THE CEDAR FALLS GROUNDWATER INVESTIGATION

Iowa Department of Natural Resources
Roger L. Lande, Director
February 2012

Iowa SOURCE WATER Protection

Cover Photograph

Aerial view of Cedar Falls from the southwest region of the city, including the water tower and new development areas. Photo by Denny Mills.

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Prepared by

Chad L. Fields
Iowa Geological & Water Survey
Iowa Dept. Natural Resources
Iowa City, IA 52242
chad.fields@dnr.iowa.gov

With contributions by

Mohammad Iqbal
University of Northern Iowa
Department of Earth Science
Cedar Falls, IA 50613
m.iqbal@uni.edu

David Pals
Iowa Geological & Water Survey
Iowa Dept. Natural Resources
Iowa City, IA 52242-1319
david.pals@dnr.iowa.gov

Caroline Davis
Lucille A. Carver Mississippi Riverside
Environmental Research Station
The University of Iowa
3388 Highway 22
Muscatine, Iowa 52761
caroline-davis@uiowa.edu

Jason Vogelgesang
Iowa Geological & Water Survey
Iowa Dept. Natural Resources
Iowa City, IA 52242-1319
jason.vogelgesang@dnr.iowa.gov

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INTRODUCTION

The primary source of drinking water for the city of Cedar Falls is the limestone and dolomite of the Silurian-Devonian aquifer. The city of Cedar Falls currently uses eight wells to provide drinking water for the community. The Silurian-Devonian aquifer is the first bedrock unit encountered in the region, and bedrock depth in the region is highly variable. Depending on the area, the Silurian-Devonian aquifer can be within a few feet of the land surface or buried under over 100 feet of glacial till.

The Silurian-Devonian aquifer has undergone extensive erosion and weathering from flowing water and past glaciation events. This erosion and weathering has fractured the underlying shallow bedrock, forming large open channels where water can move through very quickly. Geologists call these types of geologic features 'karst' terrain. Karst can be seen on the land surface as sinkholes, cave openings, and low-lying wet areas on a flat land surface (Figure 1).

Although the karsted Silurian-Devonian limestone near Cedar Falls is an excellent, high yielding source of water, certain issues arise when water moves through the subsurface so quickly. Because of the fast moving water, wells open in karst systems have water quality concerns usually found in surface water (Figure 1; Figure 2). In Iowa, the most prominent water quality issue in karst is contamination from non-point sources such as fertilizer and septic systems. Cedar Falls has relatively high nitrate-N concentrations in three out of the eight wells.

SOURCE WATER PROTECTION

Source Water Protection is an established method for a city or community to take action in protecting their source of drinking water

