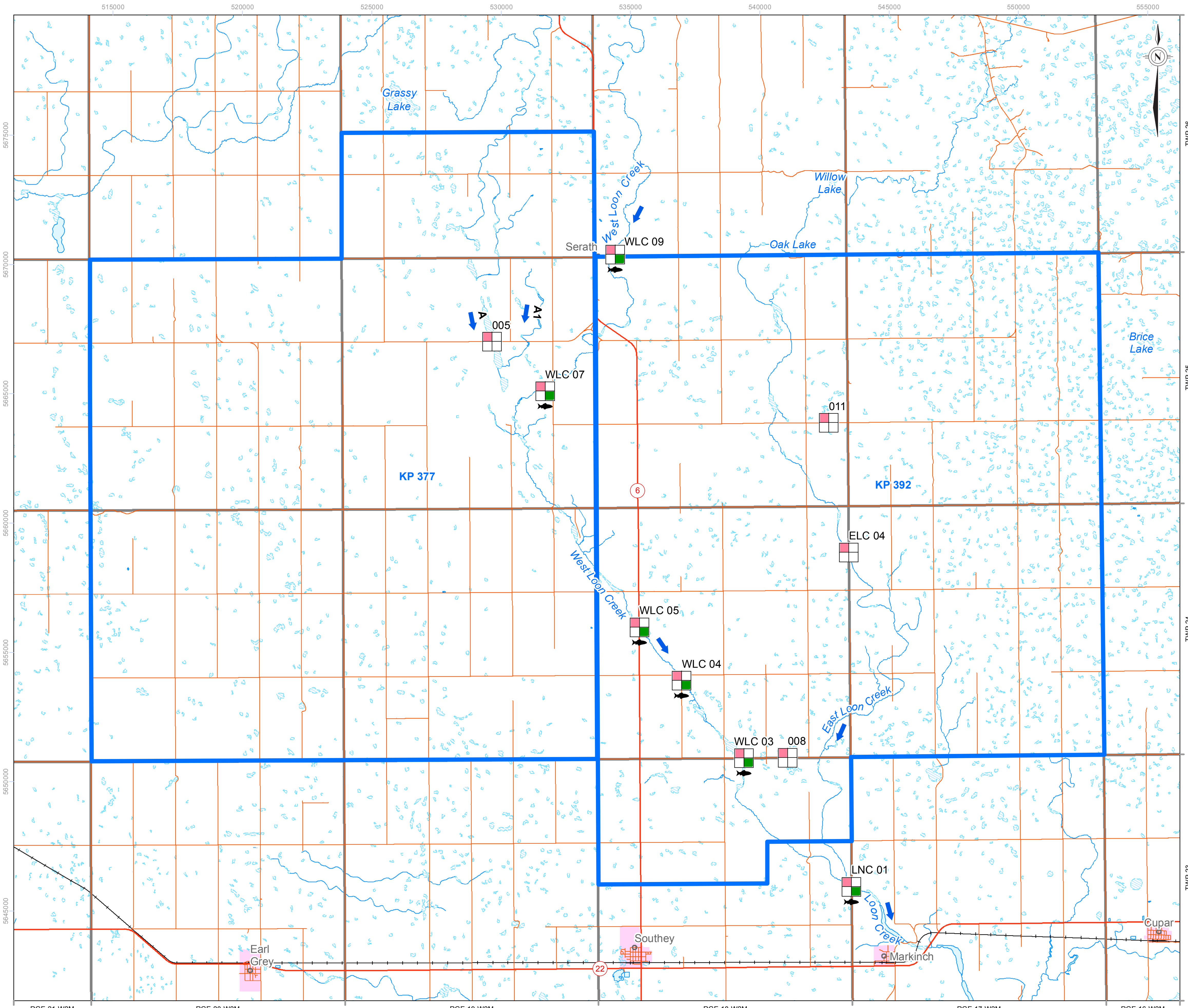
Captured fish were assessed and the following information was recorded:

- species;
- fork length;
- weight; and
- external health (i.e., body deformities, external parasites, and general appearance of the eyes, skin, thymus, opercula, gills, pseudobranchs, fins, and hindgut).

11.3.1.2 Results

Two fish species were captured in the ESA; these were Brook Stickleback (*Culaea inconstans*) and Fathead Minnows (*Pimephales promelas*). Catch per unit effort data for each species are provided for minnow trapping and backpack electrofishing efforts (Tables 11.3-1 and 11.3-2).

Fish capture data indicate that small-bodied species represented 100% of the total catch, with Fathead Minnow and Brook Stickleback comprising 94% and 6% of the total, respectively. Both species were found in West Loon Creek and Loon Creek. No fish were captured in East Loon Creek or any of the sampled wetlands. No large-bodied fish species were captured, which appears to indicate that large-bodied fish species do not use the waterbodies and watercourses near the Project. Large-bodied fish species are known to occur downstream of Loon Creek in the Qu'Appelle River; however, the barriers to fish movement observed near the Project during the fish habitat assessment (e.g., dry areas, beaver [*Castor canadensis*] dams, and culverts [Section 11.3.2]), would likely prevent upstream movements.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- PERMIT BOUNDARY
- 2013 FISH HABITAT SAMPLING STATION
- 2013 FISH INVENTORY SAMPLING LOCATION
- SMALL-BODIED FISH CAPTURE

REFERENCE

POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
FISH AND FISH HABITAT SAMPLING LOCATIONS IN THE EFFECTS STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	KT/BH	10/07/14	SCALE AS SHOWN	REV. 0
GIS	LMS	12/05/15		
CHECK	AO	25/05/15		
REVIEW	BC	25/05/15		

FIGURE: 11.3-1

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Table 11.3-1: Minnow Trap Catch-Per-Unit-Effort by Species and Station in the Effects Study Area

Waterbody/Watercourse	Station	Effort (h)	Brook Stickleback		Fathead Minnow	
			Total Number of Fish	CPUE (Number of fish/h)	Total Number of Fish	CPUE (Number of fish/h)
005	005	253.50	0	-	0	-
008	008	175.17	0	-	0	-
011	011	259.40	0	-	0	-
West Loon Creek	WLC 03	225.20	16	0.07	402	1.79
	WLC 04	118.90	3	0.03	1	0.01
	WLC 05	183.70	0[(a)]	-	0[(a)]	-
	WLC 07	232.48	0	-	421	1.81
	WLC 09	285.27	31	0.11	111	0.39
East Loon Creek	ELC 04	181.67	0	-	0	-
Loon Creek	LNC 01	226.68	37	0.16	857	3.78

Notes:
(a) Brook Stickleback and Fathead Minnows were observed, but not captured at station WLC 05.
h = hour; Brook Stickleback = *Culaea inconstans*; Fathead Minnow = *Pimephales promelas*; CPUE = catch-per-unit-effort (number of fish captured per hour); "–" = no data.

Table 11.3-2: Backpack Electrofishing Catch-Per-Unit-Effort by Species and Station in the Effects Study Area

Waterbody/ Watercourse	Station	Effort (s)	Brook Stickleback		Fathead Minnow	
			Total Number of Fish	CPUE (Number fish/100 s)	Total Number of Fish	CPUE (Number fish/100 s)
005	005	695	0	-	0	-
008	008	588	0	-	0	-
011	011	308	0	-	0	-
West Loon Creek	WLC 03	926	2	0.22	70	7.56
	WLC 04	405	18	4.44	0	-
	WLC 05	416	0[(a)]	-	0[(a)]	-
	WLC 07	694	0	-	1	0.14
East Loon Creek	ELC 04	537	0	-	0	-
Loon Creek	LNC 01	1206	14	1.16	16	1.33

Notes:
(a) Brook Stickleback and Fathead Minnows were observed, but not captured at station WLC 05.
s = seconds; Brook Stickleback = *Culaea inconstans*; Fathead Minnow = *Pimephales promelas*; CPUE = catch-per-unit-effort (number of fish captured per 100 seconds); "–" = no data.

11.3.2 Fish Habitat Assessment

11.3.2.1 Methods

Fish habitat assessments were completed at six sampling stations where fish were captured or observed during the 2013 field season (Figure 11.3-1). Habitat assessments were completed during the season in which fish were first captured and extra information and photographs were collected during subsequent sampling events. Stream habitat assessments were completed up to 200 metres (m) upstream or downstream of existing road crossings, depending on landowner permission. Information collected during the stream habitat assessments included the following:

- stream channel width and depth;
- flow status;
- presence of channel blockages and potential fish passage constraints;
- riparian and aquatic vegetation;
- substrate and sediment characteristics;
- land use adjacent to stream; and
- fish presence/absence.

Fish habitat information was entered into a computer-aided design (CAD) system to enable production of fish habitat maps.

11.3.2.2 Results

Fish habitat maps were produced for the six locations where fish were captured or observed (Annex III, Section 5.3.2, Figures 5.3-1 to 5.3-6). It appears that West Loon Creek and Loon Creek are the only waterbodies within the ESA capable of supporting fish, at least on a seasonal basis. Small-bodied fish habitat appears to be dependent on annual flow volumes and flow durations, as well as the presence of deeper impoundments and dugouts. Stream bottoms were mainly composed of silt, followed by sand and clay. Barriers to fish movement were observed in West Loon Creek, East Loon Creek and Loon Creek; barriers included dry stream sections, beaver dams, and perched/hanging culverts.

11.3.2.2.1 West Loon Creek

West Loon Creek flows south-southeast, through the approximate midpoint of the ESA. West Loon Creek joins East Loon Creek to form Loon Creek approximately 3.5 km northwest of the community of Markinch.

Fish habitat assessments were completed at five locations along West Loon Creek. Generally, the creek was characterized by intermittent flow and a wide, unconfined channel. Observed substrates consisted of silt, coarse sand, and organics. Deep water areas were usually impoundments created by road crossings or beaver activity. Dominant fish cover usually consisted of aquatic vegetation, inundated terrestrial vegetation, and over-hanging vegetation.

11.3.2.2.2 East Loon Creek

East Loon Creek was almost entirely dry at each of the potential sampling locations visited, with the exception of two locations where pooled water was present during the spring season. No fish were captured or observed in

East Loon Creek during the 2013 fish inventory surveys. During the summer and fall sampling sessions, the observed sections of East Loon Creek were dry with no defined channel, or consisted of dry depressions within cultivated fields. As such, no fish habitat assessment of East Loon Creek was completed.

11.3.2.2.3 Loon Creek

The main stem of Loon Creek is approximately 20 km in length and flows south into the Qu' Appelle River. Fish habitat was assessed at a single location, approximately 500 m downstream of the West Loon Creek-East Loon Creek confluence. The assessed section of channel was intersected by a gravel road and culvert. Beaver activity resulted in the formation of an impoundment upstream of the culvert. The active channel and riparian area immediately downstream of the culvert were influenced by active cattle grazing.

Substrate material upstream and downstream of the crossing consisted primarily of silt, clay, and organics. Dominant cover types suitable for use by fish were comprised mainly of aquatic vegetation and inundated terrestrial vegetation. The mean water depth at the time of assessment was approximately 0.40 m. Flow downstream of the crossing on Loon Creek was intermittent.

11.3.2.2.4 Waterbodies

Three permanent wetlands were sampled for fish; however, no fish were captured. These wetlands lack hydraulic connections to fish-bearing waterbodies or streams, and are considered too shallow to provide over-wintering habitat for fish. During the winter, anoxic conditions were observed in areas of the wetlands that were not frozen to the substrate. For these reasons, fish habitat assessments were not completed for these wetlands.

11.4 Pathways Analysis

11.4.1 Methods

Pathways analysis identifies and assesses the linkages between Project components or activities, and corresponding changes to the environment and potential residual effects (i.e., effects occurring after implementation of mitigation) on fish and fish habitat. The first part of the analysis is to identify all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on the VC. Potential pathways through which the Project could affect fish and fish habitat were identified from a number of sources including:

- a review of the Project Description (Section 4.0) and scoping of potential effects by the environmental and engineering teams for the Project;
- information obtained from community engagement sessions (Section 5.0);
- scientific knowledge and experience with other potash mines in Saskatchewan; and
- consideration of potential effects identified from the TOR.

For an effect to occur there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a correspondent effect on the VC.

Project activity → change in environment → effect on VC

A key aspect of the pathways analysis is to identify environmental design features and mitigation that might reduce or eliminate potential effects from the Project to fish and fish habitat. Mitigation has been developed for the Project according to the following hierarchy proposed by the MOE (2014):

- avoidance;
- minimize (limit);
- restoration; and
- compensation.

Environmental design features include engineering design elements, environmental best practices, management policies and procedures, and spill response and emergency contingency plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on fish and fish habitat. Pathways are determined to be primary, secondary (minor), or as having no linkage, using scientific, local, and traditional knowledge, logic, experience with similar developments, and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- **No linkage** – analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on fish and fish habitat relative to the Base Case or guideline values; or
- **Secondary** – pathway could result in a measurable minor environmental change, but would have a negligible residual effect on fish and fish habitat relative to the Base Case or guideline values, and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects and cause a significant effect; or
- **Primary** – pathway is likely to result in environmental change that could contribute to residual effects on fish and fish habitat relative to the Base Case or guideline values.

Pathways with no linkage to fish and fish habitat are not assessed further because implementation of environmental design features or mitigation will remove the pathway and result in no measureable change to fish and fish habitat. Pathways that are assessed as secondary and demonstrated to have a negligible residual effect on fish and fish habitat through simple qualitative or semi-quantitative evaluation of the pathway are also not advanced for further assessment. In summary, pathways determined to have no linkage to fish and fish habitat or those that are considered secondary are not expected to result in environmentally significant effects for self-sustaining and ecologically effective fish populations. Primary pathways require further evaluation through more detailed quantitative and qualitative effects analysis (Section 11.5).

11.4.2 Results

Project components and activities, effects pathways, and environmental design features and mitigation are summarized in Table 11.4-1. Classification of effects pathways (i.e., no linkage, secondary, or primary) to fish and fish habitat also is summarized in Table 11.4-1 and detailed descriptions are provided in the subsequent sections.

Table 11.4-1: Potential Pathways for Effects on Fish and Fish Habitat

<table>
<tr><th>Project Component/ Activity</th><th>Effects Pathways</th><th>Environmental Design Features and Mitigation</th><th>Pathway Classification</th></tr>
<tr><td rowspan="2">Physical disturbance from the Project Footprint</td><td>Ground disturbance during site preparation and soil storage in stockpiles can increase erosion potential and change surface water quality, which can affect fish and fish habitat.</td><td>■ An Erosion and Sediment Control Plan will be developed and implemented, and provide input into adaptive management.
■ Diversion structures to control runoff will be implemented, as needed, to divert surface runoff from exposed soils.
■ Salvaged topsoil will be stored on-site and will be kept away from surface waterbodies.
■ Erosion and sediment control measures, such as silt fences, sediment stops, and settling ponds will be implemented as necessary to prevent sediment from entering watercourses during all phases of the Project.
■ Soil storage stockpiles and exposed areas may be vegetated to protect against wind and water erosion.
■ The compact layout of the core facilities area will limit the area that is disturbed by construction.
■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance.
■ Progressive reclamation of well pads will occur where applicable.
■ Existing public roads will be used where possible to provide access to the mine wellfield, which will reduce the amount of new road construction required for the Project.
■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible.
■ A Water Management Plan will be developed to safely manage site water, store on-site run-off and divert freshwater run-off.
■ Best practices during construction will be adopted as part of the Erosion and Sediment Control Plan for disturbed areas to reduce erosion and limit sediment transport.</td><td>No Linkage</td></tr>
<tr><td>Changes in surface flows, drainage patterns (distribution) and drainage areas from the Project footprint can affect fish and fish habitat.</td><td>■ The compact layout of the core facilities area will limit the area that is disturbed by construction.
■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance.
■ Progressive reclamation of well pads will occur where applicable.
■ Existing public roads will be used where possible to provide access to the mine well field area, and to reduce the amount of new road construction required for the Project.
■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible.
■ Where practical, natural drainage patterns will be maintained.
■ Culverts will be installed along site access roads, as necessary, to maintain drainage.
■ A Water Management Plan will be incorporated at the detailed design stage, and provide input into adaptive management.</td><td>No Linkage</td></tr>
<tr><td rowspan="3">General construction, operations, and decommissioning and reclamation activities</td><td>Air and dust emissions and subsequent deposition can cause changes to the chemical properties of surface water, which can affect fish and fish habitat.</td><td rowspan="3">■ Compliance with regulatory emission requirements.
■ Dryer burners will be high efficiency, low NO_x burners to limit the amount of NO_x present in the exhaust stream.
■ Baghouses will be installed throughout the dry process area and dust collected in these baghouses will be conveyed back to the compactors.
■ A dustless chute and loading system will be installed in the product storage area to reduce dust generation in the storage and load-out.
■ The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment.
■ An Erosion and Sediment Control Plan will be implemented during all phases of the Project to limit dust production, and subsequent deposition on surrounding areas, and to limit water erosion of exposed soils.
■ Dust-producing components of the potash refinement process (i.e., dryers or compaction circuit) will have controls to recover and return dust to the circuit.
■ Wet scrubbers will be used to clean the air of dust particles from off-gases from the product dryers.
■ Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site.
■ Enforced speed limits will assist in reducing production of dust.
■ Operating procedures will be developed to reduce dust generation from the TMA over the long-term.
■ The cyclone exhaust will be treated in high-energy scrubbers operating at a high-pressure drop.</td><td>Secondary</td></tr>
<tr><td>Dust deposition can cover substrates and affect the quality of fish habitat.</td><td>Secondary</td></tr>
<tr><td>Long-term dust emissions from the tailings management area can cause local changes to surface water quality, which can affect fish and fish habitat.</td><td>No Linkage</td></tr>
</table>

Table 11.4-1: Potential Pathways for Effects on Fish and Fish Habitat

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Solution Mining	Ground subsidence caused by solution mining can change surface flows, drainage patterns (distribution), and drainage areas which can affect fish and fish habitat.	■ Unmined pillars will be left between caverns to increase stability during mining and reduce the potential for subsidence. ■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence and will provide input into adaptive management. ■ Subsidence will be non-disruptive. Disruptive subsidence, such as the formation of sinkholes, is not expected to occur. ■ Subsidence will be gradual and ultimate (maximum) subsidence (i.e., final, steady state) will not occur for centuries. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface topography.	Secondary
Tailings Management Area	Vertical and lateral migration of brine from the tailings management area can cause changes to surface water quality and affect fish and fish habitat.	■ The location of the TMA was selected based on site-specific geologic and hydrogeologic studies completed to identify an appropriate foundation for the TMA, which provides natural containment of brine material. ■ The TMA will be located over soils that are known to provide natural retention of brine solutions and offer protection against seepage into nearby ground and surface water resources.	No Linkage
Tailings Management Area	Long-term brine migration from the tailings management area can cause changes to groundwater and surface water quality, which can affect fish and fish habitat.	■ Brine reclaim ponds will be designed to provide containment of brine under normal and extreme (i.e., storm) conditions over the life of the mine. ■ A perimeter dyke will be constructed around the TMA to contain waste salt and decanted brine. ■ Excess brine reclaimed from the TMA will be disposed of by deep well injection, a proven practice used to manage brine and prevent release to surface waters and fresh-water aquifers. ■ A containment system will be designed to control deep migration of brine from the TMA to underlying aquifers and horizontal migration of brine, as required. ■ A Waste Salt Management Plan for the TMA will be incorporated into the detailed design. ■ The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan and adaptive management will be implemented, if required. ■ A Decommissioning and Reclamation Plan will be developed and will incorporate new technologies as they become available to reduce the length of the decommissioning period and the associated duration of salt storage at surface.	No Linkage
Tailings Management Area	Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality, and change surface water and soil quality, which can affect fish and fish habitat.	■ An evaluation of the capacity of potential deep injection horizons has been conducted identifying the Winnipeg Formation and the Deadwood Formation to be suitable for brine disposal.	No Linkage
Water Management	Site run-off and associated soil erosion from the core facilities area can change surface water quality, and affect fish and fish habitat.	■ A Water Management Plan will be designed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. ■ A diversion channel will be constructed to intercept waterflow from upland areas along the north and east borders of the core facilities area. ■ Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the core facilities area. ■ The surface water diversion will be designed to convey the runoff associated with the 300 mm 24-hour design storm event. ■ Surface water diversion channels along the perimeter of the core facilities area will be designed to collect and redirect external drainage.	No Linkage

Table 11.4-1: Potential Pathways for Effects on Fish and Fish Habitat

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Accidents, Malfunctions, and Unplanned Events	Spills (e.g., waste oil, petroleum products, reagents, potash product, project equipment leaks, vehicle accidents, and wash-down) can cause changes to surface water quality, and affect fish and fish habitat.	■ Instruction will be provided to employees as part of the Health, Safety, Security, and Environmental Management System; training will be provided to all employees on transportation of dangerous goods, as well as on spill reduction, control, and clean up procedures. ■ Basic, core, and specific training of workers as part of the Health, Safety, Security, and Environmental Management System. ■ An Emergency Response Team will be formed on-site and members will be trained to implement the Emergency Response Plan. ■ Spills will be promptly reported and managed according to procedures identified in the Spill Response and Control Plan. ■ Chemical spill containment will be incorporated into the plant design to mitigate environmental effects from spills (i.e., installation of concrete floors, drains, and sump mechanisms). ■ Smaller fuel dispensing tanks will be double-walled, and all dispensing will be performed over concrete containment slabs. ■ Reagent tanks and larger fuel tanks will be located inside a bermed, lined storage compound. ■ Liquid, solid spills, and wash-down within the processing facilities will be contained within the mill facility (e.g., door curbs, sloped floors, and sumps) or engineered site area. ■ Diesel and gasoline will be stored in accordance with applicable regulations. ■ On-site storage facilities for hazardous substances and waste dangerous goods will be designed to meet regulatory requirements. ■ Domestic and recyclable waste dangerous goods will be stored in appropriate containers until shipped off site to an approved facility. ■ Spill response material will be located throughout the site in designated areas, where fuel and chemicals are stored, and in company vehicles. ■ Best practices will be adopted within the Waste Management Plan for proper handling and storage of waste dangerous goods. ■ Salvageable product from centrifuging, drying, screening, and compaction will be recycled back to the process. ■ Construction equipment will be regularly inspected and maintained. ■ To limit the occurrence of vehicular accidents, training for equipment operators will be implemented as part of the Health, Safety, Security, and Environmental Management System. ■ Equipment will be inspected for leaks and repaired prior to entry into the Project area and routinely inspected throughout the duration of the Project. ■ Daily vehicle inspections will be required, and a preventative maintenance program will be implemented for all vehicles used on-site. ■ Speed limits will be enforced. ■ Timely snow removal and sanding will occur on site access roads during winter to improve traction.	No Linkage
	Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to groundwater and surface water quality, which can affect fish and fish habitat.	■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ Brine will be transported by steel pipeline lined with high-density polyethylene which provides additional pipe flexibility and resistance to corrosion. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface developments. ■ Unmined pillars will be left between the caverns to increase stability during mining and reduce the potential for subsidence. ■ As part of the Environmental Protection Plan, regular monitoring of pipelines will be carried out to limit the potential for leaks and allow for early detection and management of spills. ■ Piping and valve arrangements will be routed so that each cavern works independently from the others at difference stages of cavern development and production. ■ During the detailed design stage, additional spill response and mitigation will be included in the Spill Response and Control Plan.	No Linkage
	Slope failure of waste salt storage pile can cause translocation of waste salts and change surface water quality, which can affect fish and fish habitat.	■ Salt pile side slopes of 4H:1V were applied to the TMA layout, which were found to provide a stable slope configuration based on preliminary slope stability analysis. ■ The final configuration of salt pile slopes will be refined based on subsequent analyses calibrated to pore-water pressure and slope movement data obtained during the initial development of the waste salt pile. ■ Regular inspections of the TMA. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan.	No Linkage

Table 11.4-1: Potential Pathways for Effects on Fish and Fish Habitat

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
	Failure of the brine containment pond and resulting brine leakage can cause changes to surface water quality, and affect fish and fish habitat	■ The brine reclaim pond will provide adequate storage to accommodate storage of process streams under normal and extreme operating conditions and design storm events. ■ Sufficient freeboard will be provided to account for wind induced set-up and wave run-up on the sides of the pond slopes. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan. ■ Maximum operating levels will be developed to provide adequate storage volumes for the design storm event (300 mm in 24 hours). ■ Containment berms and dykes will be constructed around the tailings management area to contain salt tailings and decanted brine, as well as to divert surface water. ■ Containment dykes will be keyed into surficial materials as necessary. ■ Brine levels will be monitored and excess brine will be injected into deep well injection zones after mining is complete. Sub-surface brine migration will be monitored and groundwater wells will be monitored to confirm the adequacy of the brine containment pond. ■ In the event of high flows due to precipitation events, additional flow capacity from the collection ditch to the reclaim pond would be provided by an overflow spillway in the embankment. ■ The brine reclaim pond will be monitored regularly; monitoring results will provide input into adaptive management.	No Linkage
	Deposition of air emissions from the failure of air emission control systems can result in chemical changes to the surrounding environment and affect fish and fish habitat.	■ The environmental performance of air emissions control systems will be monitored on an on-going basis and will support adaptive management. ■ Preventative maintenance will be completed regularly to confirm that emissions systems are functioning as designed.	No Linkage

TMA = tailings management area; R.M. = rural municipality; NO_x = oxides of nitrogen; mm = millimetres

11.4.2.1 Pathways with No Linkage

A pathway may have no linkage to environmental effects if the activity does not occur, or if the pathway is removed by mitigation or environmental design features so that the Project results in no measurable change in measurement indicators. Subsequently, no residual effect on fish and fish habitat is expected. The pathways described in the following bullets have no linkage to fish and fish habitat and will not be carried forward in the assessment.

- **Ground disturbance during site preparation and soil storage in stockpiles can increase erosion potential and change surface water quality, which can affect fish and fish habitat.**

Project construction activities, such as site clearing and soil salvage, stockpiling, and transport could increase the potential for soil erosion and subsequent movement of sediment into nearby watercourses within the ESA. Sediment entering the watercourse could affect surface water quality by altering the chemical properties of the water (e.g., increase total dissolved solids [TDS] levels), which could affect fish and fish habitat. Erosion is a concern within the Project footprint during construction and operations because of the removal of the vegetation cover and the disturbance of soils. Stockpiles maintained through operations may be susceptible to erosion due to factors such as absence of vegetation, steep slopes, and desiccation.

Soils occurring in the Project footprint are predominantly rated as having moderate water erosion potential and medium wind erosion potential under Base Case conditions (Section 12.3.2.4). In areas of gullied or dissected terrain, the erosion potential would increase and where slope gradients decrease, the erosion potential will decrease. The soil erosion ratings represent the maximum erosion that would occur to exposed mineral soils with no mitigation in place. Soil erosion can be managed in a number of ways, thus limiting the potential for changes to surface water quality and therefore reducing effects on fish and fish habitat.

Soil erosion from site-clearing and soil salvage, stockpiling, and transport will be reduced through the use of environmental design features and mitigation. An Erosion and Sediment Control Plan, which includes the use of best practices, will be developed and implemented. The Project footprint (i.e., area of physical disruption) will be limited to the smallest reasonable size (e.g., the Project will use existing public roads for site access, where possible, and as many caverns as practicable will be managed from each well pad). Additionally, areas of exposed soils will be reclaimed in the shortest practical timeframes (e.g., progressive reclamation of well pads will occur). Disturbed areas will be re-sloped to create stable landforms, and seeded to provide a vegetation cover, where required, as outlined in the Erosion and Sediment Control Plan and Decommissioning and Reclamation Plan. Sensitive areas located within or near the Project, such as streams, wetlands, natural flow pathways, and floodplains, will be protected with erosion and sedimentation control structures (e.g., silt fences, sediment stops, and settling ponds). Salvaged topsoil will be stored on-site away from surface waterbodies, and revegetated as practical. Erosion control measures will be applied to topsoil and overburden stockpiles, particularly if they are to be stored for long periods. On-site runoff (i.e., runoff from exposed soil areas) that has been diverted away from nearby watercourses and the natural drainages will be safely stored and managed on-site, as part of a Water Management Plan that will be developed for the Project. Diversion structures will be used, as required, to divert water unaffected by site activities away from the site into the natural hydrologic system downstream from the Project.

Implementation of the above mentioned environmental design features and mitigation is expected to reduce the potential for erosion from disturbed areas and on soil storage stockpiles and not result in measurable changes to water quality. Consequently, this pathway was determined to have no linkage to effects on fish and fish habitat.

- **Changes in surface flows, drainage patterns (distribution), and drainage areas from the Project footprint can affect fish and fish habitat.**

Constructions of the Project infrastructure, including the core facilities area and required water diversions (e.g., berms, dykes, and ditches), has the potential to affect hydrology within the ESA by disrupting natural flow patterns and drainage areas. Changes in surface flows and drainage patterns could potentially affect fish and fish habitat.

Surface water flows, drainage patterns, and drainage areas within the Project footprint are expected to be affected by the construction of the Project. The natural drainage area near the Project has already been disturbed by the existing road network used to access cultivated areas, rural homes, and communities near the Project. The Project is within an area that has poorly defined runoff pathways. During the Base Case, most runoff contributes to a low-lying area south of the core facilities area and it may occasionally contribute to West Loon Creek under high magnitude snowmelt and/or rainfall events (Section 9.5). The hydrology assessment predicted that the Project footprint will result in a reduction in runoff that will change the amount of water reporting to the low-lying area downstream, but would only rarely affect inflows to West Loon Creek (Section 9.5). During decommissioning and reclamation, most Project infrastructure will be removed and surface water flows and drainage patterns will be reclaimed. The tailings management area (TMA) is considered permanent. The surface water flows and drainage patterns in residual footprint areas will not be reclaimed; however, no reduction in flow volume in West Loon Creek is predicted.

A Water Management Plan will be implemented to maintain streamflow quantity along natural flow pathways as much as possible. Environmental design features will be implemented to allow off-site precipitation and snow melt to remain part of the natural water cycle. The core facilities area will be limited to the minimum spatial extent required. The mine well field area access roads constructed during the Project will be designed to maintain the natural flow paths and use adequately designed cross-drainage structures (e.g., culverts), as required.

By implementing environmental design features and mitigation, it is anticipated that the Project footprint will result in minor changes to surface water flows and drainage patterns. The minor changes to surface water flows and drainage patterns are not anticipated to cause measurable changes to fish and fish habitat. Given that no reduction in flow volume is predicted in West loon Creek, which flows into Loon Creek (i.e., the only fish bearing waters in the ESA), effects on fish or fish habitat are not expected. Therefore, this pathway was determined to have no linkage to effects on fish and fish habitat.

- **Long-term dust emissions from the tailings management area can cause local changes to surface water quality, which can affect fish and fish habitat.**

Solution mining produces waste salt (i.e., sodium chloride [NaCl] tailings) as a by-product of the potash refinement process; these waste salts will be stored in the salt storage area in the TMA. Surface storage of waste salts creates the potential for dust emissions, which may cause changes to surface water quality and affect fish and fish habitat, within the ESA. However, implementation of environmental design features and mitigation is expected to reduce changes on local surface water quality.

The volume of tailings produced by solution mining is expected to be lower than that of conventional underground mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only potassium chloride (KCl) is removed from the caverns.

The tailings that are precipitated during processing (i.e., "slurry") are transported, in a controlled manner, to the TMA for storage. Transporting the slurry thorough a pipeline is expected to reduce the handling of the tailings and exposure to sources of erosion. A solid crust will form over the outer layer of the waste salt pile as the salt slurry dries. The formation of a rigid crust over the pile is expected to limit effects of exposure to wind and will reduce the potential for erosion. Operating procedures will be developed to limit dust emissions from the TMA. Monitoring programs for the waste salt storage area will be incorporated into the design and will include monitoring pile stability and related dust production. Due to the crusting of the outer layer of the waste salt pile and the implementation of the operating procedures and monitoring programs for the salt storage area, long-term dust emissions are not expected, and are predicted to result in no measureable changes to surface water quality. Consequently, this pathway was determined to have no linkage to effects on fish and fish habitat.

- **Vertical and lateral migration of brine from the tailings management area can cause changes to surface water quality and affect fish and fish habitat.**
- **Long-term brine migration from the tailings management area can cause changes to groundwater and surface water quality, which can affect fish and fish habitat.**
- **Failure of the brine containment pond and resulting brine leakage can cause changes to surface water quality and affect fish and fish habitat.**

The TMA will consist of the Stage I and Stage II salt storage areas, the Stage I and Stage II brine reclaim ponds, sewage lagoon, and surface diversion works. The TMA will be in operation during the life of the Project, and following decommissioning and reclamation of the mine. Brine is primarily composed of NaCl, with smaller amounts of KCl and other insoluble materials (e.g., metals) (Tallin et al. 1990). Vertical or lateral migration of brine into groundwater systems or directly into the surrounding environment may lead to salt accumulation and changes in ground and surface water quality, which could affect fish and fish habitat.

The location of the TMA was selected based on geologic and hydrogeologic studies that were completed to identify a suitable foundation that will provide natural containment for the brine material. The stratified clay and clayey tills of the Saskatoon Group are the main geological units that would mitigate the vertical migration of seepage from the TMA (Golder 2015). Soil-bentonite cut-off walls will be used to contain brine areas where shallow stratified sand and gravel deposits are present. The necessity for a deep cut-off wall extending through competent till materials will be determined based on the results of detailed site characterization. Containment berms and dykes will be constructed around the TMA to contain decanted brine. The containment system will be designed to control migration of brine from the salt storage area to underlying aquifers and control the horizontal migration of brine, as required. The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan, with monitoring results providing input for adaptive management. Further, excess brine reclaimed from the TMA will be disposed of by deep well injection, thereby reducing the volume of brine in the TMA and the potential for migrations of brine from the TMA.

Implementation of environmental design features, mitigation, and monitoring programs have shown good performance in preventing vertical and lateral seepage in similar potash projects. No changes to groundwater and surface water quality are expected. Therefore, these pathways were determined to have no linkage to effects on fish and fish habitat.

- **Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality and can affect surface water quality and soil quality, which can affect fish and fish habitat.**

As part of the solution mining process, brine will be disposed of through deep well injection to reduce the amount of brine stored in the TMA. Injecting brine into deep wells can change sub-surface and deep groundwater flows, levels, and quality, which could alter surface water and soil quality. This, in turn, can affect fish and fish habitat. Depending on the chemical composition of the brine being injected, the brine may introduce NaCl, KCl, and other insoluble materials (e.g., metals) to groundwater (Tallin et al. 1990). Disruption in groundwater flow may adversely affect water levels in surface wetlands by changing recharge and discharge areas and rates (Chen and Hu 2004). The potential for brine injection induced changes in groundwater flow and quality to affect surface water hydrology and quality is based on existence of a linkage between the groundwater, where the brine is injected, and the surface water.

Deep well injection of excess brine is a proven practice used to manage brine and prevent release to surface waters and fresh waters aquifers. Methods used in the solution mining process will maintain stability of shallow and deep groundwater aquifers. An assessment of target zones for brine disposal was completed, identifying the Winnipeg Formation and the Deadwood Formation to be suitable for brine disposal. Both formations are sufficiently isolated from the overlying fresh water aquifers, distant from recharge and discharge areas, and have the capacity to accept the waste brine solution from the Project (Appendix 4-A). Given that the formations used for deep well injection are isolated from overlying aquifers and surface water, no changes to surface water quality are expected. Subsequently, this pathway was predicted to have no linkage to effects on fish and fish habitat.

- **Site runoff and associated soil erosion from the core facilities area can affect surface water quality and affect fish and fish habitat.**

Site runoff and associated soil erosion from the core facilities area have the potential to occur during Project construction, operation, and decommissioning and reclamation phases. Runoff and associated soil erosion in the core facilities area and diversion channels may transport sediment and contaminants off-site and change surface water quality, thereby affecting fish and fish habitat.

Several environmental design features and mitigation measures will be implemented to prevent water release from the core facilities area entering the surrounding environment. The general site layout has been developed to use natural topography to assist site drainage to the extent practical. The topography in the area is gently sloping toward the south and slightly to the west. A diversion channel will be constructed to intercept water flowing from upland areas along the north and east borders of the core facilities area.

A Water Management Plan will be developed and infrastructure will be constructed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the facility. The surface water diversion works will be designed to accommodate runoff from a 300-millimetre (mm) rainstorm event over a 24-hour period.

Runoff within the TMA will be redirected to the brine reclaim pond for temporary storage prior to deep-well injection. Salt storage area internal channels (i.e., brine return channels) are designed to collect and redirect runoff originating from precipitation and brine discharges on the tailings areas to the brine reclaim pond. The

TMA will be graded to drain free brine to the brine reclaim pond by gravity. Internal salt tailings dykes and ditches may be required to direct surface flow to the collection ditch during early stages of deposition.

The brine reclaim pond will be constructed to provide containment of brine during the Project. The brine reclaim pond is designed to allow sufficient storage capacity to contain brine decant from the salt storage area during normal operations, store runoff resulting from a design storm event equivalent to 300 mm over a 24-hour period (Section 4.6.2), and possess a 0.9-m freeboard that will accommodate wind-induced setup and wave run-up on the sides of the pond slopes.

Erosion protection of the surface water diversion channel will be provided by topsoil replacement and hydro-seeding to establish grass cover within the diversion channel. A tackifier may be used to increase the temporary soil stability prior to establishment of permanent root systems.

Inspection and maintenance procedures for infrastructure will be outlines in the Water Management Plan and provide input into adaptive management as required. Implementation of environmental design features and mitigation is expected to prevent site runoff and soil erosion from the core facilities area from entering the surrounding environment. Therefore, this pathway was determined to have no linkage to effects on fish and fish habitat.

- **Spills (e.g., waste oil, petroleum products, reagents, potash product, Project equipment leaks, vehicle accidents, and wash-down) can cause changes to surface water quality and affect fish and fish habitat.**
- **Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to groundwater quality and surface water quality, which can affect fish and fish habitat.**

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks, and to limit effects on surface water quality and fish and fish habitat. Pipelines will be used to transport water, brine solution, and potash product to and within the Project footprint. Pipelines will be constructed of standard carbon steel and lined with high-density polyethylene. Pipelines will be installed underground at a depth that will reduce the possibility of damage from frost and surface activities (e.g., farming) and will be monitored for pressure and flow using flow meters. Double-walled pipe for secondary containment will be used in critical crossing areas, based on site-specific analysis to meet environmental conditions. All pipelines will be insulated to maintain the required temperature for the process with the exception of the cold water and the early brine return pipelines. Trains and vehicles will transport chemicals, potash product, and other reagents on- and off-site.

An Emergency Response Plan will be developed as part of the Health, Safety, Security, and Environmental Management System to provide rapid and competent response to incidents that may occur during the Project. Aspects of this plan include instructions and procedures for quick detection, control, and management of spills occurring on site. Other mitigation will include a leak detection system for mining-area pipelines that will consist of monitoring and appropriate pipe isolation to limit potential leaks and promote early detection. Leak detection and monitoring of pipelines will be based on flow and pressure measurements at points along the pipeline. In addition to the pipeline monitoring program, liquid spills, and wash-down occurring within the potash processing facilities will be contained within the mill facility or the engineered site area; salvageable product spills will be recycled into the process feed.

If a spill originates in the tank farm, the hazardous substance will be pumped and properly disposed off-site. The tank farm will be designed to include an adequately sized containment berm for containing potential leaks or spillage. Storage facilities for hazardous wastes will meet regulatory requirements and site personnel will be trained in spill reduction, control, and clean-up procedures. Inspections and maintenance will be completed regularly to prevent leaks from mobile equipment and vehicles. Spill response materials will be maintained at locations where hazardous materials are stored. Disposal of all hazardous materials, such as waste chemicals, hydrocarbons, reagents, and petroleum products, will be handled by a licensed contractor and will be hauled off-site to an approved facility. Waste products from the Project (e.g., hazardous waste, domestic waste, or recyclable waste) will be stored and disposed of following designated procedures by federal and provincial legislation. Domestic and recyclable waste dangerous goods will be stored in appropriate containers until shipped off-site to an approved management facility for licensed disposal. A Waste Management Plan will be developed and will outline best practices for the proper handling and storage of all waste dangerous goods.

Implementation of environmental design features and mitigation are expected to reduce the likelihood and extent of spills and leaks occurring on-site and along transportation corridors resulting in no measureable change to water quality, and no effects on fish and fish habitat are expected to occur. Therefore, these pathways are determined to have no linkage to effects on fish and fish habitat.

- **Slope failure of waste salt storage pile can cause translocation of waste salts and change surface water quality, which can affect fish and fish habitat.**

Failure of the salt storage pile could allow material to enter adjacent watercourses, which could change surface water quality and therefore affect fish and fish habitat. The occurrence of a slope failure is dependent on the design of the salt storage piles; slope failures are generally preventable and local in scale. The volume of tailings produced by the solution mining method for the Project is expected to be lower than conventional underground potash mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only KCl is removed from the caverns during this process.

Salt tailings stockpile stability is governed primarily by the salt pile height, shear strength of the underlying soils, and the degree to which soil pore water pressures are generated in response to the surcharge load of the stockpile. Detailed slope stability analysis for the salt pile will be completed to determine the optimal salt pile height for the Project. The final design of the waste salt storage area will provide for flexibility to expand the storage area in stages through modifications to the footprint or increasing salt pile height should additional storage be required.

The probability of slope failure of the waste salt storage pile will be limited by the implementation of operating procedures and monitoring programs for the salt storage area. Salt pile stability monitoring will be incorporated into the design. As such, this pathway was determined to have no linkage to effects on fish and fish habitat.

- **Deposition of air emissions from the failure of air emission control systems can result in chemical changes to the surrounding environment and affect fish and fish habitat.**

Dust and emissions are generated during the drying and handling of potash and are managed using a combination of dust collection and suppression practices. Dust collection equipment, such as wet scrubbers, cyclones, and baghouses, are used to limit dust and emissions. The cyclone exhaust will be treated in high-energy scrubbers operating at a high-pressure drop. Wet scrubbers will be used to clean the air and rid it of dust particles associated with off-gases produced by the product dryers. The potential exists for failure of air emission control systems, which could result in short-term reductions in air quality.

Testing of emissions from stacks and discharge locations will be employed on an on-going basis to monitor the performance of the system operations. Additionally, regular maintenance of the emission control system components will be completed to reduce the potential for system failure and to confirm that the system is functioning as designed.

Preventative maintenance and monitoring of the air emissions control system is expected to limit the likelihood of system failure. The minor and short-term changes to air quality from a system failure are not anticipated to cause measurable changes to surface water quality, and therefore no effects to fish and fish habitat are expected. As such, this pathway was determined to have no linkage to effects on fish and fish habitat.

11.4.2.2 Secondary Pathways

In some cases, both a source and a pathway exist, but because the change caused by the Project is anticipated to be minor relative to Base Case or guideline values, it is expected to have a negligible residual effect on fish and fish habitat. The pathways described in the following bullets are expected to be secondary and will not be carried forward in the assessment.

- **Air and dust emissions and subsequent deposition can cause changes to the chemical properties of surface water, which can affect fish and fish habitat.**
- **Dust deposition can cover substrates and affect the quality of fish habitat.**

Construction and operation of the Project will generate air emissions such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter with aerodynamic diameter less than 2.5 micrometres (µm) ($PM_{2.5}$), particulate matter with aerodynamic diameter less than 10 µm (PM_{10}), and total suspended particulates (TSP), and KCl. Air emissions can result from Project activities, including the burning of fossil fuels in diesel-fired construction and operating equipment (e.g., trucks, earth movers, and locomotives), and natural gas-fired boilers and product dryers. Transportation routes used to access the Project are predicted to be the main source of dust (i.e., $PM_{2.5}$, PM_{10}, and TSP) due to the resuspension of soil particles. Deposition of dust, metals, acidifying compounds (i.e., SO_2 and NO_2), and other constituents has the potential to change the chemical properties of surface water in the ESA, and therefore affect fish and fish habitat.

Generally, deposition of air emissions and dust is expected to increase total suspended solids (TSS) concentrations and cover bottom substrates. Increased TSS concentrations may reduce fish feeding rates and feeding success in some case, and may result in reduced growth or poor condition (Newcombe and Jensen 1996). Coarse substrates that are generally used for spawning and egg incubation may be covered and rendered unusable or unsuitable. Additionally, KCl-laden dust generated by the Project can cause salinization of the aquatic environment, which can affect fish health and fish habitat quality.

Environmental design features and mitigation will be incorporated into the Project design to limit air emissions and dust from the Project and will reduce changes to surface water quality (Section 7.5 and Table 11.4-1). The dryer burners will be high efficiency, low nitrogen oxide (NO_x) burners to limit the amount of NO_x present in the exhaust stream. The process plant will use cyclones, baghouses, and wet scrubbers to reduce air and dust emissions so that an acceptable working environment is achieved and government standards are met. The cyclone exhaust will be treated in high-energy scrubbers operating at a high-pressure drop. Wet scrubbers will be used to clean the air of dust particles that could result from off-gases produced by the product dryers. A dustless chute and loading system will be installed in the product storage area to reduce dust generation during storage and load-out. Dust-producing components of the potash refinement process (i.e., dryers and compaction circuit) will have controls to recover and return dust to the circuit. Baghouses will be installed throughout the dry process area and dust collected in these baghouses will be conveyed back to the compactors. All conveyors between buildings will be enclosed. Compliance with regulatory stack emissions and ambient air quality standards will be maintained throughout construction and operation of the Project.

To reduce dust generated by vehicles and equipment, paved roads will be used on site as much as possible. Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. Enforced speed limits will assist in reducing production of dust. The Project will be compliant with regulatory emission requirements (i.e., Saskatchewan Ambient Air Quality Standards [SAAQS] [Government of Saskatchewan 2015] or the Canadian Ambient Air Quality Standards [CAAQS] [CCME 2013]).

Air quality modelling was completed to predict the spatial extent of dust deposition and air emissions from the Project (Section 7.5). Air quality modelling was completed using the maximum emissions profile expected during the operations phase of the Project. The cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are predicted to evaluate changes to measurement indicators for air quality during the Application Case. This provides the maximum potential effects from the Project. Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates.

Results of air quality modelling indicate that $PM_{2.5}$ and TSP emissions from the Project are not predicted to exceed CAAQS and SAAQS. The maximum predicted 24-hour PM_{10} concentrations (53.4 micrograms per cubic metre [$\mu g/m^3$]) during the Application Case exceeded the SAAQS value of 50 $\mu g/m^3$ (Section 7.5.2); the maximum concentration occurs east of the mine. However, the background concentration (Base Case) of PM_{10} is 36.3 $\mu g/m^3$, which represents 72.6% of the ambient air quality standard. This background concentration is from the City of Regina, rather than rural Saskatchewan; no rural PM_{10} measurements are available from the MOE. The analysis shows that the averaged days during the Application Case only exceed the SAAQS for three days during the modeling years. Based on air quality monitoring data completed in rural Saskatchewan (i.e., K+S Potash Canada), analysis of rural data from Montana and North Dakota, and current monitoring from near the Project, a more appropriate background value would be approximately 17.9 $\mu g/m^3$. Using a rural background PM_{10} concentration of 17.9 $\mu g/m^3$ results in a maximum predicted concentration of 35 $\mu g/m^3$, which is below the SAAQS.

An extensive assessment of potassium and chloride deposition was completed to assess potential effects on surface water quality (Section 10.4.2.2; Appendix 10-A); results were used to assess effects on fish and fish habitat. Potassium and chloride were included in the assessment, since these constituents were identified in the air quality assessment as having higher than Base Case deposition rates within the ESA (Section 7.5.2). A mass balance approach was used to assess the effects of dust deposition on water chemistry characteristics in West Loon Creek, East Loon Creek, and Loon Creek. Even though East Loon Creek is not considered a fish-bearing watercourse, it was retained in the assessment of effects on fish and fish habitat because the runoff it receives from the surrounding environment eventually flows into Loon Creek, which supports fish, at least on a seasonal basis. Estimated concentrations (milligrams [mg]) of particulate potassium and chloride deposited per square centimetre per month (mg/cm^2/month) were obtained from the air quality modelling team (Section 7.5); dust receptors used in the modelling were based on individual grid cells spread over a 50 km by 50 km area that overlapped most of the ESA. Predictions of potassium and chloride deposition (mg/cm^2/month) were apportioned into the effective drainage areas associated with the West Loon Creek, East Loon Creek, and Loon Creek sub-basins based on boundaries determined from a Light Detection and Ranging (LiDAR)-based digital elevation model and modelled overland flow patterns (Section 9.3.4, Figure 9.3-3). For areas within the West Loon Creek, East Loon Creek, and Loon Creek drainages that fell outside the 50 km by 50 km air quality modelling receptor grid, but within the effective drainage areas of the assessed streams, receptor points were generated and assigned deposition values based on their closest receptor within the modelling grid (Appendix 10-A).

The most realistic, conservative case for potassium and chloride deposition was evaluated to assess possible increases in potassium and chloride concentrations within selected watercourses in the ESA (Appendix 10-A). A seven month period of total accumulation was used in the mass balance model to conservatively represent the total load of particulate material that would likely accumulate in the snowpack and then flow into streams during the spring freshet. It was also assumed that the entire effective drainage area associated with each stream would contribute to runoff, and therefore potassium and chloride loads. The assessment also assumed that 100% of the potassium and chloride deposited in the effective drainage areas would be carried into the streams.

Because West Loon Creek, East Loon Creek, and Loon Creek generally flow only during the spring months, (i.e., during the period of runoff associated with spring snowmelt), the total estimated accumulation of potassium and chloride was added to the total volume of water associated with the spring freshet. Freshet volumes for each sub-basin were modelled based on the behaviour of nearby Jumping Deer Creek, which is monitored by Environment Canada. Three freshet flow volume scenarios were considered, including the average, 80th percentile (i.e., high), and 20th percentile (i.e., low) flow volumes.

Based on the results of the surface water quality assessment, it is anticipated that deposition of potassium and chloride will result in only very small (i.e., less than or equal to 3.5 milligrams per litre [mg/L]) changes to surface water quality in West Loon Creek, East Loon Creek, and Loon Creek (Section 10.4.2.2, Table 10.4-2 and Appendix 10-A). Because water quality changes of this magnitude are well within the range of observed Base Case conditions and below applicable water quality guidelines for the protection of aquatic life (CCME 2015), it is anticipated that air emissions and KCl deposition will have negligible effects on fish and fish habitat.

Overall, is anticipated that air and dust emissions and subsequent deposition from the Project will be minimized through implementation of mitigation. Based on the effects analysis for air quality and surface water quality, it is anticipated that deposition of potassium and chloride will result in minor changes to surface water quality in West Loon Creek, East Loon Creek, and Loon Creek. The minor changes to surface water quality could result in minor and local changes to fish and fish habitat relative to Base Case conditions. Therefore, these pathways were predicted to have negligible residual effects on fish and fish habitat.

- **Ground subsidence caused by solution mining can change surface flows, drainage patterns (distribution), and drainage areas, which can affect fish and fish habitat.**

Solution mining and related removal of solid, liquid, and gaseous materials from below the ground surface results in ground subsidence (i.e., terrain settling). The changes in topography (i.e., slope, gradient, and terrain) resulting from subsidence can alter hydrology, drainage patterns, and drainage areas, change water quality, and affect fish and fish habitat.

The rate of ground subsidence, maximum subsidence depth, and time to reach maximum depth range are based on site and mine-specific conditions (Chrzanowski et al. 1998); however, subsidence generally occurs over the long-term and may require hundreds of years to reach its maximum. Surface subsidence will depend on the specific sequence and timing of well pad development, cavern geometry, material properties of the mining horizon and overlying rock and soils, as well as the actual closure rate of the caverns. As a result, the potential effects due to subsidence were based on ultimate (maximum) subsidence (i.e., after total cavern closure and subsequent translation of this volume change to the ground surface), which is assumed as the worst-case scenario.

The area affected by subsidence is predicted to extend over a distance of approximately 17 km from west to east and about 8 km from north to south and approximately 1.3 km outside the 65-year mine field (Appendix 9-A). Maximum settlement is predicted to occur in the western section of the 65-year mine field directly overlying the caverns. The predicted vertical displacement is predicted to range from 0.5 to 6.7 m. The final gradient surface subsidence at the boundary of the 65-year mine field is expected to be gradual from unaffected areas to the area of maximum subsidence with an average gradient of approximately 3.9 meters per kilometre (m/km). In areas of steeper subsidence gradients, settlement is predicted to increase from 0.5 m to 6.7 m over a distance of approximately 1.6 km, with maximum gradients of 5.0 m/km.

Alteration of surface topography associated with subsidence is predicted to result in small, localized changes to flow pathways and drainage areas within the West Loon Creek basin in the ESA. Changes in flow pathways are mainly predicted along the north and west edges of the 65-year mine field (Appendix 9-A). The volume of flows along major flow paths (i.e., the West Loon Creek) are predicted to be maintained, although localized alterations of flow pathways are predicted to occur and ponded sections may appear. Alterations to smaller drainage area boundaries in the central section of the mine well field area are predicted; however, drainage is expected to continue to direct runoff to West Loon Creek. The major flow paths (i.e., West Loon Creek) are expected to be maintained.

Subsidence is predicted to alter stream channel slopes or gradients of West Loon Creek and two of its smaller tributaries (Appendix 9-A). Sections of these channels occur within the area of maximum subsidence. The gradient of each stream is therefore likely to increase where the stream crosses the area of greatest subsidence. An increase in stream gradient can increase the flow velocities, which may also increase erosion of streambeds and banks. Increased erosion can lead to higher concentrations of suspended solids and other water quality parameters that have the potential to adversely affect fish health. Changes to stream gradients and erosion of stream beds and banks can affect fish habitats by altering the numbers and types of channel units available (e.g., riffle, pool) as well as other habitat features such as cover and substrate composition.

West Loon Creek is the only watercourse within the area of maximum subsidence that is capable of supporting fish, at least on a seasonal basis (Section 11.3). Existing and predicted post-subsidence stream channel invert profiles (Appendix 9-A) indicate the channel gradient of West Loon Creek will likely increase along the north section of the stream (i.e., between 1 and 3.8 km); however, the channel gradient is predicted to decrease or even reverse at three other locations. These predicted decreases in stream gradient are expected to result in the formation of depositional (i.e., pool) habitats between 3.8 and 5.5 km and 9 and 10 km. Fine substrates (e.g., silt) eroded at higher-gradient habitats upstream of 3.8 km are likely to settle out in the slower-water habitat formed between 3.8 and 5.5 km. Stream connectivity is still expected to be intermittent and largely dependent on high-flow events. Pool habitats that can be accessed during high flows are expected to be favourable for Fathead Minnow and for Brook Stickleback (i.e., additional cover and habitat provided by deeper water). Aquatic vegetation, inundated terrestrial vegetation, and overhanging vegetation are expected to continue to provide cover for small-bodied fish in West Loon Creek. Large-bodied fish will continue to be unable to access the creek (Section 11.3).

Subsidence is expected to also affect storage of water on the landscape in the ESA. Existing depressions and wetlands are predicted to receive more runoff in settlement areas because of surface subsidence. It is expected that differential settlement will cause reductions in the water storage capacity of some depressions and wetlands along the west and north sides of the mine area. However, wetlands identified within the ESA are not considered fish-bearing and are unlikely to contain critical fish habitat (Section 11.3). These wetlands are expected to have little to no hydraulic connection to fish-bearing waterbodies or watercourses that would promote fish access and use.

Effects of subsidence will be mitigated by applying environmental design features and specialized techniques for solution mining. For example, pillars of unmined material will be left between the mine caverns to isolate the caverns, to increase stability of the overlying strata, and to reduce the potential effects of subsidence. Cavern spacing may be increased below the pipelines to reduce surface strains and to meet industry standards. Cavern layout will be refined after additional modeling is completed to optimize potash recovery and limit the potential effects of subsidence on surface topography. Secondary mining techniques that reduce the amount of material removed from the mine cavern will be employed after development of primary caverns wherever possible. Finally, extraction ratios will be controlled to limit strain on the overlying environment.

Changes in stream gradients caused by subsidence will occur gradually and take place over hundreds of years such that stream bed erosional and depositional processes are expected to remain within their natural range of variability. Because subsidence will occur very gradually, no acute, adverse effects are expected. West Loon Creek will continue to support small-bodied fish. Therefore, residual effects to fish and fish habitat from ground subsidence caused by solution mining are predicted to be negligible.

11.4.2.3 Primary Pathways

No pathways were identified as having a primary linkages to fish and fish habitat (Table 10.4-1). As such, a residual effects analysis is not required for this section of the EIS.

11.5 Prediction Confidence and Uncertainty

Technical limitations are expected to be present when predicting the response of natural systems to man-made disturbances. Uncertainties may arise from:

- adequacy of baseline data required to understand current condition and predictions of Project-induced effects;
- external influences not related to the Project;
- model uncertainty; and
- knowledge of the effectiveness of mitigation for limiting effects on fish and fish habitat.

The main source of uncertainty is related to the random variability in natural processes (e.g., runoff, discharge) and model uncertainty related to the simplification that occurs when representing complex systems with mathematical equations.

A conservative approach was used to evaluate Project effects on fish and fish habitat. However, there is a level of uncertainty associated with the air quality modeling, mass balance equations, and hydrological data used to assess the potential effects from air emissions and dust deposition on surface water quality and fish and fish habitat. Similarly, there is uncertainty associated with the models used to assess changes to drainage patterns and fish and fish habitat that could result from solution mining and ground subsidence.

For the assessment of air emissions and dust deposition, it is unclear how much of the deposited potassium and chloride will be retained in terrestrial soils and plants relative to the quantities that will enter ESA waterbodies where effects on fish and fish habitat could occur. This uncertainty was addressed by evaluating the most realistically conservative possible case. It was assumed that 100% of the potassium and chloride deposited over snowpack covering the effective drainage areas of West Loon Creek, East Loon Creek, and Loon Creek would be washed into ESA streams during the spring freshet (Section 10.4.2.2). Because effects predictions were based on the most realistically conservative assessment case, it is considered likely that the true surface water effects will not exceed the maximum predicted effects. Given that the effects assessment for fish and fish habitat is based on the results of the effects predictions for water quality, it is considered highly likely that the assessment for fish and fish habitat is sufficiently protective or conservative.

The hydrological data used to assess dustfall and potential effects on fish and fish habitat in West Loon Creek and Loon Creek were limited spatially and temporally. Data for Loon Creek are only available for approximately ten years. Hydrological data collection for the Project, including measurements of flow volumes associated with the spring freshet, was completed in 2013, only. Although conditions recorded in 2013 are considered to represent an average spring freshet, the data do not adequately capture conditions representative of high or low flow years. To address the lack of temporal data within the ESA watercourses, as well as insufficient representation of high and low flow years, the most acceptable baseline data from historical records available for the area were used. Specifically, spring freshet volumes used in the mass-balance equations (Appendix 10-A) were verified or derived using data from Jumping Deer Creek, which is similar to ESA creeks in terms of hydrological conditions and location. Jumping Deer Creek has a more complete flow record (i.e., 73 years) than the ESA watercourses (Section 9.3.4; Appendix 10-A).

Model uncertainty associated with dustfall and surface water quality predictions was addressed by using widely acceptable models to describe the processes under consideration. Parameter uncertainty (i.e., uncertainty related to the lack of actual knowledge of the parameter used in the equations) was addressed by examining the processes occurring at similar developments, primarily existing potash mines in Saskatchewan, and by using model inputs and parameters based on best estimators and conservative scenarios where information is limited. Because the assessment of effects on fish and fish habitat is based on the dustfall and surface water quality predictions, it is anticipated that the use of acceptable models and model inputs would be sufficient to promote confidence in the predictions for fish and fish habitat.

In the assessment of subsidence, use of LiDAR data and Geographic Information Systems (GIS) tools reduced uncertainty in the evaluation of existing drainage patterns. The predicted topography after the terrain has subsided is subject to model and parameter uncertainties. To increase the level of confidence in the subsidence evaluation, parameters were estimated based on observed subsidence values from long-term ground surface elevation surveys at operating potash mines in Saskatchewan (see Appendix 9-A). The evolution in time of subsidence is uncertain due to potential changes in the mine plan and the future technical advances in solution mining that may be adopted to mitigate the environmental effects of subsidence. To be conservative, the hydrological assessment is based on maximum predicted subsidence.

Uncertainty was addressed in the assessment by incorporating information from available and applicable literature, and using past experience in similar areas. Conservative estimates were used so that effects on fish and fish habitat were not underestimated. Best practices during construction, operations, and reclamation activities will be implemented to mitigate residual effects on fish and fish habitat.

11.6 Monitoring and Follow-up

Typically, monitoring includes one or more of the following categories, which may be applied during the development of the Project:

- **Compliance monitoring** – monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments (e.g., inspecting the installation and effectiveness of a silt fence).
- **Follow-up monitoring** – programs designed to test the accuracy of effects predictions, reduce or address uncertainties, determine the effectiveness of environmental design features, or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., monitoring of downstream lakes for aquatic effects, wildlife effects monitoring, and socio-economic monitoring). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

Follow-up programs are typically implemented to determine the accuracy of the predictions or test the effectiveness of environmental design features and mitigation. If monitoring or follow-up detect effects that are different from predicted effects, or the need for improved or modified design features and mitigation, then adaptive management will be implemented. This may include increased monitoring, changes in monitoring programs, and additional mitigation.

Fish and fish habitat monitoring is anticipated to include compliance monitoring; there is no follow-up monitoring program anticipated for fish and fish habitat. Air quality (which can affect water quality) will be monitored during operations to confirm emissions standards are met (Section 7.8). Compliance inspections of environmental design features and mitigation (e.g., silt fences and water diversion structures) will be completed to confirm they are used and operating properly. Regular inspections will confirm the integrity of tanks, ponds, and above-ground and below-ground pipelines and detect potential leaks.

Ground subsidence due to solution mining occurs gradually, with ultimate (maximum) subsidence occurring over a period of hundreds of years. The dynamic change in ground elevation has to be considered for future developments and infrastructure upgrades in this area. Long term monitoring of topographic changes, combined with an adaptive management approach will be used to mitigate potential effects and uncertainty related to subsidence and streamflow.

11.7 Summary and Conclusions

The Project is not expected to affect the ability of fish populations to be self-sustaining and ecologically effective.

Most of the Project footprint is located within the Loon Creek drainage; however, the northwest portion of KP377 drains towards Last Mountain Lake. The main tributaries of Loon Creek include West Loon Creek and East Look Creek. Both West and East Loon creeks have well-defined stream channels. A tributary of West Loon Creek that is referred to as “unnamed stream” has a poorly-defined stream channel and drains a large part of the ESA, including the proposed core facilities area and a portion of the mining area. Although there are no lakes present in the water quality effects study area, there are numerous ephemeral wetlands.

Fish inventory surveys were completed in West Loon Creek, East Loon Creek, Loon Creek, and three disconnected land-locked waterbodies during the spring, summer, and fall of 2013. Brook Stickleback and Fathead Minnows were the only fish species captured or observed in the ESA. Both species were found in West Loon Creek and Loon Creek; no fish were captured in East Loon Creek or any of the sampled wetlands. No large-bodied fish species were captured.

Fish habitat assessments were completed at six sampling stations where fish were captured or observed during the 2013 field season. West Loon Creek and Loon Creek were identified as the only watercourses within the ESA that are capable of supporting fish, at least on a seasonal basis. Small-bodied fish habitat appears to be dependent on annual flow volumes and flow durations, as well as the presence of deeper impoundments and dugouts. Barriers to fish movement were observed in West Loon Creek, East Loon Creek, and Loon Creek. Permanent wetlands within the ESA lacked hydraulic connections to fish-bearing waterbodies or streams and are considered too shallow to provide over-wintering habitat for fish.

Based on the assessment, it is anticipated that deposition of potassium and chloride will result in only very small (i.e., less than or equal to 2.6 mg/L increase in potassium or chloride concentrations) changes to surface water quality in West Loon Creek and Loon Creek (i.e., the only fish-bearing watercourses identified). Therefore, the change in potassium and chloride concentrations is not considered biologically significant. Total predicted surface water concentrations of potassium and chloride during the Application Case are expected to be within the natural range of variability for West Loon, East Loon, and Loon creeks. Salinization of watercourses is not predicted to occur, and chloride concentrations will remain well below the CCME water quality guidelines of 640 mg/L (short-term guideline) and 120 mg/L (long-term guideline) for the protection of aquatic life (CCME 2015). Deposition of potassium and chloride is not predicted to adversely affect fish and fish habitat.

Solution mining and related removal of solid, liquid, and gaseous materials from below the ground surface results in subsidence (i.e., terrain settling). The area affected by subsidence is predicted to extend over a distance of approximately 17 km from west to east and about 8 km from north to south, and may extend approximately 1.3 km outside the 65-year mine field. Maximum settlement is predicted to occur in the western section of the 65-year mine field that lies directly over the caverns. The predicted vertical displacement is predicted to range from 0.5 to 6.7 m. The final gradient of surface subsidence at the boundary of the 65-year mine field are expected to be gradual from unaffected areas to the area of maximum subsidence with an average gradient of approximately 3.9 m/km and a maximum gradient of 5.0 m/km.

Changes to flow pathways are mainly predicted along the north and west edges of the 65-year mine field. However, drainage is expected to continue to direct runoff to West Loon Creek, which is the only watercourse within the area of maximum subsidence that is capable of supporting fish, at least on a seasonal basis. Ground subsidence is predicted to change the channel slope or gradient of West Loon Creek. The gradient of West Loon Creek is likely to increase where the stream crosses the area of greatest subsidence, resulting in increased flow rates and erosion of bed and bank materials. Alternatively, the channel gradient is predicted to decrease or even reverse at three other locations. These predicted decreases in stream gradient are expected to result in the formation of depositional (i.e., pool) habitats. Stream connectivity is still expected to be intermittent, and largely dependent on high-flow events. Pool habitats that can be accessed during high flows are expected to be favourable for both Fathead Minnow and Brook Stickleback. Large-bodied fish will continue to be unable to access the creek.

Effects of subsidence will be mitigated by applying environmental design features and specialized techniques for solution mining. For example, pillars of unmined material will be left between the mine caverns to isolate the caverns, to increase stability of the overlying strata, and to reduce the potential effects of subsidence. Cavern spacing may be increased below the pipelines to reduce surface strains and to meet industry standards. Cavern layout will be refined after additional modeling is completed to optimize potash recovery and limit the potential effects of subsidence. Secondary mining techniques that reduce the amount of material removed from the mine cavern will be employed after development of primary caverns wherever possible. Finally, extraction ratios will be controlled to limit strain on the overlying environment.

Changes to fish and fish habitat from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for more than a century. West Loon Creek will continue to support small-bodied fish. Changes in stream gradients caused by subsidence will take place over a long period such that stream bed erosional and depositional processes are expected to remain within their natural range of variability. No acute, adverse effects on fish and fish habitat are expected.

Overall, it is anticipated, through the use of environmental design feature and mitigation that the Project can be constructed, operated, and decommissioned in a manner that will result in minor and local changes and negligible residual effects on fish and fish habitat. The residual effects from the Project are not likely to contribute to significant effects on self-sustaining and ecologically effective fish populations.

11.8 References

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11.9 Glossary

Term	Description
Backpack electrofishing	An active fish sampling technique used for small wadable streams. Consists of a portable electrofishing unit and a power source attached to a pack frame, with a hand-held and operated anode pole and a cathode plate that trails in the water. The operator activates the anode pole in the water to temporarily stun the fish, while an assistant dip nets the stunned fish.
Best Practice	Method or procedure that is accepted by industry as being effective, practical and reliable in maintaining quality, and meeting Project objectives and regulatory requirements.
Brine	A concentrated solution of inorganic salts.
Boulder	Refers to the particle class size of substrate that is greater than 256-mm diameter.
Channel	A landform formed by fluvial processes and consisting of a channel bed and banks within which the flow of a stream is usually confined. Outside the stream channel is its flood plain which is flooded when water levels are backwatered by ice or beaver dams or during high discharge flood conditions.
Clay	Refers to the substrate particle class size that is less than 0.004 mm- diameter.
Creek	A branch or small tributary of a river.
Catch-per-unit-effort (CPUE)	A measure of the sampling effort expended to catch a certain number of fish with a particular type of gear. Expressed as number of fish captured per unit of effort. It may be used to define relative fish species abundance and to compare abundances of fish between sites and seasons.
Drainage area	The region of land that could contribute water to a stream or waterbody via overland or subsurface flow.
Drainage area boundary	The boundary of a drainage area for a single point on a stream or for a waterbody. Calculated using topographic data such as elevation contours or a digital elevation model. Also known as a watershed boundary.
Erosion	The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. Detachment and movement of soil or rock by water, wind, ice, or gravity.
Fish	According to the *Fisheries Act* (1985), fish refers to fish, shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals and the eggs, sperm, spawn, larvae, spat, and juvenile stages of fish, shellfish, crustaceans, and marine animals.
Gravel	Refers to the particle class size of substrate that is 2.0 to 64 mm- diameter.
Minnow trap	Passive fish capture technique used to sample for the presence of small-bodied species and small life stages (i.e., fry) of large-bodied species. Consists of two pieces of a trap that are clipped together to form a small cylinder. Each end of the trap is slightly tapered with a funnel opening that allows fish to enter, but prevents them from exiting.
Sand	Refers to the particle class size of substrate that is 0.063 to 2.0 mm- diameter.
Sediment	Solid material that is transported by, suspended in, or deposited from water. It originates mostly from disintegrated rocks but may include chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics and cause of the occurrence of sediment in streams is influenced by environmental factors (e.g., degree of slope, length of slope soil characteristics, land usage, quantity, and intensity of precipitation).
Silt	Refers to the particle class size of substrate that is between 0.004 and 0.063 mm.
Substrate	Refers to the material that comprises the bottom of a waterbody or watercourse, including all wetted and unwetted areas.
Total dissolved solids	The total concentration of all dissolved compound found in a water sample.
Total suspended solids	The amount of suspended substances in a water sample. Solids, found in wastewater or in a stream, which can be removed by filtration. The origin of suspended matter may be artificial or anthropogenic wastes or natural sources such as silt.
Waterbody	A general term that refers to ponds, bays, lakes, estuaries, and marine areas.
Watercourse	A general term that refers to riverine systems such as creeks, brooks, streams, and rivers.

12.0 SOILS

12.1 Introduction

12.1.1 Background

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project) located in central Saskatchewan, approximately 60 kilometres (km) north of Regina. Yancoal proposes to develop the Project, which includes solution mining and associated supporting infrastructure.

The Project is located in the Rural Municipality (R.M.) of Longlaketon (No. 219) and the R.M. of Cupar (No. 218). An existing network of municipal grid roads, provincial highways, and rail lines will provide access to the Project. The Project (including the core facilities area, 65-year mine field, and indicated resource boundary) encompasses approximately 143 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M).

12.1.2 Purpose and Scope

This section of the Environmental Impact Statement (EIS) for the Project addresses the effects on soils identified in the Project Terms of Reference (TOR) approved by the Environmental Assessment Branch (EAB) of the Ministry of Environment (MOE) in May 2015 (Appendix 2-B).

The purpose of this section is to meet the TOR, specifically to assess the effects from the Project on soils. The scope of this section includes an analysis of Project-related changes during construction, operation, and decommissioning and reclamation. The incremental and cumulative residual effects from the Project and other previous, existing, and reasonably foreseeable developments on soils are assessed.

The healthy functioning of soils is dependent on continual interactions among climate, air quality, the hydrological cycle, water quality, vegetation, and wildlife. Alterations to soil resources can influence their use by people. As such, related assessments are provided in the following sections:

- Atmospheric Environment (Section 7.0);
- Hydrogeology (Section 8.0);
- Hydrology (Section 9.0);
- Surface Water Quality (Section 10.0);
- Vegetation (Section 13.0);
- Wildlife (Section 14.0); and
- Socio-economic Environment (Section 16.0).

12.1.3 Valued Components, Assessment Endpoints, and Measurement Indicators

The TOR identified soils as a valued component (VC) that should be included in the assessment of effects on the terrestrial environment. Valued components (VCs) represent physical, biological, cultural, social, and economical properties of the environment determined to be important by the proponent, the public, First Nations and Métis communities, and government agencies. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development, and therefore, are used to predict the effects of the Project on all environmental components. Rationale for selection of soils as a VC is as follows:

- sensitivity to Project-related effects;
- can be measured or described with one or more practical indicators; and
- soils can influence other terrestrial and societal components.

Community and regulatory engagement, and local and traditional knowledge were key considerations for selecting VCs, but assessment endpoints for soils do not explicitly consider societal values, such as continued suitability of soils for human use. Changes in soils are important and must be considered to understand the full suite of potential effects of the Project (i.e., both biophysical and socio-economic dimensions). Consequently, measurement indicators from the soils section were carried forward so that effects on societal values could be appropriately captured in the sections dealing specifically with those values (Section 16.0).

Assessment endpoints are qualitative expressions used to assess the significance of effects on a VC and represent the key properties of the VC that should be protected for use by future human generations (i.e., incorporate sustainability). Assessment endpoints are general statements about what is to be protected. Measurement indicators are quantitative and/or qualitative expressions of changes to the assessment endpoints. The assessment endpoint for the soils VC is soil capability to support agriculture and other plant communities. The measurement indicators include the following:

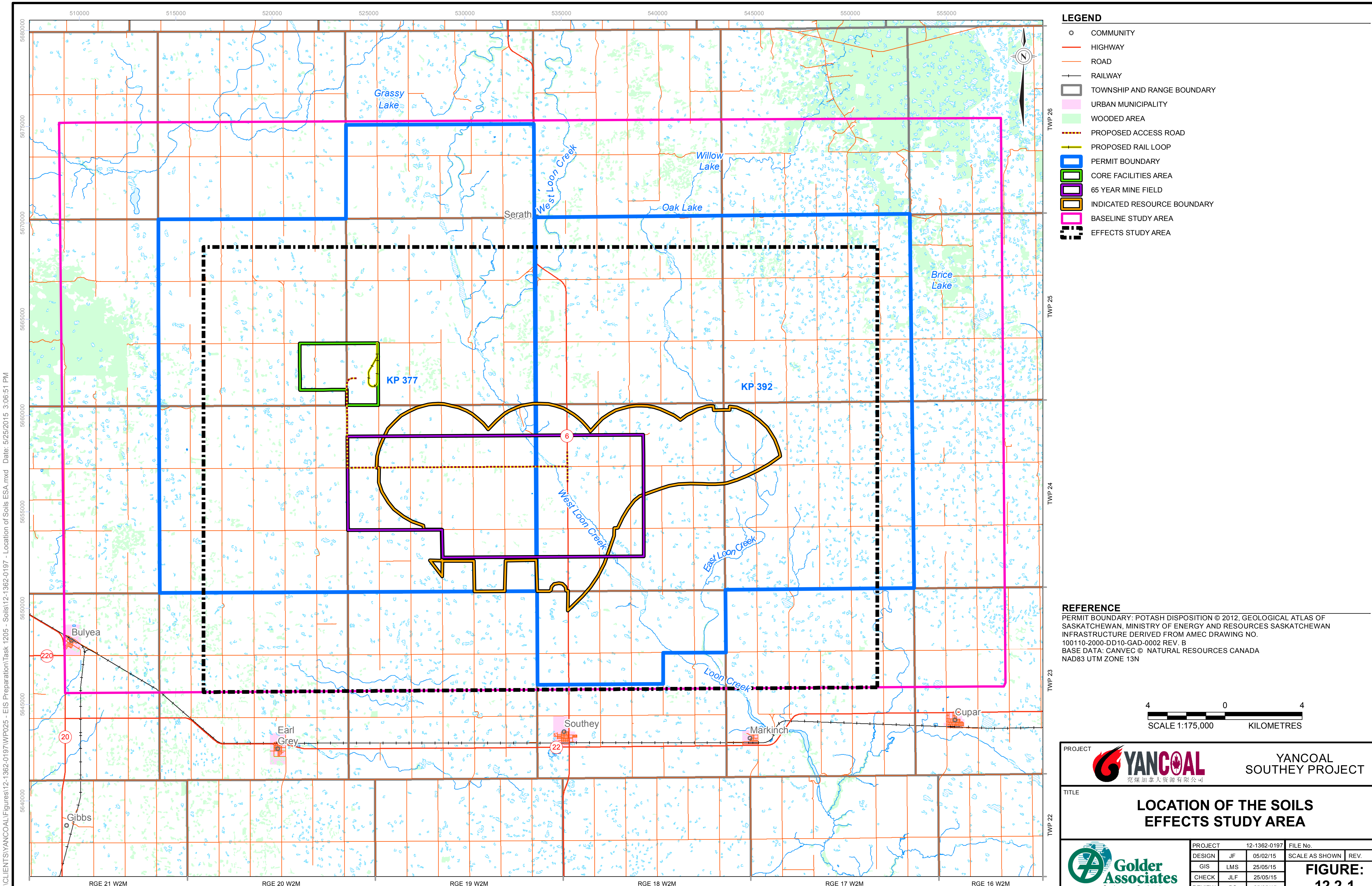
- soil quality (i.e., physical, biological, and chemical properties); and
- soil quantity and distribution.

12.2 Environmental Assessment Boundaries

12.2.1 Spatial Boundaries

12.2.1.1 Baseline Study Area

To quantify baseline conditions of the terrestrial environment, a baseline study area (BSA) was delineated for terrain and soils, vegetation, and wildlife (Figure 12.2-1). The terrestrial BSA was designed to measure and characterize existing environmental conditions on a continuum of scales from the anticipated Project footprint to broader, regional levels. At the initiation of field programs, the location of the Project footprint was unknown; therefore, a preliminary focus area was delineated for the Project (Annex IV, Section 2.0). The focus area was buffered by 5 km to encompass potential indirect effects from the Project on vegetation and wildlife. As the Project design evolved, this area was increased to encompass the entire KP377 and KP392 permit areas and a 5-km buffer area. The final BSA selected for terrestrial components encompassed an area of approximately 1,444 km^2 (144,425 ha) (Annex IV, Section 2.0). The north portion of KP377 and the south portion of KP392 were not buffered by 5 km for the final BSA, because of the low likelihood that the Project footprint will occur in these areas.



LEGEND
COMMUNITY
HIGHWAY
ROAD
RAILWAY
TOWNSHIP AND RANGE BOUNDARY
URBAN MUNICIPALITY
WOODED AREA
PROPOSED ACCESS ROAD
PROPOSED RAIL LOOP
PERMIT BOUNDARY
CORE FACILITIES AREA
65 YEAR MINE FIELD
INDICATED RESOURCE BOUNDARY
BASELINE STUDY AREA
EFFECTS STUDY AREA
Grassy Lake
Willow Lake
West Loon Creek
Serath
Oak Lake
Brice Lake
KP 377
KP 392
East Loon Creek
Loon Creek
Bulyea
Earl Grey
Southey
Markinch
Cupar
Gibbs
20
220
22
6
TWP 26
TWP 25
TWP 24
TWP 23
TWP 22
RGE 21 W2M
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REFERENCE
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INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N
4 0 4
SCALE 1:175,000 KILOMETRES
PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT
TITLE
LOCATION OF THE SOILS EFFECTS STUDY AREA
Golder Associates
Saskatoon, Saskatchewan
PROJECT 12-1362-0197
FILE No.
DESIGN JF 05/02/15
SCALE AS SHOWN REV. 0
GIS LMS 25/05/15
CHECK JLF 25/05/15
REVIEW BC 25/05/15
FIGURE: 12.2-1
G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1205 - Soils\12-1362-0197 - Location of Soils ESA.mxd Date: 5/25/2015 3:06:51 PM

12.2.1.2 Effects Study Area

To assess Project-related effects on the terrestrial environment, an effects study area (ESA) was delineated for terrain and soils, vegetation, and wildlife. The ESA defined for terrain and soils, vegetation, and wildlife is approximately 804 km^2 (80,385 ha), and is located within the BSA (Figure 12.2-1). The ESA includes both unaffected (i.e., reference) areas, as well as areas influenced by the Project. Wildlife has the largest range and was the key factor in defining the ESA. As described in the Terrestrial Baseline report (Annex IV, Section 2.0), the Project is located near Highway 6, grid roads 641 and 731, the towns of Southey and Earl Grey, and is in an area dominated by cultivation. It is anticipated that songbirds, waterbirds, and raptors will likely be the only wildlife species negatively affected by the Project. Therefore, an approximate 5-km buffer was used to define the ESA to encompass the predicted maximum spatial extent of direct and indirect effects (i.e., zones of influence) from the Project on songbirds, waterbirds, and raptors.

Although soil development and distribution can change over geological time, it is expected that the soil associations will not be naturally altered within the temporal boundary of the assessment. Therefore, the ESA is large enough to provide ecologically relevant and confident assessment of the direct and indirect effects on soils from the Project, and the potential cumulative effects from the Project and other previous, existing, and reasonably foreseeable developments.

The ESA is situated on a transitional area between the boundaries of the Moist Mixed Grassland and Aspen Parkland Ecoregions of the Prairie Ecozone in Saskatchewan (Acton et al. 1998). The west portion of the ESA is in the Strasbourg Plain Landscape Area within the Moist Mixed Grassland Ecoregion. The east portion of the ESA is situated in the Touchwood Hills Upland Landscape Area of the Aspen Parkland Ecoregion.

The Moist Mixed Grassland Ecoregion represents the northern-most extent of open grassland in the province and has a warm and subhumid continental climate (Acton et al. 1998). Glacial till and glaciolacustrine deposits are the dominant parent materials in the ecoregion. The Aspen Parkland Ecoregion represents the transition zone between the open grasslands in the south and the continuous forests of the north. Glaciofluvial and glaciolacustrine deposits are prevalent in the region.

The Strasbourg Plain Landscape Area is a moderately sloping, hummocky glacial till plain interspersed with glacial kettles. The area mainly supports crop production, except in areas limited by wet or saline soils. The dominant soils in upland areas of the Strasbourg Plain are Dark Brown Chernozems formed on loamy glacial till parent material (Acton et al. 1998).

The Touchwood Hills Upland Landscape Area is a moderately sloping, hummocky glacial till landscape. Most of the landscape area supports cultivated cropland with rangeland and pasture in areas associated with steep slopes and treed landscapes. Approximately 30% of the landscape area is uncultivated aspen parkland on hummocky terrain. The dominant soils in the Touchwood Hills Upland Landscape Area are Black Chernozems formed on loamy glacial till parent material (Acton et al., 1998).

Gleysols or Gleyed Chernozems may be present in wetland areas or saturated depressions within the ESA and Regosols or Rego Chernozems may be present in areas of poor soil development or where the upper soil profile has been eroded (e.g., at upper slope positions on hillsides).

12.2.2 Temporal Boundaries

Temporal boundaries for the soils assessment were defined by the life of the Project (Section 4.0) and the existing and future cumulative effects to which the Project might contribute. The Project phases are construction, operation, and decommissioning and reclamation. Final relinquishment of the Project will occur after the completion of reclamation. Many effects of the Project will end when operations cease or at decommissioning and reclamation, but effects on soils will continue until previous land-use is re-established.

The effects analysis encompasses the Project phases as follows:

- construction (2016 to 2019);
- operations (2019 to 2119); and
- decommissioning and reclamation (2119 onward).

The above timeframes are intended to be sufficiently flexible to capture the effects of the Project on the soils VC. Effects on soils begin during the construction phase with the removal and alteration of soil for site development, and continue through the operation phase and for a period during the completion of reclamation activities (unless determined to be permanent). Therefore, effects on soils were analyzed and assessed for significance from Project construction through decommissioning and reclamation. This approach generates the maximum potential spatial and temporal extent of effects on soil quality and quantity, which provides confident and ecologically relevant effects predictions.

Although the assessment of residual effects of the Project considers all Project phases listed above, temporal snapshots (i.e., static moments in time) were used to characterize the ESA landscapes and facilitate quantitative and qualitative comparisons for each of the assessment cases described below.

12.2.2.1 Base Case

The Base Case (existing environment) represents existing conditions before application of the Project. Previous and existing developments and activities include roads, communities, and agricultural activities. Consequently, the Base Case represents the cumulative outcome of all previous and existing developments and activities.

12.2.2.2 Application Case

The incremental contributions of residual effects from the Project to existing cumulative effects were assessed at the ESA scale by adding the Project to the Base Case to form the Application Case. The temporal snapshot used was the Project footprint at a maximum point of development of the Project (i.e., core facilities area, plant site access road, and 19 well pads and associated well site access roads). Changes to measurement indicators for soils were predicted and incremental contributions of the Project and cumulative effects of the Project plus previous and existing developments and activities were evaluated.

12.2.2.3 Reasonably Foreseeable Development Case

The Reasonably Foreseeable Development (RFD) Case represents the Application Case plus reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. The minimum temporal boundary for the Application Case and RFD Case is the expected lifespan of the Project that, like the Base Case, includes a range of conditions over time. The difference between the Application and RFD Case is that the Application

Case considers the incremental effect from the Project in isolation of potential future land use activities. The RFDs are defined as projects that:

- are currently under regulatory review or have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project or may be induced by the Project;
- have been approved but not yet developed; or
- have the potential to change the Project or the effects predictions.

The reasonably foreseeable developments identified in Section 6.0 include the supporting infrastructure required for the Project, the Muskowekwan Potash Mine Project, and the Vale Kronau Project. Supporting infrastructure will include a water supply pipeline, an overhead transmission line, a natural gas supply pipeline, telecommunication services, and a railway line. Screening assessment reports will be completed by each of the utility providers once the final routing options are determined. Most of the preferred routes for the supporting infrastructure are not within the ESA and the final routing options are not known at this time. Muskowekwan Potash Mine Project, which is located approximately 52 km northeast of the Project, and the Vale Kronau Project, which is located approximately 71 km south of the Project, both are outside the ESA. Effects to soils from development of the Muskowekwan Potash Mine Project and the Vale Kronau Project are not expected to overlap with effects to soils in the ESA. Therefore, the RFD Case is not included in this section of the EIS.

12.3 Existing Environment

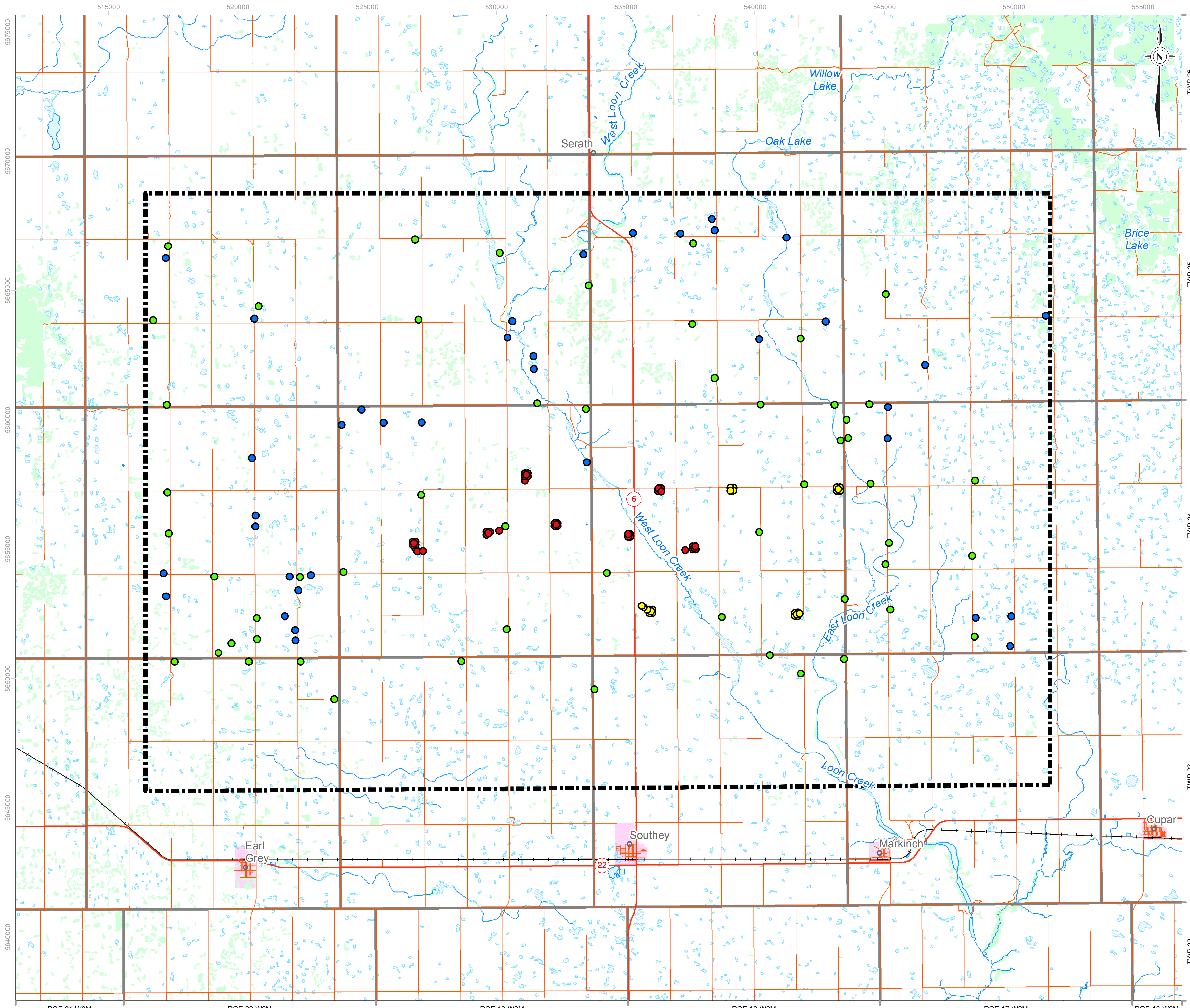
The purpose of this section is to describe the existing environment (Base Case) within the ESA as a basis to assess the potential Project-specific effects on soils. The detailed methods and results for the baseline surveys are located in the Terrestrial Environment Baseline Report (Annex IV, Section 3.0).

12.3.1 Methods

12.3.1.1 Data Collection

A baseline field program was completed to confirm that field survey data correlates with mapped soils identified in provincial soil maps. Soils that were selected to be surveyed were identified from existing soil mapping (i.e., soil map unit and soil association distribution) obtained from published soil surveys available in digital format (SLRU 2004). The published soil survey data also includes agriculture capability information.

The baseline field program was completed between September 30, 2013 and October 10, 2013 and encompassed all possible locations of the Project footprint identified at the time of the field program. The field program was designed to target three soil survey locations for each representative soil association in the ESA; with more focus on dominant soil associations. Detailed soil and terrain information was collected from 113 locations that were surveyed; 91 of these locations are within the ESA (Figure 12.3-1). Of the 91 soil survey locations within the ESA, 37 were sampled for baseline chemistry. Soil survey locations were selected so that representative locations within each soil association were characterized and sampled.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- WOODED AREA
- EFFECTS STUDY AREA
- SOIL SURVEY LOCATION CLASSIFIED - 2013
- SOIL SURVEY LOCATION CLASSIFIED AND SAMPLED - 2013
- PRE-DISTURBANCE SITE ASSESSMENT - 2012
- PRE-DISTURBANCE SITE ASSESSMENT - 2013

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
SOUTHEY PROJECT

TITLE
SOIL SURVEY LOCATIONS IN THE EFFECTS STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	JF	05/02/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	FIGURE: 12.3-1	
CHECK	JLF	25/05/15		
REVIEW	BC	25/05/15		

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Pre-disturbance site assessments (PDSA) were completed at 11 exploration well sites in 2012 and 2013 (Figure 12.3-1). Terrain and soil information was collected and a minimum of five soil test pits were characterized at each pad site. Each horizon was sampled from each test pit and composite horizon samples were analyzed for baseline chemistry.

Soil profiles were characterized to a maximum depth of 100 centimetres (cm) at each soil survey location. Soil classification and horizon designation followed *The Canadian System of Soil Classification* (SCWG 1998). Chemistry data for soils were used to determine reclamation suitability, sensitivity to acidification, and baseline metal chemistry.

12.3.1.2 Soil Associations in the Effects Study Area

Areas of map units within the ESA were quantified using the digital soil mapping data (Annex IV, Section 3.2.1; SLRU 2004) in a Geographic Information System (GIS) platform. While the soil polygon boundaries imply that there are abrupt changes in soil types across the landscape, soils vary continuously, and the soil polygon boundaries approximate where the transitions between soil map units occur. Survey data collected during the baseline program were used to update mapped soil polygon boundaries where soil associations that were classified from survey data did not correlate with the digital soil mapping data SLRU (2004).

Soil association areas in the ESA were estimated from the percent soil polygon area of dominant, sub-dominant, and co-dominant soils obtained from the digital soil mapping data (SLRU 2004). The percentage area of soil associations present within individual soil polygons was calculated to obtain the total area of each soil association in the ESA. Simple map units in the ESA represent between 85% and 100% of one soil association. The compound units in the ESA describe a dominant soil association (60% to 85% of map unit area) and a subdominant soil association (up to 40% of map unit area), or describe a co-dominant soil associations (equal map unit area). Inclusions were quantified based on SLRU (2004) information (i.e., 15% of map unit area). Inclusions in the ESA are generally Gleysolic soils and shallow water present in wetlands contained in depressional, poorly drained areas (SLRU 2004).

12.3.1.3 Soil Agriculture Capability in the Effects Study Area

Information on soil capability for agriculture (class and subclass) within the ESA was obtained from the digital soil mapping data (SLRU 2004). Areas of agriculture capability assigned to each soil map unit within the ESA were quantified in a GIS platform and the areas of agriculture capability classes and subclasses were calculated based on the percent area presented in the agriculture capability symbol, which is linked to each soil map polygon.

12.3.1.4 Sensitivity to Erosion

Water and wind are the main mechanisms of soil erosion on arable land. Depending on terrain and soil characteristics, continuous exposure of soil to wind or rain might cause soil materials to be eroded resulting in the loss of topsoil and reducing soil quality and the ability for soil to support agricultural and other vegetation communities. Potential off-site effects of soil erosion include sedimentation of adjacent waterbodies and the release of chemicals from the soil into surface water, which may alter water quality (Kuhn and Bryan 2004).

Soil sensitivity to water and wind erosion were assigned to soil map units within the ESA. Soil water erosion sensitivity ratings were assigned following methods described by the Transportation Association of Canada (TAC 2005). In areas where slope gradient increases, so does the potential for soil erosion regardless of soil texture. Water erosion sensitivity ratings are based on soils that have been disturbed and have not had mitigation applied. Wind erosion ratings were assigned based on dominant soil textures identified during the baseline field program and the criteria outlined in Coote and Pettapiece (1989). Wind erosion ratings are based on disturbed, bare soils that have not had mitigation applied. Disturbance can increase the wind erosion sensitivity of finer textured soils under dry conditions. Where available, soil textures determined by the lab were used in place of field texture data.

12.3.1.5 Sensitivity to Compaction

Compaction ratings for soils in the ESA were determined following the criteria outlined in Lewis et al. (1989). Topsoil (A horizon), upper subsoil (B horizon), and lower subsoil (BC and/or C horizons) textures in the ESA were rated for soil sensitivity to compaction based on dominant soil textures observed within each association during field surveys and prevailing moisture conditions. Soil moisture conditions are dominantly moist; however, Gleysolic soils have wet soil moisture conditions and soils with rapid drainage generally have dry moisture conditions. Where available, lab texture data were used in place of field texture data.

12.3.1.6 Sensitivity to Acidification

The sensitivity of soils to acid deposition was evaluated using the chemical criteria published by Holowaychuk and Fessenden (1987). Soils are categorized as having High, Medium, or Low sensitivity ratings. The ratings are based on the sensitivity to loss of basic cations (primarily calcium [Ca^{+}], magnesium [Mg^{2+}], and potassium [K^{+}]), sensitivity to acidification, and sensitivity to solubilization of aluminum. An overall soil sensitivity to acidification was rated for representative locations sampled during the baseline soil survey. The ratings assigned to soils were based on the pH and cation exchange capacity (CEC) of the topsoil (A horizon).

12.3.1.7 Reclamation Suitability

Methods for determining reclamation suitability in the Prairie Region are described in Alberta Agriculture (1987). Criteria for evaluating reclamation suitability are divided into two lifts: topsoil and subsoil (upper subsoil and lower subsoil). The topsoil is defined as the surface A horizon of the soil profile and includes the plant litter layer (where present). The upper subsoil is the B horizon and the lower subsoil is the upper portion of the parent material (BC and/or C horizons). Reclamation suitability classes include Good, Fair, Poor, and Unsuitable (Alberta Agriculture 1987). Chemistry results for each soil map unit were averaged and compared to the criteria in Alberta Agriculture (1987). Where 50% or less of the data were below detection limits, half of the detection limit value was used in calculations of mean. Where more than 50% of the data were below the detection limit, the mean was not calculated.

12.3.1.8 Baseline Metal Chemistry

Baseline metal concentrations (i.e., the average value of soil samples obtained from each surveyed soil association) were compared to the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health for Agricultural Land-Use Areas (CCME 2013). For calculations of mean and standard deviation, where 50% or less of the data were below detection limits, half of the detection limit value was used in calculations. Where more than 50% of the data were below the detection limit, mean and standard deviation were not calculated.

12.3.2 Results

12.3.2.1 Terrain and Soils in the Effects Study Area

The 2013 baseline field program and the 2012 and 2013 PDSAs identified the dominant surface expressions throughout the ESA as undulating and rolling. Slopes were commonly between 2% and 5% and the steepest slopes (10% to 15%) were recorded in areas associated with steep valleys. Terrain information from SLRU (2004) identified typical surface expressions in the ESA as hummocky, with mostly gentle to moderate slopes between 2% and 15%. The steepest slopes recorded in SLRU (2004) were also associated with valleys, and ranged between 10% and 45% (strong to very steep slopes).

The western half of the ESA overlaps the Dark Brown soil zone and the eastern half of the ESA overlaps the Black soil zone. Soil data collected during field programs generally correlated with soil zones. Dark Brown and Black Chernozemic soil great groups were classified in areas of the ESA overlapping the Dark Brown and Black soil zones. The dominant soils identified within the ESA included Orthic Dark Brown Chernozems, Orthic Black Chernozems, Calcareous Dark Brown Chernozems, and Calcareous Black Chernozems. The survey intensity level of the field program was approximately 1 point per 788 ha and approximately 54% of the map units present were surveyed. This corresponds to a Level 4 survey intensity level (i.e., at least 1 point within 30% to 60% of delineations, or approximately 1 point per 100 to 1,000 ha).

12.3.2.2 Soil Associations in the Effects Study Area

In the ESA, 19 soil associations were mapped in 29 simple map units and 32 compound map units (Table 12.3-1; Figure 12.3-2). The Oxbow association is the most common soil association, covering approximately 30,269 ha or 37.7% of the ESA, and is present in 15 simple and compound map units. The Weyburn association is the second most common and covers approximately 29,890 ha (37.2%) of the ESA and is present in 14 simple and compound map units (Table 12.3-1). Wetland soils (Gleysols) occupy the third largest area of the ESA, covering approximately 7,364 ha (9.2%).

Table 12.3-1: Absolute and Relative Area of Soil Map Units within the Effects Study Area for the Base Case

Soil Association(s)	Map Units	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Asquith	Aq10	191	0.2	287	0.4
	Aq14	96	0.1		
Asquith-Biggar	AqBg4	166	0.2	166	0.2
Asquith-Bradwell	AqBr4	382	0.5	382	0.5
Biggar	Bg2	216	0.3	216	0.3
Bradwell	Br12/T	248	0.3	248	0.3
Bradwell-Asquith	BrAq8	81	0.1	127	0.2
	BrAq13	46	0.1		
Elstow	Ew1	58	0.1	58	0.1
Elstow-Weyburn	EwWr4	1,007	1.3	1,465	1.8
	EwWr11	458	0.6		

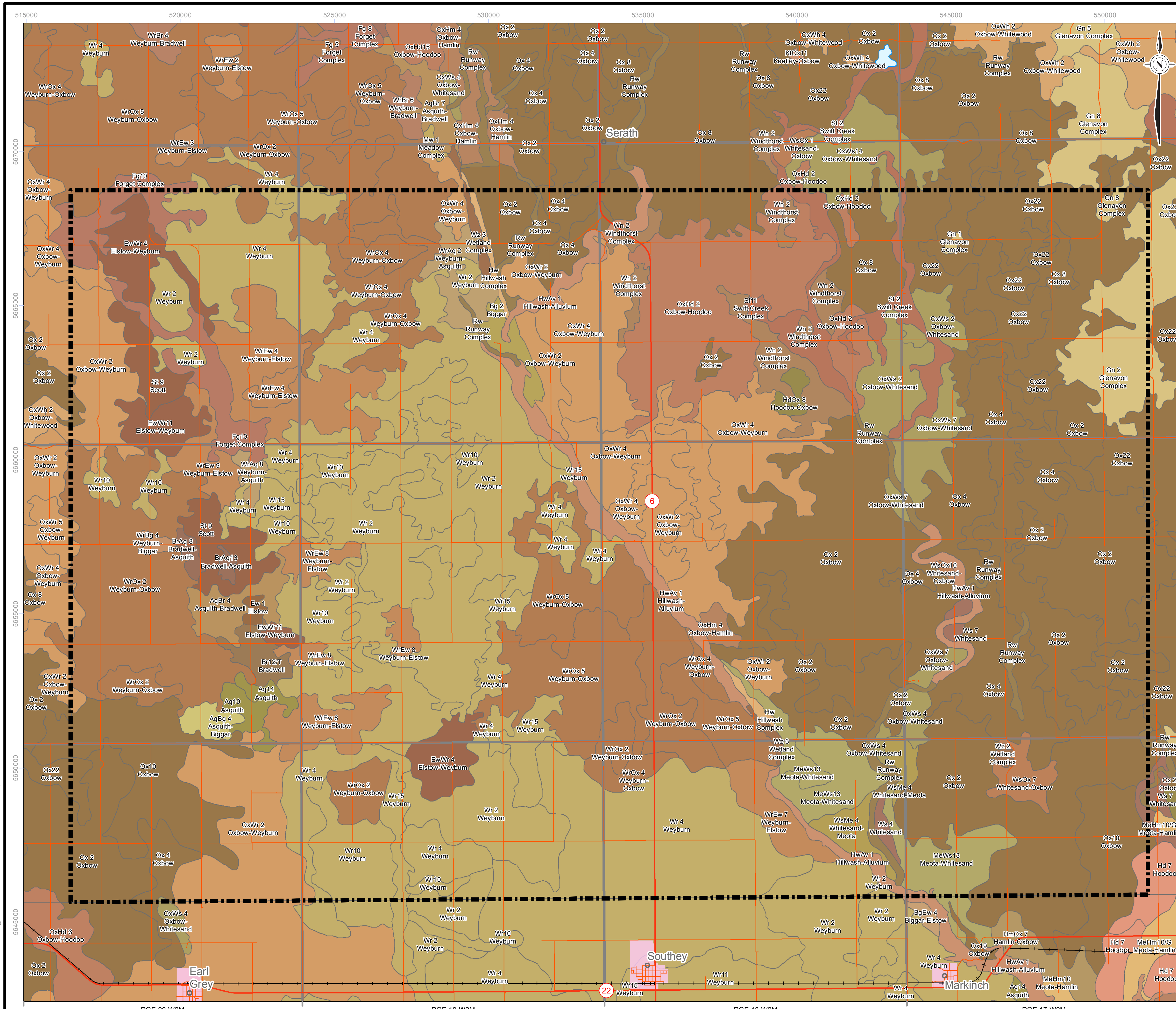
Table 12.3-1: Absolute and Relative Area of Soil Map Units within the Effects Study Area for the Base Case

Soil Association(s)	Map Units	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Forget Complex	Fg10	986	1.2	986	1.2
Glenavon Complex	Gn1	26	<0.1	1,116	1.4
	Gn2	1,034	1.3		
	Gn8	55	0.1		
Hillwash Complex	Hw	130	0.2	130	0.2
Hillwash-Alluvium Complex	HwAv1	1,328	1.7	1,328	1.7
Hoodoo	Hd 7	59	0.1	59	0.1
Hoodoo-Oxbow	HdOx8	115	0.1	115	0.1
Meota-Whitesand	MeWs13	1,446	1.8	1,446	1.8
Oxbow	Ox2	12,535	15.6	23,452	29.2
	Ox4	3,426	4.3		
	Ox8	1,317	1.6		
	Ox10	2,195	2.7		
	Ox22	3,978	4.9		
Oxbow-Hamlin	OxHm4	113	0.1	113	0.1
Oxbow- Hoodoo	OxHd2	2,996	3.7	2,996	3.7
Oxbow-Weyburn	OxWr2	3,764	4.7	7,671	9.5
	OxWr4	3,882	4.8		
	OxWr5	25	<0.1		
Oxbow-Whitewood	OxWh2	<1	<0.1	<1	<0.1
Oxbow-Whitesand	OxWs2	816	1.0	1,719	2.1
	OxWs4	182	0.2		
	OxWs7	630	0.8		
	OxWs14	91	0.1		
Runway Complex	Rw	566	0.7	566	0.7
Scott	St9	862	1.1	862	1.1
Swift Creek Complex	Sf2	472	0.6	954	1.2
	Sf11	482	0.6		
Weyburn	Wr2	8,401	10.5	18,597	23.1
	Wr4	7,081	8.8		
	Wr10	2,141	2.7		
	Wr15	973	1.2		

Table 12.3-1: Absolute and Relative Area of Soil Map Units within the Effects Study Area for the Base Case

Soil Association(s)	Map Units	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
Weyburn-Asquith	WrAq2	397	0.5	498	0.6
	WrAq8	102	0.1		
Weyburn-Biggar	WrBg4	55	0.1	55	0.1
Weyburn-Elstow	WrEw4	1,431	1.8	3,236	4.0
	WrEw7	433	0.5		
	WrEw8	1,017	1.3		
	WrEw9	356	0.4		
Weyburn-Oxbow	WrOx2	4,322	5.4	9,567	11.9
	WrOx4	1,651	2.1		
	WrOx5	3,594	4.5		
Windthorst Complex	Wn2	963	1.2	963	1.2
Whitesand	Ws4	71	0.1	176	0.2
	Ws7	105	0.1		
Whitesand-Meota	WsMe4	372	0.5	372	0.5
Whitesand-Oxbow	WsOx7	282	0.4	307	0.4
	WsOx10	25	<0.1		
Wetland Complex	Wz2	27	<0.1	154	0.2
	Wz3	127	0.2		
Total		**80,385**	**100**	**80,385**	**100**

Notes: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
ha = hectares; % = percent; < = less than.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

SYMBOL SEQUENCE

ASSOCIATION SYMBOL ← An 2 Allan → MAP UNIT

→ ASSOCIATION NAME

NOTE

1. THE NUMBERS SHOWN WITH ASSOCIATION LABELS ARE TERMED MAP UNITS AND INDICATE DIFFERENT AND SPECIFIED COMBINATIONS OF SOIL SUBGROUP PROFILES WITHIN AN ASSOCIATION THAT ARE THE RESULT OF VARIATIONS IN TOPOGRAPHY, DRAINAGE OR ASPECT.
2. SOIL POLYGONS WERE UPDATED BASED ON FIELD SURVEY RESULTS.

REFERENCE

SASKATCHEWAN LAND RESOURCES UNIT, 2004
SKSISV2, DIGITAL SOIL RESOURCE INFORMATION FOR AGRICULTURAL SASKATCHEWAN, 1:100,000 SCALE,
AGRICULTURE AND AGRI-FOOD CANADA, SASKATOON, SASKATCHEWAN.
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

2.5 0 2.5
SCALE 1:125,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
SOIL ASSOCIATIONS DISTRIBUTION FOR THE BASE CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197		FILE No.
DESIGN	JF	05/02/15	SCALE AS SHOWN REV. 0
GIS	LMS	25/05/15	
CHECK	JLF	25/05/15	FIGURE: 12.3-2
REVIEW	BC	25/05/15	

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12.3.2.3 Soil Agriculture Capability in the Effects Study Area

The soil agriculture capability ratings of map units in the ESA include Class 1 to Class 7 (Table 12.3-2; Figure 12.3-3). The Class 3 agriculture capability rating encompasses the greatest proportion of the ESA (approximately 39,291 ha or 48.9%). Approximately 16,609 ha (20.7%) of the ESA has been rated as Class 2, and approximately 9,518 ha (11.8%) of the ESA is rated as Class 4. In addition, 306 ha (0.4%) of the ESA has a Class 1 agriculture capability rating.

Table 12.3-2: Summary of Agriculture Capability Classes within the Effects Study Area for the Base Case

Agriculture Capability Class	Area (ha)	Proportion (%)
Class 1 - no limitations in use for crops	306	0.4
Class 2 - moderate limitations that restrict the range of crops or require special conservation practices	16,609	20.7
Class 3 - moderately severe limitations that restrict the range of crops or require special conservation practices	39,291	48.9
Class 4 - severe limitations that restrict the range of crops, require special conservation practices, or both	9,518	11.8
Class 5 - very severe limitations that restrict their capability to produce perennial forage crops and improvement practices are feasible	8,831	11.0
Class 6 - capable of only producing perennial forage crops and improvement practices are not feasible	5,729	7.1
Class 7 - no capability for arable agriculture or permanent pasture	102	0.1
Total	**80,385**	**100**

ha = hectares; % = percent

The most common subclass in the ESA is M (moisture limitation) and was rated in most soil associations (approximately 51% of the ESA), except for soil associations characterized by constant saturation (i.e., wetlands) and/or steep slopes and depressional areas (e.g., Hillwash Complex association) (Table 12.3-3). The W (excess water) subclass was the second most common subclass (approximately 16% of the ESA) and was mostly present as Gleysols in soil associations characterized by variable landscape with areas of poor drainage, high groundwater table, or local runoff (e.g., Oxbow association) (Table 12.3-3). The most common soil associations in the ESA, the Oxbow and Weyburn associations, were generally characterized by M (moisture limitation), T (unfavourable topography), and W (excess water) subclasses.

Table 12.3-3: Summary of Agriculture Capability Subclasses within the Effects Study Area for the Base Case

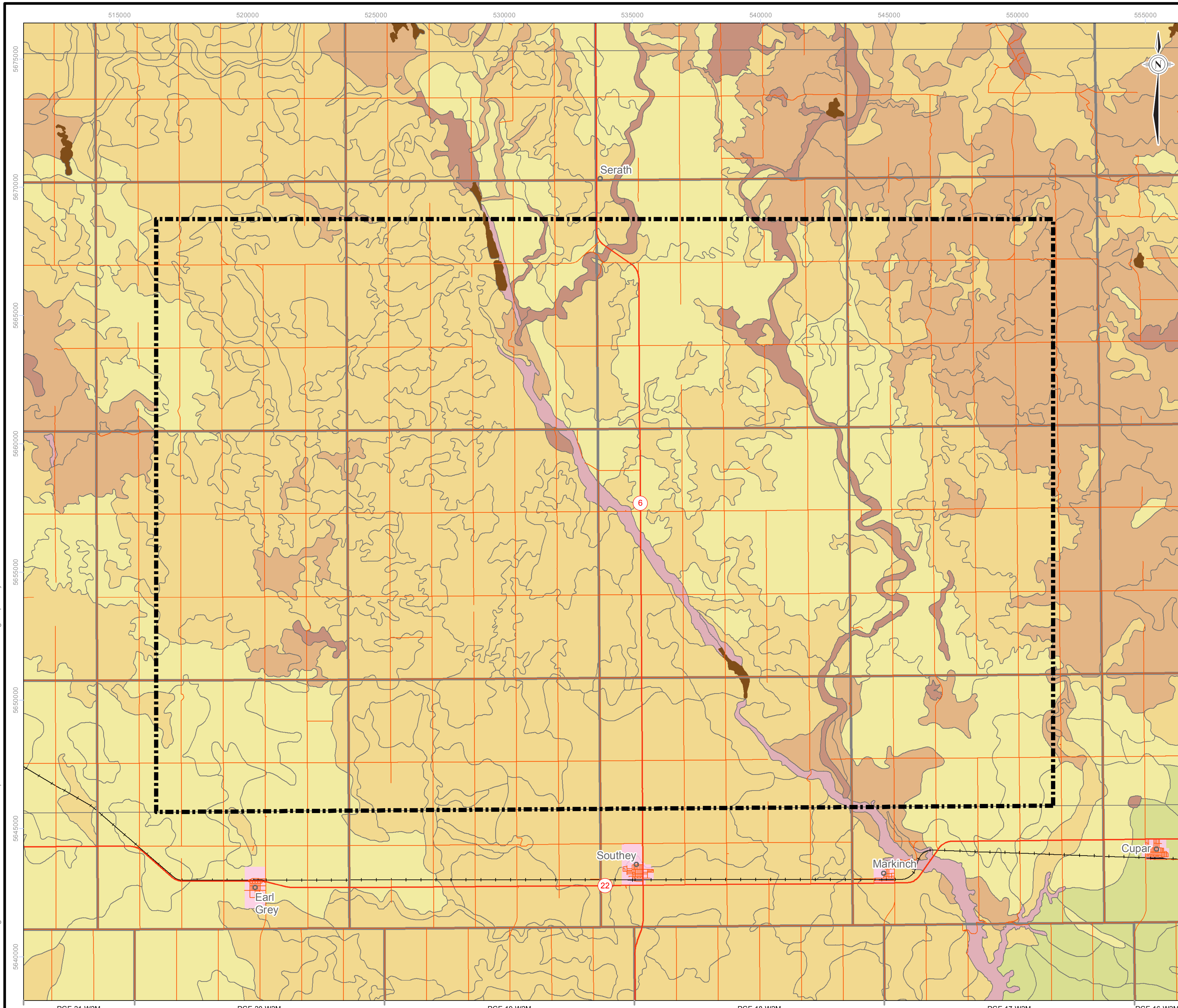
Agriculture Capability Subclass[a][b]	Area (ha)	Proportion (%)
M - moisture limitation	41,293	51.4
W - excess water	13,076	16.3
T - unfavourable topography	8,797	10.9
MT - moisture limitation and unfavourable topography	6,855	8.5
TE - unfavourable topography and erosion damage	4,054	5.0
TW - unfavourable topography and excess water	1,749	2.2
TM - unfavourable topography and moisture limitation	1,298	1.6
TP - unfavourable topography and excess stones	820	1.0
TN - unfavourable topography and salinity	553	0.7
WP - excess water and excess stones	437	0.5
WN - excess water and salinity	355	0.4
No Subclass - no limitation (Class 1)	306	0.4
WT - excess water and unfavourable topography	264	0.3
NW - salinity and excess water	219	0.3
MP - moisture limitation and excess stones	173	0.2
P - excess stones	96	0.1
MW - moisture limitation and excess water	32	<0.1
PW - excess stones and excess water	8	<0.1
Total	**80,385**	**100**

Notes: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

(a) Refer to Annex IV, Table 3.2-2 for complete descriptions of subclasses.

(b) Where two subclasses are listed, more than one limitation exists in a rated area. The first subclass identifies the primary limitation in the rated area and the second subclass identifies the secondary limitation.

ha = hectares; % = percent, <= less than



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

AGRICULTURE CAPABILITY CLASSES

- CLASS 1 - NO SIGNIFICANT LIMITATIONS
- CLASS 2 - MODERATE LIMITATIONS
- CLASS 3 - MODERATELY SEVERE LIMITATIONS
- CLASS 4 - SEVERE LIMITATIONS
- CLASS 5 - VERY SEVERE LIMITATIONS
- CLASS 6 - NATIVE FORAGE ONLY
- CLASS 7 - NOT SUITABLE FOR AGRICULTURE

NOTE

SOIL POLYGONS WERE UPDATED BASED ON FIELD SURVEY RESULTS.

REFERENCE

SASKATCHEWAN LAND RESOURCES UNIT, 2004
SKSISV2, DIGITAL SOIL RESOURCE INFORMATION FOR AGRICULTURAL SASKATCHEWAN, 1:100,000 SCALE.
AGRICULTURE AND AGRI-FOOD CANADA, SASKATOON, SASKATCHEWAN
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL SOUTHEY PROJECT

TITLE
AGRICULTURE CAPABILITY DISTRIBUTION FOR THE BASE CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	JF	05/02/15	SCALE AS SHOWN REV. 0
GIS	LMS	25/05/15	FIGURE: 12.3-3
CHECK	JLF	25/05/15	
REVIEW	BC	25/05/15	

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12.3.2.4 Sensitivity to Erosion

Soil associations with High water erosion sensitivity are generally characterized by steep slopes, and/or terrain defined by long slope lengths. These associations include Asquith (Aq10), Biggar (Bg2), Bradwell (Br12), Forget Complex (Fg10), Glenavon Complex (Gn2 and Gn8), Hillwash Complex (Hw), Hillwash-Alluvium Complex (HwAv1), Runway Complex (Rw), Swift Creek Complex (Sf2), and Weyburn-Elstow (WrEw8) map units. Where slope gradient is less, the sensitivity drops to Moderate in the Asquith (Aq10) and Hillwash-Alluvium Complex (HwAv1) map units and to Low in the Swift Creek Complex (Sf2) map unit. The dominant associations in the ESA (Oxbow and Weyburn) have Moderate water erosion potentials. Regardless of soil association, if soil disturbance occurs and mitigation is not applied in areas where vegetation cover is removed, water erosion potential can increase. Further, water erosion potential will increase in areas with steep slopes and in areas of gullied or dissected terrain.

The majority of soil associations in the ESA, including the dominant soil associations (Oxbow and Weyburn), had a Medium wind erosion rating. Soil associations with High wind erosion ratings have loamy sand texture and include the Asquith-Bradwell (AqBr4), Meota-Whitesand (MeWs13), and Oxbow-Whitesand (OxWs7) map units. Regardless of soil association, in areas where vegetation cover is removed and where soil disturbance occurs and mitigation is not applied, wind erosion ratings can increase.

12.3.2.5 Sensitivity to Compaction

Soil compaction ratings in the ESA varied between Low and Very High, depending on texture. Compaction ratings of topsoil, upper subsoil, and lower subsoil also varied, depending on texture changes between soil horizons. Generally, the Very High compaction ratings were assigned based on clayey or silty soil textures. Regardless of soil texture, the sensitivity to compaction decreases if soil disturbance takes place under dry or frozen conditions. Gleysolic soils that occur in association with wetlands and depressions in the ESA are generally wet and compaction ratings would be high in these areas.

12.3.2.6 Sensitivity to Acidification

Representative soils analysed for chemistry have a neutral pH and a mean CEC of approximately 16 milliequivalents per 100 grams of soil (meq/100 g). Sampled soils in the ESA are rated as having a Low sensitivity to acidification.

12.3.2.7 Reclamation Suitability

Reclamation suitability of soil associations ranged from Poor to Fair. The Swift Creek Complex (Sf2) is the only soil association with Poor reclamation suitability for all soil layers and is because of high calcium carbonate equivalent and salinity. The Oxbow association has a Fair reclamation suitability rating for all soil layers; the Weyburn association has a Fair reclamation suitability rating for the topsoil and upper subsoil and a Poor reclamation suitability rating in the lower subsoil because of a high calcium carbonate equivalent. Common limitations for reclamation suitability in topsoil for all associations include calcium carbonate equivalent, surface stoniness, and stone content. Common limitations for reclamation suitability in subsoil for all associations include high pH, clay or sandy textures, high calcium carbonate equivalent, and salinity (electrical conductivity [EC]). In areas with high salinity in subsoil, proper soil handling can maintain soil reclamation suitability in topsoil. Reclamation suitability can be improved through mitigation and the application of soil amendments. For example, soils with heavy textures such as clay loam can have improved reclamation suitability by incorporating organic amendments to increase soil porosity, permeability, and improve soil drainage. In addition, removing stones in soils with excessive stoniness can improve reclamation suitability.

12.3.2.8 Baseline Chemistry

Selenium exceeded the CCME guideline level of 1 milligram per kilogram (mg/kg) in one sample from the HwAv1 map unit (Hillwash-Alluvium Complex) (1.09 mg/kg) and one sample from the OxHd2 map unit (Oxbow-Hoodoo association) (2.84 mg/kg). One of these locations is adjacent to West Loon Creek and the other location is adjacent to East Loon Creek. Selenium occurs naturally as an inorganic mineral associated with geological deposits and bedrock. Although surficial concentrations of bedrock-derived selenium generally do not exceed the CCME guideline of 1 mg/kg (CCME 2009), geological surveys have identified selenium in concentrations exceeding CCME guidelines (e.g., 1.2 mg/kg and 11.7 mg/kg) in ore samples taken from central Saskatchewan (from Saskatoon area to north of La Ronge) (Dunn 1990). Selenium is used in glass production, metallurgy, manufacturing electronics, and burning of coal and oil. In addition, selenium is used in agriculture as a feed additive and is present in fertilizers and pesticides (CCME 2009). It is possible that the two elevated concentrations of selenium identified during the baseline soil survey are derived from mineral deposits or from the presence of a feed additive, fertilizer, or pesticide associated with agricultural use in the immediate vicinity of the soil survey locations.

12.4 Pathways Analysis

12.4.1 Methods

Pathways analysis identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects (after mitigation) to soils. The first part of the analysis is to identify all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on the VC. Potential pathways through which the Project could affect soils were identified from a number of sources including the following:

- a review of the Project Description (Section 4.0) and scoping of potential effects by the environmental and engineering teams for the Project;
- information obtained from community engagement sessions (Section 5.0);
- scientific knowledge and experience with other potash mines in Saskatchewan; and
- consideration of potential effects identified from the TOR.

For an effect to occur there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a correspondent effect on the VC.

Project activity → change in environment → effect on VC

A key aspect of the pathways analysis is to identify environmental design features and mitigation that might reduce or eliminate potential effects of the Project to soils. Mitigation has been developed for the Project according to the following hierarchy proposed by the MOE (2014):

- avoidance;
- minimize (limit);

- restoration; and
- compensation.

Environmental design features include engineering design elements, environmental best practices, management policies and procedures, and spill response and emergency contingency plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on soils. Pathways are determined to be primary, secondary (minor), or as having no linkage, using scientific, local and traditional knowledge, logic, experience with similar developments, and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- **No linkage** – analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on soils relative to the Base Case or guideline values; or
- **Secondary** – pathway could result in a measurable minor environmental change, but would have a negligible residual effect on soils relative to the Base Case or guideline values, and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect; or
- **Primary** – pathway is likely to result in environmental change that could contribute to residual effects on soils relative to the Base Case or guideline values.

Pathways with no linkage to soils are not assessed further because implementation of environmental design features or mitigation will remove the pathway and result in no measureable change to soils. Pathways that are assessed to be secondary and demonstrated to have a negligible residual effect on soils through simple qualitative or semi-quantitative evaluation of the pathway are not advanced for further assessment. In summary, pathways determined to have no linkage to soils or those that are considered secondary are not expected to result in environmentally significant effects for soil capability to support agriculture and other plant communities. Primary pathways require further evaluation through more detailed quantitative and qualitative effects analysis (Section 12.5).

12.4.2 Results

Project components and activities, effects pathways, and environmental design features and mitigation are summarized in Table 12.4-1. Classification of effects pathways (i.e., no linkage, secondary, and primary) to soils also is summarized in Table 12.4-1 and detailed descriptions are provided in the subsequent sections.

Table 12.4-1: Potential Pathways for Effects on Soils

<table>
<tr><th>Project Component/ Activity</th><th>Effects Pathways</th><th>Environmental Design Features and Mitigation</th><th>Pathway Classification</th></tr>
<tr><td rowspan="7">Physical disturbance from the Project Footprint</td><td>Direct loss or alteration of soils in the Project footprint (core facilities area, mining area, and access roads) can change soil quantity and distribution.</td><td rowspan="3">■ Soil disturbance will be limited to those areas required for construction and operation of the Project.
■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance.
■ Progressive reclamation will occur where applicable (e.g., progressive pad site reclamation).
■ Existing public roads will be used where possible to provide access to the Project, which will reduce the amount of new road construction required for the Project.
■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible.
■ A Decommissioning and Reclamation Plan will be developed and will incorporate new technologies as they become available to reduce the length of the decommissioning period, and the associated duration of salt storage at surface.
■ All on-site roads will be removed during decommissioning.
■ Salvaged soil material will be returned to the landscape and contoured, to the extent practical, to blend with the surrounding terrain.
■ Disturbed areas will be recontoured and reclaimed to a stable profile to permit existing land uses.</td><td>Primary</td></tr>
<tr><td>Residual ground disturbance from portions of the core facilities area can permanently alter soils.</td><td>Primary</td></tr>
<tr><td>Direct loss or alteration of soils from mine well field area pipeline corridors can change soil quantity and distribution.</td><td>Secondary</td></tr>
<tr><td>Changes in surface flows, drainage patterns (distribution) and drainage areas from the Project footprint can affect soil quality.</td><td>■ The compact layout of the core facilities area will limit the area that is disturbed by construction.
■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance.
■ Progressive reclamation of well pads will occur.
■ Existing public roads will be used where possible to provide access to the mine well field area and to reduce the amount of new road construction required for the Project.
■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible.
■ Where practical, natural drainage patterns will be maintained.
■ Culverts will be installed along site access roads, as necessary, to maintain drainage.</td><td>No Linkage</td></tr>
<tr><td>The stripping and storage of soil during site preparation can change soil quality.</td><td rowspan="3">■ Soil disturbance will be limited to those areas required for construction and operation of the Project.
■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance.
■ Existing public roads will be used where possible to provide access to the mine well field area, which will reduce the amount of new road construction required for the Project.
■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible.
■ A site-specific assessment will be completed prior to site clearing to identify topsoil-stripping depths and develop a soil salvage plan.
■ Experienced equipment operators will be used for topsoil salvage and experienced environmental personnel will monitor the process.
■ Topsoil will be salvaged and stored separately from subsoil to reduce admixing and saved for reclamation.
■ Salvaged topsoil will be stored on-site and will be kept way from surface waterbodies and areas that could be subject to travel, storage of equipment/material or future disturbances to reduce soil handling.
■ A Water Management Plan will be developed and diversion structures to control runoff will be implemented, as needed, to divert surface runoff from exposed soils.
■ Best practices during construction will be adopted as part of the Erosion and Sediment Control Plan for disturbed areas to reduce erosion and maintain soil quality.
■ Erosion and sediment control measures, such as silt fences, sediment stops, and vegetating soil salvage stockpiles will be implemented as necessary to reduce potential erosion and maintain soil quality.
Exposed soil will be seeded to provide temporary or permanent vegetation cover to protect against wind and water erosion. Soil will be seeded with self-sustaining, erosion controlling seed mix appropriate to the region.
■ Temporary erosion control measures such as mulches, mats, netting, or straw crimping may be used to control erosion prior to establishing a</td><td>Secondary</td></tr>
<tr><td>Ground disturbance during site preparation and storage in stockpiles can cause soil erosion and change soil quality.</td><td>Secondary</td></tr>
<tr><td>Ground disturbance and soil salvage during site preparation can cause admixing and change soil quality.</td><td>Secondary</td></tr>
</table>

Table 12.4-1: Potential Pathways for Effects on Soils

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Physical disturbance from the Project Footprint (continued)	Passes of equipment on the soil surface during site preparation can cause compaction and change soil quality.	protective vegetative cover. ■ Ground disturbance activities will be completed during dry or frozen conditions, where and when practical, to reduce soil compaction. ■ Vehicle traffic will be limited to designated areas to avoid widespread compaction and will avoid areas sensitive to compaction (e.g., wet, fine textured materials) when and where practical. ■ Construction and transporting equipment/materials off-road will be postponed during adverse weather or wet ground conditions. ■ Areas where soil compaction has occurred will be deep ripped prior to topsoil replacement and organic amendments will be incorporated, if required. ■ The length of time soil is stockpiled with be limited as much as possible. Topsoil will be replaced on reclaimed areas as soon as feasible. Any surplus salvaged soil from construction will be stored on-site for future reclamation activities. ■ The height of soil salvage stockpiles will be adjusted according to industry best practices so that the size and shape reduces changes to quality, erosion, and loss (e.g., slumping). ■ Progressive reclamation will occur during the Project, where applicable (e.g., progressive pad site reclamation). ■ A Decommissioning and Reclamation Plan will be developed and will be updated as new reclamation techniques become available to reduce the length of the decommissioning period, and the associated duration of salt storage at surface.	Secondary
General construction, operations, and decommissioning and reclamation activities	Air and dust emissions and subsequent deposition can change the chemical properties of soils, which can affect soil quality.	■ Compliance with regulatory emission requirements. ■ Dryer burners will be high efficiency, low NOx burners to limit the amount of NOx present in the exhaust stream. ■ Baghouses will be installed throughout the dry process area and dust collected in these baghouses will be conveyed back to the compactors. ■ A dustless chute and loading system will be installed in the product storage area to reduce dust generation in the storage and load-out. ■ The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment. ■ An Erosion and Sediment Control Plan will be implemented during all phases of the Project to limit dust production, and subsequent deposition on surrounding areas, and to limit water erosion of exposed soils. ■ Dust-producing components of the potash refinement process (i.e., dryers, compaction circuit) will have controls to recover and return dust to the circuit. ■ Wet scrubbers will be used to clean the air of dust particles from off-gases from the product dryers. ■ Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. ■ Enforced speed limits will assist in reducing production of dust. ■ Operating procedures will be developed to reduce dust generation from the TMA over the long-term. ■ The cyclone exhaust will be treated in high-energy scrubbers operating at a high-pressure drop.	Secondary
	Long-term dust emissions from the tailings management area can cause local changes to soils.		No Linkage
Solution Mining	Ground subsidence caused by solution mining can change surface flows, drainage patterns (distribution), and drainage areas, which can affect soils.	■ Unmined pillars will be left between the caverns to increase stability during mining and reduce the potential for subsidence. ■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence and will provide input into adaptive management. ■ Subsidence will be non-disruptive. Disruptive subsidence, such as the formation of sinkholes, is not expected to occur. ■ Subsidence will be gradual and ultimate (maximum) subsidence (i.e., final, steady state) will not occur for centuries. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface developments.	Primary
Tailings Management Area	Vertical and lateral migration of brine from the tailings management area can cause changes to groundwater and surface water quality, which can affect soil quality.	■ The location of the TMA was selected based on site-specific geologic and hydrogeologic studies completed to identify an appropriate foundation for the TMA, which provides natural containment of brine material. ■ The TMA will be located over soils that are known to provide natural retention of brine solutions and offer protection against seepage into nearby	No Linkage

Table 12.4-1: Potential Pathways for Effects on Soils

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
	Long-term brine migration from the tailings management area can affect soil quality.	ground and surface water resources. ■ Brine reclaim ponds will be designed to provide containment of brine under normal and extreme (i.e., storm) conditions over the life of the mine. ■ A perimeter dyke will be constructed around the TMA to contain waste salt and decanted brine. ■ Excess brine reclaimed from the TMA will be disposed of by deep well injection, a proven practice used to manage brine and prevent release to surface waters and fresh-water aquifers. ■ A containment system will be designed to control deep migration of brine from the TMA to underlying aquifers and horizontal migration of brine, as required. ■ A Waste Salt Management Plan for the TMA will be incorporated into the detailed design. ■ The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan and adaptive management will be implemented, if required. ■ A Decommissioning and Reclamation Plan will be developed and will incorporate new technologies as they become available to reduce the length of the decommissioning period and the associated duration of salt storage at surface.	No Linkage
	Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality, which can alter soil quality.	■ An evaluation of the capacity of potential deep injection horizons has been conducted identifying the Winnipeg Formation and Deadwood Formation to be suitable for brine disposal.	No Linkage
Water Management	Site run-off and associated soil erosion from the core facilities area and the freshwater diversion channels can change soil quality.	■ A Water Management Plan will be designed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. ■ A diversion channel will be constructed to intercept waterflow from upland areas along the north and east borders of the core facilities area. ■ Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the core facilities area. ■ The surface water diversion will be designed to convey the runoff associated with the 300 mm 24-hour design storm event. ■ Surface water diversion channels along the perimeter of the core facilities area will be designed to collect and redirect external drainage.	No Linkage
Accidents, Malfunctions, and Unplanned Events	Spills (e.g., waste oil, petroleum products, reagents, potash product, project equipment leaks, vehicle accidents, and wash-down) can cause changes to soil quality.	■ Instruction will be provided to employees as part of the Health, Safety, Security, and Environmental Management System; training will be provided to all employees on transportation of dangerous goods, as well as on spill reduction, control, and clean up procedures. ■ Basic, core, and specific training of workers as part of the Health, Safety, Security, and Environmental Management System. ■ An Emergency Response Team will be formed on-site and members will be trained to implement the Emergency Response Plan. ■ Spills will be promptly reported and managed according to procedures identified in the Spill Response and Control Plan. ■ Chemical spill containment will be incorporated into the plant design to mitigate environmental effects from spills (i.e., installation of concrete floors, drains, and sump mechanisms). ■ Smaller fuel dispensing tanks will be double-walled, and all dispensing will be performed over concrete containment slabs. ■ Reagent tanks and larger fuel tanks will be located inside a bermed, lined storage compound. ■ Liquid, solid spills, and wash-down within the processing facilities will be contained within the mill facility (e.g., door curbs, sloped floors, and sumps) or engineered site area. ■ Diesel and gasoline will be stored in accordance with applicable regulations. ■ On-site storage facilities for hazardous substances and waste dangerous goods will be designed to meet regulatory requirements. ■ Domestic and recyclable waste dangerous goods will be stored in appropriate containers until shipped off site to an approved facility. ■ Spill response material will be located throughout the site in designated areas, where fuel and chemicals are stored, and in company vehicles. ■ Best practices will be adopted within the Waste Management Plan for proper handling and storage of waste dangerous goods. ■ Salvageable product from centrifuging, drying, screening, and compaction will be recycled back to the process. ■ Construction equipment will be regularly inspected and maintained. ■ To limit the occurrence of vehicular accidents, training for equipment operators will be implemented as part of the Health, Safety, Security, and Environmental Management System. ■ Equipment will be inspected for leaks and repaired prior to entry into the Project area and routinely inspected throughout the duration of the Project.	No Linkage

Table 12.4-1: Potential Pathways for Effects on Soils

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
		■ Daily vehicle inspections will be required, and a preventative maintenance program will be implemented for all vehicles used on-site. ■ Speed limits will be enforced. ■ Timely snow removal and sanding will occur on site access roads during winter to improve traction.	
	Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to groundwater and surface water quality, which can affect soil quality.	■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ Brine will be transported by steel pipeline lined with high-density polyethylene, which provides additional pipe flexibility and resistance to corrosion. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface developments. ■ Unmined pillars will be left between the caverns to increase stability during mining and reduce the potential for subsidence. ■ As part of the Environmental Protection Plan, regular monitoring of pipelines will be carried out to limit the potential for leaks and allow for early detection and management of spills. ■ Piping and valve arrangements will be routed so that each cavern works independently from the others at different stages of cavern development and production. ■ During the detailed design stage, additional spill response and mitigation will be included in the Spill Response and Control Plan.	No Linkage
Accidents, Malfunctions, and Unplanned Events (continued)	Slope failure of the waste salt storage pile can cause translocation of waste salts, which can change soil quality.	■ Salt pile side slopes of 4H:1V were applied to the TMA layout, which were found to provide stable slope configuration based on preliminary slope stability analysis. ■ The final configuration of salt pile slopes will be refined based on subsequent analyses calibrated to pore-water pressure and slope movement data obtained during the initial development of the waste salt pile. ■ Regular inspections of the TMA. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan.	No Linkage

Table 12.4-1: Potential Pathways for Effects on Soils

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
	Failure of the brine containment pond and resulting brine leakage can change soil quality.	■ The brine reclaim pond will provide adequate storage to accommodate storage of process streams under normal and extreme operating conditions and design storm events. ■ Sufficient freeboard will be provided to account for wind induced set-up and wave run-up on the sides of the pond slopes. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan. ■ Maximum operating levels will be developed to provide adequate storage volumes for the design storm event (300 mm in 24 hours). ■ Containment berms and dykes will be constructed around the tailings management area to contain salt tailings and decanted brine, as well as to divert surface water. ■ Containment dykes will be keyed into surficial materials as necessary. ■ Brine levels will be monitored and excess brine will be injected into deep well injection zones after mining is complete. Sub-surface brine migration will be monitored and groundwater wells will be monitored to confirm the adequacy of the brine containment pond. ■ In the event of high flows due to precipitation events, additional flow capacity from the collection ditch to the reclaim pond would be provided by an overflow spillway in the embankment. ■ The brine reclaim pond will be monitored regularly; monitoring results will provide input into adaptive management.	No Linkage
	Deposition of air emissions from the failure of air emission control systems can result in chemical changes to the surrounding environment and affect soil quality.	■ The environmental performance of air emissions control systems will be monitored on an on-going basis and will provide input into adaptive management. ■ Preventative maintenance will be completed regularly to confirm that emissions systems are functioning as designed.	No Linkage

TMA = tailings management area; mm = millimetres.

12.4.2.1 *Pathways with No Linkage*

A pathway may have no linkage to environmental effects if the activity does not occur, or if the pathway is removed by mitigation or environmental design features so that the Project results in no measurable change in measurement indicators. Subsequently, no residual effect to soils is expected. The pathways described in the following bullets have no linkage to soils and will not be carried forward in the assessment.

- **Changes in surface flows, drainage patterns (distribution), and drainage areas from the Project footprint can affect soil quality.**

Surface water flows, drainage patterns, and drainage areas from the Project footprint are expected to be affected by the construction of the Project. The natural drainage area near the Project has already been disturbed from the existing road network used to access cultivated areas, rural homes, and communities near the Project. The Project is within an area with poorly defined runoff pathways. During the Base Case, most of the runoff contributes to a low-lying area south of the core facilities area and it may occasionally contribute to West Loon Creek under high magnitude snowmelt and/or rainfall events (Section 9.5). The hydrology assessment predicted that the Project footprint will result in a reduction in runoff that will change the amount of water reporting to the low-lying area downstream but would only rarely affect inflows to West Loon Creek. During decommissioning and reclamation, most of the Project infrastructure will be removed and surface water flows and drainage patterns will be reclaimed. The tailings management area (TMA) is considered permanent. The surface water flows and drainage patterns in residual footprint areas will not be reclaimed; however, no reduction in flow volume in West Loon Creek downstream is predicted.

A Water Management Plan will be implemented to maintain streamflow quantity along natural flow pathways as much as possible. Environmental design features will be implemented to allow off-site precipitation and snowmelt to remain part of the natural water cycle. The core facilities area will be limited to the minimum spatial extent required. The mine well field area access roads that will be constructed during the Project will be designed to maintain the natural flow paths using adequately designed cross-drainage structures (e.g., culverts) as required. It is anticipated that implementing environmental design features and mitigation will result in minor changes to surface water flows and drainage patterns from the Project footprint. The minor changes to surface water flows and drainage patterns are not anticipated to cause measurable changes to soil quality and quantity. Therefore, this pathway was determined to have no linkage to effects on soils.