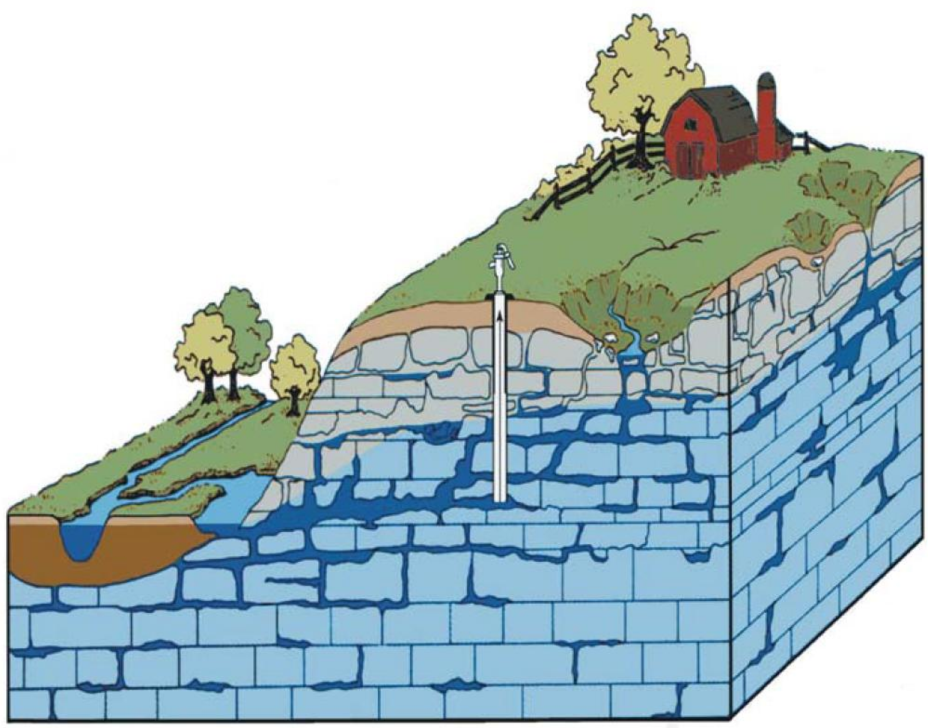

Figure 1. A diagram of a karst system with sinkholes, fractures, caves, and springs. The illustration represents the direct connection between the aquifer and land surface, resulting high water yields, and high potential for surface contamination to enter the source aquifer (Hallberg, 1982).

before there are water quantity or quality issues. These preventative measures can help save a community money and result in naturally safe, non-treated drinking water. To be successful in Source Water Protection, a community must: 1) know where their drinking water is coming from (i.e., source water area), 2) have an inventory of all potential contaminant sources and pathways, and 3) proactively address issues of concern to the community. The Iowa Source Water Protection program is a U. S. Environmental Protection Agency funded program designed to implement all of the previous steps in community water supplies. This program is federally funded and provides targeted assistance to many Iowa communities.

Through the Source Water Protection program, the Iowa Department of Natural Resources has completed a “Phase 1” Source Water Assessment for Cedar Falls (IDNR, 2009). The Phase I Assessment details the active wells, source aquifer, and potential contaminant sources to that community. Phase I assessments have been completed for all community water supplies in Iowa.

Due to the fact that typical modeling software does not work for karst systems such as Cedar Falls, default 1-mile radius circles were delineated around each active well. The entire source water capture zone was considered to be ‘highly susceptible’ to contamination from the surface due to an estimation of less than 25 ft. of cumulative confining layer such as till, clay, and shale between the source water aquifer and land surface.

This report details the scientific work completed by the Iowa Department of Natural Resources-Iowa Geological and Water Survey, and delineates the priority conservation zones for the Cedar Falls source water protection area. These specific areas are to be used as management tools for the City to focus best management practices to protect the quality of groundwater and reduce nitrate concentrations. These areas have very limited confining layers between the source aquifer and land surface, and are estimated to have water contribute to at least one city well.

BACKGROUND

The city of Cedar Falls provides an average 4.1 million gallons of water per day from eight highly productive wells located in the Silurian-Devonian aquifer. Cedar Falls wells range in depth from 145 ft. to 275 ft. below land surface, and all penetrate and are open in the bedrock. Certain wells only penetrate the upper Devonian units, and other wells penetrate through the Devonian into the Silurian aquifer. Due to the highly fractured nature of the dolomite and limestone in this region, for this report the aquifer is considered one hydrogeologic unit.

Water chemistry is highly variable between the Cedar Falls wells. Higher nitrate concentrations have been recorded in wells 3, 5, 9, and 10 (Figure 2). Nitrates in wells 6, 7, 8, and 11 are either non-detectable or significantly below the EPA's maximum contamination level of 10 parts per million (ppm) nitrate-N. The changes in water chemistry reflect the different sources and vulnerability of the aquifer in different source water areas for each of the wells. Changes in nitrate-N concentration through the last 50 years are indicative of most Iowa surface water bodies, alluvium, and upper bedrock aquifers.