- **Long-term dust emissions from the tailings management area can cause local changes to soils.**

Solution mining produces waste salt (i.e., sodium chloride [NaCl] tailings) as a by-product of the potash refinement process, which will be stored in the salt storage area in the TMA. The volume of tailings produced by the solution mining method for the Project is expected to be lower than conventional underground mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only potassium chloride (KCl) is removed from the caverns.

The waste salt product that is precipitated during processing is removed from the process and discharged to the TMA through a slurry pipeline. Monitoring programs for the waste salt storage area will be incorporated into the design and will include monitoring pile stability and related dust production.

A solid crust will form over the outer layer of the salt pile as the salt slurry dries. The formation of a rigid crust over the salt pile is expected to limit effects of exposure to wind and will reduce the potential for erosion. Operating procedures also will be developed to limit dust emissions from the TMA. Because of the crusting of the outer layer of the salt pile and the implementation of operating procedures and monitoring programs for the salt storage area, long-term dust emissions are not expected and are predicted to result in no measureable changes to soil quality. Subsequently, this pathway was determined to have no linkage to effects on soils.

- **Vertical and lateral migration of brine from the tailings management area can cause changes to groundwater and surface water quality, which can affect soil quality.**
- **Long-term brine migration from the tailings management area can affect soil quality.**
- **Failure of the brine containment pond and resulting brine leakage can change soil quality.**

The TMA will consist of the Stage I and Stage II salt storage areas, the Stage I and Stage II brine reclaim ponds, sewage lagoon and surface diversion works. The TMA will be in operation during the life of the Project, and following decommissioning and reclamation of the mine. Brine is primarily composed of soluble salts (NaCl), with smaller amounts of KCl and other insoluble materials (e.g., metals) (Tallin et al. 1990). Vertical or lateral migration of brine into groundwater systems or directly into the surrounding soil may lead to salt accumulation and change soil quality.

The concentration of salt in soil solution and salt accumulation in soil increases soil salinity and affects soil physical properties (Henry et al. 1992; Keren 2012). Sodium (and sometimes potassium) can act as dispersive cations in soil when present in high enough concentrations (Keren 2012). Salt accumulation can promote clay swelling and disrupt soil structure, which can affect soil permeability, soil plasticity, water retention capability, CEC, and crop productivity (Barbour and Yang 1993; Gabbasova et al. 2010; Keren 2012; Levy 2012). Salts also can increase soil pH, which can alter the availability of soil nutrients for plant uptake (Richards 1954; MOA 2008; Levy 2012).

Soils with high organic matter content tend to promote greater aggregate stability and have a greater resistance to inputs of sodium (Levy 2012). In addition, the presence of calcium carbonate promotes further resistance to sodium inputs to soil. Soils within the ESA had an organic matter content of between 1% and 10% and are enriched with calcium carbonate (Annex IV, Appendix IV.1). Therefore, soils in the ESA may be somewhat buffered to small inputs of sodium from brine. However, this buffering capacity would likely be ineffective in the event of large brine inputs.

The stratified clay and clayey tills of the Saskatoon Group are the main geological units that would mitigate the vertical migration of seepage from the TMA (Golder 2015). Soil-bentonite cut-off walls will be used to contain brine areas where shallow stratified sand and gravel deposits are present. The necessity for a deep cut-off wall extending through competent till materials will be determined based on the results of detailed site characterization. Containment berms and dykes will be constructed around the TMA to contain decanted brine. The containment system will be designed to control migration of brine from the salt storage area to underlying aquifers and to control the horizontal migration of brine, as required. The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan.

Implementation of the above-mentioned environmental design features, mitigation, and monitoring programs has shown good performance in preventing vertical and lateral seepage in similar potash projects. No measureable change to soil quality is predicted. Consequently, these pathways were determined to have no linkage to effects on soils.

- **Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality, which can alter soil quality.**

Brine will be disposed of through deep-well injection during the Project to reduce the amount of brine stored in the TMA. Injecting brine into deep wells can change sub-surface and deep groundwater levels and chemistry, which could alter surface water and soil quality. Depending on the chemical composition of the brine being injected, the brine may introduce NaCl, KCl and other insoluble materials (e.g., metals) to groundwater (Tallin et al. 1990). Salt accumulation can increase soil salinity and affect soil structure and soil pH, which can change the availability of soil nutrients (Richards 1954; Barbour and Yang 1993; MOA 2008; Gabbasova et al. 2010; Keren 2012; Levy 2012).

Disruption in groundwater flow may adversely affect soil moisture and surface water levels in wetlands by changing recharge and discharge areas and rates (Chen and Hu 2004). This may expose previously unsaturated soils to saturated conditions, and vice versa, and alter soil physical, chemical, and biological properties (Bedard-Haughn 2011). Changes in soil moisture regimes can reduce soil agriculture capability.

Methods used in the solution mining process will maintain stability of shallow and deep groundwater aquifers. In addition, an evaluation of the capacity of potential deep injection horizons has been completed identifying the Winnipeg Formation and the Deadwood Formation to be suitable for brine disposal. The Winnipeg and Deadwood formations are considered the best targets for brine disposal because there is a large storage capacity in these formations, the formations are well isolated from overlying freshwater aquifers, and the formations are distant from recharge and discharge areas (Appendix 4-A). No changes to sub-surface and deep groundwater flow, levels, and quality are predicted. Given that the formations used for deep well injection are isolated from overlying aquifers and surface water, no changes to surface water or soil quality are expected. Therefore, this pathway was determined to have no linkage to effects on soils.

- **Site runoff and associated soil erosion from the core facilities area and the freshwater diversion channels can change soil quality.**

Site runoff and associated soil erosion from the core facilities area could potentially affect soil quality within and adjacent to the Project footprint. Brine and salt stored in the TMA may be transported off-site via surface water runoff caused by precipitation, leading to the salinization of soils (Richards 1954; Barbour and Yang 1993; MOA 2008; Gabbasova et al. 2010; Keren 2012; Levy 2012). Increased levels of soil erosion can lead to potential redistribution or loss of soil.

Several environmental design features and mitigation measures will be implemented to prevent water release from the core facilities area entering the surrounding environment. The general site layout has been developed to use natural topography to assist site drainage to the extent practical. The topography in the area is gently sloping toward the south and slightly to the west. A diversion channel will be constructed to intercept waterflow from upland areas along the north and east borders of the core facilities area.

A Water Management Plan will be developed and infrastructure will be constructed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the facility. The surface water diversion works will be designed to accommodate runoff from a rainstorm event of 300 millimetres (mm) over 24-hours (Section 4.6.2).

Runoff within the TMA will be redirected to the brine reclaim pond for temporary storage prior to deep-well injection. Salt storage area internal channels (i.e., brine return channels) are designed to collect and redirect runoff originating from precipitation and brine discharges on the tailings areas to the brine reclaim pond. The TMA will be graded to drain free brine to the brine reclaim pond by gravity. Internal salt tailings dykes and ditches may be required to direct surface flow to the collection ditch during early stages of deposition.

The brine reclaim pond will be constructed to provide containment of brine during the Project. The brine reclaim pond is designed to allow sufficient storage capacity to contain brine decant from the salt storage area during normal operations, runoff resulting from the design storm event, and a 0.9-metre (m) freeboard to accommodate wind-induced setup and wave run-up on the sides of the pond slopes.

Erosion protection of the surface water diversion channel will be provided by topsoil replacement and hydro seeding to establish grass cover within the diversion channel. A tackifier may be used to increase the temporary soil stability prior to establishment of permanent root systems.

Inspection and maintenance procedures for infrastructure will be outlined in the Water Management Plan. Implementation of environmental design features and mitigation is expected to prevent site runoff and soil erosion from the core facilities area from entering the surrounding environment and no measureable change to soil quality or quantity is predicted. Subsequently, this pathway was determined to have no linkage to effects on soils.

- **Spills (e.g., waste oil, petroleum products, reagents, potash product, project equipment leaks, vehicle accidents, and wash-down) can cause changes to soil quality.**
- **Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to groundwater and surface water quality, which can affect soil quality.**

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks in order to limit the effects of spills and leaks on soils. Pipelines will be used to transport brine solution and potash product within the Project footprint. Pipelines will be constructed of standard carbon steel and lined with high-density polyethylene. Pipelines will be installed underground at a depth that will reduce the possibility of damage from frost and surface activities (e.g., farming), and will be monitored for pressure and flow using flow meters. Double-walled pipe for secondary containment will be used in critical crossing areas (i.e., based on site-specific analysis to meet environmental conditions). All pipelines will be insulated to maintain the required temperature for the process with the exception of the cold water and the early brine return pipelines. Trains and vehicles will transport chemicals, potash product, and other reagents on and off-site.

An Emergency Response Plan will be developed as part of the Health, Safety, Security, and Environmental Management System to provide rapid and competent response to incidents that may occur during the Project. Aspects of this plan include instructions and procedures for quick detection, control, and management of spills occurring on site. Other mitigation will include a leak detection system for mining area pipelines, which will consist of monitoring and appropriate pipe isolation to limit potential leaks and for early detection. Leak detection and monitoring of pipelines will be based on flow and pressure measurements at points along the pipeline. In addition to the pipeline monitoring program, liquid spills, and wash-down occurring within the potash processing facilities will be contained within the mill facility or the engineered site area, and salvageable product spills will be recycled into the process feed.

If a spill originates in the tank farm, the hazardous substance will be pumped and properly disposed off-site. The tank farm will be designed to include an adequately sized containment berm for containing potential leaks or spillage. Storage facilities for hazardous wastes will meet regulatory requirements, and site personnel will be trained on spill reduction, control, and clean-up procedures. Employees will receive spill response training and appropriate spill response materials (e.g., absorbent pads or booms) and equipment will be located at strategic locations on-site. Disposal of all hazardous materials, such as waste chemicals, hydrocarbons, reagents, and petroleum products, will be handled by a licensed contractor and will be hauled off-site to an approved facility. Waste products from the Project (e.g., hazardous waste, domestic waste, or recyclable waste) will be stored and disposed of following procedures prescribed by federal and provincial legislation.

Implementation of the above-mentioned environmental design features are expected to reduce the likelihood and extent of spills and leaks occurring on-site and along transportation corridors resulting in no measureable changes to soil quality relative to Base Case conditions. Therefore, these pathways are determined to have no linkage to effects on soil quality.

- **Slope failure of the waste salt storage pile can cause translocation of waste salts, which can change soil quality.**

The volume of tailings produced by the solution mining method for the Project is expected to be lower than conventional underground potash mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only KCl is removed from the caverns in this mining phase.

Salt tailings stockpile stability is governed primarily by the salt pile height, shear strength of the underlying soils, and the degree to which soil pore water pressures are generated in response to the surcharge load of the stockpile. Detailed slope stability analysis for the salt pile will be completed to determine the optimal salt pile height for the Project. The final design of the waste salt storage area will provide for flexibility to expand the storage area in stages through modifications to the footprint or increasing the salt pile height should additional storage be required.

The probability of slope failure of the waste salt storage pile will be limited by the implementation of operating procedures and monitoring programs for the salt storage area. Salt pile stability monitoring will be incorporated into the design. No measureable change to soil quality is predicted. As such, this pathway was determined to have no linkage to effects on soils.

- **Deposition of air emissions from the failure of air emissions control systems can result in chemical changes to the surrounding environment and affect soil quality.**

The potential exists for failure of air emission control systems, which may result in short-term reductions in air quality. The environmental performance of air emissions control systems will be monitored on an ongoing basis and preventative maintenance will be completed regularly to confirm that emissions systems are functioning as designed. The minor and short-term changes to air quality are not anticipated to cause measurable changes to soil quality. Therefore, this pathway was determined to have no linkage to effects on soils.

12.4.2.2 Secondary Pathways

In some cases, both a source and a pathway exist, but because the change caused by the Project is anticipated to be minor relative to Base Case or guideline values, it is expected to have a negligible residual effect on soils. The pathways described in the following bullets are expected to be secondary and will not be carried forward in the assessment.

- **Direct loss or alteration of soils from mine well field area pipelines can change soil quantity and distribution.**

Construction of the mine well field area pipelines for the Project will cause a temporary loss or re-distribution of soils. By implementing several mitigation measures, it is anticipated that minimal loss and alteration will occur due to the construction of the pipelines. Pipelines will be routed underground to allow continued use of land for agricultural or environmental purposes and will follow existing utility corridors to reduce disturbance to undisturbed areas, where possible. During construction and throughout the lifetime of the Project, Yancoal will comply with all aspects of relevant federal and provincial acts, regulations, and guidelines, and best practices to reduce and mitigate potential effects to soils, as relevant. After construction has been completed, disturbed areas within pipeline corridors will be re-contoured and reclaimed to support current land uses.

Construction of the mine well field area pipelines is expected to result in minor changes to soils relative to Base Case conditions through the use of environmental design features and mitigation. Much of the alterations to the landscape are expected to be temporary and limited to the construction period. Minor changes to the quantity and distribution of soils is predicted. Therefore, this pathway was determined to result in negligible residual effects to soils.

- **The stripping and storage of soil during site preparation can change soil quality.**

Topsoil will be salvaged from the core facilities area, and where well pads and associated access roads are constructed. Salvaged soil will be stockpiled for use during reclamation of the Project footprint because it is a more productive medium for revegetation than subsoil (Abdul-Kareem and McRae 1984).

The definition of soil quality encompasses physical, chemical, and biological characteristics that are used to determine overall soil health (Ewing and Singer 2012). In the absence of mitigation, soil salvage and stockpiling have the potential to alter physical, chemical, and biological properties of soil quality. With no mitigation, soil salvage and stockpiling would be predicted to cause gradual, negative changes to soil quality. The extent of changes to soil quality varies depending on existing soil conditions (Abdul-Kareem and McRae 1984). Ultimately, changes to soil quality will influence a soil's suitability for use during reclamation.

Stripping and stockpiling topsoil during construction is expected to cause physical changes to soil such as disturbing soil structure. Loss of soil structure may result in a reduction in the amount of soil organic matter and soil organic carbon present within the soil, and influences the bulk density, pore size distribution, microbial community structure, and resistance of soil to erosion (Wick et al. 2009). Although soil structure begins to recover following storage in stockpiles over time, Wick et al. (2009) found that soil structure broke apart more from disturbance and movement than the initial disturbance, resulting in more fine particles that are susceptible to erosion.

Biological changes are also expected following stripping and during stockpiling of soil. There is a large decrease in soil microbial activity, microbial biomass, and mycorrhizal fungi following initial stripping of topsoil (Abdul-

Kareem and McRae 1984; Stark and Redente 1987; Wick et al. 2009). Stockpiles tend to become anaerobic over time, although the depth at which this occurs is dependent on soil texture (Abdul-Kareem and McRae 1984; Kundu and Ghose 1997). The adverse effects on soil microbiological activities and mycorrhizal fungi may result in decreased rates of nutrient cycling and reduced nutrient availability, although this is dependent on the depth of the stockpile, length of time soil remains in the stockpile, and whether it has been revegetated (Abdul-Kareem and McRae 1984; Stark and Redente 1987; Wick et al. 2009). Vegetation maintained on stockpiles tends to maintain aerobic microbial community population function over time in the rooting zone of the plants (Ghose 2001; Wick et al. 2009; Baldock and Broos 2010).

Soil organic matter plays an important role in determining the overall resilience of an ecosystem to disturbance because of the chemical energy and nutrients that may be stored in the soil organic fraction (Baldock and Broos 2010). The store of chemical energy and nutrients in the soil organic matter offers resistance to the loss of soil fertility that may be induced by disturbance. However, the vegetation present on the soils prior to disturbance plays a role in the addition of soil organic matter and the initial energy store in the soil organic matter component of a soil (Baldock and Broos 2010). Losses through processes that accelerate decomposition (e.g., increased temperature and aeration) can decrease the soil organic matter reserve more quickly, which contributes to degrading the nutrient cycling ability of the soil and makes the soil more susceptible to erosion.

Organic matter content changes from stripping and stockpiling during the Project are expected to be most pronounced in sandy-textured soil (e.g., Meota Orthic Black Chernozem) (Abdul-Kareem and McRae 1984; Baldock and Broos 2010). Change to the rates of decomposition during stockpiling result in changes to the nutrient status and the organic matter content of the stockpiled soil. Mitigation, such as application of amendments (e.g., fertilizer treatment programs), can ameliorate these effects and will be considered in the Decommissioning and Reclamation Plan. The materials salvaged by the Project will include the upper surface horizon(s) (A-horizon and plant litter layer where present), thereby maintaining the organic matter content of the soil.

Although changes to physical, chemical, and biological properties of soil quality occur during the stripping and storage of soil and when placed in the reclaimed landscape, the changes to these properties will recover over time. A study completed by Adeli et al. (2013) found that physical and chemical soil quality indicators (e.g., aggregate stability, total carbon, organic carbon, and microbial biomass) increased with increasing reclamation age. Atlas et al. (1991) found that although soil microorganism community size declined following a disturbance, the surviving organisms were generalists capable of maintaining a diversity of functions in the salvaged material. Clayton et al. (2009) found that the soil microbial biomass in reclaimed soils increased with time since disturbance.

Areas prone to long-term saturation (i.e., wetlands) or high overland water flow (i.e., runoff) will be avoided when selecting soil stockpile locations. The size and shape of stockpiles will be adjusted based on industry best practices (e.g., 4H:1V) to avoid erosion and changes to soil quality. Erosion control practices, such as providing a vegetation cover, will be applied to soil stockpiles. The vegetation cover will maintain soil quality in soils stored for long periods. Following construction, soil will be re-contoured and re-vegetated as outlined in the Decommissioning and Reclamation Plan.

Soil salvage and storage of soil are predicted to result in local and minor negative changes to soil quality relative to Base Case conditions. However, the benefit of salvaging soils outweighs the negative effects that would occur if soils were not salvaged, stored, and used in the reclaimed landscape. Changes in soil quality can be minimized by implementing soil salvage and reclamation techniques, mitigation, and environmental best practices. As a result, this pathway is determined to have negligible residual effects to soils.

- **Ground disturbance during site preparation and storage in stockpiles can cause soil erosion and change soil quality.**

Soil sensitivity to erosion is dependent upon numerous soil properties including soil texture, cohesiveness, structure, aggregate stability, moisture content, and infiltration rates (permeability). Other factors that influence erosion susceptibility include topography, slope gradient, slope length, surface roughness, vegetation or residue cover, previous disturbance, weather (e.g., kinetic energy of rainfall events), and natural events (e.g., freeze-thaw) (Cruse et al. 2001; Campbell et al. 2002; Kuhn and Bryan 2004; Li et al. 2007).

Erosion is a concern within the Project footprint during construction and operations because of the removal of the vegetation cover and the disturbance of soils. Stockpiles maintained through operations may be susceptible to erosion due to factors such as absence of vegetation, steep slopes, and desiccation. Soil erosion adversely affects soil quality because erosion can remove fine soil particles and organic matter, which reduces the overall nutrient content and water holding capacity of the soil (Baldock and Broos 2010). Losses of soil organic matter can be more pronounced in coarse-textured soils because they generally lack clay particles that provide reactive surfaces to which the soil organic matter particles can be adsorbed (Baldock and Broos 2010).

Map units occurring in the Project footprint include the Elstow-Weyburn (EwWr4), Forget Complex (Fg10), Weyburn (Wr2, Wr4, Wr10), Weyburn-Elstow (WrEw8), and Weyburn-Oxbow (WrOx4, WrOx5). These units are predominantly rated as having Moderate water erosion potential and Medium wind erosion potential under Base Case conditions (Section 12.3.2.4). In areas of gullied or dissected terrain, the erosion potential would increase and where slope gradients decrease, the erosion potential will decrease. The soil erosion ratings represent the maximum erosion that would occur to exposed mineral soils with no mitigation in place. Erosion will be confined mainly to the Project footprint.

In the absence of mitigation, Project activities have the potential to directly cause soil erosion, which can cause changes to soil quality. Environmental design features and mitigation will be applied to control wind and water erosion on the Project footprint. Mitigation will include the implementation of erosion and sedimentation control structures, re-sloping and re-contouring to create stable landforms, and seeding to provide a vegetation cover, where required, as outlined in the Erosion and Sediment Control Plan and Decommissioning and Reclamation Plan. Vegetation on storage stockpiles and exposed soil surfaces helps to protect soils from wind and water erosion (Stark and Redente 1987; Ghose 2001). Plant cover shields soils from rainfall, reduces run-off velocity, disperses surface flows, and improves soil permeability, thus reducing erosion potential. Vegetation cover will act to physically bind soil particles and further reduce the effects of erosion. Erosion control measures will be applied to topsoil and overburden stockpiles, particularly if they are to be stored for long periods.

The implementation of mitigation will reduce the potential for erosion from disturbed areas and on soil storage stockpiles. Erosion is predicted to result in minor and local changes to soil quality relative to Base Case conditions. Therefore, this pathway was determined to have a negligible residual effect on soils.

- **Ground disturbance and soil salvage during site preparation can cause admixing and change soil quality.**

Admixing of surface soil material with underlying subsoil has the potential to alter soil properties important for maintaining soil quality. For example, combining topsoil material with the underlying subsoil materials can cause texture changes in salvaged soil, which alters soil quality. The potential for soil admixing may be higher if clear distinctions between topsoil (including the plant litter layer where present) and subsoil in soil profiles is not apparent. This is often the case when topsoil thickness is highly irregular over the area of the lift. The depth of the surface layer that will be salvaged from mineral soils will vary according to landscape position and soil drainage conditions. Surveyed soils in map units within the Project footprint had a clear distinction (i.e., good colour change) between topsoil and subsoil horizons. Average topsoil depths were 13 cm under Base Case conditions.

Admixing causes changes in structure and texture changes in salvaged materials, which can alter texture, bulk density, soil porosity, soil moisture, and physical characteristics. Admixing has the potential to reduce organic matter and carbon content (e.g., dilution effects), which alters microbiological activity and composition and increases the rate of organic matter decomposition due to an associated increase in soil oxygen (i.e., soil aeration) (Wick et al. 2009). Changes in soil texture could arise from admixing, particularly in soils with large textural differences between topsoil and subsoil horizons. Surveyed soils in map units within the Project footprint had little to no change in texture between topsoil and subsoil horizons. Consequently, the main concern regarding admixing is the dilution of nutrients and organic matter content of the topsoil. The reduction of nutrients and organic matter content of the soil can decrease the ability of a soil to support agriculture and other plant communities.

In the absence of mitigation, Project activities have the potential to directly cause soil admixing, which can cause changes to soil quality. The Project will mitigate the potential effects to soil quality from admixing by soil management practices that avoid or minimize admixing during soil salvage activities. These mitigations include:

- performing a site assessment prior to soil salvage operations to identify site-specific stripping depths to help refine soil salvage actions, where required;
- use experienced equipment operators for topsoil salvage operations, when possible;
- supervising of soil salvage operations by a qualified environmental monitor to provide quality control; and
- salvaging soil materials during dry conditions, where and when practical.

By employing mitigations that avoid or minimize admixing, changes to soil quality are predicted to result in minor changes to soil quality relative to Base Case conditions. As such, this pathway was determined to have a negligible residual effect to soils.

- **Passes of equipment on the soil surface during site preparation can cause compaction and change soil quality.**

Soil compaction decreases soil quality and occurs primarily from heavy equipment or repeated passes of equipment across the soil surface during site clearing, contouring and excavation, and soil salvage and stockpiling. Soil compaction decreases soil quality by increasing soil density and reducing soil porosity, influencing drainage and structure, altering soil strength and water content, altering temperature, and changing soil microclimate. Soil changes due to compaction causes shifts in the microbial community, impedes root growth and seedling establishment, decreases water, air and nutrient movement, and reduces plant productivity (Corns 1988; Tuttle et al. 1988; Busse et al. 2006; Blouin et al. 2008).

Soil compaction can influence the success of reclamation by decreasing plant establishment and subsequent plant growth. Compaction of topsoil and subsoil has the potential to lead to a decrease in long-term productivity (Heuer et al. 2008; Blouin et al. 2008). The decrease in long-term productivity is a result of increases in soil bulk density and soil strength, reductions in soil aeration (i.e., less soil oxygen), reduced water infiltration and available soil water, restricted root growth, reductions in soil microbiological activity, and influences on nutrient uptake.

The extent of compaction depends on several factors including soil texture, coarse fragment content, organic matter content, and soil moisture conditions. In general, the higher the clay content, the higher the susceptibility to compaction, especially when soils are moist or wet. For example, well-drained, medium-textured soils (loams, sandy loams, silt, and silt loams) are less prone to compaction than fine-textured soils (silty clay loam, silty clay, clay loam, and clay) under the same soil moisture conditions. Compaction can be most severe in fine-textured, wet soils (Corns 1988; Page-Dumroese et al. 2006). In addition, variability in soil particle size tends to offset compaction, such that soils with homogenous texture (i.e., clay, silt) are more prone to compaction than are soils of mixed particle size (Pritchett and Fisher 1987).

Soils in the TMA are predominantly medium- to moderately fine-textured glacial till and are moderately to very highly susceptible to compaction (Annex IV, Section 3.3.5). Soils present in most of the well field area are medium textured and have a moderate sensitivity to compaction.

In the absence of mitigation, Project activities have the potential to directly cause soil compaction, which can cause changes to soil quality. Topsoil stripping while the soil is not excessively wet will reduce risk of compaction and limit damage to soil structure (Ghose 2001). Topsoil stripping under frozen conditions can also reduce the risk of compaction. If construction is completed under frozen or dry conditions, then compaction is less likely to have an influence on soil quality and suitability for reclamation.

Mitigation to reduce the risk of compaction during construction of the Project includes:

- limit vehicle traffic and similar activities to designated areas and avoid areas containing soils most prone to compaction; and
- postpone construction and transportation of equipment and materials off-road during adverse weather or wet ground conditions.

The following mitigation may be used during reclamation activities to minimize compaction:

- rip the subsoil, where necessary, prior to surface soil replacement;
- do not deep rip the subsoil when the soil is excessively wet; and
- crimp suitable organic materials into the subsoil after ripping.

By employing mitigations that avoid or minimize compaction, soil quality degradation from compaction is expected to be local and minor. As such, this pathway was determined to have a negligible residual effect to soils.

- **Air and dust emissions and subsequent deposition can cause changes to the chemical properties of soils, which can affect soil quality.**

Construction and operation of the Project will generate air emissions such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter with aerodynamic diameter less than 2.5 micrometres (µm) ($PM_{2.5}$), particulate matter with aerodynamic diameter less than 10 µm (PM_{10}), and total suspended particulates (TSP), and KCl. Air emissions such as SO_2 and NO_2 can result from the use of fossil fuels in diesel-fired construction equipment, natural gas fired boilers and dryers, vehicles, and locomotives used during the Project. Transportation routes used to access the Project are the main source of dust ($PM_{2.5}$, PM_{10}, and TSP) due to the re-suspension of soil particles (Farmer 1993; Harrison et al. 2003; Peachey et al. 2009; Liu et al. 2011).

Air quality modelling was completed to predict the spatial extent of air and dust emissions and deposition from the Project (Section 7.5). Air quality modelling was completed using the maximum emissions profile expected during the operations phase of the Project. The cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are predicted to evaluate changes to measurement indicators for air quality during the Application Case. This provides the maximum potential effects from the Project. Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates.

The deposition of air and dust emissions can lead to changes in soil quality by altering soil pH and nutrient content, and soil fauna composition (Rusek and Marshall 2000; Jung et al. 2011). The changes to soil from atmospheric inputs is determined by complex geochemical factors, which include decomposition of vegetation, cation and anion exchange in soil, soil sensitivity to acidification, and duration and quantity of atmospheric inputs (Jung et al. 2011). Ultimately, the concentration and duration of air and dust emissions and the sensitivity of the ecosystems determine the overall influence that emission deposition will have on soil quality (Bobbink et al. 1998).

Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2)

Deposition of SO_2 and NO_2 can change soil quality by altering the soil pH causing soil acidification (van Loon 1984). Soil acidification can lead to changes in soil nutrient content, soil microbial composition, and productivity, and subsequently hinder vegetation productivity (van Loon 1984; Rusek and Marshall 2000; Henry 2003; Sparks 2003; Smyth 2012). Specifically, when soil pH decreases (acidifies) certain soil nutrients required for vegetation growth may become unavailable (e.g., phosphorus, calcium, magnesium, and molybdenum), or previously unavailable nutrients may become available at high levels (e.g., H^+, Al^{3+}, and Mn^{2+} ions) (Smyth 2012). The resulting effect is reduced soil quality and capability to support agriculture and other plant communities.

Results of the air quality modelling indicate that ground-level concentrations of SO_2 and NO_2 are not predicted to exceed Saskatchewan Ambient Air Quality Standards (SAAQS; Government of Saskatchewan 2015) during the Application Case (Section 7.5.2). The results indicate that the Application Case maximum 1-hour, 24-hour, and annual SO_2 and NO_2 predictions outside of the core facilities area are below the SAAQS. For example, the maximum 24-hour SO_2 concentration is predicted to be 4.5 micrograms per cubic metre (µg/m^3), which is below the SAAQS of 125 µg/m^3 (Section 7.5.2). The maximum 24-hour NO_2 concentration is predicted to be 49.4 µg/m^3, which is below the SAAQS of 200 µg/m^3 (Section 7.5.2).

Soils within the ESA have a low sensitivity to acidification because of the neutral pH and average CEC of 16 meq/100 g of soil (Section 12.3.2.6). No rapid negative changes on well-buffered calcareous soils, like those found in the ESA, would result from atmospheric inputs of SO_2 and NO_2. Well-buffered calcareous soils would have capability to accept high amounts of acidic inputs from sources such as acid rain and the general soil environment, including soil pH, would remain unchanged for a number of years (van Loon 1984). Therefore, it is expected there will be no changes to soil quality from atmospheric inputs of SO_2 and NO_2.

Particulate Matter ($PM_{2.5}$ and PM_{10}) and Total Suspended Particulates (TSP)

In addition to changes from the deposition of SO_2 and NO_2, chemical changes can occur from the deposition of dust. Rates of dust deposition and accumulation are dependent on the rate of supply from the source, wind speed, precipitation events, topography, and vegetation cover (Rusek and Marshall 2000; Liu et al. 2011).

Changes in soil quality depend on the chemical compositions of dust and its source (Grantz et al. 2003). Dust deposition can cause chemical loading in soils and affect soil biota composition as dust emissions can include metal particles (Grantz et al. 2003; Peachey et al. 2009). Total metal concentrations in soils were generally below Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health for Agricultural Land-Use Areas (CCME 2013a), with the exception of selenium at two locations (Section 12.3.2.8). Selenium at these locations exceeded the CCME guideline level of 1 milligram per kilogram (mg/kg) in a sample from the HwAv1 map unit (Hillwash-Alluvium Complex) (1.09 mg/kg) and a sample from the OxHd2 map unit (Oxbow-Hoodoo association) (2.84 mg/kg) (Section 12.3.2.8). However, both of these sample locations are outside the Project footprint (5 km east and 16 km east-northeast). It is possible that the two elevated concentrations of selenium identified during the baseline soil survey are derived from mineral deposits or from the presence of a feed additive, fertilizer, or pesticide associated with agricultural use in the immediate vicinity of the soil survey locations (Section 12.3.2.8; Dunn 1990; CCME 2009).

Dust is currently a frequent occurrence in the ESA due to agricultural activities and the existing grid road network. Dust movement and deposition is especially high during the planting and harvesting periods, as there is more heavy machinery and traffic using roads and travelling in fields. Fallow fields can produce a large amount of dust during periods of high winds. Therefore, soils in the ESA, particularly in areas along transportation corridors, likely have been influenced by dust already.

The maximum predicted 24-hour and annual $PM_{2.5}$ emissions during the Application Case are 19 µg/m^3 and 6 µg/m^3, respectively, which are below the Canadian Ambient Air Quality Standards (CAAQS) (CCME 2013b) of 28 µg/m^3 (24-hour) and 10 µg/m^3 (annual) (Section 7.5.2). The predicted 24-hour and annual TSP emissions during the Application Case are 53.4 µg/m^3 and 20.5 µg/m^3, respectively, and are below the SAAQS of 100 µg/m^3 (24-hour) and 60 µg/m^3 (annual). The maximum 24-hour PM_{10} emissions during the Application Case is 53.4 µg/m^3, which is above the Saskatchewan ambient air quality standard of 50 µg/m^3 and the maximum concentration occurs east of the mine. However, the background concentration (Base Case) of PM_{10} is 36.3 µg/m^3, which represents 72.6% of the ambient air quality standard. This background concentration is from the City of Regina air quality monitoring station; there are no rural PM_{10} measurements available from the MOE. The analysis shows that the average days during the Application Case only exceed the SAAQS for 3 days during the modeling years (2003 to 2007). Using a rural background PM_{10} concentration of 17.9 µg/m^3 results in a maximum predicted concentration of 35 µg/m³, which is below the SAAQS. In addition, because of the conservatism used for the air quality modelling, it is expected that the actual TSP concentrations for the Project will be lower than predicted. Generally, the influence is localized, although dust deposition can have effects on soil quality (Walker and Everett 1987; Watson et al. 2000). Most studies indicate that the majority of dust tends to settle out within 1 km of ground-level sources (Everett 1980; Walker and Everett 1987; Watson et al. 1996; Meininger and Spatt 1988; Grantz et al. 2003). It is predicted there will be minor and local changes to soil quality from deposition of $PM_{2.5}$, PM_{10}, and TSP.

Potassium Chloride (KCl)

In addition to metals, dust from the Project can contain KCl. Excessive amounts of KCl can contribute to soil salinization. Although excessive amounts of KCl can contribute to soil salinization, it is not the primary salt responsible for soil salinization (Henry et al. 1992). Typically, the soluble salts responsible for salinization include calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), magnesium sulphate ($MgSO_4$), NaCl, and sodium sulphate (Na_2SO_4). When salts accumulate in soils, they can promote clay swelling and disrupt soil structure, which can affect soil permeability, soil plasticity, water retention capability, CEC, and soil quality (Barbour and Yang 1993; Gabbasova et al. 2010; Keren 2012; Levy 2012). Salts can also increase soil pH, which can alter the availability of soil nutrients for plant uptake (Richards 1954; MOA 2008; Levy 2012). Salinization of soil with NaCl or KCl can inhibit soil available nitrogen causing a decrease in soil quality (Richards 1954). Levels of electrical conductivity (EC) of 4 to 8 deciSiemens per metre (dS/m) is considered moderately saline and levels greater than 8 is considered severely saline (Henry et al. 1992).

The predicted regional peak monthly KCl deposition is predicted to be well below the SAAQS criteria (Section 7.5.2). The potash deposition threshold of 0.15 milligrams per square centimetre (mg/cm²) is to be used either in the form of potassium or chloride (SAAQS 1996). Deposition predictions are 0.001 mg/cm^2 of potassium K and 0.001 mg/cm^2 of chloride (0.002 mg/cm^2 KCl). Even if the deposition rates were higher than those predicted, it would be expected that it would have a negligible effect on soils in the ESA as these soils are characterized as having a neutral pH and an average CEC of 16 meq/100 g. This CEC indicates that the soil has a greater capacity to hold cations (K+), but not anions (Cl-). Typically, soil bound potassium makes up 98% of the total potassium in soil and only 2% of the total is plant available (Bolan et al. 2012). In addition, chloride is not adsorbed on soil particles at neutral and alkaline pH values and, therefore, is easily leached (Bolan et al. 2012). The soils in the Project footprint area are characterized as non-saline. These soils would require an increase in salinity to over 4 dS/m to affect the ability of soil to support sensitive agricultural crops, and over 8 dS/m to affect salt tolerant crops (Henry et al. 1992). It is predicted there will be no changes to soil quality from deposition of KCl.

Environmental design features will be incorporated into the Project design to limit the changes to the chemical properties of soils from air, dust, and KCl emissions and subsequent deposition. Various dust-producing components of the potash refinement process (i.e., dryers, compaction circuit) will have controls to recover and return dust to the circuit. The process plant will use cyclones, baghouses, and wet scrubbers to reduce air and dust emissions so that an acceptable working environment is achieved and government standards are met. The dryer burners will be high efficiency, low nitrogen oxide (NO_x) burners to limit the amount of NO_x present in the exhaust stream. Several vent pick-up inlets will be provided for collecting dust at all critical transfer points and from dryer exhausts. Dust control systems will discharge to proven scrubber systems in areas where ore is handled (e.g., product screening, storage, and loadout). All conveyors between buildings will be enclosed. Compliance with regulatory stack emissions and ambient air quality standards will be maintained throughout construction and operation of the Project. Any required or scheduled maintenance of equipment will be performed as needed to meet federal and provincial air emissions standards. The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment. Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. Enforced speed limits will assist in reducing production of dust from roadways. Finally, erosion control practices will be implemented during construction and operation of the Project to limit dust production.

Overall, air and dust emissions and subsequent deposition are expected to result in minor and local changes to the chemical properties of soils relative to Base Case conditions. Therefore, this pathway was determined to have a negligible residual effect on soils.

12.4.2.3 Primary Pathways

The following primary pathways are assessed in detail in the residual effects analysis.

- **Direct loss or alteration of soils in the Project footprint (core facilities area, mining area, and access roads) can change soil quantity and distribution.**
- **Residual ground disturbance from portions of the core facilities area can permanently alter soils.**
- **Ground subsidence caused by solution mining can change surface flows, drainage patterns (distribution), and drainage areas, which can affect soils.**

12.5 Residual Effects Analysis

The residual effects analysis is focused on thoroughly evaluating the primary pathways associated with the Project and other developments on the soils VC, soil capability to support agriculture and other plant communities. The residual effects assessment is completed by calculating and estimating changes to the measurement indicators of soils that are relevant to the primary pathways. These measurement indicators are:

- soil quality (i.e., physical, biological, and chemical properties); and
- soil quantity and distribution.

The analyses were quantitative, where possible, and included data from field studies, scientific literature, and government publications. Due to the amount and type of data available, some analyses were qualitative and included professional judgment or experienced opinion.

12.5.1 Changes to Soil Quantity and Distribution from the Project

The removal of soil from the landscape is required to develop Project facilities. Site clearing and construction of the Project, particularly through the process of soil stripping and excavation, will result in changes to soil quantity and distribution. Soil quantity and distribution refers to the associated area or extent of the effect. The effect to soil quantity and distribution includes the soil map units that will be affected, as well as the agriculture capability classes associated with each map unit. Soil removal will occur mainly during the construction stage of the Project and, to a small extent, during operation.

12.5.1.1 Methods

Changes to soil quantity and distribution were assessed for the maximum predicted point of development of the Project footprint (Application Case), which should have the largest geographic extent of effects on soil capability to support agriculture and other plant communities. Progressive reclamation is expected to occur during operations to limit incremental losses and effects beyond the Application Case.

For the analysis, the proposed core facilities area was buffered by 100 m, the plant site access road buffered by 50 m (100-m right-of-way), the well pads buffered by 50 m, and the well pad access roads buffered by 25 m (50-m right-of-way) so that a maximum possible extent of disturbance was used in the analysis. Most of the proposed Project infrastructure will be removed and reclaimed during decommissioning and reclamation. The TMA (i.e., the salt storage areas, brine reclaim ponds and sewage lagoon), and the crystallization pond and site runoff collection pond are considered permanent. The footprint was buffered so that the effects analysis results represent a conservative estimate of residual effects on soils (i.e., effects are likely overestimated).

The residual effects on soils are assessed using predicted changes to soil map units and their associated agriculture capabilities. A GIS platform was used to quantify the changes in soil map units within the ESA caused by the Project footprint and previous and existing developments. This was completed by determining a summary of areas of each soil map unit within the ESA for the Base Case and Application Case. The incremental and cumulative changes from the Project and other developments on soils were estimated by calculating the relative difference or net change in the map unit between the Application Case and Base Case as follows:

(Application Case value – Base Case value)/ Base Case value

Each resulting value was then multiplied by 100 to give the percent change for each comparison, providing both direction and magnitude of the effect. For example, a high negative value would indicate a substantial loss of that soil map unit, while a low positive value would indicate a slight increase in a soil map unit. Following decommissioning and reclamation, it was assumed that there will be a net change to these soil map units relative to the ESA, because following reclamation, these soils will be reconstructed. As such, the change following decommissioning and reclamation is classified as “reclaimed”. Those areas that result in a permanent change are classified as “residual disturbance”.

12.5.1.2 Results

The dominant soil map unit within the ESA is the Oxbow unit and accounts for approximately 29.2% (23,452 ha) of the ESA under Base Case conditions. The Weyburn soil map unit covers 23.1% of the ESA, Weyburn-Oxbow covers 11.9%, Weyburn-Elstow covers 4.0%, and Forget Complex covers 1.2% of the ESA under Base Case conditions.

The predicted areas affected during the Application Case are shown in Table 12.5-1, as well as a summary of the net changes in each soil map unit following decommissioning and reclamation. The maximum (conservative) area of soil map units to be disturbed by the application of the Project is 1,550 ha (approximately 1.9% of the ESA; Figure 12.5-1). The soil map unit that will likely experience the greatest change during construction is the Weyburn-Elstow (WrEw4 and WrEw8) map unit, of which 936 ha will be disturbed (Table 12.5-1).

Following decommissioning and reclamation, an area of approximately 842 ha (approximately 1.0% of the ESA) of the Project footprint is expected to be reclaimed (Table 12.5-1). Reclamation will be carried out as outlined in the Conceptual Reclamation Plan (Section 4.11; Appendix 4-D) and soils will be reconstructed in reclaimed areas. Reclaimed areas have not been assigned a specific soil type and are classified as a reclaimed map unit.

The area of residual disturbance is predicted to be 708 ha (approximately 0.9% of the ESA); these areas will not be reclaimed at closure (Table 12.5-1; Figure 12.5-2). The area of residual disturbance includes 600 ha of Weyburn-Elstow (WrEw4), 49 ha of Weyburn (Wr4), 34 ha of Forget (Fg10), and 25 ha of Weyburn-Oxbow (WrOx4) soil map units.

Table 12.5-1: Change in Area of Soil Map Units from Development within the Effects Study Area

Map Unit Name	Map Unit Symbol(s)	Base Case (ha)	Application Case (ha)	Percent Change Base Case to Application Case (% unit)	Application Case - Post-Closure (ha)
Asquith	Aq10, Aq 14	287	287	0	287
Asquith-Biggar	AqBg4	166	166	0	166
Asquith-Bradwell	AqBr4	382	382	0	382
Biggar	Bg2	216	216	0	216
Bradwell	Br12	248	248	0	248
Bradwell-Asquith	BrAq8, BrAq13	127	127	0	127
Elstow	Ew1	58	58	0	58
Elstow-Weyburn	EwWr4, EwWr11	1,465	1,465	0	1,465
Forget	Fg10	986	924	-6.2	924
Glenavon	Gn4, Gn8	1,116	1,116	0	1,116
Hoodoo	Hd7	59	59	0	59
Hoodoo-Oxbow	HdOx8	115	115	0	115
Hillwash	Hw	130	130	0	130
Hillwash-Alluvium	HwAv1	1,328	1,321	-0.5	1,321
Meota-Whitesand	MeWs13	1,446	1,446	0	1,446
Oxbow	Ox2, Ox4, Ox8, Ox10, Ox22	23,452	23,452	0	23,452
Oxbow-Hoodoo	OxHd2	2,996	2,996	0	2,996
Oxbow-Hamlin	OxHm4	113	113	0	113
Oxbow-Whitewood	OxWh2	0	0	0	0
Oxbow-Weyburn	OxWr2, OxWr4, OxWr5	7,671	7,652	-0.3	7,652
Oxbow-Whitesand	OxWs7, OxWs14	1,719	1,719	0	1,719
Runway	Rw	566	566	0	566
Swift Creek	Sf2, Sf11	954	954	0	954
Scott	St9	862	862	0	862
Windthorst	Wn2	963	963	0	963
Weyburn	Wr2, Wr4, Wr10, Wr15	18,597	18,126	-2.5	18,126

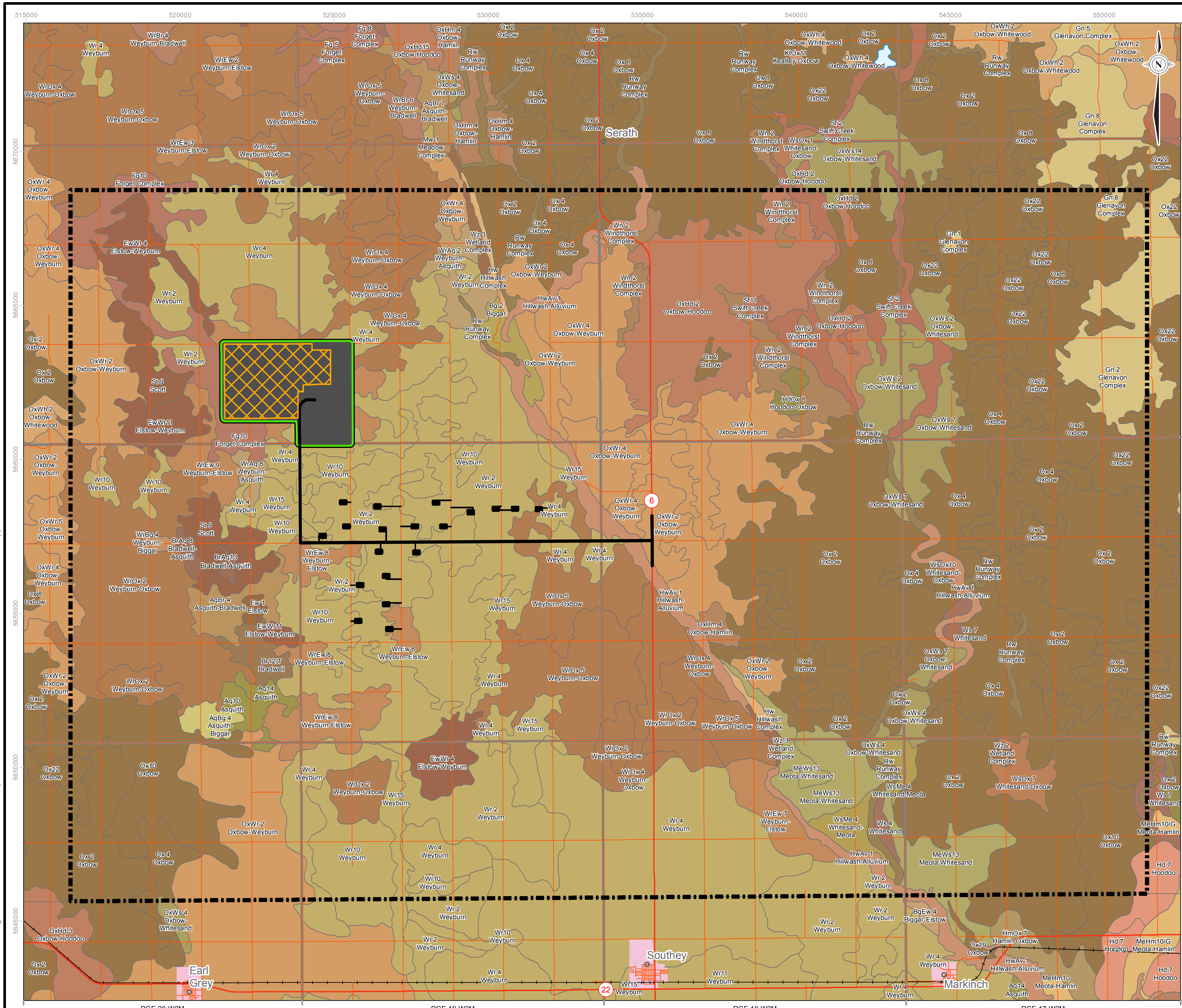
Table 12.5-1: Change in Area of Soil Map Units from Development within the Effects Study Area

Map Unit Name	Map Unit Symbol(s)	Base Case (ha)	Application Case (ha)	Percent Change Base Case to Application Case (% unit)	Application Case - Post-Closure (ha)
Weyburn-Asquith	WrAq2, WrAq8	498	498	0	498
Weyburn-Biggar	WrBg4	55	55	0	55
Weyburn-Elstow	WrEw4, WrEw7, WrEw8, WrEw9	3,236	2,300	-28.9	2,300
Weyburn-Oxbow	WrOx2, WrOx4, WrOx5	9,567	9,511	-0.6	9,511
Whitesand	Ws4, Ws7	176	176	0	176
Whitesand-Meota	WsME4	372	372	0	372
Whitesand-Oxbow	WsOx7, WsOx10	307	307	0	307
Wetland Complex	Wz2, Wz3	154	154	0	154
Project Footprint	n/a	0	1,550	n/a	0
Reclaimed	n/a	0	0	0	842
Residual Disturbance	n/a	0	0	0	708
Total		**80,385**	**80,385**	**n/a**	**80,385**

Note: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values

Negative numbers indicate a reduction in that soil map unit. Positive numbers indicate an increase in that soil map unit.

ha = hectare; % = percent; n/a = not applicable

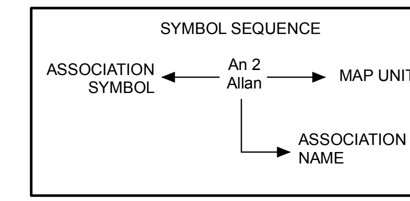


LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

PROPOSED PROJECT FOOTPRINT

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD
- TAILINGS MANAGEMENT AREA AND CRYSTALLIZATION POND



NOTE

1. THE NUMBERS SHOWN WITH ASSOCIATION LABELS ARE TERMED MAP UNITS AND INDICATE DIFFERENT AND SPECIFIED COMBINATIONS OF SOIL SUBGROUP PROFILES WITHIN AN ASSOCIATION THAT ARE THE RESULT OF VARIATIONS IN TOPOGRAPHY, DRAINAGE OR ASPECT.
2. SOIL POLYGONS WERE UPDATED BASED ON FIELD SURVEY RESULTS.

REFERENCE

SASKATCHEWAN LAND RESOURCES UNIT, 2004
SKSISV2, DIGITAL SOIL RESOURCE INFORMATION FOR AGRICULTURAL SASKATCHEWAN, 1:100,000 SCALE,
AGRICULTURE AND AGRI-FOOD CANADA, SASKATOON, SASKATCHEWAN.
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

2.5 0 2.5
SCALE 1:125,000 KILOMETRES

PROJECT

YANCOAL SOUTHEY PROJECT

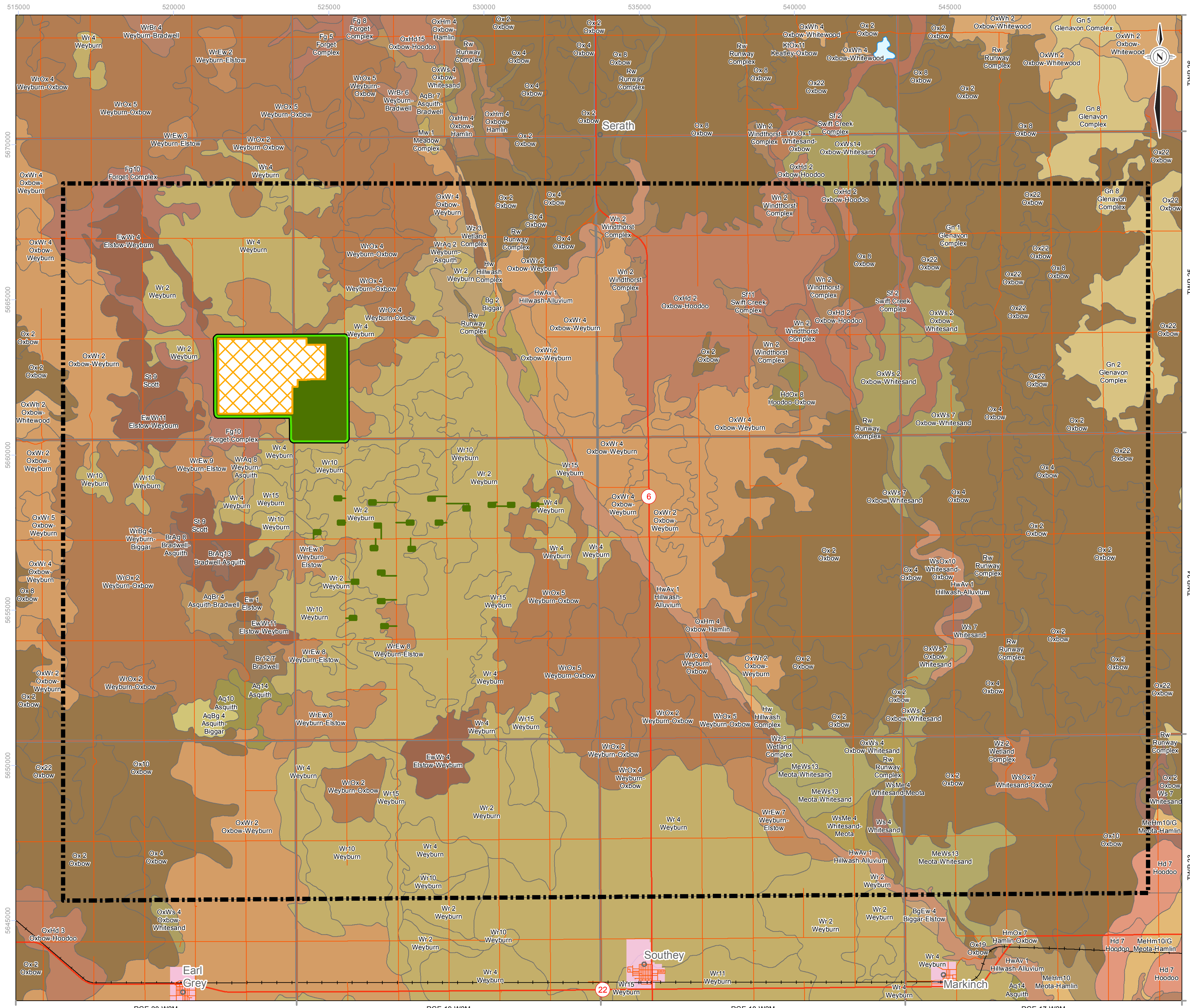
TITLE

SOIL ASSOCIATIONS DISTRIBUTION FOR THE APPLICATION CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197		FILE No.
DESIGN	JF	05/02/15	SCALE AS SHOWN REV. 0
GIS	LMS	25/05/15	
CHECK	JLF	25/05/15	FIGURE: 12.5-1
REVIEW	BC	25/05/15	

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1205 - Soils\12-1362-0197 - Soils Associations ESA - Application.mxd Date: 6/2/2015 11:30:59 AM



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

RECLAIMED AREAS

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD

NOT RECLAIMED RESIDUAL DISTURBANCE

- TAILINGS MANAGEMENT AREA AND CRYSTALLIZATION POND

SYMBOL SEQUENCE

ASSOCIATION SYMBOL ← An 2 Allan → MAP UNIT

↳ ASSOCIATION NAME

NOTE

1. THE NUMBERS SHOWN WITH ASSOCIATION LABELS ARE TERMED MAP UNITS AND INDICATE DIFFERENT AND SPECIFIED COMBINATIONS OF SOIL SUBGROUP PROFILES WITHIN AN ASSOCIATION THAT ARE THE RESULT OF VARIATIONS IN TOPOGRAPHY, DRAINAGE OR ASPECT.
2. SOIL POLYGONS WERE UPDATED BASED ON FIELD SURVEY RESULTS.

REFERENCE

SASKATCHEWAN LAND RESOURCES UNIT, 2004
SKSISV2, DIGITAL SOIL RESOURCE INFORMATION FOR AGRICULTURAL SASKATCHEWAN, 1:100,000 SCALE,
AGRICULTURE AND AGRI-FOOD CANADA, SASKATOON, SASKATCHEWAN.
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

2.5 0 2.5

SCALE 1:125,000 KILOMETRES

PROJECT

YANCOAL

YANCOAL SOUTHEY PROJECT

TITLE

SOIL ASSOCIATIONS DISTRIBUTION FOR THE APPLICATION CASE - POST CLOSURE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	JF	18/03/15	SCALE AS SHOWN	REV. 0
GIS	LS/AK	25/05/15	FIGURE: 12.5-2	
CHECK	JLF	25/05/15		
REVIEW	BC	25/05/15		

The dominant agriculture capability class within the ESA is Class 3 and accounts for approximately 48.9% (39,291 ha) of the ESA under Base Case conditions. The Class 2 covers 20.7% of the ESA, Class 4 covers 11.8%, and Class 5 covers 11.0% of the ESA under Base Case conditions.

The effect from the Project on agriculture capability classes between Base Case and Application Case is presented in Table 12.5-2. The maximum area that is predicted to be disturbed at any point in time during the Project operation will be 1,550 ha (approximately 2% of the ESA) (Table 12.5-2). An estimated area of 842 ha (approximately 1.0% of the ESA) within the Project footprint is expected to be reclaimed to an equivalent agriculture capability. This includes a predicted re-establishment of 12 ha (less than 0.1% of the ESA) of Class 2 soils, 695 ha (0.9 % of the ESA) of Class 3 soils, 29 ha (less than 0.1% of the ESA) of Class 4 soils, 56 ha (0.1% of the ESA) of Class 5 soils, and 49 ha (0.1% of the ESA) of Class 6 soils (Table 12.5-3; Figure 12.5-4).

The area of permanent change of agriculture capability associated with the residual disturbance is predicted to be 708 ha (approximately 0.9% of the ESA). These areas will become Class 7 (they have no capability for agriculture) following decommissioning and reclamation of the Project. This includes the predicted loss of 615 ha (approximately 1.0% of the ESA) of Class 3 soils, 23 ha (less than 0.1% of the ESA) of Class 4 soils, 67 ha (less than 0.1% of the ESA) of Class 5 soils, and 0.1 ha (less than 0.1% of the ESA) of Class 6 soils (Table 12.5-3; Figure 12.5-4).

Table 12.5-2: Change in Area of Agriculture Capability Classes from Development of the Project within the Effects Study Area

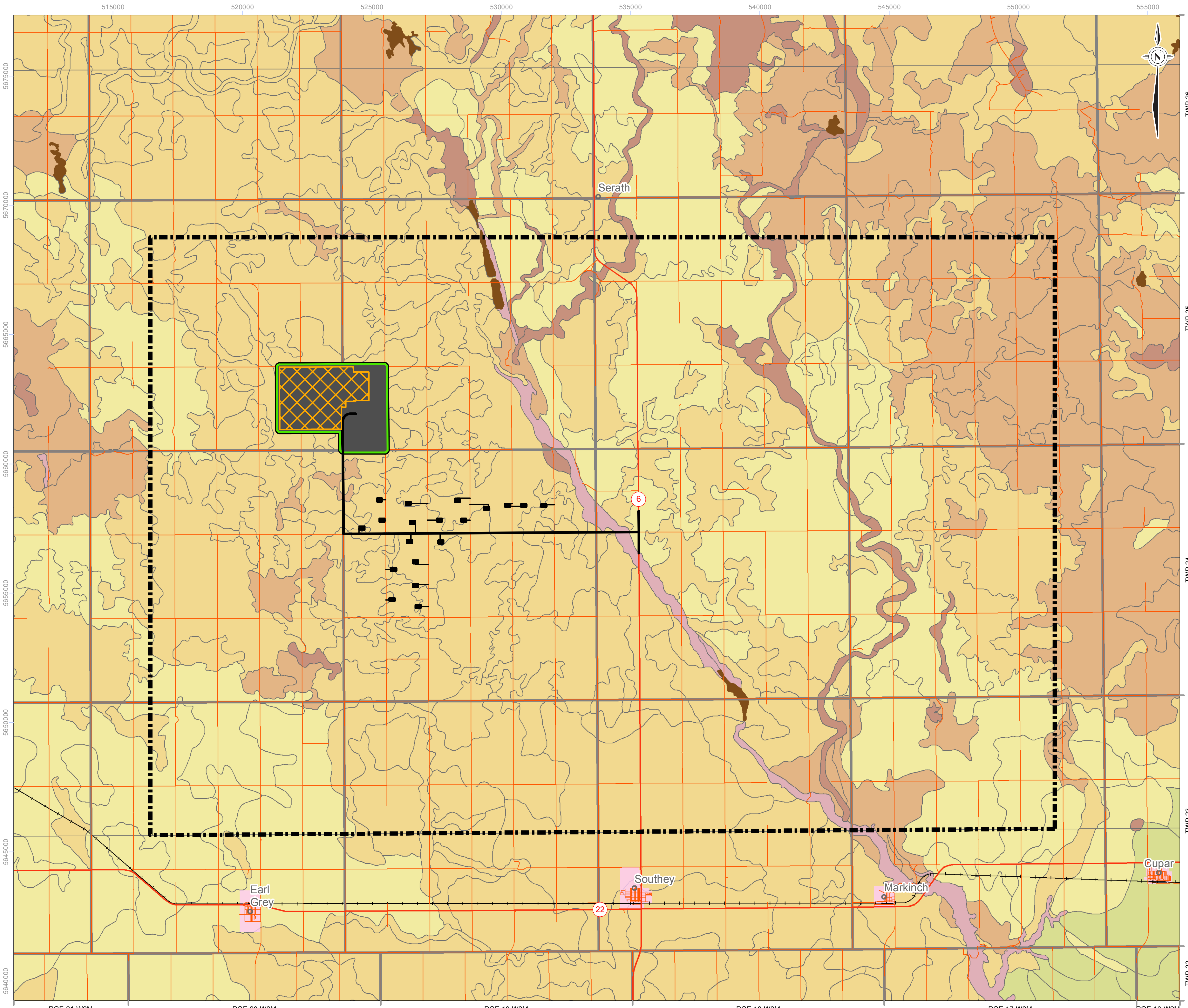
Agriculture Capability Class	Base Case (ha)	Application Case (ha)	Percent Change Base Case to Application Case (% unit)	Application Case Post-closure
Class 1	306	306	0	306
Class 2	16,409	16,397	-0.1	16,409
Class 3	39,391	38,080	-3.3	38,776
Class 4	9,618	9,566	-0.5	9,595
Class 5	8,781	8,658	-1.4	8,714
Class 6	5,779	5,727	-0.9	5,777
Class 7	102	102	0.0	809
Project Footprint	0	1,550	n/a	0
Total	**80,385**	**80,385**	**n/a**	**80,385**

Notes: Negative numbers indicate a reduction in the agriculture capability. Positive numbers indicate an increase in agriculture capability. Following decommissioning and reclamation, reclaimed areas are reclaimed to an equivalent agriculture capability. Areas of residual disturbance become Class 7.
ha = hectares; % = percent; < = less than; n/a = not applicable

Table 12.5-3: Changes to Agriculture Capability Classes in the Effects Study Area Following Application Case - Post Closure

Agriculture Capability Class	Permanent Loss (ha)	Proportion of ESA (%)	Reclaimed Area (ha)	Proportion of ESA (%)
Class 2	n/a	n/a	12	<0.1
Class 3	-615	0.8	695	0.9
Class 4	-23	0.0	29	<0.1
Class 5	-67	0.1	56	0.1
Class 6	-2	0.0	49	0.1
Total	**-708**	**0.9**	**842**	**1.0**

Note: a value <0.1 approaches zero.
Negative numbers indicate a reduction in the agriculture capability. Positive numbers indicate an increase in agriculture capability.
ha = hectares; % = percent; ESA = Effects Study Area; < = less than.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

AGRICULTURE CAPABILITY CLASSES

- CLASS 1 - NO SIGNIFICANT LIMITATIONS
- CLASS 2 - MODERATE LIMITATIONS
- CLASS 3 - MODERATELY SEVERE LIMITATIONS
- CLASS 4 - SEVERE LIMITATIONS
- CLASS 5 - VERY SEVERE LIMITATIONS
- CLASS 6 - NATIVE FORAGE ONLY
- CLASS 7 - NOT SUITABLE FOR AGRICULTURE

PROPOSED PROJECT FOOTPRINT

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD
- TAILINGS MANAGEMENT AREA AND CRYSTALLIZATION POND

NOTE

SOIL POLYGONS WERE UPDATED BASED ON FIELD SURVEY RESULTS.

REFERENCE

SASKATCHEWAN LAND RESOURCES UNIT, 2004
SKSISV2, DIGITAL SOIL RESOURCE INFORMATION FOR AGRICULTURAL SASKATCHEWAN, 1:100,000 SCALE.
AGRICULTURE AND AGRI-FOOD CANADA, SASKATOON, SASKATCHEWAN
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT

YANCOAL 兖煤加拿大资源有限公司

YANCOAL SOUTHEY PROJECT

TITLE

AGRICULTURE CAPABILITY FOR THE APPLICATION CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	JF	05/02/15	SCALE AS SHOWN REV. 0
GIS	LMS	25/05/15	
CHECK	JLF	25/05/15	
REVIEW	BC	25/05/15	

FIGURE: 12.5-3

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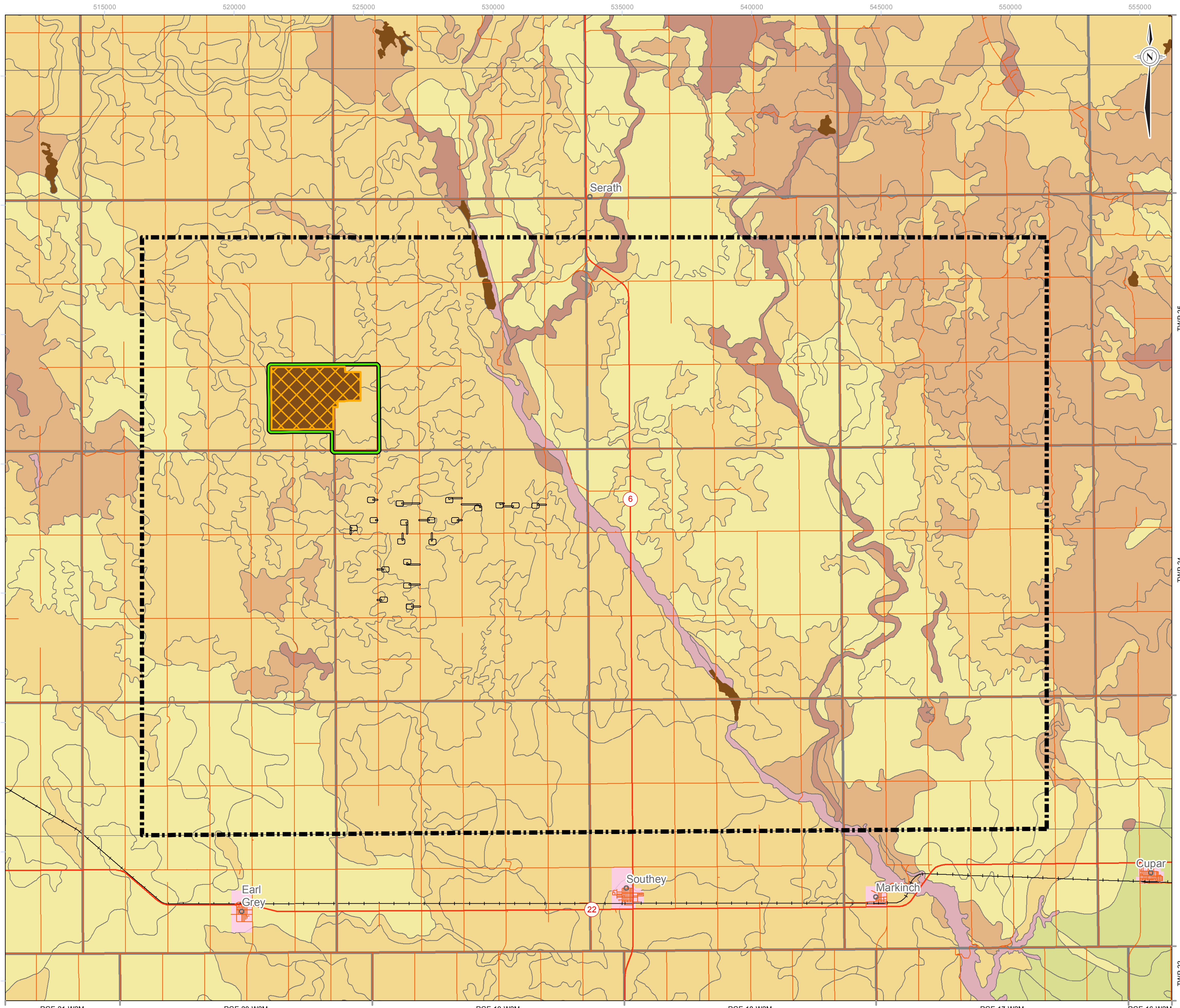

LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

AGRICULTURE CAPABILITY CLASSES

- CLASS 1 - NO SIGNIFICANT LIMITATIONS
- CLASS 2 - MODERATE LIMITATIONS
- CLASS 3 - MODERATELY SEVERE LIMITATIONS
- CLASS 4 - SEVERE LIMITATIONS
- CLASS 5 - VERY SEVERE LIMITATIONS
- CLASS 6 - NATIVE FORAGE ONLY
- CLASS 7 - NOT SUITABLE FOR AGRICULTURE

RECLAIMED AREAS

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD

NOT RECLAIMED RESIDUAL DISTURBANCE

- TAILINGS MANAGEMENT AREA AND CRYSTALLIZATION POND

NOTE

SOIL POLYGONS WERE UPDATED BASED ON FIELD SURVEY RESULTS.

REFERENCE

SASKATCHEWAN LAND RESOURCES UNIT, 2004
SKSISV2, DIGITAL SOIL RESOURCE INFORMATION FOR AGRICULTURAL SASKATCHEWAN, 1:100,000 SCALE.
AGRICULTURE AND AGRI-FOOD CANADA, SASKATOON, SASKATCHEWAN
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
AGRICULTURE CAPABILITY FOR THE APPLICATION CASE - POST CLOSURE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	JF	18/03/15	SCALE AS SHOWN	REV. 0
GIS	LS/AK	25/05/15	FIGURE: 12.5-4	
CHECK	JLF	25/05/15		
REVIEW	BC	25/05/15		

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12.5.2 Changes to Soils from Subsidence

12.5.2.1 Methods

Ground subsidence will develop over mined caverns within the mining area and is expected to begin while mining is occurring and will continue through post-mining. Subsidence is expected to alter local flows, drainage patterns and the spatial distribution of surface water within the mining boundary. These changes to surface water can change soil quality. Decreases in slope gradients may cause areas to accumulate more snowmelt runoff and rainfall, thereby increasing soil moisture and creating wetland soils. Alternatively, existing wetlands may drain and become upland soils in areas where slope gradients increase. Ground subsidence may also change the flow rates of existing streams, which may change soil erosion and alter soil quality.

Changes to surface water flow and terrain slopes from subsidence were estimated using multiple techniques. The Light Detection and Ranging (LiDAR) topographic data was used to create a digital elevation model (DEM) and determine current terrain conditions within the mining boundary. Field studies were completed in 2013 to determine baseline conditions for soil and wetlands. The subsidence settlement calculation was based partially on the 65-year mine field, which is contained within the ESA. For post-subsidence topographic conditions, the LiDAR data was modified by lowering the topography and the modified DEM was then used in the hydrological analysis. Changes from ground subsidence to surface hydrology features including drainage area, flow pathways (i.e., watercourses) and wetlands were calculated using computer modeling based on current conditions and the changes resulting from the predicted ultimate subsidence (Appendix 9-A). The subsidence assessment was based on the potential maximum subsidence expected once mining is completed, after each individual cavern has completely closed, and the insoluble materials within the cavern have consolidated to intact rock salt (Appendix 9-A).

Changes to soil quality are expected to result indirectly from the alteration of local flows, drainage patterns, and the spatial distribution of surface water resulting from ground subsidence associated with Project activities in the mining boundaries. The effects to soil quality are examined qualitatively based on an evaluation of the effects of changes to the alteration of local flows, drainage patterns, and the spatial distribution of surface water to several soil quality criteria.

12.5.2.2 Results

Solution mining and related removal of solid, liquid, and gaseous materials from below the ground surface results in ground subsidence. Within the ESA, the maximum amount of subsidence is predicted to occur in the western section of the 65-year mine field (Appendix 9-A). More subsidence is predicted to occur directly overlying the mine development caverns and decrease with distance away from the cavern locations. Changes to the surface topography from subsidence are predicted to change terrain, which may alter local flows and drainage patterns (distribution). These changes have the potential to affect soil quality. The rate of ground subsidence, maximum subsidence depth, and time to reach maximum depth range based on site and mine-specific conditions (Chrzanowski et al. 1998). Subsidence is a slow process occurring during the Project and requires several hundred years to reach ultimate (maximum) subsidence. The changes in surface drainage patterns resulting from ground subsidence may alter physical, chemical, and biological soil quality properties, and alter the soil capability to support agriculture and other plant communities.

The area affected by surface subsidence is predicted to occur over an area extending 17 km from west to east and about 8 km from north to south (Appendix 9-A). The maximum settlement is predicted to occur on the area directly overlying the caverns and it is predicted that the topographic surface should subside relatively uniformly over the 65-year mine field. The maximum vertical displacement is predicted to be approximately 6.7 m. The final gradient of surface subsidence at the boundary of the 65-year mine field will be gradual, where the average gradient from unaffected areas to the area of maximum subsidence is predicted to be 3.9 m/km. In areas of steeper subsidence gradients, settlement is predicted to increase from 0.5 m to 6.7 m over a length of approximately 1.6 km with maximum gradients of 5.0 m/km.

Alteration of surface topography associated with subsidence is predicted to result in small, localized changes to flow pathways and drainage areas within the West Loon Creek basin in the ESA (i.e., all tributary watercourses affected by subsidence flow into West Loon Creek) (Appendix 9-A). Changes to flow pathways are mainly predicted along the north and west edges of the mine well field area. While it is expected that localized alterations of flow pathways will occur and ponding sections may appear, the magnitude of flows along major flow paths (i.e., West Loon Creek) are predicted to be maintained. Alterations of smaller drainage area boundaries in the central section of the mine well field area are anticipated; however, drainage is predicted to continue to direct runoff to West Loon Creek.

Subsidence is predicted to alter stream channel slopes of the three main watercourses in the ESA including West Loon Creek, a tributary of West Loon Creek from the east, and the intermittent stream that occasionally contributes runoff to West Loon Creek from the west (Appendix 9-A). Subsidence is predicted to exceed 6.0 m in some sections of the West Loon Creek channel resulting in a channel gradient reverse in two sections with some shallow ponding likely to occur; however, downstream drainage would continue. Channel gradient increases are predicted in some sections where gradients of subsidence and topography have the same direction (e.g., both decrease). Where flow velocities increase, erosion is more likely and deposition may occur when the flow velocity is reduced. Changes to flow volumes are expected to be minimal potentially reducing flood peaks but maintaining flows for downstream areas, although attenuation may occur in ponded areas. Subsidence is predicted to reach approximately 4.0 m in the West Loon Creek east tributary. The existing channel is poorly drained with flat sections where ponded areas develop; the same conditions are predicted to remain following subsidence. The maximum predicted subsidence will be approximately 6.6 m in the intermittent stream in the west of the 65-year mine field. Subsidence may increase the storage potential on the lowered landscape and reduce the frequency that surface runoff from the area reaches West Loon Creek, but the overall effect on streamflow downstream would be negligible in most years.

Subsidence is expected to affect storage of water on the land surface in the ESA. Existing depressions and wetlands are predicted to receive more runoff in settlement areas that result from surface subsidence. It is predicted that differential settlement will cause reductions in the water storage capacity of some depressions and wetlands along the west and north sides of the mine area. In contrast, an increase in water levels is anticipated in depressions and wetlands in areas with the greatest subsidence.

The effects of ground subsidence indirectly affect soil quality by changing the moisture conditions of soils in the ESA. Infiltration of water into newly formed wetlands or enlarged drainage areas can result in saturation of previously unsaturated soils. Conversely, water drained from previously saturated areas will result in unsaturated areas. A change in soil moisture conditions initiates a number of physical, biological, and chemical properties of soil quality that can influence the capability of soil to support agriculture and natural plant communities.

Soil saturation replaces the air present in the soil pores with water, impeding the exchange of oxygen and carbon dioxide, stabilizing soil temperature, and, depending on the soil texture, can cause swelling of soil aggregates and disruption of soil structure, affecting root penetration and plant growth (Ponnamperuma 1972; Fageria et al. 2011). The dominant microbial community shifts from aerobic microorganisms, which become dormant or die in the absence of oxygen, to facultative and obligate anaerobic organisms, which proliferate in an anoxic (without oxygen) environment (Fageria et al. 2011). The shift in microbial community results in a reduced rate of soil organic matter decomposition. Microbial activities in an anoxic environment regulate a number of chemical changes, such as the reduction of nitrate and nitrogen dioxide to nitrogen gas and nitrous oxide (denitrification), and the reduction of plant-available sulfate to the soil phytotoxin, sulfide, and hydrogen sulfide gas (Ponnamperuma 1972; Patrick and Reddy 1976; Fageria et al. 2011; Lamers et al. 2013). The main chemical changes that occur in flooded soils are increases in iron and manganese concentrations. The pH of acidic soils increase and alkaline soils decrease when saturated. Other results are the reduction of carbon dioxide to methane. Saturation of soils may also improve the concentration and availability of phosphorus, calcium, magnesium, molybdenum, and silicon, and decrease the concentration and availability of zinc and copper (Ponnamperuma 1972; Fageria et al. 2011).

In contrast, draining previously saturated areas changes the soils from an anoxic state to an oxidized or aerated environment where oxygen is present. As soil volumetric water content decreases, air-filled porosity increases which allows for the return of aerobic microorganisms reversing the loss of soil nitrogen by denitrification, the production of sulfide, and by reducing the soluble iron and manganese concentrations in the soil (Ponnamperuma 1972; Patrick and Reddy 1976; Fageria et al. 2013). Organic matter decomposition rates are increased in aerobic environments, supplying more nutrients to the soil with the conversion of ammonia and ammonium and mineralization of organic sulphur to plant available nitrate and sulfate forms increases soil quality in these areas (Reddy and Patrick 1983). In general, soil chemical changes result from physical reactions between the soil and water and the biological activities of microorganisms.

Effects of subsidence will be mitigated by applying environmental design features and specialized techniques for solution mining. For example, pillars of unmined material will be left between the mine caverns to increase stability during mining and to reduce potential subsidence. The cavern layout will be refined as additional modeling is completed to optimize potash recovery and to limit the potential effects of subsidence on surface topography. Secondary mining techniques that reduce the amount of material removed from the mine cavern will be employed after development of primary caverns, wherever possible. Finally, extraction ratios will be controlled to limit strain on the overlying environment.

Changes to soil quality from ground subsidence will occur gradually over more than 100 years. Areas that become more depressional in the landscape may be expected to accumulate more snow runoff and rainfall, which will increase soil moisture and may create wetland soils. Alternatively, existing wetlands may drain and soils will become drier in some areas.

Long-term changes to soil quality from subsidence are not anticipated to be obvious and domestic activities and land uses should adjust to the changes over time. Because subsidence will occur very gradually, no acute, adverse effects to soil quality are expected. A gradual net change to soil quality (i.e., some areas will become wetter and other areas will become drier) is predicted.

12.6 Prediction Confidence and Uncertainty

A source of uncertainty for the Project is the degree to which residual effects could occur (e.g., magnitude and duration). There is a high degree of certainty that surficial materials will be moved, excavated, and re-contoured, and soil will be disturbed within the Project footprint. The areas affected have been determined based on the site plan outlined in this document. The geographic extent of effects from the Project has a high degree of certainty, as there is confidence in the location and area of the Project footprint. The soil types and associated agriculture capabilities at the location of the TMA will change permanently. Confidence in the accuracy of the magnitude of predicted changes to soil quantity and quality is related to the scale that soil maps were delineated relative to the scale for estimating the amount of disturbance from the Project. The soil maps that were used to determine Project effects are not 100% accurate; however, they provide a reasonable estimation of soil types and their distribution in the area.

The primary sources of uncertainty for determining Project effects to soils and capability to support agriculture and other plant communities are associated largely with current knowledge of the ecosystem and, subsequently, predicting the level of changes to soil from construction through decommissioning and reclamation (i.e., greater than 100 years). Thus, there is uncertainty in predicting the magnitude, duration, and reversibility of effects. Several aspects of soil quality were examined. The effects from soil removal, storage, and other Project activities on soils were assessed; however, these assessments should be treated as generalized interpretations. The main processes are biological, chemical, and physical changes during storage in stockpiles, soil admixing, compaction, erosion, soil storage, and associated changes in reclamation suitability. Minor changes in quality due to these processes are predicted with moderate certainty. Admixing, compaction, and erosion effects are expected to be localized. Prediction of a low effect is based on appropriate stockpile design and vegetating the stockpiles. This uncertainty can be reduced by completing additional site-specific soil surveys within areas expected to be disturbed to better evaluate soil conditions prior to Project construction, and to better monitor changes during and following the Project.

Uncertainty was addressed in the assessment by incorporating information from available and applicable literature, and using past experience in similar areas. In addition, proven best practices during the Project, and a Decommissioning and Reclamation Plan will be developed and implemented to mitigate effects to the soil capability to support agriculture and other plant communities. Finally, conservative estimates were used so that residual effects were not underestimated. A conservative estimate of the Project footprint (1,550 ha) was used to assess changes to soils, as this is larger than the actual area expected to be disturbed during construction. The proposed core facilities area was buffered by 100 m, the plant site access road buffered by 50 m (100-m right-of-way), the well pads buffered by 50 m, and the well pad access roads buffered by 25 m (50-m right-of-way).

There is uncertainty related to the predicted effects from subsidence, as these changes are strongly dependent on changes to the hydrological regime. Hydrology identified a number of uncertainties related to the predictions on the effects to hydrology and the surface water environment from subsidence (Section 9.6 and Appendix 9-A). These uncertainties are related to the random variability associated with the hydrology process, model uncertainty, and parameter uncertainty. There is also uncertainty in the state of regional climate variables (temperature, rainfall, and snowfall) during the period of subsidence, which can influence the outcome of subsidence. Subsequently, there is a corresponding uncertainty in the change to soil quality from subsidence. To increase the level of confidence in the subsidence evaluation, parameters were evaluated against observed subsidence values from long-term ground surface elevation surveys at operating potash mines in Saskatchewan and by using conservative scenarios when information is limited (Section 9.6). A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence.

12.7 Residual Effects Classification and Determination of Significance

12.7.1 Methods

12.7.1.1 Residual Effects Criteria

The purpose of the residual effects classification is to describe the residual incremental and cumulative adverse effects from previous and existing developments and the Project (Application Case) on the soils VC using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment.

Results from the residual effects classification are then used to determine the environmental significance from the Project and other developments on the assessment endpoint for soils (i.e., soil capability to support agriculture and other plant communities). Effects are described using the criteria defined in Table 12.7-1, and reflect the effects descriptors provided in the TOR (Appendix 2-B). Together, these criteria are used to describe the nature (e.g., severity or intensity of change, and the area and amount of time over which the change occurs) and type (e.g., direction of the change) of an effect on a VC. The focus of the EIS is to predict whether the Project is likely to cause a significant adverse (i.e., negative) effect on the environment; positive effects are not assessed for significance.

Table 12.7-1: Definitions of Residual Effects Criteria Used to Evaluate Significance for Soils

Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Negligible to Low There is no change to Agriculture Capability class or there is a change to Agriculture Capability within a class group as compared to Base Case conditions that results in no measureable or minor residual effects to soils. **Moderate:** There is a change to Agriculture Capability between class groups when compared to Base Case conditions. **High:** There is a change to Agriculture Capability of 3 or more classes when compared to Base Case conditions or a loss of agriculture capability.	**Local:** Predicted maximum spatial extent of direct and indirect effects from changes to measurement indicators due to a project or activity. **Regional:** Residual effects from changes to measurement indicator due to a project or activity exceed the local scale and can include cumulative effects from other developments in the effects study area. **Beyond Regional:** Residual cumulative effects from changes to measurement indicator due to a number of developments extend beyond the effects study area.	**Short-term:** Residual effect from change to measurement indicator is reversible at end of construction of Project. **Medium-term:** Residual effect from change to measurement indicator is reversible at end of operations of Project. **Long-term:** Residual effect from change to measurement indicator is reversible within a defined length of time past closure of a Project. **Permanent:** Residual effect from change to measurement indicator is irreversible.	**Infrequent:** Residual effect from change to measurement indicator is confined to a specific discrete event. **Frequent:** Residual effect from change to measurement indicator occurs intermittently over the life of the Project. **Continuous:** Residual effect from change to measurement indicator occurs continuously.	**Reversible:** Residual effect from change to measurement indicator is reversible within a time period that can be identified when a development or activity no longer influences soils. **Irreversible:** Residual effect from change to measurement indicator is predicted to influence soils indefinitely (duration is permanent or unknown).	**Unlikely:** Residual effect from change to measurement indicator is possible but unlikely (less than 10% chance of occurrence). **Likely:** Residual effect from change to measurement indicator may occur, but is not certain (10% to 80% chance of occurring. **Highly Likely:** Residual effect from change to measurement indicator is likely to occur or is certain (greater than 80% chance of occurring.

Magnitude - Magnitude is a measure of the intensity of a residual environmental effect, or the degree of change caused by the Project relative to Base Case conditions or a guideline value. It is classified into three scales: negligible to low, moderate, and high.

The primary classification criteria used to evaluate magnitude of changes to soils is the agriculture capability classification. Agriculture capability classification is an interpretive classification based on limitations affecting a soil's ability to support agriculture. These limitations include climate, steepness of slope, complexity of landform, soil structure, salinity, wetness, water-holding capacity, adverse fertility characteristics, stoniness, susceptibility to flooding, and damage from wind and water erosion. In general, soils within Classes 1 to 3 are considered suitable for the sustained production of common field crops (Agriculture and Agri-Food Canada et al. 2005) and have been grouped together in a Field Crop class group. Soils within Class 4 are considered physically marginal for the sustained production of common field crops. Soils within Class 5 should only be used for producing perennial forages, and Class 6 soils are suitable for grazing only. Soils within Classes 4 to 6 have been grouped together in a Marginal for Field Crops/Forage Class Group. Class 7 areas are not suitable for agriculture use. A description of the agriculture capability classes and class groups are summarized in Table 12.7-2.

Table 12.7-2: Description of Agriculture Capability Classes and Class Groups

Agriculture Capability Class	Description of Capability Class	Class Group
Class 1	Soils have no significant limitations in use for crops. Soils in this class can be managed and cropped without difficulty and have moderately high to high productivity.	Field Crop Class Group
Class 2	Soils have moderate limitations that restrict the range of crops or require special conservation practices. Soils in this class can be managed and cropped with little difficulty, and have moderately high to high productivity.	
Class 3	Soils have moderately severe limitations that restrict the range of crops or require special conservation practices. Soils in this class have limitations that affect practices such as the timing and ease of tillage, planting and harvesting, the choice of crops, and the methods of conservation. These soils are fair to moderately high in productivity.	
Class 4	Soils have severe limitations that restrict the range of crops or require special conservation practices, or both. Soils in this class have limitations that seriously affect practices such as the timing and ease of tillage, planting and harvesting, the choice of crops, and the methods of conservation. These soils are low to fair in productivity for the production of annual field crops.	Marginal for Field Crops/Forage Class Group
Class 5	Soils have very severe limitations that restrict their capability to producing perennial forage crops, and improvement practices are feasible. Soils in this class are not capable of use for sustained production of annual field crops.	
Class 6	Soils are capable of producing native forage crops only and improvement practices are not feasible. These soils provide some sustained grazing for farm animals.	
Class 7	Soils have no capability for arable agriculture or permanent pasture. This class includes rockland, other non-soil areas, and bodies of water.	Not suitable for agriculture

Sources: Agriculture and Agri-Food Canada et al. (2005); AAFC (2008).

If there is no change to the agriculture capability class when compared to Base Case conditions or if there is a change to the agriculture capability within a class group as compared to the Base Case, then the magnitude of the residual environmental effect is assessed to be negligible to low. Specifically, the magnitude of change between Class 1 to Class 2, Class 1 to Class 3, or Class 2 to Class 3 (i.e., within the Field Crop Class group) would be classified as negligible to low because all of these classes are capable of sustained use for cultivated field crops (Agriculture and Agri-Food Canada et al. [2005]; Agriculture and Agri-Food Canada [2008]). The magnitude of change between Class 4 to Class 5, Class 4 to Class 6, or Class 5 to Class 6 (i.e., within the Marginal for Field Crops/Forage class group) would be assessed as negligible to low because all of these soils have limitations for the types of crops and typically are suitable for production of perennial forage crops or for grazing. If there is a change to the agriculture capability between class groups when compared to the Base Case, then the magnitude of the residual environmental effect is assessed to be moderate. For example, a change from Class 2 to Class 4 or Class 3 to Class 5 means that soils that were easily capable of producing field crops, are no longer able to produce reasonable yields or can no longer be used for production of field crops. If there is a change to the agriculture capability of three classes or more as compared to Base Case conditions or soil can no longer be used for agriculture then the residual environmental effect is assessed as high in magnitude.

Geographic Extent – Geographic extent refers to the spatial extent of the area affected and is different from the spatial boundary (i.e., ESA) for the effects analysis. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution of VCs (Section 12.2.1). However, the geographic extent of effects can occur on a number of scales within the spatial boundary of the assessment and is VC-specific. Effects at the local scale are largely associated with the predicted maximum spatial extent of combined direct and indirect changes from the Project (i.e., cumulative effects that are specific to the Project). Effects at the regional scale occur within the ESA, and are associated with incremental and cumulative changes from the Project and other developments. The beyond regional scale includes cumulative residual effects from the Project and other developments that extend beyond the ESA. The principle applied when using geographic extent to understand magnitude is that local effects from the Project are less severe than effects that extend to the regional or beyond regional scales, all other factors being equal.

Duration - Duration is VC-specific and is defined as the amount of time from the beginning of a residual effect to when the residual effect on soils is reversed. It is usually expressed relative to Project phases (usually in years). Duration has two components, the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases), plus the time required for the effect to be reversible. Essentially, duration is a function of the length of time that VCs are exposed to Project activities and reversibility of the effect. By definition, residual effects that are short-term, medium-term, or long-term in duration are reversible.

In some cases, available scientific information and experience opinion may predict that the residual effect is irreversible. Alternately, the duration of the residual effect may not be known, except that it is expected to be extremely long and well beyond the temporal boundary of the Project. Any number of factors could cause soils and their capability to support agriculture to never return to a state that is unaffected by the Project. In other words, science and logic predict that the likelihood of reversibility is so low that the residual effect is irreversible.

12.7.1.2 Determination of Significance

The classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of incremental and cumulative effects from the Project and other existing and approved developments on the assessment endpoint for soils. The evaluation is focused on determining the significance of cumulative effects on soil capability to support agriculture and other plant communities.

Magnitude is the primary criterion used to determine environmental significance, while other criteria are used as modifiers and to provide context when assigning magnitude. Geographic extent and duration provide important context for classifying the magnitude of effects to the soils assessment endpoint. For example, determining the magnitude of an effect from changes in soil quality depends on the spatial extent (amount of area) and duration of the changes. Duration includes reversibility; a reversible effect from a development is one that does not result in a permanent adverse effect on ecological functions and properties. Frequency and likelihood are also considered as modifiers when determining significance, where applicable.

The evaluation of significance for soils considers the entire set of primary pathways that influence the assessment endpoint; thus, significance is not explicitly assigned to each pathway. Rather, the relative contribution of each pathway is used to determine the significance of the Project and other developments on the assessment endpoint, which represents a weight of evidence approach (i.e., evaluating the persuasiveness of evidence indicating that an effect is significant or not significant). For example, a pathway with a high magnitude, a large geographic extent, and a long-term duration is given more weight in determining significance relative to pathways with smaller scale effects. The relative effect from each pathway is discussed; however, pathways that are predicted to have the greatest influence on changes to the assessment endpoint are assumed to contribute the most to the determination of environmental significance.

The determination of environmental significance on soils considered the following key factors:

- results from the residual effect classification of primary pathways and associated predicted changes in measurement indicators.
- magnitude is the primary criterion used to determine significance with geographic extent and duration providing important context for assigning magnitude. Frequency and likelihood act as modifiers for determining significance, where applicable.
- level of confidence in predicted effects, established guidelines and standards, and experienced opinion are also included in the evaluation of environmental significance.

This method is used to identify predicted residual adverse effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to soils, and therefore, result in significant effects. The following definitions are used for predicting the significance of effects to soil capability to support agriculture and other plant communities.

Not significant – A non-significant effect on soils results from a change to agriculture capability of soil by less than three classes when compared to the Base Case conditions. Changes from the Project are measurable at a local scale and reversible over the life of the Project, and are unlikely to affect the capability of soil to support agriculture and other plant communities.

Significant – A significant residual effect on soils is a result of a change to agriculture capability of soil by more than three classes when compared to the Base Case. Changes from the Project are measurable at the regional scale and will permanently affect the capability of soil to support agriculture and other plant communities.

12.7.2 Results

Soils quantity and distribution will be negatively affected by the construction and operation of the Project and soil quality will be negatively affected by the changes in terrain and surface flows associated with ground subsidence resulting from solution mining. A summary of the effects classification and prediction of significance on the soils assessment endpoints are provided in Table 12.7-3.

The dominant soil map unit within the ESA is Oxbow and accounts for approximately 29.2% (23,452 ha) of the ESA under Base Case conditions. The Weyburn unit covers 23.1% of the ESA, Weyburn-Oxbow covers 11.9%, Weyburn-Elstow covers 4.0%, and Forget Complex covers 1.2% of the ESA under Base Case conditions. The related agriculture capability class within the ESA is Class 3 and accounts for approximately 48.9% (39,291 ha) of the ESA under Base Case conditions. The Class 2 covers 20.7% of the ESA, Class 4 covers 11.8%, and Class 5 covers 11.0% of the ESA under Base Case conditions.

The maximum area of soil disturbance from application of the Project is 1,550 ha. Although there will be a localized loss and alteration of some soil types associated with the Project footprint, approximately 842 ha are anticipated to be reclaimed following decommissioning and reclamation (i.e., reversible in the long-term). The residual effect on soil and the associated agriculture capabilities in reclaimed areas is predicted to be low in magnitude because these areas are expected to be reclaimed back to previous agriculture capabilities (e.g., Class 3 will be returned to Class 3 following reclamation); however, there may be a change in agriculture capability within a class group as compared to the Base Case (e.g., Class 3 could become a Class 2 following reclamation). As such, there is likely to be no change or a small incremental change to the agriculture capability class when compared to Base Case conditions.

Residual effects on soil quantity from residual ground disturbance is considered local in geographic extent and continuous in frequency (Table 12.7-3). It is predicted that approximately 708 ha of soil (0.9% of the ESA) will be permanently lost. The agriculture capability of the soils in the TMA changes to a Class 7 following closure, which results in a permanent loss of the soils capability to support agriculture and other plant communities. It is anticipated that soils from Class 2, 3, 4, and 5 at Base Case conditions will be permanently lost from the TMA, of which the largest proportion will be Class 3 (89% of the residual disturbance area). As such, the magnitude of residual effects to soil capability to support agriculture and other plant communities from residual ground disturbance is considered high and the effect is irreversible.

Not all areas that were assessed to be disturbed by the Project are expected to be altered during construction; therefore, the assessment of effects from direct loss of soils in the ESA is overestimated. Project-related disturbances are expected to occur once and the net incremental change in soil map units will be confined to the Project footprint (local scale). The incremental contribution of the Project to cumulative effects present at the Base Case is local and small. The incremental effects from the Project are expected to be reversible after decommissioning and reclamation (long-term), except for localized effects from residual disturbance (708 ha [0.8% of the ESA]), which will be permanent and irreversible.

Table 12.7-3: Summary of Residual Effects Classification of Primary Pathways and Predicted Significance of Cumulative Effects on Soils

Pathway	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Significance for Assessment Endpoint
Direct loss or alteration of soils in the Project footprint (core facilities area, mining area, and access roads) can change soil quantity and distribution.	Negligible to low	Local	Long-term	Continuous	Reversible	Highly likely	Not significant
Residual ground disturbance from portions of the core facilities area can cause permanent alteration of soils.	High	Local	Permanent	Continuous	Irreversible	Highly likely	
Ground subsidence caused by solution mining can change surface flows, drainage patterns (distribution), and drainage areas, which can affect soil quality.	Negligible to low	Regional	Permanent	Continuous	Irreversible	Highly likely	

The effect of ground subsidence on soil is highly likely and regional in geographic extent (Table 12.7-3). Ground subsidence is predicted to affect drainage corridors and wetland distribution, which will influence soil distribution. Small, localized changes to flow pathways and drainage areas are predicted within the West Loon Creek basin in the ESA. While it is expected that localized alterations of flow pathways will occur and ponding sections may appear, the flows along major flow paths (i.e., West Loon Creek) are predicted to be maintained.

The area affected by surface subsidence is expected to extend approximately 17.0 km from west to east and approximately 8.0 km from north to south). Changes to soils from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for over 100 years; therefore the effect was classed as having a continuous frequency and permanent duration (Table 12.7-3). Wetland soils may be created in depressional areas, where as other wetland and depressional areas may become drier. Subsidence will continuously occur over a timeframe of several hundred years (beyond decommissioning and reclamation), and is considered to be irreversible. However, because the change to soil will occur gradually over hundreds of years, it should not affect the overall ability for soil to support agriculture and other plant communities. Residual effects from ground subsidence are anticipated to result in a net change to agriculture capability between class groups in local wetlands when compared to Base Case conditions, however, the overall net change within the ESA is predicted to have minor residual effects to soils (i.e., negligible to low magnitude). Changes to domestic activities and land uses should adjust naturally to the changes over time.

Incremental and cumulative changes to soils from the Project and other developments are predicted to not have significant adverse effects on soil capability to support agriculture and other plant communities.

12.8 Monitoring and Follow-up

Typically, monitoring includes one or more of the following categories, which may be applied during the development of the Project:

- **Compliance monitoring** – monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments (e.g., inspecting the installation and effectiveness of a silt fence).
- **Follow-up monitoring** – programs designed to test the accuracy of effects predictions, reduce/address uncertainties, determine the effectiveness of environmental design features, and/or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., monitoring of downstream lakes for aquatic effects, wildlife effects monitoring, and socio-economic monitoring). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

These programs form part of the environmental management system for the Project. If monitoring or follow-up detect effects that are different from predicted effects, or the need for improved or modified design features and mitigation, adaptive management will be implemented. This may include increased monitoring, changes in monitoring plans, and additional mitigation. Monitoring and follow-up programs for soils will involve:

- detailed site assessments will be completed to collect specific information for topsoil depth and soil chemistry, as required;
- compliance inspections and environmental monitoring to confirm that best practices are being used to help mitigate soil erosion, admixing, compaction, and associated changes to soil quality;

- monitoring programs for soil erosion will be managed on site by qualified personnel, as outlined in the Erosion and Sediment Control Plan;
- follow-up monitoring program will be proposed to reduce uncertainty from the potential effects of subsidence on hydrology. If changes to hydrology indicate that there would be effects to terrestrial ecosystems, then a monitoring program would be designed to assess the associated changes to terrestrial components; and
- monitoring of soil conditions to estimate reclamation success during the Project. Other soil quality issues such as erosion, admixing, and compaction can be visually assessed as part of this task. Results from this program can be used to support adjustments to the Decommissioning and Reclamation Plan and will be incorporated into ongoing reclamation activities.

12.9 Summary and Conclusions

The Project is not expected to affect the capability of soil to support agriculture and other plant communities.

The soils ESA is approximately 804 square kilometres (km^2) (80,385 hectares [ha]), and includes both unaffected (i.e., reference) areas, and areas that are influenced by the Project. The maximum area of soil map units to be disturbed by the application of the Project is 1,550 ha (1.9% of the ESA). Following decommissioning and reclamation, an area of approximately 842 ha (54% of the Project footprint) is expected to be reclaimed. Soils will be reconstructed in reclaimed areas. Reclaimed areas have not been assigned a specific soil type and classified as a reclaimed map unit. The area of residual disturbance (i.e., TMA) is predicted to be 708 ha (approximately 0.9% of the ESA); these areas will not be reclaimed at closure.

At the Base Case, the dominant soil map unit within the ESA is Oxbow and accounts for approximately 29.2% (23,452 ha) of the ESA. The Weyburn soil map unit covers 23.1% of the ESA, Weyburn-Oxbow covers 11.9%, Weyburn-Elstow covers 4.0%, and Forget Complex covers 1.2% of the ESA under Base Case conditions.

The soil map unit that will likely experience the greatest change during construction is the Weyburn-Elstow (WrEw4 and WrEw8) map units, of which a total of 936 ha will be disturbed. The area of residual disturbance includes 600 ha of Weyburn-Elstow (WrEw4), 49 ha of Weyburn (Wr4), 34 ha of Forget (Fg10), and 25 ha of Weyburn-Oxbow (WrOx4) soil map units.

The dominant agriculture capability class within the ESA is Class 3 and accounts for approximately 48.9% (39,291 ha) of the ESA under Base Case conditions. The Class 2 covers 20.7% of the ESA, Class 4 covers 11.8%, and Class 5 covers 11.0% of the ESA under Base Case conditions. An area of 842 ha (approximately 1.0% of the ESA) within the Project footprint is expected to be reclaimed to an equivalent agriculture capability. This includes a predicted re-establishment of 12 ha (<0.1% of the ESA) of Class 2 soils, 695 ha (0.9 % of the ESA) of Class 3 soils, 29 ha (<0.1% of the ESA) of Class 4 soils, 56 ha (0.1% of the ESA) of Class 5 soils, and 49 ha (0.1% of the ESA) of Class 6 soils. The area of permanent change of agriculture capability associated with residual disturbance will become Class 7 (they have no capability for agriculture) following decommissioning and reclamation of the Project. This includes the predicted loss of 615 ha (approximately 1.0% % of the ESA) of Class 3 soils, 23 ha (less than 0.1% of the ESA) of Class 4 soils, 67 ha (less than 0.1% of the ESA) of Class 5 soils, and 0.1 ha (less than 0.1% of the ESA) of Class 6 soils.

The magnitude of residual effects from loss or alteration of soil is predicted to be negligible to low. Residual effects were determined to be local in geographic extent and continuous. Progressive reclamation is anticipated to occur during operations, and residual effects on soils that will be reclaimed are predicted to be reversible after decommissioning and reclamation. Effects on soil quantity from residual ground disturbance are considered local in geographic extent and continuous.

The agriculture capability of the soils in the TMA changes from Class 3, Class 4, Class 5, and Class 6 at Base Case conditions, of which approximately 89% of the permanently lost soils consisted of Class 3 soils, to a Class 7 following closure, which results in a permanent loss of the soils capability to support agriculture and other plant communities. As such, the residual effects from residual ground disturbance is considered high in magnitude and irreversible.

Residual effects from ground subsidence are anticipated to be regional and result in a net change to agriculture capability within class groups when compared to Base Case (i.e., negligible to low magnitude). Subsidence will continuously occur over a timeframe of hundreds of years (beyond closure), and is considered to be permanent and irreversible. However, because the change to soil will occur gradually over hundreds of years, it should not affect the overall ability for soil to support agriculture and other plant communities.

Overall, incremental and cumulative changes to soils from the Project and other developments are predicted to have no significant adverse effects on soil capability to support agriculture and other plant communities.

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12.11 Glossary

Term	Description
Acidification	The process of becoming acid or being converted into an acid.
Admixing	Mixing of the upper soil materials (e.g., topsoil) with the generally nutrient deficient lower soil materials (e.g., subsoil, parent material, or C horizon) to cause a dilution of texture, nutrients, and/or organic matter found in the upper soil lift.
Adsorption	Adsorption is the adhesion of atoms, ions, or molecules from a gas, liquid, or dissolved solid to a surface.
Aerobic	Living in the presence of oxygen
Aggregate, soil	'Clumps' of soil particles that are held together by moist clay, organic matter, organic compounds, and fungal hyphae.
Anaerobic	Living without oxygen.
Anion	An ion carrying a negative charge of electricity. The common soil anions are chlorine (Cl), nitrate (NO_3), sulfate (SO_4), and phosphate (PO_4).
Anoxic	An enviornment without oxygen.
Application case	Predictions of the cumulative effects of the developments in the Base Case combined with the effects from the Project.
Association, soil	A category (or level) in the Canadian system of soil classification. This is the basic unit of soil classification, and consists of soils that occur together on the same parent material to form a land pattern.
Base case	Represents a range of conditions over time within the effects assessment area before application of the Project.
Baseline	A surveyed or predicted condition that serves as a reference point to which later surveys are coordinated or correlated.
Baseline study area (BSA)	An area designed to measure and characterize existing environmental conditions on a continuum of scales from the anticipated Project footprint to broader, regional levels.
Best Practice	Method or procedure that is accepted by industry as being effective, practical and reliable in maintaining quality, and meeting Project objectives and regulatory requirements.
Brine	A concentrated solution of inorganic salts.
Buffering capacity	The ability of a soil to resist changes in pH.
Bulk Density, soil	The weight of soil in a given volume. A common measurement tool for soil compaction.
Calcareous	Soil containing sufficient calcium carbonate, often with magnesium carbonate, to effervesce visibly when treated with cold 0.1N hydrochloric acid.
Cation	An ion carrying a positive charge of electricity. The common soil cations are calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and hydrogen (H).
Cation exchange capacity (CEC)	The maximum quantity of total cations that a soil is capable of holding, at a given pH value. Cation exchange capacity is used as a measure of fertility and nutrient retention capacity. Expressed in milliequivalents per 100 grams of soil.
Canadian Council of Ministers of the Environment (CCME)	National Canadian body that sets ambient guidelines for air, water, soil, and contaminants.
Chernozemic soil	Chernozemic soils are defined as soils occurring under grassland-forest transition, grasses and forbs, usually develop in cool to cold, subarid to subhumid climates. Chernozemic soils are characterized as having a dark-coloured surface A horizon and a B or C horizon or both with a high base saturation.
Classification, soil	The systematic arrangement of soils into categories according to their inherent characteristics, or interpretation of those properties for various uses. Broad groupings are made based on general characteristics, and subdivisions according to more detailed differences in specific properties.

Term	Description
Climate	The prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, cloudiness, and winds, throughout the year, averaged over a series of years.
Compaction	An increase in soil density and a loss of soil pore space because of weight or pressure being placed on soil.
Compound, soil map unit	Contains predominantly two soils or non-soils (or a combination of both). The proportions of the two major components may vary from one considerably exceeding the other to both being approximately equal.
Conductivity	A measure of the capacity of water to conduct an electrical current. It is the reciprocal of resistance. This measurement provides an estimate of the total concentration of dissolved ions in the water.
Consistence	Soils degree of cohesion and adhesion and a soil's resistance to deformation or rupture.
Digital elevation model (DEM)	A 3-D representation of a terrain's surface.
Ecoregion	Relatively homogeneous subdivisions of an ecozone, which are characterized by distinctive climatic zones or regional landforms.
Ecosystem	A relatively homogeneous area of organisms interacting with their environment.
Effects study area (ESA)	The area where direct effects and small-scale indirect effects from the Project are expected to occur.
Electrical conductivity (EC)	The ability of soil to conduct electrical current as expressed in decisiemens per metre (dS/m) and typically used to measure salinity (e.g., of soil or water).
Emission	The act of releasing or discharging air contaminants into the ambient air from any source.
Erosion	The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep. Detachment and movement of soil or rock by water, wind, ice, or gravity.
Fertility	The status of a soil with respect to the amount and availability to plants of elements necessary for plant growth.
Footprint	The proposed development area that directly affects the soil and vegetation components of the landscape.
Geographic information system (GIS)	Computer software designed to develop, manage, analyze, and display spatially referenced data.
Glaciofluvial	Sediments or landforms produced by melt waters originating from glaciers or ice sheets. Glaciofluvial deposits commonly contain rounded cobbles arranged in bedded layers.
Glaciolacustrine	Sediments or landforms produced by glacial meltwater in lakes. Glaciolacustrine deposits commonly contain sand and gravels overlain by layered silt and clay.
Gleysolic soil	Gleysolic soils are associated with prolonged water saturation of the soil profile. Water saturation leads to depletion of oxygen and the development of soil features associated with oxygen-depleted conditions: blue-gray colours and reddish specks (called mottles) within the soil profile. These features are the diagnostic criteria for Gleysolic soils and occur within 50 cm of the soil surface.
Groundwater	Water that is passing through or standing in the soil and the underlying strata in the zone of saturation.
Habitat	The physical location or type of environment in which an organism or biological population lives or occurs.
Hummock	A small mound above ground that is typically less than 15 metres in height and tends to appear in groups or fields; known as hummocky terrain.
Hydrology	Science that deals with the waters above the land surfaces of the Earth, their occurrence, circulation and distribution, both in time and space, their biological, chemical, and physical properties, their reaction with their environment, including their relation to living beings.
Infiltration	The process by which water on the ground surface enters the soil.

Term	Description
Landform	A particular type of land formation.
Landscape	A heterogeneous land area with interacting ecosystems that are repeated in similar form throughout. From a wildlife perspective, a landscape is an area of land containing a mosaic of habitat patches within which a particular "focal" or "target" habitat patch is embedded.
LFH	The litter layer above mineral soils. Commonly composed of leaves, twigs, and dead plant material.
LiDAR	A remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth.
Litter	Organic layers developed primarily from leaves, twigs, and wood materials with minor components of mosses.
Map unit	A combination of kinds of soil, terrain, or other features that can be shown at a specified scale of mapping for the defined purpose and objectives of a particular survey.
Measurement indicator	Measurement indicators represent properties or attributes of the environment and VCs that, when changed, could result in, or contribute to, an effect on assessment endpoints. Measurement indicators may be quantitative (e.g., concentrations of metals in surface water) or qualitative (e.g., movement and behaviour of wildlife from disturbance to habitat and travel corridors).
Microclimate	The climate of a small area resulting from the modification of the general climate by local differences in elevation or exposure.
Mineral soil	Soils containing relatively low concentrations of organic matter. Soils that have evolved on fluvial, glaciofluvial, lacustrine, and morainal parent material.
Nitrogen fixation	A process in which nitrogen in the atmosphere is converted into ammonium. Nitrogen fixation in the soil is initiated biologically by soil microorganisms.
No linkage pathway	The potential pathway has no linkage or is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on soils relative to the Base Case or guideline values.
Nutrients	Environmental substances (elements or compounds) such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.
Organic matter	Plant and animal materials that are in various stages of decomposition.
Overburden	Materials of any nature, consolidated or unconsolidated, that overlie a deposit of useful materials. In the present situation, overburden refers to the soil and rock strata that overlie potash deposits.
Parameter	A particular physical, chemical, or biological property that is being measured.
Parent material	Underlying bedrock or drift deposit on which soil horizons form and are made up of consolidated or unconsolidated mineral material that has undergone physical or chemical weathering.
Particulate matter	A mixture of small particles and liquid droplets, often including a number of chemicals, dust, and soil particles.
Pathway analysis	Identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects after mitigation.
pH	The degree of acidity or alkalinity of soil or solution. The pH scale is generally presented from 1 (most acidic) to 14 (most alkaline). A difference of one pH unit represents a ten-fold change in hydrogen ion concentration.
Phytotoxin	Refers to substances in soils that are inhibitory to the growth of or poisonous to plants.
Plasticity, soil	A soil's ability to undergo deformation without cracking.
Polygon	A map delineation that represents a tract of land with certain landform, soil, hydrologic, and vegetation features. The smallest polygon on a 1:50,000 scale map is approximately 0.5 cm^2 and represents a tract of approximately 12.5 ha.
Porosity, soil	The amount of air space or void space between soil particles.

Term	Description
Potassium chloride (KCl)	A salt composed of potassium and chloride, of which potassium is the primary component in potash fertilizer.
Primary pathway	A primary pathway is likely to result in environmental change that could contribute to residual effects relative to the Base Case or guideline values.
Rare plants	A native plant species found in restricted areas, at the edge of its range or in low numbers within a province, state, territory, or country.
Reasonably foreseeable development (RFD) case	The RFD case represents the Application Case and reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities.
Reclamation	The process of reconverting disturbed land to its former or other productive uses.
Regosolic soil	Regosolic soils lack significant soil formation and occur on very young surfaces (e.g., sand dunes or river floodplains) or unstable surfaces (e.g., upper slope positions that experience high rates of soil erosion).
Runoff	The process by which water flows over the ground surface because of excess water from rain, meltwater, or other sources.
Salinity, soil	The amount of soluble salts in a soil expressed as electrical conductivity in decisiemens per metre (dS/m) and measured by the saturated paste method or equivalent.
Secondary pathway	A secondary pathway could result in a measurable minor environmental change, but would have a negligible residual effect relative to the Base Case or guideline values and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect.
Sediment	Solid particles of material that have been derived from rock weathering. They are transported and deposited from water, ice, or air as layers at the Earth's surface.
Seepage	Slow water movement in subsurface. Flow of water from man-made retaining structures. A spot or zone, where water oozes from the ground, often forming the source of a small spring.
Simple, soil map unit	Contain predominantly one soil type or non-soil.
Soil	The naturally occurring, unconsolidated mineral or organic material that occurs at the Earth's surface and is capable of supporting plant growth.
Soil fauna	Animals that inhabit the soil. Common soil fauna include protozoans, nematodes, and earthworms.
Soil great group	Used in the classification of soil and is the next division of the soil order. Differentiated based on characteristics that reflect the differences in the strengths of the dominant processes or a major contribution of an additional process.
Soil horizon	A layer of mineral or organic soil material approximately parallel to the land surface that has characteristics altered by processes of soil formation. It differs from adjacent horizons in properties such as colour, structure, texture, and consistence and in chemical, biological, or mineralogical composition.
Soil microorganisms	Any organism in soil, which requires a microscope to observe. These organisms include bacteria, fungi, algae, and protozoa. Soil micro-organisms are responsible for the breakdown of organic matter, conversion of inorganic compounds from one form to another, and the production of humus.
Soil order	Used in the classification of soil and include Brunisolic, Regosolic, Organic, Cryosolic, and Gleysolic Orders. At this level, soils are differentiated based on characteristics of the soils that reflect the nature of the total soil environment and the effects of the dominant soil forming processes.
Soil structure	Refers to the accumulation of soil particles into compound particles that are classified in terms of grade (weak, moderate, strong), class or size (fine, medium, or coarse), and type (platy, granular, prismatic, or blocky).

Term	Description
Soil subgroup	The third level of classification of soils formed by subdividing each larger grouping. Subgroups are differentiated on the basis of the kind and arrangement of horizons that reflect ■ similarity to the central concept of the larger group, ■ intergrading towards soils of another order, ■ additional features within the control section. A control section is the vertical section of soil upon which classification is based.
Soil texture	A soil property used to describe the relative proportion of different grain sizes of mineral particles in a soil.
Subsoil material	The layer of soil under the topsoil on the surface of the ground.
Survey intensity level (SIL)	Defines the thoroughess of the soil survey. It is the number of field inspections per unit area.
Terms of Reference	The Terms of Reference identify the information required by government agencies for an Environmental Impact Assessment.
Terrain	The landscape or lay of the land. This term is considered to comprise specific aspects of the landscape, namely genetic material, material composition, landform (or surface expression), active and inactive processes that modify material and form, slope, aspect, and drainage conditions. Terrain analysis is the identification of the above land surface features, to a more or less defined depth and determining their areal extent. The identification of special features such as permafrost, erosion, and landforms indicating subsurface structures is included in such analyses.
Till	An unstratified, unconsolidated mass of boulders, pebbles, sand, and mud deposited by the movement or melting of a glacier.
Topography	The surface features of a region, such as hills, valleys, or rivers.
Topsoil	Uppermost layer of soil, usually the top 5 to 20 cm. It has the highest concentration of organic matter and microorganisms and is where most of the biological activity occurs. Plants generally concentrate their roots in and obtain most of their nutrients from this layer.
Total suspended solids	The amount of suspended substances in a water sample. Solids, found in wastewater or in a stream, which can be removed by filtration. The origin of suspended matter may be anthropogenic or natural.
Upland	Areas that have typical ground slopes of 1% to 3%, have better drainage, and are not wetlands.
Valued Component (VCs)	Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by society.
Vegetation	A term to describe all of the plants or plant life of an area.
Watercourse	Riverine systems such as creeks, brooks, streams, and rivers.
Wetlands	Areas with ground slopes of less than 0.5% or depressions and typically poorly drained.
Wildlife	A term to describe all undomesticated animals living in the wild.

13.0 VEGETATION

13.1 Introduction

13.1.1 Background

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project) located in central Saskatchewan, approximately 60 kilometres (km) north of Regina. Yancoal proposes to develop the Project, which includes solution mining and associated supporting infrastructure.

The Project is located in the Rural Municipality (R.M.) of Longlaketon (No. 219) and the R.M. of Cupar (No. 218). An existing network of municipal grid roads, provincial highways, and rail lines will provide access to the Project. The Project (including the core facilities area, 65-year mine field, and indicated resource boundary) encompasses approximately 143 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M).

13.1.2 Purpose and Scope

This section of the Environmental Impact Statement (EIS) for the Project addresses the effects on vegetation identified in the Terms of Reference (TOR) approved by the Environmental Assessment Branch (EAB) of the Ministry of Environment (MOE) in May 2015 (Appendix 2-B).

The purpose of this section is to meet the TOR, specifically to assess the effects from the Project on vegetation. The scope of the vegetation section includes an analysis of Project-related changes during construction, operation, and decommissioning and reclamation. The incremental and cumulative residual effects from the Project and other previous, existing, and reasonably foreseeable developments on vegetation are assessed.

The healthy functioning of the vegetation component of the terrestrial environment is dependent on the interactions among climate, air quality, the hydrological cycle, soils, water quality, wildlife, and aquatic species. Natural and human-related disturbances can alter the timing and nature of the interactions between the physical and biological components of vegetation. Changes to vegetation can influence the availability of natural resources for traditional and non-traditional human use, which can affect the socio-economic environment. As such, related assessments are provided in the following sections:

- Atmospheric Environment (Section 7.0);
- Hydrogeology (Section 8.0);
- Hydrology (Section 9.0);
- Surface Water Quality (Section 10.0);
- Soils (Section 12.0);
- Wildlife (Section 14.0); and
- Socio-economic Environment (Section 16.0).

13.1.3 Valued Components, Assessment Endpoints, and Measurement Indicators

The TOR identified vegetation as a valued component (VC) that should be included in the assessment of effects on the terrestrial environment. In this section of the EIS, the vegetation VC is plant populations and communities and includes listed and traditional use plant species. Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by the proponent, the public, First Nations and Métis communities, and government agencies. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have potential to be adversely affected by Project development and, therefore, are used to predict the effects of the Project on all environmental components. Rationale for selection of the vegetation VC is as follows:

- represents important ecosystem processes;
- are sensitive to Project-related effects;
- can be measured or described with one or more practical indicators;
- plant populations and communities provide food and habitat for wildlife;
- protection of listed (rare) plant species is required by federal and provincial legislation; and
- several plant species are considered important for traditional and economic purposes.

The vegetation assessment focuses on measurement indicators and assessment endpoints derived from ecology and conservation science. Community and regulatory engagement, and local and traditional knowledge were key considerations for selecting the vegetation VC, but assessment endpoints for the vegetation VC do not explicitly consider societal values, such as continued opportunities for traditional and non-traditional use of plants. Societal values concerning changes in plant populations or communities are important and must be considered to understand the full suite of potential effects of the Project (i.e., both human and ecological dimensions). Consequently, measurement indicators from the vegetation section were carried forward so that effects on societal values could be appropriately captured in the sections dealing specifically with those values (Section 16.0).

Assessment endpoints are qualitative expressions used to assess the significance of effects on a VC and represent the key properties of the VC that should be protected for use by future human generations (i.e., incorporate sustainability). Assessment endpoints are general statements about what is to be protected. Measurement indicators are quantitative and/or qualitative expressions of changes to the assessment endpoints. The assessment endpoint for the vegetation VC is self-sustaining and ecologically effective plant populations and communities. The measurement indicators include the following:

- quantity, arrangement, and connectivity (fragmentation) of plant communities;
- abundance and distribution of habitat for listed plant species;
- abundance and distribution of habitat for traditional use plant species; and
- presence of weed and invasive plant species.

Long-term population viability is frequently applied as an ecologically relevant target by conservation biologists and resource managers (Ruggiero et al. 1994; With and Crist 1995; Fahrig 2001; Nicholson et al. 2006). Self-sustaining populations are healthy, robust populations capable of withstanding environmental change and accommodating stochastic demographic processes (Reed et al. 2003). Maintaining ecologically effective populations and communities goes beyond what may be required only to achieve a self-sustaining population and requires that healthy ecological relationships be maintained among species to prevent unexpected biodiversity loss due to changes in properties of highly interactive species (Soulé et al. 2003, 2005).

13.2 Environmental Assessment Boundaries

13.2.1 Spatial Boundaries

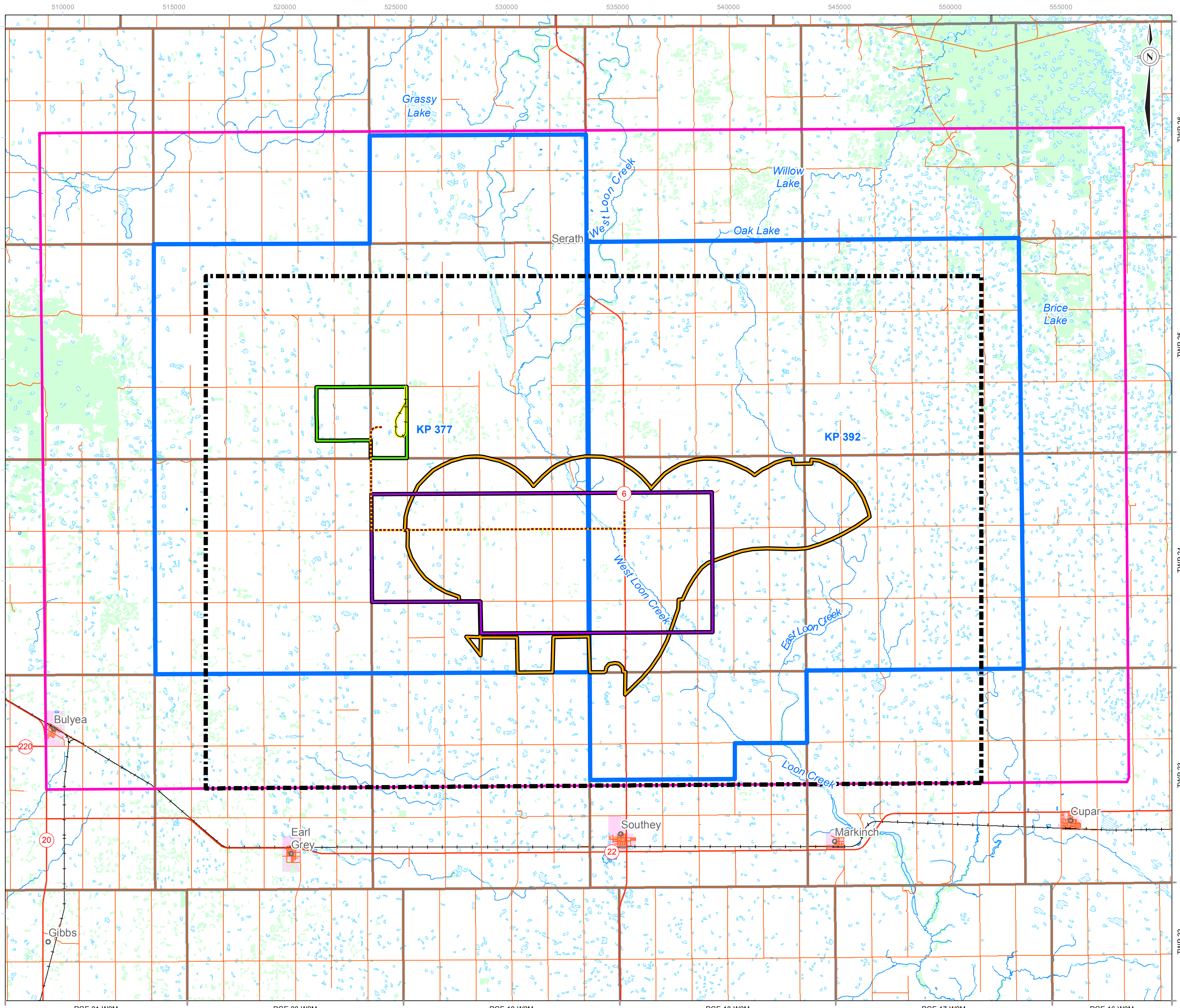
13.2.1.1 Baseline Study Area

To quantify baseline conditions of the terrestrial environment, a baseline study area (BSA) was delineated for terrain and soils, vegetation, and wildlife (Figure 13.2-1). The BSA was designed to measure and characterize existing environmental conditions on a continuum of scales from the anticipated Project footprint to broader, regional levels. At the initiation of field programs, the location of the Project footprint was unknown; therefore, a preliminary focus area was delineated for the Project (Annex IV, Section 2). The focus area was buffered by 5 km to encompass potential indirect effects from the Project on vegetation and wildlife. As Project design evolved, this area was increased to encompass the entire KP377 and KP392 permit areas and a 5 km buffer area. The final BSA selected for terrestrial components encompassed an area of approximately 1,444 km^2 (144,425 ha) area (Annex IV, Section 2). The north portion of KP377 and the south portion of KP392 were not buffered by 5 km for the final BSA, because of low likelihood that the Project footprint would occur in these areas.

13.2.1.2 Effects Study Area

To assess Project-related effects on the terrestrial environment, an effects study area (ESA) was delineated for terrain and soils, vegetation, and wildlife. The ESA defined for terrain and soils, vegetation, and wildlife is approximately 804 km^2 (80,385 ha) and is located within the BSA (Figure 13.2-1). The ESA includes both unaffected (i.e., reference) areas, as well as areas influenced by the Project. Wildlife has the largest range and was the key factor in defining the terrestrial ESA. As described in the Terrestrial Baseline report (Annex IV; Section 2), the Project is located near Highway 6, grid roads 641 and 731, the towns of Southey and Earl Grey, and in an area dominated by cultivation. It was anticipated that songbirds, waterbirds, and raptors would likely be the only wildlife species negatively affected by the Project. Therefore, an approximate 5-km buffer was used to define the ESA to encompass the predicted maximum spatial extent of direct and indirect effects (i.e., zones of influence) from the Project on songbirds, waterbirds, and raptors.

The size of the ESA is expected to be large enough to contain most or all of the populations of plant species and communities that may be influenced by the Project. A population is a group of individuals of the same species that is primarily affected by natural and human-related factors that change survival and reproduction of individuals (Berryman 2002). The ESA is also expected to be large enough to provide an ecologically relevant and confident assessment of the direct and indirect effects on vegetation from the Project, and the potential cumulative effects from the Project and other, previous, existing, and reasonably foreseeable developments.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- WOODED AREA
- PROPOSED ACCESS ROAD
- PROPOSED RAIL LOOP
- PERMIT BOUNDARY
- 65 YEAR MINE FIELD
- CORE FACILITIES AREA
- INDICATED RESOURCE BOUNDARY
- BASELINE STUDY AREA
- EFFECTS STUDY AREA

REFERENCE

PERMIT BOUNDARY: POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

4 0 4
SCALE 1:175,000 KILOMETRES

PROJECT

YANCOAL
兖煤加拿大资源有限公司

YANCOAL SOUTHEY PROJECT

TITLE

LOCATION OF THE VEGETATION EFFECTS STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	JF	21/01/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15		
CHECK	JLF	25/05/15		
REVIEW	BC	25/05/15		

FIGURE: 13.2-1

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1210 - Vegetation\12-1362-0197 - Location of Veg ESA.mxd Date: 5/25/2015 3:29:23 PM

The ESA is situated on a transitional area between the boundaries of the Moist Mixed Grassland and Aspen Parkland Ecoregions of the Prairie Ecozone in Saskatchewan (Acton et al. 1998). The west portion of the ESA is in the Strasbourg Plain Landscape Area within the Moist Mixed Grassland Ecoregion. The east portion of the ESA is situated in the Touchwood Hills Upland Landscape Area of the Aspen Parkland Ecoregion.

The Moist Mixed Grassland is characterized by a patchy landscape of prairie, woodland, and shrubland, with a warm and subhumid continental climate (Acton et al. 1998). The Moist Mixed Grassland Ecoregion is a broad, mostly level plain with the occasional deep valley, such as the Qu'Appelle Valley (Flory 1980; Acton et al. 1998). The ecoregion is predominantly cultivated land. The Moist Mixed Grassland is characterized by mid-grasses, including species of wheatgrass and needle grasses (Acton et al. 1998). Woodland and shrubland predominantly occur in depressions or the periphery of wetlands.

Native grassland in the Strasbourg Plain Landscape Area is typically limited to hummocky terrain, where interspersed with cultivated areas. Extensive areas of saltgrass, alkali grass, sedges, and rushes occur in wet and saline areas in the northern part of the Strasbourg Plain; these areas limit crop production. Wetlands are typically surrounded by willows and aspen.

The Aspen Parkland Ecoregion is characterized by hummocky landscapes where woodlands or wetlands occur in lower areas associated with pot and kettle topography and grasslands on the upper slopes. Woodlands in the Aspen Parkland are most commonly dominated by trembling aspen (*Populus tremuloides*) and an understory of native shrubs, forbs, and grasses (Acton et al. 1998). Uplands historically were dominated by fescue prairie. Much of the area of native grassland that has not been cultivated is used for livestock grazing.

The Touchwood Hills Upland Landscape Area is predominantly cultivated, although larger areas of native grassland remain. Large areas of rangeland are scattered throughout this landscape area and these typically are associated with steep terrain and wooded areas. Much of the wooded area is characterized by large expanses of aspen forest.

13.2.2 Temporal Boundaries

Temporal boundaries for the vegetation assessment were defined by the life of the Project (Section 4.0) and the existing and future cumulative effects to which the Project might contribute. The Project phases are construction, operation, and decommissioning and reclamation. Final relinquishment of the Project will occur after the completion of reclamation. Many effects of the Project will end when operations cease or following decommissioning and reclamation, but effects on vegetation communities will continue until vegetation is re-established.

The effects analysis encompasses the Project phases as follows:

- construction (2016 to 2019);
- operations (2019 to 2119); and
- decommissioning and reclamation (2119 onward).

The above timeframes are intended to be sufficiently flexible to capture the effects of the Project on the vegetation VC. Effects on plant populations and communities begin during the construction phase with the removal and alteration of vegetation for site development, and continue through the operation phase and for a period during the completion of reclamation activities (unless determined to be permanent). Therefore, effects on vegetation were analyzed and assessed for significance from Project construction through decommissioning and reclamation and consider the time it takes for vegetation recovery. This approach generates the maximum potential spatial and temporal extent of effects on the abundance and distribution of plant communities, which provides confident and ecologically relevant effects predictions.

Although the assessment of residual effects of the Project considers all Project phases listed above, temporal snapshots (i.e., static moments in time) were used to characterize the ESA landscapes and facilitate quantitative and qualitative comparisons for each of the assessment cases described below.

13.2.2.1 Base Case

The Base Case (existing environment) represents conditions before application of the Project. Existing developments (i.e., built prior to 2013) as visible from satellite imagery and available digital data (e.g., roads and communities from CanVec [NRC 2012]) were used to map current developments in the ESA. Consequently, the Base Case represents the cumulative outcome of all previous and existing developments and activities.

13.2.2.2 Application Case

The incremental contributions of residual effects from the Project to existing cumulative effects were assessed at the ESA scale by adding the Project to the Base Case to form the Application Case. The temporal snapshot used was the Project footprint at a maximum point of development of the Project (i.e., core facilities area, plant site access road, and 19 well pads and associated well site access roads). Changes to measurement indicators for plant populations and communities were predicted, and incremental contributions of the Project and cumulative effects of the Project plus previous and existing developments and activities were evaluated.

13.2.2.3 Reasonably Foreseeable Development Case

The Reasonably Foreseeable Development (RFD) Case represents the Application Case plus reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. The minimum temporal boundary for the Application Case and RFD Case is the expected lifespan of the Project that, like the Base Case, includes a range of conditions over time. The difference between the Application Case and RFD Case is that the Application Case considers the incremental effect from the Project in isolation of potential future land use activities. The RFDs are defined as projects that:

- are currently under regulatory review or have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project, or may be induced by the Project;
- have been approved but not yet developed; or
- have the potential to change the Project or the effects predictions.

The reasonably foreseeable developments identified in Section 6.0 include the supporting infrastructure required for the Project, the Muskowekwan Potash Mine Project, and the Vale Kronau Project. Supporting infrastructure will include a water supply pipeline, an overhead transmission line, a natural gas supply pipeline, telecommunication services, and a railway line. Screening assessment reports will be completed by each of the utility providers once the final routing options are determined. Most of the preferred routes for the supporting infrastructure are not within the ESA and the final routing options are not known at this time. The Muskowekwan Potash Mine Project is located approximately 52 km to the northeast of the Project, and the Vale Kronau Project is located approximately 71 km south of the Project; both are outside the ESA. Effects on vegetation from development of the Muskowekwan Potash Mine Project and the Vale Kronau Project are not expected to overlap with effects on vegetation in the ESA. Therefore, the RFD Case is not included in this section of the EIS.

13.3 Existing Environment

The purpose of this section is to describe the existing composition and distribution of plant communities within the ESA (Base Case) as a basis to assess the potential Project-specific effects on vegetation. The detailed methods and results for the baseline surveys are located in the Terrestrial Environment Baseline Report (Annex IV, Section 4.0).

13.3.1 Methods

13.3.1.1 Data Collection

Field surveys were completed during May 21 to 25, June 12 to 19, and August 12 to 17, 2013 to capture an inventory of both early and late flowering species. Field survey information was used to characterize and map vegetation types (ecological landscape classification [ELC] map units; habitats), compile a vegetation inventory of observed species in each vegetation map unit defined in the ELC map, and document listed, weed, and traditional use species found in the ESA. All field data were used to ground-truth, classify, and describe the ELC map units for the ESA.

Where trees were present, tree species recorded in the main canopy were greater than or equal to 5 m in height. The tall shrub layer includes all trees and/or shrubs between 2 and 4.9 m in height. The low shrub layer includes shrubs that are less than 2 m in height. The forb layer includes all herbaceous flowering plants and includes ferns, fern allies, and club mosses. The graminoid layer includes grasses, sedges, and rushes. At the ground layer, bryophytes (e.g., mosses), ground-dwelling lichens, and epiphytes, if observed, were recorded.

Scientific names used in this report were obtained from the Saskatchewan Conservation Data Centre (SKCDC) Saskatchewan Vascular, Non-vascular, and Fungi Plant Species Lists (SKCDC 2014a, b, c), and the PLANTS Database (USDA NRCS 2012). All species names were crosschecked so species were not counted twice (i.e., synonyms). The details of all field survey and data collection methods are described in Annex IV, Section 4.2.1.

13.3.1.2 Ecological Landscape Classification

An ELC was used to provide information about the abundance and distribution of vegetation types (ELC map units; habitats) within the ESA. The ELC provides a broad-level inventory of habitats in the ESA. Generally, ELC mapping is often completed as a part of an environmental impact assessment, as it provides a means of relating vegetation conditions with other critical resources, such as soils and wildlife, and biodiversity (Treweek 1999). Results from an ELC can facilitate the process of evaluating the effects of proposed developments on selected VCs (IUCN and ICMM 2003). The ELC also provides a basis for interpreting or modelling listed and traditional use plant habitat potentials.

The ELC map was developed for the ESA using Landsat 5 satellite imagery (30 m by 30 m pixel, acquired on September 10, 2011), Worldview 2 satellite imagery (2 m by 2 m pixel, acquired on July 13, 2013 and on August 13, 2013) and GeoEye imagery (2 m by 2 m pixel, acquired on August 11, 2013 and on August 14, 2013). The classification methods are described in detail in Annex IV, Section 4.2.2.

To provide information for the supervised classification of the ELC, vegetation cover types were surveyed and ground-truthed in the field. In addition to information collected at each of the survey locations as described in the following subsections, 399 locations were ground-truthed in the ESA (Figure 13.3-1). Selected locations from vegetation field programs, other than those used as field-validated observation points, were compared to the classification for a visual accuracy assessment. The vegetation survey data provide detailed descriptions for each ELC map unit.

13.3.1.3 Detailed Vegetation Inventory Surveys

Detailed vegetation inventory (DVI) plots were completed to obtain site-specific and descriptive information on the characteristics of the plant communities within each vegetation cover type. Data on species present, percent cover, and vegetation layer were documented. In addition, site information such as terrain, moisture regime, nutrient regime, substrate, and slope were recorded to provide additional background information.