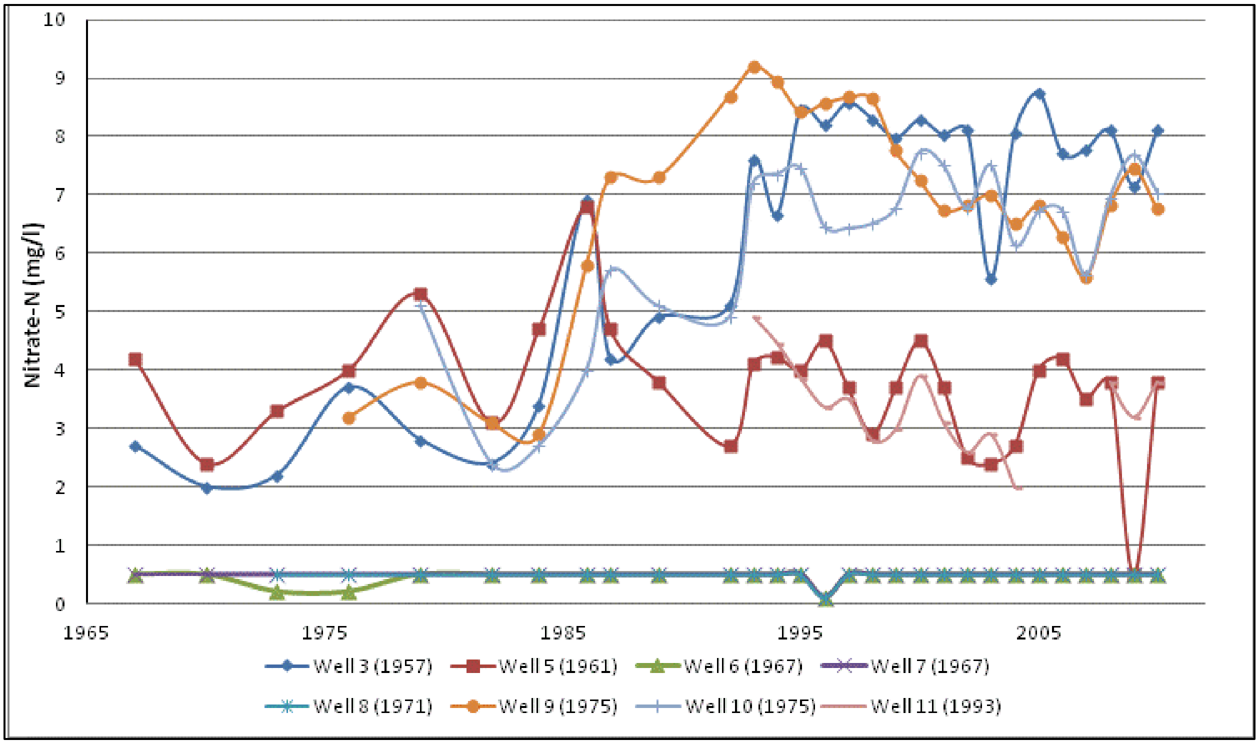

Figure 2. Time series of nitrate-N results in milligrams per liter, or parts per million (ppm) in Cedar Falls eight active wells. Wells 6, 7, and 8 all consistently measure below detection limit. Wells 3 and 11 measure from 2-5 ppm. Wells 3, 9, and 10 consistently measure above 6 ppm, and have been measured close to the 10 ppm maximum contaminant level set by the U.S. Environmental Protection Agency.

Although the Source Water Phase I assessment broadly categorized the Cedar Falls Source Water area as being 'Highly Susceptible,' (i.e., < 25 ft. of confining layers), confining layer thickness between the aquifer and land surface is highly variable in the area, with wells 3, 6, 7, 8, and 11 having between 60-100 ft. of total confining layers, and wells 5, 9, and 10 having less than 25 ft. of total confining layer thickness. The variation in well nitrates and spatial area of confining layer thickness provides an opportunity to further refine and focus the Source Water Protection area to a more manageable size and scope for the community.