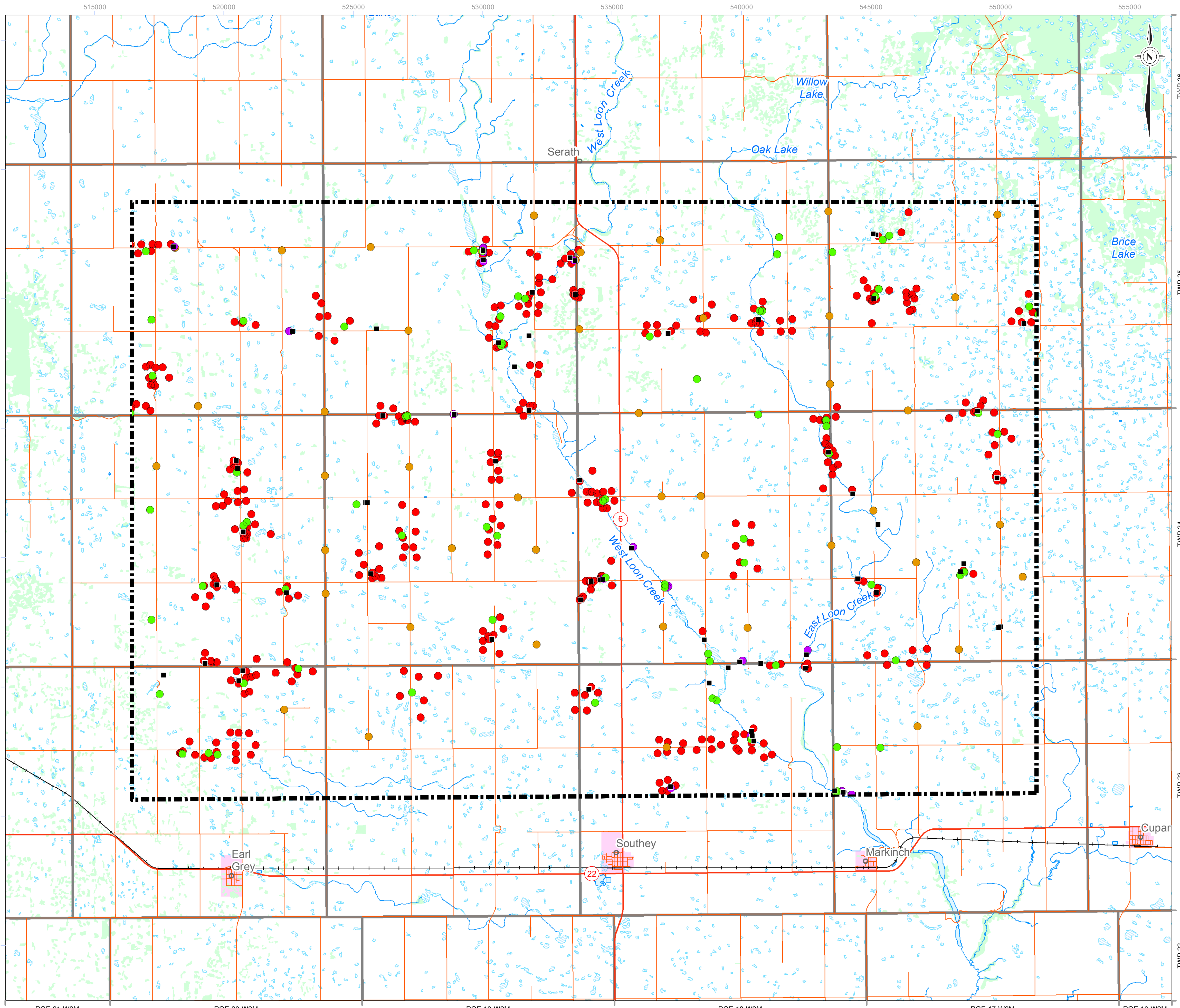
Detailed vegetation inventory plots were established at 73 locations within the ESA (Figure 13.3-1). Locations of DVI plots were selected to obtain representative information on all vegetation cover types present in the ELC. This was completed to help characterize the regional variation of species and community presence and abundance because the ESA occurs on the boundary of the Mixed Moist Grassland and Aspen Parkland Ecoregions (Section 13.2.1).

13.3.1.4 Biodiversity

For the purposes of the baseline report, biodiversity was assessed using the number of species within each of the ELC map units in the ESA. Species diversity was determined using plant survey data collected during the field surveys completed in 2013. Biodiversity was assessed for each ELC map unit based on the total numbers of species observed and the numbers of species observed within each vegetation layer. Other biodiversity measures estimated included the number of listed plant species, numbers of noxious and nuisance weed species, and the number of unique species within each ELC map unit.

13.3.1.5 Listed Plant Species and Listed Plant Habitat Potential

A listed plant species is considered rare, because of biological characteristics or for some other reason, and exists in low numbers or in very restricted areas (Drury 1974; Rabinowitz 1981). By definition, a rare plant has restricted spatial, ecological, and/or temporal distributions, and occurs more commonly within variable or diverse environments (Harper 1981). Plant rarity generally is determined by three factors: geographic range, habitat specificity, and local population size (Given 1994).



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- WOODED AREA
- EFFECTS STUDY AREA

VEGETATION SURVEY LOCATIONS

- DETAILED VEGETATION INVENTORY PLOT
- GROUND TRUTH PLOT
- LISTED PLANT PLOT
- WEED PLOT
- LISTED PLANT SURVEY TRANSECT LOCATION

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT

YANCOAL
SOUTHEY PROJECT

TITLE

VEGETATION SURVEY LOCATIONS IN THE EFFECTS STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	JF	04/02/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	FIGURE: 13.3-1	
CHECK	JLF	25/05/15		
REVIEW	BC	25/05/15		

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The occurrence and potential of listed plants within the ESA was determined through field surveys and assessing the listed plant habitat potential of ELC map units. Both approaches are described below.

13.3.1.5.1 Listed Plant Species Occurrences

For the purpose of this report, listed species includes all species that are designated as 'at risk', 'rare', 'endangered', 'threatened', 'special concern', or otherwise tracked and/or protected by provincial and federal conservation legislation and documents. These include the following:

- The Saskatchewan Conservation Data Centre (SKCDC 2014d, e, f);
- the Saskatchewan *Wildlife Act* (1998);
- the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2015); and
- the *Species at Risk Act* (SARA 2014).

Federal status documents include the Species at Risk Public Registry (SARA 2015) and COSEWIC (2015). Provincial tracking lists provided by SKCDC (2014d, e, f) distribute standardized information on the ecological status of provincial species and communities. Prior to field programs, an inventory of listed species that are known to occur or have potential to occur within the ESA was compiled using federal and provincial status documents, provincial tracking lists, references and literature, and known distributions. The habitat requirements of these listed plant species were reviewed and compared to availability of that habitat type in the ESA. Listed plant species with the potential to occur within the ESA and their preferred habitats can be found in Annex IV (Appendix IV.2, Table IV.2-2).

Sampling effort was concentrated in habitats and microsites identified as having a greater potential to support listed plant species. However, listed species surveys were not limited to areas with highest habitat potential, as suitable microhabitats exist across all vegetation types. A meander search was determined to be the most appropriate method for locating listed plant species (Robson 1998). Meander length varied based on habitat complexity and number of microhabitats present at each location. Listed plant searches were carried out at 70 transect locations within the ESA during all field programs to account for early and late flowering species, and were also completed within and around all DVI plots (Annex IV, Section 4.2.3). Listed plant species found during these searches were documented by taking photographs of the site and plants and recording the global positioning system (GPS) coordinates, ELC map unit, microhabitat, number of individuals present, and patch size.

Plant species that could not be identified in the field were collected for later identification. Samples were collected only in cases where the collection removed less than 5% of the patch. Species were identified using standard plant identification keys (Annex IV, Section 4.2.1).

13.3.1.5.2 Listed Plant Habitat Potential

Habitats present within ELC map units were assessed for potential to support listed plant species. Field survey results and habitat preference of listed species were used to determine the potential of each ELC map unit to support listed plant species. The ELC map units were assigned a Low, Moderate, or High listed plant habitat potential.

13.3.1.6 Weed Species

Assessing whether a plant is a weed is a matter of context (ANPC 2000). A commonly accepted definition for a weed is "a plant out of place". For example, certain native plants may be considered weeds in an agricultural field, while crop or forage plants may be unwanted in a natural habitat.

Invasive weeds are plant species that generally are introduced from other ecosystems or continents. While some species that are introduced to new habitats are poorly adapted and do not survive well, species that have been labelled invasive are able to not only survive and reproduce, but also have the capacity to markedly alter plant communities or displace native plants, reducing biodiversity and possibly causing economic damage to private and public lands (ANPC 2000). They are able to do this through aggressive competition for moisture, nutrients, and light and, possibly, due to the lack of predators and pathogens.

For this report, the definition of a "prohibited weed", "noxious weed", or "nuisance weed" refers to those plants in *The Weed Control Act* (2010). Weeds were documented during all vegetation surveys completed during baseline field programs as they were encountered (Section 13.2.1). Weed searches also were focused in ditches and disturbed areas at 48 additional locations within the ESA. No formal plot boundary was established to survey weeds, as the primary objectives were to document the species present, their extent, and related habitats.

13.3.1.7 Traditional Use Plants Species and Traditional Use Plant Habitat Potential

13.3.1.7.1 Traditional Use Plant Species

Historically, several First Nations collected plants in the region and may still use the region for this purpose (Annex V). Many of these plant species have medicinal, ceremonial, and spiritual uses. In addition to direct use of plant species, vegetation present in the ESA support traditional use wildlife species.

The following First Nations communities were surveyed for knowledge of traditional plant use in the region:

- Day Star First Nation;
- George Gordon First Nation;
- Kawacatoose First Nation;
- Muscowpetung First Nation; and
- Piapot First Nation.

Attempts were made to include members from the First Nations and Métis communities of Muskowekwan First Nation, Pasqua First Nation, Métis Nation Eastern Region 3, and Métis Nation Western Region 3; however, they did not participate in the traditional land use surveys (Annex V, Section 3.2).

The primary source of information regarding traditional knowledge of plant use is face-to-face surveys with aboriginal community members, including Elders and community members of five First Nations. Traditional use surveys were completed in May and June 2014 (Annex IV, Table 4.2-2). Community members were asked about plant collection in general and about use of specific plant species during past and current traditional use activities. A general list of traditional use plants applicable to the ESA was compiled based on plant species identified during interviews.

13.3.1.7.2 Traditional Use Plant Habitat Potential

To support the assessment of effects on traditional use plants, the habitats present within ELC map units were ranked according to the likelihood of an ELC unit to contain traditional use species. This was based on the traditional use species and associated habitat preferences, field data, and professional judgement. The ELC map units were assigned a Low, Moderate, or High traditional use plant habitat potential.

13.3.2 Results

13.3.2.1 Ecological Landscape Classification

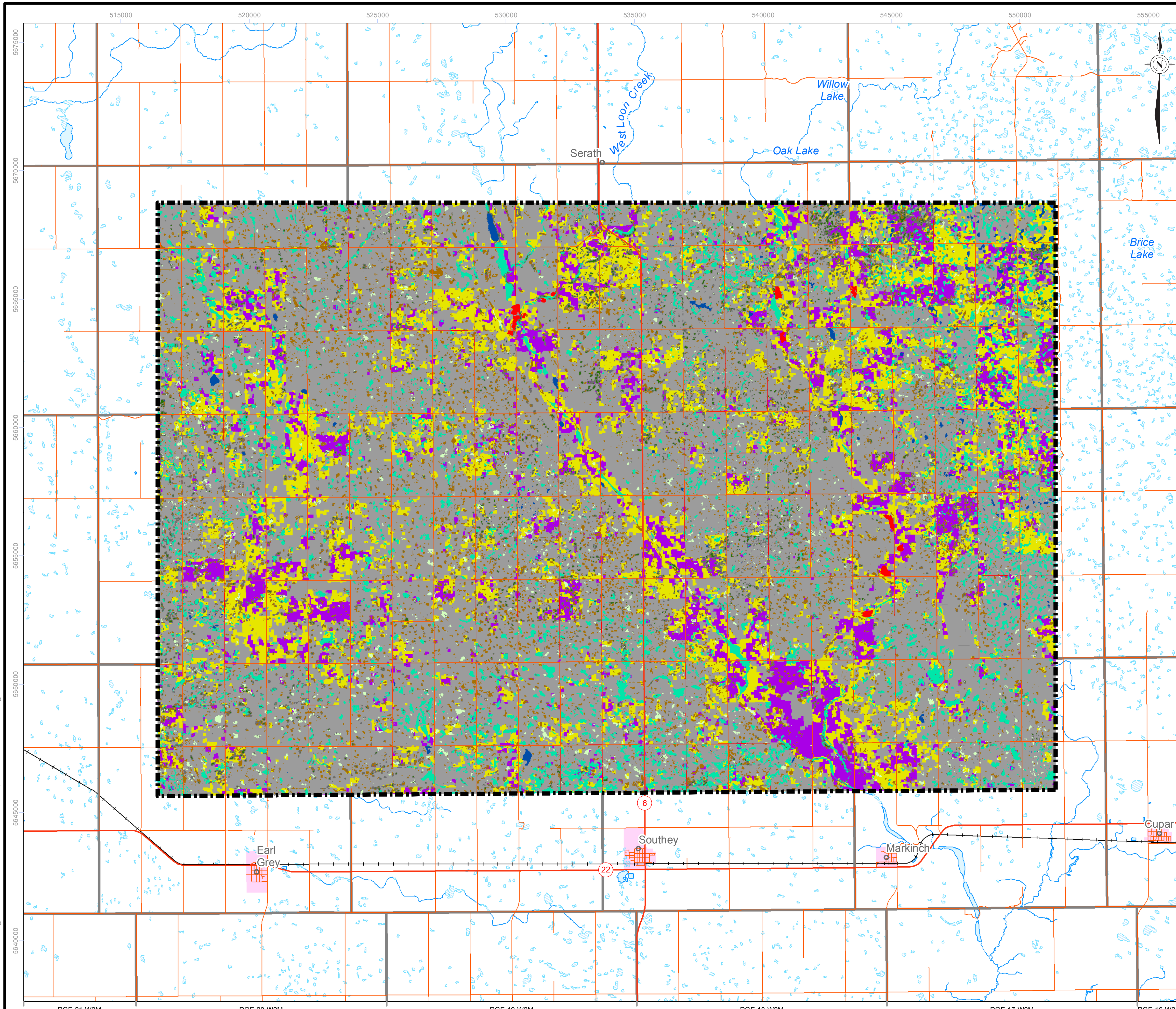
Ten ELC map units (habitat types) were classified in the ESA and include Cultivated, Modified Grassland, Native Grassland, Wooded, Class I and II Wetland, Class III Wetland, Class IV Wetland, Class V Wetland, Dugout, and Existing Disturbance (Table 13.3-1; Figure 13.3-2). The overall accuracy for upland ELC map units is 79.8% and the accuracy for the proportion of wetlands captured in the classification was 77%.

The dominant ELC map unit within the ESA is cultivated land and accounts for approximately 58% (46,834 ha) of the ESA (Table 13.3-1; Figure 13.3-2). The Modified Grassland map unit, which includes both hayland and modified prairie, covers 16% of the ESA and Native Grassland covers 8%. Wetlands cover approximately 13% of the ESA. The Existing Disturbance map unit is the result of existing human related disturbances such as roads and ditches, borrow/gravel pits, and communities. This map unit does not include the natural disturbances from fire or disturbances related to current land use (i.e., cultivation). The existing disturbance map unit accounts for approximately 1% (1,141 ha) of the ESA.

Table 13.3-1: Total Area and Percent Cover of Ecological Landscape Classification Map Units within the Effects Study Area for the Base Case

Ecological Landscape Classification Map Unit	Area (ha)	Proportion of ESA (%)
Cultivated	46,834	58.3
Modified Grassland	12,723	15.8
Native Grassland	6,432	8.0
Wooded	2,717	3.4
Class I and Class II Wetland	3,963	4.9
Class III Wetland	936	1.2
Class IV Wetland	5,321	6.6
Class V Wetland	316	0.4
Dugout	2	<0.1
Existing Disturbance	1,141	1.4
Total	**80,385**	**100**

Notes: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
Cloud obscured a portion of the imagery used for classifying wetlands in the ESA. Therefore, only upland map units were classified in these areas.
ESA = effects study area; ha = hectares; % = percent; <= less than.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

ECOLOGICAL LANDSCAPE CLASSIFICATION MAP UNITS

- CULTIVATED
- MODIFIED GRASSLAND
- NATIVE GRASSLAND
- WOODED
- CLASS I AND CLASS II WETLAND
- CLASS III WETLAND
- CLASS IV WETLAND
- CLASS V WETLAND
- DUGOUT
- EXISTING DISTURBANCE

REFERENCE

ELC DERIVED FROM LANDSAT 5, WORLDVIEW 2, AND GEOEYE IMAGERY
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
ECOLOGICAL LANDSCAPE CLASSIFICATION MAP UNIT DISTRIBUTION FOR THE BASE CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	JF	04/02/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	FIGURE: 13.3-2	
CHECK	JLF	25/05/15		
REVIEW	BC	25/05/15		

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13.3.2.2 Biodiversity

In total, 309 plant species were identified during the 2013 field program. This total includes 33 woody (tree and shrub) species, 201 forbs, 67 graminoids, and 8 non-vascular species (Annex IV, Table 4.3-2; Appendix IV.2, Table IV.2-3). All plant species recorded in each ELC map unit are listed in Annex IV (Appendix IV.2, Table IV.2-4).

13.3.2.2.1 Species Richness by Ecological Landscape Classification Map Unit

The number of woody, forb, graminoid, and non-vascular and total species among each ELC map unit was calculated as one measure of biodiversity. The highest number of woody plant species occurred within Wooded, Existing Disturbance - ditches, and riparian areas (not mapped in the ELC) (19, 17, and 12 tree and shrub species, respectively) (Table 13.3-2). The highest number of forb and graminoid species occurred within Native Grassland and the highest number of non-vascular species was observed in Wooded areas (Table 13.3-2).

Native Grassland had the highest total species diversity at 128 species (Table 13.3-2). Wooded and riparian areas had 81 species each. The lowest numbers of plant species occurred within Cultivated (23 species), Existing Disturbance - ditches (26 species), and Modified Grassland - hayland (29 species).

13.3.2.2.2 Total Number of Listed Species

Eight listed plant species were observed during 2013 field surveys and are described in more detail in Section 13.3.2.3. These species are listed and tracked by the SKCDC; however, none of these species are listed or protected under COSEWIC, SARA, or *The Wildlife Act*. The highest numbers of listed species were found in Native Grassland (five species) and riparian areas (two species) (Table 13.3-2). No listed species were found in Cultivated, Modified Grassland - hayland, Wooded, Class I Wetland, Class V Wetland, or Existing Disturbance - gravel pits (Table 13.3-2).

13.3.2.2.3 Total Number of Weed Species

A total of 14 noxious weed species and 7 nuisance weed species were documented during field surveys and are described in more detail in Section 13.3.2.4. Noxious and nuisance weeds were found in all vegetation types and the highest numbers of weed species were found in Cultivated (11 noxious, 7 nuisance species), Existing Disturbance - ditches (9 noxious, 5 nuisance species), and Modified Grassland - hayland (6 noxious, 6 nuisance species) (Table 13.3-2).

13.3.2.2.4 Total Number of Unique Species

Calculating the total number of unique species within ELC types is a way of expressing habitat uniqueness (Table 13.3-2). Native Grassland and Wooded areas had the highest numbers of unique species with 48 and 28 species, respectively. No unique species were found in Dugout.

Table 13.3-2: Biodiversity Measures by Ecological Landscape Classification Map Unit

Ecological Landscape Classification Map Unit	Number of Woody Plant Species[a]	Number of Forbs, Ferns, and Fern Allies	Number of Graminoids[b]	Number of Non-vascular Species	Total Number of Species	Number of Listed Species	Number of Noxious Weed Species	Number of Nuisance Weed Species	Number of Unique Species[c]
Cultivated	0	18	5	0	23	0	11	7	6 (4 forbs, 2 graminoids)[d]
Modified Grassland - Hayland subclass	1	22	6	0	29	0	6	6	3 (forbs)
Modified Grassland - Modified Prairie subclass	4	45	12	0	61	1 (forb)	5	2	5 (2 forbs, 3 graminoids)
Native Grassland	8	91	27	2	128	5 (4 forbs, 1 graminoid)	4	3	48 (39 forbs, 9 graminoids)
Wooded	19	46	11	5	81	0	2	2	28 (5 tree/shrub, 15 forbs, 3 graminoids, 5 non-vascular)
Class I and II Wetland - Class I subclass	6	17	9	0	32	0	3	2	3 (1 forb, 2 graminoid)
Class I and II Wetland - Class II subclass	5	42	19	1	67	1 (forb)	5	4	8 (1 tree/shrub, 7 forbs)
Class III Wetland	9	30	17	0	56	1 (forb)	3	3	4 (1 tree/shrub, 1 forb, 2 graminoid)
Class IV Wetland	6	31	17	3	57	1 (forb)	4	2	4 (1 forb, 1 graminoid, 2 non-vascular)
Class V Wetland	7	39	21	0	67	0	6	4	6 (1 tree/shrub, 4 forbs, 1 graminoid)
Dugout	4	14	8	0	26	1 (forb)	4	1	0
Existing Disturbance - Ditches	17	41	15	0	73	1 (forb)	9	5	6 (3 forbs, 3 graminoids)
Existing Disturbance - Gravel Pits	0	37	9	0	46	0	6	4	8 (7 forbs, 1 graminoid)
Not Mapped - Riparian	12	45	23	1	81	2 (1 forb, 1 graminoid)	6	3	11 (1 tree/shrub, 5 forbs, 5 graminoids)
Total Number of Species[e]	**33**	**201**	**67**	**8**	**309**	**8[f]**	**14**	**7**	**141[g]**

Note: Numbers presented are total number of species found in that ELC map unit. The same species may occur in more than one ELC map unit. All species documented during baseline surveys are included in the biodiversity assessment.
(a) Includes trees and shrubs.
(b) Includes grasses, sedges, and rushes.
(c) Does not include unidentified species.
(d) Includes crop species.
(e) This represents the total species documented during baseline surveys in 2013. This does not represent the sum of the column.
(f) This includes 6 forbs and 2 graminoids documented in 2013.
(g) Total number of species found in only one vegetation type.

13.3.2.3 Listed Plant Species and Listed Plant Habitat Potential

13.3.2.3.1 Listed Plant Species Occurrences

Listed vascular plant species confirmed to occur within the ESA are presented on Figure 13.3-3 and in Table 13.3-3. Location coordinates for all observations can be found in Annex IV (Appendix IV.2, Table IV.2-5).

Four provincial listed forbs and one listed graminoid species were documented in the ESA during the 2013 field programs (Figure 13.3-3 and Table 13.3-3). Documented species included low milk vetch (*Astragalus lotiflorus*), tall beggarticks (*Bidens frondosa*), Macoun's cryptanthe (*Cryptantha macounii*), beaked annual skeletonweed (*Shinnersoseris rostrata* [syn. *Lygodesmia rostrata*]), and big bluestem (*Andropogon gerardii*). No COSEWIC, SARA, or *The Wildlife Act* listed species were observed within the ESA during the 2013 field survey. Although provincially listed as S4 (i.e., common [more than 100 occurrences in Saskatchewan, generally widespread and abundant, may be rare in part of its range]), big bluestem remains on the tracking list because it is a host plant for the Dakota Skipper (SKCDC 2014d). Northern yellow lady's-slipper (*Cypripedium parviflorum* var. *makasin*), Seneca snakeroot (*Polygala senega*), and porcupine sedge (*Carex hystericina*) were also observed during the 2013 field programs (Annex IV, Section 4.3.3.1); however, these observations are outside the ESA.

The numbers of listed species observations documented during the field programs does not preclude the potential for other listed species to occur within the ESA. Even the best-planned surveys are limited by fluctuations in the timing of annual flowering periods of listed species. Listed plant occurrences at a survey location can be missed due to timing of plant surveys because plant species presence can vary annually and locally. Climatic fluctuations (e.g., abnormal temperatures or precipitation) might not allow adequate time for plants to mature and produce flowers, making them more difficult to spot and identify. Available microhabitats within larger habitat types can vary over time and space. Therefore, a listed plant survey cannot confirm the absence of listed plants or listed plant communities; it can only confirm their presence. Because of limitations in positive identification of some listed plant species, potential for specific habitats to support these species is rated in the following section (Section 13.3.2.3.2). All listed plant species with potential to occur in the ESA are summarized in Annex IV (Appendix IV.2, Table IV.2-2).

Table 13.3-3: Listed Vascular Plant Species Confirmed to Occur Within the Effects Study Area

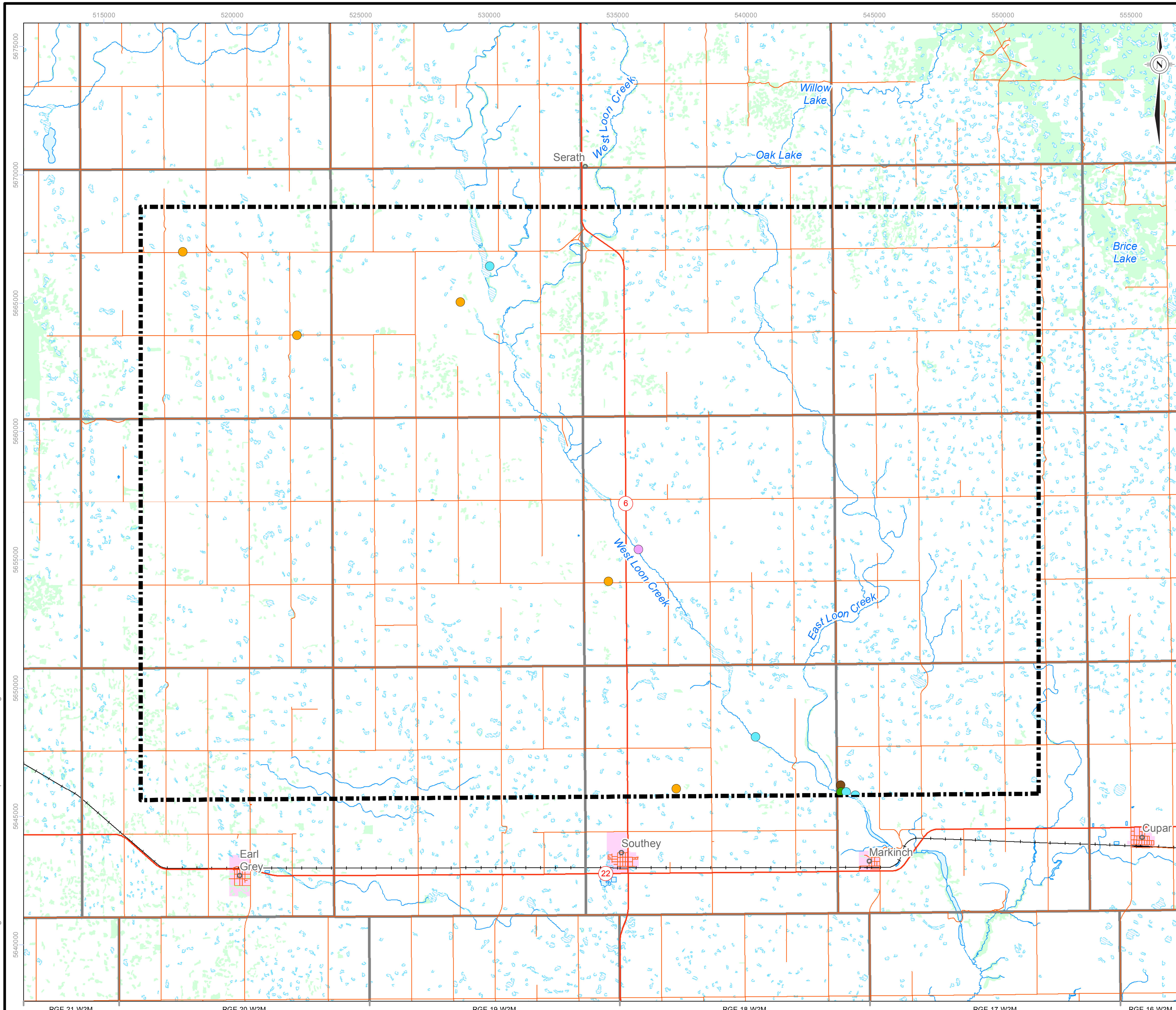
Common Name	Scientific Name	Provincial Ranking[a]	Habitat Preference[b], Location, Sighting Circa
Forbs			
Low milk vetch	*Astragalus lotiflorus*	S3	Sandy, often eroded grasslands. Observed 2 individuals at 1 location on a south facing dry slope in Native Grassland, 2013.
Tall beggarticks	*Bidens frondosa*	S2S3	Wet shores and ditches. Observed at 9 locations, 5 locations in the ESA, in Class II Wetland, Class III Wetland, in riparian areas, and along the margin of a dugout, 2013.
Macoun's cryptanthe	*Cryptantha macounii*	S1	Eroding grassland slopes. Observed at 1 location in the ESA on eroded open slope in Native Grassland, 2013.
Beaked annual skeletonweed	*Shinnersoseris rostrata* (syn. *Lygodesmia rostrata*)	S2	Dry, sandy prairies and plains, and stream banks, where it colonizes bare to semi-bare sands, mainly in blow-outs. Observed at 1 location in Native Grassland, 2013.
Graminoids			
Big bluestem[c]	*Andropogon gerardii*	S4	Mesic upland and valley slope grasslands. Observed at 4 locations in the ESA in Native Grassland, 2013.

Notes: See Annex IV, Appendix IV.2, Table IV.2-5 for location coordinates of 2013 observations.
No species listed under COSEWIC (2015), SARA (2014), or *The Wildlife Act* (1998) was observed during field programs.
Common names obtained from SKCDC (2014a).

(a) Saskatchewan Conservation Data Centre Tracked Species for Vascular Plants (SKCDC 2014d), Tracked Species for Non-Vascular Plants (SKCDC 2014e), and Tracked Species List for Fungi (SKCDC 2014f), where;
S1 = critically imperiled/extremely rare;
S2 = imperiled/very rare;
S3 = vulnerable/rare to uncommon; and
S4 = apparently secure.

(b) From Harms et al. (1992).

(c) Although provincially listed as S4, this plant species remains on the SKCDC tracking list because it is a host plant for the Dakota Skipper *(Hesperia dacotae*), listed as S1 by SKCDC (2014g), threatened by COSEWIC (2015), and threatened under Schedule 1 of SARA (2014).



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LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- WOODED AREA
- EFFECTS STUDY AREA

LISTED PLANT OCCURRENCE (2013)

- MACOUN'S CRYPTANTHE
- BEAKED ANNUAL SKELETONWEED
- BIG BLUESTEM
- LOW MILK VETCH
- TALL BEGGARTICKS

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL SOUTHEY PROJECT

TITLE
OCCURRENCES OF LISTED PLANT SPECIES WITHIN THE EFFECTS STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	JF	04/02/15	SCALE AS SHOWN REV. 0
GIS	LMS	25/05/15	FIGURE: 13.3-3
CHECK	JLF	25/05/15	
REVIEW	BC	25/05/15	

13.3.2.3.2 Listed Plant Habitat Potential

Habitat potential rankings for each vegetation cover type to support listed plant species was based on the habitat preferences and distributions of listed species described in Harms et al. (1992), University of Saskatchewan (2014), Flora of North America (2012), and SKCDC (2014h). High potential habitat that is associated with Native Grassland, Wooded, Class II to V wetlands, and riparian areas (not mapped) map units covers 20% of the ESA (Table 13.3-4). Moderate potential habitats include Modified Grassland - modified prairie and Class I wetlands that are part of the Class I and Class II Wetland unit. Low potential habitat includes Cultivated, Modified Grassland - hayland, Dugout, and Existing Disturbance map units and covers the majority of the ESA (60%).

Table 13.3-4: Distribution of Listed Plant Species Habitat Potential for the Base Case

Listed Plant Habitat Potential	Area (ha)	Proportion of ESA (%)
High	15,722	19.6
Moderate/High	3,963	4.9
Low/Moderate	12,723	15.8
Low	47,976	59.7
Total	**80,385**	**100**

Notes: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values
ESA = effects study area; ha = hectares; % = percent.

13.3.2.4 Weed Species

A total of 21 weed species were observed during baseline field programs, with 20 weed species occurring within the ESA (Table 13.3-5). Specific locations where these species were found are included in Annex IV (Appendix IV.2, Table IV.2-6). No prohibited weeds were documented in the ESA in 2013. Thirteen species listed under Schedule II (noxious) and seven species listed under Schedule III (nuisance) of *The Weed Control Act* were observed in the ESA. Most of these observations were in Cultivated, Hayland, and Ditches. Weeds generally were observed in higher densities along fence lines, field perimeters, and roadside ditches. Canada thistle, perennial sow-thistle, and common dandelion were commonly observed and occur throughout the ESA.

Table 13.3-5: Noxious and Nuisance Weed Species Present in the Effects Study Area

NOXIOUS WEED SPECIES

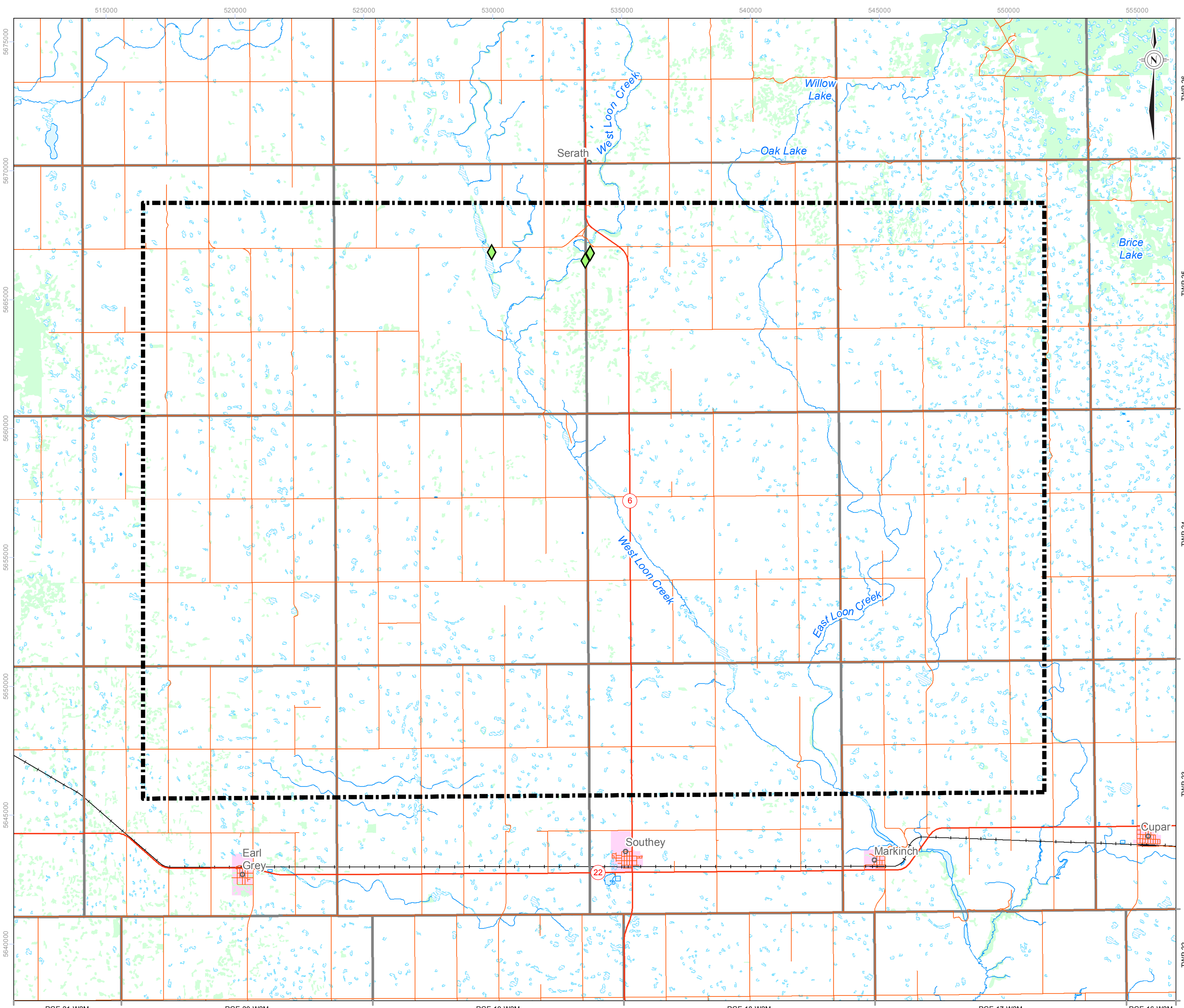
Common Name	Scientific Name	Associated Vegetation Cover Type
Absinthe	*Artemisia absinthium*	Cultivated, Hayland, Modified Prairie, Class V Wetland, Ditches, Gravel Pit, Riparian
Downy brome	*Bromus tectorum*	Cultivated, Hayland, Modified Prairie, Native Grassland, Class I Wetland
Nodding thistle	*Carduus nutans*	Cultivated, Class V Wetland, Dugout, Ditches, Gravel Pit, Riparian
Canada thistle	*Cirsium arvense*	Cultivated, Hayland, Modified Prairie, Native Grassland, Wooded, Class I, II, III, IV and V Wetlands, Ditches, Gravel Pit, Riparian
Bull thistle	*Cirsium vulgare*	Cultivated, Modified Prairie, Ditches, Riparian

Table 13.3-5: Noxious and Nuisance Weed Species Present in the Effects Study Area

NOXIOUS WEED SPECIES		
Annual hawk's-beard	*Crepis tectorum*	Cultivated
Leafy spurge	*Euphorbia esula*	Hayland, Native Grassland
Dame's rocket	*Hesperis matronalis*	Gravel Pit
Summer-cypress or kochia	*Kochia scoparia*	Cultivated, Ditches
Prickly lettuce	*Lactuca seriola*	Cultivated
Round-leaved mallow	*Malva pusilla* (syn. *M. neglecta* and *M. rotundifolia*)	Cultivated, Ditches
Perennial sow-thistle	*Sonchus arvensis*	Cultivated, Hayland, Modified Prairie, Native Grassland, Wooded, Class I, II, III, IV, and V Wetlands, Ditches, Riparian
Prickly sow-thistle	*Sonchus asper*	Cultivated, Hayland, Class II, IV, and V Wetlands
NUISANCE WEED SPECIES		
Quack grass	*Elytrigia repens* (syn. *Elymus repens* and *Agropyron repens*)	Cultivated, Hayland, Class II, III, and V Wetlands, Ditches, Riparian
Foxtail barley	*Hordeum jubatum* ssp. *jubatum*	Cultivated, Hayland, Native Grassland, Class II and V Wetlands, Ditches
Povertyweed	*Iva axillaris*	Cultivated
Common blue lettuce	*Lactuca tatarica* var. *pulchella* (syn. *L. pulchella*)	Cultivated, Hayland, Modified Prairie, Native Grassland, Class I, II, and V Wetlands, Ditches, Riparian
Russian thistle	*Salsola kali* (syn. *S. tragus*)	Cultivated, Hayland, Riparian
Common dandelion	*Taraxacum officinale* ssp. *officinale*	Cultivated, Hayland, Modified Prairie, Native Grassland, Wooded, Class I, II, III, IV, and V Wetlands, Dugout, Ditches, Gravel Pit, Riparian
Meadow goat's-beard	*Tragopogon pratensis*	Cultivated, Hayland, Wooded, Ditches

syn. = synonym; ssp. = subspecies; var. = variety.

One especially problematic noxious species, leafy spurge (*Euphorbia esula*), was observed to be established in the ESA in 2013. Leafy spurge was observed at three locations, two in Modified Grassland - hayland (NE 24-25-19 W2M and NW 19-25-18 W2M) and one in Native Grassland (NE 22-25-19 W2M) (Figure 13.3-4). These documented locations of leafy spurge were observed to be well established and ranged from several well-spaced patches to continuous occurrence of plants. Leafy spurge is especially problematic because it is a long-lived perennial with an extensive and persistent creeping root system from which it primarily re-sprouts and forms dense stands; it is also a prolific seed producer. The seed pods burst and can distribute seed as far as 5 m from the parent plant. It drastically reduces the carrying capacity (i.e., maximum stocking rate possible without damaging vegetation) of a pasture in dense infestations. Leafy spurge is very resilient and only a few licensed herbicides applied in a managed way are successful at controlling infestations of this species. Specific management and mitigation is typically required to reduce the potential for spread of this species.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- WOODED AREA
- EFFECTS STUDY AREA
- LEAFY SPURGE OCCURRENCE (2013)

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
OCCURRENCES OF LEAFY SPURGE WITHIN THE EFFECTS STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	JF	04/02/15	SCALE AS SHOWN REV. 0
GIS	LMS	25/05/15	FIGURE: 13.3-4
CHECK	JLF	25/05/15	
REVIEW	BC	25/05/15	

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1210 - Vegetation\12-1362-0197 - Leafy Spurge Occurrences ESA.mxd Date: 5/25/2015 3:37:41 PM

13.3.2.5 Traditional Use Plants

13.3.2.5.1 Traditional Use Plant Species

Traditional use plants are plant species that were historically or are currently used for food, medicinal, spiritual, or technical and trade (i.e., tools or products for use or trade) purposes by First Nations and Métis people. Historically, a wide variety of plant species were used by First Nations and Métis people (Table 13.3-6). During the 2014 traditional use surveys, Elders and First Nations community representatives identified 31 species that were used in the early 1900s (Annex V, Section 3.0). These include medicinal plants such as black root, buffalo grass, and Seneca root. Historically, plant gathering accounted for 100% of medicines used by First Nations and Métis people. Plants used for food included black currants, blueberries, buffalo berries, chokecherries, cranberries, gooseberries, pin cherries, raspberries, Saskatoon berries, and strawberries. Other plants used included cattail, hazelnuts, rose hips, sage, sweetgrass, wild mint, and wild onions. Firewood and maple syrup were commonly collected.

The majority of participants interviewed agreed that in the early 1900s they were still able to practice most of their traditional activities; however, participants indicated this has changed over time. In recent years, the participants reported that few people practice traditional land use activities. Some continue to gather berries and plants wherever they can find them; however, this is presently not as common because these plants are often difficult to find or access. The loss of traditional knowledge and the dependency on modern conveniences have also affected traditional practices, as more people buy their food and medicine from the store and pharmacy.

Table 13.3-6: Summary of Traditional Use Plants in the Effects Study Area

Reported Plant Name	Scientific Name[a]	Group	Uses	Prior to 1940	Recent Years
Black currant[b]	*Ribes* spp.	Muscowpetung	F	Yes	-
Black root	*Echinacea angustifolia*	George Gordon, Piapot, Muscowpetung	T, M	Yes	-
Blueberry	*Vaccinium myrtilloides*	Muscowpetung	F	Yes	-
Buffalo berry	*Shepherdia* spp.	Muscowpetung	F	Yes	-
Buffalo grass	*Buchloe dactyloides*	Day Star	M	Yes	-
Cattail[b]	*Typha latifolia*	George Gordon	F	Yes	-
Choke cherry[b]	*Prunus virginiana* var. *virginiana*	Kawacatoose, Day Star, George Gordon, Piapot, Muscowpetung	F	Yes	Yes
Cranberry	*Viburnum* spp. and/or *Vaccinium vitis-idaea*	Day Star, Muscowpetung	F	Yes	Yes
Fig berry (cactus berry)	*Mamillaria vivipara* and *Opuntia* spp	Muscowpetung	F	Yes	-
Frog leaf (plantain)[b]	*Alisma* spp. and *Plantago* spp.	George Gordon	-	Yes	-
Gooseberry[b]	*Ribes* spp.	Kawacatoose, Day Star, George Gordon, Piapot, Muscowpetung	F	Yes	Yes
Hazelnut	*Corylus* spp.	Kawacatoose, Day Star, Muscowpetung	F	Yes	-

Table 13.3-6: Summary of Traditional Use Plants in the Effects Study Area

Reported Plant Name	Scientific Name[a]	Group	Uses	Prior to 1940	Recent Years
Kinnikinnick	*Arctostaphylos uva-ursi*	Day Star	S	Yes	-
Maple (syrup)[b]	*Acer negundo*	Muscowpetung	F	Yes	-
Pin cherry[b]	*Prunus pensylvanica*	Kawacatoose, Day Star, George Gordon, Piapot, Muscowpetung	F	Yes	Yes
Poplar[b]	*Populus* spp.	Muscowpetung	T	Yes	-
Raspberry[b]	*Rubus idaeus*	Kawacatoose, Day Star, George Gordon, Piapot, Muscowpetung	F	Yes	Yes
Red berry	unknown	Muscowpetung	F	Yes	-
Red willow (red-osier dogwood)[b]	*Cornus sericea*	Day Star, Piapot, Muscowpetung	T, M	Yes	Yes
Rhubarb	*Rheum rhabarbarum*	Muscowpetung	F	Yes	-
Rose hip[b]	*Rosa acicularis, R. arkansana, R. woodsii.*	Day Star	M	Yes	-
Sage[b]	*Artemisia* spp.	Kawacatoose, Day Star, George Gordon, Piapot	S	Yes	Yes
Saskatoon berry[b]	*Amelanchier alnifolia*	Kawacatoose, Day Star, George Gordon, Piapot, Muscowpetung	F	Yes	Yes
Seneca root[b]	*Polygala senega*	George Gordon, Piapot, Muscowpetung	T, M	Yes	Yes
Snake berry	unknown	Muscowpetung	F	Yes	-
Strawberry[b]	*Fragaria virginiana*	George Gordon, Piapot, Muscowpetung	F	Yes	-
Sweetgrass[b]	*Hierochloe odorata*	Kawacatoose, Day Star, George Gordon, Piapot, Muscowpetung	S	Yes	Yes
Tobacco	unknown	Day Star, Piapot	S	Yes	Yes
Wild mint[b]	*Mentha arvense*	Muscowpetung	M	Yes	-
Wild onion[b]	*Allium* spp.	Muscowpetung	F	Yes	-
Wild turnip	unknown	Piapot, Muscowpetung	F	Yes	-

(a) Because of the variable nature of common names, the scientific name provided for each reported plant species name is a professional evaluation of the likely corresponding species.
(b) Recorded during baseline field programs.
F = Food; M = Medicinal; S = Spiritual; T = Technical and Trade; - = no use identified during interviews.

13.3.2.5.2 Traditional Use Plant Habitat Potential

Habitat potential rankings for each ELC map unit to support traditional use plant species was based on the habitat preferences, most probable ELC map unit, and observation locations of these species during the field programs (Table 13.3-7). High potential habitat that is associated with Native Grassland, Wooded, Class IV and V wetlands, and riparian areas covers 18% of the ESA (Table 13.3-8). Low potential habitat covers the majority of the ESA (60%).

Table 13.3-7: Potential of Ecological Landscape Classification Map Units in the Effects Study Area to Support Traditional Use Plants

Ecological Landscape Classification Map Unit	Traditional Use Plant Habitat Potential Ranking
Cultivated	Low
Modified Grassland - Hayland	Low
Modified Grassland - Modified Prairie	Moderate
Native Grassland	High
Wooded	High
Class I and Class II Wetland	Low/Moderate
Class III Wetland	Moderate
Class IV Wetland	High
Class V Wetland	High
Dugout	Low
Existing Disturbance	Low
Riparian (not mapped)	High

Table 13.3-8: Distribution of Traditional Use Plant Species Habitat Potential within the Effects Study Area

Traditional Use Plant Habitat Potential Ranking	Area (ha)	Proportion of ESA (%)
High	14,786	18.4
Moderate	936	1.2
Low/Moderate	16,687	20.8
Low	47,976	59.7
Total	**80,385**	**100**

Notes: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
ESA = effects study area; ha = hectares; % = percent.

13.4 Pathways Analysis

13.4.1 Methods

Pathways analysis identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects (after mitigation) on vegetation. The first part of the analysis is to identify all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on the VC. Potential pathways through which the Project could affect vegetation were identified from a number of sources including the following:

- a review of the Project Description (Section 4.0) and scoping of potential effects by the environmental and engineering teams for the Project;
- information obtained from community engagement sessions (Section 5.0);

- scientific knowledge and experience with other potash mines in Saskatchewan; and
- consideration of potential effects identified from the TOR.

For an effect to occur there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a correspondent effect on the VC.

Project activity → change in environment → effect on VC

A key aspect of the pathways analysis is to identify environmental design features and mitigation that might reduce or eliminate potential effects of the Project on vegetation. Mitigation has been developed for the Project according to the following hierarchy proposed by the MOE (2014):

- avoidance;
- minimize (limit);
- restoration; and
- compensation.

Environmental design features include engineering design elements, environmental best practices, management policies and procedures, and spill response and emergency contingency plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on vegetation. Pathways are determined to be primary, secondary (minor), or as having no linkage, using scientific, local and traditional knowledge, logic, experience with similar developments, and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- **No linkage** – analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on vegetation relative to the Base Case or guideline values; or
- **Secondary** – pathway could result in a measurable minor environmental change, but would have a negligible residual effect on vegetation relative to the Base Case or guideline values, and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect; or
- **Primary** – pathway is likely to result in environmental change that could contribute to residual effects on vegetation relative to the Base Case or guideline values.

Pathways with no linkage to vegetation are not assessed further because implementation of environmental design features or mitigation will remove the pathway and result in no measureable change to vegetation. Pathways that are assessed to be secondary and demonstrated to have a negligible residual effect on vegetation through simple qualitative or semi-quantitative evaluation of the pathway are also not advanced for further assessment. In summary, pathways determined to have no linkage to vegetation or those that are considered secondary are not expected to result in environmentally significant effects for self-sustaining and ecologically effective plant populations and communities. Primary pathways require further evaluation through more detailed quantitative and qualitative effects analysis (Section 13.5).

13.4.2 Results

Project components and activities, effects pathways, and environmental design features and mitigation are summarized in Table 13.4-1. Classification of effects pathways (i.e., no linkage, secondary, and primary) to vegetation also is summarized in Table 13.4-1 and detailed descriptions are provided in the subsequent sections.

13.4.2.1 Pathways with No Linkage

A pathway may have no linkage to environmental effects if the activity does not occur, or if the pathway is removed by mitigation or environmental design features so that the Project results in no measurable change in measurement indicators. Subsequently, no residual effect on vegetation is expected. The pathways described in the following bullets have no linkage to vegetation and will not be carried forward in the assessment.

- **Changes in surface flows, drainage patterns (distribution) and drainage areas from the Project footprint can affect the abundance and distribution of plant populations and communities.**

Surface water flows, drainage patterns, and drainage areas from the Project footprint are expected to be affected by the construction of the Project. The natural drainage area near the Project has already been disturbed from the existing road network used to access cultivated areas, rural homes, and communities near the Project. The Project is within an area with poorly defined runoff pathways. During the Base Case, most of the runoff contributes to a low-lying area south of the core facilities area and it may occasionally contribute to West Loon Creek under high magnitude snowmelt and/or rainfall events (Section 9.5). The hydrology assessment predicted that the Project footprint will result in a reduction in runoff that will change the amount of water reporting to the low-lying area downstream, but would only rarely affect inflows to West Loon Creek. During decommissioning and reclamation, most of the Project infrastructure will be removed, and surface water flows and drainage patterns will be reclaimed. The tailings management area (TMA) is considered permanent. The surface water flows and drainage patterns in residual footprint areas will not be reclaimed; however, no reduction in flow volume in West Loon Creek downstream is predicted.

Table 13.4-1: Potential Pathways for Effects on Vegetation

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Physical disturbance from the Project Footprint	Direct loss, alteration, and fragmentation of vegetation from the Project footprint (core facilities area, mining area, and access roads) can cause changes to plant populations and communities.	■ The compact layout of the core facilities area will limit the area that is disturbed by construction. ■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance. ■ Progressive reclamation will occur where applicable (e.g., progressive well pad site reclamation). ■ Existing public roads will be used where possible to provide access to the Project, reducing the amount of new road construction required for the Project. ■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible. ■ A Decommissioning and Reclamation Plan will be developed and will incorporate new technologies as they become available to reduce the length of the decommissioning period, and the associated duration of salt storage at surface. ■ All on-site roads will be removed during decommissioning. ■ Salvaged soil material will be returned to the landscape and contoured, to the extent practical, to blend with the surrounding terrain. ■ Disturbed areas will be recontoured and reclaimed to a stable profile to permit existing land uses.	Primary
	Residual ground disturbance from portions of the core facilities area can permanently alter the abundance and distribution of plant populations and communities.	■ Siting and construction of the Project will be planned to avoid environmentally sensitive areas (e.g., critical wildlife habitat, listed plants species, and wetlands) as much as possible. ■ If avoidance of sensitive areas is not feasible, consultation with MOE will be completed to determine the significance of the area and identify mitigation strategies.	Primary
	Direct loss or alteration of local vegetation from the mine well field area pipeline corridors can cause changes in plant populations and communities.	■ The Project will avoid listed plants as much as possible, however, if avoidance of listed plants is not possible, consultation with MOE will be completed to determine the significance of the area and identify feasible mitigation strategies. ■ If a listed plant species is encountered that was not expected, appropriate mitigation will be applied prior to further construction activities.	Secondary
	Changes in surface flows, drainage patterns (distribution) and drainage areas from the Project footprint can affect the abundance and distribution of plant populations and communities.	■ The compact layout of the core facilities area will limit the area that is disturbed by construction. ■ The well pad design will be optimized to manage as many caverns as practical from one well pad, reducing ground disturbance. ■ Progressive reclamation of well pads will occur. ■ Existing public roads will be used where possible to provide access to the mine well field area, reducing the amount of new road construction required for the Project. ■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible. ■ Where practical, natural drainage patterns will be maintained. ■ Culverts will be installed along site access roads, as necessary, to maintain drainage.	No Linkage
General construction, operations, and decommissioning and reclamation activities	Introduction of noxious and invasive weed species can affect plant populations and communities.	■ A Weed Management Plan will be designed and implemented to prevent, detect, control (remove), and monitor areas with prohibited, noxious, nuisance, and invasive plant species. ■ Construction equipment will be inspected and regularly cleaned. ■ Construction equipment will be required to undergo procurement inspections to evaluate the overall condition and cleanliness. More stringent procurement inspections will be required on equipment coming from outside the region in order to prevent the introduction and/or spread of weed species (i.e., prohibited, noxious and nuisance weeds).	Secondary
	Introduction of pests, in particular crop diseases, can affect agronomic plant species	■ When entering natural areas, such as native grassland, equipment will be carefully inspected for weed and invasive species to prevent introduction into sensitive habitats. ■ A review of crop disease extent maps may be required to determine current extent of a particular crop disease and specific mitigation required will be determined by the source of construction equipment. ■ Sanitation or disinfection for crop diseases will be used where necessary to control the introduction or spread of crop diseases from the Project. ■ To avoid further introduction or spread of crop diseases, equipment used for construction will be sourced locally when possible and disinfected (i.e., 1] rough cleaning of soil from equipment (e.g., using an air compressor or wire brush); 2] fine cleaning using a pressure washer; and 3] disinfecting all openings and wheels with a bleach solution prior to entering and exiting the area).	Secondary

Table 13.4-1: Potential Pathways for Effects on Vegetation

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
General construction, operations, and decommissioning and reclamation activities	Air and dust emissions and subsequent deposition can cause changes to the chemical properties of soils and vegetation, which can affect the abundance and distribution of plant populations and communities.	■ Compliance with regulatory emission requirements. ■ Dryer burners will be high efficiency, low NO_x burners to limit the amount of NO_x present in the exhaust stream. ■ Baghouses will be installed throughout the dry process area and dust collected in these baghouses will be conveyed back to the compactors. ■ A dustless chute and loading system will be installed in the product storage area to reduce dust generation in storage and load-out. ■ The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment. ■ An Erosion and Sediment Control Plan will be implemented during all phases of the Project to limit dust production, and subsequent deposition on surrounding areas, and to limit erosion of exposed soils. ■ Dust-producing components of the potash refinement process (i.e., dryers, compaction circuit) will have controls to recover and return dust to the circuit. ■ Wet scrubbers will be used to clean the air of dust particles from off-gases from the product dryers. ■ Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. ■ Enforced speed limits will assist in reducing production of dust. ■ Operating procedures will be developed to reduce dust generation from the TMA over the long-term. ■ The cyclone exhaust will be treated using high-energy scrubbers operating at a high-pressure drop.	Secondary
	Dust deposition can cover vegetation and lead to physical damage.		Secondary
	Long-term dust emissions from the tailings management area can alter the abundance and distribution of plant populations and communities.		No Linkage
Solution Mining	Ground subsidence caused by solution mining can change surface flows and drainage patterns (distribution), which can affect the abundance and distribution of plant populations and communities.	■ Unmined pillars will be left between caverns to increase stability during mining and reduce potential subsidence. ■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence, and provide input into adaptive management. ■ Subsidence will be non-disruptive. Disruptive subsidence, such as the formation of sinkholes, is not expected to occur. ■ Subsidence will be gradual, and ultimate (maximum) subsidence (i.e., final, steady state) will not occur for centuries. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface topography.	Primary
Tailings Management Area	Vertical and lateral migration of brine from the tailings management area can cause changes to surface water and soil quality, which can affect plant populations and communities.	■ The location of the TMA was selected based on site-specific geologic and hydrogeologic studies completed to identify an appropriate foundation for the TMA, which provides natural containment of brine material. ■ The TMA will be located over soils that are known to provide natural retention of brine solutions and offer protection against seepage into nearby ground and surface water resources. ■ Brine reclaim ponds will be designed to provide containment of brine under normal and extreme (i.e., storm) conditions over the life of the mine. ■ A perimeter dyke will be constructed around the TMA to contain waste salt and decanted brine. ■ Excess brine reclaimed from the TMA will be disposed of by deep well injection, a proven practice used to manage brine and prevent release to surface waters and fresh-water aquifers. ■ A containment system will be designed to control deep migration of brine from the TMA to underlying aquifers and horizontal migration of brine, as required. ■ A Waste Salt Management Plan for the TMA will be incorporated into the detailed design. ■ The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan, and adaptive management will be implemented, if required. ■ A Decommissioning and Reclamation Plan will be developed and will incorporate new technologies as they become available to reduce the length of the decommissioning period and the associated duration of salt storage at surface.	No Linkage
	Long-term brine migration from the tailings management area can cause changes to surface water and soil quality, which can effect plant populations and communities.		No Linkage

Table 13.4-1: Potential Pathways for Effects on Vegetation

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Tailings Management Area	Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality, and change surface water and soil quality, which can affect plant populations and communities.	■ An evaluation of the capacity of potential deep injection horizons has been conducted identifying the Winnipeg Formation and Deadwood Formation to be suitable for brine disposal.	No Linkage
Water Management	Site run-off and associated soil erosion from the core facilities area can change soil quality and affect the abundance and distribution of plant populations and communities.	■ A Water Management Plan will be designed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. ■ A diversion channel will be constructed to intercept waterflow from upland areas along the north and east borders of the core facilities area. ■ Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the core facilities area. ■ The surface water diversion will be designed to convey the runoff associated with the 300 millimetre (mm) 24-hour design storm event. ■ Surface water diversion channels along the perimeter of the core facilities area will be designed to collect and redirect external drainage.	No Linkage
Accidents, Malfunctions, and Unplanned Events	Spills (e.g., waste oil, petroleum products, reagents, potash product, project equipment leaks, vehicle accidents, and wash-down) can cause changes to soils and affect plant populations and communities.	■ Instruction will be provided to employees as part of the Health, Safety, Security, and Environmental Management System; training will be provided to all employees on transportation of dangerous goods, as well as on spill reduction, control, and clean up procedures. ■ Basic, core, and specific training of workers as part of the Health, Safety, Security, and Environmental Management System. ■ An Emergency Response Team will be formed on-site and members will be trained to implement the Emergency Response Plan. ■ Spills will be promptly reported and managed according to procedures identified in the Spill Response and Control Plan. ■ Chemical spill containment will be incorporated into the plant design to mitigate environmental effects from spills (i.e., installation of concrete floors, drains, and sump mechanisms). ■ Smaller fuel dispensing tanks will be double-walled, and all dispensing will be performed over concrete containment slabs. ■ Reagent tanks and larger fuel tanks will be located inside a bermed, lined storage compound. ■ Liquid, solid spills, and wash-down within the processing facilities will be contained within the mill facility (e.g., door curbs, sloped floors, and sumps) or engineered site area. ■ Diesel and gasoline will be stored in accordance with applicable regulations. ■ On-site storage facilities for hazardous substances and waste dangerous goods will be designed to meet regulatory requirements. ■ Domestic and recyclable waste dangerous goods will be stored in appropriate containers until shipped off site to an approved facility. ■ Spill response material will be located throughout the site in designated areas, where fuel and chemicals are stored, and in company vehicles. ■ Best practices will be adopted within the Waste Management Plan for proper handling and storage of waste dangerous goods. ■ Salvageable product from centrifuging, drying, screening, and compaction will be recycled back to the process. ■ Construction equipment will be regularly inspected and maintained. ■ To limit the occurrence of vehicular accidents, training for equipment operators will be implemented as part of the Health, Safety, Security, and Environmental Management System. ■ Equipment will be inspected for leaks and repaired prior to entry into the Project area, and routinely inspected throughout the duration of the Project. ■ Daily vehicle inspections will be required, and a preventative maintenance program will be implemented for all vehicles used on-site. ■ Speed limits will be enforced. ■ Timely snow removal and sanding will occur on site access roads during winter to improve traction.	No Linkage

Table 13.4-1: Potential Pathways for Effects on Vegetation

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Accidents, Malfunctions, and Unplanned Events	Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to groundwater, surface water, and soil quality, which can affect plant populations and communities.	■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ Brine will be transported by steel pipeline lined with high-density polyethylene, which provides additional pipe flexibility and resistance to corrosion. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface developments. ■ Unmined pillars will be left between the caverns to increase stability during mining and reduce the potential for subsidence. ■ As part of the Environmental Protection Plan, regular monitoring of pipelines will be carried out to limit the potential for leaks and allow for early detection and management of spills. ■ Piping and valve arrangements will be routed so that each cavern works independently from the others at difference stages of cavern development and production. ■ During the detailed design stage, additional spill response and mitigation will be included in the Spill Response and Control Plan.	No Linkage
	Slope failure of the waste salt storage pile can cause translocation of waste salts, which can alter soil quality and the abundance and distribution of plant populations and communities.	■ Salt pile side slopes of 4H:1V were applied to the TMA layout, which were found to provide stable slope configuration based on preliminary slope stability analysis. ■ The final configuration of salt pile slopes will be refined based on subsequent analyses calibrated to pore-water pressure and slope movement data obtained during the initial development of the waste salt pile. ■ Regular inspections of the TMA. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan.	No Linkage
	Failure of the brine containment pond and resulting brine leakage can cause changes to soil quality and the abundance and distribution of plant populations and communities.	■ The brine reclaim pond will provide adequate storage to accommodate storage of process streams under normal and extreme operating conditions and design storm events. ■ Sufficient freeboard will be provided to account for wind induced set-up and wave run-up on the sides of the pond slopes. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan. ■ Maximum operating levels will be developed to provide adequate storage volumes for the design storm event (300 mm in 24 hours). ■ Containment berms and dykes will be constructed around the tailings management area to contain salt tailings and decanted brine, as well as to divert surface water. ■ Containment dykes will be keyed into surficial materials as necessary. ■ Brine levels will be monitored and excess brine will be injected into deep well injection zones after mining is complete. Sub-surface brine migration will be monitored and groundwater wells will be monitored to confirm the adequacy of the brine containment pond. ■ In the event of high flows due to precipitation events, additional flow capacity from the collection ditch to the reclaim pond would be provided by an overflow spillway in the embankment. ■ The brine reclaim pond will be monitored regularly; monitoring results will provide input into adaptive management.	No Linkage
	Deposition of air emissions from the failure of air emission control systems can result in chemical changes to the surrounding environment and affect plant populations and communities	■ The environmental performance of air emissions control systems will be monitored on an on-going basis, and provide input into adaptive management. ■ Preventative maintenance will be completed regularly to confirm that emissions control systems are functioning as designed.	No Linkage

Table 13.4-1: Potential Pathways for Effects on Vegetation

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Accidents, Malfunctions, and Unplanned Events	Loss of vegetation from a fire caused by Project activities.	■ Site-specific response plans and mitigation for fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response Plan. ■ Fire safety measures and response will be reviewed with the R.M.s of Longlaketon and Cupar. ■ Personnel will be trained in fire prevention and response procedures. ■ Firefighting equipment will be available on site. ■ Inspections of the plant will be completed to identify potential fire hazards. ■ A fire suppression system will be activated during all phases of the Project. ■ Water will be stored on-site in the raw water pond for the fire suppression system.	No Linkage

TMA = tailings management area; MOE = Ministry of Environment; mm = millimetre; NO_x = oxides of nitrogen; R.M. = Rural Municipality

A Water Management Plan will be implemented to maintain streamflow quantity along natural flow pathways as much as possible. Environmental design features will be implemented to allow off-site precipitation and snowmelt to remain part of the natural water cycle. The core facilities area will be limited to the minimum spatial extent required. The mine well field area access roads constructed during the Project will be designed to maintain the natural flow paths using adequately designed cross-drainage structures (e.g., culverts) as required.

By implementing environmental design features and mitigation, it is anticipated that the Project footprint will result in minor changes to surface water flows and drainage patterns. The minor changes to surface water flows and drainage patterns are not anticipated to cause measurable changes to vegetation. Therefore, this pathway was determined to have no linkage to effects on plant populations and communities.

- **Long-term dust emissions from the tailings management area can alter the abundance and distribution of plant populations and communities.**

Solution mining produces waste salt (i.e., sodium chloride [NaCl] tailings) as a by-product of the potash refinement process, which will be stored in the salt storage area in the TMA. The volume of tailings produced by the solution mining method for the Project is expected to be lower than conventional underground potash mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only potassium chloride (KCl) is removed from the caverns.

The waste salt product precipitated during processing is removed from the process and discharged to the TMA through a slurry pipeline. Monitoring programs for the waste salt storage area will be incorporated into the design and will include monitoring pile stability and related dust production.

A solid crust will form over the outer layer of the waste salt pile as the salt slurry dries. The formation of a rigid crust over the salt pile is expected to limit effects of exposure to wind and will reduce the potential for erosion. Operating procedures will be developed to limit dust emissions from the TMA. Because of the crusting of the outer layer of the salt pile and the implementation of operating procedures and monitoring programs for the salt storage area, long-term dust emissions are not expected, and are predicted to result in no measureable changes to soil quality and vegetation. Subsequently, this pathway was determined to have no linkage to effects on plant populations and communities.

- **Vertical and lateral migration of brine from the tailings management area can cause changes to surface water and soil quality, which can affect plant populations and communities.**
- **Long-term brine migration from the tailings management area can cause changes to surface water and soil quality, which can effect plant populations and communities.**
- **Failure of the brine containment pond and resulting brine leakage can cause changes to soil quality and the abundance and distribution of plant populations and communities.**

The TMA will consist of the Stage I and Stage II salt storage areas, the Stage I and Stage II brine reclaim ponds, sewage lagoon, and surface diversion works. The TMA will be in operation during the life of the Project, and following decommissioning and reclamation of the mine. Brine is primarily composed of soluble salts (sodium chloride [NaCl], with smaller amounts of KCl) and other insoluble materials (e.g., metals) (Tallin et al. 1990). Vertical or lateral migration of brine into groundwater systems or directly into the surrounding soil may lead to salt accumulation and change soil quality and affect plant populations and communities.

The concentration of salt in soil solution and salt accumulation in soil increases soil salinity and affects soil physical properties (Henry et al. 1992; Keran 2012). Sodium (and sometimes potassium) can act as dispersive cations in soil when present in high enough concentrations (Keren 2012). Salt accumulation can promote clay swelling and disrupt soil structure, which can affect soil permeability, soil plasticity, water retention capability, cation exchange capacity (CEC), and crop productivity (Barbour and Yang 1993; Gabbasova et al. 2010; Keren 2012; Levy 2012). Salts can increase soil pH, which can alter the availability of soil nutrients for plant uptake (Richards 1954; MOA 2008; Levy 2012). These changes to soil quality have the potential to affect vegetation.

High soil salinity results in decreased uptake of water and nutrients by plant roots in sensitive plants (Henry et al. 1992). Plants that grow in high salinity conditions may suffer from reduced plant productivity (below and above ground), defoliation, and reduction in seed germination, and plant death (Richards 1954; Bernstein 1975; MOA 2008; Levy 2012). Plants in wetlands can also be negatively affected by increases in salinity (Hart et al. 1991).

Soils with high organic matter content tend to promote greater aggregate stability and have a greater resistance to inputs of sodium (Levy 2012). In addition, the presence of calcium carbonate promotes further resistance to sodium inputs to soil. Soils within the ESA had an organic matter content of between 1% and 10% and are enriched with calcium carbonate (Annex IV, Appendix IV.1). Therefore, soils in the ESA may be somewhat buffered to small inputs of sodium from brine. However, this buffering capacity would likely be ineffective in the event of large brine inputs that may occur if the brine pond containment fails.

The stratified clay and clayey tills of the Saskatoon Group are the main geological units that would mitigate the vertical migration of seepage from the TMA (Golder 2015). Soil-bentonite cut-off walls will be used to contain brine areas where shallow stratified sand and gravel deposits are present. The necessity for a deep cut-off wall extending through competent till materials will be determined based on the results of detailed site characterization. Containment berms and dykes will be constructed around the TMA to contain decanted brine. The containment system will be designed to control migration of brine from the salt storage area to underlying aquifers and control the horizontal migration of brine, as required. The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan, with monitoring results providing input for adaptive management.

Implementation of the above-mentioned environmental design features, mitigation, and monitoring programs have shown good performance in preventing vertical and lateral seepage in similar potash projects. Consequently, these pathways were determined to have no linkage to effects on plant populations and communities.

- **Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality, and change surface water and soil quality, which can affect plant populations and communities.**

Brine will be disposed of through deep-well injection during the Project to reduce the amount of brine stored in the TMA. Injecting brine into deep wells can change sub-surface and deep groundwater levels and chemistry, which could alter surface water and soil quality. Depending on the chemical composition of the brine being injected, the brine may introduce NaCl, KCl, and other insoluble materials (e.g., metals) to groundwater (Tallin et al. 1990). Salt accumulation can increases soil salinity and affect soil structure and soil pH, which can change the availability of soil nutrients (Richards 1954; Barbour and Yang 1993; MOA 2008; Gabbasova et al. 2010; Keren 2012; Levy 2012;)

Disruption in groundwater flow may adversely affect soil moisture and surface water levels in wetlands by changing recharge and discharge areas and rates (Chen and Hu 2004). This may expose previously unsaturated soils to saturated conditions and vice versa, and alter soil physical, chemical, and biological properties (Bedard-Haughn 2011). Changes in soil moisture regimes and soil quality can alter vegetation communities.

Methods used in the solution mining process will maintain stability of shallow and deep groundwater aquifers. In addition, an evaluation of the capacity of potential deep injection zones has been completed identifying the Winnipeg Formation and the Deadwood Formation to be suitable for brine disposal. The Winnipeg and Deadwood Formations are considered the best target for brine disposal because there is a large storage capacity in these formations, the formations are well isolated from overlying freshwater aquifers, and the formations are distant from recharge and discharge areas (Appendix 4-A). No changes to sub-surface and deep groundwater flow, levels, and quality are predicted. Given that the formations used for deep well injection are isolated from overlying aquifers and surface water, no changes to surface water or soil quality are expected. Therefore, this pathway was determined to have no linkage to effects on plant populations and communities.

- **Site run-off and associated soil erosion from the core facilities area can change soil quality and affect the abundance and distribution of plant populations and communities.**

Site runoff and associated soil erosion from the core facilities area could potentially affect vegetation within and adjacent to the Project footprint. Brine and salt stored in the TMA may be transported off-site via surface water runoff caused by precipitation. Increased salt in soils can lead to soil salinity, and when salt levels are high enough, they can negatively affect plant growth, especially in salt sensitive species. Salt in soil can cause a reduction in the ability of plant roots to take up water from surrounding soils and can lead to increased plant stress (Warrence et al. 2002). Increased levels of soil erosion can lead to increased sediment loads in wetlands, thus reducing plant abundance and diversity (Forman and Alexander 1998).

Several environmental design features and mitigation measures will be implemented to prevent water release from the core facilities area entering the surrounding environment. The general site layout has been developed to use natural topography to assist site drainage to the extent practical. The topography in the area is gently sloping toward the south and slightly to the west. A diversion channel will be constructed to intercept waterflow from upland areas along the north and east borders of the core facilities area.

A Water Management Plan will be developed and infrastructure will be constructed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the facility. The surface water diversion works will be designed to accommodate runoff from a 300-millimetres (mm) rainstorm event over a 24-hour period (Section 4.6.2).

Runoff within the TMA will be redirected to the brine reclaim pond for temporary storage prior to deep-well injection. Salt storage area internal channels (i.e., brine return channels) are designed to collect and redirect runoff originating from precipitation and brine discharges on the tailings areas to the brine reclaim pond. The TMA will be graded to drain free brine to the brine reclaim pond by gravity. Internal salt tailings dykes and ditches may be required to direct surface flow to the collection ditch during early stages of deposition.

The brine reclaim pond will be constructed to provide containment of brine during the Project. The brine reclaim pond is designed to allow sufficient storage capacity to contain brine decant from the salt storage area during normal operations, runoff resulting from the design storm event, and a 0.9-m freeboard to accommodate wind-induced setup and wave run-up on the sides of the pond slopes.

Erosion protection of the surface water diversion channel will be provided by topsoil replacement and hydro-seeding to establish grass cover within the diversion channel. A tackifier may be used to increase the temporary soil stability prior to establishment of permanent root systems.

Inspection and maintenance procedures for infrastructure will be outlined in the Water Management Plan and provide input into adaptive management, as required. Implementation of environmental design features and mitigation is expected to prevent site runoff and soil erosion from the core facilities area from entering the surrounding environment. Subsequently, this pathway was determined to have no linkage to effects on plant population and communities.

- **Spills (e.g., waste oil, petroleum products, reagents, potash product, project equipment leaks, vehicle accidents, and wash-down) can cause changes to soils and affect plant populations and communities.**
- **Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to groundwater, surface water, and soil quality, which can affect plant populations and communities.**

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks, and to limit the effects of spills and leaks on vegetation. Pipelines will be used to transport brine solution and potash product within the Project footprint. Pipelines will be constructed of standard carbon steel and lined with high-density polyethylene. Pipelines will be installed underground at a depth that will reduce the possibility of damage from frost and surface activities (e.g., farming) and will be monitored for pressure and flow using flow meters. Double-walled pipe for secondary containment will be used in critical crossing areas (i.e., based on site-specific analysis to meet environmental conditions). All pipelines will be insulated to maintain the required temperature for the process with the exception of the cold water and the early brine return pipelines. Trains and vehicles will transport chemicals, potash product, and other reagents on and off-site.

An Emergency Response Plan will be developed as part of the Health, Safety, Security, and Environmental Management System to provide rapid and competent response to incidents that may occur during the Project. Aspects of this plan include instructions and procedures for quick detection, control, and management of spills occurring on site. Other mitigation will include a leak detection system for mining area pipelines, which will consist of monitoring and appropriate pipe isolation to limit potential leaks and for early detection. Leak detection and monitoring of pipelines will be based on flow and pressure measurements at points along the pipeline. In addition to the pipeline monitoring program, liquid spills and wash-down, occurring within the potash processing facilities will be contained within the mill facility or the engineered site area, and salvageable product spills will be recycled into the process feed.

If a spill originates in the tank farm, the hazardous substance will be pumped and properly disposed off-site. The tank farm will be designed to include an adequately sized containment berm for containing potential leaks or spillage. Storage facilities for hazardous wastes will meet regulatory requirements, and site personnel will be trained on spill reduction, control, and clean-up procedures. Employees will receive spill response training, and appropriate spill response materials (e.g., absorbent pads or booms) and equipment will be located at strategic locations on-site. Disposal of all hazardous materials such as waste chemicals, hydrocarbons, reagents, and petroleum products will be handled by a licensed contractor and will be hauled off-site to an approved facility. Waste products from the Project (e.g., hazardous waste, domestic waste, or recyclable waste) will be stored and disposed of following designated procedures by federal and provincial legislation.

Implementation of environmental design features and mitigation are expected to reduce the likelihood and extent of spills and leaks occurring on-site and along transportation corridors, resulting in no measureable changes to soil and vegetation quality relative to Base Case conditions. Therefore, these pathways are determined to have no linkage to effects on plant populations and communities.

- **Slope failure of the waste salt storage pile can cause translocation of waste salts, which can alter soil quality and the abundance and distribution of plant populations and communities.**

The volume of tailings produced by the solution mining method for the Project is expected to be lower than conventional underground potash mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only KCl is removed from the caverns during this process.

Salt tailings stockpile stability is governed primarily by the salt pile height, shear strength of the underlying soils, and the degree to which soil pore water pressures are generated in response to the surcharge load of the stockpile. Detailed slope stability analysis for the salt pile will be completed to determine the optimal salt pile height for the Project. The final design of the waste salt storage area will provide for flexibility to expand the storage area in stages through modifications to the footprint or increasing the salt pile height should additional storage be required.

The probability of slope failure of the waste salt storage pile will be limited by the implementation of operating procedures and monitoring programs for the salt storage area. Salt pile stability monitoring will be incorporated into the design. As such, this pathway was determined to have no linkage to effects on plant populations and communities.

- **Deposition of air emissions from the failure of air emission control systems can result in chemical changes to the surrounding environment and affect plant populations and communities.**

The potential exists for failure of air emission control systems, which may result in short-term reductions in air quality. The environmental performance of air emissions control systems will be monitored on an ongoing basis and preventative maintenance will be completed regularly to confirm that emissions systems are functioning as designed. The minor and short-term changes to air quality are not anticipated to cause measurable changes to vegetation. Therefore, this pathway was determined to have no linkage to effects on plant populations and communities.

- **Loss of vegetation from a fire caused by Project activities.**

Fire that is caused by Project activities could result in the loss of vegetation. Fire safety measures and response will be developed in conjunction with local and regional first responders, applicable regulatory agencies and reviewed with the R.M. of Longlaketon and the R.M. of Cupar. On-site personnel will be trained in established fire prevention and response procedures and appropriate firefighting equipment will be available on-site so that trained personnel will be able to respond promptly.

Regular inspections of the process plant will be completed to identify potential fire hazards and any necessary repairs or maintenance will be performed as soon as possible following identification. A fire suppression system will be activated during all phases of the Project and its functionality will be regularly monitored. Water will be stored on-site in the raw water pond to provide water, as needed, for the fire suppression system. The implementation of the abovementioned mitigation is anticipated to result in no linkage to effects on vegetation.

13.4.2.2 Secondary Pathways

In some cases, both a source and a pathway exist, but because the change caused by the Project is anticipated to be minor relative to Base Case or guideline values, it is expected to have a negligible residual effect on vegetation. The pathways described in the following bullets are expected to be secondary and will not be carried forward in the assessment.

- **Direct loss or alteration of local vegetation from the mine well field area pipelines can cause changes in plant populations and communities.**

Construction of the mine well field area pipelines for the Project will cause a temporary loss or alteration of vegetation. By implementing several mitigation measures, minimal loss and alteration is anticipated to occur due to pipeline construction. Pipelines will be routed underground to allow continued use of land for agricultural or environmental purposes and will follow existing utility corridors to reduce disturbance to undisturbed areas, where possible. Focused pre-construction surveys will be used to determine if any listed or weed species are present at the construction site. During construction and throughout the lifetime of the Project, Yancoal will comply with all aspects of relevant federal and provincial acts, regulations, and guidelines, and best practices to reduce and mitigate potential effects on vegetation, as relevant. Disturbed areas within pipeline corridors will be re-contoured and reclaimed to support current land uses after construction has been completed.

Construction of the mine well field area pipelines are expected to result in minor changes to vegetation relative to Base Case conditions by using environmental design features and mitigation. Many of the alterations to the landscape are expected to be temporary and limited to the construction period. Therefore, this pathway was determined to result in negligible residual effects on plant populations and communities.

- **Introduction of weed species can affect plant populations and communities.**
- **Introduction of pests, in particular crop diseases, can affect agronomic plant species.**

The construction, operation, and reclamation of the Project have potential to introduce prohibited, noxious, nuisance, and invasive weed species into new areas, especially when entering areas with known populations of weeds. The introduction of weed species into natural areas (i.e., native grassland and wetland habitats) can disrupt plant communities and decrease habitat quality by affecting plant community structure and species diversity directly through competition and indirectly through alterations to soil microorganisms, nutrients, and soil moisture (Mack et al. 2000; Carlson and Shepherd 2007; Truscott et al. 2008). The introduction of weed species into agricultural areas can affect agronomic plant species. Effects on agronomic species may include a decrease in crop yield, decrease in seed quality, and possibly contribute to weed problems in subsequent years.

Most weed species introductions arise from human transport (Mack et al. 2000; Reichard and White 2001). Construction equipment and personnel have the potential to introduce weed species to new areas by transporting plant propagules (i.e., seeds and/or vegetative parts) on equipment or clothing. Roads and rail corridors also act as dispersal routes and habitat for weed species establishment (Parendes and Jones 2000). Transportation corridors to and from construction areas provide a means of ingress for weeds through direct dispersion of plant propagules from vehicles and machinery, and indirectly through the formation of suitable sites for weeds in the form of disturbed areas. Many weeds are able to spread more easily in landscapes that have been fragmented and often become established along edge habitats, such as disturbed road edges associated with transportation corridors (Lafortezza et al. 2010).

A total of 20 weed species were observed in the ESA during baseline field programs (Section 13.3.2.4). No prohibited weeds were documented in the ESA in 2013. Thirteen species listed under Schedule II (noxious) and seven species listed under Schedule III (nuisance) of *The Weed Control Act* were observed. Most of these observations were in cultivated land, hayland, and ditches. Weeds generally were observed in higher densities along fence lines, field perimeters, and roadside ditches.

Leafy spurge, a problematic noxious weed species, was observed at three locations, two in hayland, and one in Native Grassland outside of the Project footprint (Section 13.3.2.4). Leafy spurge is especially problematic because it is a long-lived perennial with an extensive and persistent creeping root system from which it can re-sprouts and form dense stands, and also because it is a prolific seed producer. The seed pods burst and can distribute seed as far as 5 m from the parent plant. It drastically reduces the carrying capacity (i.e., maximum stocking rate possible without damaging vegetation) of a pasture in dense infestations. Leafy spurge is very resilient and only a few licensed herbicides applied in a managed way are successful at controlling infestations of this species. Specific management and mitigation often is required to reduce the potential for spread of this species. Special care should be taken when moving in and out of areas with known infestations of this species to prevent its spread into new areas.

Preventing weeds from entering an area is more efficient and cost effective than dealing with their removal once established (Clark 2003; Polster 2005; Carlson and Shepard 2007). To mitigate the transport and introduction of prohibited, noxious, nuisance, and invasive plant species into new areas, construction equipment will be regularly cleaned on site, particularly before moving into natural areas or into and out-of areas with known infestations of weed species. More stringent procurement inspections will be required on equipment coming from outside the region to prevent the introduction or spread of prohibited, noxious and nuisance weeds.

Site-specific pre-disturbance surveys will be completed to delineate known patches of weeds in areas to be disturbed. Any hay or straw used for protective mats or used for erosion control will be inspected for weed species prior to their use or treated to destroy weed propagules. Post-construction monitoring will be completed to evaluate the presence and establishment of new patches of weed species, in particular leafy spurge. If weeds establish because of the Project, in particular those listed in Schedules 1 through 3 of *The Weed Control Act*, Yancoal will develop an appropriate management program as outlined in the Weed Management Plan. Certified and weed-free seed will be used for reclamation activities as outlined in the Reclamation and Closure Plan (Section 4.11, Appendix 4-D).

The construction, operation, and reclamation of the Project also have potential to introduce or spread insects, and diseases, as defined under the *Pest Control Act* (2005). The purpose of the *Pest Control Act* is to control animals, insects, and diseases (e.g., insect pests such as Bertha armyworm [*Mamestra configurata*], and crop diseases such as blackleg [*Leptosphaeria maculans* and/or *L. biglobosa*], and clubroot [*Plasmodiophora brassicae*]) that may be destructive of, or dangerous to, any crop, grain, livestock, or other property. Effects on agronomic species may include a decrease in crop yield and decrease in seed quality, and possibly contributing to disease problems in subsequent years.

To prevent the introduction or spread of crop diseases, vegetation and plant propagules that are infested with a particular crop disease will be destroyed. A review of crop disease extent maps may be required to determine current extent of a particular crop disease and specific mitigation required as determined by source of construction equipment. Mitigation practices such as sanitation of equipment will be used where necessary to control the introduction or spread of crop diseases from the Project. Sanitation practices include three steps. Step one is rough cleaning of soil from equipment (e.g., using an air compressor or wire brush). Step two is fine cleaning using a pressure washer, and step three is disinfecting all openings and wheels with a bleach solution.

The implementation of mitigation will reduce the potential for introduction or spread of prohibited, noxious, nuisance, and invasive weed species and crop disease. The localized introduction or spread of prohibited, noxious, nuisance, and invasive weed species, and crop diseases could result in minor and local changes to abundance and distribution of vegetation relative to Base Case conditions. As such, these pathways were determined to have a negligible residual effect on plant populations and communities.

- **Air and dust emissions and subsequent deposition can cause changes to the chemical properties of soils and vegetation, which can affect the abundance and distribution of plant populations and communities.**

Construction and operation of the Project will generate air emissions such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter with aerodynamic diameter less than 2.5 micrometres (µm) ($PM_{2.5}$), particulate matter with aerodynamic diameter less than 10 µm (PM_{10}), and total suspended particulates (TSP), and KCl. Air emissions such as SO_2 and NO_2 can result from the use of fossil fuels in diesel-fired construction equipment, vehicles, locomotives, and natural gas-fired boilers and dryers, used during the Project. Transportation routes used to access the Project are predicted to be the main source of dust ($PM_{2.5}$, PM_{10}, and TSP) due to the re-suspension of soil particles (Farmer 1993; Harrison et al. 2003; Peachey et al. 2009; Liu et al. 2011).

Air quality modelling was completed to predict the spatial extent of air and dust emissions and deposition from the Project (Section 7.5). Air quality modelling was completed using the maximum emissions profile expected during the operations phase of the Project. The cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are predicted to evaluate changes to measurement indicators for air quality during the Application Case. This provides the maximum potential effects from the Project. Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates.

The deposition of air and dust emissions can lead to changes in soil quality by altering soil pH and nutrient content, and soil fauna composition (Rusek and Marshall 2000; Jung et al. 2011). The changes to soil from atmospheric inputs is determined by complex geochemical factors, which include nutrient uptake by plants, decomposition of vegetation, cation and anion exchange in soil, soil sensitivity to acidification, and duration and quantity of atmospheric inputs (Jung et al. 2011). Changes in soil fauna and soil quality can lead to effects on vegetation, as there could be alterations in rates of organic matter decomposition and nutrient cycling (Rusek and Marshall 2000). Ultimately, the concentration and duration of air and dust emissions and the sensitivity of the ecosystems determine the overall influence that emission deposition will have on vegetation (Bobbink et al. 1998).

Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2)

Deposition of SO_2 and NO_2 can lead to acidification of wetlands, which can cause changes in plant communities (Bobbink et al. 1998). Deposition of SO_2 and NO_2 to vegetation can also have direct effects on plant communities. Changes to soil and vegetation from atmospheric inputs of SO_2 and NO_2 and potential for acidification depend on the buffering capacity of the soil and the vegetation cover present in the receiving environment (Bobbink et al. 1998; Barton et al. 2002).

Results of the air quality modelling indicate that ground-level concentrations of SO_2 and NO_2 are not predicted to exceed Saskatchewan Ambient Air Quality Standards (SAAQS; Government of Saskatchewan 2015) during the Application Case (Section 7.5.2). The results indicate that the Application Case maximum 1-hour, 24-hour, and annual SO_2 and NO_2 predictions outside the core facilities area are below the SAAQS. For example, the maximum 24-hour SO_2 concentration is predicted to be 4.5 micrograms per cubic metre (µg/m^3), which is below the SAAQS of 125 µg/m^3 (Section 7.5.2). The maximum 24-hour NO_2 concentration is predicted to be 49.4 µg/m^3, which is below the SAAQS of 200 µg/m^3 (Section 7.5.2).

Soils within the ESA have a low sensitivity to acidification because of the neutral pH and average CEC of 16 milliequivalents per 100 grams of soil (meq/100 g) (Section 12.3.2.6). No rapid negative changes on well-buffered calcareous soils, such as those found in the ESA, would result from atmospheric inputs of SO_2 and NO_2. Well-buffered calcareous soils would have the capability to accept high amounts of acidic inputs from sources such as acid rain, and the general soil environment, including soil pH, would remain unchanged for a number of years (van Loon 1984). Therefore, no changes to soil quality and vegetation quality from atmospheric inputs of SO_2 and NO_2 are expected.

Particulate Matter ($PM_{2.5}$ and PM_{10}) and Total Suspended Particulates (TSP)

Chemical changes can occur from the deposition of dust, in addition to changes from the deposition of SO_2 and NO_2. Rates of dust deposition and accumulation are dependent on the rate of supply from the source, wind speed, precipitation events, topography, and vegetation cover (Rusek and Marshall 2000; Liu et al. 2011). The indirect responses of vegetation to changes in soil quality depend on the chemical compositions of dust and its source (Grantz et al. 2003). Dust deposition can cause chemical loading in soils and plants, change metal concentrations in plant leaves, and affect soil biota composition if dust emissions include elevated concentrations of metal particles (Grantz et al. 2003; Peachey et al. 2009). Although additions of metals through dust deposition can change vegetation chemistry, Peachy et al. (2009) found that dust deposition did not cause direct toxicity to plants. Total metal concentrations in soils were generally below Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health for Agricultural Land-Use Areas (CCME 2013a), with the exception of selenium at two locations (Section 12.3.2.8). Selenium at these locations exceeded the CCME guideline level of 1 milligram per kilogram (mg/kg) in a sample from the HwAv1 map unit (Hillwash-Alluvium Complex) (1.09 mg/kg) and a sample from the OxHd2 map unit (Oxbow-Hoodoo association) (2.84 mg/kg) (Section 12.3.2.8). However, both sample locations are outside the Project footprint (5 km east and 16 km east-northeast). The two elevated concentrations of selenium identified during the baseline soil survey may possibly be derived from mineral deposits or from the presence of a feed additive, fertilizer, or pesticide associated with agricultural use in the immediate vicinity of the soil survey locations (Section 12.3.2.8; Dunn 1990; CCME 2009).

The maximum predicted 24-hour and annual $PM_{2.5}$ emissions during the Application Case are 19 µg/m³ and 6 µg/m³, respectively, which are below the Canadian Ambient Air Quality Standards (CAAQS) (*CCME* 2013b) of 28 µg/m³ (24-hour) and 10 µg/m³ (annual) (Section 7.5.2). The predicted 24-hour and annual TSP emissions during the Application Case are 53.4 µg/m³ and 20.5 µg/m³, respectively, and are below the SAAQS of 100 µg/m³ (24-hour) and 60 µg/m³ (annual). The maximum 24-hour PM_{10} emissions, during the Application Case, is 53.4 µg/m³, which is above the SAAQS of 50 µg/m³; the maximum concentration occurs east of the mine. However, the background concentration (Base Case) of PM_{10} is 36.3 µg/m³, which represents 72.6% of the ambient air quality standard. This background concentration is from the City of Regina air quality monitoring station; no rural PM_{10} measurements are available from the MOE. The analysis shows that the averaged days during the Application Case only exceed the SAAQS for three days during the modeling years. Using a rural background PM_{10} concentration of 17.9 µg/m³ results in a maximum predicted concentration of 35 µg/m³, which is below the SAAQS. In addition, the actual TSP concentrations for the Project are expected to be lower than predicted because of the conservatism used for the air quality modelling. Minor and local changes are predicted to soil quality and vegetation quality from deposition of $PM_{2.5}$, PM_{10}, and TSP.

Potassium Chloride (KCl)

In addition to metals, dust from the Project can contain KCl. Excessive amounts of KCl can contribute to soil salinization, which can affect vegetation and wildlife habitat. Although excessive amounts of KCl can contribute to soil salinization, it is not the primary salt responsible for soil salinization (Henry et al. 1992). Typically, the soluble salts responsible for salinization include calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), magnesium sulphate ($MgSO_4$), NaCl, and sodium sulphate (Na_2SO_4). When salts accumulate in soils, the salt can result in reduced plant growth, poor germination of plant seeds, and plant death (Richards 1954; MOA 2008). Dissolved salts in the soil result in a decrease in the rate of water uptake by plants. If the soil solution becomes too concentrated, the salts prevent the water and nutrients from entering plants, even if the soil water content and dissolved nutrients in the soil may be sufficient. Salt can increase the soil pH, which can alter the availability of nutrients in soil (Richards 1954; MOA 2008). Salinization of soil with NaCl or KCl can inhibit the net uptake of nitrate causing a nitrogen deficiency in plants (Richards 1954). Reductions in crop growth of sensitive agricultural crops (e.g., peas) can occur at electrical conductivity (EC) levels of 4 to 8 deciSiemens per metre (dS/m) and in tolerant crops (e.g., canola, wheat, barley) at 8 dS/m (Henry et al. 1992). Some salt tolerant plant species, such as alkali grass (*Distichlis spicata*), can tolerate EC up to 24 dS/m (Hardy BBT 1989).

Although excessive amounts of KCl can contribute to the salinization of soil, potassium (K^+) or chloride (Cl^-) are essential for many plant functions (Bolan et al. 2012). Plants require potassium for protein synthesis and for the functioning of plant stomata (i.e., controlling internal water balance) (Armstrong 1998). In addition, potassium functions in other physiological processes, which include photosynthesis and enzyme activation. Chloride is essential for many plant functions, which include acting as a balancing agent for potassium in the proper function of plant stomata, photosynthesis, and cation balance and transport within the plant (Bolan et al. 2012).

The predicted regional peak monthly KCl deposition is predicted to be well below the SAAQS criteria (Section 7.5.2). The potash deposition threshold of 0.15 milligrams per square centimetre (mg/cm²) is to be used either in the form of potassium or chloride (SAAQS 1996). Deposition predictions are 0.001 mg/cm^2 of potassium and 0.001 mg/cm^2 of chloride (0.002 mg/cm^2 KCl). Even if the deposition rates were higher than those predicted, it would be expected that it would have a negligible effect on soils in the ESA as these soils are characterized as having a neutral pH and an average CEC of 16 meq/100 g. This CEC indicates that the soil has a greater capacity to hold cations (K^+), but not anions (Cl^-). Typically, soil bound potassium makes up 98% of the total potassium in soil and only 2% of the total is plant available (Bolan et al. 2012). In addition, chloride is not adsorbed on soil particles at neutral and alkaline pH values and, therefore, is easily leached (Bolan et al. 2012). The soils in the Project footprint are characterized as non-saline. These soils would require an increase in salinity to over 4 dS/m to affect sensitive agricultural crops and over 8 dS/m to affect salt tolerant crops (Henry et al. 1992). No changes are predicted to soil quality and vegetation from deposition of KCl.

Environmental design features will be incorporated into the Project design to limit the changes to the chemical properties of soils and vegetation from air, dust, and KCl emissions and subsequent deposition. Various dust-producing components of the potash refinement process (i.e., dryers or compaction circuit) will have controls to recover and return dust to the circuit. The process plant will use cyclones, baghouses, and wet scrubbers to reduce air and dust emissions so that an acceptable working environment is achieved and government standards are met. The dryer burners will be high efficiency, low nitrogen oxide (NO_x) burners to limit the amount of NO_x present in the exhaust stream. Several vent pick-up inlets will be provided for collecting dust at all critical transfer points and from dryer exhausts. Dust control systems will discharge to proven scrubber systems in areas where product is handled (e.g., product screening, storage, and loadout). Particulate matter in the form of dust will be controlled and all conveyors between buildings will be enclosed. Compliance with regulatory stack emissions and ambient air quality standards will be maintained throughout construction and operation of the Project. Any required or scheduled maintenance of equipment will be performed as needed to meet federal and provincial air emissions standards. The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment. Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. Enforced speed limits will assist in reducing production of dust from roadways. Finally, erosion control practices will be implemented during construction and operation of the Project to limit dust production.

Overall, air and dust emissions and subsequent deposition are expected to result in minor and local changes to the chemical properties of soils and vegetation relative to Base Case conditions. Therefore, this pathway was determined to have a negligible residual effect on plant populations and communities.

- **Dust deposition can cover vegetation and lead to physical damage.**

Accumulation of dust (i.e., $PM_{2.5}$, PM_{10}, and TSP deposition) produced from the Project may result in a local direct change on the quantity, distribution, and quality of vegetation within the ESA. Dust covering vegetation can result in a variety of physiological effects, including reduced water content, chlorophyll content, respiration, reception of radiation or photosynthesis, carbon uptake, and increased conductivity (Spatt and Miller 1981). Larger dust particles can cause visible injuries and abrasions (Farmer 1993; Grantz et al. 2003), while smaller dust particles landing on leaves can affect photosynthesis by blocking sunlight, and reduce respiration and transpiration by clogging stomata (Farmer 1993; Grantz et al. 2003). Dust on vegetation can result in a reduction of plant growth and biomass and may alter species composition (Grantz et al. 2003). Dust containing road salt can result in a build-up of salt on vegetation, which can cause leaf damage (Hofstra and Hall 1971), thus leading to increased risk of plant disease and mortality.

Dust is currently a frequent occurrence in the ESA due to agricultural activities and the existing grid road network. Dust movement and deposition is especially high during the planting and harvesting periods, as more heavy machinery and traffic are using roads and travelling in fields. Fallow fields can also produce a large amount of dust during periods of high winds. Therefore, vegetation in the ESA, particularly plant communities along transportation corridors, has already likely been influenced by long-term dust deposition under Base Case conditions.

Dust from potash mining is primarily associated with the processing plant and transportation routes. The processing plant is one of the main sources of dust, as it is the location of potash drying, screening, and compaction processes. A variety of environmental design features for the Project will be implemented to control dust production from the processing plant and to reduce dust deposition in the surrounding area. The process plant will use cyclones, baghouses, and wet scrubbers to reduce air and dust emissions so that an acceptable working environment is achieved and government standards are met. Vent pick-up inlets will be provided for collecting dust at all critical transfer points and from dryer exhausts. Dust control systems will discharge to proven scrubber systems in areas where product is handled (e.g., product screening, storage, and loadout). Particulate matter in the form of dust will be controlled and all conveyors between buildings will be enclosed.

Transportation routes, particularly unpaved roads that are used to access the Project are another source of dust due to the re-suspension of soil particles (Farmer 1993; Harrison et al. 2003; Peachey et al. 2009). Although dust deposition can have effects on vegetation, the influence is generally localized (Walker and Everett 1987; Watson et al. 2000). Most studies indicate that the majority of dust tends to settle out within 1 km of ground-level sources (Everett 1980; Walker and Everett 1987; Watson et al. 1996; Meininger and Spatt 1988; Grantz et al. 2003). For example, Watson et al. (1996) found that most dust generated from transportation corridors is deposited within 50 m of the source, and concentrations of dust decrease by greater than 90% within that 50 m. Meininger and Spatt (1988) found that most of effects of dust occurred within 5 to 50 m of a road, with less obvious effects observed between 50 m and 500 m from a road. Auerback et al. (1997) found that vegetation biomass and species richness may be lowered in the immediate vicinity of a road corridor, although vegetation cover is maintained.

The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment. Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. Enforced speed limits will assist in reducing production of dust from roadways. Finally, erosion control practices will be implemented during construction and operation of the Project to limit dust production.

Because of the conservatism used for the air quality modelling, it is expected that the actual dust deposition from the Project will be lower than predicted. In addition, because the result represents the emissions during worst-case operations, results are likely overestimated. Dust deposition during the Application Case is expected to result in minor and local changes to vegetation relative to Base Case conditions. Therefore, this pathway was determined to have a negligible residual effect on plant populations and communities.

13.4.2.3 Primary Pathways

The following primary pathways are assessed in detail in the residual effects analysis.

- **Direct loss, alteration, and fragmentation of vegetation from the Project footprint (core facilities area, mining area, and access roads) can cause changes to plant populations and communities.**
- **Residual ground disturbance from portions of the core facilities area can permanently alter the abundance and distribution of plant populations and communities.**
- **Ground subsidence caused by solution mining can change surface flows and drainage patterns (distribution), which can affect the abundance and distribution of plant populations and communities.**

13.5 Residual Effects Analysis

The residual effects analysis is focused on thoroughly evaluating the primary pathways associated with the Project and other developments on the vegetation VC, plant populations and communities. The residual effects assessment is completed by calculating and estimating changes to the measurement indicators of plant populations and communities that are relevant to the primary pathways. These measurement indicators are:

- quantity, arrangement, and connectivity (fragmentation) of plant communities (i.e., abundance and distribution of ELC map units);
- abundance and distribution of habitat for listed plant species; and
- abundance and distribution of habitat for traditional use plant species.

13.5.1 Loss, Alteration, and Fragmentation of Vegetation from the Project

13.5.1.1 Methods

Development of the Project is expected to change the relative abundance and distribution of plant populations and communities. Plant communities that are widely distributed and common (high relative abundance) and have a high diversity are likely to be more resilient to disturbances than those with low abundance, low diversity, and limited distribution. Project changes to the relative abundance and distribution of plant populations and communities generally occur at a local scale. Changes to the abundance and distribution of plant communities and populations were examined at the regional scale so that the assessment provides an ecologically relevant and confident assessment of the direct effects on vegetation from the Project and the cumulative effects from the Project and other previous and existing developments.

Fragmentation refers to the division of a landscape into smaller habitat patches that can be more isolated from each other and is generally thought to have a negative effect on biodiversity (Turner 1996; Swift and Hannon 2010). Fragmentation influences population resilience and species richness by increasing edge effects, and altering the relative abundance of habitat, landscape connectivity, and patch size and distribution (Debinski and Holt 2000; Fahrig 2003; Fletcher et al. 2007).

The changes from loss and fragmentation of plant populations and communities are expressed by changes to ELC map units. Locally, direct loss of ELC map units from the Project can affect biodiversity, including species richness, population abundance, and habitat distribution; however, this is dependent on the Base Case unit. For example, the effects on biodiversity in a highly modified area (e.g., Cultivated) will not change to the same degree as one that is not modified (e.g., Native Grassland) before application of the Project. To understand the range and sustainability of plant populations and communities (including listed and traditional use plants), these environmental changes were examined at a regional scale. Habitat loss includes the direct removal or alteration of a vegetation type (ELC map unit). Habitat loss has negative environmental effects on biodiversity (Fahrig 2003; Fletcher et al. 2007); as specific habitat decreases, species that rely on that habitat also decrease (Andrén 1994).

Within each ELC map unit, listed and unique species were counted as part of assessing biodiversity (Section 13.3.2.2, Table 13.3.2). To support the assessment of effects on changes to plant populations and community distribution, including potential effects on listed plants, and the number and types of listed and unique species documented within the ESA during the baseline studies is considered.

The area of ELC units and the direct loss of units caused by the Project footprint and previous and existing developments were quantified in a GIS platform to predict changes of ELC map units within the ESA. This was completed by determining a summary of areas for each ELC unit within the ESA for the Base Case and Application Case. Landscape metrics such as number of patches, mean patch areas, and mean distance to nearest neighbour (MDNN) were determined for the Base Case and Application Case in the ESA. These landscape metrics were calculated using the program FRAGSTATS (Version 4.0; McGarigal et al. 2012) in a GIS platform. The FRAGSTATS analysis determined the extent of landscape fragmentation by calculating statistical outputs based on the values of each raster cell of the ELC data. The MDNN is calculated as the shortest straight-line Euclidean distance between the centroids of the closest cells of equivalent habitat patches (McGarigal et al. 2012). The Base Case includes all previous and existing developments as described in Section 13.3.

Changes to plant populations and communities (including listed and traditional use plants) were assessed for the maximum predicted point of development of the Project footprint (Application Case), which should have the largest geographic extent of effects on self-sustaining and ecologically effective plant populations and communities. Progressive reclamation is expected to occur during operations to limit incremental losses and effects beyond the Application Case.

For the analysis, the proposed core facilities area was buffered by 100 m, the plant site access road buffered by 50 m (100-m right-of-way), the well pads buffered by 50 m, and the well pad access roads buffered by 25 m (50-m right-of-way) so that a maximum possible extent of disturbance is used in the analysis. Most of the Project infrastructure will be removed and the area will be reclaimed during decommissioning and reclamation. The tailings management area (TMA) (i.e., salt storage areas, brine reclaim ponds, and sewage lagoon), the crystallization pond, and site runoff collection pond are considered permanent. The footprint was buffered so that the effects analysis results represent a conservative estimate of residual effects on vegetation (i.e., effects are likely overestimated).

The residual effects on vegetation are assessed using predicted changes to ELC map units (i.e., loss), habitat fragmentation, listed plant species habitat potential, and traditional use plant habitat potential. The incremental and cumulative changes from the Project and other developments on vegetation were estimated by calculating the relative difference or net change in the map unit between the Application Case and Base Case as follows:

(Application Case value - Base Case value) / Base Case value

Each resulting value was then multiplied by 100 to give the percent change in a landscape metric for each comparison, providing both direction and magnitude of the effect. For example, a high negative value for an ELC area would indicate a substantial loss of that ELC map unit.

13.5.1.2 Results

13.5.1.2.1 Changes in the Quantity, Arrangement, and Connectivity of Plant Communities

The dominant ELC map unit within the ESA is Cultivated and accounts for approximately 58.3% (46,834 ha) of the ESA under Base Case conditions. The Modified Grassland unit, which includes both hayland and modified prairie, covers 15.8% of the ESA, Native Grassland covers 8%, and Wooded covers 3.4%. Wetlands (Class I, II, III, IV, and V) cover approximately 13% of the ESA under Base Case conditions. The Existing Disturbance map unit (e.g., roads and communities) accounts for approximately 1% (1,141 ha) of the ESA under the Base Case.

The specific amount of natural area (native grassland, wooded areas, and wetlands) that have been removed by agricultural and development activities in the ESA cannot be determined because a landscape classification of the ESA under conditions with no development (reference condition) is not available. However, Saskatchewan census data has been collected since the early 1900s. Although the modern Saskatchewan boundaries were not defined until 1905, the 1906 census is the first and most complete data for the province. All available information was reviewed to understand the changes that have occurred on the landscape prior to development represented in the Base Case.

In 1886, there were less than 1,500 farms and approximately 28,000 cultivated ha in Saskatchewan (CPRC 2006) representing less than 1% of the entire area containing arable land. A review of 1906 census data indicated that in 1900, there were approximately 265,000 ha in cultivation. By 1906, approximately 1,335,462 ha were cultivated (4% of the entire area that can support cultivation). A consistent increase in area converted to agriculture occurred, and by 1931 approximately 13,576,794 ha were under cultivation. This represents 60% of the entire area that can support agriculture. By 1961, 17,449,160 ha were under cultivation, representing 67% of the entire area that can support agriculture. By 1986, 75% of the entire area that can support agriculture was under cultivation.

Currently, approximately 80% of native grassland is estimated to have been lost in the Prairie Ecozone in Saskatchewan, with some local areas of prime cropland recording losses of up to 98% (Hammermeister et al. 2001; Gauthier and Wiken 2003). Approximately 40% of prairie wetlands have been removed by drainage activities in the last 100 years (Cortus et al. 2010). Conversely, wooded areas appear to have increased in Saskatchewan since the 1900s, in particular along the woodland-grassland ecotone, which is likely in part, a result of the suppression of fire disturbances (Archibold and Wilson 1980).

Cultivated, modified grassland and existing disturbances cover 75.5% of the ESA under the Base Case. As such, 75.5% of native grassland, wooded, and wetland vegetation types that were in the ESA prior to human settlement are estimated to have been altered or removed by previous and existing human developments and agricultural activities. The maximum (conservative) area of ELC map units to be disturbed by the application of the Project is 1,550 ha. The land cover type that will experience the greatest change from the Project is the Cultivated (1,216 ha) map unit (Table 13.5-1; Figure 13.5-1). The Project is predicted to remove 87 ha of Class I and Class II Wetland, 77 ha of Modified Grassland, 69 ha of Class IV Wetland, 20 ha of Native Grassland and 14 ha of the Wooded ELC units. Overall, the cumulative reduction in natural habitat through application of the Project and previous and existing developments is approximately 75.8% of the ESA, an incremental change of 0.3% from the Project.

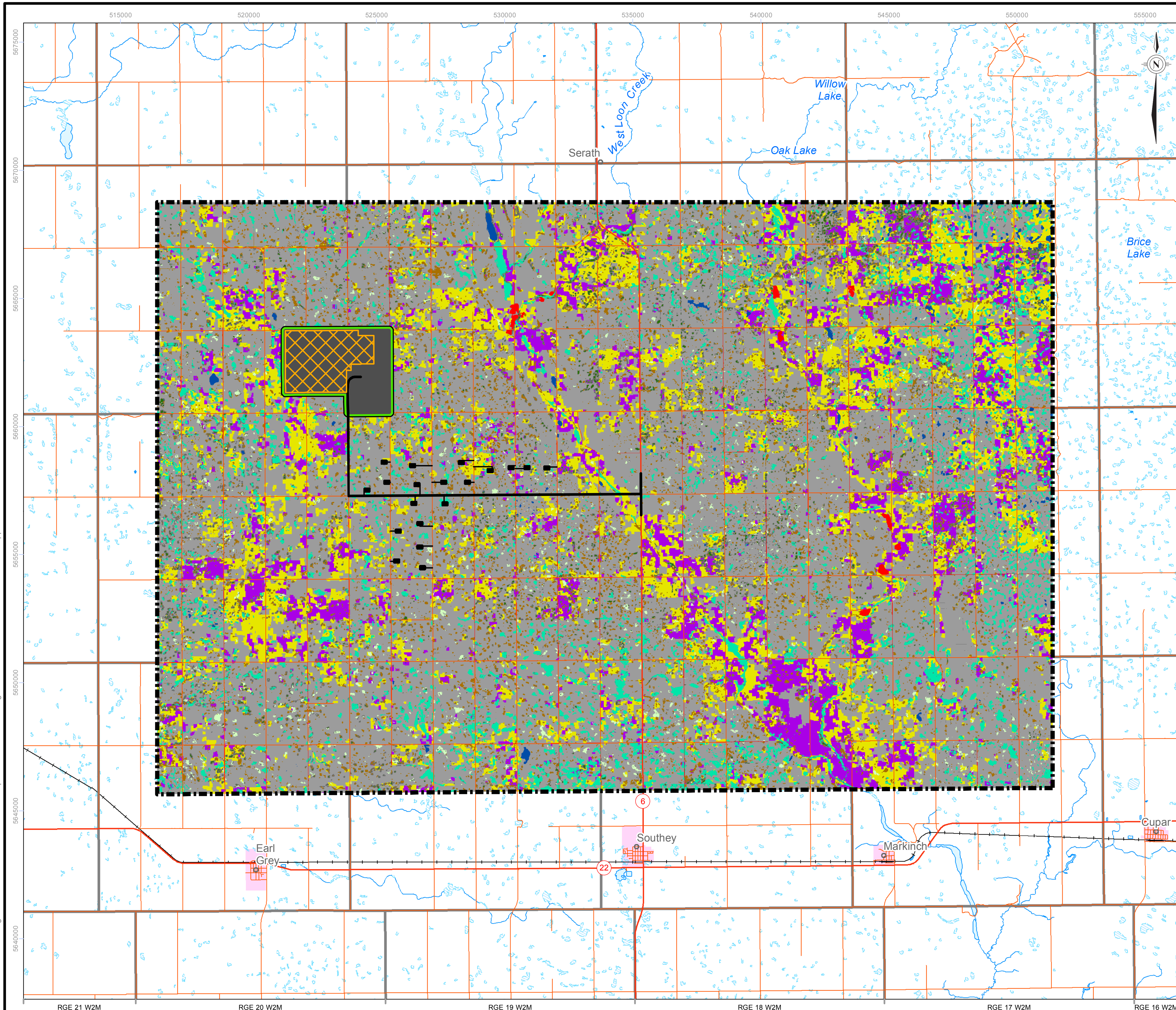
The Native Grassland map unit is not abundant within the ESA (8% of the ESA), which translates into approximately 0.3% of its current abundance within the ESA being disturbed (Table 13.5-1; Figure 13.5-1). Similar to the Native Grassland ELC map unit, Wooded and Wetland units are also not abundant (6.6% or less of the ESA). Approximately 0.5% of the Wooded ELC unit will be disturbed by the Project. Approximately 2.2% or less of the Wetland units within the ESA will be disturbed by the Project. Native Grassland and Wooded map units were among those map units that contained the highest numbers of unique species (Section 13.3.2.2; Table 13.3-2). The Native Grassland map unit was documented to contain 48 plant species that are unique to this map unit and Wooded was documented to contain 28 unique species. In addition, Native Grassland units contained the most listed plant species observations (5 species; Table 13.3-2).

Following decommissioning and reclamation, approximately 842 ha (54% of the footprint) will be reclaimed (Table 13.5-1; Figure 13.5-2). Reclamation will be carried out as outlined in the Conceptual Reclamation Plan (Section 4.11, Appendix 4-D); however, the type of vegetation in reclaimed areas is unknown at this time. Therefore, reclaimed areas have not been assigned a specific ELC type.

Table 13.5-1: Change in Area of Ecological Landscape Classification Map Units from Development within the Effects Study Area

Ecological Landscape Classification Map Units	Base Case (ha)	Application Case (ha)	Percent Change Base Case to Application Case (% unit)	Application Case Post-Closure
Cultivated	46,834	45,618	-2.6	45,618
Modified Grassland	12,723	12,646	-0.6	12,646
Native Grassland	6,432	6,413	-0.3	6,413
Wooded	2,717	2,703	-0.5	2,703
Class I and Class II Wetland	3,963	3,876	-2.2	3,876
Class III Wetland	936	924	-1.3	924
Class IV Wetland	5,321	5,252	-1.3	5,252
Class V Wetland	316	312	-1.2	312
Dugout	2	2	0	2
Existing Disturbance	1,141	1,091	-4.4	1,091
Project Footprint	0	1,550	n/a	0
Reclaimed	0	0	0	842
Residual Disturbance	0	0	0	708
Total	**80,385**	**80,385**	**n/a**	**80,385**

Notes: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values
A value <0.1 or <-0.1 approaches zero.
Negative numbers indicate a reduction in that ELC map unit. Positive numbers indicate an increase in that ELC map unit.
ha = hectare; % = percent; < = less than.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

ECOLOGICAL LANDSCAPE CLASSIFICATION MAP UNITS

- CULTIVATED
- MODIFIED GRASSLAND
- NATIVE GRASSLAND
- WOODED
- CLASS I AND CLASS II WETLAND
- CLASS III WETLAND
- CLASS IV WETLAND
- CLASS V WETLAND
- DUGOUT
- EXISTING DISTURBANCE

PROPOSED PROJECT FOOTPRINT

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD
- TAILINGS MANAGEMENT AREA AND CRYSTALLIZATION POND

REFERENCE

ELC DERIVED FROM LANDSAT 5, WORLDVIEW 2, AND GEOEYE IMAGERY
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
ECOLOGICAL LANDSCAPE CLASSIFICATION MAP UNIT DISTRIBUTION FOR THE APPLICATION CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	JF	18/02/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	FIGURE: 13.5-1	
CHECK	JLF	25/05/15		
REVIEW	BC	25/05/15		

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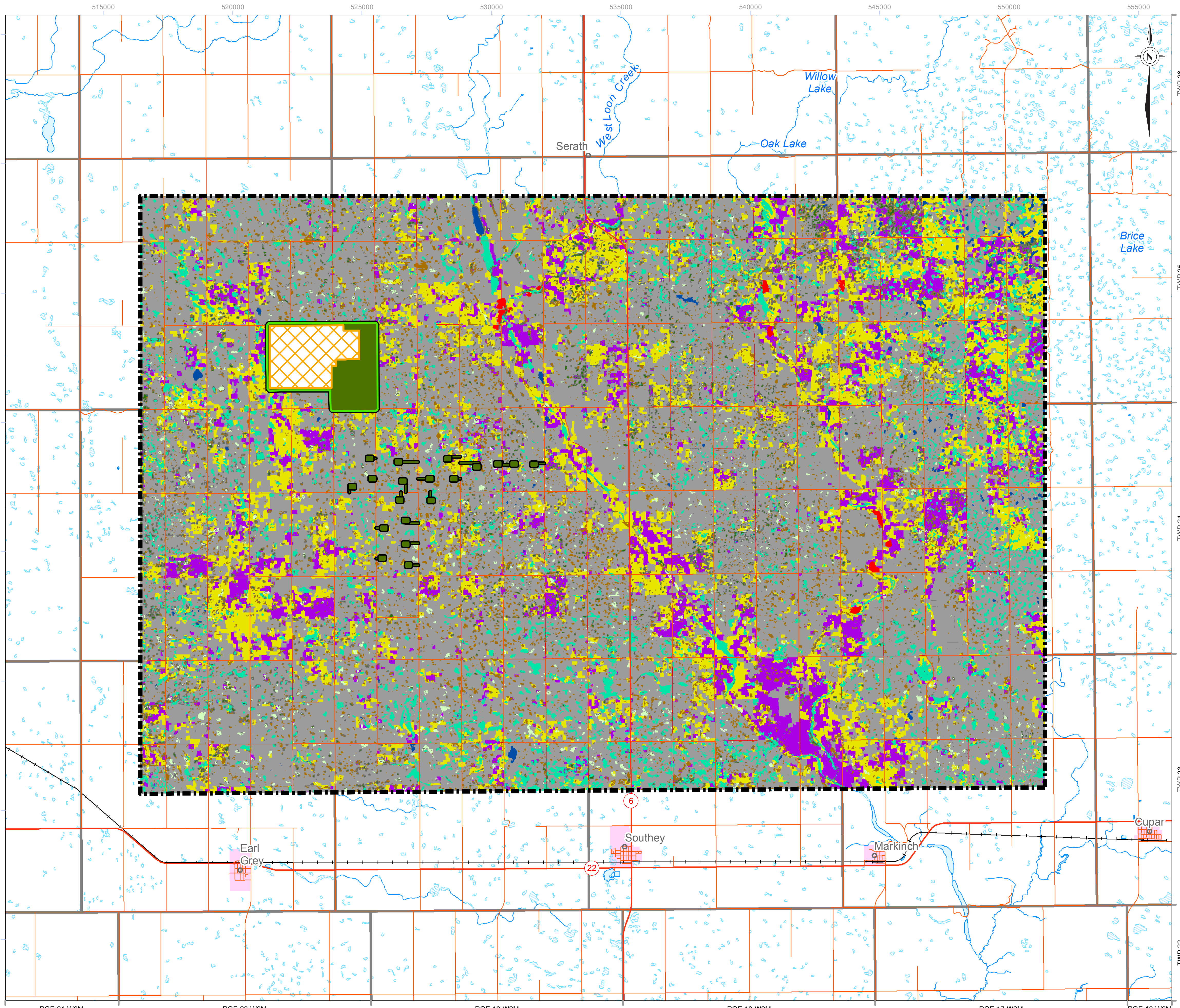

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LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

ECOLOGICAL LANDSCAPE CLASSIFICATION MAP UNITS

- CULTIVATED
- MODIFIED GRASSLAND
- NATIVE GRASSLAND
- WOODED
- CLASS I AND CLASS II WETLAND
- CLASS III WETLAND
- CLASS IV WETLAND
- CLASS V WETLAND
- DUGOUT
- EXISTING DISTURBANCE

RECLAIMED AREAS

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD

NOT RECLAIMED RESIDUAL DISTURBANCE

- TAILINGS MANAGEMENT AREA AND CRYSTALLIZATION POND

REFERENCE

ELC DERIVED FROM LANDSAT 5, WORLDVIEW 2, AND GEOEYE IMAGERY
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT

YANCOAL
SOUTHEY PROJECT

TITLE

ECOLOGICAL LANDSCAPE CLASSIFICATION MAP UNIT DISTRIBUTION FOR THE APPLICATION CASE - POST CLOSURE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	JF	18/03/15	SCALE AS SHOWN	REV. 0
GIS	ANK	25/05/15	FIGURE: 13.5-2	
CHECK	JLF	25/05/15		
REVIEW	BC	25/05/15		

The area of residual disturbance is predicted to be approximately 708 ha (46% of the footprint) as these areas will not be reclaimed following closure. The area of residual disturbance includes 600 ha of the Cultivated ELC map unit, 49 ha of Class I and II Wetland, 8 ha of Modified Grassland and 2 ha of Native Grassland (Table 13.5-2).

Table 13.5-2: Area of Ecological Landscape Classification Map Units that will be Permanently Removed by Residual Disturbance

Ecological Landscape Classification Map Units	Area (ha)
Cultivated	600
Modified Grassland	8
Native Grassland	2
Wooded	5
Class I and Class II Wetland	49
Class III Wetland	6
Class IV Wetland	30
Class V Wetland	3
Existing Disturbance	6
Total	**708**

Note: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
ha = hectare.

In addition to direct loss of vegetation, the Project will result in the fragmentation of the existing landscape. With the application of the Project, the number of patches of natural vegetation types is expected to decrease from 38,653 in the Base Case to 38,178 during the Application Case (loss of 475 patches or 1.2%) (Table 13.5-3). The largest changes in patch number from application of the Project are in the Class I and Class II Wetland unit (loss of 300 patches) (Table 13.5-3). The mean patch size under the Base Case is 0.2 ha, and is predicted to decrease slightly (less than 0.1 ha) with application of the Project. Many of the Class I Wetlands in the ESA are tilled under current land uses (Annex IV, Section 4.3.1.2). Non-tilled Class I Wetlands in the ESA were dominated by graminoids and weed species. Class II Wetlands in the ESA were dominated by graminoids.

A loss of 89 patches of the Wooded ELC unit and a loss of 60 patches of Class III and Class IV Wetlands is predicted during the Application Case (Table 13.5-3). Wooded areas in the ESA were observed mostly in association with low-lying areas, around yard sites, in tree rows, and surrounding Class III and Class IV wetlands (Annex IV, Section 4.3.1.2). The mean patch size of Wooded, Class III and Class IV Wetland units is 0.4 ha, 0.5 ha, and 1.2 ha, respectively, and mean patch size is predicted to decrease slightly (less than 0.1 ha) with application of the Project.

A loss of 19 patches of Native Grassland units is predicted under the Application Case. The mean patch size during the Base Case is approximately 1.9 ha, and is predicted to increase slightly (less than 0.1 ha) with application of the Project. This slight increase in mean patch size is related to the removal of 3 small patches (all 0.6 ha and smaller) associated with the location of the TMA.

Table 13.5-3: Change in Patch Number and Patch Size of Ecological Landscape Classification Map Units from Development within the Effects Study Area

Ecological Landscape Classification Map Units	Number of Patches		
	Base Case (ha)	Application Case (ha)	Percent Change Base Case to Application Case (% unit)
Cultivated	4,992	4,944	-1.0
Modified Grassland	7,053	7,027	-0.4
Native Grassland	3,371	3,352	-0.6
Wooded	12,019	11,930	-0.7
Class I and Class II Wetland	16,115	15,815	-1.9
Class III Wetland	2,053	2,041	-0.6
Class IV Wetland	4,581	4,533	-1.0
Class V Wetland	489	482	-1.4
Dugout	25	25	0
Ecological Landscape Classification Map Units	**Mean Patch Size**		
	Base Case (ha)	**Application Case (ha)**	**Percent Change Base Case to Application Case (% unit)**
Cultivated	9.39	9.23	-1.6
Modified Grassland	1.80	1.80	-0.2
Native Grassland	1.91	1.91	0.3
Wooded	0.38	0.38	0.1
Class I and Class II Wetland	0.25	0.25	-0.3
Class III Wetland	0.46	0.45	-0.7
Class IV Wetland	1.16	1.16	-0.2
Class V Wetland	0.65	0.65	0.2
Dugout	0.08	0.08	0

Note: <0.1 or <-0.1 implies value approaches zero.
Negative numbers indicate a reduction in the patch metric. Positive numbers indicate an increase in that in the patch metric.
ha = hectares; % = percent; < = less than.

The MDNN for Native Grassland, Wooded, Class III Wetland, and Class IV Wetland are expected to decrease by less than 1 m relative to Base Case conditions (Table 13.5-4). The MDNN for Class V Wetlands is predicted to decrease by 2.5 m relative to Base Case. The MDNN for the remaining map units is expected to increase by less than 1 m relative to Base Case conditions.

Most of the plant communities (ELC map units) expected to be affected by the Project are widely distributed in the ESA. Those ELC map units that are not abundant within the ESA at Base Case including Native Grassland, Wooded, and Wetland units are present elsewhere within the ESA (Figure 13.5-1). For example, larger areas of native grassland are present outside of the Project footprint. Some of this native grassland is associated with the valleys of West Loon Creek and large areas at the northeast and southeast sides of the ESA. These grasslands were in relatively good condition and were dominated with native grassland species; however some of the areas associated with valleys of West Loon Creek and the large area at the northeast side of the ESA contained Kentucky bluegrass (15% to 20% cover). The loss and fragmentation of these vegetation types can increase the isolation of individual plant species or populations within these map units; individual plant species will respond differently to loss or fragmentation effects. The application of mitigation for the Project will follow the mitigation hierarchy outlined in MOE (2014) (i.e., the preferred mitigation is to avoid wetlands). Well pad locations will be moved to avoid wetlands. Avoidance of wetlands will reduce the contribution to cumulative effects from the Project.

Table 13.5-4: Change in Mean Distance to Nearest Neighbour of Ecological Landscape Classification Map Units from Development within the Effects Study Area

Ecological Landscape Classification Map Units	Base Case (m)	Application Case (m)	Percent Change Base Case to Application Case (% unit)
Cultivated	25.8	25.9	0.6
Modified Grassland	30.4	30.3	-0.3
Native Grassland	50.7	50.6	-0.2
Wooded	419.2	418.9	<-0.1
Class I and Class II Wetland	55.1	55.2	0.3
Class III Wetland	182.9	182.0	-0.5
Class IV Wetland	75.5	75.4	-0.1
Class V Wetland	397.6	395.1	-0.6
Dugout	2,143.0	2,143.0	0

Note: <0.1 or <-0.1 implies value approaches zero.
Negative numbers indicate a reduction in mean distance to nearest neighbour (MDNN). Positive numbers indicate an increase in MDNN.
ha = hectare; % = percent.

13.5.1.2.2 Changes to Listed Plant Species and Habitat for Listed Plant Species

Listed plant species are considered rare, either federally or provincially, because of restricted spatial, ecological, and/or temporal distributions in variable or diverse environments (Harper 1981). Plants can be rare for many reasons; preferred habitat can be uncommon, the location could be near the edge of that species' range, biological characteristics, and exists in low numbers or in very restricted areas (Drury 1974; Rabinowitz 1981). By definition, a rare plant has restricted spatial, ecological, and/or temporal distributions and occurs more commonly within variable or diverse environments (Harper 1981). Plant rarity is generally determined by three factors including geographic range, habitat specificity, and local population size (Given 1994). Rare plants are important to humans and ecosystems because they are an irreplaceable part of our natural heritage, can have scientific value (e.g., medicinal uses), contribute to the full diversity of life on Earth, can be indicators of good stewardship and ecosystem health, and contribute to the aesthetics of the natural landscape (Neely et al. 2009).

Four provincial listed forbs and one listed graminoid species were documented in the ESA during the 2013 field programs including low milk vetch (*Astragalus lotiflorus*; S3), tall beggarticks (*Bidens frondosa*; S2S3), Macoun's cryptanthe (*Cryptantha macounii*; S1), beaked annual skeletonweed (*Shinnersoseris rostrata* [syn. *Lygodesmia rostrata*]; S2), and big bluestem (*Andropogon gerardii*; S4) (Section 13.3.2.3). Within the ESA, these observations were in Native Grassland, Modified Prairie, and Class II, III, and IV Wetlands, and riparian areas.

A status of S1 refers to a species that is extremely rare, with five or fewer known occurrences in Saskatchewan (SKCDC 2014d). A status of S2 refers to a species that is rare, with 6 to 20 occurrences in Saskatchewan with few remaining individuals. A status of S3 refers to a species that is rare to uncommon, with 21 to 100 occurrences in Saskatchewan; they may be locally abundant. Although big bluestem is provincially listed as S4 (i.e., common [more than 100 occurrences in Saskatchewan, generally widespread and abundant, may be rare in part of its range]), big bluestem remains on the tracking list because it is a host plant for the Dakota Skipper (SKCDC 2014d).

One location of tall beggarticks identified during the 2013 field survey is within areas expected to be disturbed by the Project (Figure 13.5-3). This location was documented to contain a patch with several hundred individuals spread around the margin of a Class III wetland in a ditch. This location is within the area of residual disturbance (Figure 13.5-4). The following mitigation will be used to reduce effects on known locations containing listed plant species.

- The Project will avoid listed plants as much as possible; however, if avoidance of listed plants is not possible, consultation with MOE will be completed to determine the significance of the area and identify feasible mitigation strategies.
- If a listed plant species is encountered that was not expected, appropriate mitigation will be applied prior to further construction activities.

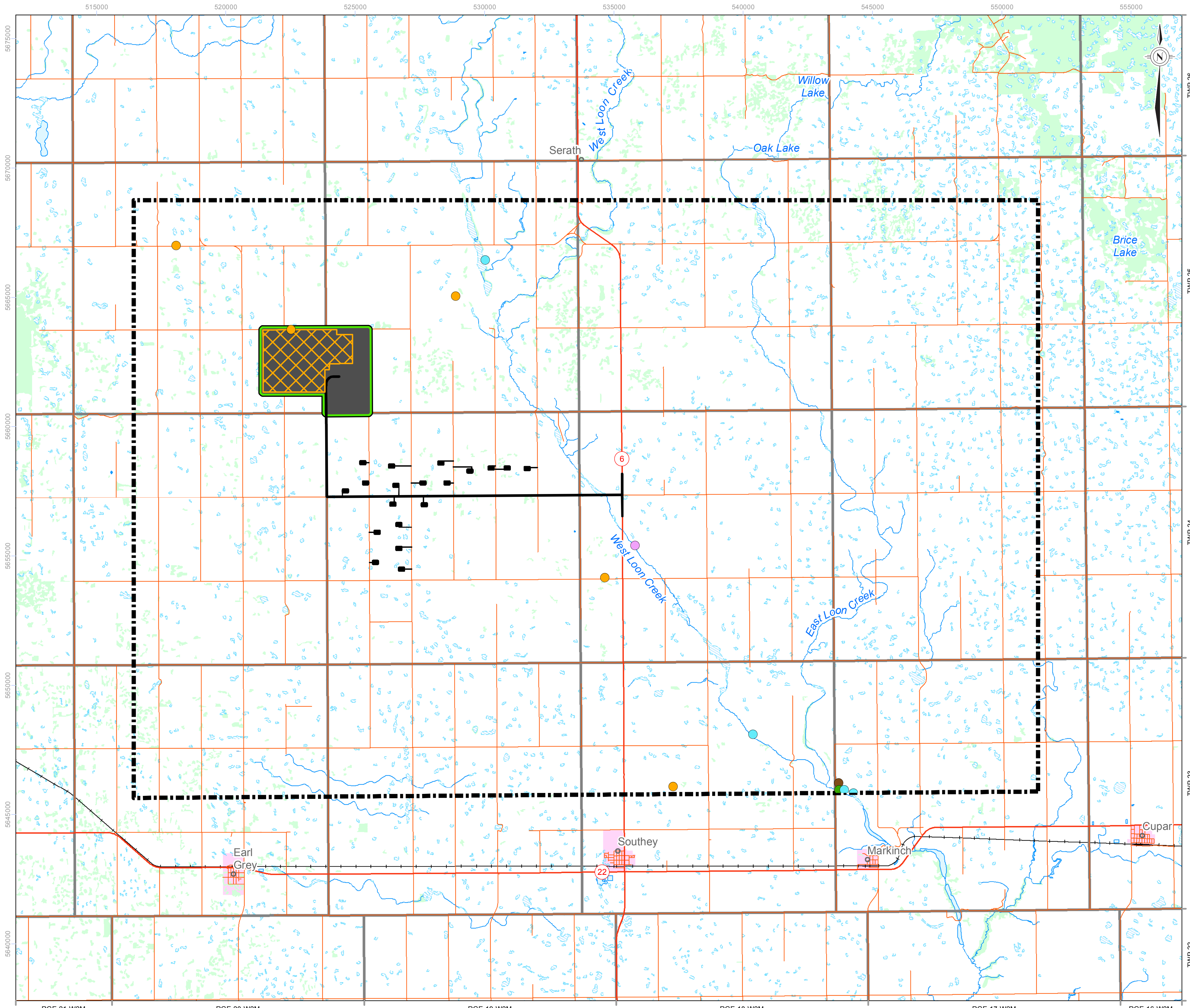
Because field surveys cannot confirm the absence of listed plants and can only confirm their presence, potential exists for other listed species to be present in areas that may be disturbed by the Project. Therefore, the ELC map unit rankings for potential of ELC map units to support listed plant species were used in the analysis (listed plant habitat potential; Section 13.3.2.3). A total of 119 ha of ELC units with high listed plant habitat potential will be disturbed during construction, resulting in a decrease of 0.8% relative to Base Case conditions (Table 13.5-5). Habitat units with moderate/high listed plant habitat potential will decrease by approximately 87 ha (2.2%). The Native Grassland, Class IV Wetland, and Wooded units comprise the majority of the high potential habitat. Approximately 20 ha of Native Grassland are predicted to be removed by the Project, as well as approximately 69 ha of Class IV Wetland and 14 ha of Wooded.

Following decommissioning and reclamation, approximately 842 ha will be reclaimed (Table 13.5-5). The area of residual disturbance includes 45 ha of high listed plant habitat potential units, 49 ha of moderate/high potential, 8 ha of low/moderate potential, and 606 ha of low potential units.

Table 13.5-5: Change in Area of Listed Plant Habitat Potential from Development of the Project within the Effects Study Area

Listed Plant Habitat Potential	Base Case (ha)	Application Case (ha)	Percent Change Base Case to Application Case (% unit)	Application Case Post-Closure
High	15,722	15,603	-0.8	15,603
Moderate/High	3,963	3,876	-2.2	3,876
Low/Moderate	12,723	12,646	-0.6	12,646
Low	47,976	46,710	-2.6	46,710
Project Footprint	0	1,550	n/a	0
Reclaimed	0	0	n/a	842
Not reclaimed	0	0	n/a	708
Total	**80,385**	**80,385**	**n/a**	**80,385**

Note: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
<0.1 or <-0.1 implies value approaches zero
Negative numbers indicate a reduction in that habitat potential. Positive numbers indicate an increase in that habitat potential.
ha = hectare; % = percent; < = less than.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- WOODED AREA
- EFFECTS STUDY AREA

LISTED PLANT OCCURRENCE (2013)

- MACOUN'S CRYPTANTHE
- BEAKED ANNUAL SKELETONWEED
- BIG BLUESTEM
- LOW MILK VETCH
- TALL BEGGARTICKS

PROPOSED PROJECT FOOTPRINT

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD
- TAILINGS MANAGEMENT AREA AND CRYSTALLIZATION POND

REFERENCE

INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

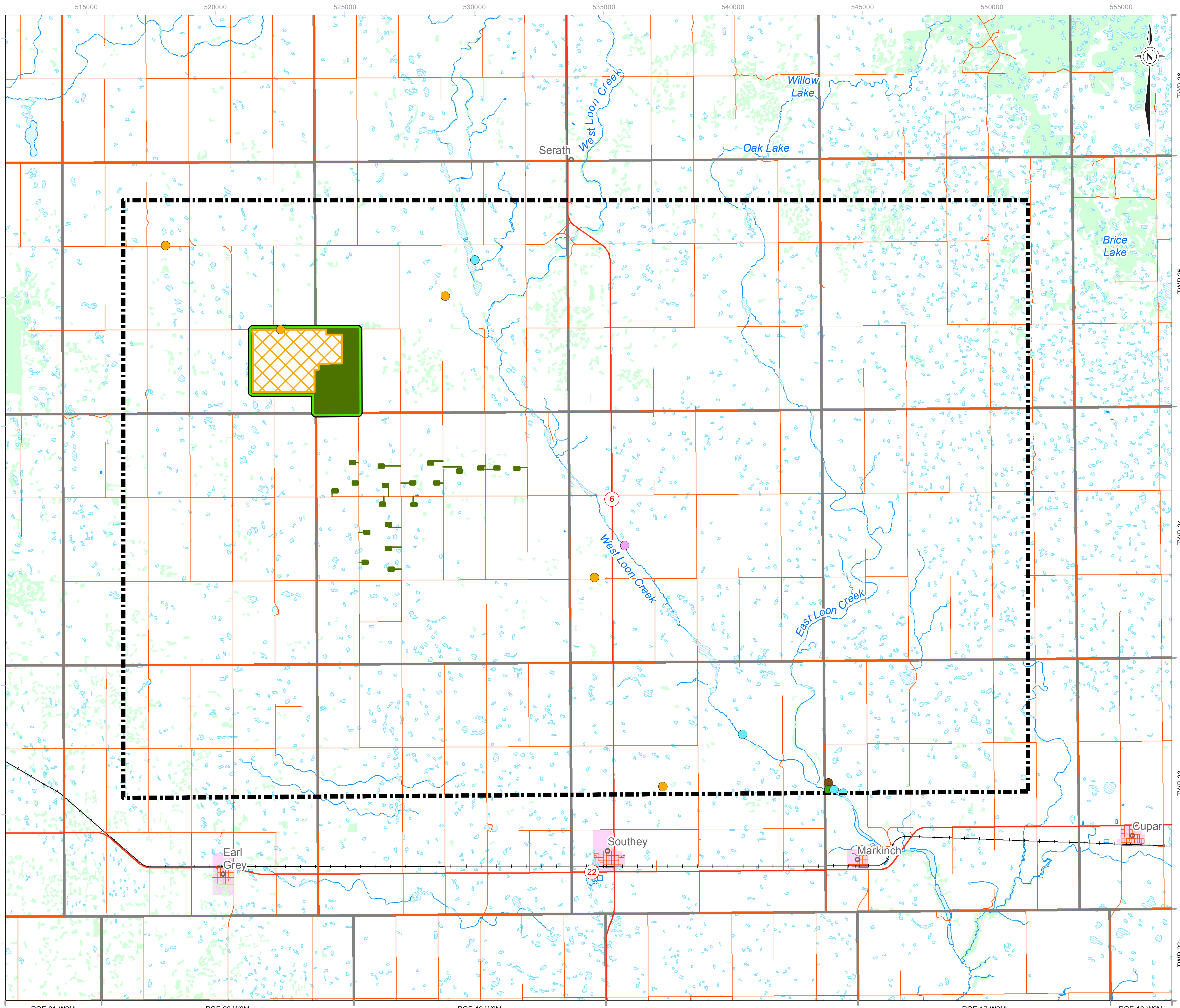
PROJECT
YANCOAL
兖煤加拿大资源有限公司
YANCOAL SOUTHEY PROJECT

TITLE
LOCATIONS OF LISTED PLANT SPECIES OBSERVATIONS FOR THE APPLICATION CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	JF	04/02/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	FIGURE: 13.5-3	
CHECK	JLF	25/05/15		
REVIEW	BC	25/05/15		

G:\CLIENTS\YANCOAL\Figures\12-1362-0197\WP025 - EIS Preparation\Task 1210 - Vegetation\12-1362-0197 - Listed Plant Occurrences ESA - Application.mxd Date: 6/2/2015 11:38:58 AM



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- WOODED AREA
- EFFECTS STUDY AREA

LISTED PLANT OCCURRENCE (2013)

- MACOUN'S CRYPTANTHE
- BEAKED ANNUAL SKELETONWEED
- BIG BLUESTEM
- LOW MILK VETCH
- TALL BEGGARTICKS

RECLAIMED AREAS

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD

NOT RECLAIMED RESIDUAL DISTURBANCE

- TAILINGS MANAGEMENT AREA AND CRYSTALLIZATION POND

REFERENCE

INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
SOUTHEY PROJECT

TITLE
LOCATIONS OF LISTED PLANT SPECIES OBSERVATIONS FOR THE APPLICATION CASE - POST CLOSURE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	JF	18/03/15	SCALE AS SHOWN	REV. 0
GIS	ANK	25/05/15	FIGURE: 13.5-4	
CHECK	JLF	25/05/15		
REVIEW	BC	25/05/15		

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13.5.1.2.3 Changes to Habitat for Traditional Use Plant Species

A total of 31 traditional use plant species were identified during the 2014 traditional plant use interviews as being used in the early 1900s and 18 of these species are known to occur within the ESA (Section 13.3.2.5). Many of these plants were historically used for medicine or food.

Those ELC map units predicted to contain the highest number of traditional use species are Native Grassland, Class IV Wetland, and Wooded. A total of 107 ha of ELC units with high traditional use plant habitat potential will be disturbed by the Project, resulting in a decrease of 0.7% relative to Base Case conditions (Table 13.5-6). Habitat units with moderate potential will decrease by approximately 12 ha (1.3%).

Following Project decommissioning and reclamation, approximately 842 ha will be reclaimed (Table 13.5-6). The area of residual disturbance includes 40 ha of high traditional use plant habitat potential units, 6 ha of moderate potential, 56 ha of low/moderate and 606 ha of low potential units.

Table 13.5-6: Change in Area of Traditional Use Plant Habitat Potential from Development of the Project

Traditional Use Plant Potential	Base Case (ha)	Application Case (ha)	Percent Change Base Case to Application Case (% unit)	Application Case Post-Closure
High	14,786	14,679	-0.7	14,679
Moderate	936	924	-1.3	924
Low/Moderate	16,687	16,522	-1.0	16,522
Low	47,976	46,710	-2.6	46,710
Project Footprint	0	1,550	n/a	0
Reclaimed	0	0	0	842
Not reclaimed	0	0	0	708
Total	**80,385**	**80,385**	**n/a**	**80,385**

Note: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
<0.1 or <-0.1 implies value approaches zero
Negative numbers indicate a reduction in that habitat potential. Positive numbers indicate an increase in habitat potential.
ha = hectare; % = percent; < = less than; n/a = not applicable.

13.5.2 Changes to Vegetation from Subsidence

13.5.2.1 Methods

Ground subsidence will develop over mined caverns within the mining area, and is expected to begin while mining is occurring and will continue through post-mining. Subsidence is expected to alter local flows, drainage patterns, and the spatial distribution of surface water within the mining boundary (Section 9.5.1). These changes to surface water can change soil quality, which can affect the abundance and distribution of upland and wetland vegetation. Decreases in slope gradients may cause areas to accumulate more snowmelt runoff and rainfall, thereby increasing soil moisture and creating wetland habitat. Alternatively, existing wetlands may drain and become upland habitats in areas where slope gradients increase. Ground subsidence may change the flow rates of existing streams, which may change soil erosion and alter vegetation.

Changes to surface water flow and terrain slopes were estimated using multiple techniques. The Light Detection and Ranging (LiDAR) topographic data was used to create a digital elevation model (DEM) and determine current terrain conditions within the mining boundary. Field studies were completed in 2013 to determine baseline conditions for soils, vegetation, and wetlands. The subsidence settlement calculation was based partially on the 65-year mine area, which is contained within the ESA. For post-subsidence topographic conditions, the LiDAR data was modified by lowering the topography and the modified DEM was then used in the hydrological analysis. Changes from ground subsidence in surface hydrology features including drainage area, flow pathways (i.e., watercourses), and wetlands were calculated using computer modeling based on current conditions and the changes resulting from the predicted ultimate subsidence (Appendix 9-A). The subsidence assessment was based on the potential maximum subsidence expected once mining is completed, after each individual cavern has completely closed, and the insoluble materials within the cavern have consolidated to intact rock salt (Appendix 9-A).

13.5.2.2 Results

Solution mining and related removal of solid, liquid, and gaseous materials from below the ground surface results in ground subsidence. Changes from subsidence will result in topographic changes in areas overlying the mine development caverns and adjacent areas. The maximum settlement is predicted to occur on the area directly overlying the caverns and the topographic surface is predicted to subside relatively uniformly over the 65-year mine area. The changes in topography (slope, gradient) can alter drainage areas, flow pathways (i.e., watercourses), and wetlands, and subsequently affect vegetation.

Within the ESA, the maximum amount of subsidence is predicted to occur in the western section of the 65-year mine field (Appendix 9-A). More subsidence is predicted to occur directly overlying the mine development caverns and decrease with distance away from the cavern locations. Subsidence is a slow process occurring during the Project, with ultimate (maximum) subsidence requiring several hundred years.

The area affected by surface subsidence would extend over a distance of approximately 17 km from west to east and approximately 8 km from north to south (Appendix 9-A). The maximum vertical displacement is estimated to be approximately 6.7 m. The final gradient of surface subsidence at the boundary of the 65-year mine field will be gradual, where the average gradient from unaffected areas to the area of maximum subsidence is predicted to be 3.9 metres per kilometre (m/km). In areas of steeper subsidence gradients, settlement is predicted to increase from 0.5 m to 6.7 m over a distance of approximately 1.6 km, with maximum gradients of 5.0 metres per kilometre (m/km).

Alteration of surface topography associated with subsidence is predicted to result in small, localized changes to flow pathways and drainage areas within the West Loon Creek basin in the ESA (Appendix 9-A). That is, all tributary watercourses affected by subsidence flow into West Loon Creek. Changes to flow pathways are mainly predicted along the north and west edges of the mine well field area. The volume of flows along major flow paths (i.e., the West Loon Creek) are predicted to be maintained, although localized alterations of flow pathways are predicted to occur and ponded sections may appear. Alterations of smaller drainage area boundaries in the central section of the mine well field area are predicted; however, drainage is predicted to continue to direct runoff to West Loon Creek.

Subsidence is predicted to alter stream channel slopes of the three main watercourses in the ESA including West Loon Creek, a tributary of West Loon Creek from the east, and the intermittent stream that occasionally contributes runoff to West Loon Creek from the west (Appendix 9-A). Subsidence is predicted to exceed 6.0 m in some sections of West Loon Creek channel resulting in a channel gradient reverse in two sections and some shallow ponding; however, downstream drainage would continue. Channel gradient increases are predicted in some sections where gradients of subsidence and topography have the same direction (e.g., both decrease). Where flow velocities increase, erosion is more likely and deposition may occur when the flow velocity is reduced. Changes to flow volumes are expected to be minimal, potentially reducing flood peaks but maintaining flows for downstream areas, although attenuation may occur in ponded areas. Subsidence is predicted to reach approximately 4.0 m in the West Loon Creek east tributary. The existing channel is poorly drained with flat areas where ponded areas develop; the same conditions are predicted to remain following subsidence. The maximum predicted subsidence is approximately 6.6 m in the intermittent stream in the west of the mine well field area. Subsidence may increase the storage potential on the lowered landscape and reduce the frequency that surface runoff from the area reaches West Loon Creek; however the overall effect on streamflow downstream would be negligible in most years.

Subsidence is also expected to affect storage of water on the landscape in the ESA. Existing depressions and wetlands are predicted to receive more runoff in settlement areas result from subsidence. Differential settlement is predicted to cause reductions in the water storage capacity of some depressions and wetlands along the west and north sides of the mine area. In contrast, an increase in water levels is anticipated in wetlands in areas with the greatest subsidence.

Effects of subsidence will be mitigated by applying environmental design features and specialized techniques for solution mining. For example, pillars of unmined material will be left between the mine caverns to increase stability during mining and to reduce potential subsidence. The cavern layout will be refined as additional modeling is completed to optimize potash recovery and to limit the potential effects of subsidence on surface topography. Secondary mining techniques that reduce the amount of material removed from the mine caverns will be employed after development of primary caverns wherever possible. Finally, extraction ratios will be controlled to limit strain on the overlying environment.

Changes to vegetation from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for more than a century. Areas that become more depressional in the landscape may be expected to accumulate more snow runoff and rainfall, which will increase soil moisture and may create wetland plant communities. Alternatively, existing wetlands may drain and become upland plant communities. Changes in soil moisture are expected to occur at a rate slow enough to allow for reciprocal changes in the distribution of plant communities. These changes in soil moisture and distribution of upland and wetland vegetation are not expected to result in a net decrease in vegetation. The distribution of upland and wetland vegetation is expected to change, but will compose similar proportions of the landscape after subsidence has occurred. Plant populations and communities are predicted to adapt to the gradual transition over time.

Long-term changes to plant populations and communities from subsidence are not anticipated to be obvious, and domestic activities and vegetation communities should adjust to the changes over time. Because subsidence will occur very gradually, no acute, adverse effects on vegetation are expected. A gradual net change to the abundance and distribution of plant communities is predicted.

13.6 Prediction Confidence and Uncertainty

Ecosystems are complex and interactions among abiotic and biotic components occur across multiple scales and are typically nonlinear (Boyce 1992; Holling 1992; Levin 1998; Wu and Marceau 2002). These characteristics can confound the understanding of ecosystem processes and limit capacity to make predictions. Similar to all scientific results and inference, residual effects predictions will have uncertainty associated with the data and current knowledge of the system. The confidence in residual effect predictions to the vegetation VC is related to:

- adequacy of baseline data for understanding current conditions and future changes unrelated to the Project;
- limitations of the ELC mapping process;
- the understanding of Project-related effects on complex ecosystems that contain interactions across different scales of time and space (e.g., exactly how the Project will influence plant species and the final composition of re-established vegetation communities); and
- knowledge of the effectiveness of the mitigation for limiting effects on vegetation (e.g., revegetation of disturbed areas).

A source of uncertainty for the Project is the degree to which residual effects could occur (e.g., magnitude and duration). A high degree of confidence exists that the Project will disturb plant populations and communities; however, it is not known what the final plant community composition will be in disturbed areas. Uncertainties occur in the direction, magnitude, and spatial extent of future natural fluctuations in plant populations and communities, independent of residual effects from the Project and from cumulative effects from previous and existing disturbances. The identified sources of uncertainty affect the magnitude and duration (which include reversibility) of predictions.

Uncertainty is associated with the ELC because it was developed using satellite imagery. Uncertainty in the ELC was reduced using field ground-truthing and professional experience in increasing the accuracy of the ELC. Vegetation survey plots completed in 2013 confirmed that the existing mapping in the ESA was representative of the vegetation present at the plot locations. The accuracy assessment results and correlations with field survey locations provided a high degree of confidence in the use of the classification for this Project. The overall accuracy for upland ELC map units is 79.8%, and the accuracy for the proportion of wetlands captured in the classification was 77%. However, because of restrictions in accessing some survey areas, not many plots are present in the final TMA and in the locations of some mine well pads, and therefore, the accuracy of the ELC in some areas is not known.

Uncertainty is associated with potential effects of disturbance or removal of known listed species occurrences. All of the species documented in 2013 are provincially listed by the SKCDC. The location or proximity of other locations that may contain these species in the ESA is unknown. Whether the Project will remove or avoid the documented and unknown patches of listed plants also is unknown.

The ELC map units were used to assess changes to plant community abundance and distribution on the landscape, and were assigned listed and traditional use plant species potentials to approximate the residual effects on plant populations and communities. Listed plant species habitat potentials were developed using field data and professional judgement; however, uncertainty remains because each listed plant species will have different habitat preferences and vulnerability. The ELC was also used to estimate changes to traditional use species. This uncertainty was reduced by understanding that these traditional species are typically distributed in many mapped units through the ESA; therefore, effects on these species could be predicted qualitatively. Similar to listed plant species, uncertainty remains because each traditional use plant species has different habitat preferences and resilience limits to disturbance of those plant communities in which they occur.

Uncertainty was addressed in the assessment by incorporating information from available and applicable literature, and using past experience in similar areas. Conservative estimates were used so that residual effects were not underestimated. A conservative estimate of the Project footprint (1,550 ha) was used to assess changes to vegetation, as this is larger than the actual area expected to be disturbed during construction. It was assumed that the Project will remove the patches of native grassland and listed species documented during the 2013 field survey, so that effects on the local populations are likely overestimated. Follow-up surveys in the Project footprint to confirm the actual ground cover in areas mapped as native grassland and wetlands will be completed prior to construction. Best practices during construction, operations, and reclamation activities will be implemented to mitigate residual effects on vegetation.

Uncertainty is related to the predicted effects from subsidence, as these changes are strongly dependent on changes to the hydrological regime. A number of uncertainties related to the predictions on the effects on hydrology and the surface water environment from subsidence were identified (Section 9.6 and Appendix 9-A). These uncertainties are related to the random variability associated with the hydrology process, model uncertainty, and parameter uncertainty. Uncertainty also exists in the state of regional climate variables (temperature, rainfall, and snowfall) during the period of subsidence, which can influence the outcome of subsidence. Subsequently, a corresponding uncertainty exists in the change to plant populations and communities. To increase the level of confidence in the subsidence evaluation, parameters are evaluated against observed subsidence values from long-term ground surface elevation surveys at operating potash mines in Saskatchewan and by using conservative scenarios when information is limited (Section 9.6). A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence.

13.7 Residual Effects Classification and Determination of Significance

13.7.1 Methods

13.7.1.1 Residual Effects Criteria

The purpose of the residual effects classification is to describe the residual incremental and cumulative adverse effects from the Project and other developments (Application Case) on the vegetation VC using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment.

Results from the residual effects classification are then used to determine the environmental significance from the Project and other developments on the assessment endpoint for vegetation (i.e., self-sustaining and ecologically effective plant populations and communities). Effects are described using the criteria defined in Table 13.7-1, and reflect the effects criteria provided in the TOR (Appendix 2-B). Together, these criteria are used to describe the nature (e.g., severity or intensity of change, and the area and amount of time over which the change occurs) and type (e.g., direction of the change) of an effect on a VC. The focus of the EIS is to predict whether the Project is likely to cause a significant adverse (i.e., negative) effect on the environment. Positive effects are not assessed for significance.

Table 13.7-1: Definitions of Residual Effects Criteria Used to Evaluate Significance for Plant Populations and Communities

Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Low: Amount of change to measurement indicator results in no measurable effect on the plant population or community, or results in a negligible residual effect on a plant population or community. **Moderate:** Amount of change to measurement indicator results in a clearly defined change to the plant population or community, but the residual effects are well within the predicted resilience limits of the plant population or community. **High:** Amount of change to the measurement indicator is sufficiently large that the resulting range of residual effects may be near or exceed the predicted resilience limits of the plant population or community.	**Local:** Predicted maximum spatial extent of direct and indirect effects from changes to measurement indicators due to a project or activity. **Regional:** Residual effects from changes to measurement indicator due to a project or activity exceed the local scale and can include cumulative effects from other developments in the effects study area. **Beyond Regional:** Residual cumulative effects from changes to measurement indicator due to a number of developments extend beyond the effects study area.	**Short-term:** Residual effect from change to measurement indicator is reversible at end of construction of Project. **Medium-term**: Residual effect from change to measurement indicator is reversible at end of operation of Project. **Long-term:** Residual effect from change to measurement indicator is reversible within a defined length of time past closure of Project. **Permanent:** Residual effect from change to measurement indicator is irreversible.	**Infrequent:** Residual effect from change to measurement indicator is confined to a specific discrete event. **Frequent:** Residual effect from change to measurement indicator occurs intermittently over the life of the Project. **Continuous:** Residual effect from change to measurement indicator occurs continuously.	**Reversible:** Residual effect from change to measurement indicator is reversible within a period that can be identified when a development or activity no longer influences the plant population or community. **Irreversible:** Residual effect from change to measurement indicator is predicted to influence the plant population or community indefinitely (duration is permanent or unknown).	**Unlikely:** Residual effect from change to measurement indicator is possible but unlikely (less than 10% chance of occurrence). **Likely:** Residual effect from change to measurement indicator may occur, but is not certain (10% to 80% chance of occurring). **Highly Likely:** Residual effect from change to measurement indicator is likely to occur or is certain (greater than 80% chance of occurring).

Note: resilience is the ability of a population or community to recover or bounce back from disturbance; it varies among populations.
% = percent.

Magnitude – Magnitude is a measure of the intensity of a residual effect on a VC, or the degree of change caused by the Project relative to Base Case conditions (i.e., effect size). Magnitude is specific to each VC and is classified into three scales: low, moderate, and high. For vegetation, magnitude is a function of the numerical and qualitative changes in measurement indicators (e.g., numerical changes in the abundance and distribution of ELC units, abundance, and distribution of habitat for listed plant species, abundance, and distribution of habitat for traditional use plants). Changes in measurement indicators are used to predict effects on the abundance and distribution of plant populations and communities, including listed and traditional use species (vegetation VC), and the ability of the VC to be self-sustaining and ecologically effective. Therefore, the magnitude of residual effects is assessed at the population and community levels (e.g., the ESA).

To provide an ecologically relevant classification of effect sizes of changes in measurement indicators for a particular VC, the assessment of magnitude includes the known or inferred ability of the associated plant populations and/or communities to recover from, or otherwise accommodate disturbance. Long-term population viability is frequently applied as an ecologically relevant target by conservation biologists and resource managers (Ruggiero et al. 1994; With and Crist 1995; Fahrig 2001; Nicholson et al. 2006). Self-sustaining populations are healthy, robust populations capable of withstanding environmental change and accommodating stochastic demographic processes (Reed et al. 2003). Maintaining ecologically effective populations and communities goes beyond what may be required only to achieve a self-sustaining population and requires that healthy ecological relationships are maintained among species to prevent unexpected biodiversity loss due to changes in properties of highly interactive species (Soulé et al. 2003, 2005). The potential to lose ecological function is more common for highly interactive vegetation species that perform important ecological functions, such as the role of big bluestem as a host plant for the Dakota Skipper.

Plant populations and communities will often continue to function after disturbance up to the point where the disturbance becomes severe enough that the plant population or community changes. The evaluation and classification of magnitude considers the ability of VCs to absorb effects from the Project and other disturbances and function as self-sustaining and ecologically effective populations and communities. Resilience is the ability of the population or ecosystem to recover or bounce back from the Project and other disturbances, and function as self-sustaining and ecologically effective populations and communities. Therefore, resilience reflects the capacity of a system to adapt to stress or change (Turetsky et al. 2012).

Responses to disturbance within a system can vary both between plant communities and between species. The ecological characteristics of a particular plant population could provide it with the defences and adaptive capacity to withstand stresses associated with landscape change, such as physical damage, changes in sunlight levels and temperature, and increased competition. Alternately, species that are sensitive to change could respond by declining in abundance gradually or immediately after a disturbance. Where biological information was lacking for a species, general ecological principles are discussed in context of the magnitude of the residual effects from changes to the physical environment on vegetation. Quantitative measures (vegetation loss and fragmentation) of the change in the physical environment were used to aid in assessing the magnitude of change.

Geographic Extent – Geographic extent refers to the spatial extent of the area affected and is different from the spatial boundary (i.e., ESA) for the effects analysis. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution of the VC (Section 13.2.1). However, the geographic extent of effects can occur on a number of scales within the spatial boundary of the assessment and is VC-specific. Effects at the local scale are largely associated with the predicted maximum spatial extent of combined direct and indirect changes from the Project (i.e., cumulative effects that are specific to the Project). Effects at the regional scale occur within the ESA, and are associated with incremental and cumulative changes from the Project and other developments. The beyond regional scale includes cumulative residual effects from the Project and other developments that extend beyond the ESA. The principle applied when using geographic extent to understand magnitude is that local effects from the Project are less severe than effects that extend to the regional or beyond regional scales, all other factors being equal.

Duration – Duration is VC-specific and defined as the amount of time from the beginning of a residual effect to when the residual effect on the vegetation is reversed. It is usually expressed relative to Project phases (usually in years). Duration has two components, the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases), plus the time required for the effect to be reversible. Essentially, duration is a function of the length of time that VCs are exposed to Project activities and reversibility of the effect. By definition, residual effects that are short-term, medium-term, or long-term in duration are reversible.

In some cases, available scientific information and experienced opinion may predict that the residual effect is irreversible. Alternately, the duration of the residual effect may not be known, except that it is expected to be extremely long and well beyond the temporal boundary of the Project. Any number of factors could cause a VC to never return to a state that is unaffected by the Project. In other words, science and logic predict that the likelihood of reversibility is so low or uncertain that the residual effect is classified as irreversible.

13.7.1.2 Determination of Significance

The classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of incremental and cumulative effects from the Project and other existing and approved developments on the assessment endpoint for the vegetation VC. The evaluation is focused on determining the significance of cumulative effects on self-sustaining and ecologically effective plant populations and communities.

Magnitude is the primary criterion used to determine environmental significance, while other criteria are used as modifiers and to provide context when assigning magnitude. Geographic extent and duration provide important context for classifying the magnitude of effects on vegetation assessment endpoints. For example, determining the magnitude of an effect from changes in plant community connectivity on a vegetation VC depends on the spatial extent (amount of area or proportion of the population) and duration of the changes. Duration includes reversibility; a reversible effect from a development is one that does not result in a permanent adverse effect on ecological functions and properties (e.g., stability and resilience). Frequency and likelihood are also considered as modifiers when determining significance, where applicable.

Duration is a function of resilience, which is the ability of the population to recover or bounce back from a disturbance. The capacity or ability of individuals in a population to change and accommodate disturbance is also related to resilience. Resilience can vary with population size, stability, and the likelihood of demographic rescue from neighbouring populations. During periods of low abundance or limited pollinator abundance, plant populations can become less resilient to natural environmental and human-related disturbances, which may reduce stability. Stable populations exhibit no long-term increasing or declining trend in abundance outside of natural fluctuations and cycles. Resilience and stability are properties of a population that influence the amount of risk to VCs from development (Turetsky et al. 2012). The duration of development-related effects may be shorter for VCs that are highly resilient and stable.

For vegetation in the ESA, ecological benchmarks or effects thresholds are not known and are challenging to define, which creates uncertainty in determining the significance of predicted effects. For example, critical thresholds and screening levels for measurement indicators such as quantity, arrangement, and connectivity are frequently not available for plant species, and the significance of effects may not be within the plant community itself, but linked to other VCs that depend on plant communities for habitat, food, and survival (i.e., ecological services).

The evaluation of significance for vegetation considers the entire set of primary pathways that influence the assessment endpoint; thus, significance is not explicitly assigned to each pathway. Rather, the relative contribution of each pathway is used to determine the significance of the Project and other developments on the assessment endpoint, which represents a weight of evidence approach (i.e., evaluating the persuasiveness of evidence indicating that an effect is significant or not significant). For example, a pathway with a high magnitude, a large geographic extent, and a long-term duration is given more weight in determining significance relative to pathways with smaller scale effects. The relative effect from each pathway is discussed; however, pathways that are predicted to have the greatest influence on changes to the assessment endpoint are assumed to contribute the most to the determination of environmental significance.

Because of the uncertainty regarding the effects of development on plant populations and communities, magnitude classification was applied conservatively to increase the level of confidence that effects will not be worse than predicted. Furthermore, the determination of significance considers the key sources of uncertainty in the effects analysis, the management of uncertainties, and the corresponding level of confidence in effects predictions.

The determination of environmental significance on vegetation considered the following key factors.

- Results from the residual effect classification of primary pathways and associated predicted changes in measurement indicators.
- Magnitude is the primary criterion used to determine significance with geographic extent and duration providing important context for assigning magnitude. Frequency and likelihood act as modifiers for determining significance, where applicable.
- The level of confidence in predicted effects, scientific principles (e.g., resilience and stability), and experienced opinion are included in the evaluation of determining environmental significance. Where uncertainty was high and the cumulative effect might be either significant or not significant, the assessment conservatively identified the effect as significant and provided additional follow-up actions to reduce uncertainty.

This method is used to identify predicted residual adverse effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to plant populations and communities, and therefore, result in significant effects. The following definitions are used for predicting the significance of effects on self-sustaining and ecologically effective plant populations and communities.

Not significant – effects are measurable at the individual or patch (local) level, and strong enough to be detectable at the population or community level, but are not likely to decrease resilience and increase the risk to remaining local or sub-regional self-sustaining and ecologically effective plant populations and communities in the ESA.

Significant – effects are measurable at the population or community level and likely to decrease resilience and increase the risk to the maintenance of remaining local and sub-regional self-sustaining and ecologically effective plant populations and communities in the ESA. Loss of habitat that causes further fragmentation and reduces connectivity to the point that it may adversely influence dispersal or demographic rescue between intact and contiguous populations and communities would likely be significant.

13.7.2 Results

13.7.2.1 Quantity, Arrangement, and Connectivity of Plant Communities

Ecosystems are dynamic and are continually undergoing compositional changes because of disturbance and succession. Disturbance and succession in plant ecology are closely linked because a perturbation in a system is often the mechanism for creating an early successional plant community, allowing different species to coexist (Turetsky et al. 2012). In areas of vegetation loss, the resilience of plant species and communities depends on the response of neighbouring plants to the disturbance (Callaway et al. 2002). The response of individual plant species in a community is dependent on the nature and magnitude of the disturbance and the characteristics of the plant species (e.g., growth form and reproductive strategy).

Approximately 80% of native grassland is estimated to have been lost during the past 100 years in the Prairie Ecozone of Saskatchewan, with some local areas of prime cropland recording losses of up to 98% (Hammermeister et al. 2001; Gauthier and Wiken 2003). Grassland habitat in Saskatchewan generally consists of small, fragmented patches throughout the Prairie Ecozone, and the majority of the larger contiguous patches that remain occur in the southwest of the province (Gauthier and Wiken 2003). The most obvious changes to native grassland in Saskatchewan are the fragmentation of this habitat and the decrease in patch size (Hammermeister et al. 2001). Less obvious changes are related to the removal of natural disturbance regimes (e.g., fire, grazing) and the introduction of invasive plant species that displace native species. Approximately 40% of prairie wetlands have been removed by drainage activities in the last 100 years (Cortus et al. 2010). Conversely, wooded areas appear to have increased in Saskatchewan since the 1900s, in particular along the woodland-grassland ecotone, which is likely, in part, a result of fire suppression (Archibold and Wilson 1980).

At the Base Case, cumulative changes from sustained agricultural practices over the last 100 years have resulted in adverse effects on natural plant populations and communities, specifically native grassland and wetlands in the ESA (high magnitude, regional scale effect; Table 13.7-2). Previous and existing disturbances have likely resulted in decreased resilience to the point where some local communities may not be self-sustaining and ecologically effective. Cultivated, modified grassland and existing disturbances cover 75.5% of the ESA under the Base Case. As such, 75.5% of native grassland and wetland vegetation types that were in the ESA prior to human settlement is estimated to have been removed by previous and existing human developments and agricultural activities. These changes are likely to be irreversible given the current and future economic benefits of agriculture and other industries in the region (Table 13.7-2).

The dominant ELC map unit within the ESA is Cultivated and accounts for approximately 58% (46,834 ha) under Base Case conditions. The Modified Grassland unit, which includes both hayland and modified prairie, covers

16% of the ESA and Native Grassland covers 8%. Wetlands (Class I, II, III, IV, and V) cover approximately 13% of the ESA under Base Case conditions. The Existing Disturbance map unit (e.g., roads and communities) accounts for approximately 1% (1,141 ha) of the ESA under the Base Case. Most of the plant communities (ELC map units) expected to be affected by the Project are widely distributed in the ESA, including Native Grassland and Wetland units. For example, larger areas of Native Grassland are present outside of the Project footprint. Some of this Native Grassland is associated with the valleys of West Loon Creek and large areas at the northeast and southeast sides of the ESA. Baseline data indicates that these grasslands are in good condition and were dominated with native grassland species; however, some of the areas associated with valleys of West Loon Creek and the large area at the northeast side of the ESA contained Kentucky bluegrass (15% to 20% cover). Many of the larger local and sub-regional plant communities associated with Native Grassland and Wetland units remaining in the ESA are likely self-sustaining and ecologically effective.

Not all plant species have been affected to the same extent as others through loss, alteration, and fragmentation on the landscape prior to application of the Project. Some species can survive in altered ecosystems (e.g., ditches and modified prairie) and are likely more resilient to the changes on the landscape present in the Base Case. For example, many ditches that were surveyed in the ESA during baseline field programs were observed to contain native grassland species such as Canada goldenrod (*Solidago canadensis*), silverberry (*Elaeagnus commutata*), prickly rose (*Rosa acicularis*), willow species (*Salix* spp.), and western snowberry (*Symphoricarpos occidentalis*) (Annex IV, Section 4.3.1). Areas such as modified prairie may have been seeded over or disturbed at some point in time, but may fulfill a similar ecological role as native grassland. Although modified prairie in the ESA was dominated by species such as Kentucky bluegrass (*Poa pratensis*) and intermediate wheatgrass (*Thinopyrum intermedium*), and may contain smooth brome (*Bromus inermis*) and alfalfa (*Medicago sativa* ssp. *sativa*), modified prairie also supported native species such as western snowberry, common yarrow (*Achillea millefolium*), pasture sage (*Artemisia frigida*), timber milk vetch (*Astragalus miser*), prairie crocus (*Pulsatilla patens* ssp. *multifida*), Canada goldenrod, and needle-and-thread (*Hesperostipa comata* ssp. *comata*). However, those species that were not wide spread prior to removal and fragmentation would have been more affected by loss, alteration, and fragmentation present in the Base Case.

The maximum area of ELC map units to be disturbed by the application of the Project is 1,550 ha. The ELC map unit that will experience the greatest change from the Project is the Cultivated (1,216 ha) land cover type. The Project is predicted to remove 87 ha of Class I and Class II Wetland, 77 ha of Modified Grassland, 69 ha of Class IV Wetland, 20 ha of Native Grassland and 14 ha of the Wooded ELC units. Overall, the cumulative reduction in natural habitat through application of the Project and previous and existing developments is approximately 75.8% of the ESA, with an incremental contribution from the Project of 0.3%. Following decommissioning and reclamation, approximately 842 ha will be reclaimed. Reclamation will be carried out as outlined in the Conceptual Reclamation Plan (Section 4.11, Appendix 4-D); however, the type of vegetation in reclaimed areas is unknown. Therefore, reclaimed areas have not been assigned a specific ELC type.

The effect of loss, alteration, and fragmentation of existing natural areas present at the Base Case is important for species dispersal where distance between patches can isolate those species within a patch (Gauthier and Wiken 2003). Size of patch is more important for some species than others. The removal of the largest patch in an existing mosaic can be important for connectivity and ability of a species to maintain enough genetic diversity to remain resilient to future changes. A larger patch may be important because it may be the minimum size required for a plant species or ecosystem to remain self-sustaining and ecologically effective. The Project is not expected to disturb large contiguous patches of native grassland remaining in the ESA. However, the removal of a smaller patch can also reduce connectivity. The smaller patch may function as a stepping stone or contain a microsite for a plant species between patches; however, they need to be close enough to allow for dispersal.

A loss of 19 patches of Native Grassland units and a loss of 60 patches of Class III and Class IV Wetlands is predicted under the Application Case. The mean patch size during the Base Case is approximately 1.9 ha, 0.5 ha, and 1.2 ha, respectively. The mean patch size of Native Grassland is predicted to increase slightly (less than 0.1 ha) with the application of the Project. This slight increase in mean patch size is related to the removal of 3 small patches (all 0.6 ha and smaller) associated with the location of the TMA. The mean patch size of Class III and Class IV Wetland units is predicted to decrease slightly (less than 0.1 ha) with application of the Project. Larger areas of native grassland are present outside of the Project footprint and are associated with the valleys of West Loon Creek and large areas at the northeast and southeast sides of the ESA. The grasslands in these locations are in good condition and were dominated with native grassland species.

The MDNN metric is important to understanding the dispersal potential among remaining patches of natural areas. Within the ESA, during the Base Case, the MDNN between patches of native grassland is 50.7 m. This means that species will need to disperse 50.7 m before encountering another patch of native grassland. With application of the Project, this mean distance is predicted to decrease slightly to 50.6 m, meaning that the Project is likely to have no ecologically measurable effect on the current ability of species to disperse between patches, given they can move these distances. A similar result was observed in Wooded and Wetland units where only small changes in MDNN were observed, a decrease in MDNN of 2.5 m and an increase of 0.1 m, respectively, relative to Base Case conditions.

Some populations of plant species that are restricted to natural habitats (native grassland, wetlands) are likely partly isolated under the Base Case. The fragmented landscape has likely resulted in a decreased quality of the remaining patches. For example, about 3% to 4% of the remaining native grassland ecosystem is in good condition (Hammermeister et al. 2001). This is in part because many grassland forbs lack specialized dispersal mechanisms and therefore only disperse over small distances (i.e., less than 1 m) (Williams et al. 2005). For species that disperse their seeds by wind, they may be less affected by habitat isolation, given the seeds fall in appropriate habitat for germination and survival. However, other factors such as the number of individuals within that patch can influence the effective dispersal distance of species (i.e., probability of establishment and subsequent reproduction).

As remaining patches of grassland become smaller under current land uses, the larger the influence from the surrounding agricultural activities, the higher the likelihood of pollinator limitations, and the lower the resilience of these populations to additional disturbances. A study by Soons and Heil (2002) found that seed germination decreased with declining population size, and was likely the result of low genetic diversity and limitations in pollinator visitation that occur in highly fragmented landscapes like that present in the Base Case. However, a poor correlation exists between patch size and plant species diversity (Donaldson et al. 2002). This poor correlation implies that some plants could be more resilient to habitat fragmentation than other taxa that depend on insects or wildlife for pollination. An increase in the distance between plant populations and pollinator habitat can result in a decrease in pollinator visitation and increase in genetic isolation of plant populations (Newman et al. 2013).

The Project is located in an area that contains a large amount of agricultural activity that will likely continue for the duration of the Project. The Project is predicted to contribute little to the existing cumulative effects on natural (native) plant populations and communities in the ESA. The majority of the patches of native grassland that will be disturbed by the Project footprint are 0.6 ha and smaller. Plant species present in wooded areas and wetlands are likely adapted to the patchy nature of these vegetation types present in the ESA. Removal of vegetation by the Project should not disrupt the existing connectivity of native grassland, wetlands, and wooded vegetation types in the ESA. The Project is located approximately 5 km from the closest known location of a large patch (approximately 125 ha) of native dominated grassland and a Class V Wetland (approximately 3 ha) in the N1/2-11-25-19-W2M. The mosaic of native dominated grassland, wooded areas and wetlands in the northeast of the ESA is approximately 224 ha, and the patch of native dominated grassland in the southeast of the ESA is approximately 270 ha.

Not all areas that were assessed to be disturbed by the Project are expected to be altered during construction; therefore, the assessment of effects from direct loss or alteration and fragmentation of vegetation in the ESA is overestimated. In addition, the application of mitigation for the Project will follow the hierarchy outlined in MOE (2014) (i.e., the preferred mitigation is to avoid wetlands). The siting of well pad locations will be modified to avoid wetlands as part of the final design phase. Avoidance of wetlands will reduce the contribution of the Project to existing cumulative effects in the ESA. The incremental effects from the Project are expected to be reversible after closure (long-term), except for localized effects from the TMA and crystallization pond (708 ha [0.8% of the ESA]), which will be permanent and irreversible (Table 13.7-3).

Overall, the weight of evidence from the analysis of the primary pathways predicts that cumulative changes to measurement indicators from previous and existing developments have had an adverse effect on self-sustaining and ecologically effective plant populations and communities. The cumulative residual effect on natural (native) plant populations and communities present in the Application Case is expected to be high in magnitude because of the previous and existing disturbances in the ESA (Table 13.7-2). However, there are several large areas of native dominated grassland in the ESA that are likely self-sustaining and ecologically effective. The incremental effects from the Project are small (low magnitude; 0.3% relative to Base Case conditions), local to regional in geographic extent, and long-term to permanent in duration (Table 13.7-3). The incremental contribution of the Project to regional cumulative effects is not likely to decrease the resilience and increase the risk to remaining local or sub-regional self-sustaining and ecologically effective plant populations and communities in the ESA. The Project will not influence the large, intact native grasslands and wetlands that exist in the ESA. Therefore, the cumulative changes from the Project and other developments are predicted to not have significant adverse effects on plant populations and communities. Confidence in this prediction is moderate because of limited knowledge about the resilience of the remaining natural areas in the ESA. However, conservative approaches were used so that effects would not be underestimated (e.g., using a larger than anticipated Project footprint), and with appropriate mitigation such as avoidance of patches of wetlands, the incremental effect related to the Project will be reduced.

Table 13.7-2: Summary of Residual Effects Classification of Primary Pathways and Predicted Significance of Cumulative Effects on Vegetation

Pathway	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Significance for Assessment Endpoint
Direct loss, alteration, and fragmentation of vegetation from the Project footprint (core facilities area, mining area, and access roads) can cause changes to plant populations and communities.	high for native grassland and wetland plant communities high for listed plant populations low for traditional use plant species	regional	long-term to permanent	continuous	reversible to irreversible	highly likely	Not Significant; there are several large areas of contiguous native grasslands and wetlands in the ESA
Residual ground disturbance from portions of the core facilities area can permanently alter the abundance and distribution of plant populations and communities.	low	regional	permanent	continuous	irreversible	highly likely	
Ground subsidence caused by solution mining can change surface flows and drainage patterns (distribution), which can affect the abundance and distribution of plant populations and communities.	low	regional	permanent	continuous	irreversible	highly likely	

ESA = effects study area

Table 13.7-3: Summary of Incremental Contributions of the Project to Cumulative Effects on Vegetation

Pathway	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Significance for Assessment Endpoint
Direct loss, alteration, and fragmentation of vegetation from the Project footprint (core facilities area, mining area, and access roads) can cause changes to plant populations and communities.	low	local	long-term	continuous	reversible	highly likely	Not Significant; the Project is predicted to contribute little to cumulative effects from previous and existing developments
Residual ground disturbance from portions of the core facilities area can permanently alter the abundance and distribution of plant populations and communities.	moderate for listed plant populations low for other plant populations and communities	local	permanent	continuous	irreversible	highly likely	
Ground subsidence caused by solution mining can change surface flows and drainage patterns (distribution), which can affect the abundance and distribution of plant populations and communities.	low	regional	permanent	continuous	irreversible	highly likely	

13.7.2.2 Listed Plant Species and Habitat for Listed Plant Species

Four provincial listed forbs and one listed graminoid species were documented in the ESA during the 2013 field programs including low milk vetch (*Astragalus lotiflorus*; S3), tall beggarticks (*Bidens frondosa*; S2S3), Macoun's cryptanthe (*Cryptantha macounii*; S1), beaked annual skeletonweed (*Shinnersoseris rostrata* [syn. *Lygodesmia rostrata*]; S2), and big bluestem (*Andropogon gerardii*; S4) (Section 13.3.2.3). All observations were in Native Grassland, Modified Prairie, and Class II, III, and IV Wetlands, and riparian areas in the ESA.

One location of tall beggarticks identified during the 2013 field survey is within the area expected to be disturbed by the Project. This location was documented to contain a patch with several hundred individuals spread around the margin of a Class III wetland in a ditch. This location is within the area of residual disturbance (i.e., TMA and crystallization pond). This species was observed at four other locations in the ESA during baseline field programs.

The following mitigation will be used to reduce effects on known locations containing listed plant species.

- The Project will avoid listed plants as much as possible; however, if avoidance of listed plants is not possible, consultation with MOE will be completed to determine the significance of the area and identify feasible mitigation strategies.
- If a listed plant species is encountered that was not expected, appropriate mitigation will be applied prior to further construction activities in consultation with MOE.

Of the area directly disturbed by the Project, 119 ha of ELC units with high listed plant habitat potential will be disturbed during construction, resulting in a decrease of 0.8% relative to Base Case conditions. Habitat units with moderate/high listed plant habitat potential will decrease by approximately 87 ha (2.2%).

For effects of the Project to have a significant effect on self-sustaining and ecologically effective listed plant populations and communities, preferred habitats for listed species would have to be removed to the extent that there would be a permanent adverse change to survival and reproduction at the population level. Significant effects could occur if individual patches become isolated to the extent that populations would no longer be resilient to other environmental pressures or changes. The natural abundance of a species can influence the effects of loss and fragmentation of listed plant habitat on specific groups of plant species (Hobbs and Yates 2003). For example, loss and fragmentation can have more pronounced effects on uncommon and rare species where a small patch can contain a population and the distance to another area containing the same species has increased (Donaldson et al. 2002). The effect of fragmentation can be enhanced simply because the abundance of rare or uncommon species is naturally restricted (Donaldson et al. 2002; Hobbs and Yates 2003).

Although high and high/moderate potential habitats have been affected by previous and existing developments, and will be altered by the Project, these habitats are not unique to the areas expected to be disturbed. For example, some of the listed species that prefer Native Grassland habitats could occur in microsites contained in other map units (e.g., ditches, modified prairie, riparian areas) and other areas of Native Grassland are located outside of the Project footprint within the ESA (Section 13.7.2.1). If all listed plant species were negatively affected or removed from the ESA and function of these species was reduced, it would be considered a significant effect on listed plants.

Not all areas that were assessed to be disturbed by the Project are expected to be altered during construction; therefore, the assessment of effects from direct loss of patches of listed plant species and the loss or alteration and fragmentation of preferred habitat in the ESA is overestimated. Project-related disturbances are expected to occur once, and although the effect is considered permanent, the net incremental change in ELC units with the highest potential to support listed plant species will be confined to the Project footprint (local scale). The incremental contribution of the Project to regional cumulative effects present at the Base Case on the relative abundance of listed plant populations and communities are small (approximately 3% of the high and high/moderate mapped units in the ESA).

With appropriate mitigation, the residual effect of the Project on listed plant populations is expected to be moderate in magnitude because if a patch of listed plants is removed, it could be measurable at the regional level, but would not be predicted to alter the state of existing listed plant populations. Confidence in this prediction is moderate because of limited knowledge about the reproductive capacity and resilience of the observed listed species, and the level of occurrence of these species in the ESA; however, other suitable habitat is available for listed plant species outside of the Project footprint in the ESA. Previous and existing disturbances in the ESA have likely removed other patches of listed plant species; therefore, the magnitude of cumulative effects on listed plants is considered high to be conservative (Table 13.7-2). The incremental effects from the Project are of moderate magnitude, local to regional in geographic extent, and long-term to permanent in duration (Table 13.7-3). The incremental contribution of the Project to regional cumulative effects is not likely to decrease resilience and increase the risk to remaining local self-sustaining and ecologically effective listed plant populations in the ESA. The Project will not influence the large, intact native grasslands and wetlands (i.e., high potential listed species habitats) that exist in the ESA. Therefore, the cumulative changes from the Project and other developments are predicted to not have significant adverse effects on listed plant populations and communities to remain self-sustaining and ecologically effective.

13.7.2.3 Traditional Use Plant Species and Habitat for Traditional Use Plant Species

Thirty-one traditional use plants species were identified during the 2014 traditional plant use interviews as being used in the early 1900s; 18 of these species are known to occur within the ESA (Section 13.3.2.5; Annex V, Section 3.0). Many of these plants were historically used for medicine or food. The majority of participants that were interviewed agreed that in the early 1900s they were still able to practice most of their traditional activities; however, this has changed over time (Annex V, Section 3.0). In recent years, the participants reported that very few people practice traditional land use activities. Some people continue to gather berries and plants wherever they can find them; however, it is not as common and these plants are often difficult to find or access. The loss of traditional knowledge and the dependency on modern conveniences have also affected traditional practices, as more people buy their food and medicine from the store and pharmacy.

Those ELC map units predicted to contain the highest number of traditional use species are Native Grassland, Class IV Wetland, and Wooded. A total of 107 ha of ELC units with high traditional use plant habitat potential will be disturbed by the Project, resulting in a decrease of 0.7% relative to Base Case conditions. Habitat units with moderate potential will decrease by approximately 12 ha (1.3%). Although high and moderate potential habitats have been affected by previous and existing developments, and will be altered by the Project, these habitats are not unique to the areas expected to be disturbed; other areas of high and moderate potential habitats are located outside of the Project footprint within the ESA.

Some areas disturbed by the Project are expected to be reclaimed after closure except for localized effects from residual disturbance (708 ha [0.8% of the ESA]), which will not be reclaimed (Table 13.7-2). Changes to traditional use plant habitat will be permanent and irreversible because the type of vegetation in reclaimed areas is unknown at this time. Residual incremental effects from the Project are expected to be low magnitude and at the local scale (confined to the Project footprint; Table 13.7-3) and have no significant effect on traditional use plant species. Similarly, the cumulative effects from the Project and previous and existing developments are predicted to have no significant influence on self-sustaining and ecologically effective traditional use plant populations and communities (Table 13.7-2).

13.7.2.4 Changes from Subsidence

The effect of ground subsidence on vegetation is highly likely, low in magnitude, and regional in geographic extent (Table 13.7-2; Table 13.7-3). Ground subsidence is predicted to affect drainage corridors and wetland distribution, which will influence vegetation distribution. Small, localized changes to flow pathways and drainage areas are predicted within the West Loon Creek basin in the ESA. The flows along major flow paths (i.e., West Loon Creek) are predicted to be maintained; however, localized alterations of flow pathways are predicted and ponding sections may appear.

The area affected by surface subsidence is predicted to extend approximately 17.0 km from west to east and approximately 8.0 km from north to south. Changes to vegetation from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for more than one hundred years, and was therefore classed as having a continuous frequency and permanent duration (Table 13.7-2). Areas that become more depressional in the landscape may be expected to accumulate more snow runoff and rainfall, which will increase soil moisture and may create wetland plant communities. Alternatively, existing wetlands may drain and become upland plant communities. Changes in soil moisture are expected to occur at a rate slow enough to allow for reciprocal changes in the distribution of plant communities. These changes in soil moisture and distribution of upland and wetland vegetation are not expected to result in a net decrease in vegetation. The distribution of upland and wetland vegetation is expected to change, but will compose similar proportions of the landscape after subsidence has occurred. As a result, the magnitude was assessed as low. Domestic activities and land uses should adjust naturally over time, although these changes will be irreversible.

13.8 Monitoring and Follow-up

Typically, monitoring includes one or more of the following categories, which may be applied during the development of the Project:

- **Compliance monitoring** – monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments (e.g., inspecting the installation and effectiveness of a silt fence).

- **Follow-up monitoring** – programs designed to test the accuracy of effects predictions, reduce/address uncertainties, determine the effectiveness of environmental design features, and/or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., monitoring for weed species). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

Follow-up programs are typically implemented when the accuracy of the determination of significance needs to be verified or the resulting residual effects cause sufficient public concern to warrant an increased effort to determine the accuracy of the predictions or test the effectiveness of mitigation and compensation. If monitoring or follow-up detects effects that are different from predicted effects, or the need for improved or modified design features and mitigation, then adaptive management will be implemented. This may include increased monitoring, changes in monitoring programs, and additional mitigation. Monitoring for vegetation will involve the following surveys and activities.

Surveys of areas mapped as native grassland, wetlands, and wooded areas will be completed in the Project footprint prior to Project construction. These surveys will be used to determine the accuracy of the ELC mapping in these areas and to confirm the actual ground cover and health of these plant communities to mitigate residual effects on these plant community types. If these areas are determined to be important natural areas, mitigation to avoid or limit effects on these areas will be developed in conjunction with the MOE.

Yancoal's Weed Management Plan will be implemented and will include surveys for weed species during the Project. Yancoal will incorporate routine weed inspection and maintenance programs to protect areas of natural vegetation.

Prior to construction of Project components, detailed site assessments will be completed to identify listed plant species that may be present in the areas to be disturbed, which were not identified during previous surveys. Listed plant species are not identifiable at all times during the growing season due to temporal variation in weather and climate. Therefore, additional listed plant species surveys prior to construction will reduce the uncertainty surrounding the potential presence of listed plant species. If translocation or transplantation is completed for known locations of listed plant species, follow-up programs will be implemented to monitor the translocation status. Appropriate mitigation practices and protocols will be implemented should any listed plant species be identified. Additional wetland surveys may be required prior to construction. Information from these surveys will be used for the development of Habitat and Wetland Compensation Plans, if required.

Topsoil will be salvaged in sensitive habitats (e.g., native grassland) to maintain the seed bank contained in the topsoil. This material will be returned to these areas and will be spread over the reclaimed/contoured area to help re-establish a vegetation cover. The topsoil will aid in revegetation of reclaimed or landscaped areas with native plant species, thereby maintaining listed plant habitat. Natural regeneration will be promoted; however, all disturbed areas will be reclaimed, stabilized, and as required, seeded with an approved native seed mixture. Certified weed free seed mixtures appropriate for the area will be used for revegetation. Revegetation techniques may be developed in collaboration with native plant experts or researchers to enhance success of revegetation, especially in those areas containing native grassland. Follow-up monitoring will include an assessment of the success of plant community establishment following reclamation.

A subsidence monitoring program will be implemented to reduce uncertainty from the potential changes to hydrology from subsidence. The monitoring program would be designed to examine changes to hydrology. If changes to hydrology indicate that there would be effects on terrestrial ecosystems, then a monitoring program would be designed to assess the associated changes to terrestrial components.

13.9 Summary and Conclusions

The Project is not expected to affect the ability of plant communities, listed plants, and traditional use plants to be self-sustaining and ecologically effective.

At the Base Case, cumulative changes from sustained agricultural practices over the last 100 years have resulted in adverse effects on plant populations and communities, specifically native grassland and wetlands in the ESA. Cultivated, Modified Grassland and Existing Disturbance cover 75.5% of the ESA under the Base

Case. As such, 75.5% of native grassland and wetland vegetation types that were in the ESA prior to human settlement are estimated to have been removed by previous and existing human developments and agricultural activities.

The dominant ELC map unit within the ESA is Cultivated and accounts for approximately 58% (46,834 ha) under Base Case conditions. The Modified Grassland unit, which includes both hayland and modified prairie, covers 16% of the ESA and Native Grassland covers 8%. Wetlands (Class I, II, III, IV, and V) cover approximately 13% of the ESA. The Existing Disturbance map unit (e.g., roads and communities) accounts for approximately 1% (1,141 ha) of the ESA under the Base Case.

The ELC map unit that will experience the greatest change from the Project is the Cultivated (1,216 ha) land cover type. The Project is predicted to remove 87 ha of Class I and Class II Wetland, 77 ha of Modified Grassland, 69 ha of Class IV Wetland, 20 ha of Native Grassland and 14 ha of the Wooded ELC units. Overall, the cumulative reduction in natural habitat through application of the Project and previous and existing developments is approximately 75.8% of the ESA, with an incremental contribution from the Project of 0.3%.

A loss of 19 patches of Native Grassland units and a loss of 60 patches of Class III and Class IV Wetlands is predicted under the Application Case. The mean patch size during the Base Case is approximately 1.9 ha, 0.5 ha, and 1.2 ha, respectively. The mean patch size of Native Grassland is predicted to increase slightly (less than 0.1 ha) with application of the Project. This slight increase in mean patch size is related to the removal of 3 small patches (all 0.6 ha and smaller) associated with the location of the TMA. The mean patch size of Class III and Class IV Wetland units is predicted to decrease slightly (less than 0.1 ha) with application of the Project.

Within the ESA, the MDNN between patches of Native Grassland is 50.7 m during the Base Case. This means that species will need to disperse 50.7 m before encountering another patch of Native Grassland. With application of the Project, this mean distance is predicted to decrease slightly to 50.6 m, which should have no ecologically measurable effect on the current ability of species to disperse between patches, given they can move these distances. A similar result was observed in Wooded and Wetland units where only small changes in MDNN were observed, a decrease in MDNN of 2.5 m and an increase of 0.1 m, respectively, relative to Base Case conditions.

The Project is predicted to contribute little to the existing cumulative effects on natural (native) plant populations and communities in the ESA. The majority of the patches of Native Grassland associated with the Project footprint are 0.6 ha and smaller. Plant species present in wooded areas and wetlands are likely adapted to the patchy nature of these vegetation types present in the ESA. Removal of vegetation by the Project should not disrupt the existing connectivity of native grassland, wetlands, and wooded vegetation types in the ESA. Larger areas of native grassland are present outside of the Project footprint. The Project is located approximately 5 km from the closest known location of a large patch (approximately 125 ha) of native dominated grassland and a Class V Wetland (approximately 3 ha) associated with the valleys of West Loon Creek. The mosaic of native dominated grassland, wooded areas and wetlands in the northeast of the ESA is approximately 224 ha and the patch of native grassland in the southeast of the ESA is approximately 270 ha. Baseline data indicates that these grasslands are in good condition and were dominated with native grassland species. The local and sub-regional plant communities associated with Native Grassland and Wetland units remaining in the ESA are likely self-sustaining and ecologically effective.

Not all areas that were assessed to be disturbed by the Project are expected to be altered during construction; therefore, the assessment of effects from direct loss or alteration and fragmentation of vegetation in the ESA is overestimated. The siting of well pad locations will be modified to avoid wetlands as part of the final design phase. Avoidance of wetlands will reduce the contribution of the Project to existing cumulative effects in the ESA. The incremental effects from the Project are expected to be reversible after closure (long-term), except for localized effects from the TMA and crystallization ponds (708 ha [0.8% of the ESA]), which will be permanent and irreversible.

Overall, the weight of evidence from the analysis of the primary pathways predicts that cumulative changes to measurement indicators from previous and existing developments have had an adverse effect on self-sustaining and ecologically effective plant populations and communities. The cumulative residual effect on natural (native) plant populations and communities present in the Application Case is expected to be high in magnitude because of the previous and existing disturbances in the ESA. However, there are several large areas of native dominated grassland in the ESA that are likely self-sustaining and ecologically effective. The incremental effects from the Project are small (low magnitude; 0.3% relative to Base Case conditions), local to regional in geographic extent, and long-term to permanent in duration. The incremental contribution of the Project to regional cumulative effects is not likely to decrease the resilience and increase the risk to remaining local or sub-regional self-sustaining and ecologically effective plant populations and communities in the ESA. The Project will not influence the large, intact natural grasslands and wetlands that exist in the ESA. Therefore, the cumulative changes from the Project and other developments are predicted to not have significant adverse effects on plant populations and communities.

Of the area directly disturbed by the Project, 119 ha of ELC units with high listed plant habitat potential will be disturbed during construction, resulting in a decrease of 0.8% relative to Base Case conditions. Habitat units with moderate/high listed plant habitat potential will decrease by approximately 87 ha (2.2%). With appropriate mitigation, the residual effect of the Project on listed plant populations is expected to be moderate in magnitude, because if a patch of listed plants is removed, it could be measurable at the regional level, but would not be predicted to alter the state of existing listed plant populations. Previous and existing disturbances in the ESA have likely removed other patches of listed plant species; therefore, the magnitude of cumulative effects on listed plants is considered high to be conservative. The incremental contribution of the Project to regional cumulative effects is not likely to decrease resilience and increase the risk to remaining local self-sustaining and ecologically effective listed plant populations; the Project will not influence the large, intact natural grasslands and wetlands that exist in the ESA. The incremental and cumulative effects from the Project and other developments are predicted to not significantly influence self-sustaining and ecologically effective listed plant populations.

A total of 107 ha of ELC units with high traditional use plant habitat potential will be disturbed by the Project, resulting in a decrease of 0.7% relative to Base Case conditions. Habitat units with moderate potential will decrease by approximately 12 ha (1.3%). The residual effect of the Project on traditional use plant populations is expected to be low in magnitude. Some areas disturbed by the Project are expected to be reclaimed after closure except for localized effects from residual disturbance, which will not be reclaimed. Changes to traditional use plant habitat will be permanent and irreversible because the type of vegetation in reclaimed areas is unknown at this time. Residual effects from the Project on traditional use plant species are expected to be small and at the local scale (confined to the Project footprint). The incremental and cumulative effects from the Project and other developments are predicted to not significantly influence self-sustaining and ecologically effective traditional use plants.

The effect of ground subsidence on vegetation from the Project is low in magnitude and regional in geographic extent. Small, localized changes to flow pathways and drainage areas are predicted within the West Loon Creek basin in the ESA. The flows along major flow paths (i.e., West Loon Creek) are predicted to be maintained; however, localized alterations of flow pathways are predicted and ponding sections may appear. Changes to vegetation from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for over more than one hundred years. Areas that have become more depressional in the landscape may be expected to accumulate more snow runoff and rainfall, which will increase soil moisture and may create wetland plant communities. Alternatively, existing wetlands may drain and become upland plant communities. Changes in soil moisture are expected to occur at a rate slow enough to allow for reciprocal changes in the distribution of plant communities. These changes in soil moisture and distribution of upland and wetland vegetation are not expected to result in a net decrease in vegetation. The distribution of upland and wetland vegetation is expected to change, but will compose similar proportions of the landscape after subsidence has occurred.

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13.11 Glossary

Term	Definition
Abundance	The number of individuals.
Adverse effect	An undesirable or harmful effect on an organism (human or animal) indicated by some result such as mortality, altered food consumption, altered body and organ weights, altered enzyme concentrations, or visible pathological changes.
At risk	Species in danger of becoming extinct (global loss) or extirpated (gone from a certain part of the world). Species at risk are usually at risk because of environmental or human-induced changes to them or their habitat on a local, regional, or global scale.
Baseline study area (BSA)	An area designed to measure and characterize existing environmental conditions on a continuum of scales from the anticipated Project footprint to broader, regional levels.
Basin	A large area that is lower in elevation than surrounding areas and contains water. Basins are separated by land or shallow channels.
Best Practice	Method or procedure that is accepted by industry as being effective, practical and reliable in maintaining quality, and meeting Project objectives and regulatory requirements.
Biodiversity	The level of variety, or diversity, that exists in a natural system, especially the number of species. Biodiversity includes the number of ecosystem types and genetic variation, within species.
Brine	A concentrated solution of inorganic salts.
Bryophytes	Non-vascular plants from the phylum Bryophyta (a division of the plant kingdom). Species within this phylum include mosses, liverworts, and hornworts.
Canadian Council of Ministers of the Environment (CCME)	National Canadian body that sets ambient guidelines for air, water, soil, and contaminants.
Chlorophyll	A biomolecule produced in plants, which gives them their green color; critical in photosynthesis, which allows plants to absorb energy from light.
Classification, vegetation	The systematic arrangement of plant communities into categories according to their inherent characteristics. Groupings are made based on dominant vegetation species, in association with commonly associated species and a commonly associated set of site and soil conditions.
Climate	The prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, cloudiness, and winds, throughout the year, averaged over a series of years.
Community (biology)	Group of co-existing organisms in an ecosystem.
Defoliation	To cause the leaves of (a plant or plants) to fall off.
Digital Elevation Model (DEM)	A three-dimensional representation of a terrain's surface.
Distribution	The pattern of dispersion of an entity within its range.
Disturbed Land	Land that has experienced a significant change, usually because of human activity or natural processes such as erosion or fire.
Diversity	A numerical index that incorporates evenness and richness; diversity measures the proportional distribution of organisms in the community.
Dominant	In natural resources mapping, the feature (soil type, terrain, or other feature) that constitutes the majority of a mapping unit (generally 40% or more, and usually 50% or more).
Drainage	The removal of excess surface water or groundwater from land by natural runoff and percolation, or by means of surface or subsurface drains.
Ecological Landscape Classification (ELC)	A means of classifying landscapes by integrating landforms, soils, and vegetation components in a hierarchical manner.

Term	Definition
Ecoregion	Subdivisions of ecozones that are relatively homogeneous with respect to soil, terrain, and dominant vegetation.
Ecosystem	An integrated and stable association of living and non-living resources functioning within a defined physical location. A community of organisms and its environment functioning as an ecological unit. For the purposes of assessment, the ecosystem must be defined according to a particular unit and scale.
Ecosystem Type	An ecosystem type is a standardized name that is given to an identifiable group of living organisms (defined by and named using the most common plant species) that interact among themselves and which, together with their environment (soil, climate, water, and light), function as a unit.
Ecotone	The transition of physical and biological characteristics from one community to the next.
Ecozone	Areas of the earth's surface representative of large and very generalized units characterized by interactive and adjusting abiotic and biotic factors. The ecozone lies at the top of the ecological hierarchy and defines, on a sub continental scale, the broad mosaics formed by the interaction of macroscale climate, human activity, vegetation, soils, geological, and physiographic features of the country.
Effect	The term “effect,” used in the effects analyses, is regarded as an “impact” in the residual impact classification. An effect represents a change in a valued component (VC). Any response by an environmental or social component to an action's impact. Under the *Canadian Environmental Assessment Act*, "environmental effect" means, in respect of a Project, "(a) any change that the Project may cause in the environment, including any effect of any such change on health and socio-economic conditions, on physical and cultural heritage, on the current use of lands and resources for traditional purposes by Aboriginal persons, or on any structure, site or thing that is of historical, archaeological, paleontological or architectural significance and (b) any change to the Project that may be caused by the environment, whether any such change occurs within or outside of Canada.
Effects study area (ESA)	A broad area defined for the description of vegetation conditions generally centered on the Project and surroundings.
Emission	The act of releasing or discharging air contaminants into the ambient air from any source.
Endangered, species	A species facing imminent (20% or greater probability) extirpation (gone from a certain part of the world) or extinction (global loss).
Fern	A type of vascular plants that reproduce via spores and have neither seeds nor flowers.
Fern allies	A diverse group of seedless vascular plants that are not true ferns (e.g., clubmoss). Like ferns, a fern ally disperses by shedding spores to initiate an alternation of generations.
Footprint	The proposed development area that directly affects the soil and vegetation components of the landscape.
Forb	An herbaceous plant that is not a grass, sedge, or rush.
Fragmentation, population	A form of population segregation often caused by habitat fragmentation. Population fragmentation causes inbreeding depression, which leads to a decrease in genetic variability in the species involved.
Frequency	Refers to how often an effect will occur.
Fungi	Are eukaryotic (possesses a clearly defined nucleus) organisms that lack chlorophyll. Fungi are clearly distinguished from all other living organisms, including animals, by their principal modes of vegetative growth and nutrient intake. Fungi grow from the tips of filaments (hyphae) that make up the bodies of the organisms (mycelia), and they digest organic matter externally before absorbing it into their mycelia.
Geographic Information System (GIS)	Computer software designed to develop, manage, analyze, and display spatially referenced data.
Germination	The process by which a plant grows from a seed.

Term	Definition
Global Positioning System (GPS)	A space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites.
Graminoid	An herbaceous plant with narrow leaves growing from the base. These include "true grasses" of the family Poaceae (*Gramineae*), as well as sedges (*Cyperaceae*) and rushes (Juncaceae). True grasses include cereals, bamboo, and the grasses of lawns (turf) and grassland.
Habitat	The physical location or type of environment in which an organism or biological population lives or occurs.
Herb	Any flowering plant except those developing persistent woody bases and stems.
Hummock	A very complex sequence of slopes extending from somewhat rounded depressions or kettles of various sizes to irregular to conical knolls or knobs. A lack of concordance exists between knolls and depressions. Slopes are generally 9% to 70%.
Individual	A single plant or organism within a larger community.
Inflow	Water flowing into a lake.
Invasive, weed(s)	Invasive weeds are typically introduced plants that have the capacity to markedly alter plant communities or displace native plants, reduce biodiversity, and can cause economic damage to private and public lands. These species are aggressive competitors for moisture, nutrients and light, and typically do not have predators or pathogens.
Landscape	A heterogeneous land area with interacting ecosystems that are repeated in similar form throughout. From a wildlife perspective, a landscape is an area of land containing a mosaic of habitat patches within which a particular "focal" or "target" habitat patch is embedded.
LiDAR	A remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth.
Map unit	A combination of kinds of soil, terrain, or other feature that can be shown at a specified scale of mapping for the defined purpose and objectives of a particular survey.
Meandering	Following a winding or intricate course.
Measurement indicator	Measurement indicators represent properties or attributes of the environment and VCs that, when changed, could result in, or contribute to, an effect on assessment endpoints. Measurement indicators may be quantitative (e.g., concentrations of metals in surface water) or qualitative (e.g., movement and behaviour of wildlife from disturbance to habitat and travel corridors).
Microhabitat	The small-scale physical requirements of a particular organism or population.
Mitigation	The elimination, reduction or control of the adverse environmental effects of a project, including restitution for any damage to the environment caused by such effects through replacement, restoration, compensation, or any other means.
Moisture regime	Represents the available moisture supply for plant growth on a relative scale assessed through an integration of species composition and soil and site characteristics. Moisture regime ranges from very dry to wet.
No linkage pathway	The potential pathway has no linkage or is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on vegetation relative to the Base Case or guideline values.
Non-vascular plant	Plants that do not possess conductive tissues (e.g., veins) for the transport of water and food.
Noxious, weed(s)	Any plant, as defined by the Weed Control Act (2010), that is designated by order of the minister as a noxious weed, and includes the seeds or any other part of that plant that may grow to produce another plant.
Nuisance, weed(s)	Any plant, as defined by *The Weed Control Act* (2010), that is designated by order of the minister as a nuisance weed, and includes the seeds or any other part of that plant that may grow to produce another plant.

Term	Definition
Nutrients	Environmental substances (elements or compounds) such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.
Organic matter	Plant and animal materials that are in various stages of decomposition.
Pathway analysis	Identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects after mitigation.
Photosynthesis	The process used by plants and other organisms to convert light energy, normally from the Sun, into chemical energy that can be later released to fuel the organisms' activities.
Plant community	A collection of plants that live together on a relatively uniform area of land with a floristic composition and structure that is distinct from surrounding vegetation.
Pollinator	The biotic agent that moves pollen from the male anthers of a flower to the female stigma of a flower to accomplish fertilization. Common pollinators are birds and insects (e.g., bees).
Potassium chloride (KCl)	A salt composed of potassium and chloride, of which potassium is the primary component in potash fertilizer.
Population	A group of individuals of the same species that is primarily affected by natural and human-related factors that change survival and reproduction of individuals.
Prohibited, weed(s)	Any plant, as defined by *The Weed Control Act* (2010), that is designated by order of the minister as a prohibited weed, and includes the seeds or any other part of that plant that may grow to produce another plant.
Propagule	Any material that is used for propagating an organism to the next stage in their life cycle. Propagules are produced by plants (in the form of seeds or spores), fungi (in the form of spores), and bacteria.
Primary pathway	A primary pathway is likely to result in environmental change that could contribute to residual effects relative to the Base Case or guideline values.
Range	The geographic limits within which an organism occurs.
Rare plant	A native plant species found in restricted areas, at the edge of its range or in low numbers within a province, state, territory, or country.
Reasonably foreseeable development (RFD) case	The RFD case represents the Application Case and reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities.
Respiration	Respiration is the gas exchange affected by living organisms for sustaining vital metabolic processes. In plants, it is the opposite of photosynthesis; carbon dioxide is consumed and oxygen is expelled.
Riparian	Refers to terrain, vegetation or simply a position next to or associated with a stream, floodplain, or standing waterbody.
Scale	The resolution at which patterns are measured, perceived, or represented. Scale can be broken into several components, including geographic extent, resolution, and other aspects.
Secondary pathway	A secondary pathway could result in a measurable minor environmental change, but would have a negligible residual effect relative to the Base Case or guideline values and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect.
Sediment	Solid particles of material that have been derived from rock weathering. They are transported and deposited from water, ice, or air as layers at the Earth's surface.
Seepage	Slow water movement in subsurface. Flow of water from man-made retaining structures. A spot or zone, where water oozes from the ground, often forming the source of a small spring.

Term	Definition
Sensitive	■ sites or organisms that are particularly vulnerable to harm. ■ a general status rank for a species with one or more of the effects. ■ in statistics, parameter sensitivity refers to a series of tests in which different parameter values are set to see how a change in the parameter causes a change in the dynamic behaviour of the system in question (e.g., how much does a change in adult female survival affect population growth of a caribou herd).
Shrub	A woody perennial plant differing from a tree by its low stature and by generally producing several basal shoots instead of a single trunk.
Soil	The naturally occurring, unconsolidated mineral or organic material that occurs at the Earth's surface and is capable of supporting plant growth.
Special concern	A plant species that may become threatened or endangered because of a combination of biological characteristics and identified threats.
Species	A group of organisms that actually or potentially interbreed and are reproductively isolated from all other such groups; a taxonomic grouping of genetically and morphologically similar individuals; the category below genus.
Species Richness	The number of different species in a given area.
Stomata	Tiny openings or pores that are found on the under-surface of plant leaves. Stomate are used plants for gas exchange with the atmosphere.
Temporal	Related to time.
Threatened	A species that is likely to become endangered if nothing is done to reverse the factors leading to its extirpation (gone from a certain part of the world) or extinction (global loss).
Topography	The surface features of a region, such as hills, valleys, or rivers.
Traditional Knowledge	The knowledge, innovations, and practices of indigenous people; refers to the matured long-standing traditions and practices of certain regional, indigenous, or local communities.
Traditional use plants	Plant species that were and/or are currently used for food, medicinal, spiritual, or technical/trade (i.e., tools or products for use or trade) purposes by First Nations and Métis people.
Translocate, transplant	To move from one location to another.
Uncertainty	Imperfect knowledge concerning the present or future state of the system under consideration; a component of risk resulting from imperfect knowledge of the degree of hazard or of its spatial and temporal distribution.
Understory	Trees or other vegetation in a forest that exist below the main canopy level.
Valued Component (VCs)	Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by society.
Vascular plant(s)	Plants possessing conductive tissues (e.g., veins) for the transport of water and food.
Vegetation Type	Base unit of identification during field surveys. Can be analogous to ecosystem type but is generally used to describe vegetation at the site-level.
Weed	A plant that is undesirable in its current location. For example, weedy species in an agricultural field may include native plants, while crop and forage plants are considered weeds in native habitat.
Wetland	Land having the water table at, near, or above the land surface or which is saturated for a long enough period to promote wetland or aquatic processes as indicated by hydric soils, hydrophytic vegetation and various kinds of biological activity which are adapted to the wet environment.
Woody species	A plant that produces wood as its structural tissue. The main stem, larger branches, and roots of these plants are usually covered by a layer of bark.
Wildlife	A term to describe all undomesticated animals living in the wild.

Term	Definition
Zone of influence	The defined area affected by alterations or disturbances from sensory disturbance that may have an effect on wildlife abundance and distribution.

14.0 WILDLIFE

14.1 Introduction

14.1.1 Background

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project) located in central Saskatchewan, approximately 60 kilometres (km) north of Regina. Yancoal proposes to develop the Project, which includes solution mining and associated supporting infrastructure.

The Project is located in the Rural Municipality (R.M.) of Longlaketon (No. 219) and the R.M. of Cupar (No. 218). An existing network of municipal grid roads, provincial highways, and rail lines will provide access to the Project. The Project (including the core facilities area, 65-year mine field, and indicated resource boundary) encompasses approximately 143.2 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M).

14.1.2 Purpose and Scope

This section of the Environmental Impact Statement (EIS) for the Project addresses the effects on wildlife identified in the Terms of Reference (TOR) approved by the Environmental Assessment Branch (EAB) of the Ministry of Environment (MOE) in May 2015 (Appendix 2-B).

The purpose of this section is to meet the TOR, specifically to assess the effects from the Project on wildlife. The scope of the wildlife section includes an analysis of Project-related changes during construction, operation, and decommissioning and reclamation. The incremental and cumulative residual effects from the Project and other previous, existing, and reasonably foreseeable developments on wildlife are assessed.

Strong relationships exist among soils, vegetation (wildlife habitat), and wildlife that inhabit the landscape. Terrestrial ecosystem function relies on the interactions among climate, soils, the hydrological cycle, vegetation, and wildlife species. Natural and human-related disturbances can change the interactions between the physical and biological components of the terrestrial environment. Changes in the terrestrial environment can also influence the opportunity for human use of natural resources (e.g., hunting, trapping), which can affect the socio-economic environment. As such, related assessments are provided in the following sections:

- Atmospheric Environment (Section 7.0);
- Hydrogeology (Section 8.0);
- Hydrology (Section 9.0);
- Surface Water Quality (Section 10.0);
- Soils (Section 12.0);
- Vegetation (Section 13.0); and
- Socio-economic Environment (Section 16.0).

14.1.3 Valued Components, Assessment Endpoints, and Measurement Indicators

The TOR identified wildlife as a valued component (VC) that should be included in the assessment of effects on the terrestrial environment. Wildlife VCs selected for the Project are listed in Table 14.1-1. Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by the proponent, the public, First Nations and Métis communities, and government agencies. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development and, therefore, are used to predict the effects of the Project on all environmental components. Seven wildlife VCs were selected for detailed study in the EIS (Table 14.1-1). The VC selection was based on the following criteria:

- represent important ecosystem processes;
- potential for interaction with the Project and sensitivity to Project-related effects;
- can be measured or described with one or more practical indicators;
- the species or species group is of ecological or socio-economic value to government agencies or the public; and
- designated by federal and provincial legislation.

Table 14.1-1: Rationale for Selection of Wildlife Valued Components

Valued Component	Rationale
white-tailed deer	large home range size; societal importance (hunting)
elk	large home range size; societal importance (hunting); limited distribution in Saskatchewan
upland birds	small territory size and high bird density means large numbers of upland birds may be affected by habitat loss; migratory birds are susceptible to population declines as a result of changing environmental conditions on breeding and overwintering habitats; includes numerous federally listed and provincially tracked species
waterbirds	waterbirds may be affected by loss of shoreline habitat for breeding; important staging habitat may also be lost; sensitive to noise disturbance and human activity; includes numerous federally listed and provincially tracked species
ferruginous hawk	breeding habitat is limited because the Project is near the northern extent of the species breeding range; sensitive to noise disturbance and human activity during nesting; federally listed species
short-eared owl	breeding habitat is limited; federally listed species
northern leopard frog	breeding habitat is limited; federally listed species

Moose (*Alces alces*), coyote (*Canis latrans*), muskrat (*Ondatra zibethicus*), and beaver (*Castor canadensis*) were initially considered as wildlife VCs but were ultimately not considered in the assessment of potential effects from the Project on wildlife for the following reasons. Coyote that inhabit prairie ecosystems are known to habituate to human presence on the landscape (Van Deelen and Gosselink 2006). The Project is located in a highly cultivated landscape, close to Highway 6 and the community of Southey. As such, coyote in the proximity of the Project are anticipated to be habituated to the presence of humans and human activity on the landscape. In addition, coyote populations are resilient to human disturbance because of their high reproductive rates and large population sizes. The moose population in southern Saskatchewan has been increasing over recent years and harvest quotas have increased from 250 tags in 2008 to 1,335 tags in 2012 (McEachern 2012), a 5-fold increase. As such, it appears moose are resilient to human disturbance in southern Saskatchewan and the Project is not likely to negatively affect moose populations. Similarly, beaver and muskrat have not been found to be negatively affected by the presence of human developments and have high reproductive rates (Jenkins and Busher 1979; Willner et al. 1980).

The wildlife assessment focuses on measurement indicators and assessment endpoints derived from ecology and conservation science. Community and regulatory engagement, and local and traditional knowledge were a key consideration for selecting VCs, but assessment endpoints for wildlife VCs do not explicitly consider societal values, such as continued opportunities for traditional and non-traditional use of wildlife. Societal values concerning changes in wildlife VCs are important and must be considered to understand the full suite of potential effects of the Project (i.e., both human and ecological dimensions). Consequently, measurement indicators from the wildlife section were carried forward so effects on societal values could be appropriately captured in the sections dealing specifically with those values (Section 16.0).

Assessment endpoints are qualitative expressions used to assess the significance of effects on a VC and represent the key properties of the VC that should be protected for use by future human generations (i.e., incorporate sustainability). Assessment endpoints are general statements about what is to be protected. Measurement indicators are quantitative and/or qualitative expressions of changes to the assessment endpoints. The assessment endpoint for wildlife VCs is self-sustaining and ecologically effective wildlife populations.

Long-term population viability is frequently applied as an ecologically relevant target by conservation biologists and resource managers (With and Crist 1995; Fahrig 2003; Ruggiero et al. 2007). Self-sustaining populations are healthy, robust populations capable of withstanding environmental change and accommodating stochastic demographic processes (Reed et al. 2003). Maintaining ecologically effective populations and communities goes beyond what may be required only to achieve a self-sustaining population and requires that healthy ecological relationships are maintained among species to prevent unexpected biodiversity loss due to changes in properties of highly interactive species (Soulé et al. 2003, 2005).

The measurement indicators include the following:

- habitat quantity, arrangement, and connectivity (fragmentation);
- habitat quality;
- survival and reproduction; and
- abundance and distribution of wildlife VCs.

Changes in abundance and distribution of wildlife VCs are not quantified at the population level, but are inferred from the independent or combined results of the numerical and qualitative analyses of changes in habitat quantity and quality, and survival and reproduction.

14.2 Environmental Assessment Boundaries

14.2.1 Spatial Boundaries

14.2.1.1 Baseline Study Area

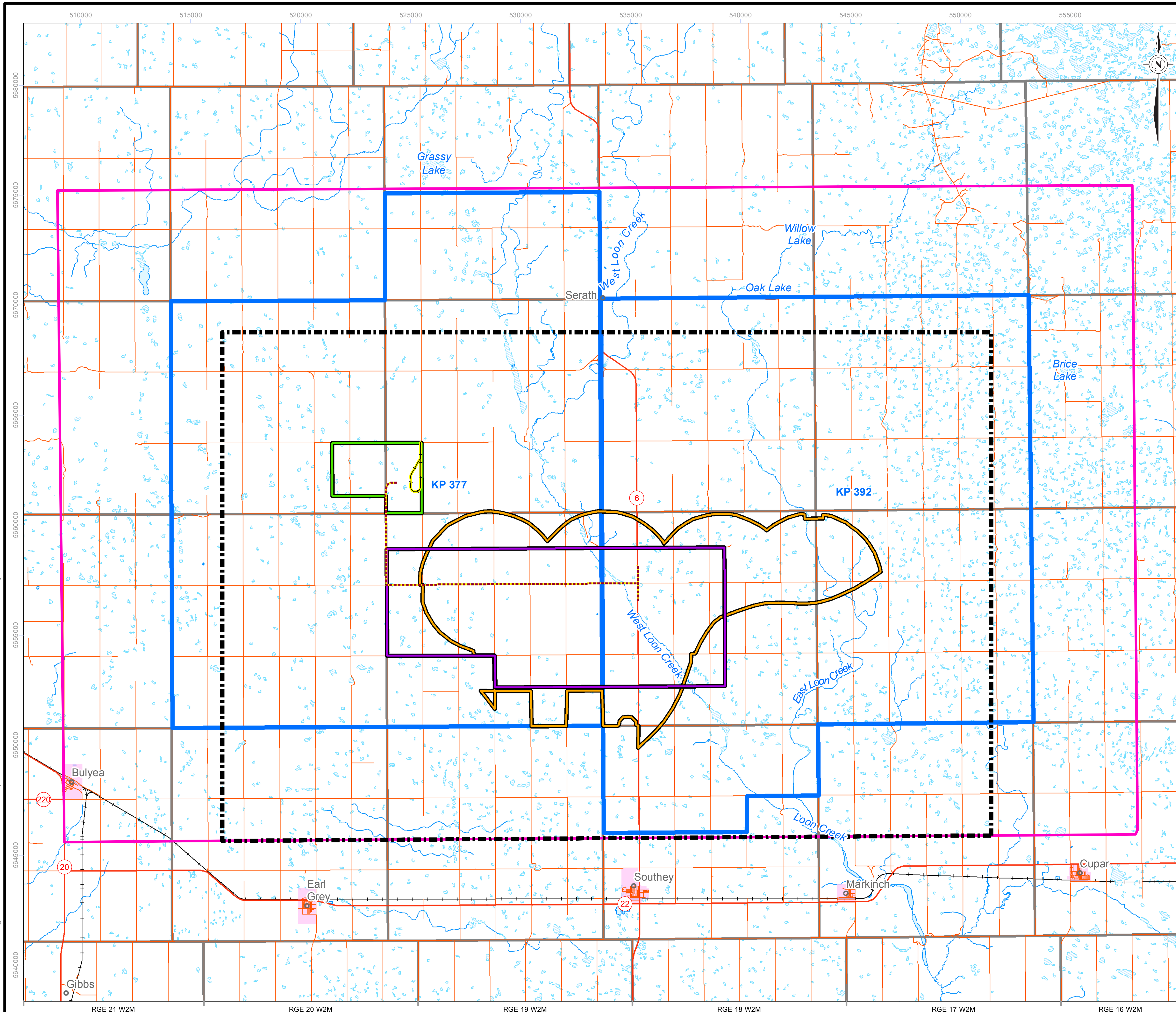
To quantify baseline conditions of the terrestrial environment, a baseline study area (BSA) was delineated for terrain and soils, vegetation, and wildlife. The BSA was designed to characterize existing environmental conditions on a continuum of scales from the Project footprint to broader, regional levels. At the initiation of field programs, the location of the Project footprint was unknown; therefore, a preliminary focus area was delineated for the Project (Annex IV, Section 2.0). The focus area was buffered by 5 km to encompass potential indirect effects from the Project on vegetation and wildlife. As Project design evolved, this area was increased to encompass the entire KP377 and KP392 permit areas and a 5 km buffer area. The final BSA selected for terrestrial components encompassed an area of approximately 1,444 km^2 (144,425 ha) area (Annex IV, Section 2.0). The north portion of KP377 and the south portion of KP392 were not buffered by 5 km for the final BSA, because of low likelihood that the Project footprint would occur in these areas.

Data collected at the Project site and local scales were used to provide precise measures of baseline environmental conditions and predict the direct and indirect changes from the Project on VCs (e.g., changes to terrestrial habitat from the Project's physical footprint and dust and air emissions). Data collected at larger scales were used to measure broader-scale baseline environmental conditions and to provide regional context for the combined direct and indirect effects from the Project on VCs.

14.2.1.2 Effects Study Area

The effects study area (ESA) is 803.9 km^2 (80,385 ha) and is located within the BSA (Figure 14.2-1). The scale and boundaries of the birds ESA were defined to capture the diversity of habitats that support the seasonal requirements of wildlife VCs. Benitez-Lopez et al. (2010) reported that most songbirds and waterbirds have lower abundances within 1 km of human developments. Therefore, an approximate 5-km buffer was used to define the ESA to encompass the predicted maximum spatial extent of direct and indirect effects (i.e., zones of influence) from the Project on songbirds, waterbirds, and raptors. The ESA encompasses unaffected (i.e., reference) areas, as well as areas affected by the Project. Amphibians, songbirds, waterbirds, and raptors are anticipated to be the primary wildlife species likely to be negatively affected by the Project.

The assessment of Project effects on amphibians and birds is completed at the scale of the ESA, which is intended to be large enough to contain all or most individuals that comprise the breeding populations that inhabit the area for part or all of the year. Here, the population (or population area) is defined by a group of individuals of the same species occupying an area of sufficient size so that emigration and immigration are infrequent, and most of the changes in abundance and distribution are determined by reproduction and survival (Berryman 2002). For species with small to moderate breeding home ranges (e.g., amphibian and bird VCs), the population should be primarily affected by natural and human-related factors that change survival and reproduction of individuals within the ESA, and should be little influenced by dispersal. In other words, developments outside of the ESA should have no or little influence on these populations while they inhabit the area for part of the year.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- PROPOSED ACCESS ROAD
- PROPOSED RAIL LOOP
- PERMIT BOUNDARY
- 65 YEAR MINE FIELD
- CORE FACILITIES AREA
- INDICATED RESOURCE BOUNDARY
- BASELINE STUDY AREA
- EFFECTS STUDY AREA

REFERENCE

PERMIT BOUNDARY: POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

4 0 4
SCALE 1:175,000 KILOMETRES

PROJECT

YANCOAL 兖煤加拿大资源有限公司

YANCOAL
SOUTHEY PROJECT

TITLE

LOCATION OF THE WILDLIFE EFFECTS STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	LD	25/05/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	**FIGURE: 14.2-1**	
CHECK	LD	25/05/15		
REVIEW	JV	25/05/15		

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14.2.2 Temporal Boundaries

Temporal boundaries for the wildlife assessment were defined by the life of the Project (Section 4.0) and the existing and future cumulative effects to which the Project might contribute. The Project phases are construction, operation, and decommissioning and reclamation. Final relinquishment of the Project will occur after the completion of reclamation. Many effects of the Project will end when operations cease or at Project closure, but effects on wildlife will continue after Project closure until wildlife habitat is re-established.

The effects analysis encompasses the Project phases as follows:

- construction (2016 to 2019);
- operations (2019 to 2119); and
- decommissioning and reclamation (2119 onward).

The above timeframes are intended to be sufficiently flexible to capture the effects of the Project on the wildlife VCs. Effects on wildlife populations begin during the construction phase with the removal and alteration of wildlife habitat for site development, and continue through the operation phase and for a period during the completion of reclamation activities (unless determined to be permanent). Therefore, effects on wildlife were analyzed and assessed for significance from Project construction through decommissioning and reclamation and consider the time it takes for vegetation recovery. This approach generates the maximum potential spatial and temporal extent of effects on the abundance and distribution of wildlife populations, which provides confident and ecologically relevant effects predictions.

Although the assessment of residual effects of the Project considers all Project phases listed above, temporal snapshots (i.e., static moments in time) were used to characterize the ESA landscapes and facilitate quantitative comparisons for each of the assessment cases described below.

14.2.2.1 Base Case

The Base Case (existing environment) represents conditions before application of the Project. Existing developments (i.e., built prior to 2013) as visible from satellite imagery and available digital data (e.g., roads and communities from CanVec [NRC 2012]) were used to map current developments in the ESA. Consequently, the Base Case represents the cumulative outcome of all previous and existing developments and activities.

14.2.2.2 Application Case

The incremental contributions of residual effects from the Project to existing cumulative effects were assessed at the ESA scale by adding the Project to the Base Case to form the Application Case. The temporal snapshot used was the Project footprint at a maximum point of development of the Project (i.e., core facilities area, plant site access road, and 19 well pads and associated well site access roads). Changes to measurement indicators for wildlife VCs were predicted for the incremental contributions of the Project, and cumulative effects of the Project plus previous and existing developments and activities were evaluated.

14.2.2.3 Reasonably Foreseeable Development Case

The Reasonably Foreseeable Development (RFD) Case represents the Application Case plus reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. Thus, the minimum temporal boundary for the Application Case and RFD Case is the expected lifespan of the Project that, like the Base Case, includes a range of conditions over time. The difference between the Application and RFD Case is that the Application Case considers the incremental effect from the Project in isolation of potential future land use activities. The RFDs are defined as projects that:

- are currently under regulatory review or have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project or may be induced by the Project;
- have been approved but not yet developed; or
- have the potential to change the Project or the effects predictions.

The reasonably foreseeable developments identified in Section 6.0 include the supporting infrastructure required for the Project, the Muskowekwan Potash Mine Project, and the Vale Kronau Project. Supporting infrastructure will include a water supply pipeline, an overhead transmission line, a natural gas supply pipeline, telecommunication services, and a railway line. Screening assessment reports will be completed by each of the utility providers once the final routing options are determined. Most of the preferred routes for the supporting infrastructure are not within the ESA and the final routing options are not known at this time. The Muskowekwan Potash Mine Project is located approximately 52 km to the northeast of the Project, and the Vale Kronau Project is located approximately 71 km south of the Project, both of which are outside of the ESA. Effects on wildlife from development of the Muskowekwan Potash Mine Project and the Vale Kronau Project are not expected to overlap with effects on wildlife in the ESA. Therefore, the RFD Case is not included in this section of the EIS.

14.3 Existing Environment

The purpose of this section is to describe the existing environment (Base Case) as a basis to assess the Project-specific effects on wildlife. The detailed methods and results for baseline conditions are located in the Terrestrial Environment Baseline Report (Annex IV, Section 5.0).

14.3.1 White-Tailed Deer

White-tailed deer are the most abundant and widely distributed ungulate in Saskatchewan (MOE 2013). White-tailed deer populations in Saskatchewan are highest in farmland and parkland Wildlife Management Zones (WMZs) (MOE 2013). No population estimate is available for WMZ 21, which contains the BSA. Populations in prairie wildlife management zones have remained relatively stable from 2006 to 2011 and are near their long-term averages, but harsh winters in 2009/2010 and 2010/2011 have caused a downward population trend (MOE 2013). In general, populations in WMZs 15 to 30 are limited by the quality of winter habitat, which constrains population size and growth (MOE 2013). There does not appear to be critical wintering habitat in the BSA (MOE 2013).

Due to of the difficultly in determining age, sex, and species of deer because of the timing of the aerial surveys, all observations of deer species were grouped for analysis. The estimate of deer species density (± 1SE) from the aerial survey was 0.68 ± 0.24 individuals per km^2 A total of 447 deer in 64 observations (12 individuals and 52 groups ranging in size from 2 to 60 individuals) were recorded within transects during the aerial survey (Annex IV, Section 5.3.5.1). Approximately 3,705 deer are estimated to be in the BSA, based on the number of deer observed during the aerial survey.

Most deer species recorded during the ungulate aerial surveys were observed in wooded habitats (168 individuals [38%]) and cultivated habitats (157 individuals [36%]) (Annex IV, Section 5.3.5.1). Deer were also observed in wooded wetland (111 individuals [25%]), modified grassland (4 individuals [1%]), and disturbance (1 individuals [less than 1%]) habitats during the aerial survey.

Tracks of white-tailed deer and mule deer were combined for the winter track count (WTC) survey analysis because it was difficult to differentiate tracks between these two species. Deer tracks occurred in the highest density in non-wooded wetland habitat (Table 14.3-1). Track density was lowest in cultivated habitat.

Table 14.3-1: Snow Track Density and Habitat Selection of Deer Species among Habitats within the Baseline Study Area, 2014

Habitat Type	Mean TKD[(a)] (± 1SE)	Total TKD[(a)]	Distance Sampled (km)	Proportion of Total Tracks (Use)	Proportion of Total Habitat Available[(b)]	95% Confidence Intervals for Use
Cultivated	0.58 ± 0.24	106.65	91.70	0.10	0.55	0.08 - 0.12
Disturbance	0	0	1.02	0	0.01	0
Modified grassland	1.14 ± 0.65	151.31	43.70	0.14	0.17	0.11 - 0.17
Native grassland	0.91 ± 0.58	44.70	9.34	0.04	0.07	0.03 - 0.06
Non-wooded wetland	3.92 ± 2.79	297.60	8.47	0.52	0.14	0.48 - 0.56
Wooded	3.37 ± 1.63	208.82	7.38	0.20	0.06	0.16 - 0.23
Wooded wetland	2.44 ± 1.50	261.32	10.29	n/a[(c)]	n/a[(c)]	n/a[(c)]
Total	**1.73 ± 0.49**	**1,070.39**	**171.94**	**1.00**	**1.00**	**n/a**

(a) TKD = number of tracks per kilometre sampled per number of days since last snowfall or wind event to the nearest half-day.
(b) Proportion of total habitat available = expected proportion of use. A habitat type is preferred if the expected proportion of use is below the 95% confidence intervals for use of that habitat type, the habitat is neutrally selected if the expected proportion of use is within the 95% confidence interval, and the habitat is avoided if the expected proportion of use is above the 95% confidence interval.
(c) No value is available because wooded wetland habitat could not be identified in the Ecological Landscape Classification (Annex IV, Section 4.3.1).
SE = standard error; km = kilometres; % = percent; n/a = not applicable.

Habitat selection analysis for deer species within the BSA indicated that deer winter track densities were significantly different among six habitat types (Chi-square = 1,805.24, df = 5, P <0.001). Bonferroni confidence intervals indicate that cultivated, disturbance, and native grassland habitats were avoided relative to availability (Table 14.3-1). Wetland and wooded habitats were preferred relative to availability, while modified grassland was used in proportion to its availability (Table 14.3-1).

14.3.2 Elk

Cypress Hills and Moose Mountain Provincial Parks contain most of the Saskatchewan elk population at an estimated 1,100 and 1,400 individuals, respectively (MOE 2013). Outside of these two areas, two thirds of the elk population in Saskatchewan is found east of Tisdale and north of Canora to Cumberland Lake (MOE 2013). In WMZ 21, which contains the BSA, there are estimated to be 300 elk. Elk density (± 1SE) during the aerial survey was estimated to be 0.02 ± 0.01 individuals per km^2. Two groups of elk (three individuals and seven individuals) were observed during the aerial survey at distances of 9 and 19 km from the proposed core mine facilities area. The estimated number of elk within the BSA was 84 individuals.

Elk track density observed during WTC surveys was the highest in wooded habitat (Table 14.3-2). Track density was lowest in non-wooded wetland habitat and no elk tracks were observed in cultivated, disturbance, or wooded wetland habitat. Habitat analysis of WTC survey data suggested that the occurrence of elk tracks was significantly different among five habitat types (Chi-square = 704.81, df = 4, P <0.001). Bonferroni confidence intervals indicated that cultivated, disturbance, and wetland habitats were avoided relative to availability, while modified grassland was used in proportion to its availability (Table 14.3-2). Wooded habitat and native grassland were preferred relative to their availability.

Table 14.3-2: Snow Track Density and Habitat Selection of Elk among Habitats within the Baseline Study Area, 2014

Habitat Type	Mean TKD[(a)] (± 1SE)	Total TKD[(a)]	Distance Sampled (km)	Proportion of Total Tracks (Use)	Proportion of Total Habitat Available[(b)]	95% Confidence Intervals for Use
Cultivated	0	0	91.70	0	0.55	0
Disturbance	0	0	1.02	0	0.01	n/a[(c)]
Modified grassland	0.33 ± 0.14	43.59	43.70	0.24	0.17	0.16 - 0.33
Native grassland	0.82 ± 0.40	40.29	9.34	0.23	0.07	0.14 - 0.31
Non-wooded wetland	0.11 ± 0.08	8.14	8.47	0.05	0.14	0.01 - 0.09
Wooded	1.40 ± 0.45	86.50	7.38	0.48	0.06	0.39 - 0.58
Wooded wetland	0	0	10.29	n/a[(d)]	n/a[(d)]	n/a[(d)]
Total	**0.29 ± 0.07**	**178.53**	**171.94**	**1.00**	**1.00**	**n/a**

(a) TKD = number of tracks per kilometre sampled per number of days since last snowfall or wind event to the nearest half-day.
(b) Proportion of total habitat available = expected proportion of use. A habitat type is preferred if the expected proportion of use is below the 95% confidence intervals for use of that habitat type, the habitat is neutrally selected if the expected proportion of use is within the 95% confidence interval, and the habitat is avoided if the expected proportion of use is above the 95% confidence interval.
(c) Expected proportion of use was less than 5.
(d) No value is available because wooded wetland habitat could not be identified in the Ecological Landscape Classification (Annex IV, Section 4.3.1).
SE = standard error; km = kilometre; % = percent; n/a = not applicable.

14.3.3 Upland Breeding Birds

Upland breeding birds include songbirds (members of the order Passeriformes, excluding corvids [e.g., crows, jays]), pigeons and doves (members of the order *Columbiformes*), and yellow-bellied sapsucker (*Sphyrapicus varius*). Corvids, hummingbirds, waterbirds (e.g., ducks, grebes, rails, cranes), shorebirds (e.g., sandpipers), raptors (e.g., owls, hawks), and woodpeckers (except yellow-bellied sapsucker) were excluded from breeding bird analyses because they are not adequately sampled using the point count method (Kirk and Hyslop 1998; Schmiegelow et al. 1997).

Upland bird species that are listed under the *Species at Risk Act* (SARA) that may occur in the ESA include Sprague's pipit (*Anthus spragueii*), loggerhead shrike (*Lanius ludovicianus excubitorides*), barn swallow (*Hirundo rustica*), bank swallow (*Riparia riparia*), Baird's sparrow (*Ammodramus bairdii*), chestnut-collared longspur (*Rhynchophanes ornatus*), McCown's longspur (*Rhynchophanes mccownii*), and bobolink (*Dolichonyx oryzivorus*). No species-specific surveys were completed for these species as all (except bank swallow) are adequately sampled using upland breeding bird surveys. As the Project is not located in areas that have the potential to support bank swallow colonies, species-specific surveys were not completed for this species.

Eleven barn swallows and one bank swallow were observed within 100 m of observers during upland breeding bird surveys (Annex IV, Appendix IV.3, Table IV.3-11). Two of the barn swallow observations occurred within the proposed mine well field area. All other observations of barn and bank swallows, observed within 100 m of observers during upland breeding bird surveys, were outside of areas of proposed Project infrastructure. Two bank swallow, two Baird's sparrow, and 14 bobolinks were incidentally observed during breeding bird surveys (Annex IV, Appendix IV.3, Table IV.3-1). A total of 83 barn swallows were incidentally observed during numerous baseline surveys, including breeding bird, waterbird breeding, and waterbird productivity surveys (Annex IV, Appendix IV.3, Table IV.3-1). One loggerhead shrike was observed during raptor stick nest surveys. Nine of the incidental barn swallow and one of the bobolink observations were within the proposed mine well field area. The incidental loggerhead shrike observation was recorded approximately 10 km southeast of the mine well field area. The two incidental bank swallow observations were made approximately 7 km northeast of the proposed core facilities area.

Relative abundance (i.e., density [individuals per ha]) of upland bird species was calculated for each habitat type. Non-wooded wetland had the highest mean density of birds, followed by wooded habitat (Table 14.3-3). Wooded habitat had the highest observed species richness, followed by wooded wetland. Cultivated and modified grassland had the lowest mean densities and species richness of birds.

Table 14.3-3: Density (Individuals per Hectare) and Observed Species Richness of Upland Birds for Habitats in the Baseline Study Area, 2013

Habitat Type	Number of Plots	Density		Species Richness	
		Mean ± 1SE	Min – Max	Mean ± 1SE	Min – Max
Cultivated	99	0.28 ± 0.03	0 - 1.33	0.6 ± 0.1	0 - 3
Modified grassland	35	0.28 ± 0.04	0 - 0.66	0.8 ± 0.1	0 - 3
Native grassland	20	0.72 ± 0.14	0 - 2.99	1.5 ± 0.3	0 - 4
Wooded	54	3.27 ± 0.21	0 - 11.74	5.3 ± 0.3	0 - 12
Non-wooded wetland	42	3.55 ± 0.45	0 - 14.93	2.4 ± 0.3	0 - 8
Wooded wetland	45	2.60 ± 0.22	1.79 - 10.76	5.2 ± 0.3	1 - 11

SE = standard error; Min = minimum; Max = maximum.

14.3.4 Waterbirds

Waterbirds include grebes, geese, ducks, rails (e.g., sora [*Porzana carolina*]), herons, and other bird species that require water for either foraging or nesting habitat. Waterbird species that are listed under SARA that may occur in the ESA include horned grebe (*Podiceps auritus*) and yellow rail (*Coturnicops noveboracensis*). Species-specific surveys were completed for yellow rail (Annex IV, Section 5.2.1.1), while horned grebe were surveyed for during waterbird breeding and productivity surveys (Annex IV, Section 5.2.7). No yellow rails were recorded during baseline surveys. Thirty seven horned grebes were observed during waterbird breeding surveys, and six horned grebes were observed during waterbird productivity surveys. Six horned grebes were incidentally observed during waterbird productivity surveys and upland breeding bird surveys.

Class V wetlands had the highest mean density of adult waterbirds during breeding surveys, and Class IV wetlands had the highest density during productivity surveys (Tables 14.3-4 and 14.3-5). Class V wetlands had the highest species richness during the breeding and productivity surveys.

Table 14.3-4: Density (Individuals per Hectare) (± 1SE) and Observed Species Richness of Waterbirds among Wetland Permanency Classes during Waterbird Breeding Ground Surveys in the Baseline Study Area, 2013

Habitat Type[(a)]	Number of Wetlands Surveyed	Density		Species Richness	
		Mean ± 1SE	Min – Max	Mean ± 1SE	Min – Max
Class I and II Wetlands	47	15.78 ± 3.72	0 – 110.81	1.5 ± 0.2	0 - 6
Class III Wetlands	191	11.49 ± 1.16	0 – 72.96	1.1 ± 0.1	0 - 7
Class IV Wetlands	345	15.27 ± 1.23	0 – 210.47	2.0 ± 0.1	0 - 11
Class V Wetlands	11	25.42 ± 11.18	0 – 133.50	4.2 ± 1.3	0 - 13

[(a)] Wetland classes determined according to Stewart and Kantrud (1971).
SE = standard error; Min = minimum; Max = maximum.

Table 14.3-5: Density (Individuals per Hectare) (± 1SE), and Observed Species Richness of Waterbirds among Wetland Permanency Classes during Waterbird Productivity Ground Surveys in the Baseline Study Area, 2013

Habitat Type[(a)]	Number of Wetlands Surveyed	Density		Species Richness	
		Mean ± 1SE	Min – Max	Mean ± 1SE	Min – Max
Class I and II Wetlands	43	2.57 ± 0.94	0 – 24.94	0.4 ± 0.1	0 - 4
Class III Wetlands	185	2.77 ± 0.60	0 – 49.15	0.4 ± 0.1	0 - 10
Class IV Wetlands	291	5.03 ± 0.62	0 – 58.73	1.0 ± 0.1	0 - 8
Class V Wetlands	11	4.49 ± 1.18	0 – 10.37	2.8 ± 1.2	0 - 14

[(a)] Wetland classes determined according to Stewart and Kantrud (1971).
SE = standard error; Min = minimum; Max = maximum.

14.3.5 Ferruginous Hawk

Ferruginous hawk are raptors of open habitats found in 17 US states and three Canadian provinces (Bechard and Schmutz 1995). Ferruginous hawk are protected under the *SARA* (SARA 2014) and they breed in the prairie habitats of Saskatchewan, Manitoba, and Alberta, with overwintering sites in the southwestern United States. The BSA is not expected to support a self-sustaining and ecologically effective population of ferruginous hawks because the Project is located at the northern extent of the historic breeding range (Downey 2006). There has been a contraction of the northern extent of the breeding range from the early 1900s to the present (Downey 2006). Although a few individuals may nest in the north parts of the former range, these outliers are small in number (Downey 2006). The majority of the ferruginous hawk population breeds in the mixed grassland areas of Alberta and Saskatchewan (Downey 2006). The range contraction may be due to the increase in cultivation. Ferruginous hawk abundance declines as the amount of cultivation in an area increases (Schmutz 1987). In Saskatchewan, the breeding range has retreated southwesterly to areas where native grassland still dominates the landscape (i.e., areas where ranching on native grassland pastures is common) (Downey 2006).

Population trends for this species show declines across breeding ranges with an estimated 14,000 individuals in the grasslands of the Great Plains (Bechard and Schmutz 1995). Based on historical data, ferruginous hawk have been recorded nesting in proximity (within 25 km) of the BSA (SKCDC 2015) and two individuals were incidentally observed in the BSA during raptor stick nest surveys; however, no active ferruginous hawk nests were found in the BSA.

14.3.6 Short-eared Owl

Short-eared owls are a ground nesting raptor found across Canada where they forage and nest in open habitats (Wiggins et al 2006). Short-eared owls are a *SARA* protected species that prefers grassland, agricultural land, fallow pastures, wetland, and shrubland habitats (COSEWIC 2008a). Short-eared owl population estimates have declined annually at 3% over the last 40 years according to the Christmas Bird Count, with the greatest decline observed in Canada (COSEWIC 2008a). Based on historical data, short-eared owls have been observed in close proximity (approximately 1.5 km) to the BSA (SKCDC 2015) and one was incidentally observed in the BSA during waterbird breeding surveys.

14.3.7 Northern Leopard Frog

Northern leopard frogs were not observed during baseline surveys (Annex IV, Section 5.3.2). There are no historical observations of northern leopard frog within the BSA (SKCDC 2015). Most populations of northern leopard frogs in Saskatchewan are associated with major river valleys, such as the Qu'Appelle Valley (Environment Canada 2013). No major river valleys are present in the BSA; the Qu'Appelle Valley is located approximately 15 km south of the southern boundary of the ESA and approximately 10 km south of the southern boundary of the BSA.

Northern leopard frogs are semi-aquatic and use both aquatic and terrestrial environments during their life cycle. Different habitats are required throughout the year: breeding occurs in shallow marshes, moist uplands are used for foraging, and permanent water bodies are required for overwintering (Environment Canada 2013). These three habitat types must be located in close proximity to each other and must be connected in some way because leopard frogs have limited dispersal capability (Environment Canada 2013).

14.4 Pathways Analysis

14.4.1 Methods

Pathways analysis identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects (after mitigation) to wildlife. The first part of the analysis is to identify all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on the VC. Potential pathways through which the Project could affect wildlife were identified from a number of sources including the following:

- a review of the Project Description (Section 4.0) and scoping of potential effects by the environmental and engineering teams for the Project;
- information obtained from community engagement sessions (Section 5.0);
- scientific knowledge and experience with other potash mines in Saskatchewan; and
- consideration of potential effects identified from the TOR.

For an effect to occur there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a correspondent effect on the VC.

Project activity → change in environment → effect on VC

A key aspect of the pathway analysis is to identify environmental design features and mitigation that might reduce or eliminate potential effects of the Project on wildlife. Mitigation has been developed for the Project according to the following hierarchy proposed by the MOE (2014):

- avoidance;
- minimize (limit);
- restoration; and
- compensation.

Environmental design features include engineering design elements, environmental best practices, management policies and procedures, and spill response and emergency contingency plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on wildlife. Pathways are determined to be primary, secondary (minor), or as having no linkage, using scientific, local, and traditional knowledge, logic, and experience with similar developments and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- **No linkage** – analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on wildlife relative to the Base Case; or
- **Secondary** – pathway could result in a measurable minor environmental change, but would have a negligible residual effect on wildlife relative to the Base Case, and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect; or
- **Primary** – pathway is likely to result in environmental change that could contribute to residual effects on wildlife relative to the Base Case.

Pathways with no linkage to wildlife are not assessed further because implementation of environmental design features or mitigation will remove the pathway and result in no measurable change to wildlife. Pathways that are assessed to be secondary and demonstrated to have a negligible residual effect on wildlife through simple qualitative or semi-quantitative evaluation of the pathway are also not advanced for further assessment. In summary, pathways determined to have no linkage to wildlife or those that are considered secondary are not expected to result in environmentally significant effects for self-sustaining and ecologically effective wildlife populations. Primary pathways require further evaluation through more detailed quantitative and qualitative effects analysis (Section 14.5).

14.4.2 Results

Project components and activities, effects pathways and environmental design features and mitigation are summarized in Table 14.4-1. Classification of effects pathways (i.e., no linkage, secondary and primary) to wildlife also is summarized in Table 14.4-1 and detailed descriptions are provided in the subsequent sections.

Table 14.4-1: Potential Pathways for Effects on Wildlife

<table>
<tr><th>Project Component/ Activity</th><th>Effects Pathways</th><th>Environmental Design Features and Mitigation</th><th>Pathway Classification</th></tr>
<tr><td rowspan="6">Physical disturbance from the Project Footprint</td><td>Direct loss, alteration, and fragmentation of wildlife habitat from Project footprint (core facilities area, mining area, and access roads) can cause changes to bird and amphibian VCs.</td><td rowspan="5">■ The compact layout of the core mine facilities area will limit the area that is disturbed by construction.
■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance.
■ Progressive reclamation will occur where applicable (e.g., progressive well pad site reclamation).
■ Existing public roads will be used where possible to provide access to the Project, reducing the amount of new road construction required for the Project.
■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible.
■ A Decommissioning and Reclamation Plan will be developed and will incorporate new technologies as they become available to reduce the length of the decommissioning period, and the associated duration of salt storage at surface.
■ All on-site roads will be removed during decommissioning.
■ Salvaged soil material will be returned to the landscape and contoured, to the extent practical, to blend with the surrounding terrain.
■ Disturbed areas will be re-contoured and reclaimed to a stable profile to permit existing land uses.
■ Siting and construction of the Project will be planned to avoid environmentally sensitive areas (e.g., critical wildlife habitat and wetlands) as much as possible.
■ If avoidance of sensitive areas is not feasible, consultation with MOE will be completed to determine the significance of the area and identify mitigation strategies.</td><td>Primary</td></tr>
<tr><td>Direct loss, alteration, and fragmentation of wildlife habitat from Project footprint (core facilities area, mining area, and access roads) can cause changes to ungulate VCs.</td><td>Secondary</td></tr>
<tr><td>Residual ground disturbance from portions of the core facilities area can cause permanent alteration of wildlife habitat, which could affect the abundance and distribution of bird and amphibian VCs.</td><td>Primary</td></tr>
<tr><td>Residual ground disturbance from portions of the core facilities area can cause permanent alteration of wildlife habitat, which could affect the abundance and distribution of ungulate VCs.</td><td>Secondary</td></tr>
<tr><td>Direct loss and fragmentation of wildlife habitat from the mine well field area pipelines can affect the abundance and distribution of wildlife VCs.</td><td>Secondary</td></tr>
<tr><td>Changes in surface flows, drainage patterns (distribution) and drainage areas from the Project footprint can cause degradation of wildlife habitat and change the abundance and distribution of wildlife habitat, and affect wildlife VCs.</td><td>■ The compact layout of the core facilities area will limit the area that is disturbed by construction.
■ The well pad design will be optimized to manage as many caverns as practical from one well pad, reducing ground disturbance.
■ Progressive reclamation of well pads will occur.
■ Existing public roads will be used where possible to provide access to the mine well field area and to reduce the amount of new road construction required for the Project.
■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible.
■ Where practical, natural drainage patterns will be maintained.
■ Culverts will be installed along site access roads, as necessary, to maintain drainage</td><td>No Linkage</td></tr>
<tr><td>Solution Mining</td><td>Ground subsidence caused by solution mining can change surface flows and drainage patterns (distribution) and the abundance and distribution of wildlife habitat, which can affect wildlife VCs.</td><td>■ Unmined pillars will be left between caverns to increase stability during mining and reduce potential subsidence.
■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment.
■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence and provide input into adaptive management.
■ Subsidence will be non-disruptive. Disruptive subsidence, such as the formation of sinkholes, is not expected to occur.
■ Subsidence will be gradual and ultimate (maximum) subsidence (i.e., final, steady state) will not occur for centuries.
■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface topography.</td><td>Primary</td></tr>
</table>

Table 14.4-1: Potential Pathways for Effects on Wildlife

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Tailings Management Area	Vertical and lateral migration of brine from the tailings management area can change the quality of soil and vegetation, and, consequently, affect wildlife habitat and wildlife VCs.	■ The location of the TMA was selected based on site-specific geologic and hydrogeologic studies completed to identify an appropriate foundation for the TMA, which provides natural containment of brine material. ■ The TMA will be located over soils that are known to provide natural retention of brine solutions and offer protection against seepage into nearby ground and surface water resources.	No Linkage
	Long-term brine migration from the tailings management area can change the quality of soil and vegetation and, consequently, affect wildlife habitat and wildlife VCs.	■ Brine reclaim ponds will be designed to provide containment of brine under normal and extreme (i.e., storm) conditions over the life of the mine. ■ A perimeter dyke will be constructed around the TMA to contain waste salt and decanted brine. ■ Excess brine reclaimed from the TMA will be disposed of by deep well injection, a proven practice used to manage brine and prevent release to surface waters and fresh-water aquifers. ■ A containment system will be designed to control deep migration of brine from the TMA to underlying aquifers and horizontal migration of brine, as required. ■ A Waste Salt Management Plan for the TMA will be incorporated into the detailed design. ■ The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan and adaptive management will be implemented, if required. ■ A Decommissioning and Reclamation Plan will be developed and will incorporate new technologies as they become available to reduce the length of the decommissioning period and the associated duration of salt storage at surface.	No Linkage
	Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality, and change surface water, soil and vegetation quality, which can affect wildlife habitat and wildlife VCs.	■ An evaluation of the capacity of potential deep injection horizons has been conducted identifying the Winnipeg Formation and Deadwood Formation to be suitable for brine disposal.	No Linkage
General construction, operations, and decommissioning and reclamation activities	Air and dust emissions and subsequent deposition can cause changes to the chemical properties of soils and vegetation, which can effect wildlife VCs.	■ Compliance with regulatory emission requirements. ■ Dryer burners will be high efficiency, low NOx burners to limit the amount of NOx present in the exhaust stream. ■ Baghouses will be installed throughout the dry process area and dust collected in these baghouses will be conveyed back to the compactors. ■ A dustless chute and loading system will be installed in the product storage area to reduce dust generation in the storage and load-out. ■ The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment. ■ An Erosion and Sediment Control Plan will be implemented during all phases of the Project to limit dust production, and subsequent deposition on surrounding areas, and to limit water erosion of exposed soils.	Secondary
	Long-term dust emissions from the tailings management area can cause local changes to soil and vegetation quality and alter wildlife habitat, which can affect wildlife VCs.	■ Dust-producing components of the potash refinement process (i.e., dryers, compaction circuit) will have controls to recover and return dust to the circuit. ■ Wet scrubbers will be used to clean the air of dust particles from off-gases from the product dryers. ■ Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. ■ Enforced speed limits will assist in reducing production of dust. ■ Operating procedures will be developed to reduce dust generation from the TMA over the long-term. ■ The cyclone exhaust will be treated in high-energy scrubbers operating at a high-pressure drop.	No Linkage
	Physical hazards from the Project cause injury or mortality to individual animals.	■ Steady-burning red or flashing white lights will be installed on the cooling tower, and possibly other elevated infrastructure. ■ Shield lines may be marked with aviation marker balls or spiral vibration dampers to improve the visibility of the line and reduce the likelihood of bird-transmission line strikes. ■ The process plant and administration buildings will be fenced to deter entry by non-employees and prevent most wildlife from entering these areas.	Secondary

Table 14.4-1: Potential Pathways for Effects on Wildlife

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
General construction, operations, and decommissioning and reclamation activities	Collisions with Project vehicles and trains can cause injury or mortality to individual animals.	■ Timely snow removal and sanding will occur on site access roads during winter to improve traction. ■ To limit the occurrence of vehicular accidents, training for equipment operators will be implemented as part of the Health, Safety, Security, and Environmental Management System. ■ Daily vehicle inspections will be required, and a preventative maintenance program will be implemented for all vehicles used on-site. ■ Speed limits will be enforced.	Secondary
	Wildlife can be attracted to the Project (e.g., by food, oil products, salt, infrastructure), which can increase human-wildlife interactions and mortality risk to individual animals.	■ Food wastes will be collected in suitable receptacles that limit attraction or impact to wildlife. ■ Mitigation to address wildlife presence within the Project footprint will be developed and implemented as part of the Environmental Protection Plan. ■ Littering and feeding of wildlife will be prohibited. ■ A Waste Management Plan will be developed for the Project. ■ Recyclables and waste hazardous materials will be stored on-site in appropriate containers to prevent exposure until shipped off-site to an approved facility. ■ Education and reinforcement of proper waste management practices will be provided to all workers and visitors to the site. ■ Site infrastructure will incorporate natural colours and materials for buildings and features such as tree rows to reduce the visual effect of the Project. ■ Lighting will be designed to limit off-site light disturbances. Low-glare fixtures will be used, where possible, and lighting will be covered and will face downwards to illuminate the ground, not the sky.	Secondary
	Attraction of predators to the Project can increase predation risk of prey species, which can cause changes to the abundance of prey populations.		Secondary
	Sensory disturbance (e.g., presence of humans, smells, and noise) from the construction and operation of the Project can cause changes to the relative abundance and distribution of bird and amphibian VCs.		Primary
	Sensory disturbance from the construction and operation of the Project can alter the amount of different quality habitats, and affect ungulate VCs.		Secondary
Water Management	Site runoff and associated soil erosion from the core facilities area, can alter soil and vegetation quality and, consequently, affect wildlife habitat and wildlife VCs.	■ A Water Management Plan will be designed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. ■ A diversion channel will be constructed to intercept waterflows from upland areas along the north and east borders of the core facilities area. ■ Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the core facilities area. ■ The surface water diversion will be designed to convey the runoff associated with the 300 mm 24-hour design storm event. ■ Surface water diversion channels along the perimeter of the core facilities area will be designed to collect and redirect external drainage.	No Linkage

Table 14.4-1: Potential Pathways for Effects on Wildlife

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Accidents, malfunctions, and unplanned events	Spills (e.g., waste oil, petroleum products, reagents, potash product , Project equipment leaks, vehicle accidents, and wash-down) can cause changes to soil and vegetation quality and, consequently, affect wildlife habitat and wildlife VCs.	■ Instruction will be provided to employees as part of the Health, Safety, Security, and Environmental Management System; training will be provided to all employees on transportation of dangerous goods, as well as on spill reduction, control, and clean up procedures. ■ Basic, core, and specific training of workers as part of the Health, Safety, Security, and Environmental Management System. ■ An Emergency Response Team will be formed on-site and members will be trained to implement the Emergency Response Plan. ■ Spills will be promptly reported and managed according to procedures identified in the Spill Response and Control Plan. ■ Chemical spill containment will be incorporated into the plant design to mitigate environmental effects from spills (i.e., installation of concrete floors, drains, and sump mechanisms). ■ Smaller fuel dispensing tanks will be double-walled, and all dispensing will be performed over concrete containment slabs. ■ Reagent tanks and larger fuel tanks will be located inside a bermed, lined storage compound. ■ Liquid, solid spills, and wash-down within the processing facilities will be contained within the mill facility (e.g., door curbs, sloped floors, and sumps) or engineered site area. ■ Diesel and gasoline will be stored in accordance with applicable regulations. ■ On-site storage facilities for hazardous substances and waste dangerous goods will be designed to meet regulatory requirements. ■ Domestic and recyclable waste dangerous goods will be stored in appropriate containers until shipped off site to an approved facility. ■ Spill response material will be located throughout the site in designated areas, where fuel and chemicals are stored, and in company vehicles. ■ Best practices will be adopted within the Waste Management Plan for proper handling and storage of waste dangerous goods. ■ Salvageable product from centrifuging, drying, screening, and compaction will be recycled back to the process. ■ Construction equipment will be regularly inspected and maintained. ■ To limit the occurrence of vehicular accidents, training for equipment operators will be implemented as part of the Health, Safety, Security, and Environmental Management System. ■ Equipment will be inspected for leaks and repaired prior to entry into the Project area and routinely inspected throughout the duration of the Project. ■ Daily vehicle inspections will be required, and a preventative maintenance program will be implemented for all vehicles used on-site. ■ Speed limits will be enforced. ■ Timely snow removal and sanding will occur on site access roads during winter to improve traction.	No Linkage
	Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to soil and vegetation quality and, consequently, affect wildlife habitat and wildlife VCs.	■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed wherever possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ Brine will be transported by steel pipeline lined with high-density polyethylene, which provides additional pipe flexibility and resistance to corrosion. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface developments. ■ Unmined pillars will be left between the caverns to increase stability during mining and reduce the potential for subsidence. ■ As part of the Environmental Protection Plan, regular monitoring of pipelines will be carried out to limit the potential for leaks and allow for early detection and management of spills. ■ Piping and valve arrangements will be routed so that each cavern works independently from the others at difference stages of cavern development and production. ■ During the detailed design stage, additional spill response and mitigation will be included in the Spill Response and Control Plan.	No Linkage

Table 14.4-1: Potential Pathways for Effects on Wildlife

Project Component/ Activity	Effects Pathways	Environmental Design Features and Mitigation	Pathway Classification
Accidents, malfunctions, and unplanned events	Slope failure of waste salt storage pile can cause translocation of waste salts and alter surface water, soil, and vegetation quality and, consequently, affect wildlife habitat and wildlife VCs.	■ Salt pile side slopes of 4H:1V were applied to the TMA layout, which were found to provide stable slope configuration based on preliminary slope stability analysis. ■ The final configuration of salt pile slopes will be refined based on subsequent analyses calibrated to pore-water pressure and slope movement data obtained during the initial development of the waste salt pile. ■ Regular inspections of the TMA. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan.	No Linkage
	Failure of the brine containment pond and resulting brine leakage can cause changes to surface water, soil, and vegetation quality and, consequently, affect wildlife habitat and wildlife VCs.	■ The brine reclaim pond will provide adequate storage to accommodate storage of process streams under normal and extreme operating conditions and design storm events. ■ Sufficient freeboard will be provided to account for wind induced set-up and wave run-up on the sides of the pond slopes. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan. ■ Maximum operating levels will be developed to provide adequate storage volumes for the design storm event (300 mm in 24 hours). ■ Containment berms and dykes will be constructed around the tailings management area to contain salt tailings and decanted brine, as well as to divert surface water. ■ Containment dykes will be keyed into surficial materials as necessary. ■ Brine levels will be monitored and excess brine will be injected into deep well injection zones. Sub-surface brine migration will be monitored and groundwater wells will be monitored to confirm the adequacy of the brine containment pond. ■ In the event of high flows due to precipitation events, additional flow capacity from the collection ditch to the reclaim pond would be provided by an overflow spillway in the embankment. ■ The brine reclaim pond will be monitored regularly; monitoring results will provide input into adaptive management.	No Linkage
	Deposition of air emissions from the failure of air emission control systems can result in chemical changes to the surrounding environment and affect wildlife habitat and wildlife VCs.	■ The environmental performance of air emissions control systems will be monitored on an on-going basis and will provide information to support adaptive management. ■ Preventative maintenance will be completed regularly to confirm that emissions systems are functioning as designed.	No Linkage
	Loss of wildlife habitat from a fire caused by Project activities.	■ Site-specific response plans and mitigation for fire safety and fire protection will be developed as part of the Occupational Health and Safety Plan and the Emergency Response Plan. ■ Fire safety measures and response will be reviewed with the R.M.s of Longlaketon, and Cupar. ■ Personnel will be trained in fire prevention and response procedures. ■ Firefighting equipment will be available on site. ■ Inspections of the plant will be completed to identify potential fire hazards. ■ A fire suppression system will be activated during all phases of the Project. ■ Water will be stored on-site in the raw water pond for the fire suppression system.	No Linkage

VC = valued components; MOE = Ministry of Environment; TMA = tailings management area; NOx = oxides of nitrogen; R.M. = Rural Municipality; mm = millimetres

14.4.2.1 Pathways with No Linkage

A pathway may have no linkage to environmental effects if the activity does not occur, or if the pathway is removed by mitigation or environmental design features so that the Project results in no measurable change in measurement indicators. Subsequently, no residual effect on wildlife is expected. The pathways described in the following bullets have no linkage to wildlife and will not be carried forward in the assessment.

- **Changes in surface flows, drainage patterns (distribution) and drainage areas from the Project footprint can cause degradation of wildlife habitat and change the abundance and distribution of wildlife habitat, and affect wildlife VCs.**

Surface water flows, drainage patterns, and drainage areas are expected to be affected by the construction of the Project. The natural drainage area in the vicinity of the Project has already been disturbed from the existing road network used to access cultivated areas, rural homes, and communities near the Project. The Project is within an area with poorly defined runoff pathways. During the Base Case, most of the runoff contributes to a low-lying area south of the core facilities area that may occasionally contribute to West Loon Creek under high magnitude snowmelt and/or rainfall events (Section 9.5). The hydrology assessment predicted that the Project footprint will result in a reduction in runoff that will change the amount of water reporting to the low-lying area downstream but would only rarely affect inflows to West Loon Creek. During decommissioning and reclamation, the majority of the Project infrastructure will be removed and surface water flows and drainage patterns will be reclaimed. The tailings management area (TMA) is considered permanent. The surface water flows and drainage patterns in residual footprint areas will not be reclaimed; however, no reduction in flow volume in West Loon Creek downstream is predicted.

A Water Management Plan will be implemented to maintain streamflow quantity along natural flow pathways as much as possible. Environmental design features will be implemented to allow off-site precipitation and snowmelt to remain part of the natural water cycle. The core facilities area will be limited to the minimum spatial extent required. Mine well field area access roads to be constructed during the Project will be designed to maintain the natural flow paths using adequately designed cross-drainage structures (e.g., culverts) as required. Implementing environmental design features and mitigation is anticipated to result in minor changes to surface water flows and drainage patterns from the Project footprint. The minor changes to surface water flows and drainage patterns are not anticipated to cause measurable changes to wildlife habitat. Therefore, this pathway was determined to have no linkage to effects on wildlife populations.

- **Long-term dust emissions from the tailings management area can cause local changes to soil and vegetation quality and alter wildlife habitat, which can affect wildlife VCs.**

Solution mining produces waste salt (i.e., sodium chloride [NaCl] tailings) as a by-product of the potash refinement process, which will be stored in the salt storage area in the TMA. The volume of tailings produced by the solution mining method for the Project is expected to be lower than conventional underground mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only potassium chloride (KCl) is removed from the caverns during this process.

The waste salt product that is precipitated during processing is removed from the process and discharged to the TMA through a slurry pipeline.

A solid crust will form over the outer layer of the waste pile as the salt slurry dries. The formation of a rigid crust over the salt pile is expected to limit effects of exposure to wind and will reduce the potential for erosion. Operating procedures will also be developed to limit dust emissions from the TMA. Because of the crusting of the outer layer of the salt pile and the implementation of operating procedures and monitoring programs for the salt storage area, long-term dust emissions are not expected, and are predicted to result in no measurable changes to soil quality, vegetation, and wildlife habitat quality. Subsequently, this pathway was determined to have no linkage to effects on wildlife.

- **Vertical and lateral migration of brine from the tailings management area can cause changes to the quality of surface water, soil, vegetation, and, consequently, affect wildlife habitat and wildlife VCs.**
- **Long-term brine migration from the tailings management area can change the quality of soil and vegetation and, consequently, affect wildlife habitat and wildlife VCs.**
- **Failure of the brine containment pond and resulting brine leakage can cause changes to surface water, soil, and vegetation quality and, consequently, affect wildlife habitat and wildlife VCs.**

The TMA will consist of the Stage I and Stage II salt storage areas, the Stage I and Stage II brine reclaim ponds, sewage lagoon, and surface diversion works. The TMA will be in operation during the life of the Project, and following decommissioning and reclamation of the mine. Brine is primarily composed of soluble salts (NaCl, with smaller amounts of KCl) and other insoluble materials (e.g., metals) (Tallin et al. 1990). Vertical or lateral migration of brine into groundwater systems or directly into the surrounding soil may lead to salt accumulation and changes in soil quality.

The concentration of salt in soil solution and salt accumulation in soil increases soil salinity and affects soil physical properties (Henry et al. 1992; Keran 2012). Sodium (and sometimes potassium) can act as dispersive cations in soil when present in high enough concentrations (Keren 2012). Salt accumulation can promote clay swelling and disrupt soil structure, which can affect soil permeability, soil plasticity, water retention capability, CEC, and crop productivity (Barbour and Yang 1993; Gabbasova et al. 2010; Keren 2012; Levy 2012). Salts can also increase soil pH, which can alter the availability of soil nutrients for plant uptake (Richards 1954; MOA 2008; Levy 2012). These changes to soil quality have the potential to affect vegetation.

Soils with high organic matter content tend to promote greater aggregate stability and have a greater resistance to inputs of sodium (Levy 2012). In addition, the presence of calcium carbonate promotes further resistance to sodium inputs to soil. Soils within the ESA had an organic matter content of between 1% and 10% and are enriched with calcium carbonate (Annex IV, Appendix IV.1). Therefore, soils in the ESA may be somewhat buffered to small inputs of sodium from brine. However, this buffering capacity would likely be ineffective in the event of large brine inputs that may occur if the brine pond containment fails.

The stratified clay and clayey tills of the Saskatoon Group are the main geological units that would mitigate the vertical migration of seepage from the TMA (Golder 2015). Soil-bentonite cut-off walls will be used to contain brine areas where shallow stratified sand and gravel deposits are present. The necessity for a deep cut-off wall extending through competent till materials will be determined based on the results of detailed site characterization. Containment berms and dykes will be constructed around the TMA to contain decanted brine. The containment system will be designed to control migration of brine from the salt storage area to underlying aquifers and control the horizontal migration of brine, as required. The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan; monitoring salts will provide information to support adaptive management.

Implementation of the above-mentioned environmental design features, mitigation measures, and monitoring programs has shown good performance in preventing vertical and lateral seepage in similar potash projects. Consequently, these pathways were determined to have no linkage to effects on wildlife.

- **Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality, and change surface water, soil and vegetation quality, which can affect wildlife habitat and wildlife VCs.**

Brine will be disposed of through deep-well injection during the Project to reduce the amount of brine stored in the TMA. Injecting brine into deep wells can change sub-surface and deep groundwater levels and chemistry, which could alter surface water and soil quality. Depending on the chemical composition of the brine being injected, the brine may introduce NaCl, KCl, and other insoluble materials (e.g., metals) to groundwater (Tallin et al. 1990). Salt accumulation can increase soil salinity and affect soil structure and soil pH, which can change the availability of soil nutrients (Richards 1954; Barbour and Yang 1993; MOA 2008; Gabbasova et al. 2010; Keren 2012; Levy 2012).

Disruption in groundwater flow may also adversely affect soil moisture and surface water levels in wetlands by changing recharge and discharge areas and rates (Chen and Hu 2004). This may expose previously unsaturated soils to saturated conditions, and vice versa, and alter soil physical, chemical, and biological properties (Bedard-Haughn 2011). Changes in soil moisture regimes and soil quality can alter vegetation communities and, therefore, wildlife habitat.

Methods used in the solution mining process will maintain suitability of shallow and deep groundwater aquifers. In addition, an evaluation of the capacity of potential deep injection zones has been completed identifying the Winnipeg Formation and Deadwood Formation to be suitable for brine disposal. The Winnipeg and Deadwood Formations are considered the best target for brine disposal because of the large storage capacity in these formations, the formations are well isolated from overlying freshwater aquifers, and the formations are distant from recharge and discharge areas (Appendix 4-A). No changes to sub-surface and deep groundwater flow, levels, and quality are predicted. Given that the formations used for deep well injection are isolated from overlying aquifers and surface water, no changes to surface water or soil quality are expected. Therefore, this pathway was determined to have no linkage to effects on wildlife.

- **Site runoff and associated soil erosion from the core facilities area, can change soil and vegetation quality and, consequently, affect wildlife habitat and wildlife VCs.**

Site runoff and associated soil erosion from the core facilities area could potentially affect wildlife habitat within and adjacent to the Project footprint. Brine and salt stored in the TMA may be transported off-site via surface water runoff caused by precipitation. Increased salt in soils can lead to soil salinity, and when salt levels are high enough, they can negatively affect plant growth, especially in salt sensitive species. Salt in soil can cause a reduction in the ability of plant roots to take up water from surrounding soils and can lead to increased plant stress (Warrence et al. 2002). Additionally, waterbirds were observed to spend less time foraging in wetlands containing high salinity (Halse et al. 1993) likely because little animal and plant matter is available (Hart et al. 1990). Increased levels of soil erosion can also lead to increased sediment loads in wetlands, thus reducing plant and animal abundance and diversity (Forman and Alexander 1998).

Several environmental design features and mitigation will be implemented to prevent water release from the core facilities area entering the surrounding environment. The general site layout has been developed to use natural topography to assist site drainage to the extent practical. The topography in the area is gently sloping toward the south and slightly to the west. A diversion channel will be constructed to intercept waterflow from upland areas along the north and east borders of the core facilities area.

A Water Management Plan will be developed and infrastructure will be constructed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the facility. The surface water diversion works will be designed to accommodate runoff from a rainstorm event of 300 millimetres (mm) over 24 hours (Section 4.6.2).

Runoff within the TMA will be redirected to the brine reclaim pond for temporary storage prior to deep-well injection. Salt storage area internal channels (i.e., brine return channels) are designed to collect and redirect runoff originated from precipitation and brine discharges on the tailings areas to the brine reclaim pond. The TMA will be graded to drain free brine to the brine reclaim pond by gravity. Internal salt tailings dykes and ditches may be required to direct surface flow to the collection ditch during early stages of deposition.

The brine reclaim pond will be constructed to provide containment of brine during the Project. The brine reclaim pond is designed to allow sufficient storage capacity to contain brine decant from the salt storage area during normal operations, runoff resulting from the design storm event, and a 0.9-metre (m) freeboard to accommodate wind-induced setup and wave run-up on the sides of the pond slopes.

Erosion protection of the surface water diversion channel will be provided by topsoil replacement and hydro seeding to establish grass cover within the diversion channel. A tackifier may be used to increase the temporary soil stability prior to establishment of permanent root systems.

Inspection and maintenance procedures for infrastructure will be outlined in the Water Management Plan, and provide input into adaptive management, as required. Implementation of environmental design features and mitigation is expected to prevent site runoff and soil erosion from the core facilities area from entering the surrounding environment. Subsequently, this pathway was determined to have no linkage to effects on wildlife.

- **Spills (e.g., waste oil, petroleum products, reagents, potash product, Project equipment leaks, vehicle accidents, and wash-down) can cause changes to soil and vegetation quality and, consequently, affect wildlife habitat and wildlife VCs.**
- **Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to soil and vegetation quality and, consequently, affect wildlife habitat and wildlife VCs.**

Several environmental design features and mitigation practices and policies are planned to reduce the potential for spills and leaks to limit the effects of spills and leaks on wildlife habitat. Pipelines will be used to transport brine solution and potash product to and within the Project footprint. Pipelines will be constructed of standard carbon steel and lined with high-density polyethylene. Pipelines will be installed underground at a depth that will reduce the possibility of damage from frost and surface activities (e.g., farming), and will be monitored for pressure and flow using flow meters. Double-walled pipe for secondary containment will be used in critical crossing areas (i.e., based on site-specific analysis to meet environmental conditions). All pipelines will be insulated to maintain the required temperature for the process, with the exception of the cold water and the early brine return pipelines. Trains and vehicles will transport chemicals, potash product, and other reagents on and off site. Wildlife may be attracted to chemical spills (e.g., petroleum product and potash product) creating additional risk for vehicle-wildlife collisions.

An Emergency Response Plan will be developed as part of the Health, Safety, Security, and Environmental Management System to provide rapid and competent response to incidents that may occur during the Project. Aspects of this plan include instructions and procedures for quick detection, control, and management of spills occurring on site. Other mitigation will include a leak detection system for mining area pipelines, which will consist of monitoring for early detection, and appropriate pipe isolation to limit potential leaks. Leak detection and monitoring of pipelines will be based on flow and pressure measurements at points along the pipeline. In addition to the pipeline monitoring program, liquid spills and wash-down occurring within the potash processing facilities will be contained within the mill facility or the engineered site area, and salvageable product spills will be recycled into the process feed.

If a spill originates in the tank farm, the hazardous substance will be pumped and properly disposed off-site. The tank farm will be designed to include an adequately sized containment berm for containing potential leaks or spillage. Storage facilities for hazardous wastes will meet regulatory requirements, and site personnel will be trained on spill reduction, control, and clean-up procedures. Employees will receive spill response training and appropriate spill response materials (e.g., absorbent pads or booms) and equipment will be located at strategic locations on-site. Disposal of all hazardous materials such as waste chemicals, hydrocarbons, reagents, and petroleum products will be handled by a licensed contractor and will be hauled off-site to an approved facility. Waste products from the Project (e.g., hazardous waste, domestic waste, and recyclable waste) will be stored and disposed of following procedures specified by federal and provincial legislation.

Implementation of the above-mentioned environmental design features and mitigation are expected to reduce the likelihood and extent of spills and leaks occurring on-site and along transportation corridors resulting in no measurable changes to soil quality, vegetation, and wildlife habitat quality relative to Base Case conditions. Therefore, these pathways are determined to have no linkage to effects on wildlife.

- **Slope failure of waste salt storage pile can cause translocation of waste salts and alter surface water, soil, and vegetation quality and, consequently, affect wildlife habitat and wildlife VCs.**

The volume of tailings produced by the solution mining method for the Project is expected to be lower than conventional underground mining on a per-tonne of product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only KCl is removed from the caverns.

Salt tailings stockpile stability is governed primarily by the salt pile height, shear strength of the underlying soils, and the degree to which soil pore water pressures are generated in response to the surcharge load of the stockpile. Detailed slope stability analysis for the salt pile will be completed to determine the optimal salt pile height for the Project. The final design of the waste salt storage area will provide for flexibility to expand the storage area in stages through modifications to the footprint or increasing the salt pile height should additional storage be required.

The probability of slope failure of the waste salt storage pile will be limited by the implementation of operating procedures and monitoring programs for the salt storage area. Salt pile stability monitoring will be incorporated into the design. As such, this pathway was determined to have no linkage to effects on wildlife.

- **Deposition of air emissions from the failure of air emission control systems can result in chemical changes to the surrounding environment and affect wildlife habitat and wildlife VCs.**

Potential exists for failure of air emission control systems, which may result in short-term reductions in air quality, and potentially, subsequent effects on wildlife. The environmental performance of air emissions control systems will be monitored on an ongoing basis and preventative maintenance will be completed regularly to confirm that emissions systems are functioning as designed. The minor and short-term changes to air quality are not anticipated to cause measurable changes to the surrounding environment. Consequently, there is no linkage to effects on wildlife.

- **Loss of wildlife habitat from a fire caused by Project activities.**

Fire that is caused by Project activities could result in the loss of wildlife habitat. Fire safety measures and response will be developed in conjunction with local and regional first responders, applicable regulatory agencies and reviewed by the R.M.s of Longlaketon and Cupar. On-site personnel will be trained in established fire prevention and response procedures and appropriate firefighting equipment will be available on-site so that trained personnel will be able to respond promptly.

Regular inspections of the process plant will be completed to identify potential fire hazards and any necessary repairs or maintenance will be performed as soon as possible following identification. A fire suppression system will be activated during all phases of the Project and its functionality will be regularly monitored. Water will be stored on-site in the raw water pond to provide water, as needed, for the fire suppression system. The implementation of the abovementioned mitigation is anticipated to result in no linkage to effects on wildlife.

14.4.2.2 Secondary Pathways

In some cases, both a source and a pathway exist, but because the change caused by the Project is anticipated to be minor relative to Base Case or guideline values, it is expected to have a negligible residual effect on wildlife. The pathways described in the following bullets are expected to be secondary and will not be carried forward in the assessment.

- **Direct loss, alteration, and fragmentation of wildlife habitat from Project footprint (core facilities area, mining area, and access roads) can cause changes to ungulate VCs.**
- **Residual ground disturbance from portions of the core facilities area can cause permanent alteration of wildlife habitat, which could affect the abundance and distribution of ungulate VCs.**
- **Sensory disturbance from the construction and operation of the Project can alter the amount of different quality habitats, and affect ungulate VCs.**

White-tailed deer are the most abundant and widely distributed ungulate in Saskatchewan (MOE 2013). White-tailed deer populations in Saskatchewan are the highest in farmland and parkland WMZs (MOE 2013). No population estimate is available for WMZ 21, which contains the BSA. Populations in prairie wildlife management zones remained stable from 2006 to 2011 and are near their long-term averages, but harsh winters in 2009/2010 and 2010/2011 caused a downward population trend (MOE 2013). The estimate of deer species density (± 1SE) from the aerial survey was 0.68 ± 0.24 individuals per km^2 A total of 447 deer in 64 observations (12 individuals and 52 groups ranging in size from 2 to 60 individuals) were recorded within transects during the aerial survey (Annex IV, Section 5.3.5.1). Approximately 3,705 deer are estimated to be in the BSA, based on the number of deer observed during the aerial survey.