Due to the high nitrates noted in the drinking water, relative vulnerability of many of the wells, opportunity in refinement of the source water area, and enthusiasm of the community for completing a source water planning process, the city of Cedar Falls was chosen by the Source Water Protection Program for a groundwater investigation. The groundwater investigation is designed to provide the city of Cedar Falls with a more manageable area than the areas delineated in the initial Source Water Assessment. This investigation is also meant to establish guidance for other communities like Cedar Falls that have source water from karst or have similar groundwater source location issues.

The purpose of this investigation is to identify the source of the nitrate concerns and address the most vulnerable areas that contribute water to the city wells, along with potential sources of contamination for the city of Cedar Falls. These high vulnerability areas are where best management practices will be identified and an implementation strategy will be developed and included in the Source Water Protection Phase II Plan. The plan will be updated as practices are implemented and environmental impacts will be recorded over time.

SCOPE OF WORK

The groundwater investigation will evaluate:

- The surrounding groundwater elevation and movement of the Silurian-Devonian aquifer through statistics on Iowa DNR database information, and interpolation from existing datasets.
- Comparison of derived water level with a previously published local groundwater elevation map compiled by the U.S. Geological Survey.
- Quaternary (i.e. surficial) material type above the Silurian-Devonian aquifer through NRCS soils and IDNR geologic records.
- The bedrock surface elevation in the Cedar Falls area from properly locating existing wells with lithologic information.
- Comparing groundwater composition through water chemistry of nitrate, tritium levels, and isotope analysis of nitrogen and oxygen.
- Bedrock elevation and fracture delineation through electrical resistivity geophysical imaging.

The results from the above investigations were compiled to produce a groundwater vulnerability map presented at the end of this report. The groundwater vulnerability map details the areas where land use changes will have the most direct impact on water quality measured in the active wells, and where most future Source Water Protection work should take place.

GEOLOGIC SETTING

The City of Cedar Falls lies on the heart of the Iowa Erosion Surface landform region (Figure 3, Prior, 1991), and overlies the Silurian-Devonian bedrock aquifer (Prior and others, 2003). The Cedar Falls area north of the Cedar River is dominated by shallow bedrock overlain by alluvial sand and gravel. The southern Cedar Falls area lies on the Iowan Erosion Surface landscape which is underlain by much older glacial tills which are mantled by a veneer of oxidized colluvial (loamy sediments) and Wisconsin-age eolian materials (loess and blow sand) all which overlie bedrock.

These two contrasting settings have a major impact on the susceptibility of the Silurian-Devonian aquifer used for the city of Cedar Falls drinking water supply. In the northern region, characterized by shallow bedrock, thin glacial till cover and thick alluvial and colluvial packages, high nitrates and low confining layer thicknesses have been an issue for the community water supply. While in the southern region the thicker underlying glacial till protects the aquifer from nitrate impacts.

Regionally, the Silurian-Devonian units dip to the south, as does the basal Maquoketa shale confining unit. Bedrock has been eroded away in recent history by the Cedar River and various current and ancestral surface water tributaries. North of the Cedar River the Silurian-Devonian bedrock are overlain by a thick alluvial package of sand and gravel, with some areas having bedrock exposed at or near the surface (Figure 3). The ground surface elevation in the region varies by over 100 ft., with high land surface elevation also located in the southern area of Cedar Falls, and the lowest surface elevation measured near the river at the northern section. These changes in elevation in both the