White-tailed deer populations in northern habitats, including Saskatchewan, are limited by the quality and availability of winter habitat (Smith 1991; MOE 2008, 2013). Extensive snow cover restricts mobility and reduces forage availability, which can contribute to overwinter mortality (Smith 1991; MOE 2013). In the aspen parkland region of Alberta, areas that contain less than 35% aspen cover do not provide suitable overwintering habitat (Smith 1991). No critical wintering habitat, as defined by the MOE (2013), exists in the ESA. In Alberta, optimal habitat for white-tailed deer that occupy aspen parkland areas contains 65% wooded habitat, 20% grassland habitat, and 15% mixed cultivated land and water habitats (Smith 1991). The ESA is comprised of 3.4% wooded habitat, 23.8% modified and native grassland habitat, and 71.4% cultivated land and wetland habitats (Section 13.5.1.2.1). As such, the ESA is not considered a prime area for white-tailed deer.

Outside of Cypress Hills and Moose Mountain Provincial Parks, which contain the majority of elk in Saskatchewan, two thirds of the elk population in Saskatchewan is found east of Tisdale and north of Canora to Cumberland Lake (MOE 2013); the southwest corner of this area is approximately 45 km north of the northeast corner of the ESA. Elk numbers in Saskatchewan were increasing prior to the moderately severe winters in 2005, 2006, and 2007 (MOE 2013). Elk numbers decreased slightly during 2005 to 2007 but mild winters in 2008 and 2009 allowed populations to increase. The severe winter in 2010/2011 caused a large decline in the number of elk in Saskatchewan (MOE 2013). Elk density (± 1SE) during the aerial survey was estimated to be 0.02 ± 0.01 individuals per km^2. Two groups of elk (three individuals and seven individuals) were observed during the aerial survey at distances of 9 km and 19 km from the proposed core mine facilities area. The estimated number of elk within the BSA was 84 individuals.

Elk prefer areas that contain a mix of forest and grassland (MOE 2013). Grassland areas are considered suitable for elk, but populations may be limited by the availability of calving habitat (Bian and West 1997). In the semi-arid grassland region of Kansas, close proximity to water was a significant factor that influenced calving site selection (Bian and West 1997).

White-tailed deer that inhabit prairie ecosystems are known to habituate to human presence on the landscape (Roseberry and Woolf 1998). The Project is located in a highly cultivated landscape, close to Highway 6 and the community of Southey. As such, deer in the proximity of the Project are anticipated to be habituated to the presence of humans and human activity on the landscape. Although improved gravel roads and highways were found to have a negative influence on elk calving in Kansas, unimproved dirt roads, and oil and gas wells did not have a significant effect on calving (Bian and West 1997). This suggests that elk may adapt to human disturbances that are widespread and unavoidable (Bian and West 1997). Similarly, the distribution of elk in Waterton Lakes National Park was not affected by road closures, although individuals were more likely to cross roads that were closed (St. Clair and Forrest 2008).

White-tailed deer and elk are anticipated to be resilient to direct loss, alteration, and fragmentation of habitat and sensory disturbance effects from the Project because both species have high reproductive rates (Smith 1991; Stewart et al. 2005) and can adapt to human disturbance (Bian and West 1997; Roseberry and Woolf 1998; St. Clair and Forrest 2008). As such, minor direct and indirect changes from the Project are anticipated to have negligible effects on the white-tailed deer and elk populations in the ESA.

- **Direct loss and fragmentation of wildlife habitat from the mine well field area pipelines can affect the abundance and distribution of wildlife VCs.**

Construction and operation activities of the mine well field area pipelines for the Project may disturb local wildlife populations during construction, including species at risk, sensitive species, and seasonal occupants protected under the *Migratory Bird Convention Act* (MBCA 1994). Wildlife habitat may be temporarily lost, altered, or fragmented. By implementation of several mitigation measures, minimal habitat loss, alteration, and fragmentation are anticipated to occur due to the construction of the pipelines. When possible, Yancoal will time construction to avoid potential impacts to species during critical periods, and environmental monitoring will be used if construction is necessary during critical periods for sensitive biota. Biologically relevant timing restrictions and setback distances will be used during construction, in accordance with guidelines recommended by the provincial ministry and Environment Canada, and in compliance with SARA, the MBCA, and the provincial *Wildlife Act* (1998), as relevant. If work must be conducted during these periods, environmental monitoring will be used so that disturbances do not disrupt rare or sensitive wildlife during critical periods. Focused pre-construction surveys may be used to determine if any rare or sensitive species are present at the work site. During construction and throughout the lifetime of the Project, Yancoal will comply with all aspects of relevant federal and provincial acts, regulations, and guidelines, and best practices to reduce and mitigate potential effects on vegetation and wildlife. After construction has been completed, disturbed areas within pipeline corridors will be re-contoured and reclaimed to support current land uses.

The above-mentioned environmental design features will be implemented to mitigate these alterations during installation of mine well field area pipelines. Pipelines will be routed underground to allow continued use of land for agricultural or environmental purposes and will follow existing utility corridors to reduce disturbance to undisturbed areas, where possible. Construction activities that occur during sensitive nesting, rearing, and breeding periods for listed and common species will be accompanied by appropriate pre-construction surveys, and provincial guidelines (i.e., setback distances; SKCDC 2014) will be applied when required.

Construction of the mine well field area pipelines are expected to result in minor changes to wildlife habitat relative to Base Case conditions by using environmental design features and mitigation. Much of the alterations to the landscape are expected to be temporary and limited to the construction period. Therefore, this pathway was determined to result in negligible residual effects on wildlife.

- **Air and dust emissions and subsequent deposition can cause changes to the chemical properties of soils and vegetation, which can affect wildlife VCs.**

Construction and operation of the Project will generate air emissions such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (particulate matter with aerodynamic diameter less than 2.5 micrometres [µm] [$PM_{2.5}$], particulate matter with aerodynamic diameter less than 10 µm [PM_{10}], total suspended particulates [TSP]), and KCl. Air emissions such as SO_2 and NO_2 can result from the use of fossil fuels in diesel-fired construction equipment, vehicles and locomotives used during the Project, as well as natural gas fired boilers and dryers. Transportation routes used to access the Project are the main source of dust ($PM_{2.5}$, PM_{10}, and TSP) due to the re-suspension of soil particles (Farmer 1993; Harrison et al. 2003; Peachey et al. 2009; Liu et al. 2011).

Air quality modelling was completed to predict the spatial extent of air and dust emissions and deposition from the Project (Section 7.5). Air quality modelling was completed using the maximum emissions profile expected during the operations phase of the Project. The cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are predicted to evaluate changes to measurement indicators for air quality during the Application Case. This provides the maximum potential effects from the Project. Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates. The air quality modelling results show that the Project-related increase in NO_2, SO_2, are limited to the atmospheric environment ESA and $PM_{2.5}$, PM_{10}, TSP concentrations, and KCl deposition are limited to the immediate vicinity of the Project (Section 7.5). Concentrations of SO_2, NO_2, $PM_{2.5}$, PM_{10}, and KCl are not predicted to exceed Saskatchewan Ambient Air Quality Standards or other applicable criteria.

Environmental design features and mitigation will be incorporated into the Project design to limit air emissions and dust from the Project (Section 7.5 and Table 14.4-1). Overall, air and dust emissions and subsequent deposition are expected to result in minor and local changes to the chemical properties of soils and vegetation relative to Base Case conditions (Section 12.4.2.2; Section 13.4.2.2). Therefore, this pathway was determined to have a negligible residual effect on wildlife habitat and wildlife VCs.

- **Physical hazards from the Project cause injury or mortality to individual animals.**

The tailings management area (TMA) may attract waterbirds because the ponds will contain high levels of salt that may support high densities of salt-tolerant insects and invertebrates (Tanner et al. 1999). Waterbirds may also use ponds in the TMA for staging and roosting during spring and fall migrations as salt concentrations prevent water from freezing. Negative effects from the TMA on waterbirds may include salt toxicity (Mitcham and Wobeser 1988). Salt toxicity in waterfowl can be induced when individuals are strictly fed water with sodium concentrations between 1,900 and 2,100 parts per million (ppm) in laboratory conditions (Wingingstand et al. 1987). Salt concentrations within brine ponds on the Project site are expected to be much greater than this. However, birds are not expected to consume all food and water from the TMA as the effects study area contains numerous non-permanent and permanent wetlands. Salt toxicity in waterfowl is not expected during the summer because the TMA will not have vegetation cover suitable for nesting and rearing young. The TMA is not expected to result in detectable changes in waterbird population mortality rates. If monitoring of the TMA detects that waterbirds are frequently using the TMA, mitigation such as installing deterrents, may be implemented to limit the use of the TMA by waterbirds.

The TMA is not anticipated to attract amphibians as there will be little vegetation cover in the TMA. The lack of vegetation cover will make taking refuge from predators and inclement weather difficult and so amphibians are expected to avoid the TMA. If monitoring of the TMA detects that amphibians are using the TMA, mitigation such as installing frog fences, may be implemented to limit the use of the TMA by amphibians.

- **Collisions with Project vehicles and trains can cause injury or mortality to individual animals.**

The Project will increase the amount of vehicle traffic in the ESA, which may result in increased injury and mortality to wildlife (Romin and Bissonette 1996; Hussain et al. 2007). Wildlife (primarily mammals, reptiles, and amphibians) are often attracted to roads where they forage for food, bask on the road surface, scavenge for carrion, and use corridors for travel (Smith-Patten and Patten 2008; Fahrig and Rytwinski 2009). Also, the risk of vehicle-wildlife collisions is not uniform in regards to species, with amphibians having a high mortality risk from crossing roads because of their small size and slow movement speeds (Hels and Buchwald 2001; Fahrig and Rytwinksi 2009). The search for prey and carrion may attract carnivores and raptors to roads (Fahrig and Rytwinski 2009) where they are insensitive to the threat of traffic (Dickson and Beier 2002). The presence of salt-covered vegetation and increased sodium levels in roadside ditches can be attractive to moose (*Alces alces*) (Laurian et al. 2008a, b) and deer (*Odocoileus* spp.) (Mastro et al. 2008).

Most of the traffic to the Project is expected to use Highway 6, Highway 22, or grid road 641. A traffic impact assessment (TIA) was completed to assess potential changes to traffic volumes from the Project (Appendix 4-C). Peak daily volumes during construction are anticipated to be roughly 750 vehicles (31 per hour) and 225 (9 per hour) during operations (Appendix 4-C). It is estimated that 90% of the total vehicle traffic will use Highway 6 to travel to and from the Project site.

The average daily traffic volume on Highway 6 between Piapot First Nation and Southey from 2008 to 2013 was 2,673 vehicles per day (975,645 vehicles per year) (SGI 2009, 2010, 2011, 2012, 2013, 2014). On Highway 6 between Southey and Raymore the average vehicle traffic level from 2008 to 2013 was 1,353 vehicles per day (493,688 vehicles per year) (SGI 2009, 2010, 2011, 2012, 2013, 2014). Overall, traffic on Highway 6 is estimated to increase by 675 vehicles per day, or 25%, during construction of the Project. An increase of 203 vehicles per day, or 8%, is predicted, on Highway 6 during Project operations. There have been 223 vehicle-wildlife collisions along Highway 6 between Piapot First Nation and Raymore from 2008 to 2014 (average of 32 vehicle-wildlife collisions per year or 1 collision every 11 days) (Wasnik 2015).

Wildlife-vehicle collisions have been observed to occur at higher rates near preferred wildlife habitat (e.g., wetlands, forested areas) (Rodriguez et al. 1997). Although traffic volume will increase during Project construction and operation, the limited amount of wildlife habitat near the Project footprint should keep the risk of increased wildlife-vehicle collisions to a minimum. Environmental design features will also be implemented to mitigate wildlife-vehicle collisions from increased traffic caused by the Project (Table 14.4-1). In summary, increases in vehicle traffic during Project construction and operation are expected to result in minor changes to vehicle-wildlife collisions as compared to Base Case conditions and are expected to have a negligible residual effect on wildlife populations.

- **Wildlife can be attracted to the Project (e.g., by food, oil products, salt, infrastructure), which can increase human-wildlife interactions and mortality risk to individual animals.**

Attraction of wildlife to the Project may result in increased mortality, risk of predation, and human-wildlife interactions. Wastes generated by human activity can be attractive to wildlife. Insectivorous birds may be attracted to salt-tolerant insects and invertebrates associated with the brine pond (Tanner et al. 1999), while birds and bats may be attracted to the abundance of insects around Project lights at night. Ungulates require the intake of salts as part of seasonal changes in diet (Atwood and Weeks 2003). These needs may be fulfilled by chemicals and wastes produced by industrial processes. Brine ponds, the TMA, and salt build-up near roads (Laurian et al. 2008a, b) may attract ungulates. Wildlife may be attracted to human infrastructure as refuge from weather and predators. Birds may seek out Project buildings as suitable nesting habitat (Brown and Bomberger 1999; White et al. 2002).

Environmental design features and management plans will be implemented to limit wildlife attraction to the Project site. A Waste Management Plan will be developed so that waste products are disposed of and stored in suitable receptacles to limit attraction of wildlife. Fences will be installed around the process plant to restrict wildlife access to the Project. A recycling program will be implemented and recycling receptacles will be made accessible for site personnel. Storage facilities for hazardous wastes will meet the appropriate regulatory requirements and site personnel will be properly trained. Disposal of hazardous wastes will be handled by a licensed contractor and hauled to an approved facility. An Environmental Protection Plan will be developed and initiated with policies that include prohibition of littering, feeding, and interacting with wildlife.

In summary, environmental design features and mitigation are expected to limit wildlife attraction to the Project and therefore result in a minor change to the mortality of wildlife relative to Base Case conditions. Therefore, these pathways are expected to have a negligible residual effect on wildlife populations.

- **Attraction of predators to the Project can increase predation risk of prey species, which can cause changes to the abundance of prey populations.**

Food smells and other aromatic compounds such as petroleum-based chemicals, grey water, and sewage can attract carnivores to human developments (Benn and Herrero 2002; Peirce and Van Daele 2006; Canadian

Wildlife Service 2007; Beckmann and Lackey 2008). In addition, infrastructure may also attract carnivores as it can serve as a temporary refuge to escape extreme heat or cold (Canadian Wildlife Service 2007). Corvids (e.g., crows and ravens) and raptors may also be attracted to infrastructure and anthropogenic food sources (Restani et al. 2001; Marzluff and Neatherlin 2006; Canadian Wildlife Service 2007; Kristan and Boarman 2007; Baxter and Allan 2008). Some predator (e.g., peregrine falcon [White et al. 2002]) species may be attracted to infrastructure as suitable nesting areas. Attraction of carnivores and predatory birds (e.g., ravens and gulls) to the Project can increase predation pressure on prey species (e.g., passerines and waterfowl), and may cause local population declines for these prey species (Monda et al. 1994; Canadian Wildlife Service 2007; Liebezeit et al. 2009).

An Environmental Protection Plan will be implemented to limit the attraction of wildlife to the Project, and the associated increased risk of mortality from predation (Table 14.4-1). For example, food wastes and oil products will be collected and temporarily stored in wildlife proof containers. The containers will be transported off site for recycling or disposal at a licensed disposal facility. Environmental design features and management plans should limit attractants to the Project and result in a minor increase in wildlife mortality risk from predation relative to the Base Case. Therefore, this pathway is predicted to have a negligible residual effect on wildlife populations.

14.4.2.3 Primary Pathways

The following primary pathways are assessed in detail in the residual effects analysis.

- **Direct loss, alteration, and fragmentation of wildlife habitat from the Project footprint (core facilities area, mining area, and access roads) can cause changes in the relative abundance and distribution of bird and amphibian VCs.**
- **Residual ground disturbance from portions of the core facilities area can cause permanent alteration of wildlife habitat, which could affect the abundance and distribution of bird and amphibian VCs.**
- **Ground subsidence can cause degradation of wildlife habitat, which can cause changes to the relative abundance and distribution of wildlife VCs.**
- **Sensory disturbance (e.g., presence of humans, smells, and noise) from the construction and operation of the Project can cause changes to the relative abundance and distribution of bird and amphibian VCs.**

14.5 Residual Effects Analysis

14.5.1 Changes to Habitat Quantity and Fragmentation

14.5.1.1 Methods

The incremental and cumulative direct habitat effects on bird and amphibian VCs from the Project footprint and other previous and existing developments in the ESA were analyzed through changes in the area and spatial configuration of habitat types on the landscape (i.e., landscape metrics). Decreases in habitat area can directly influence population size by reducing the carrying capacity of the landscape. Habitat fragmentation can also affect both locally breeding bird populations (Allen 1952; Ramirez et al. 1993; Leafloor et al. 1996) and northern leopard frog (Environment Canada 2013) populations. Therefore, in addition to habitat loss, changes to mean habitat patch area, number of habitat patches, and distance to nearest similar patch (MDNN) were assessed. Changes in habitat area, number of patches, and MDNN are reported for all habitat types (i.e., Ecological Landscape Classification [ELC] map units). The MDNN is calculated as the shortest straight-line Euclidean distance between the centroids of the closest cells of equivalent habitat patches (McGarigal et al. 2012).

The ELC map was developed for the ESA using Landsat 5 satellite imagery (30 m by 30 m pixel, acquired on September 10, 2011) and Worldview 2 satellite imagery (2 m by 2 m pixel, acquired on July 13, 2013 and August 13, 2013). Because of the prevalence of cloud and haze in portions of the Worldview 2 imagery, additional GeoEye imagery (2 m by 2 m pixel, acquired on August 11, 2013 and on August 14, 2013) was obtained to classify the obscured/occluded areas. The Landsat 5 satellite imagery was used to map larger upland classes, while the Worldview 2 and GeoEye imagery was used to delineate the wetlands and wooded areas (i.e., smaller vegetation features). Quality control measures were implemented so that the imagery was correctly calibrated and geo-referenced within the ESA. The imagery was loaded into object-based remote sensing analysis software (eCognition 8.7) for the classification process.

Ecological landscape classification map units were delineated using a multispectral segmentation algorithm. The parameters of this algorithm were adjusted until the image objects (polygons) were an appropriate shape and size to best approximate the features to be classified.

To provide information for the supervised classification of the ELC, vegetation cover types were surveyed and ground-truthed in the field. Ground-truthing required only basic data collection, such as recording location and ELC cover class. Plots were established in a representative area of the ELC polygon, based on landscape position and vegetation within the polygon with no formal site boundaries.

The ELC map units were then classified based on the spectral characteristics of known vegetation types that were collected at ground-truth locations during vegetation field programs as part of the supervised classification. Based on the spectral signatures of the field-validated ground truth locations, the remote sensing software assigned a maximum likelihood classification to all objects in the image. Image objects with spectral characteristics that deviated from the ground-truth locations were classified with the use of multispectral indices. Any spectral characteristics of an object that deviated from that of the ground-truthed field data may be the result of a different substrate type, moisture regime, or a difference in illumination at the time the imagery was collected.

The final supervised classification used a combination of rules, which considered the spectral characteristics associated with known ground features, multispectral index thresholds, and spatial relationships between adjacent objects. The final ELC map was created by merging the Landsat 5 ELC with the Worldview 2 and GeoEye classifications. Roads and communities were incorporated into the ELC by buffering the CanVec layer (NRC 2012) and incorporated into the final ELC.

Once the classification was complete, selected locations from vegetation field programs, other than those used as field-validated observation points, were compared against the classification for a visual accuracy assessment.

Previous and existing developments in ESA were determined from the CanVec database (Natural Resources Canada 2012). Because the CanVec database did not describe the footprint of developments, the physical areas of different human development footprints were estimated. Grid roads and highways were buffered by 8 m (total 16 m right-of-way [ROW]). The number and type of previous and existing developments in the ESA are listed in Table 14.5-1.

Table 14.5-1: Previous and Existing Developments in the Effects Study Area

Type of Development[(a)]	Footprint Area (ha)	Number of Sites	Linear Feature Length (km)
Transmission lines	108	n/a	67.6
Roads	1,115	n/a	699.3
Towers	<1	1	n/a

Note: Overlapping areas were merged together so the area was not counted twice.
Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

(a) Determined from the CanVec database (Natural Resources Canada 2012).

ha = hectare; km = kilometre; n/a= not applicable; < = less than.

Landscape metrics of similar habitat types were determined using the program FRAGSTATS (Version 4.0) (McGarigal et al. 2012) within a Geographic Information System (GIS) platform. The analysis determined the extent of landscape fragmentation by calculating statistical outputs based on the values of each raster cell of the ELC data. Landscape metrics were determined for the Base Case and Application Case, and for the spring through autumn period. The Base Case includes all previous, existing, and approved developments up to 2013.

Changes to wildlife habitat were assessed for the maximum predicted point of development of the Project footprint (Application Case), which should have the largest geographic extent of effects on self-sustaining and ecologically effective wildlife populations. Progressive reclamation is expected to occur during operations to limit incremental losses and effects beyond the Application Case.

For the analysis, the proposed core facilities area was buffered by 100 m, the plant site access road buffered by 50 m (100 m ROW), the well pads buffered by 50 m, and the well pad access roads buffered by 25 m (50 m ROW) so that a maximum possible extent of disturbance is used in the analysis. Most of the proposed Project infrastructure will be removed and reclaimed during decommissioning and reclamation. The TMA (i.e., salt storage areas, brine reclaim ponds, and sewage lagoon), the crystallization pond, and site runoff collection pond are considered permanent. The footprint was buffered so that the effects analysis results represent a conservative estimate of residual effects on wildlife (i.e., effects are likely overestimated).

The incremental and cumulative changes from the Project and other developments on the loss and fragmentation of habitat were estimated by calculating the relative difference between the Application Case and Base Case as follows:

(Application Case value - Base Case value) / Base Case value x 100%.

The result provides both the direction and magnitude of the effect. For example, a high negative value for habitat area would indicate a substantial loss of that habitat type. Absolute values per habitat type and assessment case (i.e., Base Case and Application Case) for the ESA are provided in Appendix 14-A (Table 1).

14.5.1.2 Results

14.5.1.2.1 Upland Breeding Birds

Cultivated habitat is the most common habitat in the ESA and covers 58.3% of the ESA under Base Case conditions. Modified grassland and native grassland habitats cover 15.8% and 8.0% of the ESA, respectively. Wooded habitat covers 3.4% of the ESA, while existing disturbance covers 1.4%. Class I, II, III, IV, and V wetlands comprise 0.4% (Class V wetlands) to 6.6% (Class IV wetlands) of the ESA under the Base Case. Dugouts cover less than 0.1% of the ESA.

Upland breeding bird densities in the ESA were highest in wooded and wetland habitats (Table 14.3-1). Most upland bird species that are protected under SARA, or are recommended to be listed under SARA by Committee on the Status of Endangered Wildlife in Canada (COSEWIC) that may breed in the ESA are associated with native grassland habitat (Annex IV, Table 5.3-1). The Project is predicted to remove 0.5% of wooded habitat, relative to the Base Case (Table 14.5-2). From 1.2% to 2.2% of Class I, II, III, IV, and V wetlands will be removed by the Project footprint. The Project footprint is predicted to remove 0.3% of native grassland habitat in the ESA, relative to the Base Case.

Approximately 40% of prairie wetlands have been removed by drainage activities in the last 100 years (Cortus et al. 2010). Additionally, in the areas of Alberta, Saskatchewan, and Manitoba that were surveyed by Bartzen et al. (2010), more than 90% of wetlands were visibly affected by agricultural activities (e.g., tilling of wetland edges). Shallow ephemeral wetlands located in agricultural fields were found to have the highest impact and lowest recovery rates, relative to semi-permanent or permanent wetlands and wetlands located in non-agricultural areas (Bartzen et al. 2010). Furthermore, wetland recovery rates in the prairie region of Canada appear to be much lower than impact rates (Bartzen et al. 2010).

Approximately 80% of native grassland habitat in Saskatchewan is estimated to have been lost in the last 150 years, with some local areas of prime cropland recording losses of up to 98% (Hammerstein 2001). Conversely, wooded habitat appears to have increased in Saskatchewan since the 1900s (Archibold and Wilson 1980).

The specific amount of native grassland and wetlands that have been removed by agricultural and development activities in the ESA cannot be determined because a landscape classification of the ESA under conditions with no development (reference condition) is not available. However, cultivated, modified grassland, and existing disturbance habitats cover 75.5% of the ESA under the Base Case. As such, 75.5% of native grassland and wetland habitats that were in the ESA prior to human settlement are estimated to have been removed by previous and existing human developments and agricultural activities. During the Application Case, the amount of cumulative disturbance in the ESA is predicted to increase to 75.8%.

The Project is predicted to remove 7 patches (1.4%) of Class V wetland, 12 patches (0.6%) of Class III wetland, 48 patches (1.0%) of Class IV wetland, and 300 patches (1.9%) of Class I and II wetland. Native grassland habitat and wooded habitat is expected to decrease by 19 patches (0.6%) and 89 patches (0.7%), respectively (Table 14.5-3). No change to dugout habitat is expected.

The MDNN metric is important to understand the dispersal potential among remaining patches of natural areas. Within the ESA, during the Base Case, the MDNN between patches of native grassland is 50.7 m. This means that species will need to disperse 50.7 m before encountering another patch of native grassland. With application of the Project, this mean distance is predicted to decrease slightly to 50.6 m, meaning the Project is likely not to have an ecologically measurable effect on the current ability of species to disperse between patches, given they can move these distances. A similar result was observed in wooded and wetland habitats where only small changes in MDNN were observed. Predicted changes in MDNN ranged from 0 to 2.4 m for wooded and wetland habitats (including dugouts) relative to Base Case conditions.

The application of mitigation for the Project will follow the mitigation hierarchy outlined in MOE (2014) (i.e., the preferred mitigation is to avoid wetlands). As such, some well pad locations used in this assessment will be moved and sited to avoid wetlands. Avoidance of wetlands will reduce the contribution to cumulative effects from the Project and so the calculated changes predicted in the assessment are conservative (i.e., overestimate effects).

Table 14.5-2: Change in Area of Habitat Types from Development within the Effects Study Area

Habitat Type	Base Case (ha)	Application Case (ha)	Percent Change Base Case to Application Case (%)
Cultivated	46,834	45,618	-2.6
Modified Grassland	12,723	12,646	-0.6
Native Grassland	6,432	6,413	-0.3
Wooded	2,717	2,703	-0.5
Class I and Class II Wetland	3,963	3,876	-2.2
Class III Wetland	936	924	-1.3
Class IV Wetland	5,321	5,252	-1.3
Class V Wetland	316	312	-1.2
Dugout	2	2	0.0

Note: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
ha = hectare; % = percent.

Table 14.5-3: Change in Configuration of Habitat Types from Development within the Effects Study Area

Habitat Type	Base Case	Application Case	Percent Change Base Case to Application Case (%)
Number of Patches			
Cultivated	4,992	4,944	-1.0
Modified Grassland	7,053	7,027	-0.4
Native Grassland	3,371	3,352	-0.6
Wooded	12,091	11,930	-0.7
Class I and Class II Wetland	16,115	15,815	-1.9
Class III Wetland	2,053	2,041	-0.6
Class IV Wetland	4,581	4,533	-1.0
Class V Wetland	489	482	-1.4
Dugout	25	25	0.0

Table 14.5-3: Change in Configuration of Habitat Types from Development within the Effects Study Area

Habitat Type	Base Case	Application Case	Percent Change Base Case to Application Case (%)
Mean Distance to Nearest Neighbour (m)			
Cultivated	25.8	25.9	0.6
Modified Grassland	30.4	30.3	-0.3
Native Grassland	50.7	50.6	-0.2
Wooded	419.2	418.9	<-0.1
Class I and Class II Wetland	55.1	55.2	0.3
Class III Wetland	182.9	182.0	-0.5
Class IV Wetland	75.5	75.4	-0.1
Class V Wetland	397.6	395.1	-0.6
Dugout	2,143.2	2,143.2	0.0

Note: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
Values <-0.01 approach zero.
% = percent; m = metres.

14.5.1.2.2 Waterbirds

Waterbirds are a diverse group of species and nesting habitats for this group are also diverse. However, one ecological aspect that they all require is water, either for foraging or for nesting habitat. Class I, II, III, IV, and V wetlands comprise 0.4% (Class V wetlands) to 6.6% (Class IV wetlands) of the ESA under the Base Case. Dugouts cover less than 0.1% of the ESA.

The Project footprint is predicted to remove from 1.2% to 2.2% of Class I, II, III, IV, and V wetlands in the ESA (Table 14.5-2). No dugouts are predicted to be removed by the Project.

Approximately 40% of prairie wetlands have been removed by drainage activities in the last 100 years (Cortus et al. 2010). Prairie wetlands continue to be drained and annual rates of loss in Saskatchewan from 1985 to 1999 were estimated to be 4.65% (SWA 2002). Similar annual rates of wetland loss from drainage activities were reported for 1985 to 2001 and this trend is likely to continue, as the rate of wetland loss on the prairies has not slowed in the past 50 years (Cortus et al. 2010). In the prairie region of Canada, the rate and number of wetlands that are being affected by human activities is much higher than recovery rates for wetlands (Bartzen et al. 2010).

Human developments and agricultural activities are estimated to have removed 75.5% of native habitats that were in the ESA prior to human settlement in the prairies. In the 1880s, townships that are encompassed by the ESA had 0% to 15% of coverage by wetlands (marshlands) (Archibold and Wilson 1980). Taking that the upper limit of coverage by wetlands was 15% (12,058 ha) in the ESA prior to human development (Archibold and Wilson 1980), then 12.6% (1,522 ha) of wetland habitat has been removed by previous and existing human developments, including agricultural activities (i.e., cultivated and modified grassland habitats) relative to the condition prior to human development. Cumulative loss of wetland habitat during the Application Case is predicted to be 14.1% (1,694 ha), relative to the landscape prior to human development.

The Project is predicted to remove no patches of dugout, 7 patches (1.4%) of Class V wetlands, 12 patches (0.6%) of Class III wetlands, 48 patches (1.0%) of Class IV wetlands, and 300 patches (1.9%) of Class I and II wetlands (Table 14.5-3).

The MDNN between wetland patches range from 55 to 398 m under Base Case conditions. Changes to distance between wetlands patches under the Application Case are predicted to range from 0.1 to 2.4 m (Table 14.5-3). The MDNN is not predicted to change for dugouts. As such, the Project is not likely to have an ecologically measurable effect on the current ability of species to move between patches.

The application of mitigation for the Project will follow the wetland mitigation hierarchy outlined in MOE (2014), with the preferred mitigation being to avoid wetlands. As such, some well pad locations used in this assessment will be moved during construction and sited to avoid wetlands. Placing Project infrastructure (e.g., well pads) to avoid wetlands will reduce the contribution of Project effects to cumulative effects on wildlife in the ESA (i.e., the predicted change presented in this assessment is conservative).

14.5.1.2.3 Ferruginous Hawk

Ferruginous hawks are strongly dependent on native grasslands for breeding habitat (COSEWIC 2008a). Under Base Case conditions, native grassland covers 8% of the ESA. The Project is predicted to remove 0.3% of native grassland habitat, relative to the Base Case (Table 14.5-2).

Approximately 80% of native grassland habitat in Saskatchewan is estimated to have been lost in the last 150 years, with some local areas of prime cropland recording losses of up to 98% (Hammerstein 2001). Approximately 40% of Saskatchewan's remaining native grassland occurs in the Aspen Parkland and Moist Mixed Grassland Ecoregions (approximately 20% within each ecoregion) (Hammerstein 2001). However, native grassland habitat only covers 13% of the Aspen Parkland Ecoregion and 16% of the Moist Mixed Grassland Ecoregion (Hammerstein 2001).

The loss of native grassland to cultivation is likely the primary reason why the northern extent of the ferruginous hawk range has contracted from the 1900s (Downey 2006). Ferruginous hawk abundance decreases as the proportion of cultivated land in an area increases (Schmutz 1987). In Saskatchewan, the breeding range appears to have retreated to the southwest to where native grassland still dominates the landscape (Downey 2006). Although a few ferruginous hawk pairs may breed in the ESA, these are considered outliers and not part of the self-sustaining and ecologically effective population in Saskatchewan. In Saskatchewan, the majority of ferruginous hawks breed in the Mixed Grassland Ecoregion (Downey 2006).

In the 1880s, all townships in the ESA were comprised of greater than 75% grassland cover (Archibold and Wilson 1980). As such, it was assumed that 75% of the ESA (60,289 ha) was comprised of native grassland habitat prior to human settlement. There are 6,432 ha of native grassland habitat in the ESA under Base Case conditions. Therefore, previous and existing developments in the ESA, including agriculture, are predicted to have removed 89.3% of native grassland habitat that was present in the ESA prior to human settlement. Cumulative loss of native grassland habitat during the Application Case is predicted to be 89.4%, relative to the landscape in the ESA prior to human settlement.

The Project is predicted to remove 19 patches (0.6%) of native grassland and to decrease the MDNN of native grassland habitat by less than 0.1 m (0.2%) (Table 14.5-3).

14.5.1.2.4 Short-Eared Owl

Short-eared owls breed in a wide variety of open habitats including native grasslands, marshes, and old pastures (COSEWIC 2008a). Short-eared owls occasionally nest in cultivated areas but their breeding success is low in this habitat type (COSEWIC 2008a). Potentially suitable habitat for short-eared owl in the ESA was defined as Class I, II, and III wetlands, native grassland, and modified grassland habitats. The Project is predicted to remove 0.3% and 0.6% of native grassland and modified grassland habitats, respectively (Table 14.5-2). Approximately 2.2% of Class I and II wetland habitat is predicted to be removed by the Project footprint.

Approximately 75.0% (60,289 ha) of the ESA was covered by native grassland habitat prior to human settlement (Archibold and Wilson 1980). Previous and existing developments in the ESA, including agriculture, are predicted to have removed 89.3% (53,856 ha) of native grassland habitat that was present in the ESA prior to human settlement. Cumulative loss of native grassland habitat during the Application Case is predicted to be 89.4%, relative to the landscape in the ESA prior to human development.

Wetlands were assumed to cover 15.0% (12,058 ha) of the ESA prior to human settlement (Archibold and Wilson 1980). Approximately 12.6% (1,522 ha) of wetland habitat that was present in the ESA prior to human settlement has been removed by human developments and agricultural activities. Cumulative loss of wetland habitat during the Application Case is predicted to be 14.1% (1,694 ha), relative to the landscape that was present in the ESA prior to human development.

The Project is predicted to remove 12 patches (0.6%) of Class III wetlands and 300 patches (1.9%) of Class I and II wetlands. Nineteen patches (0.6%) of native grassland habitat and 26 patches (0.4%) of modified grassland habitat are predicted to be removed by the Project (Table 14.5-3).

The MDNN between patches of native grassland is 50.7 m under Base Case conditions in the ESA. With application of the Project, the MDNN is predicted to decrease by 0.1 m to 50.6 m. As such, the Project is not likely to have an effect on the current ability of short-eared owl to move between patches. A similar result was observed in wetland habitats where only small changes in MDNN were observed. Predicted changes in MDNN ranged from 0 to 2.4 m for wetland habitats (including dugouts), relative to Base Case conditions.

The application of mitigation for the Project will follow the mitigation hierarchy outlined in MOE (2014) and the primary mitigation will be to avoid disturbing wetlands. As such, some well pad locations will be moved during construction and sited to avoid wetlands.

14.5.1.2.5 Northern Leopard Frog

Potential suitable breeding habitat for northern leopard frogs includes Class III and Class IV wetlands. Potential suitable overwintering habitat includes Class V wetlands and dugouts. Class III and IV wetlands cover 1.2% and 6.6% of the ESA, respectively, under the Base Case. Class V wetlands cover 0.4% of the ESA under the Base Case, while dugouts cover less than 0.1% of the ESA.

The Project is predicted to remove 1.3% of Class III and Class IV wetlands, relative to the Base Case (Table 14.5-2). Approximately 1.2% of Class V wetlands will be removed by the Project. No dugouts will be removed from the Base Case to the Application Case.

Wetlands were assumed to cover 15.0% (12,058 ha) of the ESA prior to human settlement (Archibold and Wilson 1980). Human developments and agricultural activities have removed approximately 12.6% (1,522 ha) of wetland habitat that was present in the ESA prior to human settlement. Cumulative loss of wetland habitat during the Application Case is predicted to be 14.1% (1,694 ha), relative to the landscape that was present in the ESA prior to human development. However, it is likely that not all of this wetland habitat is suitable for northern leopard frog because breeding, foraging, and overwintering habitats must be located in close proximity to each other and must be connected in some way (Environment Canada 2013).

The Project is predicted to remove 12 patches (0.6%) of Class III wetlands, 48 patches (1.0%) of Class IV wetlands, and 7 patches of Class V wetlands (Table 14.5-3). No dugouts will be removed by the Project. The MDNN for Class III, IV, and V wetlands is predicted to decrease by 0.1 to 2.4 m with the application of the Project. The MDNN for dugouts is not predicted to change from the Base Case to the Application Case.

During the Base Case, the MDNN for Class III, IV, and V wetlands ranged from 76 to 398 m (Table 14.5-3). This means that under current conditions in the ESA, northern leopard frogs are required to travel 76 to 398 m between wetland patches. The Project is predicted to result in a negligible decrease in the MDNN between Class III, IV, and V wetlands (range 0.1 to 2.4 m). The small decreases in distance between habitat patches are not likely to have an effect on the current ability of northern leopard frogs to move between patches.

The application of mitigation for the Project will follow the mitigation hierarchy outlined in MOE (2014) (i.e., the preferred mitigation is to avoid wetlands). As such, the location of some well pads used in this assessment will be moved and sited to avoid wetlands.

14.5.2 Changes to Habitat Quality, Movement, and Behaviour

14.5.2.1 Methods

14.5.2.1.1 Upland Breeding Birds

Project development will generate sensory disturbances including increased noise levels during construction and operations. Noise emission levels of greater than 50 A-weighted decibels (dBA) can adversely affect migratory birds (Environment Canada 2014). Adverse effects include decreased reproductive success, lowered predator detection, and avoidance of the area by individuals.

The proportion of the ESA that is being affected by sensory disturbance from existing human developments under the Base Case was calculated using noise emission levels (Table 14.5-4) from the Federal Highway Administration Construction Noise Handbook (FHA 2011) and Towers (2015). Noise emission levels in the Construction Noise Handbook (FHA 2011) and Towers (2015) were measured at 50 feet (15 m) from the noise source. Noise is dissipated by the air and objects (e.g., hills and trees); noise levels drop six decibels when the distance from the source doubles (Ortega 2012). The distances for noise emissions from large trucks, pickup trucks, tractors, and vehicles travelling at speed to reach 50 dBA were determined using the following formula (Claus Environmental Engineering 2014):

$$Drop\ in\ dBA\ from\ near\ to\ far\ distance = 20\ x\ log\ (\frac{distance\ far}{distance\ near})$$

Table 14.5-4: Noise Emission Levels for Vehicles

Vehicle Type	Noise Emission Level (dBA) Measured at 15 m
Pickup Truck	75[a]
Dump Truck	76[a]
Tractor	84[a]
Vacuum Truck	85[a]
Commuter Bus Travelling at 80 km/h	87[b]

[a] Source: FHA (2011).
[b] Source: Towers (2015).
km/h = kilometres per hour; m = metres; dBA = A-weighted decibels.

Using the formula and noise emission levels presented above, noise from large trucks, pickup trucks, and tractors is predicted to reach a level of 50 dBA at a distance of 470 to 840 m from the source. Noise from commuter buses travelling at 80 km/h (used as a surrogate for semi-trucks travelling at highway speed) reaches 50 dBA at 1,070 m from the source.

Most noise from human activities in the ESA is anticipated to be intermittent. Traffic volumes on grid roads in the ESA are relatively low. Additionally, no communities are present in the ESA. Agricultural lands are common throughout the ESA but farming activities are infrequent, temporary sources of noise. Most sensory disturbances from agricultural activities occur during seeding, which is during the breeding bird season, and harvest, which is generally outside of the breeding bird season. As such, the maximum distance buffer calculated for vehicles (840 m) was not applied to existing grid roads because this was thought to overestimate effects from existing developments, which, in turn, would underestimate Project effects.

For the habitat quality analysis, existing grid roads were buffered by 300 m (total 600 m ROW). This buffer distance is deemed appropriate because of the current level of traffic and other human activity in the ESA. Bird species in the Netherlands were found to avoid roads with 5,000 vehicles per day by 20 to 1,700 m (Reijnen et al. 1996); this traffic volume is much greater than expected traffic levels on grid roads in the ESA. Benitez-Lopez et al. (2010) found that most birds have lower abundance within 1 km of human infrastructure. Conversely, studies at the Ekati Mine in the Canadian Arctic found few effects on the upland bird community within 1 km of the Ekati Mine (Smith et al. 2005) and no measurable effect on the reproductive success of Lapland longspurs nesting adjacent to roads (Male and Nol 2005). Existing highways in the ESA were buffered by 1,100 m (total 2,200 m ROW).

For the Application Case, noise modelling results (Appendix 14-B) were used to determine the magnitude of sensory disturbance effects from the Project. During construction of the Project noise levels greater than or equal to 50 dBA are primarily located in the core facilities area and in the mine well field area. During Project operations, noise levels greater than or equal to 50 dBA are expected to be primarily concentrated in the core facilities area. Because the areas of high noise levels are concentrated in different areas during the construction and operations phases of the Application case, the two Project phases are considered independently for this analysis. Using noise modelling results (Appendix 14-B), the area of habitats within the 50-dBA contours for the construction and operations phases was calculated. Upland bird densities (Table 14.5-3) were then multiplied by the habitat area within the 50-dBA contour to estimate the reduction in bird abundance caused by direct and indirect effects from the Project. Baseline abundances estimated within areas that will be affected by Project noise levels greater than 50 dBA were used to predict the absolute and relative number of birds that may be lost and displaced within the ESA due to the Project.

Upland breeding birds are not expected to experience direct mortality from construction activities as the Project will be constructed outside of the breeding season or there will be surveys completed to locate and protect any nests found within the construction area. However, upland breeding birds may be displaced by the construction of the Project as the Project may remove breeding territories for some individuals (i.e., decrease the carrying capacity of habitats in the ESA). Therefore, as a conservative approach, upland breeding birds were assumed to be removed by the Project.

For the Base Case, regional abundance estimates for upland breeding birds were calculated by multiplying mean density estimates (number of birds per hectare) calculated from baseline survey data by the area of the habitat type within the ESA (Table 14.5-5). All calculations were completed using raster file types within a GIS platform. Each 30 by 30 m raster cell in the ESA representing a habitat type, other than Class V wetland (Stewart and Kantrud 1971), dugout, disturbance, and unclassified habitats, was assigned a density value equal to the mean density estimate for the habitat type. Class V wetlands, dugouts, disturbance and unclassified habitats were assigned a bird density of zero. Class V wetland and dugout habitats were not included in the analysis because upland breeding birds do not nest in these habitat types, although they may nest in the riparian zone.

Class I, II, and III wetlands (Stewart and Kantrud 1971) were assigned the bird density calculated for non-wooded wetlands because typically most Class I, II, and III wetlands did not have a shrub or tree ring around the perimeter of the wetland (Annex IV, Section 4.3.1.2). Class IV wetlands (Stewart and Kantrud 1971) were assigned the bird density calculated for wooded wetlands because most Class IV wetlands had a shrub or tree ring around the perimeter of the wetland (Annex IV, Section 4.3.1.2).

Table 14.5-5: Mean Relative Abundance of Upland Breeding Birds in Habitat Types within the Effects Study Area under the Base Case

Habitat Type	Number of Plots	Relative Abundance (birds/ha)[a]	Area in ESA under the Base Case (ha)
Cultivated	99	1.37	46,834
Modified Grassland	35	1.44	12,723
Native Grassland	20	4.98	6,432
Wooded	54	16.78	2,717
Class I, II, and III Wetlands [b]	42	8.14	4,899
Class IV Wetlands [c]	45	13.51	5,321

[a] Calculated from baseline survey data (Annex IV, Section 5.3.6).
[b] Non-wooded wetland (Annex IV, Section 4.3.1.2).
[c] Wooded wetland (Annex IV, Section 4.3.1.2).
ha = hectares; ESA = effects study area.

A landscape classification of the ESA under conditions with no development (reference condition) is not available. However, to estimate cumulative sensory disturbance effects from a landscape without human development, the proportion of change of habitats from a landscape with just human development footprints (direct effects only; Table 14.5-1) was compared to a landscape with human developments buffered by zones of influence (ZOIs) (300 m for grid roads and 1,100 for highways) using the following formula:

$$Proportion\ of\ habitat\ altered\ by\ sensory\ disturbance\ under\ Base\ Case = \frac{ID - DD}{DD} * 100$$

where: DD = area of habitat on the Base Case landscape when human developments were not buffered with a ZOI (direct disturbance); and

ID = area of habitat on the Base Case landscape when human developments were buffered with a ZOI (indirect disturbance).

Although, the types of habitats removed by agricultural activities cannot be determined, this method will provide an estimate of the cumulative alteration of habitats by human developments.

The following equation was used to calculate the relative change in upland breeding bird abundance for the different conditions on the landscape:

(Application Case abundance – Base Case abundance) / Base Case abundance x 100%.

The resulting value gives the percent change in bird abundance, and provides both direction and magnitude of the effect.

14.5.2.1.2 Waterbirds

A habitat suitability index (HSI) approach was used to determine changes to the quality of waterbird nesting habitat in the ESA from sensory disturbance effects associated with the Project. Waterbirds include waterfowl (i.e., ducks, geese, and swans), loons, grebes, pelicans, cormorants, American coots (*Fulica americana*), cranes, herons, terns, and gulls. Waterfowl can be divided into two main groups: dabbling species (i.e., species that remain on the water surface while foraging) and diving species (i.e., species that submerge beneath the water surface to forage). Dabbling species (e.g., mallard [*Anas platyhyrnchos*], Canada goose [*Branta canadensis*]) generally nest in upland areas adjacent to wetlands. In contrast, diving ducks (e.g., canvasback [*Aythya valisineria*], redhead [*Aythya americana*]) generally nest over water either in emergent vegetation or on other structures (e.g., muskrat lodge).

Waterbird densities have been found to be strongly linked to the amount and spatial distribution of emergent vegetation in a wetland (Kaminski and Prince 1981; Murkin et al. 1982; Murkin et al. 1997), as well as to the presence and abundance of aquatic invertebrates (Joyner 1980; Nummi et al. 1994). Wetlands that are flooded for most the breeding season have higher waterbird densities than more temporary wetlands. Wetlands that have a combination of the above listed characteristics are preferred for rearing broods because there is protection from predators and there is an adequate supply of protein (i.e., invertebrates) to support feather development of juveniles (Hornung 2005). The availability of brood-rearing wetlands has been identified as a key limiting factor for waterbird populations (Ringelman 1992).

Habitat suitability models provide a numerical index that represents the capacity of a given habitat to support a wildlife species or species group. Habitat preference information in an area of interest can be easily viewed when this numerical index is linked to a GIS platform to generate habitat suitability maps. In this assessment, the HSI models have a minimum value of 0.0 (i.e., unsuitable habitat) and a maximum value of 1.0 (i.e., optimal habitat) and assume a direct linear relationship between the HSI values and carrying capacity of the ESA (i.e., number of individuals per unit area). The models were not used to estimate population sizes or other demographic parameters (e.g., survival and reproduction) of waterbirds in the ESA.

Habitat suitability models were used to identify and quantify suitable habitat in the ESA for the Base Case and the Application Case using the following equation:

(Application Case area – Base Case area) / Base Case area x 100%.

Habitat suitability values were reclassified into four ranked habitat classes of approximately equal area, defined as poor-, low-, good-, and high-quality habitat. The waterbird model also included a nil habitat category that included upland habitat that was greater than 50 m from the edge of a wetland or open water body as these habitats were thought to have little use for waterbird nesting and foraging (see below). In order to compare habitat quality between temporal scenarios, the quartile break-points that were calculated for baseline conditions were used in all scenarios. The upper quartile represents the most valuable habitats on the landscape and the lower quartile represents the least valuable habitats on the landscape. This is a relative measure of habitat quality within the ESA. This means that although better quality habitat may exist outside of the ESA, the upper quartile of habitat suitability values calculated by the HSI models contains the most valuable habitats within the ESA. The quartiles may contain a large range of HSI values but the habitats within the upper quartile are expected to be preferred relative to other areas in the ESA. The areas within poor- and low- quality habitat quartiles were pooled (non-suitable habitat) as were areas within good- and high-quality habitat quartiles (suitable habitat).

If values are not ranked by quartiles, the standard threshold value for determining high-quality habitat is typically 0.5 (i.e., values 0.5 to 1.0 are considered high-quality habitat) (Ackakaya et al. 2004; Strimbu and Innes 2011). Therefore, if the high-quality habitat quartile includes values less than 0.5 there is likely not much high-quality habitat present in the ESA.

The suitability of variables for the waterbird HSI is described below and applied to the ESA. This model is similar to the model used in the Legacy Project EIS (Potash One Ltd. 2010), the Milestone Project EIS (Western Potash Inc. 2013), and the Kronau Project EIS (Vale Potash Canada Ltd. 2013) because these projects are located in similar landscapes to the Southey Project. All projects are located in the Moist Mixed Grassland Ecoregion (Acton et al. 1998) and landscapes around all projects have a large amount of human disturbance. The habitat model was based on reproduction habitat components and considered adjacent terrestrial habitat that can influence productivity.

First, the suitability of waterbodies for foraging and rearing young was inferred through reports of waterbird densities in various waterbody types:

- Optimal wetland conditions consisted of Class IV and Class V wetlands. These wetlands types may provide “hemi marsh” conditions (i.e., approximately equal areas of emergent vegetation and open water in an interspersed pattern), which support the highest densities of dabbling ducks (Kaminski and Prince 1981; Murkin et al. 1982). Hemi marshes support approximately twice as many breeding pairs as wetlands with more open water or more vegetation cover. Open water provides foraging habitat, while emergent vegetation cover provides protection from predators and inclement weather. Class V wetlands had the highest density of waterbirds during baseline breeding surveys, while Class IV wetlands had the highest density during productivity surveys (Table 14.3-2 and Table 14.3-3).

- Medium suitability habitat was characterized by Class I, Class II, and Class III wetlands. Non-permanent wetlands are shallow, and therefore, may not provide suitable foraging habitat for diving ducks, loons, grebes, herons, cranes, gulls, and terns. The type of vegetation (e.g., shrubs and forbs) and scarcity of emergent vegetation in non-permanent wetlands may not provide adequate foraging and nesting cover for waterbirds. Although lakes may provide foraging conditions that persist through the summer, emergent vegetation is likely limited to the shoreline and, therefore, may not represent ideal conditions for supporting a large number of waterbirds.

- Marginal suitability habitat was characterized by dugouts. Dugouts typically have little emergent vegetation cover and potentially low water quality because of agricultural inputs (Carpenter et al. 1998).

Next, the suitability of nesting and rearing habitat was inferred from the dominant riparian cover surrounding a water body.

- Optimal suitability habitat was characterized by undisturbed habitat (i.e., wooded, native grassland) surrounding a water body. Intact riparian areas may provide ideal conditions for high nest success (e.g., vegetation cover to avoid predation; Stavne 2005).

- Medium suitability habitat was characterized by wetlands surrounded by pasture (i.e., modified grassland). Cattle can decrease the amount of vegetation cover surrounding water bodies (Kirsch 1969; Fondell and Ball 2004). Waterbirds nest densities can be high in moderately grazed areas because of retained vegetation cover (Stavne 2005). However, nest success in grazed areas is generally lower than ungrazed areas (Kirsch 1969; Stavne 2005; Fondell and Ball 2004), most likely because of increased predation due to inadequate vegetation cover at the nest.

- Marginal suitability habitat was characterized by wetlands surrounded by agriculture (i.e., cultivated land). Agricultural usually retains little vegetation cover around wetlands. This does not greatly affect diving ducks; however, dabbling ducks are negatively affected by the lack of vegetation cover (Dwyer 1970; Greenwood et al. 1995). Nest success in cultivated areas is at least 7.5 times lower than nest success in native grassland, modified grassland, wetland, and woodland areas (Greenwood et al. 1995).

Waterbird HSI formula

$$HSI = HT \times (RC \times SD)^{\frac{1}{2}}$$

HT = Waterbody habitat types were ranked. Raster cells within Class I, Class II, and Class III wetlands = 0.6, Class IV and V wetlands = 1.0, dugouts = 0.4; all other cells = 0.

RC = Dominant riparian cover within 50 m of wetlands modifier. If the dominant riparian cover was cultivated land the modifier = 0.3, disturbance modifier = 0.3, modified grassland modifier = 0.6, and native grassland or wooded modifier = 1.0.

SD = Sensory disturbance modifier. Change between 0 m to 1,000 m from disturbance was defined as a curvilinear one-asymptote relationship with equation y = 1.0442 × (1 - 〚0.9969〛^distance) (Figure 14.5-1).

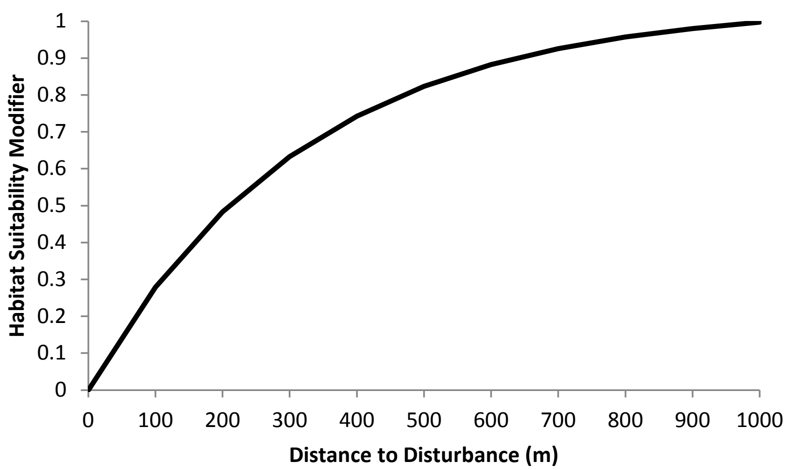


Figure 14.5-1: Relationship between Distance from Human Disturbance and Habitat Suitability Modifier for Waterbirds

14.5.2.1.3 Ferruginous Hawk

A HSI approach was used to determine changes to the quality of ferruginous hawk breeding habitat in the ESA. The approach used was similar to that used for waterbirds (Section 14.5.2.1.2).

Ferruginous hawks prefer to nest in lone trees in areas of undisturbed native grassland (Gilmer and Stewart 1983; Bechard and Schmutz 1995; Downey et al. 2004). Ferruginous hawks in Washington were found to nest an average of 4.0 km away from primary roads, 1.6 km away from secondary roads, and 4.8 km away from areas with human habitation (Bechard et al. 1990). Therefore, areas with low levels of human presence (e.g., native grassland areas) are likely to provide more suitable nesting habitat than other habitat types (e.g., cultivated land, modified grassland).

Large tracts of native grassland supply higher densities of prey species (e.g., ground squirrels [*Spermophilus* spp.]) than cultivated areas (Schmutz 1989; Zelenak and Rotella 1997). Prey abundance is one limiting factor that influences abundance of ferruginous hawks (Smith et al. 1991; Downey et al. 2004; Schmutz et al. 2008). Ferruginous hawk population declines have been noted as more native grassland is converted into cultivated land (COSEWIC 2008b). These declines are likely related to a decrease in prey abundance (Schmutz 1989; Zelenak and Rotella 1997) and/or a decrease in suitable nesting habitat (Schmutz 1987; Downey et al. 2004).

Several habitat suitability indices have been developed for the ferruginous hawk (Jasikoff 1982; Blouin et al. 2004; Downey et al. 2004). The ferruginous hawk model developed for the Project was based on some of the information provided in these documents. The HSI model is the same model used in the Legacy Project EIS (Potash One Ltd. 2010), the Milestone Project EIS (Western Potash Inc. 2013), and the Kronau Project EIS

(Vale Potash Canada Ltd. 2013) because these projects are located in similar landscapes to the Southey Project. The suitability of local and regional-scale variables used in the ferruginous hawk HSI model is described below.

- Optimal suitability landscapes contained more than 48% native grassland (3 km scale) and included raster cells associated with more than 3.24 ha of contiguous native grassland (Bechard et al. 1990; Blouin et al. 2004).
- Optimal suitability habitats contained gravelly sandy loam, sandy loam, coarse sandy loam, sandy loam, and fine sandy loam soil textures (moderately coarse soil texture group; Agriculture and Agri-Food Canada et al. 2005) and very fine sandy loam, loam, silt loam, and gravelly loam soil textures (medium soil texture group; Agriculture and Agri-Food Canada et al. 2005) because these soil types are the most suitable for ground squirrel burrows (Blouin et al. 2004).
- Medium suitability landscapes contained approximately 10% to 30% native grassland within 3 km of a raster cell and included cells associated with approximately 1 to 2 ha of contiguous native grassland.
- Medium suitability habitats contained sandy clay loam, silt clay loam, and clay loam soil textures (moderately fine soil texture group; Agriculture and Agri-Food Canada et al. 2005).
- Marginal suitability habitats contained sand, gravelly sand, fine sand, gravelly loamy sand, loamy sand, and loamy fine sand soil textures (coarse soil texture group; Agriculture and Agri-Food Canada et al. 2005) and silt clay, clay, and heavy clay soil textures (fine soil texture group; Agriculture and Agri-Food Canada et al. 2005).
- Unsuitable habitats and landscapes included raster cells not categorized as native grassland and cells with no native grassland cover within 3 km.

Ferruginous Hawk HSI Formula

$$HSI = [(\%NG + NG) \div 2 \times ST]^{1/2} \times SD$$

%NG = Modifier related to the percentage of native grassland surrounding a cell (within 3 km). From 0.0 at 0% cover to 1.0 at >48% cover. Change between 0% and 48% native grassland cover defined as a straight line of y=0.0208 ×% native grassland cover (Figure 14.5-2a).

NG = Modifier related to the size of contiguous native grassland surrounding a raster cell. From 0.0 at 0 km^2 to 1.0 at 3.24 km^2. Change between 0 km^2 to 3.24 km^2 defined as a straight line with equation y = 0.3086 × area of native grassland (Figure 14.5-2b).

ST = Soil texture group modifier where coarse texture = 0.2, moderately coarse texture = 1.0, medium texture = 1.0, moderately fine texture = 0.5, fine = 0.2. A soil complex represents different soils that have developed on various parent materials and have various textures (i.e., coarse to fine texture groups). Therefore, soil complexes in the ESA were given a mean value between fine texture and coarse texture groups (i.e., 0.6).

SD = Sensory disturbance modifier. Change between 0 m to 5,000 m from disturbance was defined as a curvilinear one-asymptote relationship with equation $y = 1.0442 \times (1 - [0.9994]^{distance})$ (Figure 14.5-3).

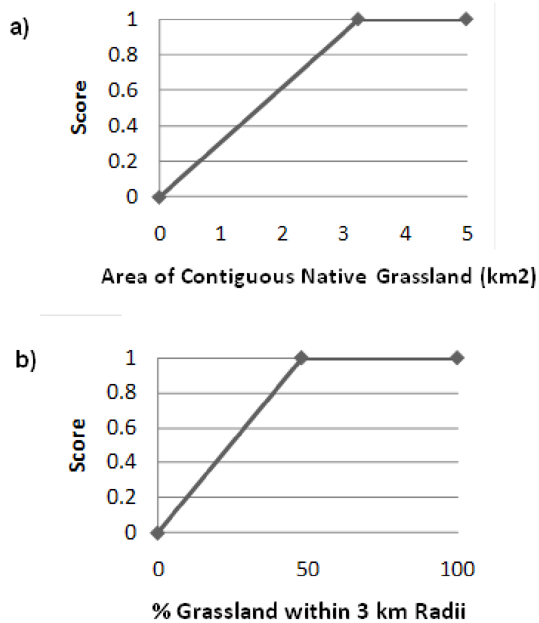


Figure 14.5-2: Relationships between Suitability Scores and Two Habitat Variables for Ferruginous Hawk

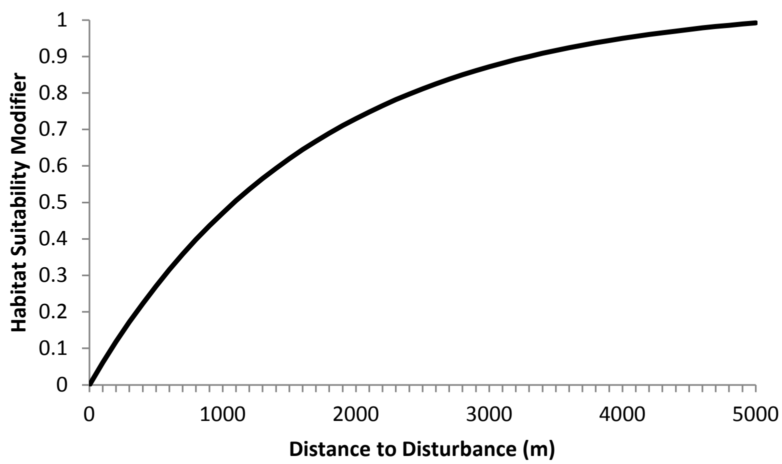


Figure 14.5-3: Relationship between Distance from Human Disturbance and Habitat Suitability Modifier for Ferruginous Hawk

14.5.2.1.4 Short-Eared Owl

A HSI approach was used to determine changes to the quality of short-eared owl breeding habitat in the ESA. The approach used was similar to that used for waterbirds (Section 14.5.2.1.2).

Short-eared owls nest in a variety of grassland and wetland habitats (Wiggins et al. 2006) and they are most common in the prairie regions of Alberta, Saskatchewan, and Manitoba, and along the Arctic coast (COSEWIC 2008a). Females prefer to nest in areas with short (<60 centimetres [cm]), dense grass (Wiggins et al. 2006). This can include native grassland and modified grassland types such as brome/fescue fields (Herkert et al. 1999; Wiggins et al. 2006). Conversion of native grassland to cultivated land and modified grassland types such as alfalfa/brome fields may be the cause of the dramatic population decline from the 1970s to present (COSEWIC 2008b).

The suitability of variables for the short-eared owl HSI model is described below. The HSI model is the same model used in the Legacy Project EIS (Potash One Ltd. 2010), the Milestone Project EIS (Western Potash Inc. 2013), and the Kronau Project EIS (Vale Potash Canada Ltd. 2013) because these projects are located in similar landscapes to the Southey Project. The landscape cover modifiers in the HSI model were based on the approximate home range of short-eared owls (i.e., 80 ha; Clark 1975).

- Optimal habitats at the regional scale included areas with 82 ha of contiguous cover of native grassland and wetland habitat, and areas with 100% native grassland and wetland habitat, within 0.5 km radii. Wiggins et al. (2006) contends that short-eared owls require relatively large tracts of grassland because they are ground nesters and susceptible to the increased predation pressure that is typical within fragmented habitats and near rural developments.
- Optimal habitats at the local scale include raster cells classified as native grassland or wetland habitat (Wiggins et al. 2006).
- Moderately suitable habitats at the regional scale included areas with at least 23 ha of contiguous cover of grassland and wetland habitats, and areas with at least 50% of the surrounding landscape in native grassland and wetland cover.
- Moderately suitable habitats at the local scale included raster cells classified as modified grassland. Although grass-dominated modified grassland habitat has been found to be preferred by short-eared owls (Herkert et al. 1999), hayland (i.e., alfalfa/brome fields) could not be separated in the ELC and is included in the modified grassland habitat type in the ELC. Therefore, to be conservative, in the HSI model, modified grassland habitat was given a median value (i.e., moderate suitability) as it may be high-quality habitat (modified prairie) or poor-quality habitat (hayland).
- Marginal habitats at the regional scale included areas with less than 50% native grassland and wetland.
- Marginal habitats at the local scale included raster cells classified as cultivated land and disturbance.

Short-eared Owl HSI Formula

$$Index = [(LC + \%LC) \div 2 \times HT]^{\frac{1}{2}} \times SD$$

LC = Landscape cover calculation of native grassland and wetland habitat: contiguous area less than 23 ha = 0.5, contiguous area greater than 82 ha =1, and a linear relationship assumed for scores between 23 and 82 ha (y = 0.305 + 0.00847x) (Figure 14.5-4a).

%LC = Percentage of landscape cover (within 0.5 km radii) containing native grassland and wetland habitat where 0% = 0.1, 100% = 1.0, and for scores between 0 and 100%, y = 0.1 + 0.009x (Figure 14.5-4b).

HT = the habitat type of the raster cell was ranked such that disturbance = 0, cultivated cropland = 0.4, modified grassland = 0.6, wetland = 0.8, and native grassland = 1.0.

SD = Sensory disturbance modifier. Change between 0 m to 2,000 m from disturbance was defined as a curvilinear one-asymptote relationship with equation y = 1.0442 × (1 - 〖0.9985〗^distance) (Figure 14.5-5).

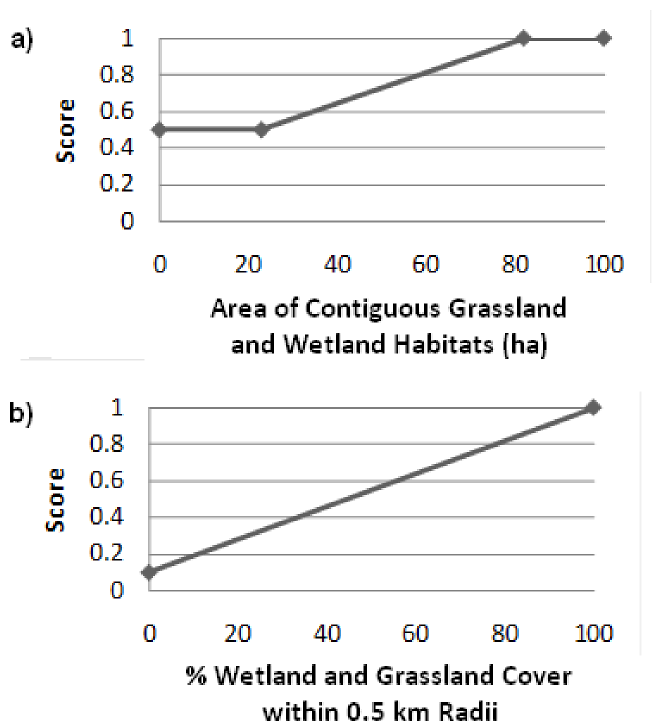


Figure 14.5-4: Relationships between Suitability Scores and Two Habitat Variables for Short-Eared Owl

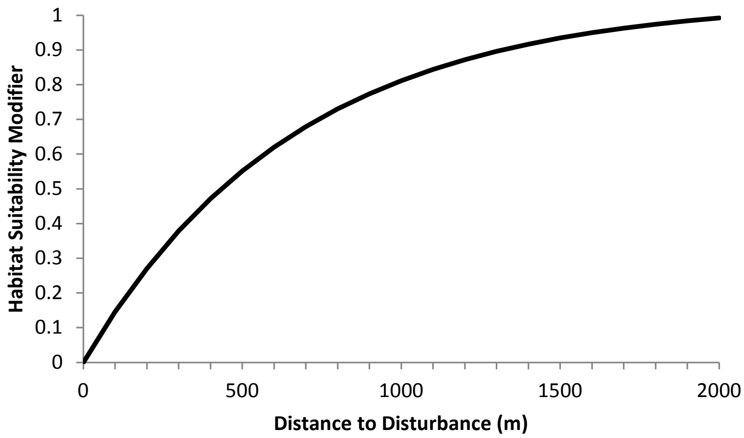


Figure 14.5-5: Relationship between Distance from Human Disturbance and Habitat Suitability Modifier for Short-Eared Owl

14.5.2.1.5 Northern Leopard Frog

A HSI approach was used to determine changes to the quality of northern leopard frog breeding habitat in the ESA. The approach used was similar to that used for waterbirds (Section 14.5.2.1.2).

The northern leopard frog is a pond-breeding amphibian with an aquatic and terrestrial life cycle. Leopard frogs require shallow marsh habitat for breeding and deep, permanent water for overwinter survival. During non-breeding periods in the summer, northern leopard frogs prefer abandoned fields and grasslands as foraging habitat. The main factor limiting sizes of post-metamorphic populations is the quantity, quality, and spatial arrangement of breeding habitats (Skelly et al. 1999; Pope et al. 2002; Gibbons et al. 2006; Environment Canada 2013).

The suitability of variables for the northern leopard frog HSI model is described below. The HSI model is a modified version of that developed by Golder (2007) and is similar to the model used in the Legacy Project EIS (Potash One Ltd. 2010) because the Legacy Project is located in a similar landscape to the Southey Project.

- Optimal breeding habitat was considered Class IV wetlands (Stewart and Kantrud 1981). This habitat type provides vegetation cover from predators and hydroperiods that extend through the larval period (i.e., summer; Stewart and Kantrud 1981) (Wellborn et al. 1996; Stevens et al. 2002; Babbitt et al. 2003).
- Medium suitability habitats were characterized by Class III wetlands (Stewart and Kantrud 1981) because these wetlands are commonly surrounded by a tree ring (wooded wetland; Annex IV, Section 4.3.1). Tree rings around wetlands intercept solar radiation, resulting in cooler water and delayed development of larvae. Additionally, Class III wetland types do not typically have hydroperiods that extend throughout the summer (Stewart and Kantrud 1981).
- Class V wetlands (Stewart and Kantrud 1981) and dugouts were considered to provide marginal suitability breeding habitats. Although Class V wetlands and dugouts provide deep waters persisting through the summer (Stewart and Kantrud 1981), they are often cold, which slows larval development (Wellborn et al.

1996; Babbitt et al 2003). Additionally, Class V wetlands are often comprised of predatory fish (Wellborn et al. 1996; Babbitt et al 2003).

- Marginal breeding habitat occurs when intense agriculture (i.e., cultivated land) occurred in close proximity to wetlands (i.e., <100 m). Practices associated with intense agriculture (e.g., fertilizers, pesticides) in close proximity to wetlands can result in low rates of survival of developing larvae (Bishop et al. 1999; Houlahan and Findlay 2003), which may result in smaller populations of post-metamorphic amphibians. Intense agriculture fails to provide adequate cover and microclimates for post-metamorphic leopard frogs (Mazerolle and Desrochers 2005). For example, Mazerolle and Desrochers (2005) demonstrated that when presented with a choice, 72% of northern leopard frogs avoided disturbed surfaces, such as agricultural fields.

The suitability of breeding habitats was also related to their proximity to suitable overwintering areas (i.e., permanent water [Class V wetlands and dugouts]) (Figure 14.5-6) (Environment Canada 2013).

- Optimal breeding habitats were those in close proximity (approximately 750 m) to Class V wetlands and dugouts (Dole 1971; Emery et al. 1972; Cunjak 1986) (Figure 14.5-6). Class V wetlands and dugouts are likely to provide suitable deep water refugia for overwintering.
- Medium suitability habitats were those with moderate distance (>750 to <2,000 m) to Class V wetlands and dugouts (Figure 14.5-6).
- Marginal breeding habitats were wetlands at distances of 2,000 m or more from Class V wetlands and dugouts (Figure 14.5-6).

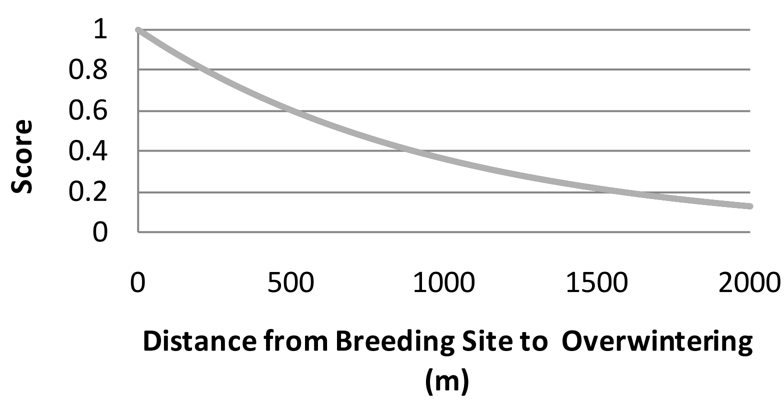


Figure 14.5-6: Relationship between Suitability Scores and Distance of Breeding Sites to Overwintering Sites for Northern Leopard Frog

Northern Leopard Frog HSI Formula

$$Index = (HT \times D2PW)^{1/2} \times AG100 \times SD$$

HT = the habitat type of the raster cell was ranked such that cells within Class IV wetlands =1.0, Class III wetlands =0.8, Class V wetlands and dugouts = 0.4. Only cells within 15 m of lake shorelines were assigned a rank as northern leopard frogs are not anticipated to use areas located in deep water. All other cells = 0.

D2PW - Distance to suitable overwintering site (i.e., Class V wetlands and dugouts) was calculated per breeding site (Figure 14.5-6). Values were assigned to all cells within the breeding site. Wetland cells were ranked 1.0 at 0 km, and ranks approached 0.1 at 2 km. The relationship was based on a negative exponential model [score=$e^{(D2PW \times -0.001)}$].

AG100 - Occurrence of cultivated (agricultural) land within 100 m of shorelines was determined per breeding site. Breeding habitats that did not have cultivated land nearby had cells assigned a value of 1.0; breeding habitats near cultivated land had cells assigned a value of 0.5.

SD = Sensory disturbance modifier. Change between 0 m to 2,000 m from disturbance was defined as a curvilinear one-asymptote relationship with equation $y = 1.0442 \times (1 - [0.9985]^{distance})$ (similar to short-eared owl; Figure 14.5-5).

14.5.2.2 Results

14.5.2.2.1 Upland Breeding Birds

When compared to a landscape with only direct disturbance, sensory disturbance is affecting 50.1% (40,139 ha) of the ESA under Base Case conditions. Sensory disturbance effects combined with direct effects from removal of habitat by cultivated, modified grassland, and existing disturbance habitats are predicted to have adversely altered 87.2% (70,082 ha) of the ESA under the Base Case.

Compared to a landscape with only direct effects, sensory disturbance is predicted to be influencing 53.0% (3,021 ha) of native grassland and 54.9% (1,226 ha) of wooded habitat in the ESA under the Base Case (Table 14.5-6). Sensory disturbance from previous and existing developments in the ESA are predicted to be influencing 49.9% (2,454 ha) and 52.3% (2,536 ha) of Class I, II and III and Class IV wetland habitat in the ESA, respectively.

Sensory disturbance from Project construction and Project operations is predicted to affect an additional 6.7% (5,455 ha) and 8.0% (6,444 ha) of the ESA, respectively, relative to the Base Case. Sensory disturbance is anticipated to influence less than 0.1% (3,022 ha) of native grassland habitat during the construction phase and 0.3% (3,031 ha) of native grassland habitat during the operations phase of the Application Case (Table 14.5-7). Sensory disturbance during Project construction and Project operations is predicted to influence 0.4% (1,231 ha) and 1.2% (1,241 ha) of wooded habitat, respectively. During Project construction, noise is predicted to affect from 0.4% (2,546 ha) to 0.7% (2,471 ha) of wetland habitat. From 1.4% (2,571 ha) to 2.1% (2,505 ha) of wetland habitat is predicted to be affected by noise during Project operations, relative to Base Case.

Cumulatively, sensory disturbance from previous and existing developments and the Project is predicted to affect 56.7% of the ESA during the construction phase of the Application Case. During the operations phase of the Application Case, there is predicted to be a cumulative loss of 57.9% of the ESA from sensory disturbance from human developments. Cumulatively, sensory disturbance effects from human developments combined with direct effects from removal of native habitats (e.g., wooded, wetland, and native grassland) by cultivated, modified grassland, and existing disturbance habitats are predicted to affect 94.0% (75,537 ha) of the ESA during Project construction. During Project operations, sensory disturbance effects from previous and existing human developments and the Project, as well as the direct loss of native habitats by cultivated, modified grassland, and existing disturbance habitats are predicted to affect 95.2% (76,526 ha) of the ESA.

Table 14.5-6: Areas of Habitat Types in the Effects Study Area that are being Influenced by Sensory Disturbance under the Base Case

Habitat Type	Area of Habitats (ha) in ESA with Direct Disturbance[(a)] Only	Area of Habitats in ESA within Sensory Disturbance Buffers[(b)]	Proportion (%) of Habitats Influenced by Sensory Disturbance
Cultivated	46,834	23,043	-50.8
Modified Grassland	12,723	6,597	-48.1
Native Grassland	6,432	3,021	-53.0
Wooded	2,717	1,226	-54.9
Class I, II, and III Wetlands	4,899	2,454	-49.9
Class IV Wetlands	5,321	2,536	-52.3

Note: Numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values
(a) direct disturbance = the area of habitat on the Base Case landscape when human developments were not buffered with a zone of influence.
(b) A 300 m buffer was used for grid roads and a 1,100 m buffer was used for highways in the ESA.
ha = hectare; % = percent; < = less than; m = metre; ESA = effects study area.

Table 14.5-7: Proportion of Areas of Habitat Types in the Effects Study Area that are being Influenced by Sensory Disturbance under the Application Case (Construction and Operations Phases)

Habitat Type	Proportion (%) of Habitats Influenced by Sensory Disturbance	
	Base Case to Application Case (Project Construction Phase)	Base Case to Application Case (Project Operations Phase)
Cultivated	-0.9	-2.4
Modified Grassland	-0.1	-0.8
Native Grassland	<-0.1	-0.3
Wooded	-0.4	-1.2
Class I, II, and III Wetlands	-0.7	-2.1
Class IV Wetlands	-0.4	-1.4

Note: Numbers are rounded for presentation purposes.
Numbers <-0.1 approach 0
% = percent; < = less than.

Sensory disturbance effects from the Project are expected to decrease bird abundance in the ESA by 3.2% and 4.2% during Project construction and Project operations, respectively, relative to Base Case (Table 14.5-8). Native grassland habitat is predicted to have the least decrease in upland breeding bird abundance due to sensory disturbance during both Project construction (0.6%) and Project operations (0.9%). Upland breeding bird abundance in cultivated habitat is expected to have the greatest decrease under both the Project construction phase and Project operations phase (6.0% and 7.4%, respectively).

Table 14.5-8: Change in Upland Breeding Bird Abundance from the Base Case to the Application Case (Construction and Operations Phases)

Habitat Type	Base Case Abundance	Application Case (Project Construction)		Application Case (Project Operations)	
		Abundance	Change (%) in Abundance from Base Case	Abundance	Change (%) in Abundance from Base Case
Cultivated	32,598	30,632	-6.0	30,177	-7.4
Modified Grassland	8,821	8,704	-1.3	8,634	-2.1
Native Grassland	16,986	16,884	-0.6	16,838	-0.9
Wooded	25,026	24,703	-1.3	24,538	-1.9
Class I, II, and III Wetlands[(a)]	19,903	18,958	-4.7	18,678	-6.2
Class IV Wetlands[(b)]	37,620	36,548	-2.9	36,213	-3.7
Total	**140,954**	**136,429**	**-3.2**	**135,078**	**-4.2**

(a) Relative abundance calculated from non-wooded wetland (Annex IV, Section 4.3.1.2)
(b) Relative abundance calculated from wooded wetland (Annex IV, Section 4.3.1.2)
% = percent

14.5.2.2.2 Waterbirds

Approximately 15.0% (12,058 ha) of the ESA was covered by wetland habitat prior to human settlement (Archibold and Wilson 1980). It is predicted that 55.2% (5,400 ha) of wetland habitat that was present in the ESA prior to human settlement has been directly and indirectly affected by human activities. Cumulative loss of wetland habitat from direct and sensory disturbance effects during the Project construction and operations phases of the Application Case is predicted to be 57.2% (6,895 ha) and 56.7% (6,836 ha), respectively, relative to the landscape that existed in the ESA prior to human settlement.

Most of the ESA (86.9%) is comprised of upland habitat that is considered unusable for waterbirds as nesting habitat under the Base Case (nil habitat; Table 14.5-9; Figure 14.5-7). However, high- and medium-quality habitat quartiles (suitable habitat) for waterbirds contain HSI values of 0.5 to 1.0 (Appendix 14-A; Table 2). Approximately 25% of the potentially suitable habitat in the ESA has HSI scores greater than or equal to 0.5 (Appendix 14-A; Table 2). This indicates moderate to high levels of highly preferred habitats are present in the ESA under the Base Case.

The Project is predicted to remove 2.9% of suitable waterbird habitat in the ESA, relative to the Base Case (Table 14.5-9; Figure 14.5-8). During the Application Case, there is expected to be an increase of 0.5% in habitat that is considered to have nil suitability as waterbird nesting habitat, relative to the Base Case. Changes to waterbird habitat suitability from the Project are likely to be less than predicted because the location of some well pads used in the assessment will be moved and sited to avoid wetlands to follow the wetland mitigation hierarchy developed by the MOE (2014).

Table 14.5-9: Relative Changes in the Availability of Different Quality Habitats in the Effects Study Area for Waterbirds from Base Case to Application Case

Habitat Quality	Habitat Area under Base Case[(a)] (ha)	Change from Base Case[(a)] to Application Case[(b)] (ha)	% Change Base Case[(a)] to Application Case[(b)]
Suitable[(c)]	5,253	-234	-2.9
Non-suitable[(d)]	5,268	-151	-4.4
Nil[(e)]	69,869	385	0.5

Note: Percent change per habitat category was calculated as area lost or gained divided by the area of the habitat category in the previous assessment case.

(a) Base Case = existing conditions before application of the Project including cumulative changes from previous and existing developments.

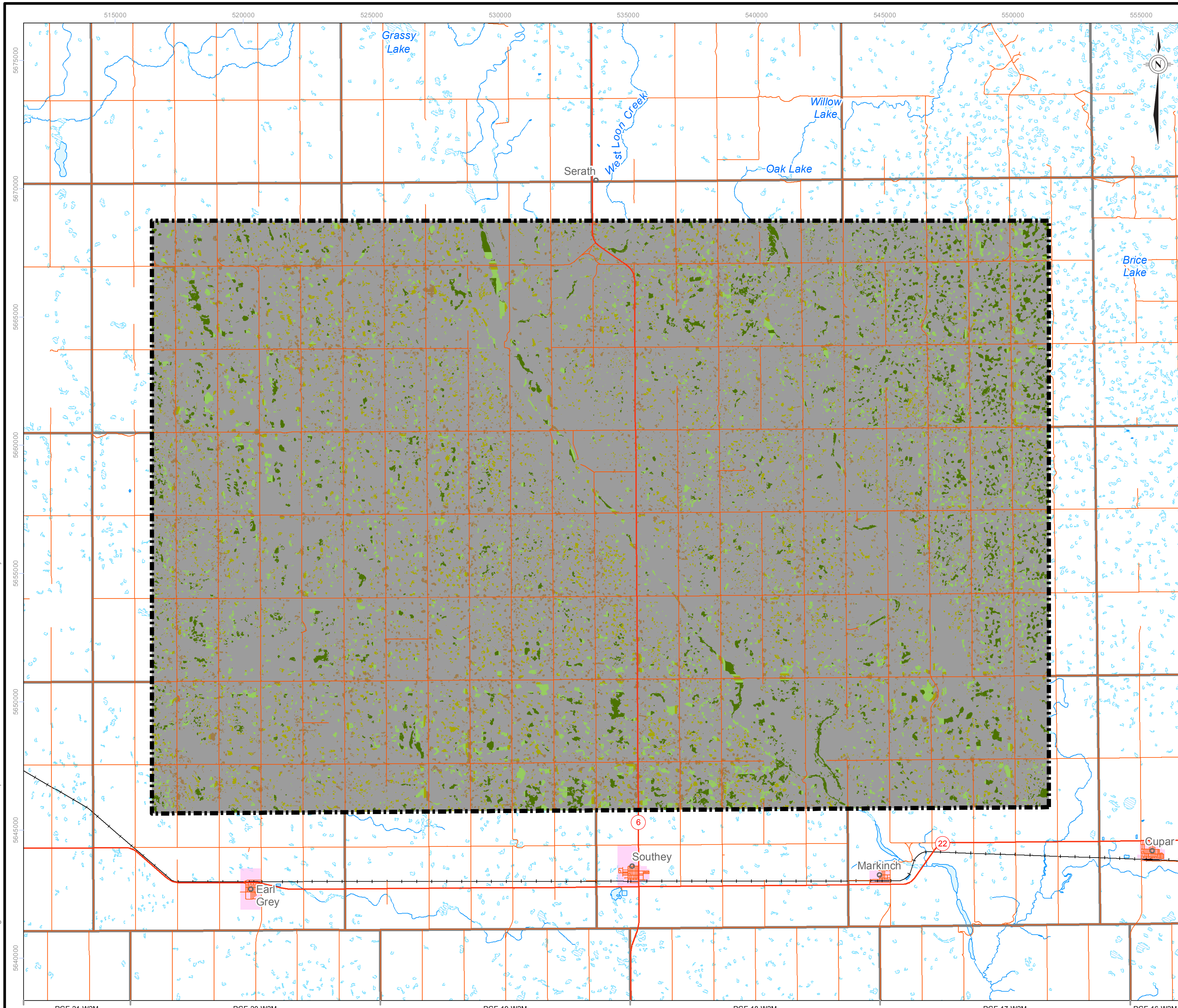
(b) Application Case = Project plus base case conditions.

(c) Includes area from the medium- and high-quality habitat quartiles.

(d) Includes area from the poor- and low-quality habitat quartiles.

(e) Nil habitat quality refers to upland habitat that is greater than 50 m from the edge of a wetland or open water body.

ha = hectares; % = percent.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

HABITAT SUITABILITY INDEX

- HIGH
- GOOD
- LOW
- POOR
- NIL

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
兖煤加拿大资源有限公司
YANCOAL SOUTHEY PROJECT

TITLE
HABITAT SUITABILITY FOR WATERBIRDS: BASE CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	LD	25/05/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	**FIGURE: 14.5-7**	
CHECK	LD	25/05/15		
REVIEW	JV	25/05/15		

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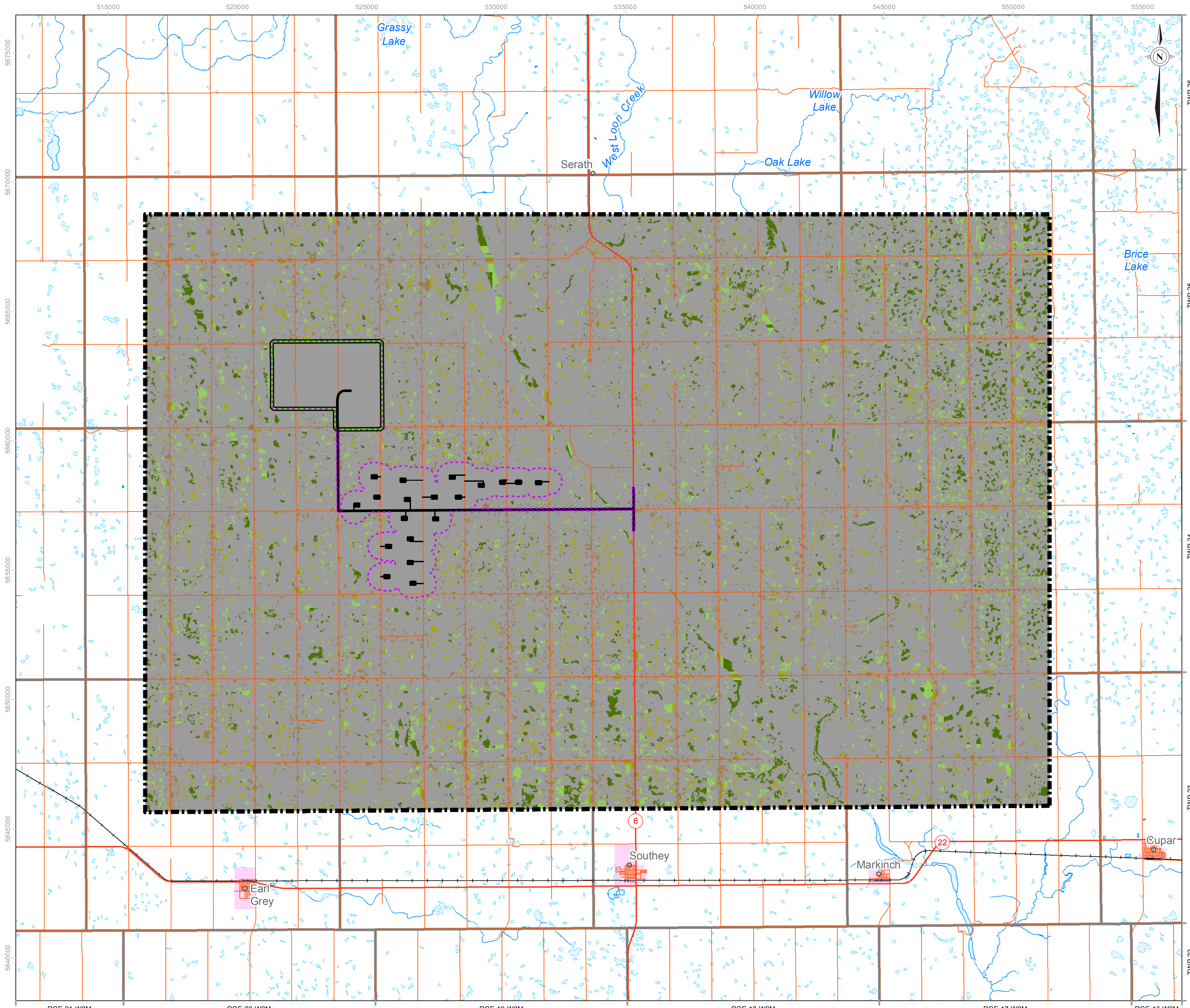

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LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA
- HSI APPLICATION FOOTPRINT

PROPOSED PROJECT FOOTPRINT

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD

HABITAT SUITABILITY INDEX

- HIGH
- GOOD
- LOW
- POOR
- NIL

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
SOUTHEY PROJECT

TITLE
HABITAT SUITABILITY FOR WATERBIRDS: APPLICATION CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	LD	25/05/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	FIGURE: 14.5-8	
CHECK	LD	25/05/15		
REVIEW	JV	25/05/15		

14.5.2.2.3 Ferruginous Hawk

Approximately 75.0% (60,289 ha) of the ESA was covered by native grassland habitat prior to human settlement (Archibold and Wilson 1980). Cumulative loss of native grassland habitat from direct and sensory disturbance effects during the Project construction and operations phases of the Application Case is predicted to be 95.0% (57,267 ha) and 95.0% (57,258 ha), respectively, relative to the landscape that existed in the ESA prior to human settlement.

High- and medium-quality habitat quartiles (suitable habitat) for ferruginous hawk contained HSI values from 0.07 to 1.00. This wide range of HSI scores indicates that few patches of large, contiguous native grasslands suitable for breeding pairs are present in the ESA under Base Case conditions. Less than 0.1% of the ESA contained habitat with HSI scores above 0.5 (Appendix 14-A; Table 3). The negligible amount of suitable habitat (i.e., HSI >0.5) in the ESA is supported by baseline studies, which incidentally observed two ferruginous hawk individuals during raptor stick nest surveys; however, no active ferruginous hawk nests were found (Section 14.3.5). In Saskatchewan, the breeding range appears to have retreated to the southwest to where native grassland still dominates the landscape (Downey 2006).

The Project is predicted to remove 5.4% of medium- and high-quality ferruginous hawk habitat in the ESA, relative to the Base Case (Table 14.5-10; Figures 14.5-9 and 14.5-10).

Table 14.5-10: Relative Changes in the Availability of Different Quality Habitats for Ferruginous Hawk from Base Case to Application Case

Habitat Quality	Habitat Area in the Effects Study Area under Base Case[a] Conditions (ha)	Change from Base Case[a] to Application Case[b] (ha)	% Change Base Case[a] to Application Case[b]
Suitable[c]	40,210	-2,153	-5.4
Non-suitable[d]	40,179	2,153	5.4

Note: Percent change per habitat category was calculated as area lost or gained divided by the area of the habitat category in the previous assessment case.

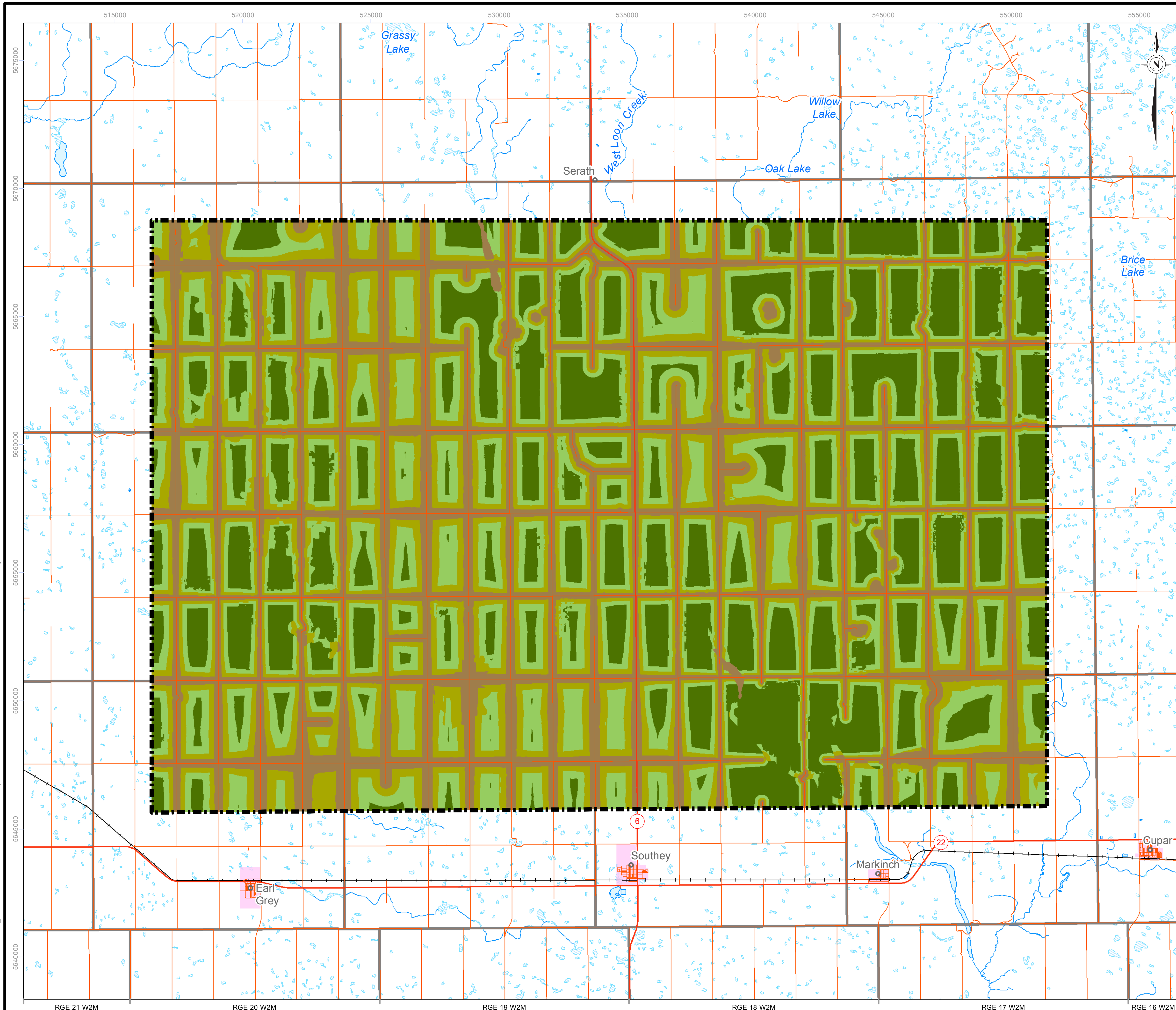
(a) Base Case = existing conditions before application of the Project including cumulative changes from previous and existing developments.

(b) Application Case = Project plus base case conditions.

(c) Includes area from the medium- and high-quality habitat quartiles.

(d) Includes area from the poor- and low-quality habitat quartiles.

ha = hectares; % = percent.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

HABITAT SUITABILITY INDEX

- HIGH
- GOOD
- LOW
- POOR
- NIL

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT

YANCOAL

YANCOAL SOUTHEY PROJECT

TITLE

HABITAT SUITABILITY FOR FERRUGINOUS HAWK: BASE CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	LD	25/05/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	**FIGURE: 14.5-9**	
CHECK	LD	25/05/15		
REVIEW	JV	25/05/15		

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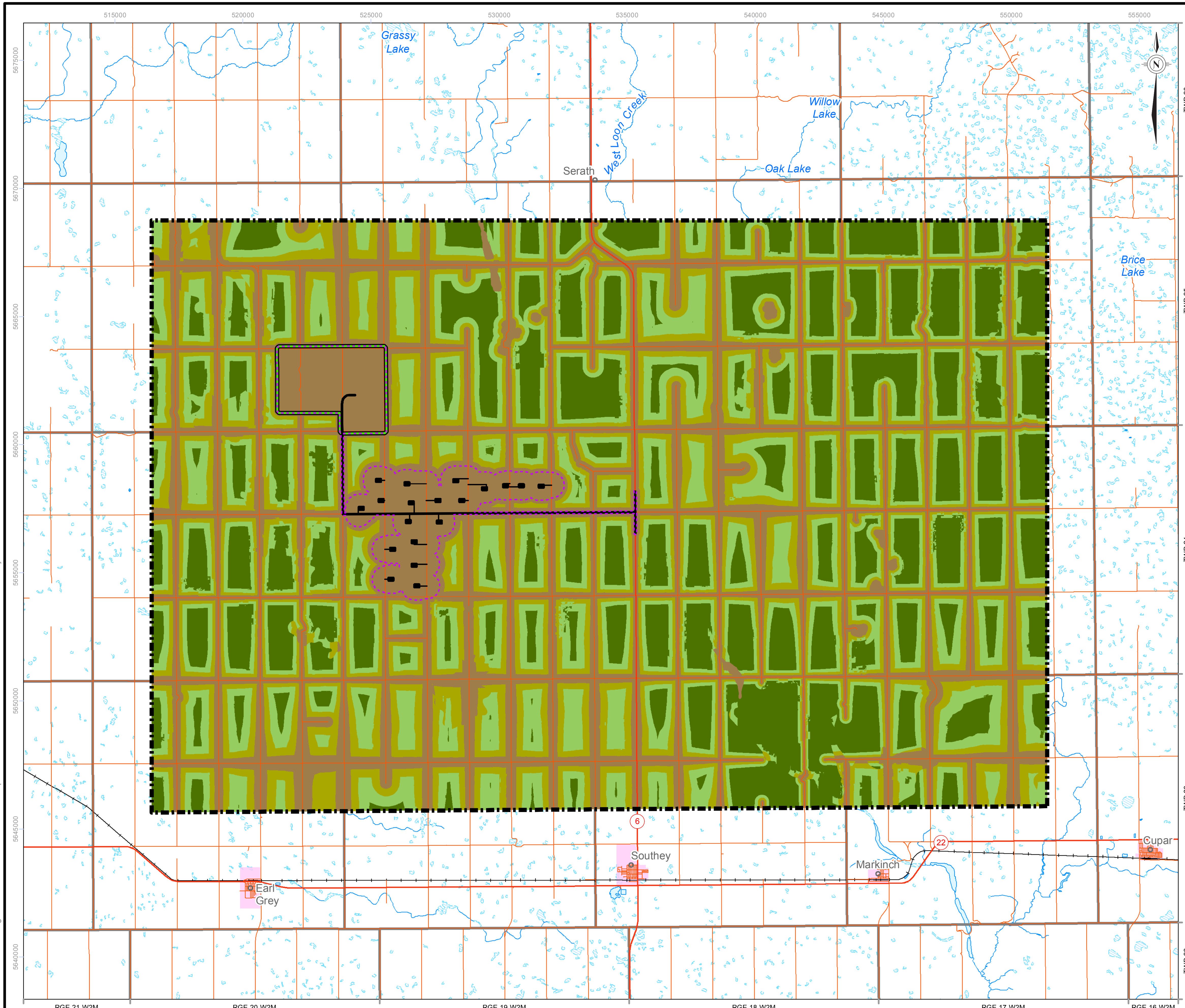

LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA
- HSI APPLICATION FOOTPRINT

PROPOSED PROJECT FOOTPRINT

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD

HABITAT SUITABILITY INDEX

- HIGH
- GOOD
- LOW
- POOR
- NIL

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
兖煤加拿大资源有限公司
YANCOAL SOUTHEY PROJECT

TITLE
HABITAT SUITABILITY FOR FERRUGINOUS HAWK: APPLICATION CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	LD	25/05/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	FIGURE: 14.5-10	
CHECK	LD	25/05/15		
REVIEW	JV	25/05/15		

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14.5.2.2.4 Short-Eared Owl

Prior to human settlement, wetland and native grassland habitats are predicted to have covered 15.0% (12,058) and 75.0% (60,289 ha) of the ESA, respectively (Archibold and Wilson 1980). Sensory disturbance effects and direct removal of habitat from existing human developments and agriculture are predicted to have removed or be influencing 95.0% (57,268 ha) of native grassland habitat, relative to the ESA prior to human development. Approximately 57.4% (6,921 ha) of wetland habitat that was present in the ESA prior to human settlement has been removed by, or is being influenced by, sensory disturbance from human developments and agricultural activities under the Base Case.

Cumulative loss of native grassland habitat from direct and sensory disturbance effects during the Project construction and operations phases of the Application Case is predicted to be 95.0% (57,267 ha) and 95.0% (57,258 ha), respectively, relative to the landscape that existed in the ESA prior to human settlement. Cumulatively, direct and sensory disturbance effects from previous and existing developments and the construction of the Project are predicted to remove 57.2% (6,894 ha) of wetland habitat that was present in the ESA under the reference condition (Archibold and Wilson 1980). During Project operations the cumulative loss of wetland habitat from direct and indirect effects from human activities is predicted to be 56.7% (6,834 ha), relative to the reference condition.

High- and medium-quality habitat quartiles (suitable habitat) for short-eared owl contained HSI values from 0.2 to 1.0 (Appendix 14-A; Table 3). This wide range of HSI values indicates that there a low amount of highly preferred habitats present in the ESA under the Base Case. Habitat with HSI scores above 0.5 covered 2.6% of the ESA (Appendix 14-A; Table 2). One short-eared owl was incidentally observed in the BSA during waterbird breeding surveys.

The Project is predicted to remove 4.6% of suitable short-eared owl habitat in the ESA relative to the Base Case (Table 14.5-11; Figure 14.5-11 and 14.5-12). Changes to short-eared owl habitat suitability from the Project are likely to be less than predicted because some well pad locations that were used in the assessment will likely be moved and sited to avoid wetlands (MOE 2014) during Project construction.

Table 14.5-11: Relative Changes in the Availability of Different Quality Habitats for Short-Eared Owl from Base Case to Application Case

Habitat Quality	Habitat Area in the Effects Study Area under Base Case[(a)] Conditions (ha)	Change from Base Case[(a)] to Application Case[(b)] (ha)	% Change Base Case[(a)] to Application Case[(b)]
Suitable[(c)]	40,036	-1,845	-4.6
Non-suitable[(d)]	40,353	1,845	4.6

Note: Percent change per habitat category was calculated as area lost or gained divided by the area of the habitat category in the previous assessment case.

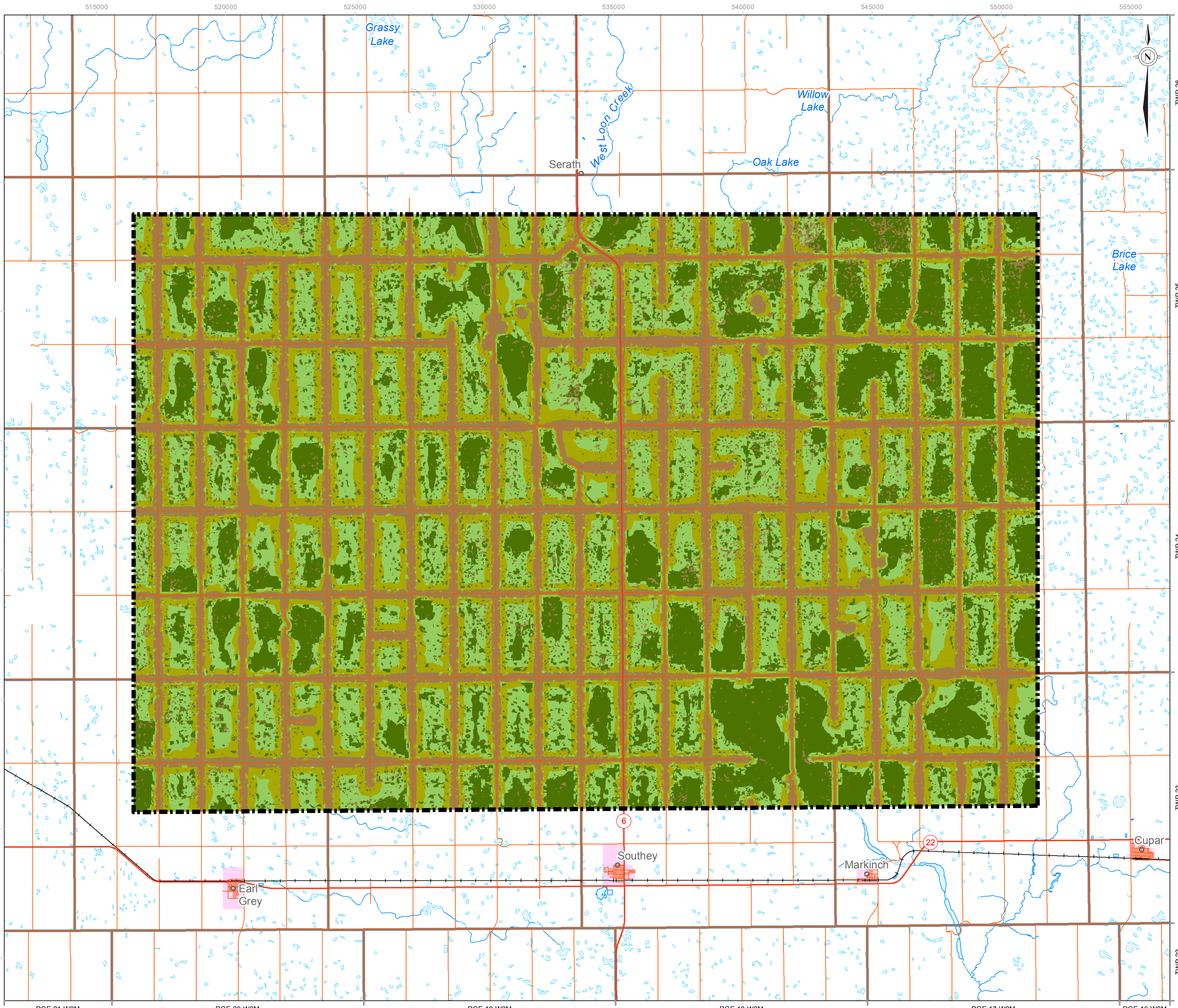
(a) Base Case = existing conditions before application of the Project including cumulative changes from previous and existing developments.

(b) Application Case = Project plus base case conditions.

(c) Includes area from the medium- and high-quality habitat quartiles.

(d) Includes area from the poor- and low-quality habitat quartiles.

ha = hectares; % = percent.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

HABITAT SUITABILITY INDEX

- HIGH
- GOOD
- LOW
- POOR
- NIL

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
HABITAT SUITABILITY FOR SHORT-EARED OWL: BASE CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	LD	25/05/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	**FIGURE: 14.5-11**	
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REVIEW	JV	25/05/15		

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LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA
- HSI APPLICATION FOOTPRINT

PROPOSED PROJECT FOOTPRINT

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD

HABITAT SUITABILITY INDEX

- HIGH
- GOOD
- LOW
- POOR
- NIL

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT

YANCOAL
SOUTHEY PROJECT

TITLE

HABITAT SUITABILITY FOR SHORT-EARED OWL: APPLICATION CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	LD	25/05/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	**FIGURE: 14.5-12**	
CHECK	LD	25/05/15		
REVIEW	JV	25/05/15		

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14.5.2.2.5 Northern Leopard Frog

Wetland habitats are predicted to have covered 15.0% (12,058) of the ESA prior to human settlement (Archibold and Wilson 1980). Approximately 57.4% (6,921 ha) of wetland habitat that was present in the ESA prior to human settlement has been removed by, or is being influenced by, sensory disturbance from human developments and agricultural activities under the Base Case. Cumulatively, direct and sensory disturbance effects from previous and existing developments and the construction of the Project are predicted to remove 57.2% (6,894 ha) of wetland habitat that was present in the ESA under the reference condition (Archibold and Wilson 1980). During Project operations the cumulative loss of wetland habitat from direct and indirect effects from human activities is predicted to be 56.7% (6,834 ha), relative to the reference condition.

High- and medium-quality habitat quartiles (suitable habitat) for northern leopard frog contained HSI values from 0.13 to 0.43 (Appendix 14-A, Table 3). This wide range of HSI values indicates that a low amount of highly preferred habitats are present in the ESA under the Base Case. No habitat with HSI scores greater than 0.44 is present in the ESA (Appendix 14-A, Table 2), which suggests the overall landscape has low capability to support leopard frog populations. These results are support by baseline studies, which detected no northern leopard frogs during field surveys.

The Project is predicted to remove 3.5% of suitable northern leopard frog habitat in the ESA relative to the Base Case (Table 14.5-12; Figure 14.5-13 and 14.5-14). Changes to northern leopard frog habitat suitability from the Project are likely to be less than predicted because the location of some well pads used in the assessment will be moved during construction and sited to avoid wetlands (MOE 2014).

Table 14.5-12: Relative Changes in the Availability of Different Quality Habitats for Northern Leopard Frog from Base Case to Application Case

Habitat Quality	Habitat Area in the Effects Study Area under Base Case[(a)] Conditions (ha)	Change from Base Case[(a)] to Application Case[(b)] (ha)	% Change Base Case[(a)] to Application Case[(b)]
Suitable[(c)]	3,204	-111	-3.5
Non-suitable[(d)]	3,204	-76	-2.4
Nil[(e)]	73,981	187	0.25

Note: Percent change per habitat category was calculated as area lost or gained divided by the area of the habitat category in the previous assessment case.

(a) Base Case = existing conditions before application of the Project including cumulative changes from previous and existing developments.

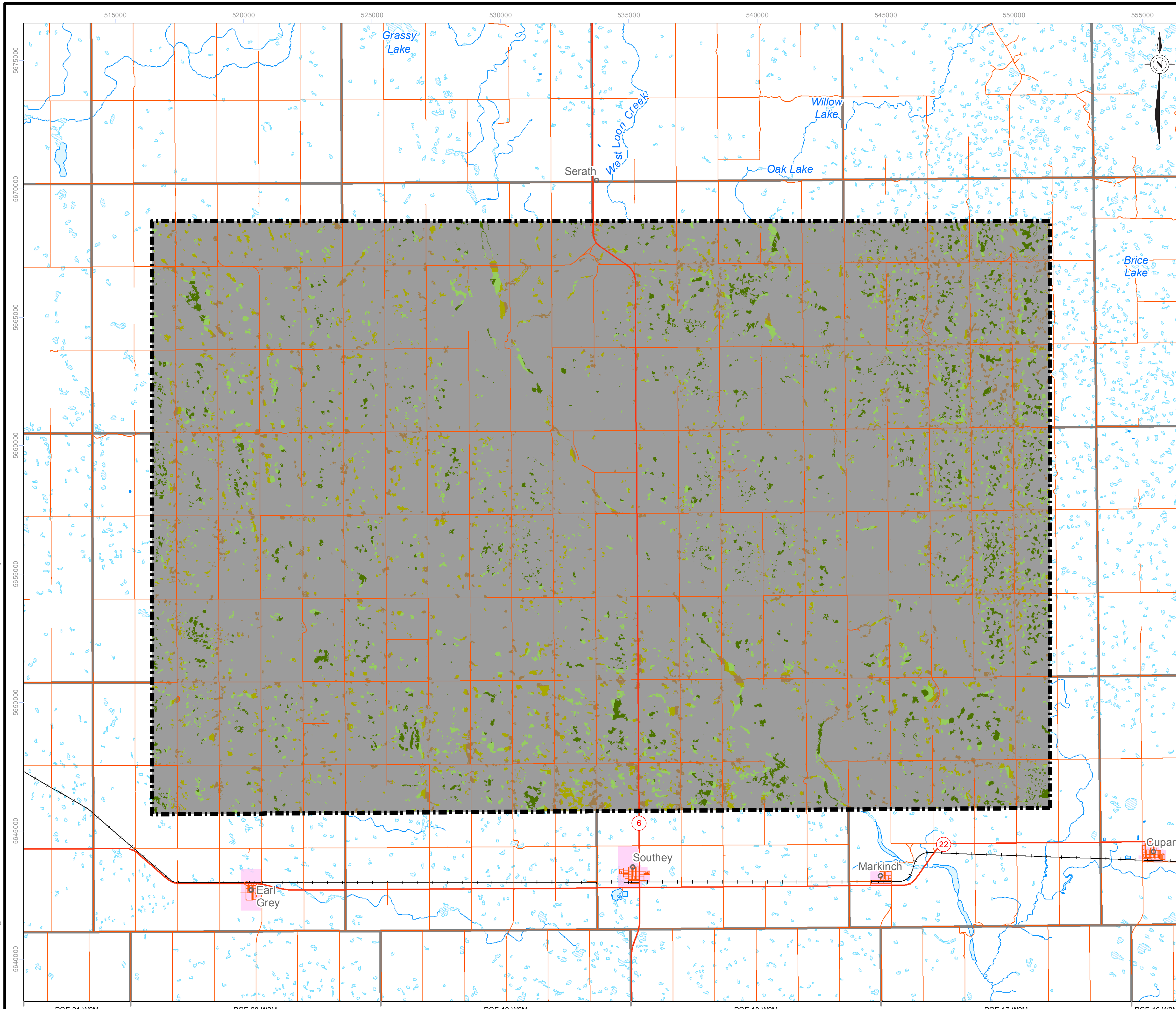
(b) Application Case = Project plus base case conditions.

(c) Includes area from the medium- and high-quality habitat quartiles.

(d) Includes area from the poor- and low-quality habitat quartiles.

(e) Nil habitat quality refers to upland habitat that is not within a wetland or deep water habitat that is greater than 15 m from the shoreline of Class V wetlands.

ha = hectares; % = percent.



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LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA

HABITAT SUITABILITY INDEX

- HIGH
- GOOD
- LOW
- POOR
- NIL

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT

YANCOAL SOUTHEY PROJECT

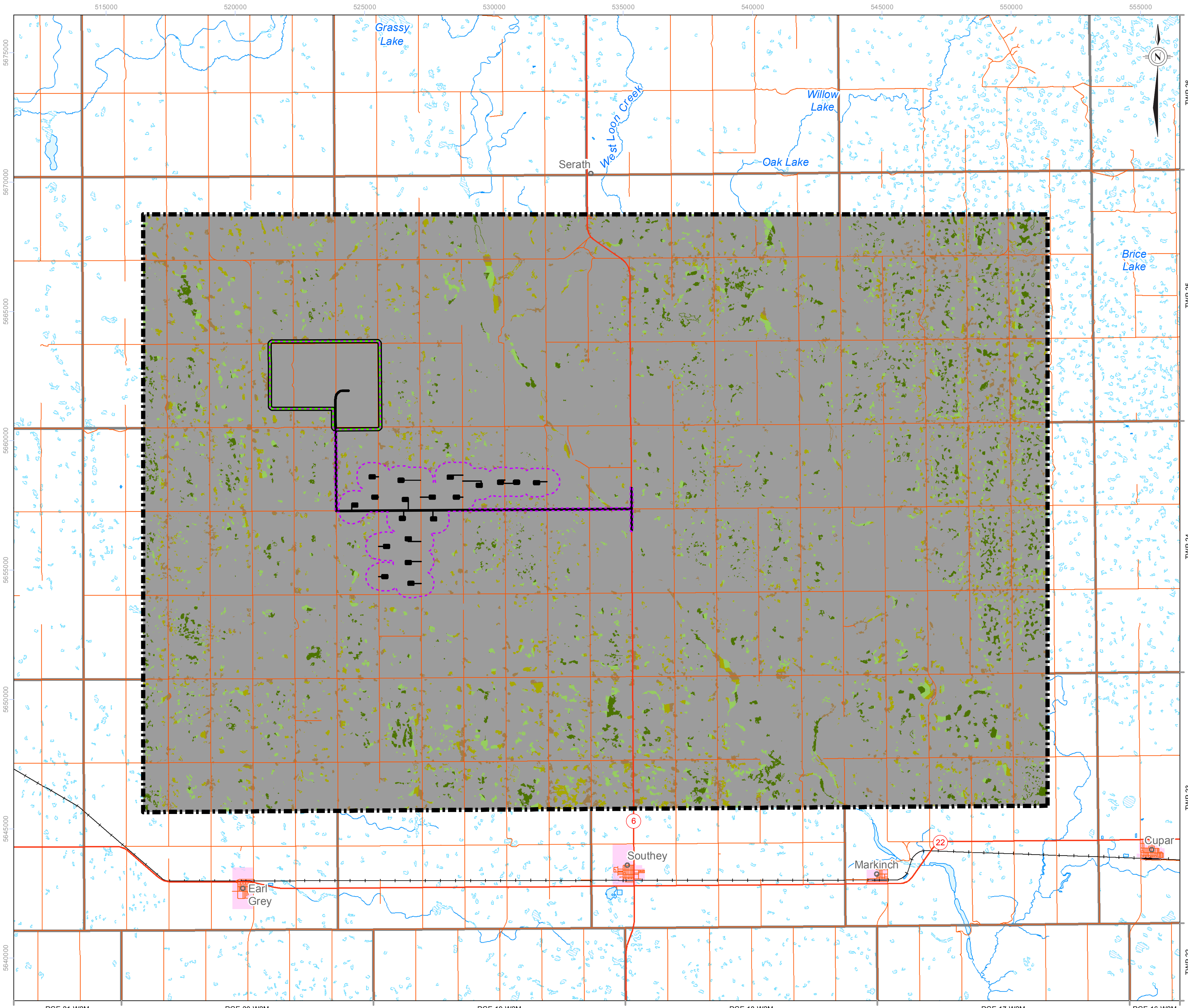
TITLE

HABITAT SUITABILITY FOR NORTHERN LEOPARD FROG: BASE CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	LD	25/05/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15		
CHECK	LD	25/05/15		
REVIEW	JV	25/05/15		

FIGURE: 14.5-13



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- EFFECTS STUDY AREA
- HSI APPLICATION FOOTPRINT

PROPOSED PROJECT FOOTPRINT

- CORE FACILITIES AREA
- WELL PAD AND ACCESS ROAD

HABITAT SUITABILITY INDEX

- HIGH
- GOOD
- LOW
- POOR
- NIL

REFERENCE

BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13N

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL
兖煤加拿大资源有限公司
YANCOAL SOUTHEY PROJECT

TITLE
HABITAT SUITABILITY FOR NORTHERN LEOPARD FROG: APPLICATION CASE

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.	
DESIGN	LD	25/05/15	SCALE AS SHOWN	REV. 0
GIS	LMS	25/05/15	FIGURE: 14.5-14	
CHECK	LD	25/05/15		
REVIEW	JV	25/05/15		

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14.5.3 Changes to Wildlife Habitat from Ground Subsidence

14.5.3.1 Methods

Ground subsidence will develop over mined caverns within the mining area, and is expected to begin while mining is occurring and will continue through post-mining. Subsidence is expected to alter local flows, drainage patterns, and the spatial distribution of surface water within the mining boundary. These changes to surface water can change soil quality, which can affect the abundance and distribution of upland and wetland vegetation, and wildlife habitat. Decreases in slope gradients may cause areas to accumulate more snowmelt runoff and rainfall, thereby increasing soil moisture and creating wetland habitat. Alternatively, existing wetlands may drain and become upland habitats in areas where slope gradients increase. Ground subsidence may also change the flow rates of existing streams, which may change soil erosion and alter wildlife habitat quality and quantity.

Changes to surface water flow and terrain slopes were estimated using multiple techniques. The LiDAR topographic data were used to determine current terrain conditions within the mining boundary. Field studies were completed in 2013 to determine baseline conditions for soil, vegetation, wetlands, and wildlife habitat. The subsidence settlement calculation was based partially on the 65-year mine field, which is contained within the ESA. Changes from ground subsidence in all hydrology features including drainage area boundaries, drainage pathways, and wetlands were calculated using computer modeling that was based on current conditions and predicted changes resulting from the anticipated ultimate subsidence (Appendix 9-A).

14.5.3.2 Results

An accurate estimate of the rate of vertical and horizontal movements of terrain due to ground subsidence is complex because of the number of interrelated factors affecting the process. Within the ESA, the maximum amount of subsidence is predicted to occur in the western section of the 65-year mine field (Appendix 9-A). Greater subsidence is predicted to occur directly overlying the mine development caverns and to decrease with distance away from the cavern locations.

The area affected by subsidence would extend over approximately 17 km from west to east and approximately 8 km from north to south (Appendix 9-A). The maximum vertical displacement is estimated to be approximately 6.7 m. The final gradient of surface subsidence at the boundary of the 65-year mine field will be gradual, where the average gradient from unaffected areas to the area of maximum subsidence is predicted to be 3.9 metres per kilometre (m/km). In areas of steeper subsidence gradients, settlement is predicted to increase from 0.5 m to 6.7 m over a length of approximately 1.6 km, with maximum gradients of approximately 5.0 m/km.

Alteration of surface topography associated with subsidence is predicted to result in small localized changes to flow pathways and drainage areas within the West Loon Creek basin in the ESA (Appendix 9-A). That is, all tributary watercourses affected by subsidence flow into West Loon Creek. Changes to flow pathways are mainly predicted along the north and west edges of the mine well field area. While it is expected that localized alterations of flow pathways will occur and ponding sections may appear, the magnitude of flows along major flow paths (i.e., West Loon Creek) are predicted to be maintained. Alterations of smaller drainage area boundaries in the central section of the mine well field area are anticipated; however, drainage is predicted to continue to direct runoff to West Loon Creek.

Subsidence is also predicted to alter stream channel slopes of the three main watercourses in the ESA including West Loon Creek, a tributary of West Loon Creek from the east, and the intermittent stream that occasionally contributes runoff to West Loon Creek from the west (Appendix 9-A). Subsidence is predicted to exceed 6.0 m in some sections of West Loon Creek channel resulting in a channel gradient reverse in two sections where some shallow ponding is likely to occur; however, downstream drainage would continue. Channel gradient increases are predicted in some sections where gradients of subsidence and topography have the same direction (e.g., both decrease). Where flow velocities increase, erosion is more likely and deposition may occur when the flow velocity is reduced. Changes to flow volumes are expected to be minimal, potentially reducing flood peaks but maintaining flows for downstream areas, although attenuation may occur in ponded areas. Subsidence is predicted to reach approximately 4.0 m in the West Loon Creek east tributary. The existing channel is poorly drained with flat areas where ponded areas develop; the same conditions are predicted to remain following subsidence. The maximum predicted subsidence is approximately 6.6 m in the intermittent stream in the west of the mine well field area. Subsidence may increase the storage potential on the lowered landscape and reduce the frequency that surface runoff from the area reaches West Loon Creek, but the overall effect on streamflow downstream would be negligible in most years.

Subsidence is also expected to affect storage of water on the landscape in the ESA. Existing depressions and wetlands are predicted to receive more runoff in settlement areas that are a result of subsidence. Differential settlement is predicted to cause reductions in the water storage capacity of some depressions and wetlands along the west and north sides of the mine area. In contrast, an increase in water levels is anticipated in wetlands in areas with the greatest subsidence.

Effects of subsidence will be mitigated by applying environmental design features and specialized techniques for solution mining. For example, pillars of unmined material will be left between the mine caverns to increase stability during mining and to reduce potential subsidence. The cavern layout will be refined as additional modeling is completed to optimize potash recovery and to limit the potential effects of subsidence on surface topography. Secondary mining techniques that reduce the amount of material removed from the mine cavern will be employed after development of primary caverns wherever possible. Extraction ratios will be controlled to limit strain on the overlying environment.

Changes to wildlife habitat from ground subsidence will occur gradually over more than 100 years. Depressional areas in the landscape may accumulate more snow runoff and rainfall, which will increase soil moisture and may create wetland habitat. Alternatively, existing wetlands may drain and become upland habitat in some areas. Changes in soil moisture are expected to occur at a rate slow enough to allow for reciprocal changes in the distribution of plant communities. These changes in soil moisture and distribution of upland and wetland vegetation are not expected to result in a net decrease in vegetation and wildlife habitat. Distribution of upland and wetland vegetation is expected to change, but will compose similar proportions of the landscape after subsidence is completed as are currently in the ESA. Wildlife populations are expected to adapt to the gradual transition of habitats over time.

14.6 Prediction Confidence and Uncertainty

The purpose of the prediction confidence and uncertainty section is to identify the key sources of uncertainty and to discuss how uncertainty has been managed to increase the level of confidence that effects are not worse than expected. Confidence in the residual effects analysis and assessment of environmental significance is related to the following elements:

- adequacy of baseline data for understanding current conditions and future changes unrelated to the Project (e.g., extent of future developments, climate change, catastrophic events);
- model inputs (e.g., ZOI and disturbance coefficients from developments);
- understanding of Project-related effects on complex ecosystems that contain interactions across different scales of time and space (e.g., exactly how the Project will influence wildlife); and
- knowledge of the effectiveness of the environmental design features and mitigation for reducing or removing effects (e.g., revegetation of wildlife habitat).

Like all scientific results and inferences, residual effects predictions must be tempered with uncertainty associated with the data and current knowledge of the system. Each of these key elements is discussed in the context of residual effects analysis and assessment for each VC.

The baseline data are anticipated to be sufficient for understanding current conditions and future changes not related to the Project, and that there is a moderate to high level of understanding of Project-related effects on the ecosystem. Development activities are understood to directly and indirectly affect habitat, and the behaviour and movement of wildlife and associated species at risk. However, long-term monitoring studies documenting the time required to reverse effects are lacking.

Although quantitative and less biased than models based on expert opinion, HSI-based habitat maps have numerous sources of uncertainty; these include the structure of the models, the accuracy and precision of underlying data layers, and biases associated with the chosen GIS algorithms (Burgman et al. 2005). Further, habitat maps are a static view between a species and its environment, ignoring changes over time with ecological succession and natural disturbances such as harmful climatic events. However, when considering the predictions of the effects from the Project on VCs, sources of uncertainty were reduced by using multiple habitat mapping methods (Burgman et al. 2005). For example, the assessment included both fragmentation analyses and the use of HSI models, which together reduce bias and increase precision in predictions.

Uncertainty exists related to the predicted effects from subsidence, as these changes are strongly dependent on changes to the hydrological regime. Hydrology identified a number of uncertainties related to the predictions on the effects on hydrology and the surface water environment from subsidence (Appendix 9-A). These uncertainties are related to the random variability associated with the hydrology process, model uncertainty, and parameter uncertainty. Uncertainty exists of the state of regional climate variables (temperature, rainfall, and snowfall) during the period of subsidence, which can influence the outcome of subsidence. Subsequently, there is a corresponding uncertainty in the change to wildlife populations from subsidence.

Adding to the challenges of understanding complex systems is the difficulty of forecasting a future that may be outside the range of observable baseline environmental conditions (Walther et al. 2002). For example, both waterbirds and raptors are migratory species and are under pressures from natural and anthropogenic (e.g., waterfowl harvest) factors on their wintering grounds.

Several conservative assumptions were implemented in the effects analyses to address uncertainty and improve confidence in predictions. The conservative assumptions used and their implications to effects estimates for upland breeding birds, waterbirds, short-eared owl, ferruginous hawk, and northern leopard frog are presented in Table 14.6-1.

Table 14.6-1: Conservative Assumptions Implemented to Manage Uncertainty and Improve Prediction Confidence for Bird and Amphibian Valued Components

Effects Pathway	Conservative Assumption	Implication to Effect
Habitat Quantity and Fragmentation	Undisturbed habitat within Project footprint and other development footprints is unavailable to wildlife	Overestimates habitat loss and fragmentation
	Project footprint was buffered by 25 to 100 m	Overestimates habitat loss and fragmentation
Habitat Quality, Behaviour and Movement	Conservative ZOIs around developments	Overestimates the spatial extent of sensory disturbance
		Captures extent of noise levels from the Project that are greater than 50 dBA
	The greater disturbance coefficient was used when ZOIs overlapped	Overestimates the magnitude of change from sensory disturbance on habitat quality

ZOI = zone of influence; m = metre; dBA = A-weighted decibels.

14.7 Residual Effects Classification and Determination of Significance

14.7.1 Methods

14.7.1.1 Residual Effects Criteria

The purpose of the residual effects classification is to describe the residual incremental and cumulative adverse effects from the Project and previous and existing developments (Application Case) on wildlife using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment.

Results from the residual effects classification are then used to determine the environmental significance from the Project and other developments on the assessment endpoint for wildlife (i.e., self-sustaining and ecologically effective wildlife populations). Effects are described using the criteria defined in Table 14.7-1, and reflect the impact descriptors provided in the TOR (Appendix 2-B). Together, these criteria are used to describe the nature (e.g., severity or intensity of change, and the area and amount of time over which the change occurs) and type (e.g., direction of the change) of an effect on a VC. The main focus of the EIS is to predict whether the Project is likely to cause a significant adverse (i.e., negative) effect on the environment. Therefore, positive effects are not assessed for significance.

Table 14.7-1: Effects Criteria Used in the Determination of Significance for Wildlife Valued Components

Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood
Low: Amount of change to measurement indicator results in no measurable effect on population abundance and distribution, or results in a negligible residual effect on the population. **Moderate:** Amount of change to measurement indicator results in a clearly defined change to population abundance and distribution, but the residual effects are well within the predicted resilience limits and adaptive capacity of the VC. **High:** Amount of change to the measurement indicator is sufficiently large that the resulting ranges of residual effects may be near or exceeding the predicted resilience limits and adaptive capacity of the VC.	**Local:** Predicted maximum spatial extent of direct and indirect effects from changes to measurement indicators due to a project or activity. **Regional:** Residual effects from changes to measurement indicator due to a project or activity exceed the local scale and/or can include cumulative effects from other developments in the effects study area. **Beyond Regional:** Residual cumulative effects from changes to measurement indicator due to a number of developments extend beyond the effects study area.	**Short-term:** Residual effect from change to measurement indicator is reversible at end of construction of a project. **Medium-term:** Residual effect from change to measurement indicator is reversible at end of operations of a project. **Long-term:** Residual effect from change to measurement indicator is reversible within a defined length of time past closure of a project. **Permanent:** Residual effect from change to measurement indicator is irreversible.	**Infrequent:** Residual effect from change to measurement indicator is confined to a specific discrete event. **Frequent:** Residual effect from change to measurement indicator occurs intermittently. **Continuous:** Residual effect from change to measurement indicator occurs continuously.	**Reversible:** Residual effect from change to measurement indicator is reversible within a time period that can be identified when a development or activity no longer influences the population. **Irreversible:** Residual effect from change to measurement indicator is predicted to influence the population indefinitely (duration is permanent or unknown).	**Unlikely:** Residual effect from change to measurement indicator is possible but unlikely (less than 10% chance of occurrence). **Likely:** Residual effect from change to measurement indicator may occur, but is not certain (10% to 80% chance of occurrence). **Highly Likely:** Residual effect from change to measurement indicator is likely to occur or is certain (80% to 100% chance of occurrence).

Note: resilience is the ability of a population to recover or bounce back from disturbance; it varies among VCs.
VC = valued component; % = percent.

Magnitude – Magnitude is a measure of the intensity of a residual effect on a VC. For example, magnitude can represent the degree of change caused by the Project relative to baseline conditions (i.e., effect size). Magnitude is VC-specific and is classified into three scales: low, moderate, and high. For wildlife, magnitude is a function of the numerical and qualitative changes in measurement indicators and the associated influence on the abundance and distribution of VCs. Project-specific (incremental) and cumulative changes in physical (e.g., habitat quantity, quality, and fragmentation) and biological (e.g., survival, reproduction, movement, and behaviour) measurement indicators result in effects on the abundance and distribution of populations. Because the assessment endpoint for wildlife VCs is self-sustaining and ecologically effective populations, the magnitude of residual effects is assessed at the population level. Self-sustaining populations are healthy, robust populations capable of withstanding environmental change and accommodating random demographic processes (Reed et al. 2003). For VCs that have strong effects on ecosystem structure and function (i.e., highly interactive species), the concept of ecologically effective populations also is used (Soulè et al. 2003). An ecologically effective population of a highly interactive species is one that is large enough to maintain ecosystem function.

The assessment of magnitude included the known or inferred ability of the VC to absorb or otherwise accommodate disturbance to provide an ecologically relevant classification of effect sizes of changes in measurement indicators for a particular VC. The evaluation and classification of magnitude considers the adaptive capacity and resilience of VCs to absorb effects from the Project and other disturbances and continue as self-sustaining and ecologically effective populations. Adaptable VCs can change their behaviour, physiology, or population characteristics (e.g., birth rate) in response to a disturbance such that there is little change in abundance and distribution. For example, behavioural plasticity allows for adaptation to disturbance, high birth rates allow for replacement of harvested individuals, and good dispersal ability allows for connection of fragmented populations (Weaver et al. 1996). Highly adaptable populations also exhibit strong and quick responses to favourable environmental conditions. Less adaptable VCs will be more strongly influenced by human and natural disturbance than VCs with greater adaptive capacity.

A concept closely related to ecological adaptability is ecological resilience. Ecosystems and populations often have inertia and will continue to function after disturbance up to the point where the disturbance becomes severe enough that the system or population changes. Ecological resilience is the capacity of the system to absorb disturbance, and reorganize and retain the same structure, function, and feedback responses (Holling 1973; Curtin and Parker 2014). Population resilience can be considered to share similar features as ecological resilience with adaptability influencing the ability of the population to absorb or recover from change. Highly resilient VCs have the potential to recover quickly after disturbance (i.e., they are also adaptable), whereas VCs with narrower resilience limits will recover more slowly or may not recover at all.

Ideally, effect threshold values for adaptability and resilience limits of a VC would be known, and changes in measurement indicators can be quantified with a high degree of confidence to evaluate whether thresholds are expected to be exceeded. However, critical thresholds such as amount of quality habitat required to maintain a self-sustaining population or the specific number of individuals required for an ecologically effective population size are not available for wildlife VCs in this assessment. Moreover, ecological thresholds vary by species, landscape type, and spatial scale (Fahrig 1997; Swift and Hannon 2010). Consequently, a detailed and transparent account of the predicted effects associated with incremental and cumulative changes to each measurement indicator are provided for each VC using available scientific literature, logical reasoning, and experience of the practitioners completing the assessment (reasoned narrative approach). Because of the uncertainty regarding the effects of development on VCs, magnitude classification was applied conservatively to avoid underestimating effects.

Geographic Extent – Geographic (spatial) extent refers to the area (or distance covered or range) of the effect, and is different from the spatial boundary (i.e., effects study area) for the effects analysis. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution and movement of VCs (Section 14.2.1). However, the geographic extent of effects can occur on a number of scales within the spatial boundary of the assessment, and is VC-specific. Geographic extent is categorized into three scales of local, regional, and beyond regional. Effects at the local scale are largely associated with the predicted maximum spatial extent of combined direct and indirect changes from a specific development or activity (e.g., cumulative effects that are specific to the Project). Effects at the regional scale occur within the effects study area, and are associated with incremental and cumulative changes from the Project and other developments. The beyond regional scale includes cumulative residual effects from the Project and other developments that extend beyond the effects study area. The principle applied when using geographic extent to understand magnitude is that local effects from the Project are less severe than effects that extend to the regional or beyond regional scales, all other factors being equal.

Duration – Duration is defined as the amount of time (usually in years) from the beginning of a residual effect to when the residual effect on wildlife populations is reversed. Typically, duration is expressed relative to development phases. Both the duration of individual events and the overall period during which the residual effect may occur are considered. Some residual effects may be reversible soon after the effect has ceased, while other residual effects may take longer to be reversed. By definition, residual effects that are short-term, medium-term, or long-term in duration are reversible.

In some cases, available scientific information and professional judgment may predict that the residual effect is irreversible. Alternately, the duration of the residual effect may not be known, except that it is expected to be extremely long and well beyond the temporal boundary of the Project. As such, any number of factors could cause wildlife populations to never return to a state that is unaffected by the Project. In other words, science and logic predict that the likelihood of reversibility is so low that the residual effect is irreversible.

14.7.1.2 Determination of Significance

The classification of primary pathways and the associated predicted changes in measurement indicators provide the foundation for determining the significance of incremental and cumulative effects from the Project and other existing and approved developments on the assessment endpoint for wildlife. The significance of the contribution of incremental effects from the Project on VCs is provided, but the evaluation is focused on determining the significance of cumulative effects on wildlife.

Magnitude is the primary criterion used to determine environmental significance, while other criteria are used as modifiers and to provide context when assigning magnitude. Geographic extent and duration provide important context for classifying the magnitude of effects on wildlife assessment endpoints. Frequency and likelihood are also considered as modifiers when determining significance, where applicable.

The evaluation of significance for wildlife considers the entire set of primary pathways that influence the assessment endpoint; thus, significance is not explicitly assigned to each pathway. Rather, the relative contribution of each pathway is used to determine the significance of the Project and other developments on the assessment endpoint, which represents a weight of evidence approach (i.e., evaluating the persuasiveness of evidence indicating that an effect is significant or not significant). For example, a pathway with a high magnitude, a large geographic extent, and a long-term duration is given more weight in determining significance relative to pathways with smaller scale effects. The relative effect from each pathway is discussed; however, pathways that are predicted to have the greatest influence on changes to the assessment endpoint are assumed to contribute the most to the determination of environmental significance.

The determination of environmental significance on wildlife considered the following key factors:

- Results from the residual effects classification of primary pathways and associated predicted changes in measurement indicators.
- Magnitude is the primary criterion used to determine significance with geographic extent and duration providing important context for assigning magnitude. Frequency and likelihood act as modifiers for determining significance, where applicable.
- the level of confidence in predicted effects, scientific principles (e.g., resilience and stability), and scientific interpretation are also included in the evaluation of determining environmental significance. Where uncertainty was high and the cumulative effect might be either significant or not significant, the assessment conservatively identified the effect as significant and provided additional follow-up actions to manage uncertainty.

This method is used to identify predicted residual adverse effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to wildlife, and therefore, result in significant effects. The following definitions are used for predicting the significance of effects on self-sustaining and ecologically effective wildlife populations.

Not significant – effects are measurable at the individual level, and strong enough to be detectable at the population level, but are not likely to decrease resilience and increase the risk to remaining self-sustaining and ecologically effective populations.

Significant – effects are measurable at the population level and likely to decrease resilience and increase the risk to the maintenance of a remaining self-sustaining and ecologically effective population. Loss of habitat that causes permanent adverse changes to survival or reproduction at the population level would likely be significant. A significant effect may also result from habitat loss and fragmentation that reduces population connectivity to the point that it disrupts demographic rescue between source and sink habitats (or areas).

14.7.2 Results

The primary threat to ferruginous hawk, short-eared owl, and many federally listed upland breeding bird species (e.g., Sprague’s pipit, bobolink) is thought to be habitat loss from agricultural and industrial development (COSEWIC 2006; 2007; 2008a,b; 2010a,b,c). Similarly, habitat alteration and degradation that results from human activities (e.g., wetland drainage) are thought to be primary causes of the decline of many waterbird species (BirdLife International 2008) and the northern leopard frog (Environment Canada 2013). Approximately 80% of native grassland in Saskatchewan has been lost to agriculture since European settlement and in some areas of the province only 2% of native grassland remains (Hammerstein et al. 2001). Similarly, 40% of wetlands in Saskatchewan are estimated to have been drained since European settlement (SWA 2002) and the rate of drainage has not decreased in the last 50 years (Cortus et al. 2010). More than 90% of wetlands in the prairie region of Canada are visibly affected by agricultural activities (e.g., tilling of wetland edges) (Bartzen et al. 2010).

At the Base Case, cumulative changes from sustained agricultural practices over the last 100 years have likely resulted in adverse effects on some wildlife VC populations in the ESA (high magnitude, regional scale effect; Table 14.7-2). Previous and existing disturbances have likely decreased resilience to the point where some local populations may not be self-sustaining and ecologically effective. Considering the amount of cultivated and modified grassland habitat types in the Base Case, 75.5% of native grassland and wetland vegetation types that were in the ESA prior to human settlement is estimated to have been removed by previous and existing human developments and agricultural activities. These changes are likely to be irreversible given the current and future economic benefits of agriculture and other industries in the region (Table 14.7-2).

The Project is located in an area that contains a large amount of agricultural activity that will likely continue for the duration of the Project. Most of the habitat types expected to be affected by the Project is widely distributed in the ESA, including native grassland and wetland habitats, and subsequently the Project should have little influence on grassland and wetland wildlife VCs. For example, larger areas of native grassland are present outside of the Project footprint (125 to 270 ha; Section 13.7.2.1). Some of this native grassland is associated with the valleys of West Loon Creek and contiguous, intact areas at the northeast and southeast sides of the ESA. The Project is approximately 5 km from the closest known location of a large patch of native grassland (approximately 125 ha). Baseline data indicates that these grasslands are in good condition and are dominated with native grassland species (Section 13.7.2.1). As such, these areas are predicted to be able to support self-sustaining and ecologically effective populations of listed native grassland-dependent wildlife species, except ferruginous hawk. Similarly, the local and sub-regional plant communities associated with wetland habitats are anticipated to be ecologically functional (Section 13.7.2.1), and should support self-sustaining and ecologically effective populations of wetland-dependent wildlife VCs.

The dominance of cultivation in the ESA, combined with the southwesterly contraction of the breeding range in Saskatchewan, likely means that although a few individuals may occasionally breed in or use the ESA, there is not likely to be a self-sustaining population in the area (Schmutz 1987). Self-sustaining and ecologically effective population(s) of ferruginous hawks in Saskatchewan are likely limited to the southwest portion of the province (i.e., in the Mixed Grassland Ecoregion) (Downey 2006).

The maximum extent of the Project footprint is 1,500 ha. Cultivated land is the dominant habitat in the footprint and covers 1,216 ha. For comparison, the next largest areas of habitat to be removed by the Project are 87 ha of Class I and II wetlands and 77 ha of modified grassland habitat. The Project is predicted to remove 19 ha of native grassland habitat, 12 ha of Class III wetland habitat, and 69 ha of Class IV wetland habitat. Overall, the cumulative reduction in natural habitat through application of the Project and previous and existing developments is approximately 75.8% of the ESA, with an incremental contribution from the Project of 0.3%, relative to the Base Case. A loss of 19 patches of native grassland habitat and a loss of 60 patches of Class III and Class IV

Wetlands is predicted from the Project. The removal of these patches of habitat is expected to have an ecologically negligible (i.e., low magnitude) effect on wildlife VCs as there are larger and contiguous patches of these habitats that will not be influenced by the Project. These larger, intact areas of natural grassland not influenced by the Project will remain suitable for ferruginous hawks that may use the area for foraging and/or nesting.

Changes to the MDNN between habitat patches are not anticipated to influence bird VCs as these species are highly mobile. The MDNN of Class I and II wetlands are predicted to increase by 0.1 m with the application of the Project. The MDNN for other wetland habitat is predicted to decrease by 0.1 to 2.5 m from the Base Case to the Application Case. The decreases in MDNN may be a result of the removal of wetland habitat patches that are farther than average from other wetland patches. Another explanation for the decrease in MDNN may be the fragmentation of some wetland patches. The small change in distance between wetland habitats is not anticipated to influence northern leopard frog as this species has been found to travel up to 800 m in two to three days and may disperse up to 10 km from their natal pond (Dole 1971; COSEWIC 2009).

In addition to changes from direct habitat loss and fragmentation, indirect changes from sensory disturbance associated with existing developments and the Project may influence wildlife abundance and distribution by altering movement and behaviour among habitats at the population scale (Habib et al. 2007; Bayne et al. 2008). Cultivated land habitat is anticipated to be the most influenced by sensory disturbance associated with the Project. The Project is predicted to influence an additional 0.9% and 2.4% of cultivated land habitat during construction and operations, respectively, when compared to the Base Case. Sensory disturbance from the Project is anticipated to influence less than 0.1% and 0.3% of native grassland habitat during construction and operations, respectively. Approximately 0.4% and 1.4% of Class V wetland habitat will be affected by sensory disturbance from the Project. Sensory disturbance from the Project is not anticipated to influence the large, contiguous patches of native grassland and Class V wetland habitats that exist in the ESA as these habitat patches are 5 km or more from the Project (Section 13.7.2.1).

Changes in habitat quality from sensory disturbance do not necessarily result in demographic consequences to populations (Gill et al. 2001). Most effects from indirect changes in habitat quality from the Project are anticipated to be related to a local shift in distribution with little influence on survival and reproduction rates (low magnitude). Most birds are adaptable, and can respond to disturbance so that there is little change in abundance and distribution. Locally, most migratory birds have high reproductive rates that allow for replacement of individuals that may be removed from the population due to the loss or alteration of habitat from the Project. Studies that have focused on the effects of noise on upland bird behaviour and movement have shown that some bird species may benefit from human disturbance, while others do not (Spellerberg and Morrison 1998; Canaday and Rivadeneyra 2001; Male and Nol 2005; Habib et al. 2007; Bayne et al. 2008). Therefore, sensory disturbance and associated changes in habitat quality from Project construction and operation activities is expected to have a low magnitude effect on the abundance and distribution of wildlife VCs in the ESA.

Not all areas that were assessed to be disturbed by the Project are expected to be altered during construction; therefore, the assessment of effects from direct loss or alteration and fragmentation of habitats in the ESA is overestimated. In addition, the application of mitigation for the Project will follow the mitigation hierarchy outlined in MOE (2014) (i.e., the preferred mitigation is to avoid wetlands). The siting of well pad locations will be modified to avoid wetlands as part of the final design phase. Avoidance of wetlands will reduce the contribution of the Project to existing cumulative effects in the ESA. The incremental effects from the Project are expected to be reversible after closure (long-term), except for localized effects from the TMA and crystallization ponds (708 ha [0.8% of the ESA]) and subsidence, which will be permanent and irreversible (Table 14.7-3).

Overall, the weight of evidence from the analysis of the primary pathways predicts that cumulative changes to measurement indicators from previous and existing developments have had an adverse effect on self-sustaining and ecologically effective wildlife populations in the ESA. The cumulative residual effect on wildlife VCs present in the Application Case is expected to be high in magnitude because of the previous and existing disturbances in the ESA (Table 14.7-2). However, there are remaining large areas of contiguous native grasslands and wetlands in the ESA that likely support self-sustaining and ecologically effective wildlife VCs. The one exception is ferruginous hawk. Self-sustaining and ecologically effective population(s) are predicted to not exist in the ESA, but are likely limited to the Mixed Grassland Ecoregion of the province.

The incremental effects from the Project are small (low magnitude), local to regional in geographic extent, and long-term to permanent in duration (Table 14.7-3). The incremental contributions of the Project to regional cumulative effects are not likely to decrease resilience and increase the risk to remaining local self-sustaining and ecologically effective wildlife populations; the Project will not influence the large, intact natural grasslands and wetlands that currently exist in the ESA. Therefore, the cumulative changes from the Project and other developments are predicted to not have significant adverse effects on wildlife VC populations. Confidence in this prediction is moderate because of limited knowledge about the resilience of listed wildlife species in the ESA. However, conservative approaches were used so that effects would not be underestimated (e.g., using a larger than anticipated Project footprint), and with appropriate mitigation such as avoidance of patches of wetlands, the incremental effect related to the Project will be reduced.

Table 14.7-2: Summary of Residual Effects Classification of Primary Pathways and Predicted Significance of Cumulative Effects on Wildlife Valued Components

Pathway	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Significance for Assessment Endpoint[(a)]
Loss, alteration, and fragmentation of habitat from ground disturbance from the core facilities area, Project mine well field area, and transportation corridors can cause changes in the relative abundance and distribution.	high	regional	long-term to permanent	periodic (migratory species) to continuous (non-migratory species)	reversible to irreversible	highly likely	Not Significant; there are remaining large areas of contiguous native grasslands and wetlands in the ESA
Residual ground disturbance from portions of the core facilities area can cause permanent alteration of wildlife habitat, which could affect the abundance and distribution.	low	regional	permanent	periodic (migratory species) to continuous (non-migratory species)	irreversible	highly likely	
Sensory disturbance (e.g., presence of humans, smells, noise) from the construction and operation of the Project can cause changes to the relative abundance and distribution.	moderate	regional	long-term	periodic (migratory species) to continuous (non-migratory species)	reversible	highly likely	
Ground subsidence can cause degradation of wildlife habitat, which can cause changes to the relative abundance and distribution.	low	regional	permanent	periodic (migratory species) to continuous (non-migratory species)	irreversible	highly likely	

(a) Self-sustaining and ecologically effective wildlife populations.

Table 14.7-3: Summary of Incremental Contributions of the Project to Cumulative Effects on Wildlife Valued Components

Pathway	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Significance for Assessment Endpoint[(a)]
Loss, alteration, and fragmentation of habitat from ground disturbance from the core facilities area, Project mine well field area, and transportation corridors can cause changes in the relative abundance and distribution.	low	local	long-term	periodic (migratory species) to continuous (non-migratory species)	reversible	highly likely	Not Significant; the Project is predicted to contribute little to cumulative effects from previous and existing developments
Residual ground disturbance from portions of the core facilities area can cause permanent alteration of wildlife habitat, which could affect the abundance and distribution.	low	local	permanent	periodic (migratory species) to continuous (non-migratory species)	irreversible	highly likely	
Sensory disturbance (e.g., presence of humans, smells, noise) from the construction and operation of the Project can cause changes to the relative abundance and distribution.	low	local	long-term	periodic (migratory species) to continuous (non-migratory species)	reversible	highly likely	
Ground subsidence can cause degradation of wildlife habitat, which can cause changes to the relative abundance and distribution.	low	regional	permanent	periodic (migratory species) to continuous (non-migratory species)	irreversible	highly likely	

(a) Self-sustaining and ecologically effective wildlife populations.

14.8 Monitoring and Follow-up

Typically, monitoring includes one or more of the following categories, which may be applied during the development of the Project:

- **Compliance monitoring** – monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments (e.g., inspecting the installation and effectiveness of a silt fence).
- **Follow-up monitoring** – programs designed to test the accuracy of effects predictions, reduce/address uncertainties, determine the effectiveness of environmental design features, and/or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., monitoring of downstream lakes for aquatic effects, wildlife effects monitoring, and socio-economic monitoring). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

Following approval of the Project, environmental monitoring programs may be developed and reviewed during the permitting phase to track conditions or issues during the development lifespan, and implement appropriate and necessary adaptive management. Specifically, once the final routings for the supporting utilities (e.g., water supply pipeline, transmission corridor) and transportation infrastructure have been determined surveys for federally and provincially listed wildlife and plant species will be completed prior to construction. Similar surveys may be implemented for the pipelines, access roads, and well pads associated with the mining area during Project development. If suitable habitat for listed wildlife species is located in close proximity to the construction activity, surveys will be completed that follow the guidelines for development activities. If listed wildlife species are identified, appropriate mitigation will be identified and implemented in consultation with MOE.

A follow-up monitoring program will be proposed to reduce uncertainty from the potential effects of subsidence on hydrology. The monitoring program would be designed to examine changes to hydrology. If changes to hydrology indicate that there would be effects on terrestrial ecosystems, then a monitoring program would be designed to assess the associated changes to terrestrial components. Monitoring of revegetation success will be completed following decommissioning and reclamation of the Project.

Compliance inspections and environmental monitoring data reporting will be undertaken as part of a site comprehensive Environmental Protection Plan. The plan will provide flexibility for Yancoal and the MOE to effectively identify and respond to unanticipated changes to wildlife, and to adapt to new regulatory frameworks (e.g., Saskatchewan Environmental Code). Data reporting is expected to occur annually, with data analysis being undertaken every five years and communicated in the form of Status of the Environment reports.

14.9 Summary and Conclusions

The Project is not expected to affect the ability of wildlife VCs to be self-sustaining and ecologically effective.

Based on information presented in Archibold and Wilson (1980), previous and existing human developments, including cultivated and modified grassland habitats, are estimated to have removed 75.5% of wetland and native grassland habitats that were present in the ESA prior to human settlement. Consequently, cumulative effects from previous and existing human activities are expected to have adversely affected ferruginous hawk, short-eared owl, and northern leopard frog populations as well as some upland breeding bird and waterbird populations in the ESA.

The Project is predicted to contribute little to cumulative effects on wildlife VCs in the ESA. The Project is expected to result in a 1.5% loss of wetland habitat and a less than 0.1% loss of native grassland habitat. Yancoal is committed to following the wetland mitigation hierarchy presented in MOE (2014). As such, during construction, Project infrastructure (i.e., well pads) will be sited to avoid wetlands, and the anticipated direct loss to wetlands will be less than predicted.

In addition to direct habitat loss, indirect changes from sensory disturbance associated with existing developments and the Project may influence wildlife abundance and distribution by altering movement and behaviour among habitats at the population scale. When compared to a landscape with only direct disturbance, sensory disturbance is affecting 50.1% (40,139 ha) of the ESA under Base Case conditions. Sensory disturbance effects combined with direct effects from removal of habitat by cultivated, modified grassland, and existing disturbance habitats are predicted to have altered 87.2% (70,082 ha) of the ESA under the Base Case. Sensory disturbance from Project construction and operations is predicted to affect an additional 6.7% (5,455 ha) and 8.0% (6,444 ha) of the ESA, respectively, relative to the Base Case.

Overall, the weight of evidence from the analysis of the primary pathways predicts that cumulative changes to measurement indicators from previous and existing developments have had an adverse effect on self-sustaining and ecologically effective wildlife populations in the ESA. However, there are remaining large areas of contiguous native grasslands and wetlands in the ESA that likely support self-sustaining and ecologically effective wildlife VCs. The incremental effects from the Project are small (low magnitude), local to regional in geographic extent, and long-term to permanent in duration. The incremental contributions of the Project to regional cumulative effects are not likely to decrease resilience and increase the risk to remaining local self-sustaining and ecologically effective wildlife populations; the Project will not influence the large, intact natural grasslands and wetlands that currently exist in the ESA. Therefore, the cumulative changes from the Project and other developments are predicted to not have significant adverse effects on wildlife VC populations.

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14.11 Glossary

Term	Definition
Abundance	The number of individuals.
Adverse effect	An undesirable or harmful effect on an organism (human or animal) indicated by some result such as mortality, altered food consumption, decreased abundance and distribution, altered body and organ weights, altered enzyme concentrations, or visible pathological changes.
Attenuation	A gradual reduction in intensity.
At risk	Species in danger of becoming extinct (global loss) or extirpated (gone from a certain part of the world). Species at risk are usually at risk because of environmental or human-induced changes to them or their habitat on a local, regional, or global scale.
Baseline study area (BSA)	An area designed to characterize existing environmental conditions on a continuum of scales from the anticipated Project footprint to broader, regional levels.
Basin	A large area that is lower in elevation than surrounding areas and contains water. Basins are separated by land or shallow channels.
Best Practice	Method or procedure that is accepted by industry as being effective, practical and reliable in maintaining quality, and meeting Project objectives and regulatory requirements.
Biodiversity	The level of variety, or diversity, that exists in a natural system, especially the number of species. Biodiversity includes the number of ecosystem types and genetic variation, within species.
Brine	A concentrated solution of inorganic salts.
Carrion	Dead and decaying animals.
Climate	The prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, cloudiness, and winds, throughout the year, averaged over a series of years.
Community (biology)	Group of co-existing organisms in an ecosystem.
Cumulative effects	Changes to the environment that are caused by natural and human-related factors (e.g., previous, existing and reasonably foreseeable human developments).
Distribution	The pattern of dispersion of a physical property (e.g., soil) or biological organism within its range.
Diversity	A numerical index that incorporates evenness and richness; diversity measures the proportional distribution of organisms in the community.
Drainage	The removal of excess surface water or groundwater from land by natural runoff and percolation, or by means of surface or subsurface drains.

Term	Definition
Ecological Landscape Classification (ELC)	A means of classifying landscapes by integrating landforms, soils, and vegetation components in a hierarchical manner.
Ecoregion	Subdivisions of ecozones that are relatively homogeneous with respect to soil, terrain, and dominant vegetation.
Ecosystem	An integrated and stable association of living and non-living resources functioning within a defined physical location. A community of organisms and its environment functioning as an ecological unit. For the purposes of assessment, the ecosystem must be defined according to a particular unit and scale.
Effect	An effect represents a change in a valued component (VC). Any response by an environmental or social component to an action's impact. Under the *Canadian Environmental Assessment Act*, "environmental effect" means, in respect of a Project, "(a) any change that the Project may cause in the environment, including any effect of any such change on health and socio-economic conditions, on physical and cultural heritage, on the current use of lands and resources for traditional purposes by Aboriginal persons, or on any structure, site or thing that is of historical, archaeological, paleontological or architectural significance and (b) any change to the Project that may be caused by the environment, whether any such change occurs within or outside of Canada.
Effects Study Area (ESA)	The spatial assessment boundary for the effects analysis and determination of significance defined by the geographic distribution and movement of a valued component.
Emission	The act of releasing or discharging air contaminants into the ambient air from any source.
Footprint	The proposed development area that directly affects the biophysical components of the landscape.
Frequency	Refers to how often an effect will occur.
Geographic Information System (GIS)	Computer software designed to develop, manage, analyze, and display spatially referenced data.
Ground-truthing	Verification of models using field survey data. For example, checking the accuracy of the ELC using field visits to confirm that the ELC is correctly interpreting imagery and to provide data to fine-tune the ELC.
Habitat	The physical location or type of environment in which an organism or biological population lives or occurs.
Incremental contribution	A change to the environment that is caused by one human action, separate from other past, present, and future human actions.
Individual	A single plant or organism within a population.
Inflow	Water flowing into a waterbody.
Invertebrates	Animals that lacka backbone (e.g., insects, worm, crab).

Term	Definition
Insectivorous	Animals and plants that consume insects.
Landscape	A heterogeneous land area with interacting ecosystems that are repeated in similar form throughout. From a wildlife perspective, a landscape is an area of land containing a mosaic of habitat patches within which a particular “focal” or “target” habitat patch is embedded.
LiDAR	A remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth.
Measurement indicator	Measurement indicators represent properties or attributes of the environment and VCs that, when changed, could result in, or contribute to, an effect on assessment endpoints. Measurement indicators may be quantitative (e.g., concentrations of metals in surface water) or qualitative (e.g., movement and behaviour of wildlife from disturbance to habitat and travel corridors).
Mitigation	The avoidance, minimization (reduction), restoration/reclamation or compensation of the adverse environmental effects of a project.
Organic matter	Plant and animal materials that are in various stages of decomposition.
Pathway analysis	Identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects after mitigation.
Population	A group of individuals of the same species whose abundance and distribution is primarily influence by survival and reproduction.
Post-metamorphic	The life form that exists after an animal has experienced an abrupt change to body form (e.g., frogs changing from tadpoles).
Quartile	One of four equal groups into which values of a variable can be divided according to the distribution of values of a particular variable.
Range	The geographic limits within which an organism occurs.
Raptor	A bird of prey (e.g., hawk, eagle, or owl).
Riparian	Refers to terrain, vegetation or simply a position next to or associated with a stream, floodplain, or standing waterbody.
Scale	The resolution at which patterns are measured, perceived, or represented. Scale can be broken into several components, including geographic extent, resolution (grain), and other aspects.
Self-sustaining Population	A population that is sufficiently large to maintain is numbers over time.
Sensitive	■ sites or organisms that are particularly vulnerable to harm ■ a general status rank for a species with one or more of the effects.
Sensory disturbance	A change that may affect senses (e.g., a noise affecting hearing, light affecting vision) and influence behaviour, movement, energy balance, reproduction and survival.

Term	Definition
Species	A group of organisms that actually or potentially interbreed and are reproductively isolated from all other such groups; a taxonomic grouping of genetically and morphologically similar individuals; the category below genus.
Species Richness	The number of different species
Temporal	Related to time.
Topography	The surface features of a region, such as hills, valleys, or rivers.
Traditional Knowledge	The knowledge, innovations, and practices of indigenous people; refers to the matured long-standing traditions and practices of certain regional, indigenous, or local communities.
Ungulate	A hoofed animal (e.g., moose or deer).
Uncertainty	Imperfect knowledge concerning the present or future state of the system under consideration; a component of risk resulting from imperfect knowledge of the degree of hazard or of its spatial and temporal distribution.
Upland breeding bird	Songbirds (excluding common raven), woodpeckers, pigeons, upland game birds, shorebirds, and other non-waterbird and non-raptor species that nest in upland areas.
Valued Component (VCs)	Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by society.
Waterbird	A bird that requires open water or wetlands for breeding (e.g., ducks, geese, gulls, loons, grebes).
Wetland	Land having the water table at, near, or above the land surface or which is saturated for a long enough period to promote wetland or aquatic processes as indicated by hydric soils, hydrophytic vegetation and various kinds of biological activity which are adapted to the wet environment.
Wildlife	A term to describe all undomesticated animals living in the wild.
Zone of influence	The defined area where changes in habitat quality affect the distribution and abundance of animals.

15.0 HERITAGE RESOURCES

15.1 Introduction

15.1.1 Background

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project) located in central Saskatchewan, approximately 60 kilometres (km) north of Regina. Yancoal proposes to develop the Project, which includes solution mining and associated supporting infrastructure.

The Project is located in the Rural Municipality (R.M.) of Longlaketon (No. 219) and the R.M. of Cupar (No. 218). An existing network of municipal grid roads, provincial highways, and rail lines will provide access to the Project. The Project (including the core facilities area, 65-year mine field, and indicated resource boundary) encompasses approximately 143 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M).

15.1.2 Purpose and Scope

This section of the Environmental Impact Statement (EIS) for the Project addresses the effects to heritage resources identified in the Project Terms of Reference (TOR) approved by the Environmental Assessment Branch (EAB) of the Ministry of Environment (MOE) in May 2015 (Appendix 2-B).

The purpose of this section is to meet the TOR, specifically to assess the effects from the Project on heritage resources. The scope of this section includes an analysis of Project-related changes during construction, operation, and decommissioning and reclamation. The incremental and cumulative residual effects from the Project and other previous, existing, and reasonably foreseeable developments on heritage resources are assessed.

Heritage resources are linked to cultural, traditional, and societal values; whereas land use is linked to individuals and communities that are influenced by components of the physical, biological, cultural, and socio-economic environments. As such, related assessments are provided in the following sections:

- Hydrology (Section 9.0);
- Surface Water Quality (Section 10.0);
- Fish and Fish Habitat (Section 11.0);
- Soils (Section 12.0);
- Vegetation (Section 13.0);
- Wildlife (Section 14.0); and
- Socio-economic Environment (Section 16.0).

15.1.3 Valued Components, Assessment Endpoints, and Measurement Indicators

The TOR identified heritage resources as a valued component (VC) that should be included in the assessment of Project effects. Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important by the proponent, the public, First Nations and Métis communities, and government agencies. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have potential to be adversely affected by Project development and, therefore, are used to predict the effects of the Project on all environmental components. Rationale for selection of heritage resources as a VC is as follows:

- are sensitive to Project-related effects;
- can be measured or described with one or more practical indicators; and
- changes to heritage resources can influence other societal VCs.

Community and regulatory engagement, and local and traditional knowledge were key considerations for selecting the heritage resources VC, but assessment endpoints for the heritage resources VC do not explicitly consider societal values. Changes in heritage resources are important and must be considered to understand the full suite of potential effects of the Project (i.e., both human and ecological dimensions). Consequently, measurement indicators from the heritage resources section were carried forward so that effects on societal values could be appropriately captured in the sections dealing specifically with those values (Section 16.0).

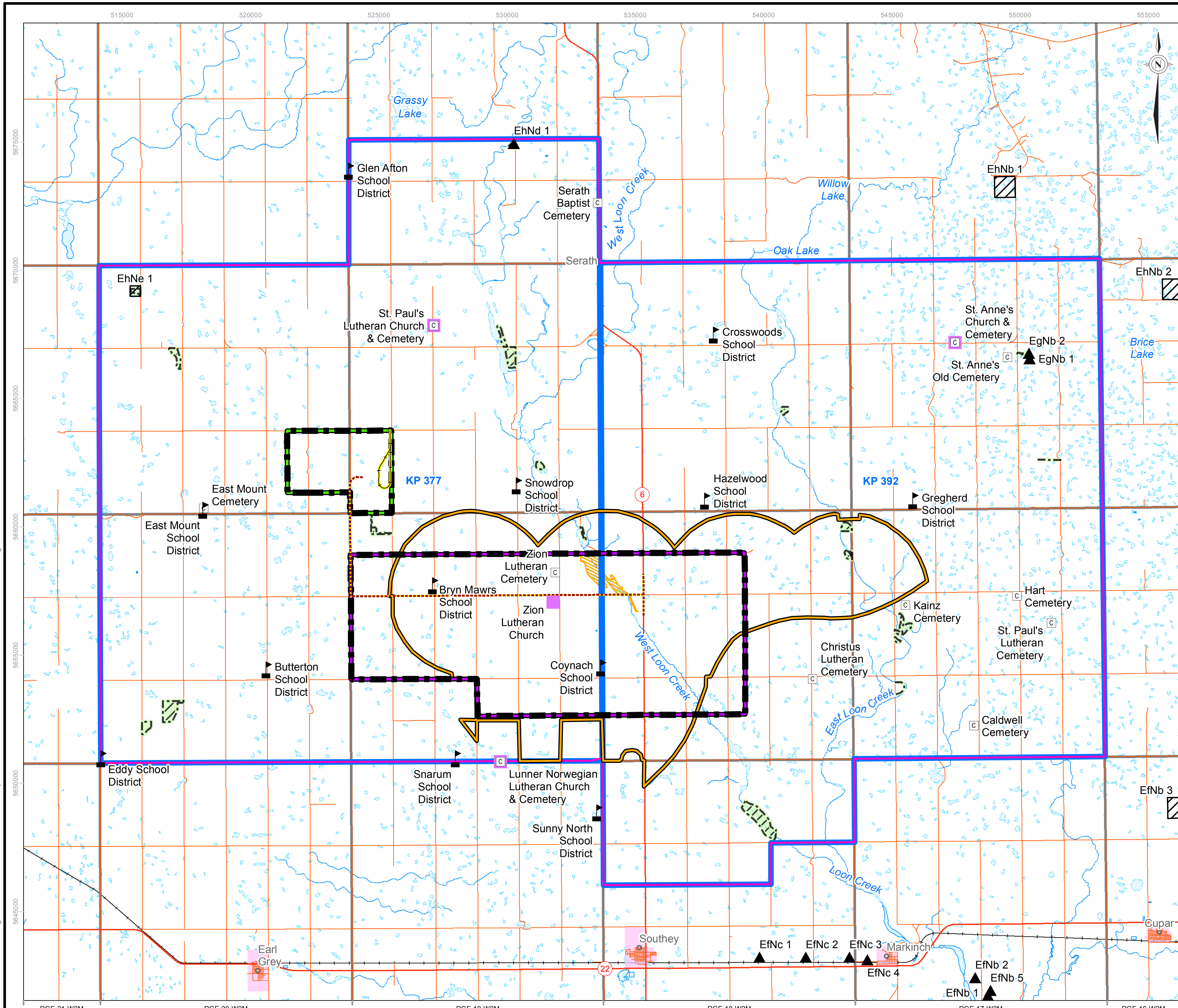
Assessment endpoints are qualitative expressions used to assess the significance of effects on a VC and represent the key properties of the VC that should be protected for use by future human generations (i.e., incorporate sustainability). Assessment endpoints are general statements about what is to be protected. Measurement indicators are quantitative and/or qualitative expressions of changes to the assessment endpoints. The assessment endpoint for the heritage resources VC is protection of heritage resources. The measurement indicator for the heritage resources VC is the number and quality of archaeological and sacred sites.

15.2 Environmental Assessment Boundaries

15.2.1 Spatial Boundaries

15.2.1.1 Baseline Study Area

To quantify baseline conditions, a baseline study area (BSA) was defined for heritage resources and was defined as a local study area (Annex V, Section 2.2; Figure 15.2-1). The BSA includes lands contained within the Project Permit Boundaries KP377 and KP392 located within Townships 23, 24, 25, and 26, Ranges 17, 18, 19, and 20, and is 84,541 ha. This area was selected to describe the existing heritage baseline environment and give a broader understanding of the types of heritage resources that occur or could be expected to occur within the BSA.



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- PROPOSED ACCESS ROAD
- PROPOSED RAIL LOOP
- PERMIT BOUNDARY
- 65 YEAR MINE FIELD
- CORE FACILITIES AREA
- INDICATED RESOURCE BOUNDARY
- CEMETERY
- CHURCH BUILDING
- SCHOOL DISTRICT MARKER
- KNOWN HERITAGE RESOURCE
- ASSESSED AREA
- BASELINE STUDY AREA
- EFFECTS STUDY AREA
- HERITAGE SENSITIVE AREA
- KNOWN HERITAGE RESOURCE

REFERENCE

HERITAGE RESOURCES: HERITAGE CONSERVATION BRANCH, MINISTRY OF PARKS, CULTURE AND SPORT, 2014.
PERMIT BOUNDARY: POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
BASE DATA: CANVEC © NATURAL RESOURCES CANADA
NAD83 UTM ZONE 13

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
YANCOAL SOUTHEY PROJECT

TITLE
LOCATION OF THE HERITAGE RESOURCES BASELINE AND EFFECTS STUDY AREAS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		12-1362-0197	FILE No.
DESIGN	PY	08/04/15	SCALE AS SHOWN REV. 0
GIS	LMS	25/05/15	FIGURE: 15.2-1
CHECK	PY	25/05/15	
REVIEW	BC	25/05/15	

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The BSA is situated on a transitional area between the boundaries of the Moist Mixed Grassland and Aspen Parkland Ecoregions of the Prairie Ecozone in Saskatchewan (Acton et al. 1998). Encompassing the western and southern portions of the BSA, the Strasbourg Plain Landscape Area of the Moist Mixed Grassland Ecoregion is best described as a nearly level plain interspersed with hummocky morainal locales. Conversely, the Touchwood Hills Upland Landscape Area of the Aspen Parkland Ecoregion is a hummocky upland that covers the eastern and northern portions of the BSA. Many glacial kettles are scattered throughout the two Landscape Areas; however, the most significant water sources within the BSA are West Loon and East Loon creeks and their associated tributaries. These creeks carry water out of the BSA via Loon Creek, which then transports the water approximately 20 km south into the Qu'Appelle River valley. Most of the BSA has been disturbed previously by agricultural activities. However, patches of undisturbed areas are interspersed throughout the cropland. Native prairie is commonly found in association with areas of hummocky moraine towards the northeast corner of the BSA and along the margins of West Loon and East Loon creeks and their tributaries.

15.2.1.2 Effects Study Area

To assess Project-related effects on heritage resources, an effects study area (ESA) was delineated. The ESA is located within the BSA and corresponds with the Project footprint including the core facilities area and the 65-year mine field (Figure 15.2-1). The core facilities area is approximately 1,256 ha and encompasses Sections 6 and 7-25-19 W2M, N1/2 1, NE 2, E1/2 11, and all of Section 12-25-20 W2M. The 65-year mine field is approximately 9,223 ha and encompasses Sections 10 to 30-24-19 W2M, Sections 7 to 9, 16 to 21, Sections 28 to 30-24-18 W2M; and W1/2 10, 15, 22 and 27-24-18 W2M. The ESA was designed to predict direct effects from the Project on heritage resources. Potential direct effects on heritage resources are associated with construction of the core facilities area, facilities within the mine well field area (e.g., well pads) and the plant site access road. Potential direct effects to heritage resources arise from the removal of soil, subsoils and vegetation during the construction phase of these facilities. Heritage resources are non-renewable and they can be damaged or destroyed during ground disturbance activities if present.

The majority of the ESA is within the Moist Mixed Grassland; however, the northeast corner of the 65-year mine field crosses into the Aspen Parkland Ecoregion. The physical environment for the ESA is the same as described above for the BSA, with generally flat terrain that has been largely modified by agricultural practices. The West Loon Creek transects the eastern portion of the 65-year mine field.

15.2.2 Temporal Boundaries

Temporal boundaries for the heritage resources assessment were defined by the life of the Project (Section 4.0) and the existing and future cumulative effects to which the Project might contribute. The Project phases are construction, operation, and decommissioning and reclamation. Final relinquishment of the Project will occur after the completion of reclamation.

The effects analysis encompasses the Project phases as follows:

- construction (2016 to 2019);
- operations (2019 to 2119); and

- decommissioning and reclamation (2119 onward).

The above timeframes are intended to be sufficiently flexible to capture the effects of the Project on heritage resources. Effects to heritage resources begin during the construction phase, and continue through the operations phase. Decommissioning and reclamation activities are expected to have no effects to heritage resources because no new disturbance will occur during this Project phase. Therefore, effects on heritage resources were analyzed and assessed for significance from Project construction through operations. This approach generates the maximum potential spatial and temporal extent of effects on heritage resources.

15.2.2.1 Base Case

The Base Case (existing environment) represents conditions before application of the Project. Previous and existing developments and activities include roads, communities, and agricultural activities. Consequently, the Base Case represents the cumulative outcome of all previous and existing developments and activities.

15.2.2.2 Application Case

The incremental contributions of residual effects from the Project to existing cumulative effects were assessed at the ESA scale by adding the Project to the Base Case to form the Application Case. The maximum effect is associated with ground disturbance that occurs during construction of the core facilities area and associated infrastructure, as well as construction of well pads and associated well site access roads within the 65-year mine field boundary. The incremental contributions of the Project and the cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are predicted in order to evaluate changes to measurement indicators for heritage resources during the Application Case.

15.2.2.3 Reasonably Foreseeable Development Case

The Reasonably Foreseeable Development (RFD) Case represents the Application Case plus reasonably foreseeable developments. The RFD Case includes the predicted duration of residual effects from the Project, plus other previous, existing, and future projects and activities. The minimum temporal boundary for the Application Case and RFD Case is the expected lifespan of the Project that, like the Base Case, includes a range of conditions over time. The difference between the Application and RFD cases is that the Application Case considers the incremental effect from the Project in isolation of potential future land use activities. The RFDs are defined as projects that:

- are currently under regulatory review or have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project, or may be induced by the Project;
- have been approved but not yet developed; or
- have the potential to change the Project or the effects predictions.

The reasonably foreseeable developments identified in Section 6.0 include the supporting infrastructure required for the Project, the Muskowekwan Potash Mine Project, and the Vale Kronau Project. Supporting infrastructure will include a water supply pipeline, an overhead transmission line, a natural gas supply pipeline, telecommunication services, and a railway line. Screening assessment reports will be completed by each of the utility providers once the final routing options are determined. Most of the preferred routes for the supporting infrastructure are not within the ESA and the final routing options are not known at this time. The Muskowekwan Potash Mine Project is located approximately 52 km to the northeast of the Project, and the Vale Kronau Project is located approximately 71 km south of the Project; both are outside the ESA. The effects on heritage resources from development of the RFDs are not expected to overlap with effects on heritage resources in the ESA. Therefore, a RFD Case is not included in this section of the EIS.

15.3 Existing Environment

The purpose of this section is to describe the existing environment (Base Case) within the ESA as a basis to assess the potential Project-specific effects on heritage resources. The detailed methods and results for baseline data collection are located in the Cultural Environment Baseline Report (Annex V, Section 2.0).

15.3.1 Heritage Resources

Heritage resources, as defined under *The Heritage Property Act* (1979-80), include all Saskatchewan's historic and Precontact archaeological sites, architecturally significant structures, and paleontological resources. As per Section 66 of *The Heritage Property Act*, all heritage resources on privately owned land and provincial Crown land are considered property of the Crown. The Heritage Conservation Branch at the Saskatchewan Ministry of Parks, Culture and Sport manage these sites. Section 63 of *The Heritage Property Act* empowers the Minister to require a proponent to conduct a Heritage Resources Impact Assessment (HRIA) for any project that has the potential to impact significant heritage resources. The proponent is responsible for submitting all proposed operations to the Heritage Conservation Branch for regulatory review to determine HRIA requirements.

Baseline studies were carried out to identify heritage resources present within the ESA. Project plans for the ESA, as defined by the core facilities area and mine well field boundaries were submitted to the Heritage Conservation Branch for review to determine HRIA requirements. Baseline studies included a literature and database review as well as a field assessment (Annex V, Section 2.0; Golder 2014). The methods and results are summarized below.

15.3.2 Methods

Several data sources were consulted to understand the existing heritage resource environment of the ESA. This included a query of the Saskatchewan Archives Board's Pre-1930 Homestead File Search Series, the Saskatchewan Homestead Index (n.d.), the Glenbow Museum's Canadian Pacific Railway (CPR) Land Sales Catalogue (Glenbow Museum Archives n.d.), the Saskatchewan Genealogical Society Cemetery Index (n.d.), and the database of known heritage resources maintained by the Heritage Conservation Branch (Ministry of Tourism, Parks, Culture and Sport). In addition, a literature review of pertinent publications, articles from academic journals, report manuscripts, and previous HRIA reports was conducted. These data sources were used to identify the types of heritage resources that are known to occur or that could potentially occur in the ESA.

Several data sources were consulted to assist with the execution of the field assessment, and a field assessment was completed within and around the ESA. The Heritage Conservation Branch identifies two primary factors for determining if a HRIA is required for a project. These include the presence of previously recorded heritage resources and the archaeological potential (sensitivity) for undocumented heritage resources to be present in the Project footprint. Secondary factors include the nature and extent of previous land disturbance (including cultivation) and the nature and scope of proposed land alteration. For southern Saskatchewan, the Heritage Conservation Branch considers lands archaeologically sensitive if they meet the following criteria:

- in the same quarter section (or within 500 metres [m]) as a Site of Special Nature (SSN) or other previously recorded site(s), unless shown to be of low heritage significance;
- within 1 km of permanent watercourses and well-formed valleys containing seasonal or permanent watercourses;
- within 1 km of permanent/seasonal watercourses greater than 2 km in length;
- within 1 km of smaller waterbodies located in well-defined drainage basins;
- in proximity to readily identifiable ancient lake shores;
- in hummocky terrain;
- within or on the periphery of sand dune complexes; and
- on escarpments, prominent uplands, and hills/ridges, including eskers.

Although the majority of the ESA has been disturbed by agricultural practices, patches of undisturbed terrain are interspersed throughout the cropland. Undisturbed terrain is commonly found in association with hummocky morainal areas outside of the ESA and along the margins of West Loon and East Loon creeks and their associated tributaries.

Given the large area defined for baseline studies, a strategy was designed to identify areas of heritage resource potential and then conduct a sampling strategy of select areas. The HRIA was conducted in two stages. First, all Township and Range roads were driven to identify any historical markers and structures immediately adjacent to the roads. An in-field screening was carried out at this stage to identify and verify lands that could potentially contain Precontact heritage resources. After the vehicular survey was completed, known heritage resources were revisited and a sample of potentially heritage sensitive areas was assessed. The sample was identified using information obtained from satellite imagery and the in-field screening. Sampled locations included areas of undisturbed terrain adjacent to East and West Loon creeks, areas adjacent to large seasonal sloughs, areas within hummocky terrain, and remnant patches of native prairie in cultivated fields (Figure 15.2-1).

Field methods for the sampling strategy included pedestrian reconnaissance and visual inspection of the ground surface, as well as a sub-surface shovel testing program. Pedestrian surface reconnaissance is the most common method used by archaeologists to identify archaeological sites, including surface features (Ruppé 1966). Visual inspection of the ground is particularly effective in areas with good surface visibility, such as regions of limited soil development and sparse vegetation (Schiffer et al. 1978). Shovel tests are used by archaeologists to locate and identify subsurface archaeological deposits and are useful in areas of poor surface visibility (Krakker et al. 1983; Nance and Ball 1986; Kintigh 1988). Beyond their use as tools for site discovery, shovel probes can provide important information on the integrity, dimensions, and density of cultural materials found at archaeological sites (Kintigh 1988). Detailed field notes and digital photographs were taken to document the existing environment and heritage resources found during baseline studies, while hand-held Global Positioning System (GPS) units were used to document surveyed areas, shovel tests, heritage resources, and other historic or cultural markers.

15.3.3 Results

15.3.3.1 Database and Literature Review

The database of recorded heritage resources maintained by the Heritage Conservation Branch revealed that two archaeological sites were previously recorded outside of the ESA, EgNb 1 in W1/2 23-25-17 W2M and EhNe 1 in SE 31-25-20 W2M (Figure 15.2-1). Both sites date to the Precontact period and were identified by local landowners or avocational archaeologists. A review of HRIA reports from the region indicated that only two previous assessments have been completed in the region and included projects for SaskPower (Cottonwood 1991) and Saskatchewan Highways (Western Heritage 1993). No archaeological sites were recorded as a result of these assessments. The Saskatchewan Genealogical Society Cemetery Index further indicated that 11 church and private cemeteries were documented during the baseline database review. Relevant heritage resources and cultural sites are discussed further below.

15.3.3.2 Field Assessment

The field assessment was initiated on October 9, 2012 and concluded on October 16, 2012 under Archaeological Resource Investigation Permit No. 13-208 (Golder 2014). A total of 755 km of Township and Range roads were driven during the baseline survey as part of the in-field screening to identify historic markers/structures and heritage sensitive lands. Approximately 340 ha of land in portions of 18 quarter sections were further assessed as part of the sampling strategy. This included the excavation of 99 shovel probes and 14 shovel tests.

Four heritage resources (EgNb 1, EgNb 2, EhNd 1 and EhNe 1) were identified or revisited (Table 15.3-1). This included two Precontact lithic artifact scatter and find sites, and two newly recorded Euro-Canadian farmsteads consisting of building remains dating to the early twentieth century. No heritage resources were identified within the ESA. Recorded heritage resources are located 8 km or more from the ESA (i.e., core facilities area and 65-year mine field).

Table 15.3-1: Heritage Resources Identified or Revisited during the Baseline Field Program

Heritage Resources Borden No.	Site Type	Cultural Affiliation	Distance from ESA
EgNb 1	Artifact Scatter	Unknown Precontact	13 km
EgNb 2	Multiple Feature	Euro-Canadian Farmstead	13 km
EhNe 1	Artifact Find	Unknown Precontact	8 km
EhNd 1	Multiple Feature	Euro-Canadian Farmstead	12 km

ESA = effects study area; km = kilometres.

Twenty-four historic markers and historic structures were identified or revisited during the baseline survey. This included 12 school district markers, 4 churches and 8 cemeteries. Four other cemeteries could not be revisited because landowner access was restricted. No historic markers or structures were identified in the core facilities area. Two school markers, one church, and one cemetery were found within the 65-year mine well field boundary of the ESA (Table 15.3-2). Zion Lutheran Church (North Southey) is designated a Municipal Heritage Property and is still in use along with the Zion Lutheran Cemetery. Commemorative sign markers erected by local organizations are all that remain of the former Bryn Mawr and Coynach schools that operated in the first half of the twentieth century.

Table 15.3-2: Historic Markers and Structures within the Effects Study Area

Legal Location	Marker/Structure Type	Years in Operation	Comments
NE-23-24-19 W2M	Zion Lutheran Church (North-Southey)	1910 to Present	Designated Municipal Heritage Property by Saskatchewan Heritage Foundation
NE-26-24-19 W2M	Zion Lutheran Cemetery	1910 to Present	Documented by Saskatchewan Genealogical Society
SE-29-24-19 W2M	Bryn Mawr School #3312	1918 to 1952	Commemorative Sign Erected
SE-13-24-19 W2M	Coynach School #3360	1915 to 1952	Commemorative Sign Erected

Note: all of these historic markers and structures are within the 65-year mine well field portion of the ESA.
NE = northeast; SE = southeast; W2M = West of the Second Meridian; # = number.

15.3.3.3 Heritage Conservation Branch Review

Plans of the core facilities area and 65-year mine field were submitted to the Heritage Conservation Branch for review to identify further HRIA requirements based on criteria outlined in Section 15.3.2. The Heritage Conservation Branch (File No. 2854; Appendix 15-A) determined that the core facilities area has low heritage potential and there are no further heritage concerns. However, although the majority of the mine well field has no heritage concerns, areas of native prairie in three sections associated with the margins of West Loon Creek were identified as having heritage potential. Further HRIA would be required in advance of any disturbance in these areas (Table 15.3-3; Figure 15.2-1).

Table 15.3-3: Heritage Conservation Branch Screening Results of Effects Study Area (File No. 14-2854)

Project Footprint	Heritage Sensitive Lands Identified	Heritage Requirement
Core Facilities Area	n/a	No Further Heritage Concerns
65-Year Mine Field	E1/2 25-24-19 W2M	HRIA of only Native Prairie Areas adjacent to West Loon Creek
	NW and S1/2 30-24-18 W2M	
	N1/2 and SE 19-24-18 W2M	

n/a = not applicable; E = east; NW = northwest; S = south; N = north; SE = southeast; W2M = West of the Second Meridian; HRIA = Heritage Resources Impact Assessment.

The four historic structures and markers (i.e., church, cemetery, and two school markers) located within the 65-year mine field boundary are not designated as archaeological sites and are not regulated by the Archaeological Resource Management Section of the Heritage Conservation Branch (Friesen 2014, pers. comm.). Rather, the property is regulated by the local municipality. In the event development is proposed in these areas, the R.M. of Longlaketon must be contacted to identify local concerns and approve any modifications or encroachment on these properties (Evans 2014, pers. comm.).

15.4 Pathways Analysis

15.4.1 Methods

Pathways analysis identifies and assesses the linkages between Project components or activities and the correspondent changes to the environment and potential residual effects (after mitigation) on heritage resources. The first part of the analysis is to identify all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on the VC. Potential pathways through which the Project could affect heritage resources were identified from a number of sources including the following:

- a review of the Project Description (Section 4.0) and scoping of potential effects by the environmental and engineering teams for the Project;
- information obtained from community engagement sessions (Section 5.0);
- scientific knowledge and experience with other potash mines in Saskatchewan; and
- consideration of potential effects identified from the TOR.

For an effect to occur there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a correspondent effect on the VC.

Project activity → change in environment → effect on VC

A key aspect of the pathways analysis is to identify environmental design features and mitigation that might reduce or eliminate potential effects of the Project on heritage resources. Mitigation has been developed for the Project according to the following hierarchy proposed by the MOE (2014):

- avoidance;
- minimize (limit);
- restoration; and
- compensation.

Environmental design features include engineering design elements, environmental best practices, management policies and procedures, and spill response and emergency contingency plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on heritage resources. Pathways are determined to be primary, secondary (minor), or as having no linkage, using scientific, local, and traditional knowledge, logic, and experience with similar developments, and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- **No linkage** – analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change and would therefore have no residual effect on heritage resources relative to the Base Case or guideline values; or
- **Secondary** – pathway could result in a measurable minor environmental change, but would have a negligible residual effect on heritage resources relative to the Base Case or guideline values and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect; or
- **Primary** – pathway is likely to result in environmental change that could contribute to residual effects on heritage resources relative to the Base Case or guideline values.

Pathways with no linkage to heritage resources are not assessed further because implementation of environmental design features or mitigation will remove the pathway and result in no measureable change to heritage resources. Pathways that are assessed to be secondary and demonstrated to have a negligible residual effect on heritage resources through simple qualitative or semi-quantitative evaluation of the pathway are also not advanced for further assessment. In summary, pathways determined to have no linkage to heritage resources or those that are considered secondary are not expected to result in environmentally significant effects to archaeological and sacred sites. Primary pathways require further evaluation through more detailed quantitative and qualitative effects analysis.

15.4.2 Results

Project components and activities, effects pathways, and environmental design features and mitigation are summarized in Table 15.4-1. Classification of effects pathways (i.e., no linkage, secondary and primary) to heritage resources is also summarized in Table 15.4-1 and detailed descriptions are provided in the subsequent sections.

Table 15.4-1: Potential Pathways for Effects on Heritage Resources

<table>
<tr><th>Project Component/ Activity</th><th>Effects Pathways</th><th>Environmental Design Features and Mitigation</th><th>Pathway Classification</th></tr>
<tr><td rowspan="2">Physical disturbance from the Project Footprint</td><td>Ground disturbance from the Project footprint (e.g., core facilities area, mining area, and access roads) can cause disturbance or destruction to heritage resources.</td><td rowspan="2">■ The compact layout of the core facilities area will limit the area that is disturbed by construction.
■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance.
■ Mine well field area pipelines will be routed along existing utility or transportation corridors to reduce disturbance to undisturbed areas, where possible.
■ Existing public roads will be used where possible to provide access to the mine well field area, which will reduce the amount of new road construction required for the Project.
■ Project plans for Project facilities that occur in identified heritage sensitive areas within the 65-year mine field boundary and any future plans that fall outside the 65-year mine field boundary will be submitted to the Heritage Conservation Branch for review to determine if further HRIA is required prior to construction.
■ Management options for archaeological and/or heritage materials fortuitously discovered during construction activities will be developed in consultation with the Saskatchewan Ministry of Parks, Culture and Sport - Heritage Conservation Branch.
■ If unanticipated archaeological materials or features are encountered as a result of construction activities, all work in the immediate area will cease and the Saskatchewan Ministry of Parks, Culture and Sport - Heritage Conservation Branch contacted.</td><td>No Linkage</td></tr>
<tr><td>Ground disturbance from the mine well field area pipeline corridors can cause disturbance or destruction to heritage resources.</td><td>No Linkage</td></tr>
<tr><td>Accidents, malfunctions, and unplanned events</td><td>Ground disturbance as a result of unplanned events (e.g., spills, containment failure or underground pipeline leaks) or construction activities can cause disturbance or destruction to heritage resources.</td><td>■ Management options for archaeological or heritage materials fortuitously discovered during or because of unplanned events will be developed in consultation with the Saskatchewan Ministry of Parks, Culture and Sport - Heritage Conservation Branch.</td><td>No Linkage</td></tr>
</table>

HRIA = Heritage Resources Impact Assessment.

15.4.2.1 Pathways with No Linkage

A pathway may have no linkage to environmental effects if the activity does not occur, or if the pathway is removed by mitigation or environmental design features so that the Project results in no measurable change in measurement indicators. Subsequently, no residual effect on heritage resources is expected. The pathways described in the following bullets have no linkage to heritage resources and will not be carried forward in the assessment.

- **Ground disturbance from the Project footprint (e.g., core facilities area, mining area, and access roads) can cause disturbance or destruction of heritage resources.**
- **Ground disturbance from the mine well field area pipeline corridors can cause disturbance or destruction to heritage resources.**

No known heritage resources are located within the core facilities area, and the land is not considered heritage sensitive by the Heritage Conservation Branch. The 65-year mine field contains no recorded heritage resources, and most of the land is considered to have low heritage potential. However, areas of native prairie adjacent to West Loon Creek will require additional HRIA if development occurs in these areas. Mitigation measures in this instance will include the submission of any proposed facility plans (e.g., well pads and well field pipelines) located in the E1/2 25-24-19 W2M, NW and S1/2 30-24-18 W2M, and N1/2 and SE 19-24-18 W2M to the Heritage Conservation Branch for review to determine further HRIA requirements. Any conflicts with heritage resources will be addressed in advance of construction. Similarly, any Project plans located near historic structures or markers located in the NE-23-24-19 W2M, NE-26-24-19 W2M, SE-29-24-19 W2M, and SE-13-24-19 W2M will require consultation with the R.M. of Longlaketon to address any concerns prior to construction. Water and brine pipelines required between the core facilities area and the mine well field will be routed along existing utility or transportation corridors to reduce disturbance, where possible. Existing public roads will be used where possible to provide access to the mine well field. As a result, these pathways were determined to have no linkage to effects on heritage resources.

- **Ground disturbance as a result of unplanned events (e.g., spills, containment failure or underground pipeline leaks) or construction activities can cause disturbance or destruction of heritage resources.**

As part of the Environmental Protection Plan, a heritage management program will be prepared and distributed to the appropriate parties (e.g., contractors) that will outline the practices to be undertaken in the event that unanticipated archaeological resources are discovered as a result of unplanned events or during construction activities. In the event unanticipated heritage resources are discovered, all work in the immediate area will cease, and further management options developed in consultation with the Heritage Conservation Branch will reduce or avoid any negative effects to heritage resources. As a result, this pathway was determined to have no linkage to effects on heritage resources.

15.4.2.2 Secondary Pathways

No pathways were identified as having secondary linkages to heritage resources (Table 15.4-1).

15.4.2.3 Primary Pathways

No pathways were identified as having primary linkages to heritage resources (Table 15.4-1). As such, a residual effects analysis is not required for this section of the EIS.

15.5 Monitoring and Follow-up

Typically, monitoring includes one or more of the following categories, which may be applied during the development of the Project:

- **Compliance monitoring** – monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments (e.g., inspecting the installation and effectiveness of a silt fence).
- **Follow-up monitoring** – programs designed to test the accuracy of effects predictions, reduce/address uncertainties, determine the effectiveness of environmental design features, and/or provide appropriate feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., monitoring of downstream lakes for aquatic effects, wildlife effects monitoring, and socio-economic monitoring). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

These programs form part of the Health, Safety, Security, and Environmental Management System for the Project. If monitoring or follow-up detect effects that are different from predicted effects, or the need for improved or modified design features and mitigation, adaptive management will be implemented. This may include increased monitoring, changes in monitoring programs, and additional mitigation.

Follow-up programs for heritage resources are anticipated to be minimal as most mitigation measures for heritage resources are applied and completed in advance of ground disturbance activities. However, the following compliance actions are required so that the necessary mitigation measures for heritage resources are carried out.

- Submission of any mine well field area plans (e.g., well pads, mine well field area pipelines and access roads) located in E1/2 25-24-19 W2M, NW and S1/2 30-24-18 W2M, and N1/2 and SE 19-24-18 W2M to the Heritage Conservation Branch for review to determine if heritage sensitive lands will be affected and whether further HRIA is required prior to construction. Assessments will be carried out by a qualified archaeologist.
- Consultation with the local municipality to address any concerns in the event Project components are planned near historic structures or markers located in the NE-23-24-19 W2M, NE-26-24-19 W2M, SE-29-24-19 W2M, and SE-13-24-19 W2M within the mine well field.
- As part of the Environmental Protection Plan, development of a heritage management program to handle archaeological or heritage materials fortuitously discovered during construction activities or as a result of unplanned events. The management plan will be developed in consultation with the Heritage Conservation Branch.

15.6 Summary and Conclusions

Potential pathways to effects on heritage resources include the disturbance or destruction of archaeological and sacred sites that may occur as a result of construction and operations activities. All pathways were determined to have no linkage to effects to heritage resources. Therefore, no residual effects analysis was required for the heritage resources section of the EIS.

The Project will implement several environmental design features and mitigation measures to avoid or limit effects to heritage resources. The Project will be located in an area that has largely been disturbed previously by agricultural activities. No known heritage resources are located within the core facilities area, and the land is not considered heritage sensitive by the Heritage Conservation Branch. The 65-year mine field contains no recorded heritage resources, and most of the land is considered to have low heritage potential. However, areas of native prairie adjacent to West Loon Creek will require additional HRIA if development occurs in these areas. Any proposed facility plans (e.g., well pads and mine well field area pipelines) located in the E1/2 25-24-19 W2M, NW and S1/2 30-24-18 W2M, and N1/2 and SE 19-24-18 W2M will be submitted to the Heritage Conservation Branch for review to determine further HRIA requirements. Any conflicts with heritage resources will be addressed in advance of construction. Similarly, any Project plans located near historic structures or markers located in the NE-23-24-19 W2M, NE-26-24-19 W2M, SE-29-24-19 W2M, and SE-13-24-19 W2M will require consultation with the R.M. of Longlaketon to address any concerns prior to construction.

Management options for archaeological and/or heritage materials fortuitously discovered during construction activities will be developed in consultation with the Saskatchewan Ministry of Parks, Culture and Sport - Heritage Conservation Branch. In the event unanticipated archaeological materials or features are encountered during construction or unplanned events, all work in the immediate area will cease and the Saskatchewan Ministry of Parks, Culture and Sport - Heritage Conservation Branch will be contacted. Decommissioning and reclamation activities are expected to have no effects to heritage resources because no new disturbance will occur during this Project phase.

15.7 References

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15.8 Glossary

Term	Definition
Archaeology	The study of past cultures through the scientific investigation of their material remains.
Artifact	Any object used or modified by humans.
Artifact Find	A category for archaeological sites consisting of five or fewer artifacts.
Artifact Scatter	A category for archaeological sites consisting of more than five artifacts.
Best Practice	Method or procedure that is accepted by industry as being effective, practical and reliable in maintaining quality, and meeting Project objectives and regulatory requirements.
Feature	The remains of any non-portable human activity that cannot be removed from a site without disturbing it (e.g., hearth or historical building foundation).
Heritage Resource	Any human or natural artifact or feature that is of interest for its architectural, historical, cultural, environmental, archaeological, palaeontological, aesthetic, or scientific value.
Lithics	A general term used to refer to stone artifacts such as tools, cores, or debitage.
Precontact	Refers to the period in North America prior to the arrival and contact with Europeans. In Saskatchewan this is generally considered the period prior to Henry Kelsey's journey to the plains in 1690.
Shovel Probe	A 40 centimetre (cm) by 40 cm subsurface test where the excavated soils and sediments are hand-trowelled for cultural materials.
Shovel Test	A 50 cm by 50 cm subsurface test where the excavated soils and sediments are passed through a 6 millimetre (mm) mesh screen.
Site	Any location with detectable evidence of past human activity.

16.0 SOCIO-ECONOMIC ENVIRONMENT

16.1 Introduction

16.1.1 Background

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project) located in central Saskatchewan, approximately 60 kilometres (km) north of Regina. Yancoal proposes to develop the Project, which includes solution mining and associated supporting infrastructure.

The Project is located in the Rural Municipality (R.M.) of Longlaketon (No. 219) and the R.M. of Cupar (No. 218). An existing network of municipal grid roads, provincial highways, and rail lines will provide access to the Project. The Project (including the core facilities area, 65-year mine field, and indicated resource boundary) encompasses approximately 143 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M).

16.1.2 Purpose and Scope

This section of the Environmental Impact Statement (EIS) for the Project addresses potential effects on the socio-economic environment, a requirement in the Project Terms of Reference (TOR) approved by the Environmental Assessment Branch (EAB) of the Ministry of Environment (MOE) in May 2015 (Appendix 2-B).

The purpose of the socio-economic environment section is to meet the TOR, specifically to assess potential socio-economic effects from the Project. The scope of this section includes an analysis of Project-related changes during construction, operation, and decommissioning and reclamation. The incremental and cumulative residual effects from the Project and other previous, existing, and reasonably foreseeable developments on the socio-economic environment are assessed.

People interact with the surrounding atmospheric, aquatic, and terrestrial environments. Changes to these environments can affect aspects of the socio-economic environment such as quality of life and recreational opportunities for individuals, residents, and communities. Other aspects of the socio-economic environment such as employment and income are not directly affected by the atmospheric, aquatic, or terrestrial environments, but are assessed. The socio-economic assessment considers the results provided in the following sections:

- Atmospheric Environment (Section 7.0);
- Hydrogeology (Section 8.0);
- Hydrology (Section 9.0);
- Surface Water Quality (Section 10.0);
- Fish and Fish Habitat (Section 11.0);
- Soils (Section 12.0);
- Vegetation (Section 13.0); and
- Wildlife (Section 14.0).

16.1.3 Valued Components, Assessment Endpoints, and Measurement Indicators

The TOR identified the following as valued components (VCs) that should be included in the assessment of effects on the socio-economic environment:

- employment and economy - includes labour force and economic factors such as job opportunities, income, tax revenue, contribution to Gross Domestic Product (GDP), and education and training opportunities.
- community services and infrastructure - includes health and social services, emergency services (e.g., fire, emergency medical services (EMS), and protective services), housing, temporary accommodation, education, waste and water management, recreation, and tourism.
- traffic and transportation infrastructure - includes changes in traffic volume, traffic routes, traffic accidents, and increased wear and tear on roads.
- quality of life - for the purposes of this environmental assessment, quality of life is defined by outer aspects of quality of life (e.g., liveability of the environment), rather than inner aspects which are highly subjective (e.g., appreciation of life or perceived general health and wellbeing) (Veenhoven 2000). This includes changes or deterioration in air quality, water quality, visual aesthetics, and a change in intermittent and/or ambient noise.
- traditional and non-traditional land use - includes traditional activities (e.g., hunting, trapping, and plant gathering) and non-traditional land use (e.g., agriculture, tourism, recreation, and hunting).

Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered important by the proponent, the public, First Nations and Métis communities, and government agencies. The inter-relationships between components of the biophysical and socio-economic (human) environments provide the structure of a social-ecological system (Walker et al. 2004; Folke 2006). The value of a component not only relates to its role in the ecosystem, but also to the value placed on it by humans. Valued components have a potential to be adversely affected by Project development, and therefore, are used to predict the effects of the Project on all environmental components. Rationale for selection of socio-economic VCs is as follows:

- anticipated sensitivity to Project-related effects (i.e., based on Project details, baseline information, and professional experience with similar Projects);
- importance to stakeholders (i.e., individuals, groups, organizations, and communities); and
- availability of indicators of changes in VCs that can be measured or described.

Assessment endpoints are qualitative expressions used to assess the significance of effects on a VC and represent the key properties of the VC that should be protected for use by future human generations (i.e., incorporate sustainability). Assessment endpoints are general statements about what is to be protected. Measurement indicators are quantitative and/or qualitative expressions of changes to the assessment endpoints. The assessment endpoint for the socio-economic VC is sustainability of social and economic properties, which includes the improvement of socio-economic conditions or the mitigation of effects to acceptable levels of change. The measurement indicators for the socio-economic VCs include:

- employment;

- labour income;
- tax revenue;
- gross domestic product;
- Project workforce requirements;
- potential changes in the demand for housing, accommodations, social, health, emergency and protective services, and physical infrastructure;
- commitments regarding employment training;
- Project traffic volumes;
- commitments regarding safety measures and reducing traffic;
- changes in land use;
- changes in visual aesthetics;
- changes in noise levels;
- changes in air quality; and
- changes in water quality and quantity.

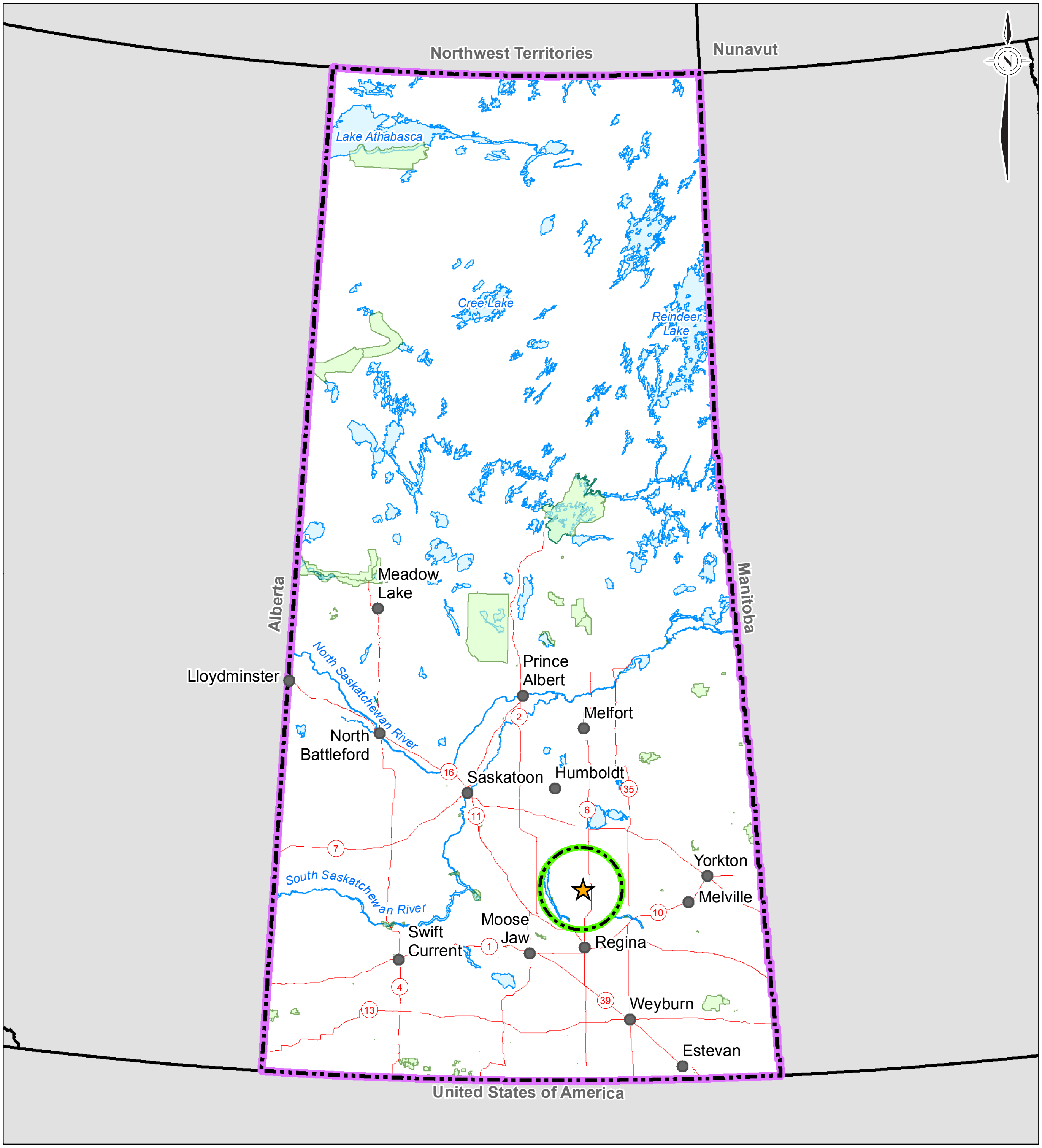
16.2 Environmental Assessment Boundaries

16.2.1 Spatial Boundaries

The study areas for the socio-economic environment were designed to measure and characterize the existing environmental conditions from the Project footprint to broader, regional levels. Some conditions of the socio-economic environment, such as traditional and non-traditional land use, can be characterized at the scale of the Project footprint and immediately surrounding area. Others, such as community services, infrastructure, traffic, and quality of life, require a larger scale that incorporates surrounding communities and municipalities. Finally, the economy is measured at a provincial scale, because some economic properties (e.g., contributions to GDP) are measured at the provincial scale. For the purposed of establishing the characteristics of the socio-economic and traditional and non-traditional land use environment, four study areas were defined: two regional study areas (socio-economic regional study area [RSA] and traditional and non-traditional land use RSA) and two local study areas (socio-economic local study area [LSA] and traditional and non-traditional land use LSA).

The socio-economic RSA comprises the entire province of Saskatchewan, which is the level at which some economic effects are measureable (Figure 16.2-1). For example, given the low unemployment in the socio-economic LSA, most of the workforce is expected to be from outside the socio-economic LSA and potentially from outside the socio-economic RSA (i.e., province of Saskatchewan). Further, economic benefits such as tax revenue and increased spending are expected to occur at a provincial scale. The socio-economic RSA is used in assessing the potential effects to employment and economy.

The traditional and non-traditional land use RSA corresponds to the boundaries of the R.M. of Longlaketon and the R.M. of Cupar (Figure 16.2-2).



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LEGEND

- CITY
- HIGHWAY
- NATIONAL/PROVINCIAL PARK
- GENERAL PROJECT LOCATION
- SOCIO-ECONOMIC LOCAL STUDY AREA
- SOCIO-ECONOMIC REGIONAL STUDY AREA

REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
NAD 83 UTM ZONE 13

PROJECT

YANCOAL
兖煤加拿大资源有限公司

YANCOAL SOUTHEY PROJECT

TITLE

SOCIO-ECONOMIC REGIONAL STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

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DESIGN			SCALE AS SHOWN	REV. 0
GIS	SB/LS	21/05/15	FIGURE: 16.2-1	
CHECK	CF	21/05/15		
REVIEW	BC	21/05/15		

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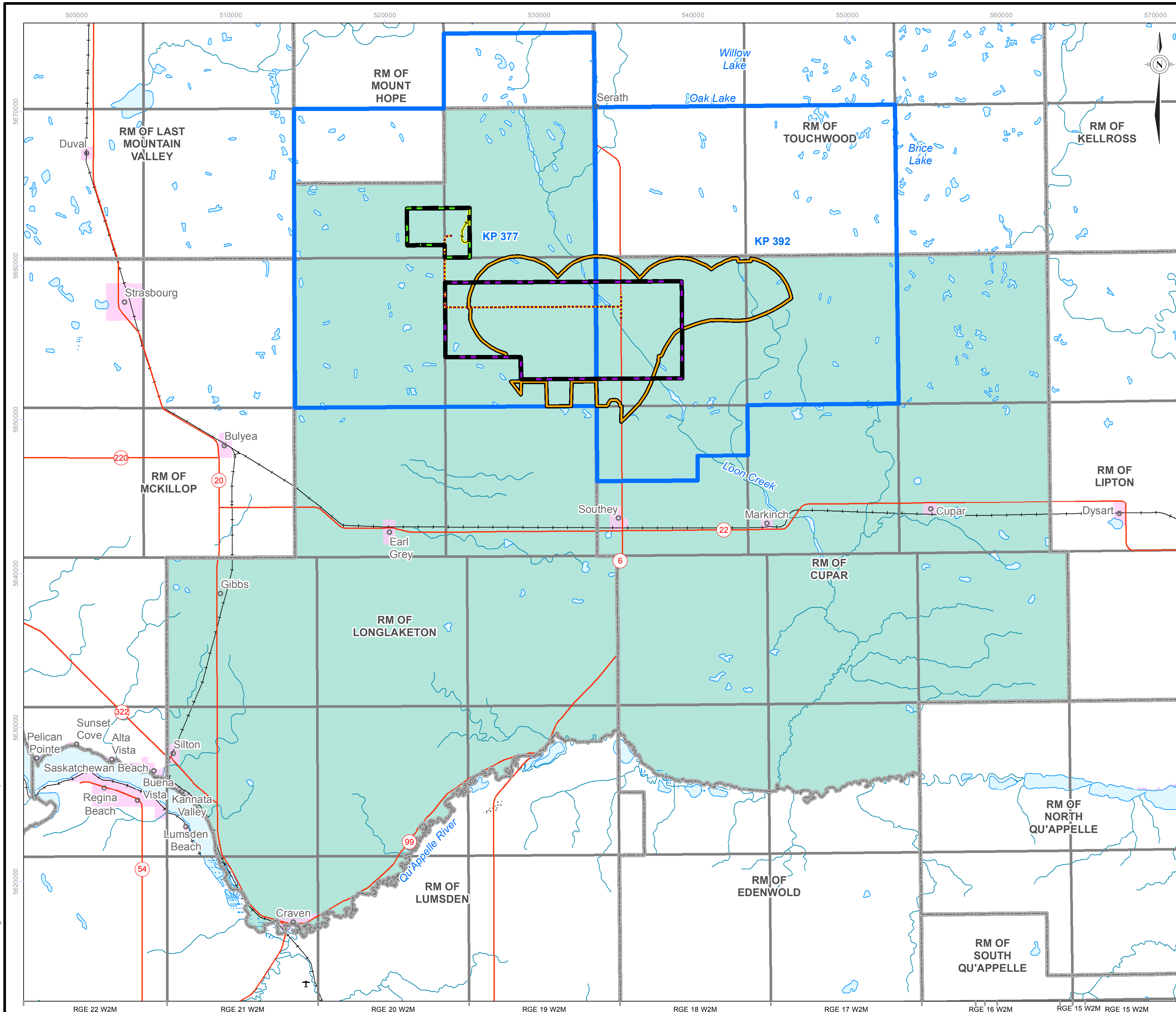

LEGEND

- COMMUNITY
- HIGHWAY
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- RURAL MUNICIPALITY BOUNDARY
- URBAN MUNICIPALITY
- PROPOSED ACCESS ROAD
- PROPOSED RAIL LOOP
- PERMIT BOUNDARY
- 65 YEAR MINE FIELD
- CORE FACILITIES AREA
- INDICATED RESOURCE BOUNDARY
- LAND USE LOCAL STUDY AREA
- LAND USE REGIONAL STUDY AREA

REFERENCE

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PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT

TITLE
LAND USE REGIONAL AND LOCAL STUDY AREAS

Golder Associates
Saskatoon, Saskatchewan

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DESIGN		SCALE AS SHOWN	REV. 0
GIS	LMS	21/05/15	
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FIGURE: 16.2-2

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The socio-economic LSA includes communities within approximately 50 km, a reasonable commuting distance to the Project (Figure 16.2.-3). The socio-economic LSA communities could participate in employment and business opportunities that arise from the Project. The socio-economic LSA includes 6 R.M.s, 29 hamlets, 9 Indian Reserves, 1 city, 9 towns, 13 villages, 11 resort villages, and 9 organized hamlets (Table 16.2-1). Hamlets generally have small populations that are included in R.M. statistics or may be historical and no longer have residents; therefore, for the purposes of this document hamlets are not discussed separately from the R.M. in which they are located. The six R.M.s are included because the Project is located within the R.M. boundaries or because they are close enough to potentially experience positive and negative effects from the Project. Other R.M.s that are only partially located within 50 km of the Project were not included because they are far enough away that their communities are not expected to experience effects. The nine Indian Reserves included in the socio-economic LSA are within commuting distance of the Project. The remaining 43 cities, towns, villages, resort villages, and organized hamlets included in the socio-economic LSA are located within roughly 50 km of the Project. The large number of hamlets, villages, resort villages, and organized hamlets is due partly to the presence of Last Mountain Lake on the west side of the socio-economic LSA. Two of the larger centres, the city of Regina and town of Fort Qu'Appelle, are slightly further than 50 km from the Project but were included because of their function as economic centres for the area.

The socio-economic LSA is used in assessing the potential effects to community services and infrastructure, traffic and transportation infrastructure, and quality of life. The communities in the socio-economic LSA are expected to experience the most noticeable increase in population, which will result in increased pressure on community services and infrastructure. Traffic in the socio-economic LSA is expected to increase because of workers commuting to site and equipment and supplies being transported to site. Some equipment and supplies will come from outside the socio-economic LSA, but this is not expected to be noticeable as it will be on major highways and will be more broadly dispersed. A traffic impact assessment (TIA; Appendix 4-C) was completed for the main access route to the Project, focusing on Highway 6 and grid road 731, where the largest changes to traffic and transportation infrastructure are expected. Potential changes to quality of life (i.e., increased population and traffic, air quality, noise levels, visual aesthetics, and water quantity and quality) are expected to be contained within the socio-economic LSA.

Table 16.2-1: Socio-economic Local Study Area Communities

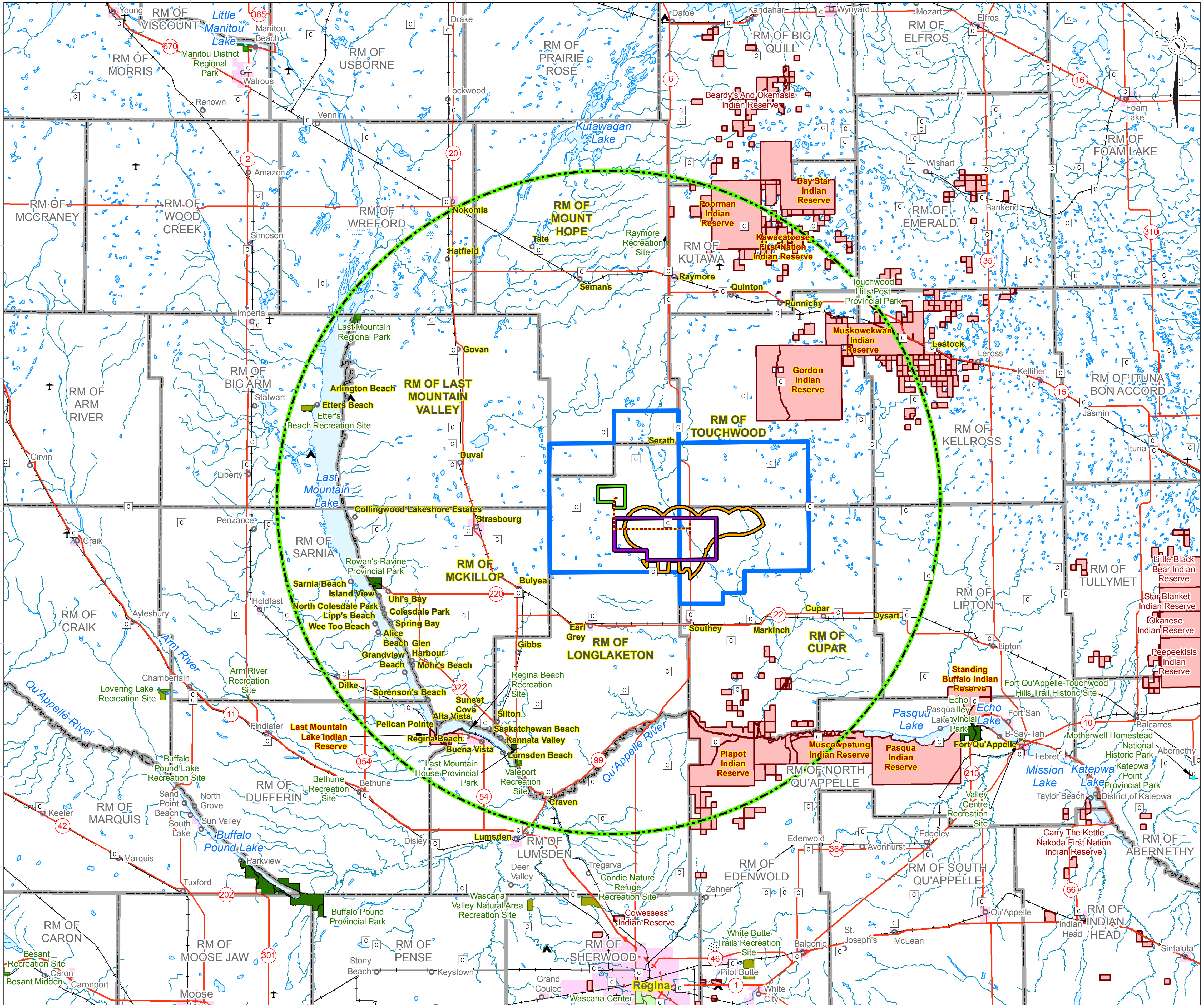
Community Type	Communities	
Rural Municipality	■ Cupar No. 218	■ McKillop No. 220
	■ Last Mountain Valley No. 250	■ Mount Hope No. 279
	■ Longlaketon No. 219	■ Touchwood No. 248
Hamlet	■ Arbury	■ Kedleston Beach
	■ Butterton	■ Kennell
	■ Collingwood Lakeshore Estates	■ Kutawa
	■ Cymric	■ Last Mountain
	■ Elbourne	■ Magyar
	■ Enid	■ Marieton
	■ Fairy Hill	■ McDonald Hills
	■ Fox Hills	■ Pryors Beach
	■ Gibbs	■ Serath
	■ Glenbrea	■ South Touchwood
	■ Gregherd	■ Tate

Table 16.2-1: Socio-economic Local Study Area Communities

Community Type	Communities	
	■ Hatfield ■ Hendersons Beach ■ Imperial Beach ■ Kedleston	■ Valeport ■ Watertown ■ Zala
Indian Reserve	■ Day Star No. 87 ■ Gordon (George Gordon) No. 86 ■ Last Mountain (Muscowpetung) No. 80 ■ Muscowpetung No. 80 ■ Muskowekwan No. 85	■ Pasqua No. 79 ■ Piapot No. 75 ■ Poorman (Kawacatoose) No. 88 ■ Standing Buffalo No. 78
City	■ Regina	
Town	■ Cupar ■ Fort Qu'Appelle ■ Govan ■ Lumsden ■ Nokomis	■ Raymore ■ Regina Beach ■ Southey ■ Strasbourg
Village	■ Buena Vista ■ Bulyea ■ Craven ■ Dilke ■ Duval ■ Dysart ■ Earl Grey	■ Lestock ■ Markinch ■ Punnichy ■ Quinton ■ Semans ■ Silton
Resort Village	■ Alice Beach ■ Etters Beach ■ Glen Harbour ■ Grandview Beach ■ Island View ■ Kannata Valley	■ Lumsden Beach ■ Pelican Pointe ■ Saskatchewan Beach ■ Sunset Cove ■ Wee Too Beach (includes Lipp's Beach)
Organized Hamlet	■ Alta Vista ■ Arlington Beach ■ Colesdale Park ■ Mohr's Beach ■ North Colesdale Park	■ Sarnia Beach ■ Sorenson's Beach ■ Spring Bay ■ Uhl's Bay

No. = number

The traditional and non-traditional land use LSA includes the core facilities area and mine field because these are the areas that will be directly affected by construction and operation of the Project (Figure 16.2-2).



LEGEND

- COMMUNITY
- CEMETERY
- HIGHWAY
- RURAL MUNICIPALITY BOUNDARY
- URBAN MUNICIPALITY
- FIRST NATION RESERVE
- PROVINCIAL PARK
- HISTORIC SITE/PARK
- RECREATION SITE
- WASCANA CENTRE AUTHORITY
- REGIONAL PARK
- PROPOSED ACCESS ROAD
- PERMIT BOUNDARY
- 65 YEAR MINE FIELD
- CORE FACILITIES AREA
- INDICATED RESOURCE BOUNDARY
- SOCIO-ECONOMIC LOCAL STUDY AREA (50 KM RADIUS)
- COMMUNITIES INCLUDED IN THE LOCAL STUDY AREA

REFERENCE

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BASE DATA: NTS MAPSHEET: 62L/M, 72I/J/O/P
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SCALE 1:600,000 KILOMETRES

PROJECT

YANCOAL

YANCOAL SOUTHEY PROJECT

TITLE

SOCIO-ECONOMIC LOCAL STUDY AREA

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197		FILE No.
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GIS	SB/LMS	14/05/15	
CHECK	CF	21/05/15	FIGURE: 16.2-3
REVIEW	BC	21/05/15	

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Effects to land use are typically closely linked to related resources such as soil, vegetation, wetlands, and wildlife and wildlife habitat. Land use is expected to be affected directly within the Project footprint (i.e., changes from the Project footprint) and has the potential to be indirectly affected by changes in soil quality, vegetation, wetlands, and wildlife and wildlife habitat in the immediate surrounding area. Therefore, effects to land use will be assessed using a traditional and non-traditional land use ESA (land use ESA) that is the same as the ESA defined for the terrestrial environment (i.e., the core facilities area and 65-year mine field and an approximate 5-km buffer [Sections 12.2, 13.2, and 14.2]) (Figure 16.2-4).

16.2.2 Temporal Boundaries

Temporal boundaries for the socio-economic environment assessment were defined by the life of the Project (Section 4.0) and the existing and future cumulative effects to which the Project might contribute. The Project phases are construction, operation, and decommissioning and reclamation. Most construction will occur from mid-2016 through 2019. Following the first two years of primary mining during Project operations (starting in 2020), secondary mining will begin. This will require a smaller construction workforce in 2022 and 2023 for construction associated with secondary mining. The first year of full Project operation will be in 2024. Final relinquishment of the Project will occur after the completion of reclamation.

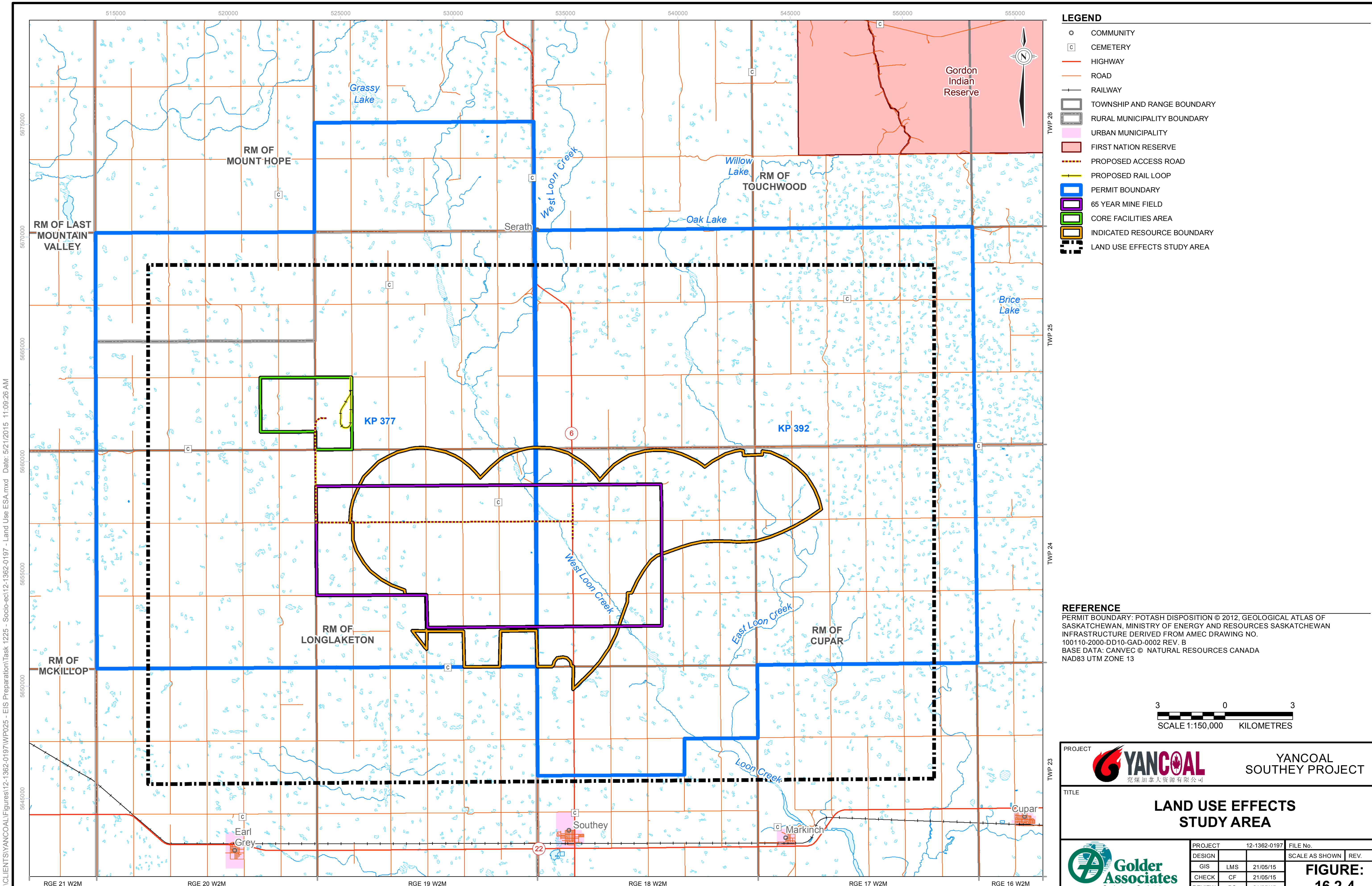
The socio-economic effects analysis encompasses the Project phases as follows:

- construction (2016 to 2019):
  - for the socio-economic effects analysis, this also includes a small secondary mining workforce in 2022 and 2023.
- operations (2019 to 2119); and
- decommissioning and reclamation (2119 onward).

The above timeframes are intended to be sufficiently flexible to capture the effects of the Project on the socio-economic environment. Effects on socio-economic VCs begin during the construction phase, and continue through the operations phase and for a period during the completion of reclamation activities. Therefore, effects on socio-economic VCs were analyzed and assessed for significance from Project construction through decommissioning and reclamation. This approach generates the maximum potential spatial and temporal extent of effects on socio-economic VCs. Although the assessment of residual effects of the Project considers all Project phases listed above, assessment cases were used to characterize the study areas and facilitate quantitative and qualitative comparisons for the assessment cases described below.

16.2.2.1 Base Case

The Base Case (existing environment) represents existing conditions in Saskatchewan without the Project. Existing conditions include the cumulative outcome from all previous and existing developments and activities. The socio-economic Base Case is the result of historical conditions, rapid expansion of resource industries, and numerous social and cultural processes and trends. The Base Case is described in detail in Section 16.3 and Annex V.



LEGEND
COMMUNITY
CEMETERY
HIGHWAY
ROAD
RAILWAY
TOWNSHIP AND RANGE BOUNDARY
RURAL MUNICIPALITY BOUNDARY
URBAN MUNICIPALITY
FIRST NATION RESERVE
PROPOSED ACCESS ROAD
PROPOSED RAIL LOOP
PERMIT BOUNDARY
65 YEAR MINE FIELD
CORE FACILITIES AREA
INDICATED RESOURCE BOUNDARY
LAND USE EFFECTS STUDY AREA
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Grassy Lake
RM OF MOUNT HOPE
RM OF LAST MOUNTAIN VALLEY
West Loon Creek
Serath
Willow Lake
RM OF TOUCHWOOD
Oak Lake
Gordon Indian Reserve
Brice Lake
KP 377
KP 392
RM OF LONGLAKETON
RM OF MCKILLOP
East Loon Creek
RM OF CUPAR
Loon Creek
Earl Grey
Southey
Markinch
Cupar
6
22
515000
520000
525000
530000
535000
540000
545000
550000
555000
5675000
5670000
5665000
5660000
5655000
5650000
5645000
TWP 26
TWP 25
TWP 24
TWP 23
RGE 21 W2M
RGE 20 W2M
RGE 19 W2M
RGE 18 W2M
RGE 17 W2M
RGE 16 W2M
PROJECT
YANCOAL
YANCOAL SOUTHEY PROJECT
TITLE
LAND USE EFFECTS STUDY AREA
Golder Associates
Saskatoon, Saskatchewan
PROJECT 12-1362-0197
FILE No.
DESIGN
SCALE AS SHOWN
REV. 0
GIS LMS 21/05/15
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16.2.2.2 Application Case

The incremental contributions of residual effects from the Project to existing cumulative effects were assessed at the study areas defined for each VC (Section 16.2.2.1) by adding the Project to the Base Case to form the Application Case. The Project is expected to contribute to a maximum effect on each VC at different stages in the life of the Project.

Effects on employment and economy are related to the creation of jobs, income, and taxes and royalties. The peak workforce during Project construction is anticipated to correlate with the greatest number of jobs and income generated. However, Project operations will generate additional revenue in the form of taxes and royalties. Overall, no predicted maximum effect on the economy exists. Rather, effects are expected to occur annually.

Effects on community services and infrastructure, traffic and transportation, and quality of life are closely tied to the workforce requirements of the Project. Pressure on community services and infrastructure, increase in traffic volume, and potential for nuisance effects on quality of life (e.g., noise) will occur during Project construction and operations. Construction is expected to peak with a workforce of 2,200 in 2017 and 2018. Project operations will create approximately 350 full time positions. Therefore, the maximum effect on community services and infrastructure, traffic and transportation, and quality of life is expected to occur during peak construction in 2017 and 2018. Each year of Project operations is expected to have similar workforce requirements; therefore, no maximum effect, and the first year of full operations (2024) is expected to be representative of subsequent years.

Effects on traditional and non-traditional land use are expected to be greatest when the largest area of land is disturbed. The maximum predicted point of development of the Project footprint includes the core facilities area (with a 100-metre [m] buffer), salt storage areas, brine reclaim ponds, the plant site access road (with a 50-m buffer), 19 well pad sites (with a 50-m buffer) and associated access roads (with a 25-m buffer). The footprint was buffered so that the effects analysis results would represent a conservative estimate of residual effects on land use. These areas are all expected to be developed after approximately 25 to 30 years of operation. The majority of the proposed Project infrastructure will be removed and reclaimed during decommissioning and reclamation. The tailings management area (TMA), which includes the Stage I and Stage II salt storage areas, Stage I and Stage II brine reclaim pond, sewage lagoon, surface diversion works and the crystallization pond are considered permanent. The maximum effect on traditional and non-traditional land use is expected at the maximum predicted point of development, and prior to decommissioning and reclamation.

The incremental contributions of the Project and the cumulative effects of the Project plus the Base Case (i.e., previous and existing developments and activities) are evaluated in order to predict potential changes to measurement indicators for socio-economic VCs.

16.2.2.3 Reasonably Foreseeable Development Case

The Reasonably Foreseeable Development (RFD) Case represents the Application Case plus reasonably foreseeable developments. The RFD Case includes the predicted residual effects from the Project, plus other previous, existing, and future projects and activities. The minimum temporal boundary for the Application Case and RFD Case is the expected lifespan of the Project that, like the Base Case, includes a range of conditions over time. The difference between the Application and RFD Case is that the Application Case considers the incremental effect from the Project in isolation of potential future land use activities. The RFDs are defined as projects that:

- are currently under regulatory review or have entered a regulatory application process;
- have a reasonable likelihood of being initiated during the life of the Project or may be induced by the Project;
- have been approved but not yet developed; or
- have the potential to change the Project or the effects predictions.

The Project has the potential to interact with RFDs in the area to contribute to cumulative effects on employment and economy, community services and infrastructure, traffic and transportation infrastructure, quality of life, and traditional and non-traditional land use. The Saskatchewan 2015 Major Projects Inventory identified over $50 billion of current or future Projects in Saskatchewan. This includes potash mines and expansions, uranium mines and expansions, other industrial projects, highway projects, pipeline projects, infrastructure upgrades and starts, and crown utility starts. Depending on the required workforces and timing of construction, all of these projects could compete with the Southey Project for a trained workforce. However, the projects located closest to the Southey Project are the most likely to contribute to cumulative effects on socio-economic VCs. Of the $50 billion of Projects in Saskatchewan, over $9.7 billion is from Projects worth $10 million or more in the socio-economic LSA that will be active in 2016 and beyond (Government of Saskatchewan 2015). Most of this, $6.3 billion, is from the two proposed new potash solution mines south of Regina. The remaining $3.4 billion is a mixture of commercial/retail, infrastructure, institutional, recreation and tourism, and residential developments. Depending on Project schedules and required workforce skills, these projects have the potential to contribute to cumulative economic effects and may compete with the Project for labour, particularly construction labour in 2017 and 2018 during the Project's peak construction period.

The following RFDs may interact with the Project to contribute to cumulative socio-economic effects:

- Capital Pointe - hotel and condo development, Regina ($100.0 million, 2009 to 2016);
- City of Regina - new stadium, Regina ($278.2 million, 2012 to 2017);
- City of Regina - site development of CP Rail Land, Regina ($45.7 million, 2012 to 2016);
- City of Regina - wastewater treatment plant upgrades, Regina ($224.3 million, 2008 to 2016);
- City of Regina - railway renewal project, Regina ($600.0 million, 2011 to 2025);
- Saskatchewan Highways and Infrastructure - Regina Bypass-connects Highway 11 with the Trans-Canada Highway, Regina ($200.0 million, 2015 to a date yet to be determined);
- Public Works & Government Services - RCMP headquarters office renovations, Regina ($10.0 million, 2012 to 2017);
- Saskatchewan Government - 515 Henderson upgrade, Regina ($30.0 million, 2015 to 2017);
- Saskatchewan Government - Legislative Building envelope upgrades, Regina ($50.0 million, 2015 to 2020);
- Vale Kronau Project, Kronau ($3000.0 million, 2009 to 2019);
- Western Potash Corporation - Milestone Project, Milestone ($3300.0 million, 2014 to 2017);

- City of Regina - Taylor Field redevelopment, Regina ($500.0 million, 2011 to 2025);
- Regina Exhibition Association - EVRAZ Place, Regina ($180.0 million, 2007 to 2017);
- Dundee Developments/Harvard Developments - Harbour Landing Subdivision ($1000.0 million, 2007 to 2017); and
- Sun Dale Recreation - 350-unit housing development, Last Mountain Lake ($200.0 million, 2008 to 2018).

In addition to the above Projects, Muskowekwan First Nation is proposing to construct a potash mine approximately 50 km northeast of the Project. Supporting infrastructure will include a water supply pipeline, an overhead transmission line, a natural gas supply pipeline, telecommunication services, and a railway line. Supporting infrastructure for the Project is not considered in the RFD Case, because the final routing options are not known at this time and assessments will be completed by each of the utility providers once the final routing options are determined.

16.3 Existing Environment

The purpose of this section is to describe the existing socio-economic environment (Base Case) within the study areas as a basis to assess the potential Project-specific effects on socio-economic VCs. The detailed methods and results for baseline data collection are located in the Cultural Environment Baseline Report (Annex V, Sections 3.0 and 4.0).

16.3.1 Methods

Socio-economic data for the province of Saskatchewan and socio-economic LSA was collected from secondary data sources. These include government agencies (e.g., Statistics Canada, Aboriginal Affairs, and Northern Development Canada), local community or development plans (e.g., Regina Official Community Plan Working Paper), local community websites, and other print and electronic sources for the area. The types of data collected include recent demographic trends, information about the capacity of community infrastructure and services, and local history. Data collected are used to characterize the existing environment (Base Case) and the socio-economic measurement indicators that may be affected by the Project. Traditional land use information was collected through interviews with Elders and First Nations community members (Annex V, Section 3.0).

16.3.2 Results

In the past decade, Saskatchewan has experienced economic growth that has altered the trends and current socio-economic conditions of the province. Recently, the economy has slowed because of a weak mining industry and a decline in oil and gas prices; however, the Saskatchewan economy is still relatively strong and is expected to continue to grow, albeit at a slower pace.

Saskatchewan's economy is largely natural resource dependant and mining, oil and gas, commercial and industrial development, and agriculture are major contributors to the recent economic growth. Potash development has been underway in Saskatchewan since the 1950s, but recently there has been a renewed interest in potash. The potash industry has undergone dramatic changes in the last couple of years. The dissolution of Belarusian Potash Company (BPC) in mid-2013 resulted in dramatic declines in the price of potash by more than 25%. Mining companies have been forced to reduce their labour force and Canpotex, a leading global potash exporter has seen potash prices fall. The lower prices have resulted in increased demand, which has helped stabilize the industry. However, recent signs of improvement are shown in the potash industry, including the deals Canpotex signed with Bangladesh and China for 2014. In Saskatchewan, potash exploration has been extensive during the past five years. Several companies have explored potash options in the province, four have obtained the necessary permits to begin construction of mines, and two companies have started construction. The dramatic drop in the price of potash in 2013 appears to have slowed the potash market slightly, but development is still proceeding, although at a slower pace.

The strengthening of the Saskatchewan economy between 2007 and 2013 created labour shortages and a constant demand for skilled and experienced workers. This has resulted in an influx of new residents and a rapid rise in population across many communities in the province, but particularly in the Saskatoon and Regina areas. Participation rates have remained high and unemployment has been low (i.e., the lowest in the country for all of 2013 and 2014). The more recent slowdown of the oil and gas industry in 2014 will ease labour shortages and may result in a small increase in unemployment, but overall the economy is expected to continue to be strong, which likely will mean continued low unemployment rates and potential labour shortages.

Challenges to local infrastructure and services come with rapid economic expansion and population growth, but so far, the province of Saskatchewan and city of Regina have met demand. Most of the population increase over the past decade has come from international migration, helped by the development of the Saskatchewan Immigrant Nominee Program, which facilitates immigrants with suitable skills and experience to acquire permanent residency to meet labour force skill shortages in the province. Saskatchewan has had a positive natural growth rate and interprovincial migration rate for several years, contributing to population growth. The influx of people has helped meet labour force demand. Many large projects continue to depend on temporary labour from outside Saskatchewan. As a result, Saskatchewan and Regina's economic future may depend on the ability to proactively attract residents and skilled labour to meet future labour force demand.

16.3.2.1 Regional and Local Economy

European settlement in Saskatchewan increased following the 1872 *Dominion Lands Act*, which provided settlers with 160 acres of land at no cost providing they cleared 10 acres and built a home within three years (Mooney 2007). Over the next half century, much of southern Saskatchewan was parcelled out for agriculture, which quickly replaced the fur trade as the dominant industry. Other natural resource development began in the late 1800s, though it only became an integral part of the Saskatchewan economy in the mid-1900s. Today, the economy is dominated by natural resources including agriculture, oil, potash, uranium, and other minerals (Government of Saskatchewan 2014a). Saskatchewan exports a high percentage of the goods it produces (e.g., grains, potash, and uranium), and imports many consumer goods (e.g., cars, food, and clothing). As a result, the Saskatchewan economy is dependent on trade and vulnerable to changing market prices. Recent slowdowns in the mining and oil and gas industries have the potential to adversely affect the provincial economy.

16.3.2.1.1 Potash

Potash has been increasing in importance in Saskatchewan over the past half century. Saskatchewan is home to approximately 50% of the world's potash reserves and currently has 10 producing potash mines (Phillips 2007; Prud'Homme 2009). The first Saskatchewan potash mine began operating in 1962, using conventional mining techniques (i.e., pit mining). By 1964, the first solution mine was operating near Belle Plaine (Prud'Homme 2009; SMA 2014). All 10 of the currently producing potash mines in Saskatchewan were in operation by 1971 (Prud'Homme 2009; SMA 2014).

In the early years of potash mining, the Saskatchewan government offered low royalty rates that barely covered the costs of public services provided to potash mines (Warnock 2011). In the 1970s and 1980s, the government increased royalties dramatically before pursuing ownership of potash mines in the province in the form of the crown Potash Corporation of Saskatchewan (PotashCorp), which was later privatized (Burton 2007).

Today, the three main producers of potash in the province are PotashCorp, Mosaic, and Agrium. However, in the past decade, potash mining in Saskatchewan has attracted renewed interest. Several companies have explored the potential for developing potash mines in the province. To date, four companies have successfully obtained Ministerial Approval from the MOE, and two of the four, BHP Billiton and K+S, have begun construction of potash mines.

In the past three years, the global potash industry has changed. Historically, the industry was able to influence prices by controlling the supply. This was accomplished by selling the majority of the global potash supply through two trading consortiums, Canpotex and BPC. However, in 2013, Russian mining company Uralkali left the BPC partnership with Belaruskali to sell potash independently, thus breaking up BPC (Globe and Mail 2014a). As the supply of available potash rose quickly, potash prices fell from $363 United States dollar per tonne (USD/tonne) before regaining some stability at $250 USD/tonne in early 2014 (Globe and Mail 2014a). Prices have since stabilized somewhat at approximately $400 Canadian dollar per tonne (CAD/tonne) (early 2015), which is equivalent to just over $300 USD/tonne, depending on the current exchange rate.

The fall in price of potash has prompted some layoffs as potash companies downsize to meet new market conditions. However, the lower prices have resulted in increased sales as potash becomes more affordable. PotashCorp reported selling 2.82 million tonnes of potash in Q1 2014, an increase of 48% from Q1 2013 (Agrimoney 2014). Canpotex has recently signed agreements with Bangladesh, China, and India to provide potash between 2014 and 2017. Recent unrest in the Ukraine and resulting export restrictions experienced by Russia has the potential to limit potash exports and affect global supply.

16.3.2.1.2 Minerals

A wide variety of minerals and ores were discovered in Saskatchewan in the nineteenth and twentieth centuries. Besides potash, ores and minerals mined in Saskatchewan include clay, copper, coal, zinc, diamond, gold, kaolin, salt, nickel, platinum, palladium, sodium sulfate, and uranium (Phillips 2007; Saskatchewan Mining Association 2014).

16.3.2.1.3 Oil and Gas

Although the first oil and gas wells in Saskatchewan were drilled in 1874 and 1883, respectively, oil and gas development began in earnest in the early 1950s (Government of Saskatchewan 2014b). Today, the oil and gas industry is nearly as important as agriculture for the province. For example, between 1995 and 2000, oil and gas revenues ranged from 10% to 25% of Saskatchewan tax revenue (Golder 2013; Government of Saskatchewan 2014c). Approximately 20% of oil produced in Saskatchewan is used in the province, with the remainder being shipped to other parts of Canada (approximately 10%) and the United States (approximately 70%) (Hanly 2007; Phillips 2007). In 2013, 2,433 horizontal wells were drilled and 177.8 million barrels of oil were produced (Huffington Post 2014). Saskatchewan is estimated to have an additional 1.1 billion barrels of recoverable oil in the province. However, in 2014 the outlook for the oil and gas industry changed notably. Leading up to 2014, oil prices had been strong, regularly over $100 USD/barrel for several years. In late 2014, oil prices began to fall, and by January 2015 were just under $50 USD/barrel, a decrease of more than 50% (Globe and Mail 2015). Oil companies have begun reducing their budgets through reduced activity and investment, which will affect employment and provincial tax revenues.

16.3.2.1.4 Commercial and Industrial Development

Manufacturing in Saskatchewan includes agriculture, forestry, mining, and energy industry product (Phillips 2007). The construction industry has experienced labour shortages in recent years because of rising demand, low wages, and a lack of available workers. Labour shortages have eased somewhat recently because of slower growth and an influx of workers. The recent slowdown in the oil and gas industry resulting from lower oil prices may reduce pressure on the industry. The labour shortage in Saskatchewan may become less pronounced as competition for workers with Alberta's oil industry lessens and worker availability increases (Leaderpost 2015a). A number of major projects (i.e., worth $10 million or more) exist near the Project, including commercial developments, subdivision developments, a new stadium in Regina, a transportation hub, waste water treatment plant upgrades, pipeline projects, and potash mine construction and expansions (Saskatchewan Ministry of the Economy 2013).

16.3.2.1.5 Agriculture

Agriculture continues to be a major driving force of the Saskatchewan economy. Approximately 40% of Canada's farmland is in Saskatchewan, and Saskatchewan produces a substantial portion of the global supply of some crops such as wheat, durum, and canola (Phillips 2007). Farming is a common occupation in the rural areas near the Project. In 2011, in the six R.M.s near the Project, there were 1,295 farm operators working on 976 farms including 123 cattle ranching operations, 673 oil seed and grain farms, and 180 other farms (Table 16.3.1; Statistics Canada 2011a to 2011f). In 2011, 503,427 ha of farmland including 358,346 ha of seeded land were reported. Farm capital in these six R.M.s in 2010 was $998.5 million with operating expenses of $166.7 million (Statistics Canada 2011a to 2011f). The agricultural industry has changed in recent years, as farms decrease in number and increase in size. More corporate farming businesses and large family operations exist than in the past. Agriculture remains the single largest industry in Saskatchewan.

Table 16.3-1: Agriculture in the Socio-economic Local Study Area

Rural Municipality	Cattle Ranching Farms	Oil Seed and Grain Farms	Other Farms	Total Number of Farms	Land in Crops (ha)	Total Area of Farms (ha)	Crops (ha)										Total Cattle and Calves	Total Sheep and Lambs	2010 Total Farm Capital ($)	2010 Total Farm Operating Expenses ($)	Total number of Operators
							Spring Wheat	Durum Wheat	Oats	Barley	Canola	Flaxseed	Dry Field Peas	Lentils	Alfalfa	Tame Hay and Fodder					
R.M. of Cupar (No. 218)	23	126	43	192	64,117	88,875	11,408	2,036	3,337	5,189	20,142	3,053	3,006	4,941	7,043	1,924	7,496	2,778	191,561,498	26,081,893	260
R.M. of Last Mountain Valley (No. 250)	8	84	10	102	52,160	68,393	15,470	2,639	1,567	1,981	15,788	4,363	3,415	1,873	2,467	890	3,937	-	132,018,802	34,732,114	130
R.M. of Longlaketon (No. 219)	28	150	50	228	67,850	101,278	14,142	2,226	3,238	6,017	19,952	4,259	3,617	3,701	6,337	2,228	10,306	375	209,088,577	28,207,707	300
R.M. of McKillop (No. 220)	16	72	29	117	47,992	65,282	12,167	1,807	1,090	2,159	13,854	2,241	2,632	2,535	7,111	928	6,953	538	121,081,094	21,346,364	160
R.M. of Mount Hope (No. 279)	19	165	22	206	87,603	119,491	20,782	1,550	5,770	6,605	34,809	4,021	5,399	-	5,075	1,303	8,184	1,055	238,764,121	38,878,822	285
R.M. of Touchwood (No. 248)	29	76	26	131	38,624	60,108	7,040	0	2,622	2,211	13,264	1,288	483	419	8,872	1,524	10,282	453	106,073,314	17,423,337	160
TOTAL	**123**	**673**	**180**	**976**	**358,346**	**503,427**	**81,009**	**10,258**	**17,624**	**24,162**	**117,809**	**19,225**	**18,552**	**13,469**	**36,905**	**8,797**	**47,158**	**5,199**	**998,587,406**	**166,670,237**	**1,295**

Source: Statistics Canada 2011a to 2011f.

ha = hectare; $ = dollar; R.M. = rural municipality; No. = number; - = not available.

16.3.2.2 Population and Demographics

The arrival of the railway in Saskatchewan allowed the population to increase dramatically in the late 1800s and early 1900s. A population of a few thousand people in 1885 rose to 91,300 by 1901 and continued to rise to 921,800 by 1931 (Phillips 2007). The population of Saskatchewan remained around 900,000 for most of the twentieth century, as the province experienced some growth but also a small, steady outmigration to neighbouring provinces, resulting in fluctuating growth that ranged from modest net growth to modest net loss in population. Similarly, Regina grew rapidly in the early twentieth century, rising from a population of 3,000 in 1903 to over 50,000 people by 1930 (U of S 1999; Coneghan 2007). Unlike the provincial population, which remained relatively steady over the next 70 years, Regina's population continued to grow from 50,000 in 1930 to approximately 180,000 in the mid-1990s, as people moved from other communities in the province to Regina (i.e., urbanization). In 2007, after 15 years of modest inclines and declines in population, the Saskatchewan and Regina populations began increasing in response to a strong economy and labour demands in natural resources and construction; since 2008, the provincial population has been steadily increasing by between 1.52% and 1.98% per year (Statistics Canada 2014a).

16.3.2.2.1 Population

During the last national census in 2011, the province of Saskatchewan (socio-economic RSA) had a total population of 1,033,381, an increase of 65,224 (6.7%) from 2006 (Table 16.3-2). Most of this growth has occurred in the city of Saskatoon, the city of Regina, and communities immediately surrounding those cities. By January 1, 2014, the population was estimated to have grown to 1,117,503, an increase of 84,122 (8.1%) (Statistics Canada 2014a).

The socio-economic LSA had a total population of 212,091 in 2011, an increase of 14,499 or 7.3% from 2006. In 2011, the socio-economic LSA comprised 20.5% of Saskatchewan's population. Most of the socio-economic LSA population is in Regina (91.0%). Regina's population increased 13,818 or 7.7% to 193,100 between 2006 and 2011 (Table 16.3-2). This represents 95.3% of the increase in population in the socio-economic LSA. Between 2006 and 2011, the remainder of the socio-economic LSA saw a population increase of 681 people (3.6%). Regina continues to grow and the labour force population (aged 15 and over) was recently estimated to have increased by 4,800 between January 2014 and January 2015 (Statistics Canada 2015). The size of the population of Regina varies by what is measured and how it is measured. For example, the 2014 health care covered population indicates a population of 221,996 whereas the Regina census metropolitan area July 2013 population was estimated at 232,090 (RQHR 2014a; Statistics Canada 2014b). This difference may be because of the presence of residents who are not covered by Saskatchewan health (i.e., Canadian armed forces, inmates, individuals who have lived in Saskatchewan less than three months) or because of differences in mailing addresses (i.e., individuals may have two homes, for example one in Regina and another in a nearby community or acreage. They might consider the home in the community or acreage their permanent residence, but could use the home in Regina as their mailing address) (RQHR 2014a).

Table 16.3-2: Socio-economic Local Study Area Population and Community Characteristics

Community Type	Communities in the Socio-economic LSA[(a)]	2006 Population	2011 Population	% of Total Socio-economic LSA Population	Population Change 2006 to 2011	
					No.	%
Rural Municipality	Cupar No. 218	502	554	0.3	52	10.4
	Last Mountain Valley No. 250	362	267	0.1	-95	-26.2
	Longlaketon No. 219	899	962	0.5	63	7.0
	McKillop No. 220	566	575	0.3	9	1.6
	Mount Hope No. 279	633	567	0.3	-66	-10.4
	Touchwood No. 248	287	267	0.1	-20	-7.0
Indian Reserve	Day Star No. 87	168	155	0.1	-13	-7.7
	Gordon (George Gordon) No. 86	866	1,017	0.5	151	17.4
	Last Mountain (Muscowpetung) No. 80	-	-	-	-	-
	Muscowpetung No. 80	290	365	0.2	75	25.9
	Muskowekwan No. 85	498	646	0.3	148	29.7
	Pasqua No. 79	472	546	0.3	74	15.7
	Piapot No. 75	448	464	0.2	16	3.6
	Poorman (Kawacatoose) No. 88	688	782	0.4	94	13.7
	Standing Buffalo No. 78	446	651	0.3	205	46.0
City	Regina	179,282	193,100	91.0	13,818	7.7
Town	Cupar	566	579	0.3	13	2.3
	Fort Qu'Appelle	1,919	2,034	1.0	115	6.0
	Govan	232	216	0.1	-16	-6.9
	Lumsden	1,523	1,631	0.8	108	7.1
	Nokomis	404	397	0.2	-7	-1.7
	Raymore	581	568	0.3	-13	-2.2
	Regina Beach	1,210	1,081	0.5	-129	-10.7
	Southey	711	778	0.4	67	9.4
	Strasbourg	732	752	0.4	20	2.7
Village	Buena Vista	490	524	0.2	34	6.9
	Bulyea	104	102	<0.1	-2	-1.9
	Craven	274	234	0.1	-40	-14.6
	Dilke	80	77	<0.1	-3	-3.8
	Duval	94	97	<0.1	3	3.2
	Dysart	198	218	0.1	20	10.1
	Earl Grey	264	239	0.1	-25	-9.5
	Lestock	138	125	0.1	-13	-9.4
	Markinch	59	72	<0.1	13	22.0
	Punnichy	277	246	0.1	-31	-11.2
	Quinton	108	111	0.1	3	2.8
	Semans	195	204	0.1	9	4.6
	Silton	91	95	<0.1	4	4.4

Table 16.3-2: Socio-economic Local Study Area Population and Community Characteristics

Community Type	Communities in the Socio-economic LSA[(a)]	2006 Population	2011 Population	% of Total Socio-economic LSA Population	Population Change 2006 to 2011	
					No.	%
Resort Village	Alice Beach	68	45	<0.1	-23	-33.8
	Etters Beach	15	30	<0.1	15	100.0
	Glen Harbour	73	65	<0.1	-8	-11.0
	Grandview Beach	35	25	<0.1	-10	-28.6
	Island View	88	65	<0.1	-23	-26.1
	Kannata Valley	133	101	<0.1	-32	-24.1
	Lumsden Beach	40	10	<0.1	-30	-75.0
	Pelican Pointe	23	15	<0.1	-8	-34.8
	Saskatchewan Beach	155	213	0.1	58	37.4
	Sunset Cove	26	25	<0.1	-1	-3.8
	Wee Too Beach (includes Lipp's Beach)	60	35	<0.1	-25	-41.7
Organized Hamlet	Alta Vista	33	30	<0.1	-3	-9.1
	Arlington Beach	39	23	<0.1	-16	-41.0
	Colesdale Park	21	10	<0.1	-11	-52.4
	Mohr's Beach	10	10	<0.1	0	0
	North Colesdale Park	24	28	<0.1	4	16.7
	Sarnia Beach	27	5	<0.1	-22	-81.5
	Spring Bay	19	0	<0.1	-19	-100.0
	Sorenson's Beach	31	38	<0.1	7	22.6
	Uhl's Bay	15	20	<0.1	5	33.3
Socio-economic LSA Total		**197,592**	**212,091**	**n/a**	**14,499**	**7.3**
Saskatchewan (Socio-economic RSA)		**968,157**	**1,033,381**	**n/a**	**65,224**	**6.7**

Source: Statistics Canada 2012a to 2012bk.
(a) Hamlets are included in the Rural Municipality in which they are located.
LSA = local study area; % = percent; No. = number; - = not available; < = less than; RSA = regional study area; n/a = not applicable.

16.3.2.2.2 Age

According to the 2011 census, the median age in the socio-economic LSA ranged from 19.8 to 62.8 years (Statistics Canada 2007a to 2007am; Statistics Canada 2012a to 2012bk), depending on the community. The wide range is attributed to the diversity of communities in the socio-economic LSA. The median age of the populations on Indian Reserves were the lowest, ranging from 19.8 to 25.0 years. Other communities with median ages lower than the Saskatchewan value include Regina, Punnichy, and Quinton. The remainder of the communities have populations with median ages in the 40s, 50s, or 60s, suggesting that these are retirement communities and that young people are leaving these smaller communities for opportunities in urban centres.

In general, an aging population would be a labour force concern, particularly combined with low natural growth rates and low immigration levels. However, between the 2006 and 2011 censuses, the median age in Saskatchewan decreased from 38.7 to 38.2 years (Statistics Canada 2007a to 2007am; Statistics Canada 2012a to 2012bk). Similarly, Statistics Canada (2014f) notes that between July 1, 2003 and July 1, 2013, Saskatoon and Regina are the only Census Metropolitan Areas (CMA) in Canada that experienced a small decrease in proportion of people 65 years of age and over, perhaps because the growing economy and labour shortages may be attracting younger workers to the Province and to Regina.

16.3.2.2.3 Population Growth Sources

The sources of population growth in Saskatchewan (socio-economic RSA) includes natural growth (i.e., births minus deaths), interprovincial migration (i.e., from other provinces to Saskatchewan), and international migration (i.e., immigration from outside Canada). Regina also experiences growth from intraprovincial migration (i.e., from smaller communities to Regina [e.g., urbanization]). The numbers and percentages of population growth from different sources in Regina between 2012 and 2013 and in Saskatchewan in 2013 are provided in Table 16.3-3.

Table 16.3-3: Source of Population Growth in the Socio-economic Regional and Local Study Areas.

Source of Population Growth	People Moving to Regina between July 2012 and July 2013		People moving to Saskatchewan in 2013	
Intraprovincial Migration (e.g., urbanization)	764	11.0%	n/a	n/a
Interprovincial Migration	417	6.0%	1,368	6.8%
International Migration (i.e., Immigration)	4,515	65.0%	13,108	65.4%
Natural Growth	1,250	18%	5,580	27.8%
Total	**6,946**	**100.0%**	**20,056**	**100.0%**

Sources: Leaderpost 2014a; Statistics Canada 2014a.
% = percent; n/a = not applicable

Natural growth (i.e., births minus deaths) accounted for an estimated population increase of 5,580 individuals, or 27.8%, of the growth in Saskatchewan in 2013 (Statistics Canada 2014a). Between July 1, 2012 and July 1, 2013, Regina's natural population growth was approximately 1,250 people (Leaderpost 2014a). The increase in natural growth corresponds to an increase in birth rates in Saskatchewan, which rose from 13,897 in 2008/2009 to 14,918 (7.3%) in 2012/2013 (Statistics Canada 2013a,b,c). The birth rates and natural growth rate may be artificially high because of a young population (i.e., younger workers starting families). This trend could slow or reverse as the number of young people starting families decreases and as the "baby boomers" age (i.e., those born between 1949 and 1963).

Intraprovincial migration accounts for individuals moving to Regina from other communities within Saskatchewan. Urbanization has been driving intraprovincial migration for years and the intraprovincial migration rate has been consistently positive. Because urbanization has been occurring for decades and is ongoing, the rate is expected to continue to be positive but small in value because much of the population has already moved to larger urban centres. Between July 2012 and July 2013, 764 people moved to Regina from other Saskatchewan communities, accounting for 11% of Regina's population growth during that period (Leaderpost 2014a).

Interprovincial migration includes all the people who move to Saskatchewan from other provinces or to other provinces from Saskatchewan. Interprovincial migration has historically been negative in Saskatchewan, but in recent years, Saskatchewan has maintained a net positive interprovincial rate. In 2013, data suggests 21,809 people moved to Saskatchewan and 20,441 moved out of the province, for a net gain of 1,368 people (Statistics Canada 2014a). From July 2012 to July 2013, Regina experienced an increase of 417 people from interprovincial migration, accounting for 6% of the total increase in population during that period

(Leaderpost 2014a). Interprovincial migration currently comprises a small positive influx of people each year, but this trend may revert to the historical negative trend in the future if the Saskatchewan economy slows.

Saskatchewan (socio-economic RSA) has a low immigrant population compared to other provinces (Statistics Canada 2014c), although high levels of immigration in recent years has added diversity to the provincial and Regina population. From January 1, 2013 to January 1, 2014, Saskatchewan's immigrant population grew by approximately 13,108, accounting for 65.4% of the population increase during the period (Statistics Canada 2014a). This was a slight decrease from 13,791 in 2012 (Statistics Canada 2014a). The Regina immigrant population increased by 4,515 people from July 1, 2012 to July 1, 2013, accounting for 65% of Regina's population increase during that period (Leaderpost 2014b). In 2011, the three countries of origin for the most immigrants coming to Saskatchewan were Philippines (18.6%), United Kingdom (10.7%), and the United States (7.3%) (CBC 2013). Historically, the United Kingdom has been Saskatchewan's largest source of immigrants, but the increase in immigration from the Philippines has been dramatic. The Filipino population in Saskatchewan increased from 2,455 in 2006 to 12,775 in 2011, an increase of 420.4% (CBC 2013). Based on recent immigration numbers, the number of people in Saskatchewan and Regina who identify as visible minorities or immigrants is expected to continue to rise. International migration (i.e., immigration) is expected to be the driving force of future population growth in Saskatchewan and Regina.

16.3.2.2.4 Saskatchewan Immigrant Nominee Program

The Saskatchewan Immigrant Nominee Program (SINP) assists skilled immigrants who can fill labour force requirements not being met by Canadian employees. Successful SINP nominees receive permanent residency and have the same rights and responsibilities as other Saskatchewan residents (Saskatchewan Ministry of the Economy 2013. In 2011, about 78% of Saskatchewan's immigrants used the SINP and approximately 36% of SINP nominees went to Regina (Saskatchewan Ministry of the Economy 2013; AEEI n.d.). Retention of immigrants has been poor in the past, (i.e., some immigrants will only stay in Regina or Saskatchewan for a short time before moving); however, SINP has an 86% retention rate in Saskatchewan (Saskatchewan Ministry of the Economy 2013). Provincial nominees (PN) generally are economically established and still are working one year after landing; most report employment earnings annually and few access employment insurance or social assistance benefits (AEEI n.d.). In 2015, the SINP will be accepting 6,500 skilled worker applications, 3,000 Saskatchewan experience applications, and 50 entrepreneur and farm applications (Saskatchewan Ministry of the Economy 2015). This is an increase from 5,250 skilled worker applications, 2,150 Saskatchewan experience applications, and 25 entrepreneur and farm applications in 2014 (Saskatchewan Immigration 2014).

The Saskatchewan government altered the SINP rules in May 2012, eliminating the family category and limiting SINP candidates to one relative nomination at a time (StarPhoenix 2013). Prior to May 2012, people could nominate entire families using the family category if the nominator had lived in Saskatchewan for more than one year and could prove that he or she could financially support the nominated family (or families) (News Talk 650 CKOM 2013). This change in the rules could make Saskatchewan a slightly less attractive destination for immigrants; however, immigration numbers were still high in 2013 and 2014.

16.3.2.2.5 Aboriginal Population

The Project is located near two Tribal Councils, the Fire Hills Qu'Appelle Tribal Council and the Touchwood Agency Tribal Council. The Fire Hills Qu'Appelle Tribal Council includes nine bands and the Touchwood Agency Tribal Council includes four bands. Based on Aboriginal Affairs and Northern Development Canada information, the December 2013 total Aboriginal population of these Tribal Councils is 6,793, with a further 559 people living on other reserves and 14,797 people living off reserve (Table 16.3-4). Four Fire Hills bands and all four Touchwood Agency bands are included in the socio-economic LSA. The socio-economic LSA overlaps the Métis Western Region IIA, Western Region III, and Eastern Region III. Aboriginal language mother tongues and languages spoken at home in the socio-economic LSA are primarily Cree with a small number of Ojibway, Dene, and Stoney speakers (Statistics Canada 2012a to 2012bk).

Table 16.3-4: Tribal Councils and First Nations near the Project

Tribal Council	First Nation	Included in the Socio-economic Local Study Area	Distance and Direction of Main Reserve from Project (km)	Registered On Reserve Population	Registered On Other Reserve Population	Registered Off Reserve Population
Fire Hills Qu'Appelle	Carry the Kettle 76	No	106 km southeast	866	37	1,781
	Little Black Bear 84	No	81 km east	-	-	-
	Muscowpetung 80	Yes	37 km southwest	-	-	-
		Yes	38 km southeast	295	56	977
	Okanese 82	No	81 km east	271	15	392
	Pasqua 79	Yes	50 km southeast	578	43	1,393
	Peepeekisis 81	No	82 km east	615	63	1,928
	Piapot 75	Yes	30 km south	588	77	1,605
	Standing Buffalo 78	Yes	55 km southeast	452	23	751
	Star Blanket 83	No	81 km east	268	15	355
Touchwood Agency	Day Star 87	Yes	48 km northeast	142	17	342
	George Gordon 86	Yes	22 km northeast	1,113	73	2,256
	Kawacatoose 88	Yes	37 km northeast	1,144	80	1,792
	Muskowekwan 85	Yes	37 km northeast	461	60	1,225
TOTAL				**6,793**	**559**	**14,797**

Source: U of S 1999; AANDC 2013a to l.
km = kilometre; - = not available.

According to the 2011 census, approximately 157,740 people or 15.6% of the provincial population identified themselves as Aboriginal and 97,825 people or 9.7% of the population were Registered or Treaty Indian (Table 16.3-5). In comparison, in the socio-economic LSA 23,305 people or 11.6% of the population identifies themselves as Aboriginal and 14,160 people or 7.1% of the population were Registered or Treaty Indian. Most of these individuals live in Regina or on Indian Reserves.

Table 16.3-5: Socio-economic Local Study Area Aboriginal Population

Community Type	Communities in the Socio-economic LSA[(a)]	Total Population in Private Households by Aboriginal Identify	Aboriginal Identify		Total Population in Private Households by Registered or Treaty Indian	Registered or Treaty Indian	
			No.	%		No.	%
Rural Municipality	Longlaketon No. 219	795	30	3.8	790	0	0
	Mount Hope No. 279	445	35	7.9	445	20	4.5
	Touchwood No. 248	265	35	13.2	265	0	0
Indian Reserve	Day Star No. 87	155	150	96.8	155	155	100.0
	Gordon (George Gordon) No. 86	1,005	1,005	100.0	1,005	990	98.5
	Muskowekwan No. 85	585	580	99.1	585	570	97.4
	Pasqua No. 79	545	540	99.1	545	520	95.4
	Piapot No 75	460	465	101.1	460	430	93.5
	Poorman (Kawacatoose) No. 88	790	775	98.1	790	765	96.8
City	Regina	189,745	18,750	9.9	189,745	10,140	5.3
Town	Cupar	530	10	1.9	530	0	0
	Fort Qu'Appelle	2,230	630	28.3	2,230	375	16.8
	Nokomis	380	20	5.3	380	0	0
	Raymore	540	25	4.6	540	0	0
	Southey	780	35	4.5	780	0	0
	Strasbourg	715	0	0	715	0	0
Village	Bulyea	60	0	0	65	0	0
	Duval	65	0	0	65	0	0
	Punnichy	245	155	63.3	245	145	59.2
	Quinton	110	50	45.5	110	50	45.5
	Silton	50	0	0	45	0	0
Resort Village	Etters Beach	60	0	0	65	0	0
	Kannata Valley	120	0	0	120	0	0
	Saskatchewan Beach	130	15	11.5	135	0	0
Socio-economic LSA Total		***200,805***	***23,305***	***11.6***	***200,810***	***14,160***	***7.1***
Saskatchewan (Socio-economic RSA)		**1,008,760**	**157,740**	**15.6**	**1,008,760**	**97,825**	**9.7**

Source: Statistics Canada 2013d to 2013ac.
[(a)] No National Household Survey data available for communities not included in this table.
LSA = local study area; % = percent; No. = number; RSA = regional study area.

The Aboriginal population is growing at a rapid rate, and may comprise as much as 32.5% of the Saskatchewan population by 2045, increasing from 13.6% of the population in 2001 (Government of Saskatchewan 2014d). Based on the National Household Survey in 2011, Regina and Fort Qu'Appelle had Aboriginal identity populations that accounted for 9.9% and 28.3%, respectively, of the total population (Statistics

Canada 2013ad,ae). By ethnic origin, the National Household Survey reported 13,180 (6.9%) First Nations, 45 (less than 0.1%) Inuit, and 7,150 (3.8%) Métis people in Regina (Statistics Canada 2013ae). Aboriginal education and employment levels are below those of the general population, but with more Aboriginal people living in urban areas, there has been a noticeable rise in education levels and opportunities for employment. In Saskatoon, Regina, and other urban areas, Aboriginal people are employed most commonly in sales and service, trades, business, finance, and education (Anderson 2007; Statistics Canada 2013ae).

16.3.2.2.6 Population Projections

The Regina Official Community Plan (City of Regina 2013) predicts that the population of Regina will increase by 100,000 people in the next 25 years, a sharp increase in growth rate considering the population increased by only 30,000 over the past 30 years. The City of Regina Official Community Plan is based on three potential growth scenarios – high, medium, and low (DCMA 2010). All three scenarios predict net-growth, varying from 0.33% per year to 1.74% per year. The high growth scenario would result in a population of 302,631 by 2035. This increase is expected to result mostly from immigration, which has increased dramatically in recent years because of new immigration policies such as the Saskatchewan Immigrant Nominee Program and the Canadian Temporary Foreign Worker Program.

Derek Murray Consulting and Associates (DCMA 2010) modeled population growth for the City of Regina based on economic and population growth patterns and trends in the early 2000s (Table 16.3-6). Key informants in 2011 suggested that the moderate growth scenario is too low and that Regina was experiencing growth in line with the high growth scenario (Golder 2013). However, the 2011 Statistics Canada census identified a 2011 population lower than the 2010 forecast for all three models. The Statistics Canada census is not the only measure of population and may miss some changes, particularly with the switch from a long-form census in 2006 to a short-form census in 2011. However, the Regina census metropolitan area was estimated to have a population of 232,090 in July 2013 (Statistics Canada 2014b). In contrast to the census numbers, the Regina Qu'Appelle Health Region (2014a) identified a population of 221,996 individuals eligible for Saskatchewan Health coverage in Regina in 2014. These last two population values suggest that Regina is growing at a rate comparable to the high growth scenario.

The Regina Regional Opportunities Commission (RROC) and City of Regina are continuing to plan and expect a population of 300,000 by 2040, which would align most closely with the high growth scenario (RROC 2015).

Table 16.3-6: Regina Population Projections

Growth Scenario	Annual Growth Rate	Actual Population	Actual Population	Projected Population					
		2005	2011	2010F	2015F	2020F	2025F	2030F	2035F
High	1.74%	183,649	193,100	196,931	218,579	240,450	261,837	282,371	302,621
Medium	1.12%	183,649	193,100	196,123	212,711	225,513	237,094	247,778	257,950
Low	0.33%	183,649	193,100	195,590	204,410	207,216	209,381	210,453	210,425

Source: DCMA 2010; Statistics Canada 2012bk.
% = percent; F = Forecast.

16.3.2.3 Labour Force Characteristics

Saskatchewan historically has had high employment rates and low unemployment rates, possibly because of the prevalence of agriculture and small town communities, which typically have high labour force participation rates.

The Saskatchewan labour market has been increasing at approximately 1.4% per year since 2001, which equates to about 7,000 jobs per year, although in 2012 there was a larger increase of 11,200 jobs (2.1%) (STM 2013a). Regina had the highest cumulative employment growth rate (i.e., 15%) in Canada from 2010 to 2013 (RROC 2014). In Regina, the RROC is anticipating the GDP to increase by 3.5% in 2014 (RROC 2014). The City of Regina and the RROC continue to expect strong growth in the next 25 years (RROC 2015).

Employment growth has been the greatest in the 55 to 64 and the over 65 age groups, followed by the 25 to 34 age group. The increase in the older age groups is likely because many people in this age group are working beyond the typical age of retirement (i.e., 65 years of age), while the increase in the younger age group may be because of the high rates of interprovincial and international immigration.

Between 2007 and 2012, the fastest growing economic sector was construction, followed by resources and utilities, and professional, technical, and scientific services (STM 2013a). During this time, employment among men grew more rapidly than among women, and Aboriginal employment grew faster than non-Aboriginal employment (STM 2013a). The construction sector slowed in summer 2013, but overall has increased by 4,900 jobs or 10.4% between April 2013 and April 2014 (LMI Division 2014a,b). The strongest employment growth between April 2013 and April 2014 was in goods-producing sectors (e.g., agriculture, forest, fishing, mining, quarrying, oil and gas, utilities, and construction) (LMI Division 2014b). Between April 2013 and April 2014, employment in the forestry, fishing, mining, quarrying, and oil and gas industry increased by 2,400 individuals, or by 9.8% (LMI Division 2014b).

Saskatchewan is facing a labour and trades shortage that will continue if the current growth levels are maintained. Saskatchewan's population growth is likely to limit future economic growth; Garven & Associates (2009) predict that a healthy economic future will depend on whether the Saskatchewan labour force can be shaped to meet future labour requirements. The recent decrease in price of oil and associated slowdown in the oil and gas industry is expected to reduce the potential for labour shortages.

16.3.2.3.1 Education

Education increases the likelihood of labour force participation and employment, and generally corresponds to higher wages. Overall, the socio-economic LSA reported a slightly higher level of educational attainment in the 2011 census compared to the Saskatchewan population (Table 16.3-7). The socio-economic LSA data are strongly influenced by the city of Regina, which has a population with higher levels of education on average than the rest of the province. This can obscure some of the trends in other communities in the socio-economic LSA. For example, in the R.M.s, Indian Reserves, and towns, individuals with apprenticeship or trade and non-university diplomas or certificates were more common and individuals holding university certificates, diplomas, or degrees were less common than in Regina.

Several communities in the socio-economic LSA had high proportions (40% to 50%) of their population with no degree, diploma, or certificate, including the Indian Reserves, the R.M. of Mount Hope, Cupar, and Punnichy. The Saskatchewan Labour Market Commission identified the Aboriginal population that is not participating in the workforce as an important group to involve in the labour force to meet future demands (SLMC 2009). This will require an increase in the number of Aboriginal students completing high school and post-secondary education. Some of the most popular post-secondary providers to Aboriginal people are Saskatchewan Polytechnic, the Saskatchewan Indian Institution of Technologies (SIIT), and the First Nations University of Canada. In 2011, 17% of students at Saskatchewan Polytechnic were of Aboriginal descent (Golder 2013).

Table 16.3-7: Socio-economic Local Study Area Education Characteristics

Community Type	Communities in the Socio-economic LSA[(a)]	Population 15 Years of Age and over	No Certificate, Diploma, or Degree		High School Certificate or Equivalent		Apprenticeship or Trades Certificate or Diploma		College, CEGEP, or other Non-university Certificate or Diploma		University Certificate or Diploma below the Bachelor Level		University Certificate, Diploma, or Degree	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Rural Municipality	Longlaketon No. 219	640	130	20.3	190	29.7	90	14.1	100	15.6	35	5.5	95	14.8
	Mount Hope No. 279	410	170	41.5	90	22.0	50	12.2	80	19.5	15	3.7	0	0
	Touchwood No. 248	235	55	23.4	115	48.9	40	17.0	15	6.4	0	0	0	0
Indian Reserve	Day Star No. 87	110	45	40.9	25	22.7	20	18.2	15	13.6	0	0	0	0
	Gordon (George Gordon) No. 86	630	335	53.2	140	22.2	80	12.7	55	8.7	10	1.6	20	3.2
	Muskowekwan No. 85	350	200	57.1	85	24.3	25	7.1	25	7.1	10	2.9	0	0
	Pasqua No. 79	370	150	40.5	130	35.1	25	6.8	50	13.5	10	2.7	10	2.7
	Piapot No 75	305	180	59.0	75	24.6	20	6.6	15	4.9	10	3.3	10	3.3
	Poorman (Kawacatoose) No. 88	495	240	48.5	110	22.2	70	14.1	55	11.1	10	2.0	15	3.0
City	Regina	156,195	28,850	18.5	46,905	30.0	15,400	9.9	23,605	15.1	7,380	4.7	34,050	21.8
Town	Cupar	420	160	38.1	85	20.2	60	14.3	55	13.1	15	3.6	45	10.7
	Fort Qu'Appelle	1,880	630	33.5	365	19.4	445	23.7	235	12.5	40	2.1	160	8.5
	Nokomis	335	105	31.3	110	32.8	45	13.4	45	13.4	0	0	30	9.0
	Raymore	475	110	23.2	140	29.5	50	10.5	60	12.6	30	6.3	85	17.9
	Southey	655	185	28.2	195	29.8	65	9.9	90	13.7	70	10.7	50	7.6
	Strasbourg	635	195	30.7	160	25.2	70	11.0	150	23.6	0	0	50	7.9
Village	Bulyea	55	15	27.3	20	36.4	0	0	0	0	0	0	0	0
	Duval	45	0	0	0	0	0	0	0	0	0	0	0	0
	Punnichy	180	100	55.6	35	19.4	0	0	30	16.7	0	0	0	0
	Quinton	85	25	29.4	35	41.2	0	0	0	0	0	0	0	0
	Silton	50	15	30.0	0	0.0	0	0	0	0	0	0	0	0
Resort Village	Etters Beach	55	15	27.3	0	0.0	0	0	0	0	0	0	0	0
	Kannata Valley	110	25	22.7	25	22.7	0	0	0	0	0	0	40	36.4
	Saskatchewan Beach	130	20	15.4	60	46.2	35	26.9	0	0	0	0	0	0
Socio-economic LSA Total		**164,850**	**31,955**	**19.4**	**49,095**	**29.8**	**16,590**	**10.1**	**24,680**	**15.0**	**7,635**	**4.6**	**34,660**	**21.0**
Saskatchewan (Socio-economic RSA)		**812,505**	**200,430**	**24.7**	**228,755**	**28.2**	**98,820**	**12.2**	**127,295**	**15.7**	**32,780**	**4.0**	**124,425**	**15.3**

Source: Statistics Canada 2013d to 2013ac.