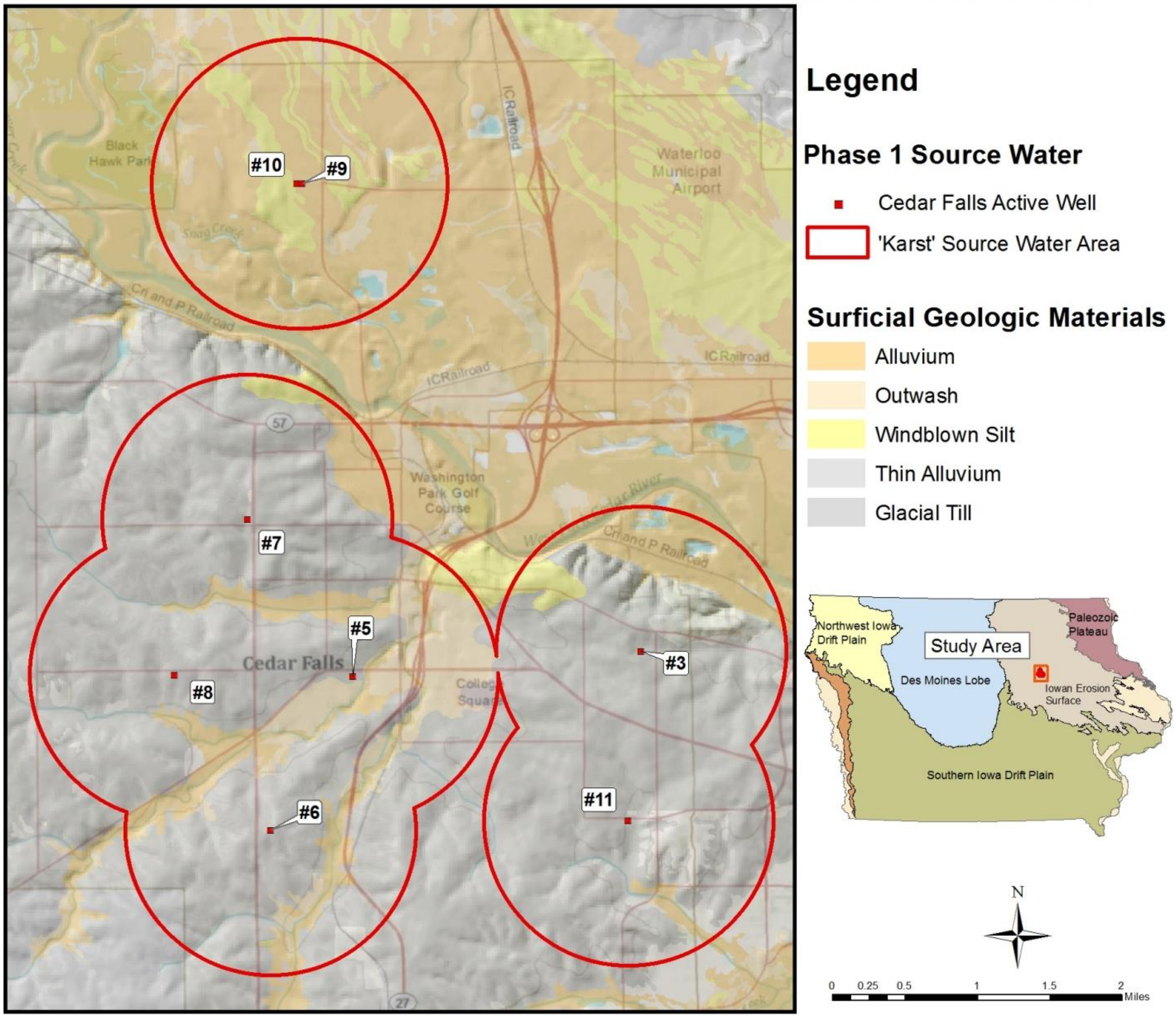

Figure 3. Map indicating the surficial geologic materials in the Cedar Falls Source Water Area. The region is dominated by weathered glacial till to the south of the Cedar River, and thick alluvial and eolian (windblown) deposits to the north of the current river channel.

ground surface and bedrock are usually the result of stream channelization and are near surface water bodies.

In this study, bedrock topography was mapped locally through the acquisition of field geophysical resistivity data to the north of Cedar Falls wells 9 and 10 (Figure 4; Figure 5), and regionally through the acquisition of lithologic records from GeoSam and Private Well Tracking System (PWTS) databases.

Electrical resistivity geophysical survey locations were chosen for areas with little current well record data, little city infrastructure, and near wells 9 and 10 as both have relatively high nitrate concentrations. The Cedar Falls City Engineer's Office and nearby land owners were contacted and permission was granted for four transect locations: a one mile west-east section along Fitkin Road between Ford Road and Center Street, a ¼-mile north-south section

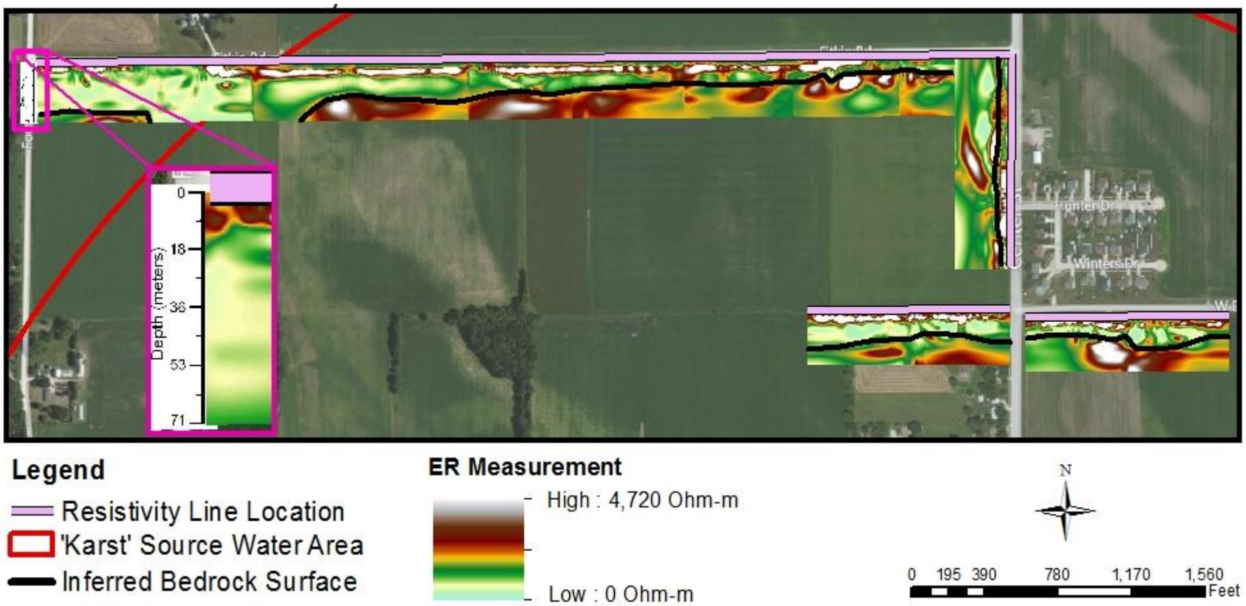

Figure 4. Map showing the electrical resistivity depth sections with inferred bedrock surface elevations north of well 9 and 10. Resistivity measurements are shown in Ohm-meters, with higher resistivity in the brown and white color spectrum and lower resistivity in the green and light blue spectrum

along Center Street between Fitkin Road and West Dunkerton, a ¼-mile west-east section along West Dunkerton Road, and a ¼-mile west-east section opposite Center Street from West Dunkerton.

An Advanced Geosciences Inc. (AGI) SuperSting R8/IP earth resistivity (ER) system was utilized to conduct the geophysical survey. The field measurement of ER was obtained by injecting a known direct current via transmitter electrodes and measuring the voltage differences between receiver electrodes. An array of 56 stainless steel electrodes were planted on the ground surface at 6-meter spacing, and connected via electrode cables to a multi-channel resistivity/IP meter. Measurements were collected in dipole-dipole configuration, and then processed using AGI EarthImager 2D inversion software. Measurements were then compared with local geologic records (strip logs, drillers' logs, etc.) to best interpret the raw ER data.