(a) No National Household Survey data available for communities not included in this table.

LSA = local study area; No. = number; % = percent; RSA = regional study area; CEGEP = Collège d'Enseignement Général et Professionnel (General and Vocational College).

16.3.2.3.2 Labour Force

Saskatchewan is experiencing labour shortages in several sectors because of rapid economic growth and a mismatch between worker demand and supply. In addition, the baby boomers (i.e., those born between 1949 and 1963) currently comprise a large portion of the employed workforce. As current workers retire, a large number of experienced workers will be required to replace them.

Regina's economy has been growing and expanding rapidly in the past decade and a half. In the early 2000s, Regina was adding an average of 1,438 jobs per year, but the population was only increasing at 1,215 per year, resulting in a labour shortage (DMCA 2010). Unemployment rates are expected to continue to be low and participation rates will continue to be high until the labour shortage ends. If the labour shortage continues or worsens, it could have negative consequences for the provincial and regional economy. A labour shortage may cause Project delays and cancellations, increase wage costs due to competition for labour, decrease company competitiveness due to increased costs, reduce productivity due to lowered hiring standards, cause downsizing, or failure of businesses, increase taxes to cover costs of infrastructure, and increase inflation (SLMC 2009).

Saskatchewan's economy had a slow start in 2014, but between March and April 2014, employment increased by 3,000 people (LMI Division 2014b). Saskatchewan consistently had the lowest unemployment rate in Canada during 2013 and 2014 (LMI Division 2014b). Saskatchewan's youth unemployment rate was 6.0% in April 2014, well below the national average of 13.4% (LMI Division 2014b). Saskatchewan's unemployment rate for June 2014 was 3.3% (Statistics Canada 2014d).

In the 2011 census, Saskatchewan's (socio-economic RSA) labour force participation rate was 69.2% and its unemployment rate was 5.9% (Table 16.3-8). The socio-economic LSA population had a slightly higher labour force participation rate of 71.5% and a lower unemployment rate of 5.1% than the overall Saskatchewan population. The socio-economic LSA numbers are influenced strongly by Regina, where most of the socio-economic LSA's population resides. In Regina, labour force participation is 72.4% and unemployment is 5.0%.

Between January 2014 and January 2015, the population of Regina increased by approximately 4,800, or 2.5% (Statistics Canada 2015). However, the labour force during this same period increased by only 900 people, which resulted in a decrease in the labour force participation rate from 73.9% to 72.5%, despite the increase in the size of the labour force. This could be because the population increase may include individuals who are not in the labour force or because individuals already in Regina chose to leave the labour force. The unemployment rate during this same period fell from 4.2% to 3.9%. The low unemployment rate suggests skilled labour is in high demand and there may be labour constraints in the area.

In socio-economic LSA communities other than Regina, the labour force participation rate ranges from 89.1% to 23.5%. Labour force participation is relatively high in the R.M.s, as is common in agricultural areas. In the Indian Reserves, the labour force participation ranges from 38.9% to 54.55% and in towns, villages, and resort villages it ranges from 23.5% to 75.0%, with most of the communities from 50% to 60% participation. Unemployment outside Regina is low and Nokomis and Fort Qu'Appelle were the only towns or villages reporting any unemployed residents. The Indian Reserves have unemployment rates ranging from 16.7% to 26.7%.

Median and average income of individuals in the socio-economic LSA varies in comparison to Saskatchewan overall (Table 16.3-8). In Regina, Southey, and the R.M. of Longlaketon, income is higher than the Saskatchewan median and average. However, other communities generally have median and average incomes below the provincial values, as is particularly apparent on the Indian Reserves.

16.3.2.3.3 Jobs by Occupation

In 2011 in Saskatchewan (socio-economic RSA), 66.7% of people were employed in management, business, finance, administration, sales and service, and trades, transport, and equipment operators (Statistics Canada 2013d to 2013ac).

In the socio-economic LSA, management positions were less common and business, finance, and administration occupations were more common. However, there was a large percentage of management occupations in the three R.M.s, perhaps because of individuals working in Regina but living in acreage developments in these R.M.s. Communities in the socio-economic LSA outside of Regina generally had more occupations than Regina in education, law and social, community and government services, sales and service, and trades, transport and equipment operators (Statistics Canada 2013d to 2013ac).

16.3.2.3.4 Jobs by Industry

In 2011, jobs in Saskatchewan (socio-economic RSA) were most commonly in agriculture, forestry, fishing, hunting, retail trade, and health care and social assistance (Statistics Canada 2013d to2013ac).

In contrast, in the socio-economic LSA, largely dominated by Regina, the number of people employed in the agriculture, forestry, fishing, and hunting industries were lower, and the number employed in information and cultural industries, finance and insurance, and public administration were higher. Smaller communities were more likely to have jobs in industries such as agriculture, forestry, fishing, hunting, construction, retail trade, educational services, health care and social assistance, and public administration (Statistics Canada 2013d to 2013ac).

Currently, mining is not a major industry employer in the socio-economic LSA. Only 0.8% of the population (980 individuals) in the socio-economic LSA is employed in mining, compared to 4.1% of Saskatchewan's labour force (Statistics Canada 2013d to 2013ac). All of these individuals are located in Regina. Low unemployment rates and a small skilled and experienced mining workforce in the area may require foreign or out-of-province workers to meet employment needs. This may mean less local and regional employment, less tax revenue, and potential economic leakage out of Saskatchewan.

Table 16.3-8: Socio-economic Local Study Area Labour Force Characteristics

Community Type	Communities in the Socio-economic LSA	Total Population 15 Years Of Age and Over	Total Population in the Labour Force	Labour Force Participation Rate (%)	Total Labour Force Employed	Total Labour Force Unemployed		2010 Total Median Income ($) of Population 15 Years Of Age and Over	2010 Total Average Income ($) of Population 15 Years Of Age and Over
						No.	%		
Rural Municipality	Longlaketon No. 219	640	570	89.1	555	0	0	35,550	49,642
	Mount Hope No. 279	415	275	66.3	275	0	0	25,484	32,555
	Touchwood No. 248	235	190	80.9	190	0	0	30,720	27,336
Indian Reserve	Day Star No. 87	110	60	54.5	50	10	16.7	-	-
	Gordon (George Gordon) No. 86	630	245	38.9	180	60	24.5	7,948	13,672
	Muskowekwan No. 85	350	150	42.9	105	40	26.7	11,319	14,260
	Pasqua No. 79	375	165	44.0	135	30	18.2	9,198	16,056
	Piapot No 75	310	135	43.5	100	30	22.2	11,064	16,011
	Poorman (Kawacatoose) No. 88	500	200	40.0	155	50	25.0	12,225	16,117
City	Regina	156,195	113,055	72.4	107,390	5,670	5.0	36,113	45,698
Town	Cupar	420	235	56.0	210	0	0	33,972	30,701
	Fort Qu'Appelle	1,880	955	50.8	910	40	4.2	23,545	33,133
	Nokomis	335	160	47.8	130	25	15.6	24,842	32,776
	Raymore	475	320	67.4	310	0	0	29,050	33,076
	Southey	660	375	56.8	365	0	0	34,885	40,392
	Strasbourg	635	350	55.1	350	0	0	23,509	29,906
Village	Bulyea	50	30	60.0	25	0	0	-	-
	Duval	40	30	75.0	30	0	0	-	-
	Punnichy	180	60	33.3	60	0	0	-	-
	Quinton	85	20	23.5	25	0	0	-	-
	Silton	50	30	60.0	30	0	0	-	-
Resort Village	Etters Beach	55	40	72.7	40	0	0	-	-
	Kannata Valley	110	70	63.6	55	0	0	-	-
	Saskatchewan Beach	130	80	61.5	80	0	0	-	-
Socio-economic LSA Total		**164,865**	**117,800**	**71.5**	**111,755**	**5,955**	**5.1**	**n/a**	**n/a**
Saskatchewan (Socio-economic RSA)		**812,505**	**562,310**	**69.2**	**529,100**	**33,210**	**5.9**	**31,408**	**40,798**

Source: Statistics Canada 2013d to 2013ac.
LSA = local study area; % = percent; $ = dollars; No. = number; - = not available; RSA = regional study area.

16.3.2.3.5 Aboriginal Population

Aboriginal people in the socio-economic LSA and Saskatchewan comprise one of the largest potential pools of future workers that could meet labour force demands; increased participation in the labour force has the potential to improve socio-economic conditions for Aboriginal people. The Aboriginal population represents 15.6% of the Saskatchewan population and 9.9% of Regina's (Statistics Canada 2013m,ab,ac,a). However, the 9,880 and 1,085 unemployed Aboriginal people in Saskatchewan and Regina, respectively, represent 29.8% and 19.1% of the unemployed people in Saskatchewan and Regina (Statistics Canada 2013m,ab,ac,ae). Approximately 45,000 Aboriginal people 15 years of age and over in Saskatchewan and 3,800 in Regina are not in the labour force (Statistics Canada 2013ac,a).

Proactive training to teach awareness about and find solutions to potential skills barriers (e.g., little work experience or limited understanding about how to access the job market) would aid in increasing Aboriginal workforce participation (Golder 2013). Several local technical schools and colleges work directly with industry employers to educate students about programs and requirements and to recruit new graduates. Employment centres serving the Aboriginal population on and off reserve are places for employers to educate potential staff about their training needs and to identify the means to build confidence and momentum in the workforce, effectively tapping into the potential of the Aboriginal workforce (Golder 2013).

16.3.2.3.6 Labour Force Demand Projections

Current labour force demands in Saskatchewan suggest an increase of 20,000 jobs per year (i.e., 75,000 to 90,000 new jobs) by 2015 (Saskatchewan Ministry of the Economy 2013). Regina is expected to require a population of approximately 250,000 people to meet labour force requirements by 2020, which would require an addition of approximately 4,000 people per year (DCMA 2010). In 2009, Sask Trends Monitor predicted that the Saskatchewan Immigrant Nominee Program would increase immigrant numbers sufficiently to provide skilled labour that would meet labour force demand until 2013 (STM 2009). After that, to meet labour force requirements, a combination of net positive in-migration to the province and increased participation of underrepresented groups will be required. In particular, the Saskatchewan Labour Market Commission identifies Aboriginal people as the largest potential pool of workers (SLMC 2009). The labour force could be bolstered by encouraging older workers to remain in the workforce, increasing the number of highly skilled and experienced immigrants, and encouraging more women to join the workforce.

16.3.2.4 Real Estate and Housing

Real estate and housing in the socio-economic LSA outside of Regina is mainly made up of single detached homes (Statistics Canada 2012a to 2012bk). In the socio-economic LSA, there were 93,554 private dwellings recorded in the 2011 census, of which 83,179 are in Regina (Statistics Canada 2012a to 2012bk). Many of the communities are within commuting distance of Regina and some residents commute to work in Regina daily. Many resort villages and organized hamlets have a high percentage of homes that are "not occupied by the usual residents". This suggests that these communities have a high proportion of rental properties, likely cabins, and summer homes. The housing market in the R.M.s in the socio-economic LSA is not growing as rapidly as that in Regina; however, because most communities are commuting distance to Regina and many seasonal properties are located on Last Mountain Lake, a relatively active market is still found in these communities.

16.3.2.4.1 Regina

Many Project workers probably will commute from Regina to the Project site. The combination of a strong economy and labour shortage in Regina and the resulting influx of people coming to Regina have resulted in a real estate boom, with increasing house values and low vacancy rates. On-going demand for rental and owned housing in Regina makes finding homes difficult for new residents. With Regina's population projected to grow relatively rapidly over the next 25 years, the City of Regina intends to direct at least 30% of population growth into existing neighbourhoods and to increase the availability, affordability, and variety of homes (City of Regina 2013). The City of Regina hopes this may be accomplished by increasing apartment buildings and multi-family dwellings in existing neighbourhoods, perhaps through building incentives (City of Regina 2013).

Regina Housing

If the demand for housing becomes greater than the supply, the resulting high prices and low vacancy have the potential to act as a barrier to population growth and attracting skilled labour. Fortunately, Regina's housing supply has been expanding rapidly to meet demand. Housing starts (i.e., number of new homes under construction) were above 3,000 in 2012 and 2013, which is three times higher than the 30-year average (RROC 2014). According to the Canada Mortgage and Housing Corporation (CMHC 2013a), the demand and supply of resale houses in Regina was balanced in 2013, likely because of the rapid increase of housing starts. In 2013, construction began on 1,026 single houses and 1,860 multiple family dwellings in Regina, a decrease of 2.5% in the number of starts for single houses and an increase of 5.1% in the number of multiple family dwellings (CMHC 2014a). In comparison, communities in the surrounding area saw a decrease of 7.2% in single house starts and a decrease of 52.9% in the number of multi-family dwellings (CMHC 2014a).

With the rapid construction of housing starts and the recent slowdown of the economy, supply is beginning to outpace demand (CMHC 2015). As a result, the number of housing starts declined in 2014 and is expected to do so again in 2015; however, it will remain positive, with an expected 2,150 housing starts in 2015 (CMHC 2014b). The City of Regina intends to direct some housing growth into existing neighbourhoods to prevent urban sprawl. In Regina, approximately 25% of new house construction is in existing neighbourhoods and 75% is in new neighbourhoods (City of Regina 2013). Derek Murray Consulting and Associates (DMCA 2010) predicted a continued demand for housing starts in Regina over the next two decades (Table 16.3-9). Even with the recent economic slowdown, housing starts are expected to continue to be in demand.

Table 16.3-9: Regina - Projected Housing Demand, 2014 to 2035

Growth Projection Model	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
High	1,960	1,961	1,962	1,962	1,962	1,945	1,936	1,919	1,911	1,894	1,878
Medium	1,549	1,415	1,222	1,222	1,213	1,131	1,122	1,105	1,088	1,079	1,070
Low	583	564	500	500	500	500	500	500	500	500	500
Growth Projection Model	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
High	1,870	1,852	1,836	1,828	1,812	1,804	1,789	1,782	1,774	1,767	1,759
Medium	1,044	1,028	1,019	1,002	994	970	962	945	929	912	896
Low	500	500	500	500	500	500	500	500	500	500	500

Source: DCMA 2010.

Regina House Prices

Housing prices have climbed rapidly in the past decade since the beginning of the economic boom in Saskatchewan. During the initial years of the real estate boom, the number of house sales in Regina increased by 30% between 2007 and 2011, while the average price of a home (including detached, semi-detached, and multi-family) increased from $130,000 in 2006 to $270,000 in 2011 (i.e., an increase of 107.7% over 6 years) (Golder 2013). Between March 2009 and March 2014, the Regina housing market experienced an overall increase in the House Price Index of 30.5% (Home Price Index 2014).

More recently, the average price of a resale home (including detached, semi-detached, and multi-family) in Regina was $314,899 in December 2014, an increase of 0.8% from $312,355 in 2013 (CMHC 2015). Housing prices actually experienced a small decrease between December 2013 and March 2014, possibly due to a long, cold winter, before rising again by December 2014 (Globe and Mail 2014b; Home Price Index 2014). Rapid development and the economic slowdown have resulted in a high volume of resale homes (Globe and Mail 2014b). Nonetheless, resale prices are expected to continue to grow moderately through 2016, forecast to rise to $322,500 in 2015 and $326,500 in 2016 (CMHC 2014b).

Although other housing types (e.g., multi-family dwellings or apartments) have been increasing in number in Regina, single detached homes account for approximately two-thirds of dwellings (STM 2008). The average price of single, detached resale homes has been increasing somewhat more rapidly than for other types of resale homes. In December 2013, the average price of a single, detached resale home was $491,292, an increase of 6.3% from 2012 (CMHC 2014a). In December 2014, the average price of a single, detached resale home was $514,165, a further increase of 4.7% from 2013 (CMHC 2015).

Regina Rental Market

The rapid rise in population in the city has had a strong effect on the rental market, with rent increasing rapidly in comparison to income. For several years, the vacancy rate in the city has been low. Recently, a new tax incentive for constructing rental properties has alleviated the pressure on the rental market slightly and the vacancy rate in Regina rose from 1.0% in October 2012 to 1.8% in October 2013 (CMHC 2013a,b). The vacancy rate is forecast to rise to 2.4% by October 2015 (CMHC 2014a). The average monthly rent for a two-bedroom apartment in Regina was $1,018 in October 2013, up 4.0% from October 2012 (CMHC 2014c). The overall average monthly rent in Regina increased by 4.1% from fall 2012 to fall 2013, with the greatest increase in one bedroom apartments (CMHC 2013a). However, these numbers include rented and vacant apartments, while the average price for vacant apartments is likely much higher than the overall average due to demand (Golder 2013).

16.3.2.5 Services and Physical Infrastructure

With Saskatchewan and Regina’s population expected to continue to increase over the coming decades, there will be increased pressure on services and physical infrastructure in the Province and the socio-economic LSA. The Saskatchewan Labour Market Commission (SLMC 2009) predicts that an increase in population of approximately 200,000 to 300,000 will be required from 2010 to 2020 to meet labour demand. This is a notable increase to the provincial population and Regina may reach a population of 300,000 or more, an increase of 55.4% or more from the 2011 population. This would require the maintenance and improvement of existing infrastructure and services and the expansion and creation of new infrastructure and services. From January

2013 to January 2014, the Regina consumer price index rose 2.4%, in comparison to the 1.5% increase seen nationally; suggesting living expenses are rising rapidly in Regina (Statistics Canada 2014e).

16.3.2.5.1 Health and Social Services

Health and social services are managed by the Government of Saskatchewan. The Ministry of Social Services offers a variety of programs including child protection, adoption and foster care programs, housing programs, income assistance, youth services, and programs and services for seniors and people with disabilities (Government of Saskatchewan 2014e).

The socio-economic LSA is located in the Regina Qu'Appelle and Saskatoon health regions. Saskatoon Health Region (SHR) facilities in the socio-economic LSA include a health centre and a special care home in Strasbourg and a health centre with attached special care home in Nokomis (Saskatchewan Health 2007; SHR 2014). Regina Qu'Appelle Health Region (RQHR) facilities in the socio-economic LSA include hospitals in Regina and Fort Qu'Appelle; a hospital with attached special care home in Lestock; health centres in Raymore, Cupar, Regina, and Fort Qu'Appelle; a health action centre in Southey; an addiction treatment centre in Regina; and special care homes in Lumsden, Cupar, Raymore, Fort Qu'Appelle, and Regina (Saskatchewan Health 2007). Other medical clinics are located in Lumsden, Regina Beach, Semans, Fort Qu'Appelle, and Regina (RQHR 2014b; Town of Regina Beach 2014; Village of Semans 2014; Town of Fort Qu'Appelle 2014; City of Regina 2014; Town of Lumsden 2014).

George Gordon First Nation is working with the federal Minister of Health, First Nations, and Inuit Health Branch as a Health Plan Demonstration Site (George Gordon First Nation 2014). This is part of Health Canada's First Nations and Inuit Health Strategic Plan, which involves collaboration with First Nations and Inuit groups as well as other government agencies and partners to achieve strategic goals (Health Canada 2012). In George Gordon First Nation, this process led to the development of a Community Health Plan, and a meeting in 2011 identified key topics including children and youth, population and wellness, healthy living, freedoms from addictions, and effective management. In 2011, the health committee identified mental wellness as a gap and created the Community Family Wellness Program, which is designed to address wellness needs from a traditional medicine wheel perspective.

The SHR and RQHR are the largest and busiest health regions in Saskatchewan and currently are working towards a target of a less than 3-month waiting period for most surgery (Government of Saskatchewan 2014f). Between August 1 and October 31, 2014, 85.9% and 79.4% of surgeries in the SHR and RQHR, respectively, were performed or offered within 3 months (Government of Saskatchewan 2014g). The SHR experienced a spike in demand for surgeries in 2013, which made it more difficult to meet the target (Government of Saskatchewan 2014f). The Regina General Hospital and Pasqua Hospital in the RQHR generally operate at or above 100% capacity, but are working to reduce occupancy levels to below 100% (RQHR 2014c). When capacity is over 100%, the hospitals use overflow space or cancel non-emergency procedures that would have required beds for patients (RQHR 2014c). For example, October 11, 2013, capacity at the Regina General Hospital and Pasqua Hospital was at 111% and 114%, respectively and the RQHR postponed a number of elective surgeries and procedures (RQHR 2013a). The steady increase in population over the past several years has increased pressure on health care in the area. In a recent presentation on the RQHR strategic plan, business plan, and supporting operating budget (RQHR 2015), RQHR identified several challenges, including infrastructure deficiencies, and a 7.9% (21,113) increase in patients and a 7.25% increase in cost ($80.9 million) between 2010 and 2014 because of population and demographic changes. Expanded health care services and additional facilities will be required to meet the demand for health care if populations continue to increase over the next two decades as predicted.

16.3.2.5.2 Emergency and Protective Services

The three main emergency and protective services are ambulance and EMS response, fire services, and police services. Because the socio-economic LSA is a relatively rural area with a low population, many of the communities have mutual aid agreements for shared services.

Ambulance and EMS services are located in Fort Qu'Appelle, Regina, and Strasbourg (Town of Fort Qu'Appelle 2014; City of Regina 2014; Town of Strasbourg 2014; Town of Cupar 2014). In addition, Govan, Cupar, Lumsden, Southey, and Saskatchewan Beach, have volunteer first responders or ambulances that will respond to emergencies in the area (Town of Cupar 2014; Town of Govan 2014; Town of Lumsden 2014; Town of Southey 2014; Village of Lestock 2014; Resort Village of Saskatchewan Beach 2014).

Police services in the socio-economic LSA include the Regina Police Service, which has jurisdiction within city boundaries, and the Royal Canadian Mounted Police (RCMP). Royal Canadian Mounted Police detachments are located in Strasbourg, Southey, and Lumsden (Town of Strasbourg 2014; Town of Southey 2014; Town of Lumsden 2014). The RCMP in these communities or communities outside the socio-economic LSA performs daily or weekly patrols and emergency response to the remaining communities in the socio-economic LSA. First Nations communities rely on the RCMP, although some First Nations communities also have local peacekeepers.

Fire services in the socio-economic LSA include the Regina Fire and Protective Service and numerous local volunteer organizations and agreements between communities. Communities with volunteer fire departments and fire trucks or pumper trucks include Cupar, Semans, Fort Qu'Appelle, Govan, Lumsden, Nokomis, Southey, Strasbourg, Lestock, and Silton (Town of Cupar 2014;, Village of Semans 2014; Town of Fort Qu'Appelle 2014; Town of Govan 2014; Town of Lumsden 2014; Town of Nokomis 2014; Town of Southey 2014; Town of Strasbourg 2014; Village of Lestock 2014; Resort Village of Saskatchewan Beach 2014).

16.3.2.5.3 Education

In 2011, the Regina Public School Division was not operating at capacity and Regina Public and Catholic schools were expected to be able to accommodate increased enrollment (Golder 2013). Since then, enrollment has increased and the school divisions appear to be operating closer to capacity, but not yet over capacity. For the 2015/2016 school year, the Regina Public School has implemented a new policy that designates which high school the students will attend, based on where they live (CBC 2015). The Regina Public School Division is predicting an increase of 2,500 high school students by 2023, and this change is partly to spread the student population between all the available schools (CBC 2015). In past years, some schools have been operating at maximum capacity while others are under capacity (Global News 2015; Leaderpost 2015b). The Regina Catholic School Division currently is able to meet demand and is not implementing a similar policy at this time (Leaderpost 2015b).

Elementary and secondary education in the socio-economic LSA is divided into different school divisions. The northern portion of the socio-economic LSA is in the Horizon School Division. Horizon School Division schools in the socio-economic LSA have approximately 985 students and include elementary schools in Bulyea and Punnichy, pre-kindergarten or kindergarten to grade 12 schools in Nokomis, Raymore, and Strasbourg, and a high school in Punnichy (Horizon School Division 2014). Semans had a school, the Margaret McClumb School, which closed in 2004 and now the students from that area are bussed to Raymore (Village of Semans 2014). Lestock students are bussed to Kelliher, outside the socio-economic LSA (Village of Lestock 2014). In addition to the kindergarten to grade 12 school, Strasbourg has the Strasbourg Tiny Tots and Helping Hands Daycare, which has been open since 2007 (Town of Strasbourg 2014).

Communities in the central and southern portions of the socio-economic LSA are in the Prairie Valley School Division. Prairie Valley School Division schools in the socio-economic LSA have approximately 2,065 students and include elementary schools in Fort Qu'Appelle, Lumsden, and Regina Beach, kindergarten to grade 12 schools in Cupar and Southey, and high schools in Fort Qu'Appelle and Lumsden (PVSD 2014). Lumsden has the Lumsden Community Playschool (Town of Lumsden 2014). Regina Beach has the Castle and Dreams Pre-school and students attend high school in Lumsden (Town of Regina Beach 2014). Students attending Bert Fox High in Fort Qu'Appelle include those from Pasqua First Nation, Standing Buffalo First Nation, Starblanket First Nation, and Muscowpetung First Nation (PVSD 2014). Students attending Punnichy Community High School in Punnichy include those from Daystar First Nation, George Gordon First Nation, and Muskowekwan First Nation (Horizon School Division 2014).

Elementary schools are located in Muskowekwan First Nation, George Gordon First Nation, and Muscowpetung First Nation, and combined elementary and high schools in Kawacatoose First Nation, Piapot First Nation, and Pasqua First Nation. Pasqua First Nation has a Stay in School/Youth Development Coordinator who provides an allowance for monthly attendance and works on finding grants or donations for training coaches and referees so sports teams can play (Pasqua First Nation 2014). George Gordon First Nation has an education coordinator who delivers education and training services in the community (George Gordon First Nation 2014). The new George Gordon Child Care Centre opened in 2013 (George Gordon First Nation 2014).

In Regina, elementary and secondary schools belong to the Regina Public School Division, the Regina Catholic School Division, or the Consel des École Fransaskoises. The Regina Public School Division has over 20,000 students in 41 public elementary schools (kindergarten to grade 8) and nine public high schools (grade 9 to grade 12) (RPSD 2014). Six elementary schools and two high schools offer French immersion programs. The Regina Public School Division has three faith-based, associate high schools and one adult campus high school. The Regina Catholic School Division has approximately 10,000 students in 24 elementary schools (kindergarten to grade 8) and four high schools (grade 9 to grade 12) (RCSD 2014). The Regina Catholic School Division has three alternate schools. Four of the elementary schools and two of the high schools offer French immersion programs. The Regina Catholic School Division has approximately 10,000 students. The Conseil des École Fransaskoises is a French-language school system that operates Fransaskois schools in Saskatchewan (CEFSK 2014). The Conseil des École Fransaskoises has one school, the École Monseigneur de Laval (pre-kindergarten to grade 12), in Regina with approximately 390 students.

Because most of communities in the socio-economic LSA are relatively small, most of the post-secondary education opportunities are in Regina. However, Carleton Trail Regional College has a campus in Southey, where they offer classes or programs in business and professional development, computers and technology, academic upgrading, health and safety, industry and trades, health care, human services, personal interest, and classes for newcomers to Canada (CTRC 2014). Similarly, Parkland College has a Fort Qu'Appelle location (Parkland College 2014) that offers degree, certification or first year programs in business, science, trades, education, health care, fire protection, journalism, engineering, social work, veterinary medicine, and others.

Post-secondary training in Regina is offered at the First Nations University, the Gabriel Dumont Institute of Applied Sciences, SIIT, Saskatchewan Polytechnic, the University of Regina, and other colleges and schools. Each of these schools offers technical training in a variety of fields and formats. Saskatchewan Polytechnic and SIIT offer courses focusing on industry requirements. In addition to programs in business and information technology, health, and trades and industrial, SIIT has industrial career centres. These centres offer career services including job coaching, technical training, career planning and counselling, and academic upgrading. Both SIIT and Saskatchewan Polytechnic work with industry to identify knowledge gaps and to provide training to meet demands on the labour force. A specific program can be developed to train students for careers in upcoming fields based on industry knowledge and plans. Programs at Saskatchewan Polytechnic relevant to employment for the Project may include electrical, civil, water resources, environmental engineering, natural resource management, electronics, and geomatics. Saskatchewan Polytechnic works directly with industry members and regional colleges to offer in-demand training in rural and remote communities (Golder 2013). In 2011, a Saskatchewan Polytechnic (formerly SIAST) Graduate Employment Survey found that the graduates from the 2010 to 2011 terms had an employment rate of 93% and a full-time job related to the field of study employment rate of 61% (SIAST 2012). The 2010 to 2011 Aboriginal graduates had an employment rate of 90% and a full-time job related to the field of study employment rate of 60% (SIAST 2012).

16.3.2.5.4 Water and Waste Management

Water and waste management often is managed in joint ventures between communities. Many of the smaller communities get water from aquifers in the area (Village of Dysart 2014). Regina receives its water from the Buffalo Pound Water Treatment Plant and disperses the water to over 60,000 customers by way of 900 km of water mains (City of Regina 2014). Wastewater is sent to the wastewater treatment plant, while storm water is collected and drained into Pilot Butte Creek and Wascana Creek (City of Regina 2014). Currently, Regina is upgrading the wastewater treatment plant to meet new regulations, to improve water quality for downstream users, and to meet the needs of the growing population in Regina (City of Regina 2014).

Many of the communities in the socio-economic LSA share landfills, such as the Last Mountain Regional Landfill, which services Bulyea, Earl Grey, Glen Harbour, Island View, Pelican Pointe, Rowan's Ravine, Saskatchewan Beach, Silton, Strasbourg, Sunset Cove, and R.M.s 219, 220, and 250 (Town of Strasbourg 2014). Regina operates residential garbage collection and has a landfill that serves the city and surrounding area (City of Regina 2014).

16.3.2.5.5 Transportation Infrastructure and Traffic

Saskatchewan (socio-economic RSA) has over 190,000 km of highway and roads (Ward 2009). The socio-economic LSA has a relatively low-density population, but nonetheless has an extensive network of paved and gravel roads that divide the area into a grid pattern (Figure 16.3-1). The main north-south travel route is Highway 6, between Regina and Highway No 16, north of the socio-economic LSA.

Traffic levels in the socio-economic LSA have increased over the past ten years (Table 16.3-10). Between 2003 and 2005 there was a small decrease in traffic on many roads, followed by a gradual increase in traffic between 2006 and 2009 and a sharp increase in traffic between 2009 and 2010. Traffic increases between 2003 and 2012 ranged from 5.3% on Highway 20 between Strasbourg and Govan to 65.6% on Highway 6 north of Southey. Between 2011 and 2012, traffic on Highway 6 remained the same or decreased up to 9.0% north of Regina, traffic on Highway 20 increased by approximately 4 to 5%, Highway 15 increased by 71.4% near

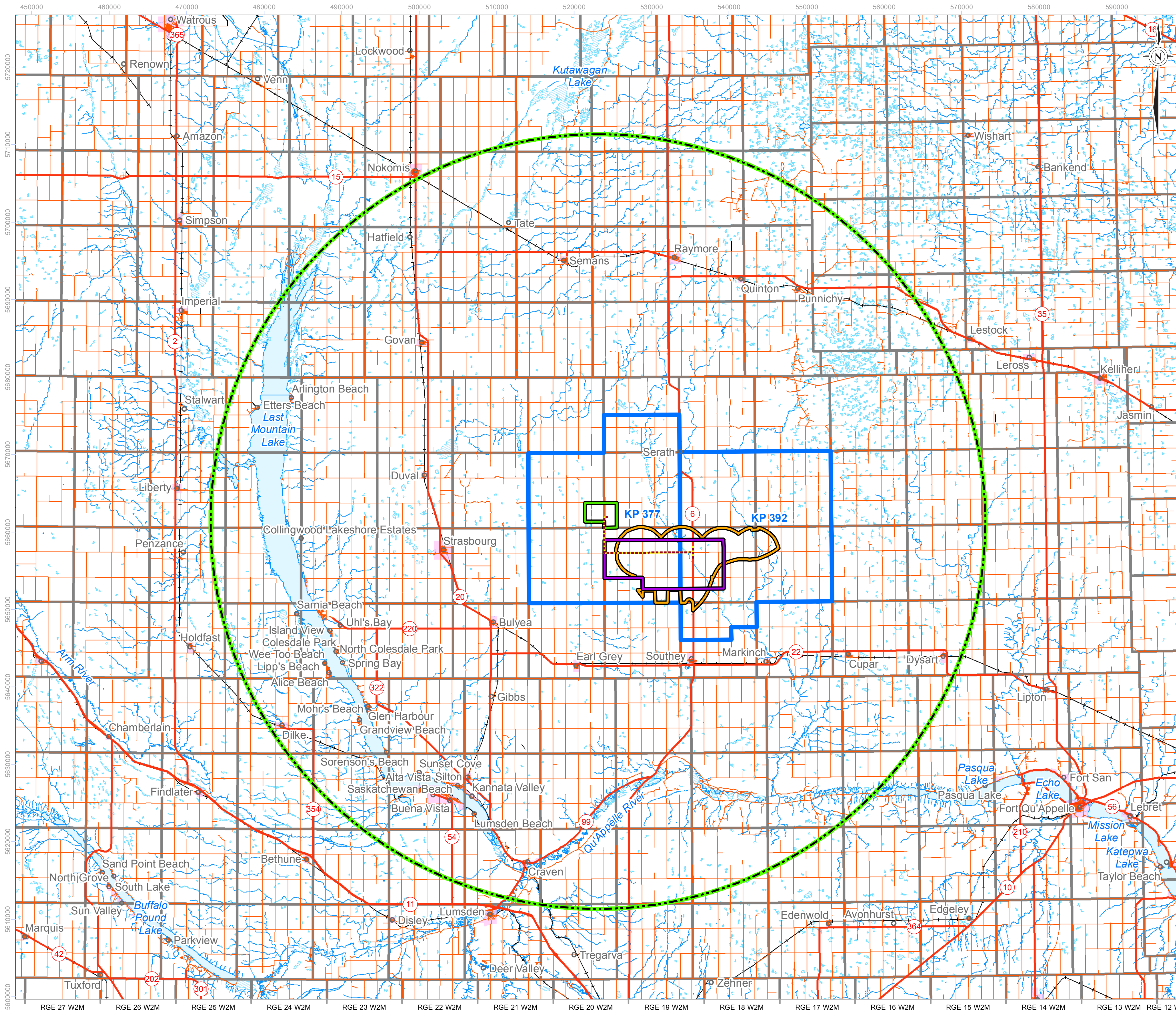
Highway 20, and traffic on Highway 22 decreased by 22.2% east of Southey. Highway 99 and 220 traffic was the same between 2011 and 2012, but Highway 322 increased by 7.4%.

Year-to-year increases and decreases can be influenced by a variety of factors. For example, a construction project may cause a temporary increase of traffic or road construction could cause a decrease in traffic on an individual road and an increase on alternative routes in the area. Similarly, the communities on Last Mountain Lake are dependent on tourism and recreation, so the strength of the market and willingness of people to rent summer homes and cabins would increase the traffic in the area. The steady overall increase in traffic over the ten-year period suggests an increasing population and increased use of the socio-economic LSA.

16.3.2.5.6 Tourism and Recreation

Many or most of the individual communities in the socio-economic LSA have a library, a credit union, a skating rink, a recreation or fitness centre, and ball diamonds. Common local recreation activities include softball, curling clubs, badminton programs, and hockey. Regina has many parks and recreation areas, including fitness and leisure centres (City of Regina 2014).

Tourism and recreation in the socio-economic LSA includes several campgrounds, golf courses, and provincial or regional parks, as well as an interpretive/viewing area on Last Mountain Lake and several cross-country skiing and hiking trails (U of S 1999). Summer recreation and tourism activities include swimming, sailing, hiking, boating, fishing, water skiing, playing horseshoes, and going to the beach, playground, or picnic sites. Winter recreation and tourism activities include snowmobiling, ice fishing, skating, and cross-country skiing. Last Mountain Lake has outfitters present to provide hunting and fishing guidance and expertise, including G&S Marina Outfitters in Rowan's Ravine Provincial Park and Last Mountain Lake Outfitters in Strasbourg (G&S Marina 2013, LML Outfitters 2011).



LEGEND

- COMMUNITY
- HIGHWAY
- ROAD
- RAILWAY
- TOWNSHIP AND RANGE BOUNDARY
- URBAN MUNICIPALITY
- PROPOSED ACCESS ROAD
- PERMIT BOUNDARY
- 65 YEAR MINE FIELD
- CORE FACILITIES AREA
- INDICATED RESOURCE BOUNDARY
- SOCIO-ECONOMIC LOCAL STUDY AREA

REFERENCE

PERMIT BOUNDARY: POTASH DISPOSITION © 2012, GEOLOGICAL ATLAS OF SASKATCHEWAN, MINISTRY OF ENERGY AND RESOURCES SASKATCHEWAN
INFRASTRUCTURE DERIVED FROM AMEC DRAWING NO. 100110-2000-DD10-GAD-0002 REV. B
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SCALE 1:500,000 KILOMETRES

PROJECT
YANCOAL 兖煤加拿大资源有限公司
YANCOAL SOUTHEY PROJECT

TITLE
SOCIO-ECONOMIC BASE CASE LOCAL STUDY AREA TRANSPORTATION INFRASTRUCTURE

Golder Associates
Saskatoon, Saskatchewan

PROJECT	12-1362-0197	FILE No.
DESIGN		SCALE AS SHOWN REV. 0
GIS	SBM 04/05/15	FIGURE: 16.3-1
CHECK	CF 21/05/15	
REVIEW	BC 21/05/15	

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Table 16.3-10: Average Annual Daily Traffic Volumes in the Socio-economic Local Study Area, 2003 to 2012

Highway	Approximate Location	Average Annual Daily Traffic Volume										% Change 2003 to 2012	% Change 2011 to 2012
		2003	2004	2005	2006	2007	2008	2009	2010	2011	2012		
No. 6	North of Regina	3,600	3,520	3,500	3,760	3,600	3,600	3,600	4,660	4,660	4,240	17.8	-9.0
	South of Southey	2,300	2,220	2,200	2,200	2,200	2,200	2,450	2,910	2,910	2,910	26.5	0.0
	North of Southey	1,280	1,260	1,240	1,250	1,290	1,640	1,640	1,680	2,270	2,120	65.6	-6.6
	South of Raymore	1,310(a)	1,300(a)	1,275(a)	1,285(a)	1,355	1,350(a)	1,410(a)	1,415(a)	1,500	1,470(a)	12.2	-2.0
	North of Raymore	1,090	1,190	1,160	1,170	1,280	1,280	1,160	1,270	1,270	1,190	9.2	-6.3
No. 20	North of Lumsden	2,510	2,440	2,790	2,760	2,610	2,610	2,860	3,040	3,020	3,160	25.9	4.6
	Between Highways 99 and 322	1,660(a)	1,625 (75)(b)	1,695 (85)(b)	1,660	1,755 (105)(b)	1,765 (115)(b)	1,930 (120)(b)	2,120 (130)(b)	2,105 (125)(b)	2,205 (130)(b)	32.8	4.8
	South of Highway 22 Junction	710	690	660	650	780	780	890	970	1,030	1,080	52.1	4.9
	Between Strasbourg and Govan	750	680	720	610	610	610	610	660	760	790	5.3	3.9
	North of Govan	410	320	290	300	300	300	300	510	510	530	29.3	3.9
No. 15	East of Highway 20 Junction	190	130	120	130	130	130	130	140	140	240	26.3	71.4
	West of Raymore	490	560	550	590	590	570	530	570	570	600	22.4	5.3
	East of Raymore	580	570	570	600	740	740	740	710	810	730	25.9	-9.9
No. 22	East of Highway 20 Junction	200	240	210	210	210	210	210	210	230	230	15.0	0.0
	East of Southey	690	690	720	720	790	770	770	800	940	750	8.7	-20.2
	West of Highway 35 Junction	410	410	390	400	400	400	410	410	620	620	51.2	0.0
No. 99	East of Highway 20 Junction	110	150	150	150	150	150	170	170	180	180	63.6	0.0
No. 322	Northwest of Highway 20 Junction	515(a)	505(a)	520(a)	530(a)	560(a)	590(a)	645(a)	665(a)	675(a)	725(a)	40.8	7.4
No. 220	West of Highway 20 Junction	140	210	170	170	170	180	210	190	190	190	35.7	0.0

Source: Saskatchewan Highways and Transportation 2005, 2007, 2009, 2011, 2013.

Note: the Average Annual Daily Traffic numbers come from an estimated annual total of traffic on a highway, with vehicles counted in both directions, divided by 365.

(a) These numbers are calculated from a continuous count, where a permanent sensor is used to collect daily data.

(b) These numbers are from a continuous classification count – numbers in brackets are the AADT of trucks.

% = percent: AADT = Average Annual Daily Traffic.

Golf courses include the San Green 9-Hole Golf Course near Strasbourg, the Bulyea Eddy Golf Course east of Bulyea, and two golf courses near Lumsden and Fort Qu'Appelle (Town of Strasbourg 2014; Town of Lumsden 2014; Town of Fort Qu'Appelle 2014; SaskParks 2014a). Lumsden has a petting zoo, as well as numerous nearby camps and retreats such as the Dallas Valley Ranch Camp, Lumsden Beach Camp, St. Michael's Retreat, and the Beaver Creek Ranch and Horse Centre (Town of Lumsden 2014). Numerous museums, a provincial historical site, and several handicraft, antique, or teashops are located in the socio-economic LSA (U of S 1999). Local museums include the Cupar Heritage Museum, the Lumsden Historical Museum, the Southey and District Museum, the Strasbourg and District Museum, the Dysart Museum, and the Lakeside Heritage Museum and the Last Mountain Lake Cultural Centre in Regina Beach (Village of Dysart 2014; Town of Strasbourg 2014; Town of Southey 2014; Town of Lumsden 2014; Town of Cupar 2014; SaskParks 2014b). Festivals in the area include the Govan Fiddle Festival, the Great Pumpkin Scarecrow Festival in Lumsden, and the Last Mountain District Music Festival organized each year by the towns of Strasbourg, Raymore, Southey, and Earl Grey (Town of Govan 2014; Tourism Saskatchewan 2014; LMDMF 2014).

The following recreation destinations are located in the socio-economic LSA.

- Rowan's Ravine Provincial Park offers beaches, water sports, sailing, fishing, mini-golf, baseball, a hiking trail, and camping and cabins (SaskParks 2014a) and hosts the Last Mountain Fall Walleye Classic annually in September.
- Last Mountain House was built in 1869 by the Hudson's Bay Company (HBC) and used as a HBC post for a short time before the fur trade ended. Last Mountain House Provincial Park offers tours of historical buildings, a hiking trail, and winter education opportunities for schools (SaskParks 2014c).
- Valeport Marsh offers a picnic site and access to the Qu'Appelle River in an area that attracts thousands of shorebirds during migrations periods; nearby is a corn maze, paint ball, and market gardens near Highway 20 between Lumsden and Craven (SaskParks 2014a).
- Touchwood Hills Post (in Touchwood Hills Post Provincial Park) was built in 1879 by the HBC and includes a depressed cellar area and a commemorative plaque (SaskParks 2014d).
- Last Mountain Regional Park offers a beach, campground, playground, swimming pool, fishing, golfing, and hiking (Regional Parks of Saskatchewan 2010).
- Regina Beach Recreation Site offers a beach, volleyball, swimming, and picnic sites within the town of Regina Beach, which has restaurants, shops, a yacht club, and walking trails (SaskParks 2014b).
- The northern portion of Last Mountain Lake was set aside for migratory bird breeding in 1887, as the first federal bird sanctuary; over 280 bird species have been identified on Last Mountain Lake and this area is a common destination for tourists and bird-lovers during spring and fall (Environment Canada 2013).

Temporary accommodation is scattered throughout the communities of the socio-economic LSA, but is available in the largest quantities in the largest communities, Regina and Fort Qu'Appelle. Year-round tourists, visitors, and temporary workforce may rely largely on temporary accommodation in Regina, with dozens of hotels with several thousand rooms. North of Regina, a small number of hotels and motels are found in larger communities. Resort communities along Last Mountain Lake are more likely to have hotels, motels, or rental properties

(U of S 1999). Many smaller communities have campgrounds, including River Park Campground in Lumsden, Nokomis Campground (Regina Beach), Butler's Campground, Lions Park Campground (Strasbourg), and Etters Beach Recreation Site. Arlington Beach Camp and Conference Centre is a private facility on the north shore of Last Mountain Lake (Arlington Beach Camp 2014). It has two main buildings that can accommodate up to 100 people, as well as 78 recreational vehicle (RV) sites for campers. Many of the communities along the shores of Last Mountain Lake are resort communities. These communities have small year-round populations, but receive an influx of residents every summer. For example, approximately 36 people reside year-round at Island View, but in summer the population increases to 210 residents (Island View 2014).

16.3.2.6 Traditional and Non-traditional Land Use

16.3.2.6.1 Traditional Land Use

People have been residing in the plains of southern Saskatchewan for more than 12,000 years. The first inhabitants were nomadic hunters and gatherers who relied heavily on bison herds (Walker 1999). Near the traditional and non-traditional land use RSA, Aboriginal people would have moved through the Qu'Appelle Valley hunting, trapping, and gathering plants and eggs (Mandelbaum1979). The arrival of Europeans and the establishment of the fur trade had various impacts on the Aboriginal people in the traditional and non-traditional land use RSA and led to a more sedentary lifestyle. However, it was not until the introduction of the Treaties between 1871 and 1906 that most Aboriginal people were required to settle on Reserves. The Project is located in the Treaty Four region, which was signed in 1874 in Fort Qu'Appelle. First Nations communities began to settle on the Reserve lands that were allocated to them as part of the Treaty in the years following the signing of Treaty Four. European settlers began arriving in the traditional and non-traditional land use RSA in the mid- to late-1800s, enticed by the availability of good agricultural land. The Treaty system, as well as the introduction of privately owned land and agricultural practices, changed the landscape, and greatly restricted the ability of First Nations people to practice their traditional activities.

Traditional land use interviews were held in May and June 2014 with 56 Elders and community members from Muscowpetung First Nation, George Gordon First Nation, Day Star First Nation, Piapot First Nation, and Kawacatoose First Nation. Participants identified a variety of traditional activities that occur in the traditional and non-traditional land use RSA, including hunting and gathering of numerous animals and plants. The participants identified that, in the early 1900s, hunting, fishing, trapping, camping, and gathering eggs, plants, and berries were common activities carried out in the traditional and non-traditional land use RSA. Hunting and trapping included deer, elk, moose, muskrat, beaver, weasel, mink, coyote, fox, rabbit, prairie chicken, goose, and duck. Duck, mudhen, prairie chicken, and goose eggs were gathered. Fishing was carried out on the creeks in the region. Historically, 100% of the meat consumed by First Nations people was collected through hunting, trapping, and fishing.

Berries that were picked include blueberry, fig berry (cactus berry), buffalo berry, red berry, black currant, snake berry, cranberry, Saskatoon berry, chokecherry, pin cherry, raspberry, strawberry, and gooseberry. Plants gathered include sage, sweetgrass, Seneca root, black root, cattail, frog leaf (plantain), wild mint, buffalo grass, kinnikinnick, tobacco, rose hip, wild turnip, wild onion, hazelnut, and rhubarb. Firewood and maple syrup were commonly collected. Historically, plant gathering accounted for 100% of the medicines that were used.

Most interviewed participants agreed that in the early 1900s most traditional activities were practiced; however, this has changed over time. The participants reported that, in recent years, few members of their community practice traditional land use activities. The participants identified many reasons for this change including increased development and exploration, increased agricultural activities in the area, increased use of chemicals on agricultural crops that are harmful to surrounding plants and animals, and increased difficulty in obtaining permission to access private land as many private landowners post no trespassing signs. Government regulations, including changes to gun laws and protection of specific wildlife species have affected the ability of First Nations people to continue their traditional activities. Lastly, the loss of traditional knowledge, loss of interest, and the dependency on modern conveniences have affected these practices, as more people buy their meat, eggs, berries, and medicine from the store and pharmacy.

Most of the participants agreed that, while some traditional land use activities are still carried out in the traditional and non-traditional land use RSA, few or no traditional land use activities are taking place within the traditional and non-traditional land use LSA (Annex V, Section 3.0). However, some of the participants did identify concern for how dust and impacts to the water could have an effect on the larger environment and therefore affect traditional land use activities in the wider region.

The participants were asked if they knew of any historical, archaeological, or significant sites (e.g., graves or other sacred locations) in the traditional and non-traditional land use LSA or RSA. Specific locations were not known, however some of the participants identified campsites, and other archaeological sites that are likely located along creeks in the area or on hills that have not been disturbed by agriculture.

16.3.2.6.2 Non-traditional Land Use

According to the 2011 Census of Agriculture, the primary use of land in the R.M. of Longlaketon and the R.M. of Cupar was agriculture (Statistics Canada 2011a,c). Within the R.M. of Longlaketon in 2011, 91,592 ha was reported for agricultural use (90%); 74% of the agricultural land was used for crop production or summerfallow practices, and 17% was used for pastureland. The most common crops produced in the R.M. of Longlaketon include canola (30%), wheat (25%), alfalfa (9%), and barley (9%). Other crops produced include lentils, oats, peas, other hay and fodder crops, and mustard seed (Statistics Canada 2011c). A total of 228 farms were reported within the R.M. of Longlaketon; 70% of the farms are related to crop production, and 19% are related to livestock production.

Within the R.M. of Cupar in 2011, 80,773 hectares of land were reported for agricultural use (91%); 76% of the agricultural land was used for crop production or summer fallow practices and 15% was used for pastureland. The most common crops produced in the R.M. of Cupar include canola (32%), wheat (22%), and alfalfa (11%). Other crops produced include barley, lentils, oats, flaxseed, peas, other hay and fodder crops, canary seed, and mustard seed (Statistics Canada 2011a). A total of 192 farms were reported within the R.M. of Cupar, of these, 68% are related to crop production, and 21% are related to livestock production (Statistics Canada 2011a).

Almost all of the land within the traditional and non-traditional land use LSA has been cultivated previously and currently is used for crop production. In addition to this cropland, 48 yard sites are currently located within the traditional and non-traditional land use RSA (R.M. of Cupar 2014; R.M. of Longlaketon 2014).

Two provincial highways are located within the traditional and non-traditional land use RSA; Highway 6 runs through the center of the traditional and non-traditional land use RSA and the traditional and non-traditional land use LSA from north to south, while Provincial Highway 22 transects the traditional and non-traditional land use RSA from east to west and is located approximately 6.5 km south of the traditional and non-traditional land use LSA.

The traditional and non-traditional land use LSA is located within Wildlife Management Zones 21 and 38, while the traditional and non-traditional land use RSA is located within Wildlife Management Zones 21, 36, and 38 (MOE 2014a). Wildlife Management Zones 21, 36, and 38 are designated for archery, muzzleloader, crossbow, and rifle hunting. According to the 2014 Saskatchewan Hunters' and Trappers' Guide, the 2014 hunting season for these zones includes moose, mule deer (Zones 21 and 36 only), white tailed deer, elk (Zone 21 only), and black bear (only Zones 36 and 38). The traditional and non-traditional land use RSA and traditional and non-traditional land use LSA are located within the South Game Bird District. This district includes ring-necked pheasants, sharp-tailed grouse, Hungarian partridge, ruffed grouse, dark geese, white geese, sandhill cranes, ducks, coots, and snipe (MOE 2014b). The traditional and non-traditional land use RSA and traditional and non-traditional land use LSA are located within the South Saskatchewan Open Trapping Area. Eligible fur-bearing species expected to occur within the traditional and non-traditional land use LSA include badgers, beavers, bobcat, coyotes, foxes, minks, muskrats, raccoons, skunks, squirrels, and weasels.

16.4 Pathways Analysis

16.4.1 Methods

Pathways analysis identifies and assesses the linkages between Project components or activities, and the correspondent changes to the environment and potential residual effects (after mitigation) on the socio-economic environment. The first part of the analysis is to identify all potential effects pathways for the Project. Each pathway is initially considered to have a linkage to potential effects on the VCs. Potential pathways through which the Project could affect socio-economics were identified from a number of sources including the following:

- a review of the Project Description (Section 4.0) and scoping of potential effects by the environmental and engineering teams for the Project;
- information obtained from community engagement sessions (Section 5.0);
- scientific knowledge and experience with other potash mines in Saskatchewan; and
- consideration of potential effects identified from the TOR.

For an effect to occur there has to be a source (Project component or activity) that results in a measurable change to the environment (pathway or measurement indicator) and a corresponding effect on the VC.

Project activity → change in environment → effect on VC

A key aspect of the pathways analysis is to identify environmental design features and mitigation that might reduce or eliminate potential effects of the Project on socioeconomics. Mitigation has been developed for the Project according to the following hierarchy proposed by the MOE (2014c):

- avoidance;
- minimize (limit);
- restoration; and
- compensation.

Environmental design features include engineering design elements, environmental best practices, management policies and procedures, and spill and emergency response plans. Environmental design features and mitigation were developed as an integral part of the Project's design through an iterative process between the Project's engineering and environmental teams to avoid or mitigate adverse effects identified by the pathways analysis.

After applying environmental design features and mitigation, a screening level analysis is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the Project. This screening step is largely a qualitative assessment and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on socio-economic VCs. Pathways are determined to be primary, secondary (minor), or as having no linkage, using scientific, local and traditional knowledge, logic, experience with similar developments, and environmental design features and mitigation. Each potential pathway is assessed and described as follows:

- **No linkage** – analysis of the potential pathway reveals that there is no linkage or the pathway is removed by environmental design features or mitigation such that the Project would not be expected to result in a measurable environmental change, and would therefore have no residual effect on the socio-economic environment relative to the Base Case or guideline values; or
- **Secondary** – pathway could result in a measurable minor environmental change, but would have a negligible residual effect on the socio-economic environment relative to the Base Case or guideline values and is not expected to contribute to effects of other existing, approved, or reasonably foreseeable projects to cause a significant effect; or
- **Primary** – pathway is likely to result in environmental change that could contribute to residual effects on the socio-economic environment relative to the Base Case or guideline values.

Pathways with no linkage to socio-economics are not assessed further because implementation of environmental design features or mitigation will remove the pathway and result in no measureable change to socio-economics. Pathways that are assessed to be secondary and demonstrated to have a negligible residual effect on socio-economics through simple qualitative or semi-quantitative evaluation of the pathway are not advanced for further assessment. In summary, pathways determined to have no linkage to socio-economics or those that are considered secondary are not expected to result in significant effects on the sustainability of social and economic properties. This indicates that these pathways may improve socio-economic conditions and that the mitigation implemented is expected to reduce negative effects to acceptable levels of change. Primary pathways require further evaluation through more detailed quantitative and qualitative effects analysis (Section 16.5).

16.4.2 Results

Project components and activities, effects pathways and environmental design features and mitigation are summarized in Table 16.4-1. Classification of effects pathways (i.e., no linkage, secondary, and primary) to socio-economics also is summarized in Table 16.4-1 and detailed descriptions are provided in the subsequent sections.

16.4.2.1 Pathways with No Linkage

A pathway may have no linkage to environmental effects if the activity does not occur, or if the pathway is removed by mitigation or by environmental design features so that the Project results in no measurable change in measurement indicators. Subsequently, no residual effect on the socio-economic environment is expected. The pathways described in the following bullets have no linkage to socio-economics and will not be carried forward in the assessment.

- **The Project footprint will reduce the area of land available for purposes other than agriculture (e.g., traditional land use, hunting, fishing, recreation).**

During the Base Case, agriculture is the main land use in the land use ESA. No traditional land use activities are known to occur in the core facilities area and 65-year mine field, although some activities (e.g., berry picking) may occur outside of the land use ESA. Fishing could occur in Loon Creek; however, the fish and fish habitat assessment (Section 11.7) determined that there will be no residual effects on fish and fish habitat. Hunting activity could occur in the land use ESA; however the land use ESA consists mostly of private land and hunting opportunities are not generally open to the public. Recreation in the area is centred around Last Mountain Lake or within the communities. None is known to occur in the land use ESA.

The dominant ELC map unit within the land use ESA is Cultivated and accounts for approximately 58.3% (46,834 ha) of the land use ESA under Base Case conditions (Section 13.5.1.2). The Modified Grassland unit, which includes both hayland and modified prairie, covers 15.8% of the land use ESA, Native Grassland covers 8%, and Wooded covers 3.4%. Wetlands (Class I, II, III, IV, and V) cover approximately 13% of the land use ESA under Base Case conditions. The Existing Disturbance map unit (e.g., roads and communities) accounts for approximately 1% (1,141 ha) of the land use ESA under the Base Case. The maximum (conservative) area of ELC map units to be disturbed by the application of the Project is 1,550 ha. The land cover type that will experience the greatest change from the Project is the cultivated land (-2.6%). The Project is predicted to remove 2.2% of Class I and Class II Wetland, 0.6% of Modified Grassland, 1.3% of Class IV Wetland, 0.3% of Native Grassland and 0.5% of the Wooded ELC units. Following decommissioning and reclamation, approximately 842 ha (54% of the footprint) will be reclaimed. The area of residual disturbance (i.e., TMA and crystallization pond) is predicted to be approximately 708 ha (46% of the footprint) as these areas will not be reclaimed following closure.

No known traditional land use, tourism, recreation, or other non-agricultural land use activities are known to occur in the land use ESA. Combined with the minor changes to land cover types described above, the Project is not anticipated to cause measurable changes to traditional and non-traditional land use. Therefore, this pathway was determined to have no linkage to effects on traditional and non-traditional land use.

Table 16.4-1: Potential Pathways for Effects on Socio-economics

Project Component/Activity	Effects Pathways	Valued Component(s)	Environmental Design Features and Mitigation	Pathway Classification
Physical disturbance from the Project Footprint	The Project core facilities area overlaps approximately 2.4 km of two north-south grid roads that will be closed to the public during Project construction, operations, and decommissioning and reclamation.	■ Traffic and Transportation Infrastructure	■ Yancoal will work with local R.M.s to discuss road closures and facilitate local traffic movement.	Secondary
	The Project will reduce the area of agricultural land.	■ Traditional and Non-traditional Land Use	■ The compact layout of the core facilities area will limit the area that is disturbed by construction. ■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance. ■ Progressive reclamation will occur during the Project where applicable (e.g., progressive pad site reclamation). ■ Existing public roads will be used where possible to provide access to the mine well field area, which will reduce the amount of new road construction required for the Project. ■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible. ■ Yancoal will develop guidelines for leasing agricultural land and pasture agreements on land not being used for Project activities. ■ A Decommissioning and Reclamation Plan will be developed that will incorporate new technologies as they become available to reduce the length of the decommissioning period, and the associated duration of salt storage at surface. ■ All on-site roads will be removed during decommissioning. ■ Salvaged soil material will be returned to the landscape and contoured, to the extent practical, to blend with the surrounding terrain. ■ Disturbed areas will be recontoured and reclaimed to a stable profile to permit existing land uses.	Primary
	The Project footprint will reduce the area of land available for purposes other than agriculture (e.g., traditional land use, hunting, fishing, recreation).	■ Traditional and Non-traditional Land Use		No linkage
	Changes in surface flows, drainage patterns (distribution) and drainage areas from the Project footprint can affect surrounding land use (e.g., traditional land use, agriculture).	■ Traditional and Non-traditional Land Use	■ The compact layout of the core facilities area will limit the area that is disturbed by construction. ■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance. ■ Progressive reclamation of well pads will occur. ■ Existing public roads will be used where possible to provide access to the mine well field area and to reduce the amount of new road construction required for the Project. ■ Mine well field area pipelines will be routed along existing utility corridors to reduce disturbance to undisturbed areas, where possible. ■ Where practical, natural drainage patterns will be maintained. ■ Culverts will be installed along site access roads, as necessary, to maintain drainage.	No Linkage
Traffic and Transportation	Project activities will modify local transportation infrastructure and affect traffic (e.g., changing road access to the site) through increased municipal road maintenance requirements, altered travel routes, and increased traffic volume.	■ Traffic and Transportation Infrastructure	■ A traffic impact assessment was completed to assess the effects of Project traffic and identify relevant mitigation (e.g., road upgrades). ■ Relevant mitigation identified in the traffic impact assessment will be applied. ■ Yancoal will work with local R.M.s to address traffic and transportation infrastructure concerns.	Primary
	Vehicle accidents can result in injuries to people or affect buildings and infrastructure.	■ Traffic and Transportation Infrastructure ■ Quality of Life ■ Community Services and Infrastructure	■ Daily vehicle inspections will be required, and a preventative maintenance program will be implemented for all vehicles used on-site. ■ Basic, core, and specific training of workers as part of the Health, Safety, Security, and Environmental Management System. ■ Defensive driving and vehicle/equipment specific training. ■ To limit the occurrence of vehicular accidents, training for equipment operators will be implemented as part of the Occupational Health and Safety Plan. ■ Speed limits and seat belt use will be enforced. ■ Timely snow removal and sanding will occur on site access roads during winter to improve traction.	Secondary

Table 16.4-1: Potential Pathways for Effects on Socio-economics

Project Component/Activity	Effects Pathways	Valued Component(s)	Environmental Design Features and Mitigation	Pathway Classification
General construction, operations, and decommissioning and reclamation activities	Project noise from facilities, equipment, and vehicles are nuisances that may affect quality of life for some individuals and could affect wildlife distribution, which could affect traditional and non-traditional land use.	■ Quality of Life ■ Traditional and Non-traditional Land Use	■ Project design will use conventional insulation, baffles, and noise suppressors on equipment. ■ Stationary equipment will be housed inside buildings, reducing the amount of noise released into the environment.	Primary
	Air and dust emissions and subsequent deposition can cause changes to soil and vegetation quality, which can affect quality of life, and alter land use (e.g., traditional land use, agriculture).	■ Quality of Life ■ Traditional and Non-traditional Land Use	■ The Project will comply with regulatory emission requirements. ■ Dryer burners will be high efficiency, low NO_x burners to limit the amount of NO_x present in the exhaust stream. ■ Baghouses will be installed throughout the dry process area and dust collected in these baghouses will be conveyed back to the compactors. ■ A dustless chute and loading system will be installed in the product storage area to reduce dust generation in the storage and load-out. ■ The use of paved roads on site, as much as possible, will reduce dust generated by vehicles and equipment. ■ An Erosion and Sediment Control Plan will be implemented during all phases of the Project to limit dust production, and subsequent deposition on surrounding areas, and to limit water erosion of exposed soils. ■ Dust-producing components of the potash refinement process (i.e., dryers, compaction circuit) will have controls to recover and return dust to the circuit. ■ Wet scrubbers will be used to clean the air of dust particles from off-gases from the product dryers. ■ Regular, seasonal watering and application of environmentally acceptable dust suppressants on unpaved roads will facilitate dust suppression around the site. ■ Enforced speed limits will assist in reducing production of dust. ■ Operating procedures will be developed to reduce dust generation from the TMA over the long-term. ■ The cyclone exhaust will be treated in high-energy scrubbers operating at a high-pressure drop. ■ The environmental performance of air emissions control systems will be monitored on an on-going basis. ■ Preventative maintenance will be completed regularly to confirm that emissions systems are functioning as designed.	Secondary
	Long-term dust emissions from the tailings management area can cause changes to soil and vegetation quality, and alter land use (e.g., traditional land use, agriculture).	■ Traditional and Non-traditional Land Use		No Linkage
	Visual changes from the Project may influence the visual character of the area (i.e., aesthetics) and affect the quality of life of some local residents,	■ Quality of Life	■ The compact layout of the core facilities area will limit the area that is disturbed by construction. ■ The well pad design will be optimized to manage as many caverns as practicable from one well pad, reducing ground disturbance. ■ Existing public roads will be used where possible to provide access to the mine well field area, which will reduce the amount of new road construction required for the Project. ■ Site infrastructure will incorporate natural colours and materials for buildings and features such as tree rows to reduce the visual effect of the Project. ■ Lighting will be designed to limit off-site light disturbances. Low-glare fixtures will be used, where possible, and lighting will be covered and will face downwards to illuminate the ground, not the sky.	Primary
	The Project can increase demand on waste management services.	■ Community Services and Infrastructure	■ Development of a recycling program to reduce wastes. ■ Training for employees on waste management. ■ Littering will be prohibited. ■ A Waste Management Plan will be developed for the Project. ■ Training for employees on spill reduction, control and clean up. ■ Use of licensed contractors to remove recyclables and wastes from site for proper disposal.	Secondary

Table 16.4-1: Potential Pathways for Effects on Socio-economics

Project Component/Activity	Effects Pathways	Valued Component(s)	Environmental Design Features and Mitigation	Pathway Classification
Project workforce requirements and revenue	Workforce requirements for the Project will increase employment within the province.	■ Employment and Economy	■ Yancoal will develop a Human Resources Plan to hire a workforce that is representative of the communities within the region. Yancoal will provide details on any employment targets and strategies for achieving those targets. ■ Yancoal will review Project education and training requirements with post-secondary schools in the region and assess their interest and capability of providing industry-specific training. Yancoal will consult with Human Resources Development Canada to assess interest and possibility of funding industry-specific skills training. The goal is to increase local opportunities to train and work at the Project and other potash operations in the region. ■ Yancoal will develop a Human Resources Plan to accommodate education and training needs for potential employees in local communities and offer to participate in/support youth apprenticeship programs. Given the long life of the Project, the goal is to find ways to increase local opportunities to train and work at the Project and other potash operations in the region.	Primary
	Workforce requirements for the Project will increase labour incomes in the province.	■ Employment and Economy		Primary
	Workforce and procurement requirements for the Project will increase Gross Domestic Product in the province.	■ Employment and Economy		Primary
	Workforce requirements can result in a better-trained regional workforce for Project-related trades and careers in the province.	■ Employment and Economy		Primary
	The Project will increase the tax base of municipalities, the province, and the country.	■ Employment and Economy	■ Not applicable.	Primary
	A non-resident Project workforce that relocates to the socio-economic LSA can place increased demand on housing, accommodations, infrastructure, and services.	■ Community Services and Infrastructure	■ A first-aid room will be established at the Project site. ■ A Community Relations Plan for ongoing engagement will be developed and reviewed with local communities. Yancoal will evaluate the process and the outcome of the ongoing engagement and communications addressing and managing Project workforce related issues as they arise. ■ A construction camp will be built near the core facilities area (exact location not yet determined) to house up to 1,500 construction workers.	Primary
Solution Mining	Ground subsidence caused by solution mining can change soil quality and affect land use.	■ Traditional and Non-traditional Land Use	■ Unmined pillars will be left between caverns to increase stability during mining and reduce potential subsidence. ■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed where possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence and will provide input into adaptive management. ■ Subsidence will be non-disruptive. Disruptive subsidence, such as the formation of sinkholes, is not expected to occur. ■ Subsidence will be gradual and ultimate (maximum) subsidence (i.e., final, steady state) will not occur for centuries. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface developments.	Secondary
	Ground subsidence caused by solution mining can change the local topography and affect building infrastructure and pipelines.	■ Community Services and Infrastructure		Secondary
Tailings Management Area	Vertical and lateral migration of brine from the tailings management area can cause changes to the environment, which can affect land use (e.g., traditional land use, agriculture).	■ Traditional and Non-traditional Land Use	■ The location of the TMA was selected based on site-specific geologic and hydrogeologic studies completed to identify an appropriate foundation for the TMA, which provides natural containment of brine material. ■ The TMA will be located over soils that are known to provide natural retention of brine solutions and offer protection against seepage into nearby ground and surface water resources. ■ Brine reclaim ponds will be designed to provide containment of brine under normal and extreme (i.e., storm) conditions over the life of the mine. ■ A perimeter dyke will be constructed around the TMA to contain waste salt and decanted brine. ■ Excess brine reclaimed from the TMA will be disposed of by deep well injection, a proven practice used to manage brine and prevent release to surface waters and fresh-water aquifers. ■ A containment system will be designed to control deep migration of brine from the TMA to underlying aquifers and horizontal migration of brine, as required. ■ A Waste Salt Management Plan for the TMA will be incorporated into the detailed design. ■ The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan and adaptive management will be implemented, if required. ■ A Decommissioning and Reclamation Plan will be developed and will incorporate new technologies as they become available to reduce the length of the decommissioning period and the associated duration of salt storage at surface.	No linkage
	Long-term brine migration from the tailings management area can cause changes to the environment, which can affect land use (e.g., traditional land use, agriculture).	■ Traditional and Non-traditional Land Use		No linkage

Table 16.4-1: Potential Pathways for Effects on Socio-economics

Project Component/Activity	Effects Pathways	Valued Component(s)	Environmental Design Features and Mitigation	Pathway Classification
	Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality, and change surface water, soil and vegetation quality, which affect land use (e.g., traditional land use, agriculture)	■ Traditional and Non-traditional Land Use	■ An evaluation of the capacity of potential deep injection horizons has been conducted identifying the Winnipeg Formation and Deadwood Formation to be suitable for brine disposal.	No linkage
Water Management	Site runoff and associated soil erosion from the core facilities area can affect surface water and soil quality, which can affect quality of life and land use (e.g., traditional land use, agriculture).	■ Traditional and Non-traditional Land Use ■ Quality of Life	■ A Water Management Plan will be designed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff. ■ A diversion channel will be constructed to intercept waterflow from upland areas along the north and east borders of the core facilities area. ■ Surface water diversion works will be constructed on the up gradient sides of the salt storage area to intercept the natural drainage flow and to convey runoff around the facility. ■ The surface water diversion will be designed to convey the runoff associated with the 300-millimetre (mm) 24-hour design storm event. ■ Surface water diversion channels along the perimeter of the core facilities area will be designed to collect and redirect external drainage.	No linkage
Accidents, Malfunctions, and Unplanned Events	Spills (e.g., waste oil, petroleum products, reagents, potash product, equipment leaks, vehicle accidents, and wash-down) can cause changes to the environment and affect land use.	■ Traditional and Non-traditional Land Use	■ Instruction will be provided to employees as part of the Health, Safety, Security, and Environmental Management System; training will be provided to all employees on transportation of dangerous goods, as well as on spill reduction, control, and clean up procedures. ■ Basic, core, and specific training of workers as part of the Health, Safety, Security, and Environmental Management System. ■ An Emergency Response Team will be formed on-site and members will be trained to implement the Emergency Response Plan. ■ Spills will be promptly reported and managed according to procedures identified in the Spill Response and Control Plan. ■ Chemical spill containment will be incorporated into the plant design to mitigate environmental effects from spills (i.e., installation of concrete floors, drains, and sump mechanisms). ■ Smaller fuel dispensing tanks will be double-walled, and all dispensing will be performed over concrete containment slabs. ■ Reagent tanks and larger fuel tanks will be located inside a bermed, lined storage compound. ■ Liquid, solid spills, and wash-down within the processing facilities will be contained within the mill facility (e.g., door curbs, sloped floors, and sumps) or engineered site area. ■ Diesel and gasoline will be stored in accordance with applicable regulations. ■ On-site storage facilities for hazardous substances and waste dangerous goods will be designed to meet regulatory requirements. ■ Domestic and recyclable waste dangerous goods will be stored in appropriate containers until shipped off site to an approved facility. ■ Spill response material will be located throughout the site in designated areas, where fuel and chemicals are stored, and in company vehicles. ■ Best practices will be adopted within the Waste Management Plan for proper handling and storage of waste dangerous goods. ■ Salvageable product from centrifuging, drying, screening, and compaction will be recycled back to the process. ■ Construction equipment will be regularly inspected and maintained. ■ To limit the occurrence of vehicular accidents, training for equipment operators will be implemented as part of the Health, Safety, Security, and Environmental Management System. ■ Equipment will be inspected for leaks and repaired prior to entry into the Project area, and routinely inspected throughout the duration of the Project. ■ Daily vehicle inspections will be required, and a preventative maintenance program will be implemented for all vehicles used on-site. ■ Speed limits will be enforced. ■ Timely snow removal and sanding will occur on site access roads during winter to improve traction.	No linkage

Table 16.4-1: Potential Pathways for Effects on Socio-economics

Project Component/Activity	Effects Pathways	Valued Component(s)	Environmental Design Features and Mitigation	Pathway Classification
	Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to soil and vegetation quality and affect land use.	■ Traditional and Non-traditional Land Use	■ Secondary mining techniques that reduce the total amount of material removed from the mine cavern will be employed where possible; extraction ratios will be controlled to limit strain on the overlying environment. ■ Brine will be transported by steel pipeline lined with high-density polyethylene, which provides additional pipe flexibility and resistance to corrosion. ■ A subsidence monitoring program will be implemented to reduce uncertainty of effects related to subsidence. ■ The cavern layout will be refined as additional modelling is completed to optimize potash recovery and to limit the potential effect of subsidence on surface developments. ■ Unmined pillars will be left between the caverns to increase stability during mining and reduce the potential for subsidence. ■ As part of the Environmental Protection Plan, regular monitoring of pipelines will be carried out to limit the potential for leaks and allow for early detection and management of spills. ■ Piping and valve arrangements will be routed so that each cavern works independently from the others at difference stages of cavern development and production. ■ During the detailed design stage, additional spill response and mitigation will be included in the Spill Response and Control Plan.	No linkage
	Slope failure of the waste salt storage pile can cause translocation of waste salts and alter surface water, soil, and vegetation quality and, consequently, affect land use	■ Traditional and Non-traditional Land Use	■ Salt pile side slopes of 4H:1V were applied to the TMA layout, which were found to provide stable slope configurations based on preliminary slope stability analysis. ■ The final configuration of salt pile slopes will be refined based on subsequent analyses calibrated to pore-water pressure and slope movement data obtained during the initial development of the waste salt pile. ■ Regular inspections of the TMA. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan.	No linkage
	Failure of the brine containment pond and resulting bring leakage can cause changes to surface water, soil, and vegetation quality and, consequently, affect land use.	■ Traditional and Non-traditional Land Use	■ The brine reclaim pond will provide adequate storage to accommodate storage of process streams under normal and extreme operating conditions and design storm events. ■ Sufficient freeboard will be provided to account for wind induced set-up and wave run-up on the sides of the pond slopes. ■ During the detailed design stage, additional mitigation will be identified and included in the Waste Salt Management Plan and Emergency Response Plan. ■ Maximum operating levels will be developed to provide adequate storage volumes for the design storm event (300 mm in 24 hours). ■ Containment berms and dykes will be constructed around the TMA to contain salt tailings and decanted brine, as well as to divert surface water. ■ Containment dykes will be keyed into surficial materials as necessary. ■ Brine levels will be monitored and excess brine will be injected into deep well injection zones. Sub-surface brine migration will be monitored and groundwater wells will be monitored to confirm the adequacy of the brine containment pond. ■ In the event of high flows due to precipitation events, additional flow capacity from the collection ditch to the reclaim pond would be provided by an overflow spillway in the embankment. ■ The brine reclaim pond will be monitored regularly; monitoring results will inform adaptive management.	No linkage

km = kilometre; NO_x = oxides of nitrogen; R.M. = Rural Municipality; TMA = tailings management area; LSA = local study area; mm = millimetre.

- **Changes in surface flows, drainage patterns (distribution) and drainage areas from the Project footprint can affect surrounding land use (e.g., traditional land use, agriculture).**

Changes to surface water patterns from the core facilities area and required water diversions have the potential to affect land use through changes to surface water quality and subsequent changes to terrestrial resources including soil, vegetation, and wildlife. During the Base Case, the natural drainage in the land use ESA has been altered by agriculture and the existing network of roads used to access cultivated areas, rural homes, and communities near the Project. The Project is in an area of poorly defined runoff pathways. During the Base Case, most of the runoff contributes to a low-lying area south of the core facilities area that may occasionally contribute to West Loon Creek under high snowmelt and/or rainfall events (Section 9.5).

According to the hydrology assessment (Section 9.5), the Application Case will result in a reduction in runoff to a low-lying area south of the Project, but would rarely affect inflows to West Loon Creek and no reduction in flow volume in West Loon Creek is predicted. The surface water quality assessment (Section 10.4) determined that the minor changes to surface water flows and drainage patterns will not be large enough to cause measureable changes in sediment load or surface water quality. The minor changes to surface water flows and drainage patterns are not anticipated to cause measurable changes to soils, vegetation, and wildlife (Sections 12.0, 13.0, and 14.0).

A Water Management Plan will be implemented to maintain streamflow along natural flow pathways as much as possible. Environmental design features will be implemented to allow off-site precipitation and snowmelt to remain part of the natural water cycle. The compact layout of the core facilities area, the optimized well pad design, and the use of existing utility and access corridors, wherever possible, are expected to reduce the physical disturbance area of the Project. This will reduce the size of the area of surface flows that will be altered or diverted. Where practical, existing drainage patterns will remain unaltered or will be maintained using culverts. By implementing environmental design features and mitigation, it is expected that the Project will result in minor changes to surface water flows and drainage patterns. The minor changes to surface water flows and drainage patterns are not anticipated to cause measurable changes to surface water quality, soils, vegetation, and wildlife. As a result, this pathway was determined to have no linkage to effects on traditional and non-traditional land use.

- **Long-term dust emissions from the tailings management area can cause local changes to soil and vegetation quality and alter land use (e.g., traditional land use, agriculture).**

Solution potash mining techniques produce waste salt (i.e., sodium chloride [NaCl] tailings) as a by-product of the potash refinement process, which will be stored in the salt storage area in the TMA. The volume of tailings produced by the solution mining method for the Project is expected to be less than in conventional underground potash mining on a per-tonne product basis because the insoluble clays associated with the potash beds are not brought to surface. The secondary mining process further reduces tailings generation because only KCl is removed from the caverns using this process. During Project engagement, (Section 5.0), several First Nations interview participants expressed concern over potential dust effects on water and, therefore, on traditional land use. Land use in the land use ESA is largely agricultural. Little traditional land use and limited non-agricultural land uses are found in the immediate Project area, although some may occur outside of the land use ESA.

The waste salt product precipitated during processing is removed from the process and discharged to the TMA through a slurry pipeline. All waste salt will be stored in the TMA during operations and following decommissioning. Monitoring programs for the waste salt storage area will be incorporated into the design and will include monitoring salt pile stability and related dust production. A solid crust will form over the outer layer of the waste salt pile as the salt slurry dries. The formation of a rigid crust over the salt pile is expected to limit effects of exposure to wind and will reduce the potential for erosion. Operating procedures will be developed to limit dust emissions from the TMA. Because of the crusting of the outer layer of the waste salt pile and the implementation of operating procedures and monitoring programs for the salt storage area, long-term dust emissions are not expected and are predicted to result in no measureable changes to water, soil and vegetation quality (Sections 10.4, 12.4 and 13.4). Therefore, no effects on land use activities, which rely on those aspects of the environment, are predicted. As a result, this pathway was determined to have no linkage to effects on traditional and non-traditional land use.

- **Vertical and lateral migration of brine from the tailings management area can cause changes to the environment, which can affect land use (e.g., traditional land use, agriculture).**
- **Long-term brine migration from the tailings management area can cause changes to the environment, which can affect land use (e.g., traditional land use, agriculture).**

The TMA will consist of the Stage I and Stage II salt storage areas, the Stage I and Stage II brine reclaim ponds, sewage lagoon, and surface diversion works. The TMA will be in operation during the life of the Project, and following decommissioning and reclamation of the mine. Vertical or lateral migration of brine into groundwater systems may lead to changes in surface water and soil quality in the land use ESA.

The TMA is located on a site with geological features that will assist in controlling brine migration. The stratified clay and clayey tills of the Saskatoon Group are the main geological units that would mitigate the vertical migration of seepage from the TMA (Golder 2015). Soil-bentonite cut-off walls will be constructed to contain brine areas where shallow stratified sand and gravel deposits are present. Based on the results of detailed site characterization, a deep cut-off wall extending through competent till materials may be constructed. Containment berms and dykes will be constructed around the TMA to contain decanted brine. The containment system will be designed to control migration of brine from the salt storage area to underlying aquifers and control the horizontal migration of brine, as required. The use of the above mentioned environmental design features and mitigation and those in Table 16.4-1 will reduce changes to the environment. The environmental performance of the brine reclaim pond will be monitored over the life of the operation as part of the Waste Salt Management Plan.

Implementation of the above mentioned environmental design features, mitigation, and monitoring programs has shown good performance in preventing vertical and lateral seepage in similar potash projects. Vertical or lateral migration of brine is predicted to result in no measurable changes to surface water quality, soil quality, vegetation, and wildlife. As a result, these pathways were determined to have no linkage to effects on traditional and non-traditional land use.

- **Deep well injection of brine can disrupt or cause changes in sub-surface and deep groundwater flow, levels, and quality, and change surface water, soil and vegetation quality, which can affect land use (e.g., traditional land use, agriculture).**

Brine will be disposed of through deep-well injection during the Project to reduce the amount of brine stored in the TMA. Injecting brine into deep wells can change sub-surface and deep groundwater levels and chemistry, which could alter surface water, soil, and vegetation quality, which in turn can affect land use in the land use ESA. Methods used in the solution mining process will maintain stability of shallow and deep groundwater aquifers. The Winnipeg and Deadwood Formations are considered the best target for brine disposal because there is a large storage capacity in these formations, the formations are well isolated from overlying freshwater aquifers, and the formations are distant from recharge and discharge areas (Appendix 4-A). No changes to sub-surface and deep groundwater flow, levels, and quality are predicted. Given that the formations used for deep well injection are isolated from overlying aquifers and surface water, no changes to surface water, soil, or vegetation quality are expected. Consequently, this pathway was determined to have no linkage to effects on traditional and non-traditional land use.

- **Site runoff and associated soil erosion from the core facilities area can affect surface water and soil quality, which can affect quality of life and land use (e.g., traditional land use, agriculture).**

Site runoff and associated soil erosion from the core facilities area could potentially affect surface water and soil quality, which in turn can affect quality of life and land use. Several environmental design features and mitigation will be implemented to prevent water release from the core facilities area entering the surrounding environment. The general site layout has been developed to use natural topography to assist site drainage to the extent practical. The topography in the area is gently sloping toward the south and slightly to the west. A diversion channel will be constructed to intercept waterflow from upland areas along the north and east borders of the core facilities area.

A Water Management Plan will be developed and infrastructure will be constructed to isolate potentially salt contaminated water within the core facilities area from fresh water runoff Surface water diversion works will be constructed to intercept the natural drainage flow and to convey runoff around the facility. The surface diversion works will be designed for a 300- millimetre (mm), 24-hour rainstorm event.

Runoff within the TMA will be redirected to the brine reclaim pond for temporary storage prior to deep-well injection. Salt storage area internal channels (i.e., brine return channels) are designed to collect and redirect runoff originated from precipitation and brine discharges on the tailings areas to the brine reclaim pond. The TMA will be graded to drain free brine to the brine reclaim pond by gravity. Internal salt tailings dykes and ditches may be required to direct surface flow to the collection ditch during early stages of deposition.

The brine reclaim pond will be constructed to provide containment of brine during the Project. The brine reclaim pond is designed to allow sufficient storage capacity to contain brine decant from the salt storage area during normal operations, runoff resulting from the design storm event, and a 0.9-m freeboard to accommodate wind-induced setup and wave run-up on the sides of the pond slopes.

Erosion protection of the surface water diversion channel will be provided by topsoil replacement and hydro-seeding to establish grass cover within the diversion channel. A tackifier may be used to increase the temporary soil stability prior to establishment of permanent vegetation root systems.

Inspection and maintenance procedures for infrastructure will be outlined in the Water Management Plan and provide input into adaptive management, as required. Implementation of environmental design features and mitigation is expected to prevent site runoff and soil erosion from the core facilities area from entering the surrounding environment. Therefore, this pathway was determined to have no linkage to effects on quality of life and traditional and non-traditional land use.

- **Spills (e.g., waste oil, petroleum products, reagents, potash product, equipment leaks, vehicle accidents, and wash-down) can cause changes to the environment and affect land use.**
- **Underground pipeline/casing failure from subsidence and pipeline leaks can cause changes to soil and vegetation quality and affect land use.**
- **Slope failure of the waste salt storage pile can cause translocation of waste salts and alter surface water, soil, and vegetation quality and, consequently, affect land use.**
- **Failure of the brine containment pond and resulting bring leakage can cause changes to surface water, soil, and vegetation quality and, consequently, affect land use.**

Accidents, malfunctions, and unplanned events related to the Project and occurring on-site or off-site have the potential to adversely affect the socio-economic environment. Most of these pathways have the potential to affect the traditional and non-traditional land use VC, which is strongly linked to changes in air, water, soil, vegetation, and wildlife. Implementation of environmental design features and mitigation are expected to avoid or minimize the likelihood of accidents, malfunctions, and unplanned events, resulting in no measureable changes to air quality, hydrogeology, hydrology, surface water quality, fish and fish habitat, soil quality, vegetation, and wildlife relative to Base Case conditions (Section 7.4; Section 8.4; Section 9.4; Section 10.4; Section 12.4; Section 13.4; Section 14.4). Therefore, the accidents and malfunctions pathways were determined to have no linkage to effects on the socio-economic VCs. Accidents, malfunctions, and other unplanned event pathways are not expected to interact with the employment and economy, quality of life, community services and infrastructure, or traffic and transportation infrastructure VCs. Traffic accidents are discussed in Section 16.4.2.3.

16.4.2.2 Secondary Pathways

In some cases, both a source and a pathway exist, but because the change caused by the Project is anticipated to be minor relative to Base Case or guideline values, it is expected to have a negligible residual effect on the socio-economic environment. The pathways described in the following bullets are expected to be secondary and will not be carried forward in the assessment.

- **The Project core facilities area overlaps approximately 2.4 km of two north-south grid roads that will be closed to the public during Project construction, operations, and decommissioning and reclamation.**

The Project will require legally closing and removing two local low volume north-south roadways within the R.M. of Longlaketon. This will affect the traffic and transportation infrastructure VC. Traffic on these roads is expected to consist primarily of local agriculture and resident traffic. The socio-economic LSA is covered by an extensive road network of gravel and paved roads every 1.6 km. Traffic that currently uses the portions of the two north-south road in the core facilities area is expected to be able to find alternate routes using numerous grid roads east and west of the core facilities area. However, Yancoal will work closely with government and local R.M.s to discuss road closures and facilitate local traffic movement around the core facilities area. Considering the low volume of traffic that is expected to use those roads and the extensive grid road network that is present in the socio-economic LSA, this pathway was determined to result in negligible residual effects on traffic and transportation infrastructure.

- **Vehicle accidents can result in injuries to people or affect buildings and infrastructure.**

Construction and operation of the Project will cause an increase in the volume of traffic in the socio-economic LSA, which could result in an increased potential for traffic collisions. Collisions have the potential to cause injuries to people and damage to buildings and infrastructure.

Yancoal will include defensive driving and vehicle/equipment specific training as part of the Occupational Health and Safety Management System to reduce the potential for traffic collisions. Speed limits and seat belt use will be enforced, and a preventative maintenance program and daily vehicle inspections to identify problems and hazards will be required for all vehicles used on site. In addition, timely snow removal and sanding will occur on site access roads, as necessary in winter, to improve traction. Project-related traffic will be expected to comply with provincial Occupational Health and Safety standards and traffic safety laws. Where possible, alternate worker transportation options will be examined, including bussing workers, or organizing and creating incentives for carpooling.

A Traffic Impact Assessment (TIA) was completed for the Project (Appendix 4-C). The TIA predicted the volume of Project-related traffic and focused on the intersection of Highway 6 and grid road 731, which is expected to be the main access route to the Project. Up to 1,500 employees are expected to stay in a construction camp near the Project during Project construction. This will reduce the distance of travel and the number of daily trips on Highway 6 and other main access routes. As a result, during peak Project construction, the workforce is conservatively expected to increase traffic in the area by just over 1,000 vehicles per day (i.e., 2,000+ Annual Average Daily Traffic [AADT]). During Project operations, the workforce is expected to increase traffic by approximately 300 vehicles per day (i.e., 600 AADT). In addition, there will be weekly and monthly large and over-size truck deliveries, mostly during Project construction.

Most (85%) traffic is expected to travel north on Highway 6 and turn west on grid road 731 to reach the Project. A small portion of traffic (5% each) is expected to travel from the west and east on grid road 731 or from the north on Highway 6 (i.e., heading south). Depending on the existing infrastructure, these routes may require geometric and structural upgrades to safely accommodate the additional traffic. Based on the results of the TIA, the following improvements are warranted at the intersection of Highway 6 and grid road 731:

- construct an eastbound right-turn lane (on grid road 731);
- pave the eastbound approach to Highway 6 on grid road 731 to limit wear and maintenance; and
- construct a channelized intersection on Highway 6 in the northbound approach.

A southbound right-turn lane on Highway 6 was not deemed warranted during Project construction or operations; however, if traffic levels increase by 10 to 15 vehicles during the morning peak traffic during Project operations, a southbound right-turn lane would be warranted. This is equivalent to an increase in background traffic of 10 to 15 vehicles or an additional 200 operations employees (5% of which would be expected to travel to the Project site from the north). Traffic levels have been rising steadily over the past decade (Section 16.3; Annex V, Section 4.4.6). As a result, an increase in background traffic of 10 to 15 vehicles by 2017 or 2018 is considered possible. With these three road improvements above and the potential southbound right-turn lane on Highway 6, all traffic movement is expected to operate acceptably.

If a traffic collision occurs, the effect ranges from minor (i.e., property damage), to high (i.e., personal injury), to catastrophic (i.e., death). Any collision resulting in the severe injury or death of an individual would result in a significant effect on that individual, their family, and the community. The implementation of the above mitigation is expected to greatly reduce the potential for traffic collisions to occur. However, the possibility cannot be eliminated. Consequently, this pathway is considered secondary (i.e., measureable change) and determined to result in a negligible residual effect on traffic and transportation infrastructure and community services and infrastructure.

- **Air and dust emissions and subsequent deposition can cause changes to soil and vegetation quality and affect quality of life and alter land use (e.g., traditional land use, agriculture).**

Air emissions and dust can result from mine activities during Project construction and operation. Air emissions measurement indicators included carbon monoxide (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter ($PM_{2.5}$ and PM_{10}), potash (KCl), and greenhouse gases (GHGs [e.g., CO_2, N_2O, CH_4]) (Section 7.0). Use of fossil fuels for construction equipment, boilers, dryers, vehicles, and locomotives will result in SO_2 and NO_2 emissions, while Project-related traffic is expected to be the main source of dust. In addition to changing air quality, air and dust emissions have the potential to change soil quality by altering soil pH, nutrient content, and fauna composition and, subsequently, can lead to effects on vegetation through changes to decomposition and nutrient cycling (Section 13.4.2.2). Changes to air, soil, and vegetation quality resulting from air and dust emissions in the socio-economic LSA and land use ESA have the potential to alter quality of life and traditional and non-traditional land use. A variety of environmental design features and mitigation measures are identified in Table 16.4-1 to reduce air emissions.

Air quality modelling was completed to predict the spatial extent of air and dust emissions and deposition from the Project (Section 7.5). Air quality modelling was completed using the maximum emissions profile expected during the operations phase of the Project, which provides the maximum potential effects from the Project on air quality. Operations are expected to have the longest duration for residual effects on the atmospheric environment (Section 7.5). Assumptions were incorporated into the model to contribute to conservative estimates of emission concentrations and deposition rates (Section 7.0). Air emissions results were compared to applicable federal and provincial air quality standards and emissions guidelines.

Residual effects of air quality on quality of life are assessed based on the air quality model results and applicable air quality standards relating to CO, NO_2, SO_2, $PM_{2.5}$, PM_{10}, total suspended particulate matter, KCl, and greenhouse gas emissions. Results of the air quality modelling indicate that the maximum CO, NO_2, SO_2, $PM_{2.5}$, total suspended particulate matter, and potash (KCl) emissions are not expected to exceed Saskatchewan Ambient Air Quality Standards (SAAQS) (Section 7.0). The PM_{10} maximum 24-hour emission during the Application Case is 53.4 micrograms per cubic metre (µg/m^3), which is above the SAAQS of 50 µg/m^3. The air quality model predicted this PM_{10} maximum to exceed the SAAQS for three days during the modelling years. However, the background (Base Case) PM_{10} concentration used in the model is 36.3 µg/m^3, which represents 72.6% of the SAAQS. This background concentration is from the City of Regina air quality monitoring station; no rural PM_{10} measurements are available from the MOE. If the model instead used a rural background PM_{10} concentration of 17.9 µg/m^3, based on several rural sites in North Dakota and Montana, the maximum predicted concentration of PM_{10} is 35 µg/m^3, which is below the SAAQS. Greenhouse gas (GHG) emissions from the Project are estimated at 1.09 million tonnes (MT) of CO_2 annually. This is equivalent to 1.4% of Saskatchewan's GHG emissions in 2012 and 0.16% of Canada's GHG emissions in 2012. Any GHG emissions over

50,000 tonnes must be reported to Environment Canada and will be regulated by the MOE. Based on these results, minor and local changes are predicted to air quality relative to Base Case conditions. Therefore, this pathway was determined to have a negligible residual effect on quality of life.

Residual effects of air quality on traditional and non-traditional land use are assessed based on the effects to the terrestrial environment. During First Nations traditional land use interviews (Section 5.0), concerns were expressed regarding the effect of dust on traditional land use. The primary land use in the land use ESA is agriculture. Based on the traditional land use interviews (Section 5.0), little or no traditional land use exists in the Project footprint or immediate vicinity. The land is privately owned and mostly cultivated, with little or no land use other than agriculture (e.g., recreation or hunting).

Traditional and non-traditional land use has the potential to be affected by any changes from air quality on the terrestrial environment, but particularly by residual effects to soils. For example, deposition of SO_2 and NO_2 can lead to acidification of wetlands. Soils in the land use ESA have low sensitivity to acidification because of neutral pH and average cation exchange capacity of 16 milliequivalents per 100 grams of soil (Section 12.3). The soils assessment predicted that soils in the land use ESA could accept high SO_2 and NO_2 inputs and remain unchanged. Based on this and the low levels of SO_2 and NO_2 emissions predicted by the air quality model, no changes to soil and vegetation quality from SO_2 and NO_2 are expected.

Deposition of $PM_{2.5}$, PM_{10}, and total suspended particulates (TSP) can cause chemical loading, change metal concentrations, and affect soil biota composition. The modelling results indicate that the emissions levels for $PM_{2.5}$, PM_{10}, and TSP will be below SAAQS, with the exception of the PM_{10} maximum concentration, which was predicted to exceed SAAQS for three days during the modelling years. As discussed above, this prediction is believed to be artificially high due to the use of a City of Regina PM_{10} concentration for the Base Case. Nevertheless, minor and local changes to soil and vegetation quality from $PM_{2.5}$, PM_{10}, and TSP are predicted. Deposition of KCl can contribute to soil salinization and have subsequent effects on vegetation and wildlife habitat; however, it is not the primary salt responsible for soil salinization (Henry et al. 1992). Soil salinization can cause a reduction in crop growth, in particular in sensitive agricultural crops (e.g., peas). Although excessive amounts of KCl can contribute to the salinization of soil, potassium (K^+) and chloride (Cl^-) are essential for certain processes in plants. The Project related dust emission KCl concentrations are predicted to be below SAAQS. In summary, minor and local changes to soil and vegetation quality are predicted as a result of air quality emissions. These changes are not expected to result in residual effects to traditional and non-traditional land use.

Overall, air and dust emissions and subsequent deposition are expected to result in minor and local changes to the surrounding environment relative to Base Case conditions. As a result, this pathway is predicted to result in negligible residual effects on quality of life and traditional and non-traditional land use.

- **The Project can increase demand on waste management services.**

Yancoal will develop a Waste Management Plan that will meet Saskatchewan regulatory requirements and address site-specific waste management requirements. The Waste Management Plan will describe expected waste products and identify procedures for collecting, handling, and disposing of these products. Training will be provided for employees on waste management as well as spill reduction, control, and clean up. Yancoal will develop a recycling program to assist in the reduction of waste. Licensed contractors will be hired for the removal of recyclables and wastes from the Project site for proper disposal.

Domestic waste will include food wastes, sanitary sewage, and wastes from construction, operations, and administrative offices. Food wastes will be collected in suitable containers and covered to reduce wildlife attraction and odour effects. Appropriate sorting and collection containers for recycling will be provided. All domestic waste will be collected and transferred to disposal facilities by a licensed contractor. Sanitary sewage will be collected from washroom and toilet areas and directed to a two-cell sewage lagoon treatment system, which will be managed to MOE and municipal standards and requirements.

Non-hazardous wastes will include plastics, wood, metal, and other inert materials. The recycling program Yancoal will develop will provide appropriate recycling containers near work areas to reduce the volume of material going to landfills. Recycling and inert, non-hazardous waste materials will be collected and transferred to off-site recycling companies and landfills by a licensed contractor.

The storage, handling, and disposal of hazardous materials will meet requirements of the *Hazardous Substances and Waste Dangerous Goods Regulations* (1989), as well as *The Dangerous Goods Transportation Act* (1984-85-86). This includes employee training, storage facility design and operation, labelling and material control (e.g., Workplace Hazardous Materials Information System [WHMIS]). Hazardous industrial waste is likely to include hydrocarbons, chemicals, glycols, solvents, oil, fuel, acid, reagents, antifreeze, and batteries. The Waste Management Plan will include collecting and storing these materials, and potentially the containers they were received in, in suitable containers and storing them for shipment to an appropriate recycling or disposal facility with a licensed contractor.

The Waste Management Plan will include recycling and suitable storage of waste products. Waste disposal will be managed by a licensed contractor and Yancoal will work with surrounding municipalities to identify the most appropriate landfill for non-hazardous, non-recyclable waste materials. As a result, Project related waste is expected to be noticeable in the socio-economic LSA, but is not expected to place undue strain on existing waste management systems. Consequently, this pathway is expected to have a negligible residual effect on community services and infrastructure.

- **Ground subsidence caused by solution mining can change soil quality and affect land use.**
- **Ground subsidence caused by solution mining can change the local topography and affect building infrastructure and pipelines.**

Solution potash mining removes solid, liquid, and gaseous materials from below the surface and leaves behind brine-filled underground caverns. The massive pressure of the overlying terrain's weight will slowly close the caverns over an extended period. Unmined pillars left between caverns will increase stability and secondary mining techniques will reduce the amount of material removed, both of which will reduce the extent of subsidence. Subsidence will be non-disruptive (i.e., sinkhole formation is not expected).

The maximum amount of subsidence is predicted to occur in the western section of the 65-year mine field (Appendix 9-A). More subsidence is predicted to occur directly overlying the mine development caverns and decrease with distance away from the cavern locations. The area affected by surface subsidence would extend over approximately 17 km from west to east and approximately 8 km from north to south (Appendix 9-A). The maximum vertical displacement due to subsidence is estimated to be 6.7 m. The final gradient of surface subsidence at the boundary of the 65-year mine field will be gradual, where the average gradient from unaffected areas to the area of maximum subsidence is predicted to be 3.9 metres per kilometre (m/km). In areas of steeper subsidence gradients, settlement is predicted to increase from 0.5 m to 6.7 m over a length of approximately 1.6 km with maximum gradients of 5.0 m/km.

The entire area affected by subsidence from the Project is located in the West Loon Creek basin. West Loon Creek may be altered slightly by subsidence, as some channel sections are flattened, which can result in ponding, and others become steeper, which can result in increased erosion. These changes are expected to occur gradually, and may be difficult to distinguish from natural erosional, sediment transport, and depositional processes. Flow volumes are predicted to be maintained. Subsidence will affect water storage in the mine well field area as existing depressions and wetlands store more runoff because of their lower elevation. Storage in this region is expected to increase substantially, meaning less snowmelt or rainwater will reach West Loon Creek in high runoff years. In average or low runoff years, flows from the mine well field area do not reach West Loon Creek due to poorly developed drainage systems in the area. The overall effect on streamflow downstream is expected to be negligible in most years.

Surface topography in the land use ESA and socio-economic LSA will slowly be altered as the overlying terrain subsides in certain areas. These changes are expected to occur over hundreds of years. Changes to topography have the potential to directly affect existing infrastructure, such as buildings and pipelines and indirectly affect land use through changes to surface water, soil, vegetation, and wildlife.

Changes to infrastructure (i.e., community services and infrastructure and traffic and transportation infrastructure) depend largely on the gradient at which subsidence is expected to occur. Subsidence along Highways 6 and grid road 731 was estimated at a maximum of 5 m/km (i.e., 1/200 metres per metre [m/m]). This exceeds the maximum allowable settlement for paved roads and the Canadian Foundation Engineering Manual maximum settlement before structural damage to buildings and load-bearing walls is expected, both of which are 1/250 m/m. However, because paved roads require regular maintenance and the maximum effect of subsidence is expected to occur over an extended period, the maximum slope changes between maintenance periods is expected to be less and cosmetic damage to highways is not expected. Houses and buildings that are planned in the near future in the areas affected by strong subsidence should proceed with caution, especially in the first few years of mine operation. However, the design life of most buildings is shorter than the time it will take for maximum subsidence to occur, which will further limit possible effects. As a result, small measureable changes are predicted for community services and infrastructure and traffic and transportation infrastructure.

Residual effects to land use from subsidence are dependent on the effects to surface water quality, soils, vegetation, and wildlife. Changes to surface water quality from ground subsidence were assessed as secondary (Section 10.4), while changes to soils, vegetation, and wildlife (Sections 12.5, 13.5, 14.5) were assessed as primary. Residual effects to surface water quality, soils, vegetation, and wildlife were determined to not be significant. Long-term changes resulting from subsidence are expected to be localized and land is expected to adjust to the changes over time. As a result, this pathway was determined to have negligible residual effects on traditional and non-traditional land use.

Overall, ground subsidence is expected to result in localized changes over a period of hundreds of years. As a result, this pathway is predicted to result in negligible residual effects on community services and infrastructure, traffic and transportation infrastructure, and traditional and non-traditional land use.

16.4.2.3 Primary Pathways

The following primary pathways are assessed in detail in the effects analysis.

16.4.2.3.1 Employment and Economy

- **Workforce requirements for the Project will increase employment within the province.**
- **Workforce requirements for the Project will increase labour incomes in the province.**
- **Workforce and procurement requirements for the Project will increase Gross Domestic Product in the province.**
- **Workforce requirements can result in a better-trained regional workforce for Project-related trades and careers in the province.**
- **The Project will increase the tax base of municipalities, the province, and the country.**

16.4.2.3.2 Community Services and Infrastructure

- **A non-resident Project workforce that relocates to the socio-economic LSA can place increased demand on housing, infrastructure, and services.**

16.4.2.3.3 Traffic and Transportation Infrastructure

- **Project activities will modify local transportation infrastructure and affect traffic (e.g., changing road access to the site) through increased municipal road maintenance requirements, altered travel routes, and increased traffic volume.**

16.4.2.3.4 Quality of Life

- **Project noise from facilities, equipment, and vehicles are nuisances that may affect quality of life for some individuals and could affect wildlife distribution which could affect traditional and non-traditional land use.**
- **Visual changes from the Project may influence the visual character of the area (i.e., aesthetics) and affect the quality of life of some local residents.**

16.4.2.3.5 Traditional and Non-traditional Land Use

- **The Project will reduce the area of agricultural land.**

16.5 Residual Effects Analysis

16.5.1 Effects to Employment and Economy

The following primary pathways were assessed to determine effects on employment and economy.

- **Workforce requirements for the Project will increase employment within the province.**
- **Workforce requirements for the Project will increase labour incomes in the province.**
- **Workforce and procurement requirements for the Project will increase Gross Domestic Product in the province.**
- **Workforce requirements can result in a better-trained regional workforce for Project-related trades and careers in the province.**
- **The Project will increase the tax base of municipalities, the province, and the country.**

Effects on the employment and economy VC are assessed for Saskatchewan (i.e., socio-economic RSA).

16.5.1.1 Methods

The following aspects of the Project were considered in the assessment of economic effects.

- Total construction costs are estimated at $3.66 billion.
- Construction is scheduled to occur in two phases. The first phase from 2016 to 2019 will provide an initial production capacity of 2 Mt per year. The second phase in 2022 and 2023 will increase production capacity to 2.8 Mt per year.
- Total construction labour costs are estimated at $1,483 million and total construction person years are estimated at 6,848.
- During construction, labour requirements will peak at approximately 2,200 in 2017 and 2018, and average 1,500 employees.
- Annual revenue was estimated using production of 2.0 Mt in 2020 to 2023 and 2.8 million tonnes per year from 2024 onward, using a conservative potash price of $287 USD.
- Mine life is estimated to be 100 years.
- During operations (beginning in 2020), the Project will employ approximately 350 workers (an earlier estimate of 305 workers was used in the economic analysis).
- The economic effects of Project operations were estimated for 2024, the first year of full operation. Effects in 2024 are expected to be representative of subsequent years of operation.

Economic input-output models were used to measure the provincial and local economic effects associated with construction, investment, and mine operation. Effects were measured for the Saskatchewan and the socio-economic LSA. SJ Research Services developed the SJ Research Services 2010 Saskatchewan Input-Output Model based on Statistics Canada's 2010 Saskatchewan input-output model (Appendix 16-A). A separate model was developed for the socio-economic LSA economy. The Saskatchewan (the socio-economic RSA) and socio-economic LSA Input-Output models identify inter-industry production and trading linkages of an economy, and are tools to assess the economic impact of an event, new spending or investment, a new industry, or other changes to the economy.

The model predicts effects on the provincial economy in terms of gross output, gross domestic product, new employment, and labour income. Results are expressed as direct, indirect, or induced effects. The development of the input-output models is explained in detail in Appendix 16-A. Direct effects reflect the initial expenditures made by the Project after adjusting for leakages (i.e., imports or Project spending that occurs outside the province). Indirect effects measure the secondary business transactions that result from initial expenditures. Induced effects are third round effects from the spending of incremental labour income in the economy after removing a portion for taxes and savings. Results are typically expressed in terms of Gross Output, GDP, labour income (included in GDP), and employment (person years). Gross output is the total value of sales or shipments. The GDP is the sum of all goods and services produced within a geographic area (i.e., gross value of production firms less the purchases of immediate goods and services from other firms). The GDP is the measurement of the size of an economy.

In mixed input-output models, direct gross output effects equal the initial Project outlay and the GDP component is the value added portion of the Project. Inter-industry inputs are adjusted for leakages. This corresponds to the geographic definition of GDP as activity taking place within a prescribed region (because construction takes place within Saskatchewan and the socio-economic LSA; GDP accrues within the same regions).

Additional effects, related to design and construction, are not taken into consideration in this study. For example, the area may benefit from improved productivity, quality, and workmanship because of the additional training and experience of engineering design firms, suppliers, vendors, and construction workers. In addition, best practices of large, well-managed projects can be introduced into local communities and organisations.

16.5.1.2 Results

The Base Case for employment and economy is described in Section 16.3.2. The following sections discuss the Application case (Base Case plus Project). The RFD case includes a variety of developments in the Regina area, which may act cumulatively with the Project to increase employment opportunities, labour income, GDP, tax revenue, and education levels in Saskatchewan.

16.5.1.2.1 Employment and Labour Income Effect

When hiring, Yancoal will give priority to skilled local labour. However, given existing labour force conditions, most of the workforce may come from outside the province. If the Project proceeds, Yancoal will look at potential partnerships with communities and First Nations in the socio-economic LSA. A Project-specific Human Resources Plan will be developed.

Changes to employment are expressed as changes above the status quo (i.e., no investment) in the number of direct, indirect, and induced person years of employment that are predicted to result from construction (2016 to 2023) and the first full year of operations (2024). Total (direct, indirect, and induced) employment effects by industry for construction and operation are presented in Table 16.5-1.

Table 16.5-1: Total Employment Effects by Industry, 2016 to 2024

Industry	Cumulative Construction Employment Effects, 2016 to 2023 (person-years)		Operation Employment Effects in the first year of full capacity operation, 2024 (person-years)	
	Saskatchewan	Local Study Area	Saskatchewan	Local Study Area
Crop and animal production	288	73	8	1
Forestry and logging	4	0	0	0
Fishing, hunting and trapping	1	0	0	0
Support activities for agriculture and forestry	13	2	0	0
Mining and oil and gas extraction	65	12	305	305
Utilities	130	63	148	1
Construction	6,848	6,848	53	1
Manufacturing	991	506	26	4
Wholesale trade	544	338	21	7
Retail trade	5,100	14	162	0
Transportation and warehousing	357	266	13	5
Information and cultural industries	441	278	15	5
Finance, insurance, real estate and rental and leasing	1,925	1,423	62	28
Professional, scientific, and technical services	1,155	791	16	4
Administration and support, waste management and remediation services	436	192	15	4
Educational services	237	0	7	0
Health care and social assistance	618	203	19	4
Arts, entertainment and recreation	587	16	18	0
Accommodation and food services	2,362	0	73	0
Other services (except public administration)	1,140	46	37	1
Operating, office, cafeteria, and laboratory supplies	0	0	0	0
Travel, entertainment, advertising, and promotion	0	0	0	0
Transportation margins	0	0	0	0
Non-profit institutions serving households	384	43	12	1
Government sector	935	262	30	5
Total	**24,560**	**11,377**	**1,041**	**377**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

During construction (2016 to 2023), particularly during peak construction in 2017 and 2018, a large portion of direct employment will occur in the construction industry. There will be high demand for trades people and labourers, including carpenters, electricians, welders, concrete workers, equipment operators, pipe fitters, and sheet metal workers. However, the professional, scientific, and technical services industry will experience direct employment effects because of services required for mine design and construction. The local economy in the immediate vicinity of the Project largely consists of agriculture. The local agriculture industry is only expected to experience minor labour force effects from the Project. Within the socio-economic LSA, the economic model predicts an increase in crop and animal production and support activities for agriculture and forestry of 75 person-years during construction and 1 person-year during each year of operation. This increase is related to population growth and indirect and induced employment from the Project.

The low unemployment rate and high participation rate of the Base Case labour force (Section 16.3.2.3) suggests that there may be labour shortages in Saskatchewan and that filling the Project workforce with Saskatchewan employees may be challenging. Recent slowdowns in the oil and gas industry are expected to reduce the degree of existing labour shortages. The Aboriginal population near the Project has the greatest capacity to supply a labour force for the Project; however, increased education and training would be required. Similarly, labour force characteristics and the rapid growth of the potash industry in Saskatchewan suggest that there may be a limited pool of existing solution mine workers who are not currently employed. The Project will move ahead despite potential labour shortages; Saskatchewan will still benefit because not all workers will have to be accessed through in-migration. Even if an out of province workforce is required, many workers will relocate to the area, contributing to the economy and local tax base. For the purposes of this assessment, it was assumed that 100% of direct operating employment, 50% of indirect operating employment, and 10% of induced operating employment will be met through in-migration.

Indirect effects are focused in industries providing inputs to construction and manufacturing, such as utilities, administrative and support, and waste management and services. Induced effects are focused on industries affected by increased consumer spending of earned wages, such as retail trade and service industries.

When direct, indirect, and induced employment are taken into consideration, Project construction is expected to generate approximately 24,560 person-years of employment in Saskatchewan. Approximately 11,377 of those person years will be employment in the socio-economic LSA, which includes Regina. Job quality during construction is expected to be high. Approximately 6,848 person years of employment will be created in the construction industry. Average industry salaries used for the economic assessment include an average wage of $100,000 for construction workers and approximately $60,000 for engineering and design workers, although these numbers are from provincial average wages and may be low (i.e., Project engineers are likely to be earning more than $60,000 per year).

Project operation is expected to create approximately 1,041 person-years of direct, indirect, and induced employment in 2024 in Saskatchewan. Approximately 377 of these person-years of employment will be in the socio-economic LSA, including Regina. Project employment effects in 2024 are expected to be representative of subsequent years of operations. During the operations phase, the bulk of total and direct activity occurs within the mining industry. Indirect effects are concentrated in industries providing input into the mining sector, such as utilities, transportation, finance, professional, and specialized business services. Induced effects, which represent the additional effects on consumer spending of wages earned, are concentrated heavily in trade and personal services. Direct operations jobs include millwrights, process engineers, electricians, mechanics, drillers, safety, health, and environment personnel, and other trades. Long term employment quality is expected to be high due to the concentration of jobs in the mining industry, with an average wage of $105,000 per year.

Combined, construction and operations will have the following incremental effects on Saskatchewan (i.e., socio-economic RSA) employment levels (Table 16.5-2).

Table 16.5-2: Employment Effects of Construction and Operations, 2016 to 2024

Employment Effects	2016	2017	2018	2019	2020	2021	2022	2023	2024
	Positions								
Saskatchewan									
Direct[(a)]	772	2236	2465	692	305	305	660	633	305
Indirect	240	696	767	215	249	249	359	351	249
Induced	1757	5088	5609	1574	487	487	1295	1234	487
Total	2769	8019	8841	2482	1041	1041	2315	2218	1041
Local Study Area									
Direct[(a)]	772	2236	2465	692	305	305	660	633	305
Indirect	129	375	413	116	0	0	60	55	0
Induced	381	1104	1217	342	72	72	247	234	72
Total	1283	3715	4095	1150	377	377	966	922	377

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

(a) In all cases, direct effects are effects after adjusting for leakages for imports and inventory withdrawals. Direct populations effects were predicted based on initial estimates of peak construction workforce in 2017 and 2018 of 2,236 and 2,465, respectively. The initial estimate averaged approximately 1,540 workers per year from 2016 to 2019. Current estimates for the workforce are approximately 2,200 workers in 2017 and 2018 and an average of 1,500 workers from 2016 to 2019.

Labour income is included in GDP and includes wages, salaries, and supplemental labour income (i.e., employer contributions to pension plans and benefit packages). The labour income effects from construction and operations by industry are shown in Table 16.5-3. In Saskatchewan and the socio-economic LSA, the six years of Project construction are expected to result in $2,134.9 million in incomes in Saskatchewan, $1,735.9 of which will be in the socio-economic LSA (including Regina). Project operations is expected to result in $69.9 million in direct, indirect, and induced income in 2024 and subsequent years, $36.1 million of which will be generated in the socio-economic LSA.

Table 16.5-3: Total Labour Income Effects by Industry, 2016 to 2024

Industry	Cumulative Construction Labour Income Effects 2016 to 2023 ($ million)		Operation Labour Effects in the first year of full capacity operation, 2024 ($ million)	
	Saskatchewan	Local Study Area	Saskatchewan	Local Study Area
Crop and animal production	2.1	0.6	0.1	0.0
Forestry and logging	0.2	0.0	0.0	0.0
Fishing, hunting and trapping	0.0	0.0	0.0	0.0
Support activities for agriculture and forestry	0.5	0.1	0.0	0.0
Mining and oil and gas extraction	6.3	1.3	32.1	32.1
Utilities	13.5	7.4	15.3	0.1
Construction	1483.0	1483.0	3.1	0.1
Manufacturing	60.3	29.6	1.6	0.2
Wholesale trade	29.5	19.9	1.1	0.4
Retail trade	136.7	0.4	4.3	0.0
Transportation and warehousing	16.8	17.9	0.6	0.3
Information and cultural industries	25.5	16.6	0.8	0.3
Finance, insurance, real estate and rental and leasing	118.8	88.9	3.8	1.7
Professional, scientific, and technical services	52.5	39.5	0.7	0.2
Administration and support, waste management and remediation services	13.9	6.2	0.5	0.1
Educational services	1.9	0.0	0.1	0.0
Health care and social assistance	19.2	6.3	0.6	0.1
Arts, entertainment and recreation	13.3	0.4	0.4	0.0
Accommodation and food services	49.3	0.0	1.5	0.0
Other services (except public administration)	27.6	1.2	0.9	0.0
Operating, office, cafeteria, and laboratory supplies	0.0	0.0	0.0	0.0
Travel, entertainment, advertising, and promotion	0.0	0.0	0.0	0.0
Transportation margins	0.0	0.0	0.0	0.0
Non-profit institutions serving households	11.0	1.4	0.3	0.0
Government sector	53.0	15.4	1.7	0.3
Total	**2134.9**	**1735.9**	**69.6**	**36.1**

$ = dollars.

Incremental effects on labour income are provided in Table 16.5-4. The incremental income effects will be greatest in Saskatchewan (i.e., the socio-economic RSA) and the socio-economic LSA (including Regina) in 2017 and 2018 during peak Project construction.

Table 16.5-4: Labour Income Effects of Construction and Operations, 2016 to 2024

Labour Income Effects	2016	2017	2018	2019	2020	2021	2022	2023	2024
	($Million)								
Saskatchewan									
Direct[(a)]	167	484	534	150	32	32	109	103	32
Indirect	12	34	38	11	20	20	26	25	20
Induced	62	178	197	55	17	17	45	43	17
Total	**241**	**697**	**768**	**216**	**70**	**70**	**180**	**172**	**70**
Socio-economic Local Study Area									
Direct[(a)]	167	484	534	150	32	32	109	103	32
Indirect	7	20	22	6	0	0	3	3	0
Induced	22	63	69	19	4	4	14	13	4
Total	**196**	**567**	**625**	**175**	**36**	**36**	**126**	**119**	**36**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.

(a) In all cases, direct effects are effects after adjusting for leakages for imports and inventory withdrawals.

$ = dollars.

16.5.1.2.2 Education and Training Effects

Increased education and training is another potential effect from the Project on the labour force. The demand for skilled labour has the potential to increase the number of people entering related post-secondary education programs in Saskatchewan and will attract an educated workforce to the area. The increased education and training levels improve potential future earning potential and employment opportunities for workers. In recent years, the capacity for training and education related to the potash industry has increased with the renewed interest in potash. Yancoal will review Project training requirements with post-secondary schools in the region and assess the availability of industry specific training and education. Yancoal will also work with First Nations and Métis communities. Increased training and education opportunities will lead to increased local opportunities to work at Potash operations.

16.5.1.2.3 Gross Domestic Product Effects

The GDP is the measure of the sum of all goods and services produced within a geographic area and is the measurement of the size of an economy. The GDP is included within gross output, represents value added or payments to final factors of production, and includes both profits and labour income. Project construction and operations effects by industry are shown in Table 16.5-5. Construction is expected to add $3,047.5 million to the Saskatchewan (i.e., socio-economic RSA) GDP, $2,258.4 million of which will be in the socio-economic LSA (including Regina). Each year of operations is expected to add $685.3 million to Saskatchewan (the socio-economic RSA) GDP, $580.4 million of which will be in the socio-economic LSA (including Regina).

Table 16.5-5: Total Gross Domestic Product Effects by Industry, 2016 to 2024

Industry	Cumulative Construction GDP Effects (at basic prices), 2016 to 2023 ($ million)		Operation GDP Effects in the first year of full capacity operation (at basic prices), 2024 ($ million)	
	Saskatchewan	Socio-economic Local Study Area	Saskatchewan	Socio-economic Local Study Area
Crop and animal production	30.0	6.1	0.9	0.1
Forestry and logging	0.4	0.0	0.0	0.0
Fishing, hunting and trapping	0.3	0.0	0.0	0.0
Support activities for agriculture and forestry	0.7	0.1	0.0	0.0
Mining and oil and gas extraction	51.2	11.0	567.1	567.1
Utilities	60.1	29.8	68.0	0.6
Construction	1483.0	1483.0	5.6	0.1
Manufacturing	139.4	63.0	3.6	0.5
Wholesale trade	65.8	44.1	2.5	0.9
Retail trade	198.2	0.6	6.3	0.0
Transportation and warehousing	38.8	32.4	1.4	0.6
Information and cultural industries	51.8	34.1	1.7	0.7
Finance, insurance, real estate and rental and leasing	566.5	440.8	18.3	8.7
Professional, scientific, and technical services	91.7	67.7	1.3	0.3
Administration and support, waste management and remediation services	19.2	8.6	0.6	0.2
Educational services	3.4	0.0	0.1	0.0
Health care and social assistance	41.3	14.3	1.3	0.3
Arts, entertainment and recreation	19.9	0.6	0.6	0.0
Accommodation and food services	66.9	0.0	2.1	0.0
Other services (except public administration)	42.0	1.8	1.4	0.0
Operating, office, cafeteria, and laboratory supplies	0.0	0.0	0.0	0.0
Travel, entertainment, advertising, and promotion	0.0	0.0	0.0	0.0

Table 16.5-5: Total Gross Domestic Product Effects by Industry, 2016 to 2024

Industry	Cumulative Construction GDP Effects (at basic prices), 2016 to 2023 ($ million)		Operation GDP Effects in the first year of full capacity operation (at basic prices), 2024 ($ million)	
	Saskatchewan	Socio-economic Local Study Area	Saskatchewan	Socio-economic Local Study Area
Transportation margins	0.0	0.0	0.0	0.0
Non-profit institutions serving households	11.8	1.5	0.4	0.0
Government sector	64.8	18.9	2.1	0.4
Total	**3047.5**	**2258.4**	**685.3**	**580.4**

GDP = Gross Domestic Product; $ = dollars.

Incremental effects from Project construction and operations up to 2024 on Saskatchewan's (i.e., socio-economic RSA) and the socio-economic LSA GDP are shown in Table 16.5-6. Effects will be greatest in 2017 and 2018 during peak construction.

Table 16.5-6: Gross Domestic Product Effects of Construction and Operations, 2016 to 2024

GDP Effects	2016	2017	2018	2019	2020	2021	2022	2023	2024
	($Million)								
Saskatchewan									
Direct[(a)]	167	484	534	150	359	359	436	430	567
Indirect	29	84	92	26	78	78	91	90	78
Induced	147	427	471	132	40	40	108	103	40
Total	**344**	**995**	**1097**	**308**	**477**	**477**	**635**	**623**	**685**
Socio-economic Local Study Area									
Direct[(a)]	167	484	534	150	359	359	436	430	567
Indirect	15	44	48	14	0	0	7	6	0
Induced	72	209	231	65	13	13	47	44	13
Total	**255**	**737**	**813**	**228**	**372**	**372**	**490**	**481**	**580**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
(a) In all cases, direct effects are effects after adjusting for leakages for imports and inventory withdrawals.
GDP = Gross Domestic Product; $ = dollars.

16.5.1.2.4 Fiscal Effects

The economic activity generated by construction and operation is expected to generate government revenues at the provincial (i.e., Saskatchewan) and federal level. The economic model's fiscal module is based on the latest provincial and federal budgets and estimates government revenue as follows.

- Provincial personal income tax is calculated using the provincial personal income tax rate that would apply to average industry annual income. This is applied to model-generated labour income.
- Federal personal income tax is calculated by using the federal personal income tax rate that would apply to average industry annual income applied to model-generated labour income.

- Corporate income tax is calculated by applying the respective provincial and federal corporate tax rate to incremental corporate profits before taxes calculated by the model.
- Unincorporated business income taxes are calculated by applying the small business tax rate to incremental unincorporated business profits calculated by the model.
- Sales tax calculation is based on the ratio of provincial and federal sales taxes collected to retail trade gross output applied to incremental retail trade output calculated by the model.
- Non-renewable resource revenue is calculated using the 5-year average ratio of non-renewable resource revenue in mining, oil, and gas output multiplied by incremental mining, oil, and gas output. The estimate derived in this fashion is scaled down by 50% to reflect average differences between model-generated estimates to proponent provided estimates.

Estimated government revenues are for direct, indirect, and induced effects and do not represent solely taxes and royalties paid by Yancoal. Estimates are not adjusted for any changes to equalization entitlements. The breakdown of fiscal effects by level of government for Project construction is shown in Table 16.5-7. Total revenue is expected to be approximately $325.6 million for the provincial government and $485.4 million for the federal government.

Table 16.5-7: Estimated Government Fiscal Effects, Construction, 2016 to 2023

Level of Government	Personal Income Tax	Corporate Income Tax	Taxes on Unincorporated Business Profits	Non-Renewable Resource Revenue	Sales and Excise Tax	Total Revenue
	($ Million)					
Federal	404.7	30.4	29.0	n/a	21.3	**485.4**
Provincial	244.1	24.3	21.2	3.8	32.0	**325.6**
Total	**648.8**	**54.8**	**50.2**	**3.8**	**53.4**	**811.0**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
n/a = Not applicable; $ = dollars.

The breakdown of fiscal effects by level of government for Project operations is shown in Table 16.5-8. The 2024 operational fiscal effects are expected to repeat annually throughout Project operations. Project operations are expected to generate approximately $70.0 million for the provincial government and $45.8 million for the federal government annually.

Table 16.5-8: Estimated Government Fiscal Effects, First Year of Full Capacity Operation, 2024

Level of Government	Personal Income Tax	Corporate Income Tax	Taxes on Unincorporated Business Profits	Non-Renewable Resource Revenue	Sales and Excise Tax	Total Revenue
	($ Million)					
Federal	14.5	29.7	1.0	n/a	0.7	**45.8**
Provincial	7.7	23.7	0.7	36.7	1.0	**70.0**
Total	**22.2**	**53.4**	**1.7**	**36.7**	**1.7**	**115.8**

Note: Some numbers are rounded for presentation purposes. Therefore, it may appear that the totals do not equal the sum of the individual values.
n/a = Not applicable; GDP = Gross Domestic Product; $ = dollars.

16.5.1.2.5 Summary of Employment and Economy Effects

The Project will contribute substantially to the provincial and local economies. Over the course of the construction phase (2016 to 2023), the Project will add the following to the Saskatchewan (i.e., socio-economic RSA) economy:

- 24,560 person years of employment within the province;
- A cumulative $3,047 million to provincial gross domestic product;
- A cumulative $2,135 million in new wages and salaries (included in GDP); and
- $811 million in federal and provincial government revenues.

Of the total contributions to the provincial economy, construction will add the following to the local economy (i.e., socio-economic LSA, which includes Regina):

- 11,377 person years of employment within the region;
- A cumulative $2,258 million to local gross domestic product; and
- A cumulative $1,736 million in new wages and salaries (included in GDP) in the region.

Once the Project is at full operation in 2024, and for the production life of the Project, the Project will have the following annual effects on the Saskatchewan (i.e., socio-economic RSA) economy:

- 1,041 new positions within the province;
- $685 million in provincial gross domestic product;
- $70 million in new wages and salaries (included in GDP) in Saskatchewan; and
- $115.8 million in federal and provincial government revenues.

Of the total contributions to the provincial economy, operations in 2024 will have the following annual effects on the local (i.e., socio-economic LSA, which includes Regina) economy:

- 377 new positions within the region;
- $580 million in regional gross domestic product;
- $36 million in new wages and salaries (included in GDP) in the region; and
- add 1,760 persons to the regional population.

Over the course of an assumed 90-year operational phase, provincial (i.e., socio-economic RSA) effects of the Project are expected to include:

- 93,719 person years of employment;
- $61,674 million in GDP;
- $6,262 million in labour income; and
- $10,422 million in federal and provincial government revenues.

16.5.2 Effects to Community Services and Infrastructure

The following primary pathway was assessed to determine effects on community services and infrastructure.

- **A non-resident Project workforce that relocates to the socio-economic LSA can place increased demand on housing, infrastructure, and services.**

The pathway relating to waste management services is assessed as a secondary pathway in Section 16.4.2.3. Effects to the community services and infrastructure VC are assessed for the socio-economic LSA.

16.5.2.1 Methods

Effects of the Project on housing, services, and physical infrastructure are assessed based on the predicted increase in local population size that may result from workforce requirements, the current capacity of the socio-economic environment, and mitigation proposed by Yancoal.

The population increase was modelled using a simple cohort survival model using birth rates, death rates, and migration data from Statistic Canada (Appendix 16-A). Natural population increase was estimated based on the number of women of childbearing age and historical birth rates by age group, combined with historical death rates per age group. Migration data includes international, interprovincial, and intraprovincial migration. Migration data from the past five years in Statistics Canada's Census Division 6, which includes Regina, was used to predict future baseline migration in the socio-economic LSA. Due to existing labour force conditions in the socio-economic LSA, it was assumed that the entire construction workforce will come from outside the socio-economic LSA, but based on previous, large-scale resource projects, it was assumed that 10% of the construction workforce will relocate permanently to the socio-economic LSA. Some of the population that migrates to the socio-economic LSA is expected to bring family, which was taken into consideration in the population assessment. During operations, 100% of direct, 50% of indirect, and 10% of induced employment is expected to be met by in-migration. All operations related workers who migrate are expected to relocate permanently.

16.5.2.2 Results

The Base Case is discussed in Section 16.3 and Annex V. During the Application Case, the Project is expected to add approximately 1,731 people to the socio-economic LSA by the end of construction and start of full operations (Table 16.5-9). Based on the Statistics Canada 2011 census population of 208,515, the population in the socio-economic LSA is expected to grow to 250,840 (20.3%) without the Project and to 252,571 (21.1%) with the Project. During construction, out-of-region workers will temporarily place demand on rental housing, hotel accommodation, and services during the construction period. Because Regina's temporary accommodation is typically in moderate demand, Regina's temporary accommodations do not have the capacity to house the entire construction workforce. As a result, up to 1,500 workers are expected to be housed in a construction camp, which will reduce potential negative interactions with surrounding communities (e.g., drugs or crime). However, the work camp will be within driving distance of Regina and small towns including Southey and Strasbourg, and workers may possibly travel to these communities when they are off shift. Peak construction is expected in 2017 and 2018. About 10% of the construction-related workforce (direct, indirect, and induced labour) is expected to relocate to the socio-economic LSA, which includes Regina. With families, this is equivalent to approximately 1,042 people. During Project operations, the entire workforce is expected to relocate to the socio-economic LSA, including Regina. With families, this is equivalent to 653 people. With migration and natural growth of the migrating population combined, the total population increase of 1,731 is equivalent to 0.8% of the socio-economic LSA population. Population growth in the socio-economic LSA is expected to benefit the local economy; however, demand for services and infrastructure could increase.

Due to the small population and limited infrastructure and services in the immediate vicinity of the Project, most of the in-migrating population is expected to relocate to Regina. A small number of workers may relocate to communities or acreages north of Regina and closer to the Project. This assessment will focus on the effects on Regina, based on the expectation that most of the population increase will be experienced there. Other communities may still experience minor changes to real estate and housing, and other services and infrastructure, because of small increases in population.

Table 16.5-9: Project-related Labour, Migration, and Population Effects (Direct, Indirect, and Induced Labour)

Year	Labour Demand (Direct, Indirect, and Induced)	Incremental Labour Demand (only new demand for each year)	Permanently Relocating Workers[(a)]	In-migration Including Families	Incremental Population Growth[(b)]
2016	1283	1283	128	268	267
2017	3715	2432	243	509	774
2018	4095	380	38	67	845
2019	1150	0	0	0	852
2020	377	377	312	653	1,506

Table 16.5-9: Project-related Labour, Migration, and Population Effects (Direct, Indirect, and Induced Labour)

Year	Labour Demand (Direct, Indirect, and Induced)	Incremental Labour Demand (only new demand for each year)	Permanently Relocating Workers[(a)]	In-migration Including Families	Incremental Population Growth[(b)]
2021	377	0	0	0	1,515
2022	572	572	95	198	1,712
2023	922	0	0	0	1,731

Note: Numbers are rounded.
(a) 10% of construction workforce, 100% of direct operations workforce, 50% of indirect operations workforce, 10% of induced operations workforce.
(b) Incremental population impacts include natural growth and will not correspond exactly to in-migration.

The City of Regina has experienced a surge in growth over the past decade. In 2010, the Regina Official Community Plan Working Paper identified three potential growth scenarios for Regina over the next 30 years: high, medium, and low (DCMA 2010). The City of Regina is planning for growth in line with the high growth scenario, which would result in a population of approximately 300,000 by 2035 or 2040 (City of Regina 2013; RROC 2015). Although census data from 2011 suggested that Regina may be growing more slowly than the low growth scenario, this may be a result of the change from the mandatory census to a voluntary census. More recently, Statistics Canada estimated the Regina CMA population to be 232,090 in 2013 and RQHR estimated the Regina population with health coverage at 221,996 in 2014 (Statistics Canada 2014b; RQHR 2013b). These values suggest that the City of Regina may be growing at a rate comparable to the high growth scenario. The economy slowed in 2014 and the demand for some services and infrastructure eased.

In addition to the workforce that permanently relocated to the socio-economic LSA, a temporary workforce will be required. A temporary workforce, particularly one partially housed in a construction camp, is not expected to have as great an effect on community services and infrastructure as a permanently relocating population, but will still require the use of some hotel rooms and is expected to visit local restaurants and stores and occasionally use EMS or health services. The recent slowdown in the oil and gas industry is expected to further reduce pressure on infrastructure and services in the socio-economic LSA.

Service and infrastructure providers in Regina are aware of the predicted increase in Regina's population over the next 25 years, and some services and infrastructure are already nearing capacity, or may be experiencing negative effects if they are already over capacity.

16.5.2.2.1 Health Care

The Project is located in the SHR and RQHR, but most of the relocating workforce is expected to reside in the RQHR. The RQHR has recently been working towards reducing surgery wait times, and between August 1 and October 31, 2014 79.4% of surgeries were performed or offered within 3 months (Government of Saskatchewan 2014g). By March 31, 2015, only 200 patients are expected to have waited longer than 3 months for surgery (RQHR 2015). In Regina, both the Regina General Hospital and the Pasqua Hospital often operate at or above 100% capacity, and may have to use overflow space or cancel non-emergency procedures (RQHR 2014c). The RQHR is facing several challenges, including infrastructure deficiencies and a 7.9% (21,113) increase in patients and a 7.25% increase in cost ($80.9 million) between 2010 and 2014 because of population and demographic changes. An increase in population of 1,731 in the Application Case represents 8.2% of the increase the RQHR experienced between 2010 and 2014, but this increase will act cumulatively with RFDs, temporary Project workforce during construction, and background population growth.

16.5.2.2.2 Education

The construction workforce is expected to be met largely by a temporary, trained, out of province workforce. Some local workers may be hired, depending on availability and skill sets, but the construction period is short-term and is not expected to encourage people to train specifically for construction. Based on the unemployment and participation rates and the recent expansions in the potash industry, the operations workforce is largely expected to be met by in-migration of trained workers. As a result, a large change in demand for post-secondary education is not expected. However, Yancoal will work with post-secondary institutes in the province to assess availability of industry specific training. As a result, post-secondary institutes with relevant programs may experience a small increase in enrollment. However, most effects of education are expected from the general population increase and families that migrate with workers.

The socio-economic LSA includes the Horizon, Prairie Valley, Regina Public, and Regina Catholic School Divisions, as well as the Consel des École Fransaskoises school with 390 students (Consel des École Fransaskoises 2014). The Horizon School Division has approximately 985 students in communities in the socio-economic LSA (Horizon School Division 2014). The Prairie Valley School Division has approximately 2,065 students in communities in the socio-economic LSA (PVSD 2014). During the community information sessions (Section 5.0), a stakeholder indicated that the Southey school is operating at capacity. The Regina Public School Division has over 20,000 students in 41 elementary schools and nine high schools, while the Regina Catholic School Division has approximately 10,000 students in 24 elementary schools and four high schools (RPSD 2014; RCSD 2014).

In Regina, where most permanently relocating workers are expected to move, school enrollment has been increasing steadily and the Regina Public and Catholic School Boards appear to be nearing, but not yet over, capacity. The Regina Public School has implemented a new policy that designates which high school students will attend based on where they live (CBC 2015). This policy will address a predicted increase of 2,500 high school students by 2023. The population modelling for the Project suggests that the Project is expected to result in approximately 1,695 people in-migrating, including 816 workers and 879 family members, including spouses and children. Consequently, the Project is expected to moderately increase demand on schools in the Application Case and will act cumulative with other future developments during the RFD Case.

16.5.2.2.3 Accommodation

The Regina housing market has been growing rapidly over the past several years and has included increasing house prices and low vacancy rates. In 2012 and 2013, The Canada Mortgage and Housing Corporation reported that the demand and supply for resale houses in Regina was balanced (CMHC 2013c). The number of housing starts in Regina increased substantially to over 3,000 in 2012 and 2013 (CMHC 2014a,b). However, the recent weakening of the economy resulted in a decline of housing starts in 2014 and 2015, with an expected 2,150 housing starts in 2015 (CMHC 2014b). Demand for housing is expected to continue over the next two decades, but has eased somewhat in the past two years. The City of Regina is aware of the demand for housing and intends to encourage 30% of population growth to existing neighbourhoods by increasing development of apartment buildings and multi-family dwellings (City of Regina 2013).

With the rapid population growth Regina has experienced, the rental market has been under pressure. Vacancy rates have been low and rents have risen quickly. In 2013, tax incentives put into place by the City of Regina to encourage construction of rental properties contributed to increasing the vacancy rate to 1.8% (CMHC 2013a). With the recent slowdown in the economy and the oil and gas industry, vacancy rates are expected to rise to 2.4% by October 2015 (CMHC 2014a,b). Average monthly rent for a two-bedroom apartment was $1,018 in October 2013, but this includes both rented and vacant apartments (CMHC 2014c). Actual rent for vacant apartments is likely much higher due to demand and new rental properties on the market.

A construction camp will be built to house approximately 1,500 temporary workers. At peak, the Project will require 2,200 workers. In addition to the construction camp for temporary workers, some workers could be local and some may relocate permanently to the area. However, there will be a portion of the temporary workforce (i.e., any temporary, non-local workforce over 1,500) that requires hotel rooms in the socio-economic LSA. Regina has dozens of hotels and thousands of hotel rooms that provide temporary accommodation to visitors, tourists, and industry. The recent slowdown in the oil and gas industry is expected to reduce demand on temporary accommodation.

During the Application Case, permanently relocating workers are expected to increase demand on the housing and rental markets, particularly since relocating workers are expected to be a mixture of experienced workers with families looking for family homes and young workers who may start in rental accommodation and eventually purchase their first house. This increase is expected to be concentrated in Regina. The temporary workforce during the Application Case will increase demand for temporary accommodations, as the construction camp will not house the entire workforce during peak construction. The RFD Case includes a variety of Projects that may use a workforce from Regina or require a temporary workforce to stay in Regina. Increased demand for resale homes, rental properties, and temporary accommodations has positive effects on local businesses, but may have negative effects on tourism and vacancy and rental rates (which can affect the labour force).