Earth resistivity measurements suggest that bedrock elevation is highly variable locally, and is nearer to the surface than previously thought to the north of wells 9 and 10. Previous studies (Witzke, et al., 2010), had an extensive bedrock valley located in this region that was upwards of 200 ft. deep, with extensive sand and gravel fill above. Results from this study indicate that bedrock is as shallow as 50-60 ft. deep in the Fitkin Road area, with the exception of an area west of Fitkin Road near Ford Road, where bedrock dropped below the ER detection limit of 232 ft.

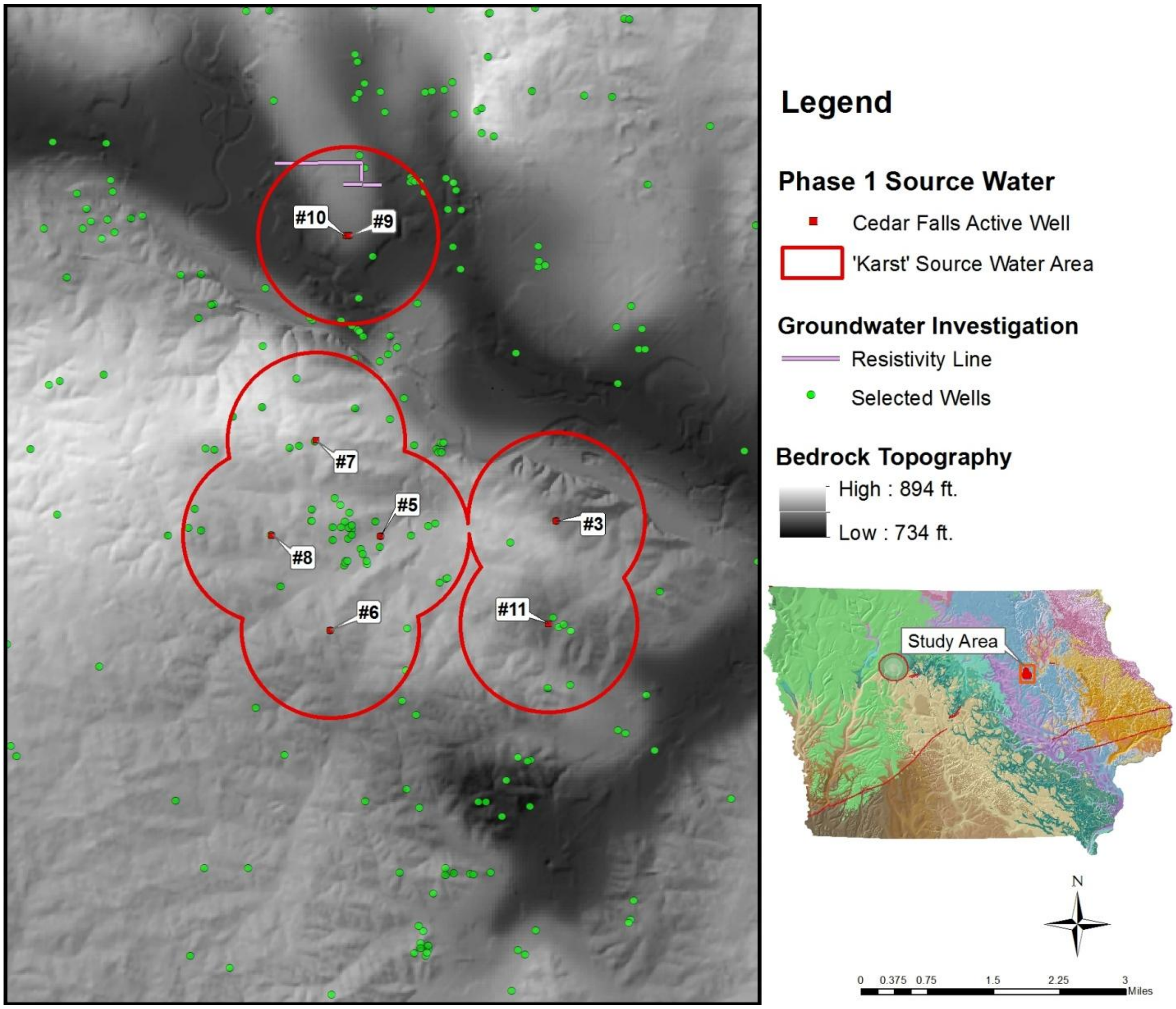

Figure 5. Map indicating the bedrock topography, study area, lithologic wells, and geophysical resistivity lines used to determine bedrock topography in the study region. In the study region, the surface unit of bedrock is the Cedar Valley Formation of the Devonian System.

Resistivity measurements also suggest that bedrock is highly fractured in the area north of wells 9 and 10. The discontinuous nature of the inferred higher resistivity bedrock surface, which is cross-cut in numerous areas by lower resistivity zones, suggests the presence of fractures and karst features in the subsurface along all four transects (Figure 4). These fractures can move water very quickly through great distances.

For regional bedrock elevation, in addition to resistivity measurements, lithologic well records from GeoSam and PWTS databases were re-located, and bedrock depth was recorded for 277 local wells in the study region (Appendix A). Soil maps from the Natural Resources Conservation Service (NRCS) were also used to denote areas where bedrock is within 50 ft. of the ground surface. Figure 5 shows the study area bedrock elevation and supporting data locations. Geophysical, well record, and soils data, along with surface topography were compiled together to form the bedrock topographic map (Figure 5). Bedrock elevation in the study area can be as low as 734 ft., and as high as 894 ft., with an elevation change of over 160 ft. Bedrock topography generally mimics surface topography, and the deepest bedrock units are located in the surface lows of the Cedar River. Bedrock is noted close to the surface (<50 ft.) in a few locations, including around well 5 near Dry Run Creek, to the north of well 3 near the Cedar River alluvium, and near the Waterloo International Airport. These bedrock highs mark areas where the aquifer is only slightly protected, if at all, from surface pollutants. These bedrock high areas are marked as highly vulnerable areas.