16.5.2.2.4 Emergency and Protective Services

An increase in population from the Project will increase pressure on emergency services, including ambulance, police, and fire. Increased pressure on these services is expected to primarily come from the permanently relocating population, but the temporary population may require these services. However, unless a major incident or emergency is associated with construction of the Project, the construction workforce is not expected to place noticeable demand on health services. The recent Regina Police Service Strategic Plan (2015) acknowledges the rapid population growth Regina has experienced and expects in the future, and identifies this as a challenge in the future.

16.5.2.2.5 Tourism and Recreation

Tourism and recreation is widespread in the socio-economic LSA. Regina provides most of the municipal recreation opportunities and facilities and has numerous tourist attractions and facilities. Last Mountain Lake is a major tourism destination in the area and has cabin development and scattered temporary accommodation and parks. For example, Sun Dale Recreation has a $200.0-million, 350-unit housing development planned for Last Mountain Lake (RFD Case, Section 16.2.2.3). Individuals who permanently relocated to the socio-economic LSA are expected to take advantage of tourism and recreation opportunities in the area, but the temporary workforce is less likely to use tourism and recreation services and infrastructure. In general, demand for parks has been increasing in Saskatchewan over the past several decades. The socio-economic LSA contains two parks with campground accommodation: Rowan's Ravine Provincial Park and Last Mountain Lake Regional Park.

16.5.3 Effects to Traffic and Transportation Infrastructure

The following primary pathway was assessed to determine effects on traffic and transportation infrastructure.

- **Project activities will modify local transportation infrastructure and affect traffic (e.g., changing road and rail access to the site) through increased municipal road maintenance requirements, altered travel routes, and increased traffic volume.**

Pathways relating to potential traffic accidents and the closing of local roadways within the core facilities area are assessed as secondary pathways in Section 16.4.2.3. Residual effects on the traffic and transportation VC are assessed for the socio-economic LSA.

16.5.3.1 Methods

The Base Case is described in Section 16.3 and Annex V, Section 4.0. A TIA was completed for the Project to identify anticipated effects of Project-related traffic and recommended mitigation improvements to existing transportation infrastructure (Appendix 4-C). Background traffic information was obtained from the Ministry of Highways and Infrastructure (MHI) for Highway 6 north and south of the junction with grid road 731. The TIA determined the total new Project-related trips as a result of the Project at peak weekday morning and afternoon times and identified expected origins, destinations, and routes. The TIA further assessed a key intersection to determine if traffic volumes at peak times would cause undue congestion or require changes to the roadway, intersection, or access to provide acceptable levels of service and safety. The specific intersection analysis was completed for the Highway 6 and grid road 731 intersection. The intersection analysis determined the level of service, volume capacity ratio, and 95th percentile queue length to assess the quality and efficiency of traffic flow at this intersection. This intersection was selected because it is expected to experience the greatest effects from Project-related traffic.

16.5.3.2 Results

For the purposes of the TIA, background traffic levels were predicted to increase by 2% per year, based on recent growth rates but accounting for the recent slowdown of the economy in Saskatchewan. No known reasonably foreseeable developments in the immediate vicinity of the Project are expected to further increase traffic volumes.

Project-related traffic during construction was conservatively estimated using a peak workforce of 2,500 and average workforce of 2,000. Currently a peak workforce of 2,200 and average workforce of 1,500 are expected. A construction camp is expected to house up to 1,500 people, reducing the number of vehicles commuting daily to the Project site to approximately 1,000 at peak and 500 on average, based on the estimates used in the TIA (Table 16.5-10). Workers staying at the construction camp will be transported to site in multi-passenger vehicles and the location of the work camp is assumed to be close to the Project. These individuals will travel to the camp every few weeks. This traffic was therefore not included in the intersection analysis for Highway 6 and grid road 731. In addition to the construction work force traffic, 15 large truck deliveries per week and 14 over-dimension trucks per month are expected to access the site during construction. Further, to achieve a conservative assessment, approximately 150 Yancoal staff (operations workforce starting prior to the end of construction) are assumed to travel to the site daily in personal vehicles during construction. During operations, the TIA assumed an operations workforce of approximately 300 staff. The current estimate is approximately 350 staff. In addition, there will be five heavy truck deliveries per week.

Table 16.5-10: Project-related Traffic (Number of Trips)

Project Phase	Description	Total Trips (1 trip = 2 AADT)
Construction	Workforce commuting to site (peak)	1000
	Workforce commuting to site (average)	500
	Yancoal personnel commuting to site during construction	150
	Large trucks (weekly)	15
	Over dimension trucks (monthly)	14
Operations	Yancoal personnel commuting to site during construction	300
	Large trucks (weekly)	5

AADT = Average Annual Daily Traffic.

Construction shifts were assumed to occur six days per week and to be divided into 75% day shift work and 25% night shift work. Day shifts were estimated to be from 7:00 a.m. to 5:00 p.m. and night shifts were estimated to be from either 5:00 p.m. to 3:00 a.m. or 7:00 p.m. to 5:00 a.m. The Yancoal workforce during operations was estimated to work shifts from 8:00 a.m. to 7:00 p.m. and from 7:00 p.m. to 8:00 a.m., 7 days a week. The number of vehicles per hour was calculated based on shift times and the number of workers starting and ending shifts. It was assumed that there would be an overall reduction of traffic by 10% due to carpooling. Carpooling is expected to occur due to the distance to Regina and the economic benefits of carpooling when travelling a larger distance. Based on the shift times and workforce numbers, the peak morning and evening travel times were identified. The estimated number of vehicles during the morning and evening peak travel times is provided in Table 16.5-11.

Table 16.5-11: Peak Morning and Evening Project-related Traffic

Project Phase	Description	Morning Peak Traffic		Evening Peak Traffic	
		Enter	Exit	Enter	Exit
Construction	Workforce commuting to site (peak)	750	-	-	750
	Workforce commuting to site (average)	375	-	-	375
	Yancoal personnel during construction[(a)]	0	-	-	0
	Over-size trucks (per week)	1	-	-	1
	Large trucks (per month)	1	-	-	1
Operations	Yancoal personnel during operations	225	75	75	225
	Large trucks (per month)	1	0	0	1

(a) Yancoal personnel are not expected to contribute to the morning peak traffic during construction because they are expected to start work later than the construction workforce does and will therefore travel to site at a different time.

"-" = not applicable.

Most of Project-related traffic is expected to originate in Regina and travel north on Highway 6 and west on grid road 731 to reach the core facilities area. Some traffic may travel from the north on Highway 6, from east of Highway 6, or from the west on grid road 731. The TIA includes an assessment of the intersection between Highway 6 and grid road 731. Traffic was assumed to originate mainly (85%) from the south, which smaller portions coming from the west, east, and north (5% each). Routing of trips was determined using logical assumptions about how people will travel (i.e., minimum travel time). Some traffic will come from further than Regina (i.e., some equipment and supply delivery); however, this portion of Project-related traffic is expected to be minor compared to the existing volume of traffic on highways leading to Regina, and is, therefore, not considered in this assessment.

A summary of the traffic analysis of Highways 6 and grid road 731 are provided in Table 16.5-12. The level of service at the intersection ranged from Level A to C during construction and operations. Level A represents free flowing traffic, Level B indicates reasonably free flow, and Level C represents stable flow. At no time was the traffic estimated to be level D, E, or F, which indicate unstable, forced, or breakdown of flow. The volume to capacity ratio (V/C) assesses the capacity of the intersection, with a ratio above 1 indicating that the intersection has exceeded capacity. The V/C ratios at the intersection indicated a maximum ratio of 0.45 during construction (i.e., 45% of capacity) and 0.32 during operations (i.e., 32% of capacity). The queue length is a measure of the maximum line up of vehicles expected under 95th percentile (i.e., peak) traffic conditions. The maximum queue length of 19 m during construction indicates that during the 5% highest traffic volumes during peak traffic, a queue of four vehicles should be expected. Overall, these numbers are below the TIA established thresholds for level of service (threshold = E), V/C (threshold = 0.85), and queue length (threshold = 100 m). This suggests the intersection will operate satisfactorily during Project construction and operations.

Table 16.5-12: Combined Traffic Analysis Results of Highway 6 and Grid Road 731 Intersection.

Project Phase	Peak Traffic, a.m. or p.m.	Level of Service[(a)]	Volume to Capacity Ratio by Movement[(a)]	Queue Length (m) [(a)]
Construction	a.m.	A to C	0.0 to 0.23	0 to 7
	p.m.	A to B	0.0 to 0.45	0 to 19
Operations	a.m.	A to C	0.01 to 0.20	0 to 6
	p.m.	A to B	0.01 to 0.32	0 to 11

(a) The values in these columns include the range of high and low values in the east-, west-, north-, and south-bound lanes.
m=metres.

Ministry of Highways and Infrastructure warrants were considered for the Highway 6 and grid road 731. Applicable warrants for intersection upgrades were completed for:

- right turn lane;
- channelized intersection treatment;
- bypass lane intersection treatment; and
- flared intersection treatment.

Based on the results of the TIA, the following improvements are warranted at the intersection of Highway 6 and grid road 731:

- construct an east-bound right-turn lane on grid road 731;
- pave the eastbound approach to Highway 6 on grid road 731 to limit wear and maintenance; and
- construct a channelized intersection on Highway 6 in the north-bound approach.

A south-bound right-turn lane on Highway 6 was not deemed warranted during construction or operations; however, if traffic levels increase by 10 to 15 vehicles during the morning peak traffic during operations, a south-bound right-turn lane would be warranted. This is equivalent to an increase in background traffic of 10 to 15 vehicles or an additional 200 operations employees (5% of which would be expected to travel to the Project site from the north). The operations workforce estimate has increased from 300 to 350 since the TIA was completed, suggesting that an increase of 150 operations employees or background traffic of 7 to 12 vehicles would warrant a south-bound right-turn lane.

The rail line associated with this Project will be assessed in a separate study; however, neither of the rail options is expected to intersect with roadways used to access the core facilities area. The estimated construction workforce has declined and the operations workforce has increased since the TIA was initiated. Yancoal will work closely with government and R.M.s to manage existing roadways properly and maintain equal or better service. No trip reductions were applied for bus and shuttle services. Overall, the assumptions in the TIA are considered conservative.

16.5.4 Effects to Quality of Life

The following primary pathways were assessed to determine effects on quality of life.

- **Visual changes from the Project may influence the visual character of the area (i.e., aesthetics) and affect the quality of life of some local residents.**
- **Project noise from facilities, equipment, and vehicles are nuisances that may affect quality of life for some individuals and could affect wildlife distribution, which could affect traditional and non-traditional land use.**

Pathways relating to air and water quality are assessed as secondary pathways in Section 16.4.2.3. Residual effects on the quality of life VC are assessed for the socio-economic LSA.

16.5.4.1 Methods

For the purposes of this assessment, quality of life is defined by outer aspects of quality of life (e.g., livability of the environment), rather than inner aspects which are highly subjective (e.g., appreciation of life or perceived general health and wellbeing (Veenhoven 2000). Quality of life in this assessment includes visual aesthetics, noise, and air and water quality; however, the only quality of life primary pathways are related to visual aesthetics and noise.

16.5.4.1.1 Visual Aesthetics

No data specific to visual aesthetics is available and no applicable thresholds exist. The effects associated with changes in visual aesthetics are discussed qualitatively below.

16.5.4.1.2 Noise

Effects on the acoustic environment from Project noise emissions include increased noise levels during construction, operations, and decommissioning and reclamation. An assessment of potential Project-environment interactions with the local acoustic environment was completed for the Project (Appendix 14-B). The acoustic assessment focused on changes from ambient noise levels in the Base Case to cumulative noise levels in the Application Case. Noise levels were assessed for noise receptors in an area of 1.5 km around the Project, or the acoustic environment ESA. Based on noise level attenuation with distance, no effects on the acoustic environment are expected beyond 1.5 km. Noise receptors include all permanent and seasonally occupied dwellings (used at least six weeks per year) and can include residential homes, daycares, schools, hospitals, places of worship, nursing homes, or communities. A total of 60 noise receptors were identified in the acoustic environment ESA. Four dwellings that were considered representative were selected for a 24-hour noise monitoring to characterize existing acoustic conditions on four sides of the Project. The effects of noise emissions from Project operations were assessed using the Alberta Energy Regulator *Directive 038: Noise Control* (EUB 2007) because no requirements or methods are specific to Saskatchewan. Directive 038 only applies to Project operations; as a result, Project construction was assessed following Health Canada guidance documents (Appendix 14-B). Noise predictions were created using a model capable of assessing potential changes to noise levels as well as the effectiveness of potential noise controls. Noise levels were predicted for daytime and nighttime at individual receptors as well as for the overall acoustic environment ESA (Appendix 14-B).

16.5.4.2 Results

16.5.4.2.1 Visual Aesthetics

The Project is a large industrial installation that will occupy approximately 14,320 ha in a rural, agricultural area. Most of this area will be the 65-year mine field and indicated resource boundary, which will not be fully developed. However, the core facilities area and 19 well pads and associated access roads (i.e., point of maximum development) will occupy approximately 842 ha and the TMA will occupy approximately 708 ha. During the Base Case, the topography in the vicinity of the Project is fairly level and tree cover is limited to patches of woodland or tree rings around wetlands. Most of the surrounding landscape is cultivated, with some areas of modified or native grassland. As a result, there will likely be unobstructed views of the Project from all directions and, potentially, over long distances. Based on similar projects in similar landscapes, the Project is not expected to be discernible at a distance over 20 km. The Project will be a dominant feature of the landscape. The nearest communities are Earl Grey, Strasbourg, Southey, which are located approximately 20 km from the Project, by direct line of sight. Individuals and families living in these communities or in homes closer than 20 km to the Project will likely see it frequently. The Project will be a substantial change to the visual aesthetic of the area for local residents of Southey and Strasbourg, individuals and families within 20 km, and traffic on Highway 6. Lights from the Project are expected to be visible at these locations.

Yancoal is committed to reducing the visual disturbance of the Project to the extent feasible. Environmental design features of the Project that will reduce the visual effect of the Project include the compact layout of the core facilities area. Where possible, municipal grid roads and existing utility corridors will be used to reduce new disturbance corridors in the area. New access roads, railway lines, and utility corridors will follow existing disturbance corridors wherever possible. Well pads will be constructed to accommodate the drilling of multiple wells to reduce the surface footprint of mining. Natural colours will be used on core facilities and buildings. Lighting will be designed to control off-site light disturbance (e.g., covered, face downward, use of low-glare fixtures).

16.5.4.2.2 Noise

All noise receptors were farm houses or yard sites located in a low density area of 1 to 8 dwellings per quarter section. Permissible sounds levels for these dwellings at these receptors range from 50 to 60 A-weighted decibels (dBA) during the day and 40 to 50 dBA at night, depending on the proximity to the highways that travel through the acoustic environment ESA. Ambient sound levels at the receptors during the Base Case ranged from 45 to 55 dBA during the day and 35 to 45 dBA at night. Based on the four 24-hour noise monitoring events, Base Case noise levels for the acoustic environment were estimated at 40.1 dBA during the day and 39.0 dBA at night.

Equipment used for construction is expected to generate sound that will be detectable at some residences in the socio-economic LSA. Common construction sound sources will include traffic accessing the site and earth moving equipment, cranes, trucks, and generators working on the Project site. Much of the equipment involved is expected to be diesel-powered and mobile equipment is commonly outfitted with backup warning alarms. Sound levels will vary throughout construction based on the type and level of activity. Noise emissions from construction will be temporary. For construction, noise levels were estimated using different categories of construction equipment, including civil, cranes, construction facilities and construction materials testing, structural, mechanical, electrical, and building cladding, roofing, and architectural finishing. Noise levels were estimated based on the numbers of each vehicle type, the extent of use of each vehicle type, and the distance of the work to known noise receptors. Construction is estimated to occur from 6:00 a.m. to 7:00 p.m. daily. Receptors that are close to the access route, near drilling activity or well pad infrastructure, and close to the core facilities area typically had higher predicted noise levels. Predicted cumulative noise during construction was compared to Health Canada noise thresholds. Health Canada Thresholds include: noise-induced hearing loss (NIHL) (70 dBA); sleep disturbance (45 dBA); speech comprehension (55 dBA); complaints (55 dBA); and high annoyance (6.5% change). The predicted noise levels fell below the Health Canada Thresholds for all five categories (Appendix 14-B). Activities during decommissioning and reclamation are expected to have similar or lower noise emissions than construction.

Noise emissions during operations are expected to be confined to a small area in the socio-economic LSA that includes the core facilities area, the mining area, the rail line, and access routes. This pathway also considers effects to land use. Land use in the area consists primarily of agriculture. No traditional land use is known to occur near the Project footprint (Section 16.3.2.5). As a result, this pathway is considered no linkage to traditional and non-traditional land use even though it is primary to quality of life.

Project operation and drilling in the mining area are expected to occur 24-hours per day, with one well pad drilled at a time. Environmental design features and noise mitigation include the use of conventional insulation, baffles, and noise suppressors. In addition, stationary equipment will be located inside buildings, which will reduce noise emissions. To be conservative, it was estimated that the Project will require one 170-car train to be loaded each day, with one trip occurring during the day and one at night. To be conservative, it was assumed that both rail options will be used and that all equipment except for train loadout equipment will be used all the time. In reality, only one rail spur is expected to be operated and one train every two days will be required and not all equipment will be operational 100% of the time. In addition, the noise modeling for the wellpads was estimated for the well pad that is closest to a receptor to provide the most conservative estimate of noise effects from wellpad activities.

A low frequency noise (LFN) analysis was completed for Project operations and identified two noise receptors, R06 and R24 as having potential LFN issues. The potential LFN issues are likely a result of the conservative approach taken in the acoustic environment assessment. Monitoring would be required during Project operation to determine actual LFN effects.

Cumulative noise levels (i.e., predicted Project noise levels and ambient sound level combined using a logarithmic equation) during operations at the 60 noise receptors ranged from 45.0 to 55.0 dBA during the day and 35.0 to 45.6 dBA at night. These values are between 0.3 and 5.0 dBA below the permissible sound levels (PSLs), according to the AER Directive 038, with the exception of noise receptor R101. Noise receptor R101 has higher noise levels because it is adjacent to the core facilities area and one of the potential rail line routes. Predicted AER cumulative noise levels at R101 are 53.0 dBA during the day, 3.0 dBA above the PSL, and 45.6 dBA at night, 5.6 dBA above the PSL.

16.5.5 Effects to Traditional and Non-Traditional Land Use

The following primary pathway was assessed to determine effects on traditional and non-traditional land use.

- **The Project will reduce the area of agricultural land.**

Pathways related to other land uses (e.g., traditional land use, recreation) and the effects of changes to surface water, noise, dust and air emissions, brine migration, brine injection, and subsidence on land use are assessed as no linkage and secondary pathways in Sections 16.4.2.2 and 16.4.2.3. Residual effects on the traditional and non-traditional land use VC are assessed for the land use ESA.

16.5.5.1 Methods

To determine the effects of the Project footprint on agricultural land (i.e., cultivated land, hayland, and land used for livestock production), the change in area of different vegetation communities was evaluated (described in detail in Section 13.5.1). These changes were determined from the difference between the existing conditions (Base Case) and the Application Case at the maximum point of Project development and following reclamation. Change is then expressed as a percentage of existing agricultural land in the affected R.M. and in the overall land classification area. Cultivated land was assessed to determine the potential loss of crop production land. Modified and native grassland were assessed to determine the potential loss of cattle grazing and hay production land.

16.5.5.2 Results

Project design includes a variety of mitigation measures to reduce the effect of the Project on agriculture. The core facilities area and mine well field area have been designed to be compact and optimize space to reduce surface disturbance. Where possible, existing public roads will be used for access and mine well field area pipeline corridors will be routed along existing disturbance corridors.

During the Base Case, an estimated 46,834 ha (58.3%) of cultivated land, 12,723 ha (15.8%) of modified grassland, and 6,432 ha (8.0%) of native grassland are in the land use ESA (Table 16.5-13). During the Application Case, 1,216 ha (-2.6%) of cultivated, 77 ha (-0.6%) of modified grassland, and 19 ha (-0.3%) of native grassland will be removed and be unavailable for agricultural use. This is equivalent to 1,312 ha (2.0%) of agricultural land in the land use ESA. At the end of operations, all non-permanent Project infrastructure will be removed and the land reclaimed to blend with surrounding terrain. Reclaimed areas are expected to be returned to a similar land use as in the Base Case. The TMA, including the Stage I and Stage II salt storage area, Stage I and Stage II brine reclaim pond, sewage lagoon, surface diversion works and crystallization pond, are considered permanent. Permanent losses as a result of the Project include 600 ha (-1.3%) of cultivated land, 8 ha of modified grassland (-0.1%), and 2 ha of native grassland (<-0.1%), or 610 ha (-0.9%) of agricultural land in the land use ESA (Table 16.5-13). In the R.M. of Longlaketon, which has a total of 101,278 ha of agricultural land, the disturbance of 1,312 ha represents -1.3% of agricultural land. Following Project decommissioning and reclamation, the 610 ha of permanent, residual disturbance for the TMA is equivalent to -0.6% of agricultural land. Yancoal will develop guidelines for leasing agricultural land and pasture on land not being used for Project activities.

Table 16.5-13: Change in Area of Agricultural Land Cover Types from Development within the Traditional and Non-Traditional Land Use Effects Study Area

Ecological Landscape Classification Map Units	Base Case (ha)	Application Case (ha)	Change Base Case to Application Case (ha)	Percent Change Base Case to Application Case (% unit)	Area of Agricultural Land that will be Permanently Removed (ha)
Cultivated	46,834	45,618	1,216	-2.6	-600
Modified Grassland	12,723	12,646	77	-0.6	-8
Native Grassland	6,432	6,413	19	-0.3	-2
Total	**65,989**	**64,677**	**1,312**	**-2.0**	**-610**

Note: The land use ESA is 80,385 ha in size.
A value of <-0.1 approaches zero.
ha = hectare; % = percent, < = less than.

The Project has the potential to increase demand for acreages north of Regina, which could result in the development (i.e., loss) of parcels of agricultural land. Landowners will be compensated for the purchase of their land, and it is assumed that private or corporate developers would follow applicable R.M. bylaws. However, this has the potential to result in a small reduction to the area of agricultural land in the land use ESA.

None of the projects identified for the RFD Case are located within the R.M. of Longlaketon or the land use ESA and are not expected to act cumulatively with the Project to directly reduce the area of agricultural land. However, the cumulative population increase from the Project and future projects may act cumulatively to increase demand for acreages north of Regina.

16.6 Prediction Confidence and Uncertainty

16.6.1 Employment and Economy

The economic model used to assess the economic effects of the Project is based on the latest Statistics Canada Saskatchewan input-output table, which includes a number of assumptions regarding current industries and commodities. The predicted economic effects depend on specific Project expenditures, duration of construction and operations, and existing economic conditions. Changes to the schedule, duration, or expenditures would affect the economic assessment, particularly the employment and income assessment. The Saskatchewan economy is constantly changing, and the further in advance the predictions are made, the less certain they are. As such, effects expected to occur in the first year of operation were assumed representative of the annual effects for the life of the Project. In reality, the local and regional economy will change over time and the predicted effects would be more and more speculative going into the future. Overall, the prediction of confidence is moderate and the uncertainty is low for employment and economy residual effects.

16.6.2 Community Services and Infrastructure

Some uncertainty exists about the effects of the Project workforce on community services and infrastructure, in large part because the workforce that relocates permanently could stay in a variety of communities. During construction, up to 1,500 people will be housed in a work camp near the Project, with the remainder staying in hotels and temporary accommodation in Regina. Based on the availability of services and infrastructure, most permanently relocating workers during operations are assumed to be living in Regina, which is a larger centre with a wider variety of services and infrastructure. The portion of the workforce that may relocate to smaller communities near the Project is expected to be quite small, but this cannot be determined with certainty because individual preferences vary. If a larger portion of workers choose to live outside of Regina, this will change the distribution and magnitude of residual effects on community services and infrastructure. Regina has experienced relatively rapid population growth in recent years. Regina housing has been constructed and expanded to accommodate the increase in population. The residual effects of the Project workforce on community services and infrastructure in Regina will act cumulatively with other population growth in the area. The recent slowdown in the economy should reduce the cumulative effects on community services and infrastructure; however, if population growth increases in scale in the future, the residual effects may be greater. In contrast, if the economy remains slow or gets worse, the effects will be reduced. In summary, the nature, extent, and spatial distribution of the population increase within the socio-economic LSA is difficult to predict and dependant on personal preferences and existing, sometimes independent conditions (e.g., demand for housing, health care). Predicted residual effects becomes more and more speculative the further into the future predictions are made. As a result, predictions reflect the use of professional judgement and attempt to be conservative. Overall, the prediction confidence and uncertainty are moderate for residual effects on community services and infrastructure.

16.6.3 Traffic and Transportation Infrastructure

The TIA (Appendix 4-C) analyzes and summarizes the changes to traffic volumes because of construction and operations. Changes in the size of the workforce, which have already occurred, and changes to transportation arrangements, such as carpooling, would affect the results of the TIA. If the number of vehicles increased, more intersection improvements could be required. Assumptions were made regarding background traffic levels, which will change regardless of the Project. If background traffic levels increase more rapidly than predicted, additional improvements to intersections may be required. Because of the location of the Project compared to Regina, Highway 6 is understood to provide the main access route to the Project. However, if the access route were to change or if a large proportion of traffic was known to take a different route, a new TIA may be required. Overall, the TIA was designed to provide a conservative estimate of potential traffic increases and recommended mitigation. As a result, the prediction confidence is moderate and the uncertainty is low for residual effects on traffic and transportation infrastructure.

16.6.4 Quality of Life

The effects of the Project on quality of life will vary between individuals and communities in the socio-economic LSA. Quality of life is defined as being affected by changes in air and water quality, noise, and visual aesthetics. The air quality and noise models were designed to provide a conservative estimate of Project effects; the prediction of confidence for the air quality and noise indicated confidence that residual effects will not be greater than predicted (Section 7.0; Appendix 14-B). Effects to visual aesthetics are expected to occur up to a distance of approximately 20 km and effects on noise are expected to be concentrated in the Project footprint and a 1.5 km buffer around the Project footprint. Proximity of residents and communities to these effects will greatly change the degree to which their quality of life is affected. The prediction confidence and uncertainty are moderate for quality of life residual effects from visual aesthetics and noise.

16.6.5 Traditional and Non-traditional Land Use

Some uncertainty is associated with the vegetation map (Section 13.6) used to determine changes to land cover types because it was developed using satellite imagery. Uncertainty in the mapping (e.g., identifying native grassland versus modified grassland) was reduced through field ground-truthing to determine mapping accuracy, as well as professional experience and judgement. Additional uncertainty stems from the unknown demand for agricultural land in the land use ESA. While much more land occurs in the ELC and R.M. of Longlaketon, the Project will reduce agricultural land available to farmers in the immediate vicinity of the Project. The degree to which this affects local landowners is expected to be highly variable. Overall, the prediction confidence and uncertainty are moderate for traditional and non-traditional land use residual effects.

16.7 Residual Effects Classification and Determination of Significance

16.7.1 Methods

16.7.1.1 Residual Effects Criteria

The purpose of the residual effects classification is to describe the residual incremental and cumulative adverse effects from previous and existing developments and the Project (Application Case) and future developments (RFD Case) on socio-economics using a scale of common words rather than numbers and units. The use of common words or criteria is accepted practice in environmental assessment.

Results from the residual effects classification are then used to determine the environmental significance from the Project and other developments on the assessment endpoint for socio-economics (i.e., sustainability of social and economic properties). Significance is determined, in most cases, qualitatively. Effects are described using the criteria defined in Table 16.7-1, and reflect the impact descriptors provided in the TOR (Appendix 2-B). Together, these criteria are used to describe the nature (e.g., severity or intensity of change, and the area and amount of time over which the change occurs) and type (e.g., direction of the change) of an effect on a VC. The focus of the EIS is to predict whether the Project is likely to cause a significant adverse (i.e., negative) effect on the environment.

Table 16.7-1: Definitions of Residual Effects Criteria Used to Evaluate Significance for Socio-economics

Magnitude	Geographic Extent	Duration[(a)]	Frequency	Reversibility	Likelihood
Negligible: No discernible change to a VC. **Low:** Effect is discernable, but the effect is limited to a slight positive effect or a nuisance effect on individuals or communities in the socio-economic LSA (i.e., is not great enough to materially affect the socio-economic environment). **Moderate:** Effect is noticeable and may be potentially detrimental or beneficial to individuals and communities in the socio-economic LSA or Saskatchewan (socio-economic RSA) without affecting the sustainability of the overall socio-economic environment. **High:** Effect is expected to substantially interfere with or enhance the socio-economic conditions in communities in the socio-economic LSA and Saskatchewan (socio-economic RSA).	**Local:** Predicted maximum spatial extent of effects from changes in measurement indicators occurs in one or more of the communities in the socio-economic LSA. **Regional:** Residual effects from changes in measurement indicators will occur within and beyond communities in the socio-economic LSA, but within Saskatchewan (the socio-economic RSA). **Beyond Regional:** Residual cumulative effects from changes to measurement indicators will extend beyond Saskatchewan (the socio-economic RSA).	**Short-term:** Residual effect from change in measurement indicator occurs during Project construction. **Medium-term:** Residual effect from change to measurement indicator occurs during Project construction and operations, or Project operations only. **Long-term:** Residual effect from change to measurement indicators extends beyond the end of Project operations.	**Most socio-economic effects are considered continuous** **By Exception:** **Infrequent:** Residual effect from change to measurement indicator is confined to a discreet period. **Frequent:** Residual effect from change to measurement indicator occurs intermittently over the assessment period.	**Most socio-economic effects are considered irreversible**[(b)] **By Exception:** **Reversible:** Residual effect from change to measurement indicator is reversible within a period that can be identified when the Project no longer influences socio-economic VCs.	**Most socio-economic effects are considered highly-likely (greater than 80% change of occurring)**[(c)] **By exception:** **Unlikely:** Residual effect from change to measurement indicator is possible but unlikely (less than 10% chance of occurring). **Likely:** Residual effect from change to measurement indicator is possible, but is not certain (10% to 80% chance of occurring).

(a) Where relevant, the time for an effect to become reversible is taken into consideration.

(b) Socio-economic effects are part of an on-going process, extending into the future, which cannot be returned to an original state (e.g., when employment opportunities end at the end of Project operations, individuals who were employed continue to have job experience and training that will influence their future employment). They are therefore predicted to influence socio-economic VCs indefinitely.

(c) Socio-economic effects typically affect at least some individuals even where community level effects are not observable.

LSA = local study area; RSA = regional study area; VC = valued component; % = percent.

Magnitude – Magnitude is a measure of the intensity of an effect or the degree of change caused by the Project relative to Base Case conditions, guideline, or established threshold values (i.e., effects size). Magnitude is classified into scales of negligible, low, moderate, and high and is qualitatively defined for socio-economic VCs. A negligible magnitude effect has no discernible or measureable change to a VC. A low magnitude effect is discernable, but is either a slight positive effect or a nuisance effect on individuals or communities in the socio-economic LSA. A moderate magnitude rating anticipates that the effect will be noticeable (either detrimental or beneficial) to individuals or communities in the socio-economic LSA or Saskatchewan (i.e., socio-economic RSA), but will not affect the sustainability of the socio-economic environment. A high magnitude rating suggests the change will be large enough to result in a severe deterioration or greatly improved sustainability of the socio-economic environment.

Geographic Extent – Geographic extent refers to the spatial extent of the area affected and is different from the spatial boundary (i.e., study areas) for the effects analysis. The study area for the effects analysis represents the maximum area used for the assessment and is related to the spatial distribution and movement of VCs (Section 16.2.1). However, the geographic extent of effects can occur on a number of scales within the spatial boundary of the assessment, and is VC-specific. Geographic extent is categorized into three scales of local, regional, and beyond regional. Socio-economic effects at the local scale are associated with one or more communities within the socio-economic LSA. Effects at the regional scale occur in communities within and beyond the socio-economic LSA, but within Saskatchewan (i.e., socio-economic RSA). Effects at a beyond regional scale will extend beyond the boundaries of Saskatchewan. The regional and beyond regional scales include cumulative residual effects from the Project and other developments that extend beyond the socio-economic LSA or Saskatchewan, respectively. The principle applied when using geographic extent to understand magnitude is that local effects from the Project are less severe than effects that extend to the regional or beyond regional scales, all other factors being equal. Some effects are experienced by some, but not other, individuals within an assessment area, and may not have community level manifestations. Any potential for particularly negative effects on some individuals needs to be identified and addressed.

Duration – Similar to magnitude and geographic extent, duration is VC-specific and defined as the amount of time for which an effect is expected to occur. Duration is typically expressed relative to Project phases (usually in years). Duration has two components, the amount of time between the start and end of a Project activity or stressor (which is related to Project development phases), plus the time required for the effect to be reversible. Essentially, duration is a function of the length of time that VCs are exposed to Project activities and reversibility. Typically, reversibility is not possible for socio-economic effects, so reversibility was not included in the definitions for duration. Where relevant, the time for an effect to become reversible is taken into consideration. Many socio-economic effects are long-term in duration because a positive or negative significant effect could alter future conditions.

16.7.1.2 Determination of Significance

The classification of primary pathways and the associated predicted changes in measurement indicators provides the foundation for determining the significance of incremental and cumulative effects from the Project and other existing and approved developments on the assessment endpoint for socio-economics. The significance of the contribution of incremental effects from the Project on VCs is provided, but the evaluation is focused on determining the significance of cumulative effects on socio-economics.

Magnitude is the primary criterion used to determine environmental significance, while other criteria are used as modifiers and to provide context when assigning magnitude. Geographic extent and duration provide important context for classifying the magnitude of effects on socio-economic assessment endpoints. Frequency and likelihood are considered as modifiers when determining significance, where applicable.

Unlike the biophysical environment, the determination of significance from Project effects on the assessment endpoint for the socio-economic environment is completed on a subset of VCs (e.g., employment and economy, community services and infrastructure, traffic and transportation infrastructure, quality of life, and traditional and non-traditional land use) and, typically, each VC is directly associated with one or more unique pathways. The evaluation of significance for each VC considers the entire set of primary pathways in the same direction (i.e., negative or positive) that influence the VC; thus, significance is not explicitly assigned to each pathway. Rather, the relative contribution of each pathway is used to determine the significance of the Project and other developments on the valued component, which represents a weight of evidence approach (i.e., evaluating the persuasiveness of evidence indicating that an effect is significant or not significant). For example, a pathway with a high magnitude, a large geographic extent, and a long-term duration is given more weight in determining significance relative to pathways with smaller scale effects. The relative effect from each pathway is discussed; however, pathways that are predicted to have the greatest influence on changes to the assessment endpoint are assumed to contribute the most to the determination of environmental significance.

The determination of environmental significance on socio-economics considered the following key factors.

- Results from the residual effect classification of primary pathways and associated predicted changes in measurement indicators.
- Magnitude is the primary criterion used to determine significance with geographic extent and duration providing important context for assigning magnitude. Frequency and likelihood act as modifiers for determining significance, where applicable.
- The level of confidence in predicted effects, established guidelines and standards, and experienced opinion are included in the evaluation of determining environmental significance.

This method is used to identify predicted residual adverse effects that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to socio-economics, and therefore, result in significant effects.

Several differences exist in the way in which significance is determined for socio-economic assessments as compared to biophysical assessments. Considerations for determining the significance of socio-economic effects include the following:

- Qualitative Assessment - often, socio-economic effects must be assessed qualitatively. Socio-economic significance depends on the perceptions and values of affected people and communities, qualitative data interpretation, observations of economic and social resilience, and experience with other projects. As such, there may be a strong element of professional judgement as opposed to quantitative tools.
- Thresholds - no established thresholds or standards exist for most socio-economic VCs. In some cases, it may be possible to establish a threshold, but the type of effect may depend on qualitative factors. For example, if a community experienced a population increase of 5%, this could be either a positive effect

(e.g., new community members, increased tax base, returning family members) or a negative effect (e.g., transient population leading to negative interactions with local population), or more likely, both.

- Determination of Significance Criteria - many criteria used in determining significance are not easily applied to socio-economic effects. Some effects may be both positive and negative. Most socio-economic effects are irreversible and continuous, because the effect is ongoing and even once it ends, the socio-economic conditions will not return to the state they were in prior to the effect. In addition, socio-economic conditions will be influenced by decisions made by individuals, families, and communities in relation to events and situations that are unrelated to the Project.
- Mitigation and Enhancement Measures - the Project will create conditions and opportunities for individuals to improve their lives. However, not everyone will take advantage of these opportunities and other socio-economic processes that are unrelated to the Project can influence both the positive and negative effects of the Project.
- Negative Effects - some negative effects will result for some people. Even if benefits are expected overall, some individuals, families, and communities will experience negative effects.

These challenges imply that socio-economic assessments generally will be more qualitative and nuanced than other biophysical assessments. Determining significance for socio-economic effects will rely on engagement results and professional experience with similar mining projects. Residual effects for each VC are determined to be not significant or significant based on the expected effect on most people or the effect at the community level. However, effects at the individual and family level are understood to be important and will be discussed. The following definitions are used for predicting the significance of effects on sustainability of social and economic properties.

Not significant – the effect is either not detectable or may be measureable at the individual, family, community, or population level, but is not expected to substantially change socio-economic conditions at the community or population level.

Significant – the effect is clearly detectable and can result in substantial change (positive or negative) to the socio-economic conditions at the community or population level.

16.7.2 Results

A summary of the effects classification and prediction of significance on the socio-economics assessment endpoints are provided in Table 16.7-2. The results of the residual effects classification and determination of significance of primary pathways for incremental (i.e., Project) and cumulative changes to the socio-economic environment are discussed in the subsequent sections.

Table 16.7-2: Summary of Residual Effects Classification of Primary Pathways and Predicted Significance of Cumulative Effects on Socio-economics

Valued Component	Pathway	Project Phase	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Significance for Assessment Endpoint
Employment and Economy	Workforce requirements for the Project will increase employment within the province.	Construction	Positive	Low	Beyond Regional	Short-term	Continuous	Irreversible	Highly likely	Significant
		Operation		Low	Regional	Medium-term				
	Workforce requirements for the Project will increase labour incomes in the province.	Construction		Low	Beyond Regional	Short-term				
		Operation		Moderate	Regional	Medium-term				
	Workforce and procurement requirements for the Project will increase Gross Domestic Product in the province.	Construction		High	Regional	Short-term				
		Operation				Medium-term				
	The Project will increase the tax base of municipalities, the province, and the country.	Construction		High	Beyond Regional	Short-term				
		Operation				Medium-term				
	Workforce requirements can result in a better-trained regional workforce for Project-related trades and careers in the province.	Construction		Low	Beyond Regional	Long-term				
		Operation		Moderate	Regional	Long-term				
Community Services and Infrastructure	A non-resident Project workforce that relocates to the socio-economic LSA can place increased demand on housing, infrastructure, and services.	Construction	Negative and Positive	High	Local	Long-term	Continuous	Irreversible	Highly likely	Significant
		Operation								
Traffic and Transportation	Project activities will modify local transportation infrastructure and affect traffic (e.g., changing road and rail access to the site) through increased municipal road maintenance requirements, altered travel routes, and increased traffic volume.	Construction	Negative	Moderate	Local	Short-term	Continuous	Irreversible	Highly likely	Not significant
		Operation		Low		Medium-term				
Quality of Life	Visual changes from the Project may influence the visual character of the area (i.e., aesthetics) and affect the quality of life of some local residents.	Construction and Operation	Negative	Moderate	Local	Long-term	Continuous	Irreversible	Highly likely	Not significant
	Project noise from facilities, equipment, and vehicles are nuisances that may affect quality of life for some individuals and could affect wildlife distribution which could affect traditional and non-traditional land use.	Construction		Low		Short-term				
		Operations		Moderate		Medium-term				
Traditional and Non-traditional Land Use	The Project will reduce the area of agricultural land.	Construction and Operation	Negative	Low	Local	Long-term	Continuous	Irreversible	Highly likely	Not significant

LSA = local study area.

16.7.2.1 Employment and Economy

During the Base Case, employment and economy in Saskatchewan (i.e., socio-economic RSA) is characterized by strong natural resource industries, low unemployment rates, and high participation rates. The Base Case is equivalent to the existing environment in Saskatchewan, and represents the cumulative outcome of all previous and existing developments and activities, including colonization, natural resource industries, social and cultural processes and trends.

The socio-economic environment will not return to the Base Case conditions at the end of operations, because although the employment opportunities and tax revenue will end, the experience, income, and training received by employees and the tax revenue generated during construction and operations will influence future employment options for the workforce and economic conditions in Saskatchewan. Therefore, employment residual effects are considered irreversible. In order for the Project to proceed, a workforce (i.e., employment opportunities, income, and trained workforce) is a requirement and during operations, the Project is guaranteed to generate tax revenue. For these reasons, employment and economy residual effects are typically considered highly likely (i.e., certain) to occur. In addition, employment and economy residual effects are typically considered continuous because they will occur throughout construction and operations. Employment and economy benefits during construction are short-term in duration, while benefits during operations are considered medium-term in duration. Magnitude and geographic extent of employment and economy residual effects are described in more detail for each individual pathway below.

16.7.2.1.1 Employment

The Application Case will result in employment opportunities in Saskatchewan; however, existing labour force shortages in Saskatchewan in recent years suggests that the employment benefits may not all accrue within Saskatchewan, and that some positions will be filled from outside the province.

Labour shortages in the construction industry have eased recently, and may continue to diminish with the slowdown in the oil and gas industry. The construction workforce requirements are likely to benefit contractors who can bring the required workforce in from out of the province. The economic model quantifies the employment benefits of the Project in the socio-economic RSA and socio-economic LSA by examining direct Project labour but predicting indirect and induced labour. However, it does not take into consideration the place of residence of construction workers. As such, direct, indirect, and induced employment residual effects will occur from the local scale to outside of Saskatchewan. Project construction employment residual effects are considered to have a beyond regional geographic extent.

Project construction is expected to generate approximately 24,560 person years of employment, including direct, indirect, and induced employment. The construction workforce is currently estimated at 2,200 in 2017 and 2018 with an average workforce of approximately 1,500. This peak construction workforce would be equivalent to roughly 0.3% of the 2011 labour force (population 15 years of age and over) in Saskatchewan and 1.8% of the 2011 (population 15 years of age and over) socio-economic LSA labour force (Table 16.3-8). Based on previous large-scale resource projects, 10% of the workforce is estimated to relocate permanently to the socio-economic LSA (i.e., interprovincial migration), which will further enhance the employment benefits of the Project. Yancoal is committed to hiring locally to the extent feasible.

Reasonably foreseeable developments in Saskatchewan include two potash Projects near Regina, the Vale Kronau and the Western Milestone projects, which have the potential to have overlapping construction schedules and similar employment levels to the Project. In addition to these two potash projects, another potential potash mine and a variety of other infrastructure, institutional, recreation and tourism, commercial and retail, and residential developments are occurring near Regina, Saskatchewan. These projects require construction workforces. However, given the existing labour conditions in Saskatchewan, including labour shortages, most construction workers are expected to come from outside Saskatchewan, both for the Project and for reasonably foreseeable developments. Therefore, the magnitude of the residual effect of Project construction on employment is considered low.

For the purposes of the economic assessment, the direct workforce for operations was conservatively assessed to be sourced 100% from outside Saskatchewan (i.e., socio-economic RSA). Job opportunities will be open to the public and socio-economic LSA and Saskatchewan residents are preferred. However, given the current labour force conditions in the province and the rapid expansion of the potash industry, an easily available pool of trained workers is not expected. However, Yancoal is committed to hiring locally where possible. First Nations reserves in the area have one of the most available pools of potential workers, although additional training and education may be required.

In the first year of operation, the Project is expected to require a workforce of up to 350 people, though an earlier estimate of 305 people was used in the economic analysis. An increase of 305 people will add approximately 1,041 jobs (direct, indirect, and induced) in Saskatchewan and 377 in the socio-economic LSA, or 0.2% of the provincial and 0.3% of the socio-economic LSA existing labour force. Workers from outside Saskatchewan or the socio-economic LSA are expected to relocate to the socio-economic LSA to be nearer to the Project, and employment residual effects are therefore more likely to be regional in geographic extent than during construction.

The workforce requirements are considered small in comparison to the existing labour force in the socio-economic LSA and RSA, and, depending on the availability of workers, may be met primarily through the in-migration of workers. Depending on the portion of the operations workforce living in the socio-economic LSA, this could increase the magnitude of the residual effect. The cumulative residual effect of the Application Case plus reasonably foreseeable developments could increase the magnitude if all projects proceed. However, the confidence in the proportion of the workforce from the socio-economic LSA and the employment targets for Vale Kronau Project and Western Milestone Project are low. Therefore, the magnitude of the residual effect on employment is considered low.

16.7.2.1.2 Labour Income

Employees will spend most of their labour income where they live. If most of the construction workforce is from out of province, as is predicted, then most of the $1,483 million in direct labour income generated between 2016 and 2023 will likely be spent outside of Saskatchewan (i.e., beyond regional geographic extent). Some of the indirect and induced labour income ($651 million) will likely be spent within the province, depending on where the indirect and induced employment is created. As a result, the magnitude of the residual effect of construction on labour income is linked to the magnitude of employment, and is therefore considered low.

During operations, the Project workforce is expected to be hired locally or to relocate to the socio-economic LSA. As such, labour income spending is expected to occur in Saskatchewan and socio-economic LSA and, particularly in Regina, the largest economic centre in the area. Direct, indirect, and induced labour income during the first year of full Project Operations (anticipated to be the same for subsequent years of operation throughout the life of the Project), is estimated at $69.6 million in Saskatchewan ($36.1 million of which will be in the socio-economic LSA). This will have a moderate positive residual effect on the socio-economic LSA and a more modest positive residual effect on Saskatchewan. Similar labour income residual effects are expected from reasonably foreseeable developments (i.e., the Vale Kronau Project and the Western Milestone Project). Cumulatively, these residual effects are considered moderate in magnitude.

16.7.2.1.3 Education and Training

Commitments made by Yancoal to review Project training requirements with post-secondary institutes and government departments should increase opportunities for individuals to train and work at the Project and other similar opportunities. The increase in potash-related education and training and educated individuals in Saskatchewan can improve earning potential and opportunities for workers following their employment with the Project, resulting in a long-term duration residual effect. Project construction is expected to result in only minor training and education opportunities because the construction workforce requirements are largely expected to be met by a trained workforce from outside of Saskatchewan. However, Yancoal will provide an employee-training program to provide necessary training so workers can complete their jobs in a safe, competent manner. The residual effect is therefore considered low in magnitude and beyond regional in geographic extent. Project operations will require specific training and lead to increased education levels, but the workforce required is relatively small (i.e., 350 people). However, operations will act cumulatively with other potash projects in Saskatchewan and result in a moderate magnitude and regional residual effect.

16.7.2.1.4 Gross Domestic Product

Saskatchewan's GDP in 2013 was $58.5 billion, an increase of 4.8% from 2012 (Government of Saskatchewan 2014a). Construction of the Project is expected to add a total of $3.0 billion to the provincial GDP over six years of construction (direct, indirect, and induced labour), an average of $0.5 billion per year or about 0.8% of the 2013 GDP. Operations of the Project are expected to add $685.3 million per year, or 1.2% of the 2013 GDP. The Project residual effects on GDP will occur at a provincial scale, and the residual effect is therefore regional in geographic extent. In addition to the Project, a variety of other RFDs, including construction of the Vale Kronau Project, the Western Milestone Project, and a variety other projects, will act cumulatively in contributing to the provincial GDP. These contributions, of the Project construction and RFDs, to the provincial GDP are positive and high in magnitude. The contribution of Project operations to provincial GDP will act cumulatively with RFDs throughout the province throughout the life of the Project. The magnitude of the residual effect of Project operations on GDP is therefore high.

16.7.2.1.5 Fiscal Effects

In the 2014/2015 fiscal year, Saskatchewan is predicting $14.1 billion in revenue from taxes, non-renewable resources, other own-source revenues, transfers from federal government, and government business enterprises (Saskatchewan Ministry of Finance 2014). Revenue from construction and operation is expected to accumulate at a provincial and federal level, and is therefore considered beyond regional in geographic extent. The revenue from Project construction is expected to be approximately $811 million, an average of $135.2

million or 1.0% of the 2014/2015 provincial revenue per year. Project construction will act cumulatively with RFDs in the area, including the Vale Kronau and Western Milestone Projects, to increase revenue for the Province. The cumulative residual effect of Project construction and RFDs is considered high in magnitude.

Project operations are expected to generate approximately $115.8 million in revenue each year for the life of the Project. This represents 0.8% of the 2014-2015 provincial revenue. During Project operations, the Project is expected to add to the tax base of local municipalities. The Project is located in the R.M. of Longlaketon; however, under *The Municipal Tax Sharing (Potash) Act* (1978), municipalities in an ‘area of influence’ around the taxing rural municipality (i.e., R.M. of Longlaketon) shall receive a portion of the tax revenue assessed on a potash operation. The proportion of tax revenue allocated to each municipality is not available for inclusion in this analysis. No RFDs in the R.M. of Longlaketon or surrounding R.M.s are expected to act cumulatively with the Project. The residual effect of Project operations on local municipalities is expected to be positive and high in magnitude, given the potential scale of the change in tax base. The Project will contribute to federal revenue, although in comparison to the federal budget this is expected to be of low magnitude. Overall, fiscal residual effects are being assessed at the provincial scale (i.e., the socio-economic RSA) and Project operations will act cumulatively with RFDs and result in a high magnitude, positive residual effect on regional government revenue.

16.7.2.1.6 Significance of Employment and Economy Residual Effects

Effects pathways related to the employment and economy VC are positive in direction. The residual effects of the remaining five pathways on employment and economy are generally irreversible, continuous, and highly likely (i.e., certain). Residual effects range from regional to beyond regional in geographic extent and short-term to medium-term in duration, although these residual effects could in some ways be considered long-term, because the socio-economic environment will be affected and will never return to an ‘original’ state. Residual effect magnitudes range from low to high. The expected need to hire workers from outside Saskatchewan will reduce some of the economic benefits of construction. Nonetheless, construction and operation will provide modest boosts to employment, income, education and training, GDP, and tax revenue in and beyond the province of Saskatchewan, particularly once RFD and cumulative residual effects are taken into consideration. Residual effects on employment and economy are expected to result in substantial and positive changes to some measurement indicators at the community or population level that could increase sustainability of social and economic properties. As a result, cumulative residual effects from the five primary pathways to employment and economy are considered significant.

16.7.2.2 Community Services and Infrastructure

The recent interest in potash development and the existing labour force in the socio-economic LSA and Saskatchewan (i.e., socio-economic RSA), which has low unemployment and high participation rates, suggest that the available workforce will be limited. As a result, most of the workforce is expected to come from outside the socio-economic LSA, resulting in a high likelihood for increased population and associated increase in demand for community services and infrastructure during Project construction and operation. Most of individuals and families who relocate to work on the Project are expected to relocate to Regina, but a portion may relocate to communities in the socio-economic LSA. As a result, the geographic extent of residual effects on community services and infrastructure is considered local because the effects will occur in communities in the socio-economic LSA. Like most socio-economic effects, residual effects on community services and infrastructure are considered irreversible, because once population increases, the system will not return to what it was originally, even if the population decreases. In this case, 90% of the construction workforce is expected to be temporary; however, there will still be irreversible effects of the temporary workforce on community services and infrastructure.

During the Application Case, increased demand for services and infrastructure is expected to begin with construction and be continuous; however, the demand will be highest during peak construction and the supply of services and infrastructure will vary throughout the life of the Project as the population in the area naturally increases or declines and services and infrastructure are expanded or reduced accordingly. Most of the construction workforce is expected to be a temporary population increase in the socio-economic LSA; however, 10% of that population is expected to relocate permanently. This 10% of the construction workforce and 100% of the operations workforce will permanently be in the socio-economic LSA and increase demand for community services and infrastructure; therefore, these residual effects are considered long-term in duration.

During construction, most of the workforce will create a temporary increase in population, while 10% of the workforce is assumed to relocate to the socio-economic LSA, some with families. The estimates include direct Project employment, but also population effects from indirect and induced employment that may occur in Saskatchewan. Both permanent and transient increases in population can have a combination of positive and negative effects on local communities. The workers (direct, indirect, and induced) who permanently relocated with their families, estimated to equal a population increase of approximately 1,042 people (Table 16.5-9), will have positive effects for local businesses but may place increased pressure on services and infrastructure such as the housing market, schools, recreation, and health services. The temporary population of workers (direct, indirect, and induced), who will only be present for the construction period and will leave after construction, is estimated at 3,625 workers (Table 16.5-9). These workers will not contribute tax revenue to the region but may use services; however, they are likely to provide benefits through increased spending at local stores and restaurants.

Under the Base Case, the population in Regina and the socio-economic LSA has increase rapidly in recent years, increasing demand for services and infrastructure. Although the city, government, and businesses are aware of predictions for a continued increase in population and are planning accordingly, services and infrastructure are at or close to capacity in a variety of areas, including real estate and housing, health services, and education. The Application Case is expected to increase pressure on these services. In the RFD Case, a wide variety of RFDs in the area may contribute to increasing the permanent and temporary population of Regina and the community services and infrastructure socio-economic LSA, thereby increasing demand for infrastructure and services. These projects include the Vale Kronau and Western Milestone potash mines, as well as infrastructure work, oil and gas activity, Project-related utilities, and mining. As a result, the cumulative residual effect in the RFD case is considered high in magnitude for both Project construction and operations. Effects may have both positive (i.e., economic benefits of spending, more users for some services) and negative aspects (i.e., over-capacity, high demand), depending on the service and current level of demand. In addition to the effects noted previously, the presence of a transient workforce can result in concerns relating to public safety, as well as incidents requiring the involvement of police. While the magnitude of this type of effect has a large degree of uncertainty, the potential remains. Overall, considering the high magnitude cumulative effect and long-term residual effect, the Project is expected to result in a measureable effect on community services and infrastructure that could positively and negatively affect the sustainability of social and economic properties. Therefore, cumulative residual effects on community services and infrastructure are considered significant.

16.7.2.3 Traffic and Transportation Infrastructure

During the Base Case, traffic and transportation infrastructure is characterized by a wide network of roads, some paved and some gravel, and slowly increasing background traffic levels. A variety of reasonably foreseeable developments, including the Vale Kronau, Western Milestone, and numerous construction projects have the potential to increase traffic, particularly in the socio-economic LSA. However, none of the RFDs are located north of Regina in the immediate vicinity of the Project and the residual effect is therefore reduced.

Traffic residual effects are considered negative in direction because of the undesired effects they may cause and high likelihood (i.e., certain) because travel to site is a requirement for the Project to proceed. Residual effects will occur throughout the life of the Project, and are therefore considered continuous. Project construction will have short-term residual effects on traffic and transportation infrastructure, while Project operations will have medium-term residual effects. Residual effects on traffic and transportation infrastructure are considered irreversible because the environment cannot be returned to its original state.

The construction workforce is expected to come from outside the socio-economic LSA and reside there temporarily. Most traffic effects will be in the immediate vicinity of the Project, as workers carpool from the construction camp and travel in from Regina. There will be increased traffic on highways leading to Regina from out of province workers driving in for their shift and from equipment and supplies that have been sourced outside of Regina. However, this traffic is not expected to be noticeable given the small, irregular Project-related traffic on these roads and the high volume of regular traffic on these highways. Because most traffic increases will occur on highways and in communities in the socio-economic LSA, the residual effect of the construction workforce on traffic and transportation infrastructure is considered local in effect.

The operations workforce is largely expected to reside in the socio-economic LSA, and mostly in Regina. Most traffic residual effects will be in the immediate vicinity of the Project, on Highways 6 and grid road 731, although some degree of increase in traffic is expected in Regina and on highways and in other smaller communities near the Project. As a result, the geographic extent for residual effects on traffic and transportation is considered local. A small amount of traffic will arrive from outside the socio-economic LSA, but this number is expected to be minor and the residual effect is not considered beyond regional.

The residual effects on traffic due to Project construction and operations are mitigated by the proposed upgrades described above and in the TIA (Stantec 2015). No RFDs exist in the immediate vicinity of the Project. Upgrades to transportation infrastructure, the use of a construction camp, and carpooling will mitigate cumulative residual effects in the socio-economic LSA. The residual effects of Project construction on traffic and transportation infrastructure are therefore considered moderate in magnitude, while the residual effect of Project operations on traffic and transportation infrastructure are considered low in magnitude. Overall, the Project is expected to result in measureable, negative changes to traffic on access routes to the Project, but these changes are not expected to substantially affect the sustainability of social and economic properties at the community or population level. As a result, residual effects on traffic and transportation infrastructure are not considered significant.

16.7.2.4 Quality of Life

The Base Case for the socio-economic environment is described in Section 16.3 and Annex V, Section 4.0. Some degree of negative residual effects on visual aesthetics and the acoustic environment are unavoidable for construction and operations to proceed. As a result, residual effects on quality of life are considered highly likely (i.e., certain). Nuisance residual effects from visual disturbance and noise that can alter quality of life are considered irreversible because quality of life cannot be returned to an original state. Magnitude, geographic extent, duration, and frequency are discussed separately for visual aesthetics and noise below.

16.7.2.4.1 Visual Aesthetics

During the Base Case, the area surrounding the Project consists of a highly modified landscape dominated by agriculture and cultivated land. Under the Application Case, most of the core facilities area and the pad sites in the mining area will be reclaimed during Project decommissioning; however, the TMA is considered permanent. Permanent features will be visible for up to 20 km for hundreds of years and as a result, residual effects on visual aesthetics are considered local in geographic extent and long-term in duration. Residual effects on visual aesthetics are considered continuous because they will begin with the start of construction and will always be present and may be visible to nearby residents, traffic, and Southey and Strasbourg. The actual residual effect on quality of life is expected to vary by distance to the Project and by the value individual residents place on existing views of the rural landscape. The residual effect will be more noticeable and of more importance to residents who live in close proximity to the Project. Under the RFD Case, none of the RFD projects will be visible in the area expected to experience residual effects on visual aesthetics from the Project, and therefore, no RFD projects were taken into consideration in the assessment of residual effects on visual aesthetics. Overall, the magnitude of the residual effect on visual aesthetics is considered moderate.

16.7.2.4.2 Noise

Noise emissions will occur throughout Project construction and operations. Under the Application Case, noise emissions during Project construction are considered short-term while noise emissions during Project operations are medium-term. Noise emissions are expected to attenuate by approximately 1.5 km from the source, and are therefore considered local in geographic extent. Noise residual effects will occur daily during Project construction and 24 hours per day during Project operations, and are therefore considered continuous. Noise during construction is expected to fall within Health Canada guidelines at all noise receptors. As a result, the magnitude of noise emission residual effects from Project construction is considered low. During operations, noise levels were determined to exceed guideline values at one noise receptor by up to 3.0 dBA during the day and 5.6 dBA at night. These noise levels are expected to affect a small number of individuals. Noise levels at all other receptors were within guideline values. No RFDs are located in close enough proximity to act cumulatively with the Project on noise levels in the area. Overall, the magnitude of noise emission residual effects during Project operations is considered moderate, because it will negatively affect some individuals, but will not interfere with socio-economic conditions in the socio-economic LSA.

16.7.2.4.3 Significance of Quality of Life Residual Effects

The Project is expected to have low to moderate magnitude, adverse residual effects on quality of life at a local scale. Experiences are expected to vary, based on location and distance from the Project, and nuisance residual effects on the quality of life of some individuals may be continuous and highly likely. However, residual effects on quality of life are not expected to result in community or population level residual effects that affect the sustainability of social and economic properties; as a result, residual effects on quality of life are considered not significant.

16.7.2.5 Traditional and Non-traditional Land Use

The Base Case for traditional and non-traditional land use is described in Section 16.3 and Annex V, Section 3.0. Most of the land use ESA consists of agricultural, cultivated land. In the Application Case, the Project will result in a loss of agricultural land in the core facilities and mining areas. This residual effect is highly likely (i.e., certain), because development of Project infrastructure is necessary for the Project to proceed. Disturbance and loss of agricultural land will only occur in the Project footprint, and the residual effect is considered local in geographic extent. Some of this loss will be reclaimed following Project decommissioning, but approximately half of it will be permanent; as a result, the residual effect is considered long-term and irreversible. The loss of agricultural land is continuous, beginning with Project construction and lasting throughout the life of the Project. Private land owners will be compensated through the purchase of their land and areas of agricultural land owned by Yancoal but not currently used for the Project will be leased to local landowners. Overall, the Project will result in a reduction in agricultural land of 1,312 ha (-2.0% of the ELC map area and -1.3% of the R.M. of Longlaketon) during Project construction and operations and a permanent loss of 610 ha (-0.9% of the land use ESA and -0.6% of the R.M. of Longlaketon) of agricultural land. This is a small portion of the farmland in the traditional and non-traditional land use ESA; however, it has the potential to result in a greater change to neighbouring landowners whose access or lease agreements may change.

No RFD projects are expected to act cumulatively with the Project to reduce agricultural land in the area. Because of the mitigation in place and the small portion of land affected, the magnitude of the residual effect on agricultural land is considered low. The Project will have a modest, negative residual effect on availability of agricultural land in the land use ESA, but is not expected to result in community or population level residual effects that could affect the sustainability of social and economic properties. As a result, residual effects on traditional and non-traditional land use are not considered significant.

16.8 Monitoring and Follow-up

Yancoal intends to work with local government, organizations, businesses, and people as the Project progresses to achieve meaningful consultation on topics relating to the Project. Yancoal will continually evaluate internal processes and goals and adjust them or manage issues as they arise. A key component to this will be on-going engagement and consultation, as well as the development of Project specific management plans (e.g., Occupational Health and Safety Plan, Human Resources Plan and Community Relations Plan).

16.9 Summary and Conclusions

The Project will result in a variety of residual effects on the socio-economic environment. Residual effects will occur in relation to employment and economy, community services and infrastructure, traffic and transportation, quality of life, and traditional and non-traditional land use.

Skilled local workers will be given priority during hiring; however, based on the existing labour force conditions, the Project is expected to require an out of province workforce to meet construction and operations labour demand. Most of the construction workforce is expected to be a temporary workforce, largely residing in a construction camp near the Project, although some of the construction workforce may relocate. Depending on the availability of skilled labour, some or most of the Project operations workforce may come from outside the province as well. The Project operations workforce is expected to relocate permanently, often accompanied by family.

The Project will have a significant, positive residual effect on the local and regional economy. Project construction and operations will create jobs and generate income, although much of the construction workforce may not be hired locally, which will reduce the benefits of job creation and income during Project construction. The Project will result in increased training and experience in the labour force, which will affect future opportunities. Project spending will result in increased GDP and Project operations will generate tax revenue for municipal, provincial, and federal governments. This pathway was determined to be significant largely because of the high magnitude residual effects on GDP and government tax revenue.

The Project will result in an increased population in the socio-economic LSA from the Project operations workforce and any of the Project construction workforces that relocate. This population increase is expected to result in a significant residual effect on community services and infrastructure. Residual effects on community services and infrastructure can be both positive and negative. The region has experienced a steadily increasing population for most of the past decade and correspondingly, demand has been increasing for services and infrastructure. Some services, such as schools and health care are operating near or at capacity. The real estate market has been expanding rapidly and has met demand up to this point, but house prices have risen substantially and vacancy rates are low. Most residual effects on community services and infrastructure are expected to occur in Regina, where most of the relocated population is expected to live. The City of Regina and appropriate service providers are aware of the rapid increase in population and corresponding demand for services and infrastructure, which is predicted to continue in the future, and are planning accordingly.

The Project will increase traffic in the area and could potentially affect transportation infrastructure. Some traffic will come from outside the province or region, but the noticeable traffic increase is expected to mainly occur north of Regina (where most of the workforce is expected to live) on Project access routes. A TIA was completed and identified required road upgrades and mitigation to reduce the residual effects on traffic and transportation. Yancoal will build a construction camp and encourage carpooling. Project-related traffic could increase the potential for traffic accidents; however, appropriate training will be provided and safety measures put in place. The Project will require the closing of two stretches of grid road within the core facilities area. Yancoal will work with the R.M.s and government to facilitate local traffic movement. Overall, the residual effect on traffic and transportation is not considered significant.

Quality of life was defined in relation to air quality, water quality, visual aesthetics, and noise. Air modelling indicated that emissions will be within guideline values, while the water assessment determined that there would be no significant residual effects on water quality. Potential for changes to noise and visual aesthetics from the Project may affect quality of life for residents near the Project. Noise levels were predicted to be within guideline values at all noise receptors except one. This may result in a significant effect for individuals at this receptor. The Project will alter visual aesthetics for some distance, as the terrain will provide unobstructed views of the Project for numerous farmyards, residences, and possibly from several communities. However, this residual effect is not expected to deteriorate socio-economic conditions in the area and is not considered significant.

The Project will have minor residual effects on traditional and non-traditional land use. Changes to surface water quality, vegetation, soil, wildlife, fish and fish habitat, and the atmospheric environment can all affect land use, as can ground subsidence. These residual effects were all determined to have no linkage or negligible/minor residual effects on land use. The main land use in the area is agriculture. No known traditional land use exists within the Project footprint or immediately surrounding area, and activities such as recreation, tourism, hunting, and fishing are limited by private land ownership and the extensive modification of the landscape. The Project will reduce the area of agricultural land, which could affect landowners and nearby residents. However, landowners will be compensated and the permanent loss of agricultural land is small compared to the quantity in the area. Overall, residual effects on traditional and non-traditional land use are considered not significant.

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16.11 Glossary

Term	Definition
Annual Average Daily Traffic (AADT)	The average number of vehicles that travels over a stretch of road each day (i.e., one vehicle travelling to and from Regina on Highway 6 would be two AADT).
Aboriginal[(a)]	First inhabitants of Canada, including First Nations, Métis, and Inuit people.
Baby Boom Echo	The children of baby boomers.
Baby Boomers	Individuals born between 1949 and 1963.
Best Practice	Method or procedure that is accepted by industry as being effective, practical and reliable in maintaining quality, and meeting Project objectives and regulatory requirements.
Carpooling	Shared travel to place of work, may include multiple individuals in a private car or company-organized buses.
Commuting	Regular travel between place of residence and place of work.
Direct Employment or Income	Employment or income from Project expenditures (e.g., jobs and workforce requirements).
Educational attainment	Highest degree of education that an individual has completed.
First Nation[(a)]	A band, reserve community, or tribal grouping of bands.
First Nations[(a)]	Aboriginal peoples of Canada who are not Métis or Inuit and are considered 'Indians' under Canadian law.
Fiscal	Related to Government revenue (e.g., taxes).
Gross Domestic Product (GDP)	Gross Domestic Product is an economic measurement of goods and services produced within a geographic area. The GDP is a measure of the size of an economy.
Household income	Sum of the total incomes of all members of a household.
Indian[(a)]	The legal identify of a First Nations person in Canadian law, registered under the *Indian Act.*
Indirect Employment or Income	Employment or income created by secondary business transactions that result from initial expenditures.
Induced	Employment or income created by spending of labour income (after removal of taxes and savings).
Infrastructure	Basic physical and organizational structures (e.g., roads, housing, power).
Input-output Model	A quantitative economic model that accounts for interdependencies between different components of an economy.
Inuit[(a)]	Aboriginal peoples of Canada who live in the north and are not considered 'Indians'.
Labour force	Refers to persons who were either employed or unemployed during the week prior to Census Day.
Labour force participation rate	Labour force in the week prior to Census Day, expressed as a percentage of the population 15 years of age and over.
Labour Shortage	A situation where there is more demand (i.e., jobs) than availability of qualified workers in a given field.
Leakage (economic)	Income that leaves the economy (e.g., imports or spending outside the LSA and RSA economies).
Level of Service	Ranges of average delay for motorists travelling through an intersection.

Term	Definition
Métis[(a)]	People and cultures from historical communities and historical unions between Aboriginal and European people.
Noise Receptors	For the purpose of this assessment, any permanent or seasonally occupied dwelling within a defined area.
Peak Traffic	The greatest amount of traffic in a given time from (e.g., 1 hour) over a longer period (e.g., 1 day).
Person Years	The amount of work expressed by the total number of years' worth of work (e.g., 20 employees for 1 year is 20 person years or 2 employees for 6 months is 1 person year).
Quality of Life	For the purposes of this assessment, quality of life is defined by outer aspects of quality of life such as visual aesthetics, noise, and air and water quality.
95th Percentile Queue Length	The longest line of vehicles that can be expected at an intersection when traffic is at 95% of the maximum volume of traffic at that intersection.
Resort community	A community where tourism, recreation, or vacationing is a primary component of the community.
Revenue	Income (e.g., wages to individual workers, contracts for companies, taxes for government).
Royalties	A percentage of income from the development of a natural resource paid to government.
Secondary data	Data obtained from "other" sources (i.e., not through interviews or surveys). Typical sources of secondary data are government reports or the national Census.
Simple Cohort Survival Population Model	A simple method for forecasting future population based on predicted population growth and population birth and death rates.
Socio-economic	Related to the interactions of social and economic characteristics of a region.
Temporary Workforce	A workforce that will stay in a given area other than where they live for a period to complete a specific volume of work.
Unemployment rate	Unemployed workers, expressed as a percentage of the labour force in the week prior to Census Day.
Visual Aesthetics	The appeal or nature of the visual environment in a given area.
Volume to Capacity ratio by movement	Quantitative measure of how much of an intersections capacity is being used.

(a) Source: University of British Columbia 2009.

17.0 MONITORING AND FOLLOW-UP

This section of the Environmental Impact Statement (EIS) provides a summary of the planned monitoring and follow-up programs for the Yancoal Southey Project (the Project) located in central Saskatchewan, approximately 60 kilometres north of Regina. Monitoring and follow-up programs were selected and designed to verify the accuracy of the effects assessment and to determine the effectiveness of mitigation and environmental design features. Monitoring programs include contingency procedures, plans and adaptive management provisions that will assist Yancoal to address unforeseen effects, correct exceedances (if required), and comply with benchmarks, regulatory standards, and guidelines. Monitoring programs will incorporate baseline data, compliance data, and real time data.

The Yancoal Health, Safety, Security, and Environmental Management System will include a variety of management plans and monitoring programs, including the following:

- Emergency Response Plan;
- Occupational Health and Safety Plan;
- Community Relations Plan;
- Human Resources Plan;
- Environmental Protection Plan;
- Erosion and Sediment Control Plan;
- Spill Response and Control Plan;
- Weed Management Plan;
- Waste Management Plan;
- Waste Salt Management Plan;
- Water Management Plan; and
- Decommissioning and Reclamation Plan.

These plans focus on limiting negative residual effects and enhancing positive residual effects of the Project. They outline specific actions and guidelines for construction and operations. Many of these plans include monitoring to determine the accuracy of the effects assessments and whether additional actions need to be taken (i.e., adaptive management). Typically, monitoring includes one or more of the following categories, which may be applied during the development of the Project:

- **Compliance monitoring** – monitoring activities, procedures, and programs undertaken to confirm the implementation of approved design standards, mitigation, and conditions of approval and company commitments (e.g., inspecting the installation and effectiveness of a silt fence).
- **Follow-up monitoring** – programs designed to test the accuracy of effects predictions, reduce/address uncertainties, determine the effectiveness of environmental design features, and/or provide appropriate

feedback to operations for modifying or adopting new mitigation designs, policies, and practices (e.g., monitoring of downstream lakes for aquatic effects, wildlife effects monitoring, and socio-economic monitoring). Results from these programs can be used to increase the certainty of effect predictions in future environmental assessments.

These programs form part of the environmental management system for the Project. If monitoring or follow-up detect effects that are different from predicted effects or the need for improved or modified design features and mitigation, adaptive management will be implemented. This may include increased monitoring, changes in monitoring programs, and additional mitigation.

The environmental monitoring and follow-up identified for each valued component sections are summarized in Table 17.0-1. This table will be regularly updated during operations.

Table 17.0-1: Summary of Monitoring and Follow-up Activities

Valued Component	Environmental Monitoring and Follow-up
Atmospheric Environment	■ Current monitoring includes continuous measurement of: ▪ basic meteorological parameters including temperature, relative humidity, wind speed, wind direction, and solar radiation; and ▪ air quality parameters including NO_x (NO and NO_2), TSP, and $PM_{2.5}$.
Hydrogeology	■ Monitoring station locations and frequencies will be selected to provide sufficient data to evaluate TMA plumes and assess the effectiveness of containment infrastructure. ■ Threshold criteria will be selected so that it is clear at what point additional mitigation must be implemented to contain brine within the TMA footprint. ■ Groundwater monitoring will include: ▪ down-hole geophysical electromagnetic logging (e.g., EM39); ▪ terrain conductivity surveys (e.g., EM31); ▪ groundwater chemistry; ▪ groundwater hydraulic head; and ▪ TMA salt pile stability.
Hydrology	■ Local surface water level monitoring (established during the 2013 baseline field program) will continue and be extended to include the diversion channels through Project operations and into decommissioning and reclamation. ■ A follow-up monitoring program will be implemented to monitor the progress of ground subsidence, and an adaptive management approach will mitigate potential effects and uncertainty related to ground subsidence and hydrology. ■ Topographic elevations in the mining area will be surveyed regularly using a combination of regular RTK surveying methods, fixed pile survey monuments, and periodic LiDAR airborne surveys.
Surface Water Quality	■ Compliance inspections of environmental design features and mitigation measures (e.g., silt fences and water diversion structures) will be completed to confirm they are operating properly. ■ Regular inspections will confirm the integrity of tanks, ponds, and above-ground and below-ground pipelines and detect potential leaks.
Fish and Fish Habitat	■ Long term monitoring of topographic changes, combined with an adaptive management approach will be used to mitigate potential effects and uncertainty related to subsidence and streamflow.

Table 17.0-1: Summary of Monitoring and Follow-up Activities

Valued Component	Environmental Monitoring and Follow-up
Soil	■ Detailed site assessments will be completed to collect specific information for topsoil depth and soil chemistry, as required. ■ Compliance inspections and environmental monitoring will be used to confirm that best practices are being used to help mitigate soil erosion, admixing, compaction, and associated changes to soil quality. ■ monitoring programs for soil erosion will be managed on site by qualified personnel, as outlined in the Erosion and Sediment Control Plan. ■ If ground subsidence monitoring indicates changes to hydrology that could affect soils, then a monitoring program will be designed to assess the associated changes. ■ Soil conditions will be monitored to estimate reclamation success during the Project. Other soil quality issues such as erosion, admixing, and compaction can be visually assessed as part of this task. Results from this program can be used to support adjustments to the decommissioning and reclamation plan and be incorporated into ongoing reclamation activities.
Vegetation	■ Surveys of areas mapped as native grassland, wetlands, and wooded areas will be completed in the Project footprint prior to Project construction. These surveys will be used to confirm the actual ground cover and health of these plant communities to mitigate residual effects on these plant community types. If these areas are determined to be important natural areas, mitigation to avoid or limit effects on these areas will be developed in conjunction with the MOE. ■ Detailed site assessments will be completed to identify listed plant species that may be present in the areas to be disturbed, which were not identified during previous surveys, prior to construction of Project components, ▪ Appropriate mitigation practices and protocols will be implemented should any listed plant species be identified. ■ Additional wetland surveys may be required prior to construction. Information from these surveys will be used for the development of Habitat and Wetland Compensation Plans, if required. ■ Yancoal's Weed Management Plan will include surveys for weed species during the Project. Yancoal will incorporate routine weed inspection and maintenance programs to protect areas of natural vegetation. ■ Topsoil will be salvaged in sensitive habitats (e.g., native grassland) to maintain the seed bank contained in the topsoil. This material will be returned to these areas and will be spread over reclaimed/contoured area to help re-establish a vegetation cover, in combination with an approved, certified weed free seed mixture appropriate for the area. Follow-up monitoring will include an assessment of the success of plant community establishment following reclamation. ■ If ground subsidence monitoring indicates changes to hydrology that could affect vegetation, then a monitoring program will be designed to assess the associated changes. ■ Monitoring of revegetation success will be completed following decommissioning and reclamation of the Project.

Table 17.0-1: Summary of Monitoring and Follow-up Activities

Valued Component	Environmental Monitoring and Follow-up
Wildlife	■ Surveys for federally and provincially listed wildlife species will be completed prior to construction. Similar surveys may be implemented for the pipelines, access roads, and well pads associated with the mine well field area during Project development. ▪ If listed wildlife species are identified, appropriate mitigation will be identified and implemented in consultation with MOE. ■ Compliance inspections and environmental monitoring data reporting will be undertaken to provide flexibility for Yancoal and the MOE to effectively identify and respond to unanticipated changes to wildlife, and to adapt to new regulatory frameworks (e.g., Saskatchewan Environmental Code). ■ Data reporting is expected to occur annually, with data analysis being undertaken every five years and communicated in the form of Status of the Environment reports. ■ If ground subsidence monitoring indicates changes to hydrology that could affect wildlife, then a monitoring program will be designed to assess the associated changes.
Heritage Resources	■ Any mine well field area plans (e.g., well pads, pipelines and access roads) located in E1/2 25-24-19 W2M, NW and S1/2 30-24-18 W2M, and N1/2 and SE 19-24-18 W2M will be submitted to the Heritage Conservation Branch for review to determine if heritage sensitive lands will be affected and whether further HRIA is required prior to construction. ■ Yancoal will consult the local municipality to address any concerns in the event Project components are planned near historic structures or markers located in the NE 23-24-19 W2M, NE 26-24-19 W2M, SE 29-24-19 W2M, and SE 13-24-19 W2M within the mine well field area. ■ As part of the Environmental Protection Plan, a heritage management program will be developed to handle archaeological or heritage materials fortuitously discovered during construction activities or because of unplanned events. The management plan will be developed in consultation with the Heritage Conservation Branch.
Socio-economics	■ Yancoal intends to work with local government, organizations, businesses, and people as the Project progresses to achieve meaningful consultation on topics relating to the Project. ■ Yancoal will continually evaluate internal processes and goals and adjust them or manage issues as they arise. ▪ A key component to this will be on-going engagement and consultation, as well as the development of Project specific management plans (e.g., Health, Safety, Security and Environmental Management Plan, Human Resources Plan, Community Relations Plan).

NO_x = oxides of nitrogen; NO = nitrogen oxide; NO_2 = nitrogen dioxide; TSP = total suspended particulates; $PM_{2.5}$ = particulate matter with aerodynamic diameter less than 2.5 micrometres; TMA = tailings management area; EM = electromagnetic; RTK = real time kinematics; LiDAR = Light Detection and Ranging; MOE = Ministry of Environment; E = east; W2M = west of the second meridian; NW = northwest; S = south; N = north; SE = southeast; HRIA = Heritage Resource Impact Assessment.

18.0 CORPORATE COMMITMENTS

Yancoal Canada Resources Company Limited (Yancoal) has made corporate commitments within this Environmental Impact Statement (EIS) relating to actions required during various phases of the Yancoal Southey Project (the Project). Table 18.0-1 outlines each commitment made in the EIS to avoid or mitigate effects from the Project, to meet regulatory requirements, and for monitoring and follow-up activities. Commitments reported in Table 18.0-1 are measureable, achievable, and reportable. This table is living and adaptive, and is therefore expected to evolve over the life of the Project. For example, any terms and conditions from the Ministry of Environment will be added to the table should the Ministry approve the development.

Table 18.0-1: Yancoal Corporate Commitments for the Southey Project

Commitment ID No.	Section in the EIS	Name/Section of Additional Report	Legislation	Permit Name and ID No.	Condition(s) in Approval	Approving Agency/Branch	Commitment	Measure of Compliance	Action Required by Date	Commitment Status (e.g., met, not met, in progress)	Follow-up Action	Actual Completion Date	Comments
1	Sections 2.3, 4.5.2, 4.5.3 and 7.4.2	TBD	*Environmental Management and Protection Act*	No specific permit	TBD	MOE - Industrial Branch	Development of an air quality Environmental Protection Plan and compliance with regulatory air emission requirements and on-site, continuous measurement monitoring of air quality parameters, including NO, NO_2, TSP, and $PM_{2.5}$.	Discharge of particulate matter from the product drying process will be at or below 0.57 grams per dry standard cubic metre.	Prior to construction and operation	TBD	TBD	TBD	
2	Sections 4.5.2, 4.5.3, 7.4.2, 8.4.2, 9.4.2, 10.4.2, 11.4.2, 12.4.2, 13.4.2, 14.4.2 and 16.4.2	TBD	*Environmental Management and Protection Act*	No specific permit	TBD	MOE - Industrial Branch	Develop operating procedures related to reducing dust generation, enclose processing equipment and conveyors, and use dust controls (e.g., cyclones, baghouses, wet scrubbers) to recover and return dusts to the system.	Deposition of potash (as either K^+ or Cl^-) will be at or below 0.15 mg/cm^2 over a 30-day period.	Prior to construction and operation	TBD	TBD	TBD	
3	Sections 4.5.2, 4.5.3 and 7.4.2	TBD	*Environmental Management and Protection Act*	No specific permit	TBD	MOE - Industrial Branch	Compliance with the *Saskatchewan Management and Reduction of Greenhouse Gases Act* throughout the life of the Project.	Environmental Compliance Reporting.	Prior to construction and operation	TBD	TBD	TBD	
4	Sections 4.5.2, 4.5.3 and 7.4.2	TBD	*Canadian Emission Reduction Incentives Act*	No specific permit	TBD	MOE - Industrial Branch	Compliance with the Federal Greenhouse Gas Emissions Reporting Program throughout the life of the Project.	Environmental Compliance Reporting.	Prior to construction and operation	TBD	TBD	TBD	
5	Sections 2.3, 4.3.1, 4.6.2, 4.9.1, 9.4.2, 10.4.2 and 16.4.2	TBD	*The Water Regulations - Environmental Management and Protection Act*	Permit for the sewage lagoon if the design capacity exceeds 18 m^3/d	TBD	MOE - Industrial Branch	A sewage lagoon will be constructed on-site for proper storage, treatment, removal, and disposal of sewage.	Regular monitoring, maintenance, and Environmental Compliance Reporting.	Prior to operations	TBD	TBD	TBD	Sanitary sewage, wastewater treatment, and storm drainage collection
6			*The Public Health Act*	Permit to construct and operate a private sewage works			Wastewater will be disposed of by deep well injection and/or diverted to the wastewater treatment sewage lagoon.						Wastewater treatment and disposal, storage ponds at drill pad locations, and disposal wells
			Oil and Gas Conservation Act	Wastewater Disposal Well Permit									
7	Sections 4.3.1, 4.9.1 and 16.4.2	TBD	*Environmental Management and Protection Act*	No specific permit	TBD	MOE - Industrial Branch	A recycling program will be developed to reduce waste.	Environmental Compliance Reporting.	Prior to construction	TBD	TBD	TBD	
8	Sections 2.3 and 4.3.1	TBD	*Environmental Management and Protection Act*	Permit for the potable water treatment plant and associated reservoir if design capacity exceeds 18 m^3/d	TBD	MOE - Industrial Branch	A potable water treatment plant and reservoir will be constructed on site.	Environmental Compliance Reporting.	Prior to operations	TBD	TBD	TBD	
9	Sections 4.6.2, 8.4.2, 9.42, 10.4.2, 11.4.2, 12.4.2, 13.4.2 and 14.5.2	TBD	*Environmental Management and Protection Act*	No specific permit	TBD	MOE - Industrial Branch	A containment system will be designed to control deep migration of brine from the tailings management area and shallow lateral migration, as required.	Monitoring station locations and monitoring frequencies will be selected to provide a data record, using threshold criteria, sufficient to evaluate the potential development of plumes associated with the TMA and assess the effectiveness of the overall containment infrastructure.	Prior to operation	TBD	TBD	TBD	

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10	Sections 2.3, 4.6.2, 8.4.2, 9.4.2, 10.4.2, 11.4.2, 12.4.2, 13.4.2 and 14.5.2	TBD	*Environmental Management and Protection Act*	Approval to Construct - Waterworks	TBD	MOE - Industrial Branch	Development of a Water Management Plan to manage site water, on-site runoff, and divert freshwater run-off for up to a 24 hour 300 mm storm event. This will include surface water diversion channels and a perimeter dyke.	Regular monitoring, maintenance, and Environmental Compliance Reporting.	Prior to construction	TBD	TBD	TBD	
11	Sections 2.3, 4.6.2, 8.4.2, 9.4.2, 10.4.2, 11.4.2, 12.4.2, 13.4.2 and 14.5.2	TBD	*Environmental Management and Protection Act*	Approval to Operate - Waterworks	TBD	MOE - Industrial Branch		Regular monitoring, maintenance, and Environmental Compliance Reporting.	Prior to operation	TBD	TBD	TBD	
12	Sections 2.3 and 9.4.2	TBD	*Environmental Management and Protection Act*	Permit to Construct - Aquatic Habitat Protection Permit	TBD	MOE - Industrial Branch	Aquatic Habitat Protection Permit will be acquired and will be available on-site. Local surface water level monitoring program established in 2013 will be extended to include the diversion channels and will continue during the life of the Project.	Regular monitoring and Environmental Monitoring Reporting.	Prior to construction	TBD	TBD	TBD	
13	Sections 2.3 and 9.4.2	TBD	*The Water Security Agency Act*	Water Rights Licence	TBD	Water Security Agency	Yancoal will acquire a water rights licence from the Water Security Agency.	Regular monitoring, maintenance, and Environmental Compliance Reporting.	Prior to operations	TBD	TBD	TBD	
15	Section 2.3, 4.7.2, 4.9.3 and 4.10.3	TBD	*Environmental Management and Protection Act*	Hazardous Substances and Waste Dangerous Goods Permit to Construct	TBD	MOE - Industrial Branch	On-site storage of hazardous substances, waste dangerous goods, diesel and fuel will meet regulatory requirements.	Routine inspections and compliance audits.	Prior to construction	TBD	TBD	TBD	
16	Section 2.3, 4.7.2, 4.9.3 and 4.10.3	TBD	*Environmental Management and Protection Act*	Hazardous Substances and Waste Dangerous Goods Permit to Operate (Approval to Store)	TBD	MOE - Industrial Branch	Spill response materials will be maintained at locations where hazardous materials are stored and will be located around the Project site.	Spill Response Plan, document number of reportable spill events, and Environmental Compliance Reporting.	Prior to operation	TBD	TBD	TBD	
17	Sections 2.3 and 4.3.1	TBD	*Transportation of Dangerous Goods Act*	No specific permit, part of overall licence	TBD	MOE - Industrial Branch	All hazardous waste will be transported, stored, handled and disposed of in accordance with all regulatory requirements.	Transportation of Dangerous Goods Manifests/Bill of Lading.	Prior to construction	TBD	TBD	TBD	
18	Section 4.10	TBD	*Environmental Management and Protection Act*	No specific permit, part of overall operating licence.	TBD	MOE - Industrial Branch	A HSSE Management System will be developed.	Regular inspections and compliance audits.	Prior to construction	TBD	TBD	TBD	
19	Sections 4.10, 7.4.2, 10.4.2, 11.4.2, 12.4.2, 13.4.2, 14.4.2 and 16.4.2	TBD	*Occupational Health and Safety Act* and Regulations, and The Mines Regulations *The Saskatchewan Employment Act* *The Energy and Mines Act*	No specific permit, part of overall operating licence.	TBD	Ministry of Labour Relations and Workplace Safety	As part of the HSSE Management System, an Occupational Health and Safety Plan that will include site-specific response plans and mitigation will be developed in consultation with the Saskatchewan Construction Safety Association.	Regular monitoring, maintenance, and environmental compliance reporting and audits.	Prior to operation	TBD	TBD	TBD	

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20	Sections 4.10, 8.4.2, 10.4.2, 11.4.2, 12.4.2, 13.4.2, 14.4.2 and 16.4.2	TBD	*Environmental Management and Protection Act*	No Specific Permit, part of overall operating licence.	TBD	MOE - Industrial Branch	As part of the HSSE Management System, an Environmental Protection Plan will be developed.		Prior to construction	TBD	TBD	TBD	
21	Sections 4.10, 7.4.2, 8.4.2, 9.4.2, 10.4.2, 11.4.2, 12.4.2, 13.4.2, 14.4.2 and 16.4.2	TBD			TBD	MOE - Industrial Branch	As part of the HSSE Management System, an Emergency Response Plan, including the formation of an Emergency Response Team, will be developed.		Prior to construction	TBD	TBD	TBD	
22	Sections 4.10 and 16.4.2	TBD			TBD	MOE - Industrial Branch	As part of the HSSE Management System, an employee-training program will be developed so employees can complete their job in a safe and technically competent manner.	Regular monitoring and Environmental Monitoring Reporting.	Prior to operation	TBD	TBD	TBD	
23	Section 4.10	TBD			TBD	MOE - Industrial Branch	As part of the HSSE Management System, community relations will continue throughout the life of the Project.		Prior to construction	TBD	TBD	TBD	
24	Sections 4.9.2, 4.11, 7.4.2, 8.4.2, 10.4.2, 11.4.2, 12.4.2, 13.4.2, 14.4.2 and 16.4.2	TBD	*Environmental Management and Protection Act*	No Specific Permit, part of overall operating licence.	TBD	MOE - Industrial Branch	As part of the HSSE Management System, an Erosion and Sediment Control Plan, including best practices, will be developed. Erosion control practices will be implemented during construction and operation of the Project to limit dust production and subsequent deposition on surrounding areas and to limit water erosion to exposed soils.	Regular inspections; management strategy is implemented.	Prior to construction	TBD	TBD	TBD	
25	Sections 4.9.2, 4.11, 8.4.2, 10.4.2, 11.4.2, 12.4.2, 13.4.2, 14.4.2 and 16.4.2	TBD	*Environmental Management and Protection Act*	No Specific Permit, part of overall operating licence.	TBD	MOE - Industrial Branch	As part of the HSSE Management System, a Waste Salt Management Plan that will include monitoring of the brine reclaim pond will be developed.	Environmental performance of the waste salt storage area will be monitored.	Prior to operation	TBD	TBD	TBD	
26	Sections 4.9.2, 4.11, 12.4.2, 13.4.2, 14.4.2 and 16.4.2	TBD	*Environmental Management and Protection Act*	No Specific Permit, part of overall operating licence.	TBD	MOE - Industrial Branch	As part of the HSSE Management System, a Waste Management Plan that will include dangerous goods will be developed.	Routine inspections and compliance audits.	Prior to construction	TBD	TBD	TBD	
27	Sections 4.9.2, 4.11, 8.4.2, 9.9, 10.4.2, 11.4.2, 12.4.2, 13.4.2, 14.4.2 and 16.4.2	TBD	*Environmental Management and Protection Act* *Reclaimed Industrial Sites Act*	No Specific Permit, part of overall operating licence. Release from Site Approval	TBD	MOE - Industrial Branch	As part of the HSSE Management System, a Decommissioning and Reclamation Plan will be developed.		Prior to construction	TBD	TBD	TBD	

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28	Sections 4.9.2, 4.11, 8.4.2, 10.4.2, 11.4.2, 12.4.2, 13.4.2, 14.4.2 and 16.4.2	TBD	*Environmental Management and Protection Act*	No Specific Permit, part of overall operating licence.	TBD	MOE - Industrial Branch	As part of the HSSE Management System, a Subsidence Monitoring program will be developed.	Regular monitoring and Environmental Monitoring Reporting.	Prior to operation	TBD	TBD	TBD	
29	Sections 4.3.2 and 13.4.2	TBD	*The Weed Control Act*	No Specific Permit, part of overall operating licence.	TBD	MOE - Industrial Branch	As part of the HSSE Management System, a Weed Management Plan to control and monitor prohibited, noxious, and nuisance plant species will be developed.	Regular monitoring and Environmental Monitoring Reporting.	Prior to construction	TBD	TBD	TBD	
30	Sections 4.12 and 16.4.2	TBD	*The Saskatchewan Employment Act*	No specific permit, part of overall operating licence.	TBD	MOE - Industrial Branch	As part of the HSSE Management System, a Human Resources Plan that will include employment targets and associated strategies will be developed.	Environmental Monitoring Reporting.	Prior to construction	TBD	TBD	TBD	
31	Sections 4.3.2; 8.4.2, 9.4.2, 10.4.2, 11.4.2, 12.4.2, 13.4.2, 14.4.2 and 16.4.2	TBD	*Environmental Management and Protection Act*	No Specific Permit, part of overall operating licence.	TBD	MOE - Industrial Branch	As part of the HSSE Management System, a spill response and control plan will be developed.	Regular monitoring, maintenance, and environmental compliance reporting and audits.	Prior to construction	TBD	TBD	TBD	
32	Sections 4.6.2, 8.4.2, 9.4.2, 10.4.2, 11.4.2, 12.4.2 and 13.4.2	TBD	*Environmental Management and Protection Act*	No Specific Permit, part of overall operating licence.	TBD	MOE - Industrial Branch	As part of the HSSE Management System, a water management plan will be developed.	Regular monitoring and Environmental Monitoring Reporting.	Prior to construction	TBD	TBD	TBD	
33	Sections 4.10.3 and 4.13	TBD	*Environmental Management and Protection Act*	No Specific Permit, part of overall operating licence.	TBD	MOE - Industrial Branch	A fire suppression system will be activated throughout the life of the Project.	Environmental Monitoring Reporting.	Prior to construction	TBD	TBD	TBD	
34	Sections 2.3, 4.8.6 and16.4.2	TBD	*The Highways and Transportation Act*	Approach Permit Oversize/overweight Permits Roadside Permit Off-premise Sign Application On-premise Sign Application	TBD	Ministry of Highways and Transportation	All permits and approvals required from the Ministry of Highways and Transportation will be acquired prior to construction.	Regular monitoring and reporting as well as inspections and compliance audits.	Prior to construction	TBD	TBD	TBD	
35	Section 15.4.2	TBD	*The Heritage Act*	No specific permit, part of overall operating licence.	TBD	Ministry of Parks, Culture, and Sport – Heritage Branch	If any archaeological or heritage materials are identified during construction, work will cease immediately and management/mitigation options will be developed in cooperation with the Saskatchewan Ministry of Parks, Culture, and Sport – Heritage Branch.	Regular monitoring and Environmental Monitoring Reporting.	n/a	TBD	TBD	TBD	
36	Section 16.4.2	TBD	*Environmental Management and Protection Act*	No specific permit, part of overall operating licence.	TBD	-	Internal guidelines for agricultural and pasture land lease agreements on land not being used for the mine will be developed.	-	Prior to construction	TBD	TBD	TBD	
37	Section 2.3	TBD	*The Public Health Act*	Licence for a public eating establishment Approval for an itinerant use accommodation. Licence to operate an itinerant use accommodation.	TBD	Ministry of Health	The necessary licenses and approvals from the Ministry of Health will be acquired for the construction camp.	Environmental Monitoring Reporting.	Prior to construction	TBD	TBD	TBD	
38	Section 2.3	TBD	*Oil and Gas Conservation Act*	Drilling Licence	TBD	Ministry of Economy	Licence will be obtained.	Licence on-site during drilling.	Prior to construction	TBD	TBD	TBD	

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39	Sections 2.3 and 4.4.2	TBD	*Pipelines and Development Act*	Pipeline Licence to construct, alter, operate, or abandon.	TBD	Ministry of Economy	Licence will be obtained and appropriate leak detection, monitoring, and isolation will be provided.	Regular monitoring, maintenance, and environmental compliance reporting and audits.	Prior to operation	TBD	TBD	TBD	
40	Section 2.3	TBD	*Planning and Development Act*	Development Permit/Agreement Discretionary Use Approval. Road Haul Agreement.	TBD	Rural Municipality of Longlaketon	All planning and development permits, approvals, and agreements will be obtained.	Environmental Monitoring Reporting.	Prior to construction	TBD	TBD	TBD	

ID = identification; No. = number; MOE = Ministry of Environment; TBD = to be determined; EIS = Environmental Impact Statement; mg = milligram; cm = centimetre; m^3/d = cubic metre per day; mg/cm^2 = milligrams per square centimetre; mm = millimetre; HSSE = Health, Safety, Security, and Environmental; TMA = tailings management area; K^+ = potassium; Cl^- = chloride; SO_2 = sulphur dioxide; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter with aerodynamic diameter less than 2.5 micrometres; PM_{10} = particulate matter with aerodynamic diameter less than 10 micrometres

19.0 SUMMARY AND CONCLUSIONS

Yancoal Canada Resources Company Limited (Yancoal) is engaged in the evaluation and development of the Yancoal Southey Project (the Project). Yancoal has identified a world-class potash deposit and intends to develop the resource in an ecologically sustainable, economically efficient, and socially responsible manner.

Yancoal is a wholly owned subsidiary of Yanzhou Coal Mining Company Limited (Yanzhou Coal). Yanzhou Coal's main business is coal mining, coal chemical and fertilizer production, power generation, and equipment manufacturing. Yanzhou Coal is an international, diversified mining corporation listed on the stock exchanges of New York, Shanghai, Sydney, and Hong Kong.

Yancoal is proposing to develop the Yancoal Southey Project, which is located approximately 60 kilometres (km) north of Regina within the Rural Municipalities (R.M.s) of Longlaketon (No. 219) and Cupar (No. 218). The community of Earl Grey is located approximately 21 km southwest of the Project, the community of Strasbourg lies approximately 23 km west, and the community of Southey is approximately 28 km southeast. The Project (including the core facilities, 65-year mine field, and indicated resource boundary) encompasses approximately 143 square kilometres (km^2) (14,320 hectares [ha]) and is located in Townships 24 and 25, and Ranges 17, 18, 19, and 20 West of the Second Meridian (W2M).

19.1 Project Description

The Project is a greenfield potash solution mine that will extract potash ore (sylvinite) from the Patience Lake, Belle Plaine, and Esterhazy Members of the Saskatchewan Prairie Evaporite Formation. The Project involves the construction and operation of a mine well field area and core facilities area that will include the processing plant, administration buildings, tailings management area, product storage, rail loadout, security, and parking.

Project construction is anticipated to begin in May 2016 or as soon as all relevant permits and approvals are in place. Project construction will require a peak workforce of approximately 2,200 workers, and will average approximately 1,500 workers during the 3.5-year construction period. Project operations will begin in 2019 with primary mining and is expected to reach full capacity in 2024 when secondary mining methods are added as well. During Project operations, a workforce of approximately 300 people will be required. The process plant will be designed for a primary production mining target of 2.0 million tonnes per annum (Mtpa) of potash product. Production during secondary mining will increase overall production to 2.8 Mtpa of potash product. Hot water or brine will be pumped via pipeline from the core facilities area to the well pads within the mine well field area where the liquid will be injected into the caverns and then returned to the processing plant by pipeline using the same pipeline corridor. The process plant is composed of the following main components:

- evaporation;
- crystallization;
- centrifuging and drying;
- product screening;
- compaction;
- crystallization pond;
- loadout and storage;

- salt handling; and
- reagent storage and preparation.

Well pad sites will be progressively constructed and reclaimed during Project operations. Project decommissioning and reclamation will begin in 2119. A Project-specific Decommissioning and Reclamation (D&R) Plan will be developed to provide a framework for decommissioning facilities and infrastructure on the site, in such a way that the environment and the public will be protected over the long-term.

Support infrastructure for the Project will include water (provided by SaskWater), power (provided by SaskPower), natural gas (provided by TransGas), communication services (provided by SaskTel), road access, and rail access. Access to the core facilities area will be from Highway 6 via an upgraded road to be constructed. Two options considered for rail access are a rail spur line to the Canadian Pacific (CP) rail line (located approximately 20 km west of the Project) or a spur line to the Canadian National (CN) rail line (located approximately 32 km north of the Project).

19.2 Engagement

Yancoal initiated early contact with the local public, First Nations and Métis communities, rural municipalities and regulatory agencies. The engagement program for the Project encompasses several elements: local communities (including interested members of the public), First Nations and Métis communities, municipal representatives, regulatory agencies, and adjacent landowners.

Community information sessions have been held to provide information about Yancoal and the Project to interested members of the public. These sessions also provide an opportunity for people in the area to show support or identify concerns about the potential effects of the Project. In November 2013, community information sessions were held in the communities of Southey, Strasbourg, and Cupar. In total 175 people attended the three community information sessions. In March 2015, community information sessions were held in the communities of Southey and Strasbourg. In total, 242 people attended the two community information sessions. Following the second round of community information sessions, a neighbour relations program was initiated by Yancoal to obtain feedback from the landowners living closest to the core facilities area. In July 2015, community information sessins were held in the communities of Earl Grey, Southey, and Strasboug. In total, 351 people attended the three community information sessions.

A total of 15 First Nation and Métis communities were contacted for the Project. These communities were identified based on their proximity to the Project location, and based on having potential interest in the Project or the potential to be affected by the Project. In late 2013 and early 2014, each community received copies of the information handouts and the information panels that were provided at the first round of community information sessions. In 2015 each community received an invitation to attend the second and third rounds of community information sessions, and received a copy of the information panels that were provided.

Efforts were made to engage the R.M.s located closest to the Project; with the purpose of providing an understanding of the Project and the potential effects it could have on the region. Yancoal has met with the R.M.s of Cupar (No. 218), Longlaketon (No. 219), Mount Hope (No. 279), and Touchwood (No. 248). Invitations to attend the community information sessions were extended and information from each community information session was provided to the R.M.s. Yancoal will continue to meet with the R.M.s as the Project evolves to discuss infrastructure and service requirements and permitting.

Overall, most of the feedback received during Engagement activities has been positive. Stakeholders are interested in the Project and want to be involved in the engagement process as much as possible, as the Project progresses.

Yancoal is dedicated to maintaining the relationships created during these engagement activities, and will continue to provide updates to the identified stakeholders as the Project continues to develop.

19.3 Atmospheric Environment

The potential environmental effect of the Project on the atmospheric environment was assessed using an air quality modelling approach. The assessment employed the Ministry of Environment (MOE) approved AERMOD air quality model and was conducted in accordance with the Saskatchewan Air Quality Modelling Guidelines. The air emissions during construction and decommissioning and reclamation were determined to be less in emission intensity and in duration than air emissions during operations. Therefore, the air quality assessment focused on Project operations. The air quality assessment for Project operations was completed by comparing the predicted cumulative changes to air quality and the Base Case conditions to the applicable ambient air quality standards.

The modelling results show that, other than ground-level 24-hour particulate matter with aerodynamic diameter less than 10 micrometres (PM_{10}) concentrations, Application Case maximum predicted nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), particulate matter with aerodynamic diameter less than 2.5 micrometres ($PM_{2.5}$), and total suspended particulate concentrations (TSP), and potash (KCl) deposition for all averaging periods complies with the respective ambient air quality standards. The magnitude of the changes to air quality is negligible to low and is regional in geographic extent. The Project’s greenhouse gas emissions result in an approximately 1 percent (%) increase in total provincial emissions and 0.16% increase in total national emissions. The Project’s cumulative effects on the atmospheric environment are concluded to be not significant.

19.4 Hydrogeology

The Project is not expected to affect the continued suitability of groundwater for human use.

The potential environmental effects of the Project on hydrogeology were assessed using groundwater flow and solute transport models. The results of the solute transport analysis provide an estimate and reasonable bounds of potential effects, taking into account uncertainty in site geology and soil properties. The results indicate that implementation of environmental design features such as containment infrastructure (e.g., cutoff walls and recovery wells), should be based on additional site characterization at the detailed design stage of the Project and the results of groundwater monitoring during the initial stages of operations. The design features provide two lines of defense against the release of brine from the tailings management area, and may be used to contain brine along both deep and shallow seepage paths. A monitoring program for the tailings management area will be implemented at the start of operations and the monitoring results will be used to track plume development and assess the performance of containment infrastructure. If monitoring indicates unsatisfactory performance of containment infrastructures, further mitigation will be undertaken to contain brine within the tailings management area footprint.

Considering the application of environmental design features (containment infrastructure) and the ability to monitor plume development during operations and adapt mitigation strategies, long term changes to groundwater quality are expected to occur only within the footprint of the tailings management area. The residual effect on groundwater quality from vertical and lateral brine migration from the Project is negligible to low in magnitude and local in geographic extent. Overall, the changes to groundwater from the Project are predicted to have no significant effect on the continued suitability of groundwater for human use.

19.5 Hydrology

The Project is not expected to affect the continued availability of surface water quantity for human use and ecosystems.

Four Project components or activities that would likely affect hydrology were identified, and effects pathways were examined in this assessment. From the potential effects pathways, two Project components or activities were anticipated to have measurable effects on the hydrological system; these were evaluated in more detail to determine that the changes were not significant. Potential changes were evaluated for local flows, drainage patterns (spatial distribution), and drainage areas due to the exclusion of the core facilities area from the natural drainage system, and for surface flows, drainage patterns (distribution), drainage areas, and waterbody or stream morphology due to ground subsidence.

The other two effects pathways were not anticipated to cause a measurable effect on hydrology considering the Project location, environmental design features and mitigation that would be in place, and the use of external water sources for the Project water supply. No measurable effects are anticipated for the disruption or change in sub-surface and deep groundwater flow, levels, and quality that may affect local surface water flows and drainage patterns. In addition, no measureable effects are anticipated for run-off within the core facilities area, mine well field areas, mine well field area utility corridors, and new access roads, which can affect surface flows and water levels.

The application of mitigation for the Project will follow the hierarchy outlined in MOE (2014). The following guidelines and practices will be in place as part of the Project design to reduce, as much as possible, the potential effects from the Project on hydrology:

- The location of the Project is in the headwaters of the West Tributary of West Loon Creek and does not intersect any major streams or lakes.
- The tailings management area location was selected based on site-specific soil, geologic, and hydrogeologic properties that provide an appropriate foundation and provide natural containment of brine material.
- The Project's water supply will be sourced from an external water supply source, Buffalo Pound Lake, and will be distributed to the Project via a pipeline to be operated by SaskWater.
- The core facilities area and individual well pads will be isolated from the natural drainage system using diversion works, and berms, respectively. Semi-permanent and permanent wetlands will be avoided and existing access roads and utility corridors will be used to reduce disturbance to the natural environment and hydrology, to the extent practical. Diversion ditches will be designed to accommodate a 24-hour 300-millimetre rainfall event so the core facilities area will remain isolated from the natural drainage.
- Run-off generated within the core facilities area will be managed on site and may slightly reduce the overall Project water demands as it could be reused for process and potable water supplies. Process and wastewater may also be recycled and reused to the extent practical. The brine reclaim pond on site will be designed to accommodate storage of process streams under normal and extreme operating conditions, as

well as a 24-hour 300-millimetre rainfall event; excess brine will be disposed of by deep well injection methods.

- Where possible, existing infrastructure and corridors will be used to limit the extent of disturbance to natural flow paths and, where necessary, culverts and stream crossings will be installed along new access roads to retain natural run-off paths.
- Solution mining methods will reduce ground subsidence by leaving unmined pillars in between caverns to increase stability. Use of secondary mining techniques that reduce the total amount of material removed also will be used and extraction ratios will be monitored to limit strain on the overlying surface infrastructure.
- Additional environmental design features including containment berms and dykes around the tailings management area, seepage cut-off walls to protect groundwater quality, progressive reclamation of the mine well field, and erosion control measures will be implemented to limit losses from topsoil and overburden stockpiles.
- A Decommissioning and Reclamation Plan will be developed that will incorporate new technologies as they become available to reduce the duration of the decommissioning period.

Solution mining and related removal of solid, liquid, and gaseous materials from below the ground surface result in subsidence (i.e., terrain settling). The area affected by subsidence is predicted to extend over a distance of approximately 17 km from west to east and about 8 km from north to south and may extend approximately 1.3 km outside the 65-year mine field. Maximum settlement is predicted to occur in the western section of the 65-year mine field that lies directly over the caverns. The vertical displacement is predicted to range from 0.5 to 6.7 metres (m). The final gradients of surface subsidence at the boundary of the 65-year mine field are expected to be gradual from unaffected areas to the area of maximum subsidence with an average gradient of approximately 3.9 metres per kilometre (m/km) and a maximum gradient of 5.0 m/km.

A potential measurable environmental effect will result from ground subsidence overlying the mine well field area caverns. Although the maximum calculated settlements would be about 6 m, negligible to low effects are expected on the total annual runoff volume in the effects study area. The water conveyance efficiency in the north portion of the affected area may increase with increased slope along runoff pathways, whereas reduced conveyance efficiency in the south section of the subsided area is anticipated. Some reversal in the topographic gradient is expected along short sections of West Loon Creek. Indirect and direct hydrological effects would be local and only occur in certain areas within the Loon Creek watershed. Subsidence will be monitored on a regular basis over the period of operation and following Project closure.

Water storage capacity in low depressions (wetlands capacity) would be likely to increase, especially in the low topography area within the West Tributary of West Loon Creek sub-basin. Using modeling analysis it was determined that the storage capacity within the sub-basin is high for existing conditions. For example, after redistributing 300-millimetre and 100- millimetre (about 1:100 year precipitation event) rainfall events, the area retained 98% and 99% of the associated water volume, respectively. Following ground subsidence, these values increased to 99% and 100% respectively. The increase of water storage in low-lying depressions is likely, but the effects are low and infrequent due to the existing high storage capacity in the area.

The isolation of the core facilities area (and the well pads) from the surrounding local drainages will slightly reduce runoff and irreversibly change drainage patterns in the immediate area. The effects in annual run-off volume was classified as negligible to low and was estimated to be about a 2.3% decrease of the run-off reporting to the low-topography area within the West Tributary sub-basin of West Loon Creek, and a negligible decrease for West Loon Creek during the operations phase.

At decommissioning, part of the core facilities area could be reclaimed into the natural drainage system, while the TMA (i.e., salt storage area, brine reclaim pond) will continue to contain some run-off during decommissioning and reclamation. However, annual run-off volume would only be reduced by about 1.1% in an average year. Water quantity will still be available for human use and ecosystems.

Overall, the cumulative residual effect of the Project on hydrology is expected to be negligible to low in magnitude and regional in geographic extent. The residual effects from the Project are predicted not to have significant adverse effects on the availability of surface water quantity for human use and ecosystems.

19.6 Surface Water Quality

The Project is not expected to affect the continued suitability of surface water for human use.

Although there are no lakes present in the water quality effects study area, there are numerous ephemeral wetlands present. Within the vicinity of the Project, streams generally flow from north to south toward the Qu'Appelle River. Most of the Project footprint is located within the Loon Creek drainage; however, the northwest portion of KP377 drains towards Last Mountain Lake. The main tributaries of Loon Creek include West Loon Creek and East Loon Creek. Both West and East Loon creeks have well-defined stream channels and stream valleys. A tributary of West Loon Creek that is referred to as "unnamed stream" has a poorly defined stream channel and drains a large part of the effects study area, including the proposed core facilities area and a portion of the mining area.

Water quality samples were collected during the spring, summer, and fall of 2013 from one location in Loon Creek, two locations in East Loon Creek, three locations in West Loon Creek, and two land-locked waterbodies in the study area. Water chemistry analyses for sampled watercourses showed that water quality analysis results often exceeded Saskatchewan and Canadian water quality objectives for pH, total dissolved solids, and total ammonia. Several of the East and West Loon creek samples showed exceedences of guidelines for fluoride, aluminum, iron, and manganese. Water quality sampling of waterbodies 005 and 011 showed that water quality analysis results often exceeded Saskatchewan and Canadian water quality objectives for pH, total hardness, total ammonia, arsenic, magnesium, and manganese, with occasional exceedance of aluminum and iron.

Based on the water quality assessment, it is anticipated that deposition of potassium and chloride will result in only very small (i.e., less than or equal to 3.5 milligrams per litre (mg/L) increase in potassium or chloride concentrations) changes to surface water quality in West Loon Creek, East Loon Creek, and Loon Creek. At average and high (i.e., 80th percentile) spring flow volumes, concentrations of potassium and chloride in West Loon Creek, East Loon Creek, and Loon Creek are expected to increase by less than 1 mg/L, relative to Base Case conditions. At low (i.e., 20th percentile) spring flow volumes, potassium and chloride concentrations in East Loon Creek are also expected to increase by approximately 1 to 3.5 mg/L relative to Base Case conditions.

The change in potassium and chloride concentrations is not considered biologically significant. Because changes are expected to be on the order of a few milligrams per litre, total predicted surface water concentrations of potassium and chloride during the Application Case are expected to be within the natural range of variability for West Loon, East Loon, and Loon creeks. It is therefore considered unlikely that deposition of potassium and chloride will adversely affect surface water quality. Salinization of watercourses is not predicted to occur, and chloride concentrations will remain below Canadian Council of Ministers of the Environment water quality guidelines of 640 mg/L (short-term guideline) and 120 mg/L (long-term guideline) for the protection of aquatic life (CCME 2015).

Changes to flow pathways from ground subsidence are mainly predicted along the north and west edges of the mine well field. The volume of flows along major flow paths (i.e., West Loon Creek) are predicted to be maintained, although localized alterations of flow pathways are predicted to occur and ponded sections may appear. New surface flow pathways may also occur in sections of the effects study area. Alterations of smaller drainage area boundaries in the central section of the mine well field are anticipated; however, drainage is expected to continue to direct runoff to West Loon Creek. Generally, changes from subsidence to surface water flow pathways and drainage area boundaries in the effects study area will be small and localized; the major flow paths (e.g., West Loon Creek) are expected to be maintained.

Changes to water quality from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for more than a century. Areas that become more depressional in the landscape may be expected to accumulate more snow runoff and rainfall, which may create new wetland areas. Alternatively, existing wetlands may drain and become drier. Changes in stream gradients caused by subsidence will also occur gradually and take place over a long enough period that stream bed erosional and depositional processes are expected to remain within their natural range of variability. Because subsidence will occur very gradually, no acute, adverse effects on water quality are expected.

Overall, it is anticipated that through the use of environmental design features and mitigation, the Project can be constructed, operated, and decommissioned in a manner that will result in minor changes to the physical and chemical properties of surface water, and result in negligible residual effects on surface water quality. The negligible residual effects from the Project are not likely to contribute to significant effects on the continued suitability of surface water for human use.

19.7 Fish and Fish Habitat

The Project is not expected to affect the ability of fish populations to be self-sustaining and ecologically effective.

Most of the Project footprint is located within the Loon Creek drainage. The main tributaries of Loon Creek include West Loon Creek and East Loon Creek. Both West and East Loon creeks have well-defined stream channels. A tributary of West Loon Creek that is referred to as “unnamed stream” has a poorly defined stream channel and drains a large part of the effects study area, including the proposed core facilities area and a portion of the mining area. Although there are no lakes present in the water quality effects study area, there are many ephemeral wetlands.

Fish inventory surveys were completed in West Loon Creek, East Loon Creek, Loon Creek, and three disconnected land-locked waterbodies during the spring, summer, and fall of 2013. Brook Stickleback and Fathead Minnows were the only fish species captured or observed in the effects study area. Both species were found in West Loon Creek and Loon Creek; no fish were captured in East Loon Creek or any of the sampled wetlands. No large-bodied fish species were captured.

Fish habitat assessments were completed at six sampling stations where fish were captured or observed during the 2013 field season. West Loon Creek and Loon Creek were identified as the only watercourses within the effects study area that are capable of supporting fish, at least on a seasonal basis. Small-bodied fish habitat appears to be dependent on annual flow volumes and flow durations, as well as the presence of deeper impoundments and dugouts. Barriers to fish movement were observed in West Loon Creek, East Loon Creek, and Loon Creek. Permanent wetlands within the effects study area lacked hydraulic connections to fish-bearing waterbodies or streams and are considered too shallow to support over-wintering habitat for fish.

Based on the water quality assessment, it is anticipated that deposition of potassium and chloride will result in only very small (i.e., less than or equal to 2.6 mg/L increase in potassium or chloride concentrations) changes to surface water quality in West Loon Creek, East Loon Creek, and Loon Creek. Therefore, the magnitude of change in potassium and chloride concentrations is not considered biologically significant. Deposition of potassium and chloride is not predicted to adversely affect fish and fish habitat.

Changes to flow pathways due to ground subsidence are mainly predicted along the north and west edges of the mine well field. Drainage is expected to continue to direct runoff to West Loon Creek, which is the only watercourse within the area of maximum subsidence that is capable of supporting fish, at least on a seasonal basis. Ground subsidence is predicted to change the channel slope or gradient of West Loon Creek. The gradient of West Loon Creek is likely to increase where the stream crosses the area of greatest subsidence, resulting in increased flow rates and erosion of bed and bank materials. Alternatively, the channel gradient is predicted to decrease or even reverse at three other locations. These predicted decreases in stream gradient are expected to result in the formation of depositional (i.e., pool) habitats. Stream connectivity is still expected to be intermittent, and largely dependent on high-flow events. Pool habitats that can be accessed during high flows are expected to be favourable for both Fathead Minnow and Brook Stickleback. Large-bodied fish will continue to be unable to access the creek.

Changes to fish and fish habitat from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for more than a century. West Loon Creek will continue to support small-bodied fish. Changes in stream gradients caused by subsidence will take place over a long enough period that stream bed erosional and depositional processes are expected to remain within their natural range of variability. No acute, adverse effects to fish and fish habitat are expected.

Overall, it is anticipated through the use of environmental design features and mitigation, the Project can be constructed, operated, and decommissioned in a manner that will result in minor and local changes and negligible residual effects on fish and fish habitat. The residual effects from the Project are not likely to contribute to significant effects on self-sustaining and ecologically effective fish populations.

19.8 Soils

The Project is not expected to affect the capability of soil to support agriculture and other plant communities.

The soils effects study area is approximately 804 km^2 (80,385 ha), and includes both unaffected (i.e., reference) areas and areas that are influenced by the Project. The maximum area of soil map units to be disturbed by the application of the Project is 1,550 ha (1.9% of the effects study area). Following decommissioning and reclamation, an area of approximately 842 ha (54% of the Project footprint) is expected to be reclaimed. Soils will be reconstructed in reclaimed areas. Reclaimed areas have not been assigned a specific soil type and classified as a reclaimed map unit. The area of residual disturbance (i.e., tailings management area) is predicted to be 708 ha (approximately 0.9% of the effects study area); these areas will not be reclaimed at closure.

At the Base Case, the dominant soil map unit within the effects study area is Oxbow and accounts for approximately 29.2% (23,452 ha) of the area. The Weyburn soil map unit covers 23.1% of the effects study area, Weyburn-Oxbow covers 11.9%, Weyburn-Elstow covers 4.0%, and Forget Complex covers 1.2% of the ESA under Base Case conditions.

The soil map unit that will likely experience the greatest change during construction is the Weyburn-Elstow (WrEw4 and WrEw8) map units, of which 936 ha will be disturbed. The area of residual disturbance includes 600 hectares of Weyburn-Elstow (WrEw4), 49 hectares of Weyburn (Wr4), 34 hectares of Forget (Fg10), and 25 ha of Weyburn-Oxbow (WrOx4) soil map units.

The dominant agriculture capability class within the effects study area is Class 3 and accounts for approximately 48.9% (39,291 hectares) of the effects study area under Base Case conditions. The Class 2 covers 20.7% of the effects study area, Class 4 covers 11.8%, and Class 5 covers 11.0% of the effects study area under Base Case conditions. An area of 842 ha (approximately 1.0% of the effects study area) within the Project footprint is expected to be reclaimed to an equivalent agriculture capability. This includes a predicted re-establishment of 12 hectares (less than 0.1% of the effects study area) of Class 2 soils, 695 ha (0.9 % of the effects study area) of Class 3 soils, 29 ha (less than 0.1% of the effects study area) of Class 4 soils, 56 ha (0.1% of the effects study area) of Class 5 soils, and 49 ha (0.1% of the effects study area) of Class 6 soils. The area of permanent change of agriculture capability associated with residual disturbance will become Class 7 (i.e., has no capability for agriculture) following decommissioning and reclamation of the Project. This includes the predicted loss of 615 ha (approximately 1.0% of the effects study area) of Class 3 soils, 23 ha (less than 0.1% of the effects study area) of Class 4 soils, 67 ha (less than 0.1% of the effects study area) of Class 5 soils, and 0.1 ha (less than 0.1% of the effects study area) of Class 6 soils.

The magnitude of residual effects from loss or alteration of soil is predicted to be negligible to low. Residual effects were determined to be local in geographic extent and continuous. Progressive reclamation is anticipated to occur during operations and residual effects on soils that will be reclaimed are predicted to be reversible after decommissioning and reclamation. Effects on soil quantity from residual ground disturbance are considered local in geographic extent and continuous.

The agriculture capability of the soils in the tailings management area changes from Class 3, Class 4, Class 5, and Class 6 at Base Case conditions, of which approximately 89% of the permanently lost soils consisted of Class 3 soils, to a Class 7 following closure, resulting in a permanent loss of the soil's capability to support agriculture and other plant communities. As such, the magnitude of residual effects from residual ground disturbance is considered high in magnitude and irreversible.

Residual effects from ground subsidence are anticipated to be regional and result in a net change to agriculture capability within class groups when compared to Base Case (i.e., negligible to low magnitude). Subsidence will continuously occur over a timeframe of hundreds of years (beyond closure) and is considered permanent and irreversible. However, because the change to soil will occur gradually over hundreds of years, it should not affect the overall ability of soil to support agriculture and other plant communities.

Overall, incremental and cumulative changes to soils from the Project and other developments are predicted to have no significant adverse effects on the soil's capability to support agriculture and other plant communities.

19.9 Vegetation

The Project is not expected to affect the ability of plant communities, listed plants, and traditional use plants to be self-sustaining and ecologically effective.

At the Base Case, cumulative changes from sustained agricultural practices over the last 100 years have resulted in adverse effects on plant populations and communities, specifically native grassland and wetlands in the effects study area. Cultivated, Modified Grassland and Existing Disturbance cover 75.5% of the effects study area under the Base Case. As such, 75.5% of native grassland and wetland vegetation types that were in the effects study area prior to human settlement are estimated to have been removed by previous and existing human developments and agricultural activities.

The dominant Ecological Landscape Classification map unit within the effects study area is Cultivated and accounts for approximately 58% (46,834 ha) under Base Case conditions. The Modified Grassland unit, which includes both hayland and modified prairie, covers 16% of the effects study area and Native Grassland covers 8%. Wetlands (Class I, II, III, IV, and V) cover approximately 13% of the effects study area. The Existing Disturbance map unit (e.g., roads and communities) accounts for approximately 1% (1,141 ha) of the effects study area under the Base Case.

The Ecological Landscape Classification map unit that will experience the greatest change from the Project is the Cultivated (1,216 ha) land cover type. The Project is predicted to remove 87 hectares of Class I and Class II Wetland, 77 ha of Modified Grassland, 69 ha of Class IV Wetland, 20 ha of Native Grassland and 14 ha of the Wooded Ecological Landscape Classification units. Overall, the cumulative reduction in natural habitat through application of the Project and previous and existing developments is approximately 75.8% of the effects study area, with an incremental contribution from the Project of 0.3%.

A loss of 19 patches of Native Grassland units and a loss of 60 patches of Class III and Class IV Wetlands is predicted under the Application Case. The mean patch size during the Base Case is approximately 1.9 ha, 0.5 ha, and 1.2 ha, respectively. The mean patch size of Native Grassland is predicted to increase slightly (less than 0.1 ha) with application of the Project. This slight increase in mean patch size is related to the removal of three small patches (all 0.6 ha and smaller) associated with the location of the tailings management area. The mean patch size of Class III and Class IV Wetland units is predicted to decrease slightly (less than 0.1 ha) with application of the Project.

Within the effects study area, the mean distance to nearest neighbour (MDNN) between patches of Native Grassland is 50.7 m during the Base Case. This means that on average species will need to disperse 50.7 m before encountering another patch of Native Grassland. With application of the Project, this mean distance is predicted to decrease slightly to 50.6 m, which should have no ecologically measurable effect on the current ability of species to disperse between patches, given they can move these distances. A similar result was observed in Wooded and Wetland units where only small changes in MDNN were observed, a decrease in MDNN of 2.5 m and an increase of 0.1 m, respectively, relative to Base Case conditions.

The Project is predicted to contribute little to the existing cumulative effects on natural (native) plant populations and communities in the effects study area. Most of the patches of Native Grassland associated with the Project footprint are 0.6 ha and smaller. Plant species present in wooded areas and wetlands are likely adapted to the patchy nature of these vegetation types present in the effects study area. Removal of vegetation by the Project should not disrupt the existing connectivity of native grassland, wetlands, and wooded vegetation types in the effects study area. Larger areas of native grassland are present outside of the Project footprint. The Project is located approximately 5 km from the closest known location of a large patch (approximately 125 ha) of native dominated grassland and a Class V Wetland (approximately 3 ha) associated with the valleys of West Loon Creek. The mosaic of native dominated grassland, wooded areas, and wetlands in the northeast of the effects study area is approximately 224 ha and the patch of native grassland in the southeast of the effects study area is approximately 270 ha. Baseline data indicates that these grasslands are in good condition and were dominated with native grassland species. The local and sub-regional plant communities associated with Native Grassland and Wetland units remaining in the effects study area are likely self-sustaining and ecologically effective.

Not all areas that were assessed to be disturbed by the Project are expected to be altered during construction; therefore, the assessment of effects from direct loss or alteration and fragmentation of vegetation in the effects study area is overestimated. The siting of well pad locations will be modified to avoid wetlands during the final design phase. Avoidance of wetlands will reduce the contribution of the Project to existing cumulative effects in the effects study area. The incremental effects from the Project are expected to be reversible after closure (long-term), except for localized effects from the tailings management area and crystallization ponds (708 ha [0.8% of the effects study area]), which will be permanent and irreversible.

Overall, the weight of evidence from the analysis of the primary pathways predicts that cumulative changes to measurement indicators from previous and existing developments have had an adverse effect on self-sustaining and ecologically effective plant populations and communities. The cumulative residual effect on natural (i.e., native) plant populations and communities present in the Application Case is expected to be high in magnitude because of the previous and existing disturbances in the effects study area. However, several large areas of native dominated grassland in the effects study area are likely self-sustaining and ecologically effective. The incremental effects from the Project are small (low magnitude; 0.3% relative to Base Case conditions), local to regional in geographic extent, and long-term to permanent in duration. The incremental contribution of the Project to regional cumulative effects is not likely to decrease the resilience and increase the risk to remaining local or sub-regional self-sustaining and ecologically effective plant populations and communities in the effects study area. The Project will not influence the large, intact natural grasslands and wetlands that exist in the effects study area. Therefore, the cumulative changes from the Project and other developments are predicted not to have significant adverse effects on plant populations and communities.

Of the area directly disturbed by the Project, 119 ha of Ecological Landscape Classification units with high listed plant habitat potential will be disturbed during construction, resulting in a decrease of 0.8% relative to Base Case conditions. Habitat units with moderate/high listed plant habitat potential will decrease by approximately 87 ha (2.2%). With appropriate mitigation, the residual effect of the Project on listed plant populations is expected to be moderate in magnitude, because if a patch of listed plants is removed, it could be measurable at the regional level, but would not be predicted to alter the state of existing listed plant populations. Previous and existing disturbances in the effects study area have likely removed other patches of listed plant species; therefore, the magnitude of cumulative effects on listed plants is considered high to be conservative. The incremental contribution of the Project to regional cumulative effects is not likely to decrease resilience and increase the risk to remaining local self-sustaining and ecologically effective listed plant populations; the Project will not influence the large, intact natural grasslands and wetlands that exist in the effects study area. The incremental and cumulative effects from the Project and other developments are predicted not to significantly influence self-sustaining and ecologically effective listed plant populations.

A total of 107 ha of Ecological Landscape Classification units with high traditional use plant habitat potential will be disturbed by the Project, resulting in a decrease of 0.7% relative to Base Case conditions. Habitat units with moderate potential will decrease by approximately 12 ha (1.3%). The residual effect of the Project on traditional use plant populations is expected to be low in magnitude. Some areas disturbed by the Project are expected to be reclaimed after closure except for localized effects from residual disturbance, which will not be reclaimed.

Changes to traditional use plant habitat will be permanent and irreversible because the type of vegetation in reclaimed areas is unknown at this time. Residual effects from the Project on traditional use plant species are expected to be small and at the local scale (confined to the Project footprint). The incremental and cumulative effects from the Project and other developments are predicted not to significantly influence self-sustaining and ecologically effective traditional use plants.

The effect of ground subsidence on vegetation from the Project is low in magnitude and regional in geographic extent. Small, localized changes to flow pathways and drainage areas are predicted within the West Loon Creek basin in the effects study area. The flows along major flow paths (i.e., West Loon Creek) are predicted to be maintained; however, localized alterations of flow pathways are predicted and ponding sections may appear. Changes to vegetation from ground subsidence will occur gradually and ultimate (maximum) subsidence will not occur for over more than a century. Areas that have become more depressional in the landscape may be expected to accumulate more snow runoff and rainfall, which will increase soil moisture and may create wetland plant communities. Alternatively, existing wetlands may drain and become upland plant communities. Changes in soil moisture are expected to occur at a rate slow enough to allow for reciprocal changes in the distribution of plant communities. These changes in soil moisture and distribution of upland and wetland vegetation are not expected to result in a net decrease in vegetation. The distribution of upland and wetland vegetation is expected to change, but will compose similar proportions of the landscape after subsidence has occurred.

19.10 Wildlife

The Project is not expected to affect the ability of wildlife valued components to be self-sustaining and ecologically effective.

Based on information presented in Archibold and Wilson (1980), previous and existing human developments, including cultivated and modified grassland habitats, are estimated to have removed 75.5% of wetland and native grassland habitats that were present in the effects study area prior to human settlement. Consequently, cumulative effects from previous and existing human activities are expected to have adversely affected ferruginous hawk, short-eared owl, and northern leopard frog populations as well as some upland breeding bird and waterbird populations in the effects study area.

The Project is predicted to contribute little to cumulative effects on wildlife valued components in the effects study area. The Project is expected to result in a 1.5% loss of wetland habitat and a less than 0.1% loss of native grassland habitat. Yancoal is committed to following the wetland mitigation hierarchy presented by the MOE (2014). As such, during construction, Project infrastructure (i.e., well pads) will be sited to avoid wetlands and the anticipated direct loss to wetlands will be less than predicted.

In addition to direct habitat loss, indirect changes from sensory disturbance associated with existing developments and the Project may influence wildlife abundance and distribution by altering movement and behaviour among habitats at the population scale. When compared to a landscape with only direct disturbance, sensory disturbance is affecting 50.1% (40,139 ha) of the effects study area under Base Case conditions. Sensory disturbance effects combined with direct effects from removal of habitat by cultivated, modified grassland, and existing disturbance habitats are predicted to have altered 87.2% (70,082 ha) of the effects study area under the Base Case. Sensory disturbance from Project construction and operations is predicted to affect an additional 6.7% (5,455 ha) and 8.0% (6,444 ha) of the effects study area, respectively, relative to the Base Case.

Overall, the weight of evidence from the analysis of the primary pathways predicts that cumulative changes to measurement indicators from previous and existing developments have had an adverse effect on self-sustaining and ecologically effective wildlife populations in the effects study area. However, there are remaining large areas of contiguous native grasslands and wetlands in the effects study area that likely support self-sustaining and ecologically effective wildlife valued components. The incremental effects from the Project are small (low magnitude), local to regional in geographic extent, and long-term to permanent in duration. The incremental contributions of the Project to regional cumulative effects are not likely to decrease resilience and increase the risk to remaining local self-sustaining and ecologically effective wildlife populations; the Project will not influence the large, intact natural grasslands and wetlands that currently exist in the effects study area. Therefore, the cumulative changes from the Project and other developments are predicted not to have significant adverse effects on wildlife valued components populations.

19.11 Heritage Resources

The Project is not predicted to affect heritage resources. The Project will implement several environmental design features and mitigation to avoid or limit effects to heritage resources. The Project will be located in an area that has largely been disturbed previously by agricultural activities. No known heritage resources are located within the core facilities area, and the land is not considered heritage sensitive by the Heritage Conservation Branch. The mine well field area contains no recorded heritage resources, and most of the land is considered to have low heritage potential. However, areas of native prairie adjacent to West Loon Creek will require additional Heritage Resources Impact Assessment if development occurs in these areas. Any proposed facility plans (e.g. well pads and well field pipelines) located in the E1/2 25-24-19 W2M, NW and S1/2 30-24-18 W2M, and N1/2 and SE 19-24-18 W2M will be submitted to the Heritage Conservation Branch for review to determine further Heritage Resources Impact Assessment requirements. Any conflicts with heritage resources will be addressed in advance of construction. Similarly, any Project plans located near historic structures or markers located in the NE-23-24-19 W2M, NE-26-24-19 W2M, SE-29-24-19 W2M, and SE-13-24-19 W2M will require consultation with the R.M. of Longlaketon to address any concerns prior to construction.

Management options for archaeological and/or heritage materials fortuitously discovered during construction activities will be developed in consultation with the Saskatchewan Ministry of Parks, Culture and Sport - Heritage Conservation Branch. In the event of unanticipated archaeological materials or features being encountered during construction or unplanned events, all work in the immediate area will cease and the Saskatchewan Ministry of Parks, Culture and Sport - Heritage Conservation Branch will be contacted. Decommissioning and reclamation activities are expected to have no effects to heritage resources because no new disturbance will occur during this Project phase.

19.12 Socio-economic Environment

The Project is predicted to result in residual effects on the socio-economic environment related to employment and economy, community services and infrastructure, traffic and transportation, quality of life, and traditional and non-traditional land use.

Skilled local workers will be given priority during hiring; however, based on the existing labour force conditions, the Project is expected to require an out of province workforce to meet construction and operations labour demand. Most of the construction workforce is expected to be a temporary workforce, largely residing in a construction camp near the Project, although some of the construction workforce may relocate to the Project area. Depending on the availability of skilled labour, some or most of the Project operations workforce may come from outside the province. The Project operations workforce is expected to relocate to the area permanently, often accompanied by family.

The Project will have a significant, positive residual effect on the local and regional economy. Project construction and operations will create jobs and generate income, although much of the construction workforce may not be hired locally, which will reduce the benefits of job creation and income during Project construction. The Project will result in increased training and experience in the labour force, which will affect future opportunities. Project spending will result in increased Gross Domestic Product and Project operations will generate tax revenue for municipal, provincial, and federal governments. This pathway was determined to be significant largely because of the high magnitude residual effects on Gross Domestic Product and government tax revenue.

The Project workforce will result in an increased population in the local area from the Project operations workforce and any of the Project construction workforces that relocate. This population increase is expected to result in a significant residual effect on community services and infrastructure. Residual effects on community services and infrastructure can be both positive and negative. The region has experienced a steadily increasing population for most of the past decade and correspondingly, demand has been increasing for services and infrastructure. Some services, such as schools and health care are operating near or at capacity. The real estate market has been expanding rapidly and has met demand up to this point, but house prices have risen substantially and vacancy rates are low. Most residual effects on community services and infrastructure are expected to occur in Regina, where most of the relocated population is expected to live. The City of Regina and service providers are aware of the rapid increase in population and corresponding demand for services and infrastructure, which is predicted to continue in the future, and are planning accordingly.

The Project will increase traffic in the area and could potentially affect transportation infrastructure. Some traffic will come from outside the province or region, but the noticeable traffic increase is expected mainly to occur north of Regina (where most of the workforce is expected to live) on Project access routes. A traffic impact assessment was completed and identified required road upgrades and mitigation to reduce the residual effects on traffic and transportation. Yancoal will build a construction camp and encourage carpooling. Project-related traffic could increase the potential for traffic accidents; however, appropriate training will be provided and safety measures put in place. The Project will require the closing of two stretches of grid road within the core facilities area. Yancoal will work with the rural municipalities and governments to facilitate local traffic movement. Overall, the residual effect on traffic and transportation is not considered significant.

Quality of life was defined in relation to air quality, water quality, visual aesthetics, and noise. Air modelling indicated that emissions will be within guideline values, while the water quality assessment determined that there would be no significant residual effects on water quality. Potential for changes to noise and visual aesthetics from the Project may affect quality of life for residents near the Project. Noise levels were predicted to be within guideline values at all noise receptors except one. This may result in a significant effect for individuals at this receptor. The Project will alter visual aesthetics for some distance, as the terrain will provide unobstructed views of the Project for numerous farmyards, residences, and possibly from several communities. However, this residual effect is not expected to deteriorate socio-economic conditions in the area and is not considered significant.

The Project will have minor residual effects on traditional and non-traditional land use. Changes to surface water quality, vegetation, soil, wildlife, fish and fish habitat, and the atmospheric environment can all affect land use, as can ground subsidence. These residual effects were all determined to have no linkage or negligible/minor residual effects on land use. The main land use in the area is agriculture. No known traditional land use exists within the Project footprint or immediate surrounding area, and activities, such as recreation, tourism, hunting, and fishing, are limited by private land ownership and the extensive modification of the landscape. The Project will reduce the area of agricultural land, which could affect landowners and nearby residents. However, landowners will be compensated and the permanent loss of agricultural land is small compared to the quantity in the area. Overall, residual effects on traditional and non-traditional land use are considered not significant.

19.13 Conclusions

Based on the Project information and analysis provided in this environmental impact assessment and the mitigation aimed at reducing negative effects, the Yancoal Southey Project is not likely to cause significant adverse residual effects on most valued components of the biophysical and socio-economic environments. The Project workforce requirements and tax revenue will have significant positive residual effects on employment and economy. The population increase associated with the Project, including workers and their families who migrate to the area, will result in an increase in demand for infrastructure and services in the area. Cumulatively, this will act with previous, existing, and future projects, having the potential to result in a significant adverse residual effect on community infrastructure and services. For all other components of the environment, adverse residual effects from the Project are predicted not to significantly influence the following assessment endpoints:

- compliance with regulatory air emission guidelines and standards;
- continued suitability of groundwater for human use;
- availability of surface water quantity for human use and ecosystems;
- continued suitability of surface water for human use;
- self-sustaining and ecologically effective fish populations;
- soil capability to support agriculture and other plant communities;
- self-sustaining and ecologically effective plant populations and communities;
- self-sustaining and ecologically effective wildlife populations;
- protection of heritage resources; and
- sustainability of social and economic properties.

Based on the detailed Project information and assessment of Project effects provided in this Environmental Impact Statement, Yancoal believes that this Project can be constructed, operated, and decommissioned in a manner that, taking into account environmental design features and mitigation, is not likely to cause significant adverse effects to the biophysical or human environments. This Project is expected to result in a positive effect on employment levels and socio-economic conditions in the R.M.s of Longlaketon and Cupar and the province of Saskatchewan.

19.14 References

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