CONFINING LAYERS

Confining layer thickness determines the vertical travel time of groundwater through the subsurface to the aquifer. In Iowa, confining layers are typically composed of shale, clay, and glacial till. Extensive research has indicated that thickness of confining layers such as till, clay, and shale between the aquifer and the land surface provide a good estimation to determine susceptibility to surface contamination from both point and nonpoint sources (Canter, 1997). Aquifers overlain by thicker confining beds are less susceptible to surface contamination than aquifers overlain by thinner confining beds.

Confining layer thickness was estimated in the Cedar Falls area using two different methods. The first method was through using information from drillers' logs, and geologic strip logs to aggregate lithology into confining layer types. Drillers typically note the type and thickness of the subsurface layers that they are drilling through on a well record sheet. Often drill chip samples are sent in at five-foot increments and studied by a geologist. Additionally, soils information from the NRCS denotes the percentage of near surface sand in the soil. If the surficial Quaternary package is thin, or contains alluvial deposits such as sand and gravel, this is a good indicator of limited confining layers located above the bedrock.

Figure 6 indicates the soil and lithologic coverages where it has been determined that natural confining layers are inferred to be thin or absent, and thus allow the easy access of surface contaminants to enter the Silurian-Devonian aquifer. Areas highlighted in red are believed to have less than 25 ft. of total confining layer separating the land surface from the aquifer. These areas are believed to be of highest priority when protecting the Silurian-Devonian aquifer from surface pollution such as leaking underground gas storage tanks or non-point source pollution such as nitrate contamination.

GROUNDWATER FLOW AND DIRECTION

Due to the karst conditions in the area, the Silurian-Devonian aquifer is very productive, with wells easily producing 1-3,000 gallons per minute with little or no drawdown in water levels in the well. The high production in the area also indicates a fast travel time for groundwater under pumping conditions. With such fast groundwater movement, it's important that groundwater flow direction is properly mapped for an accurate assessment of the source water area.

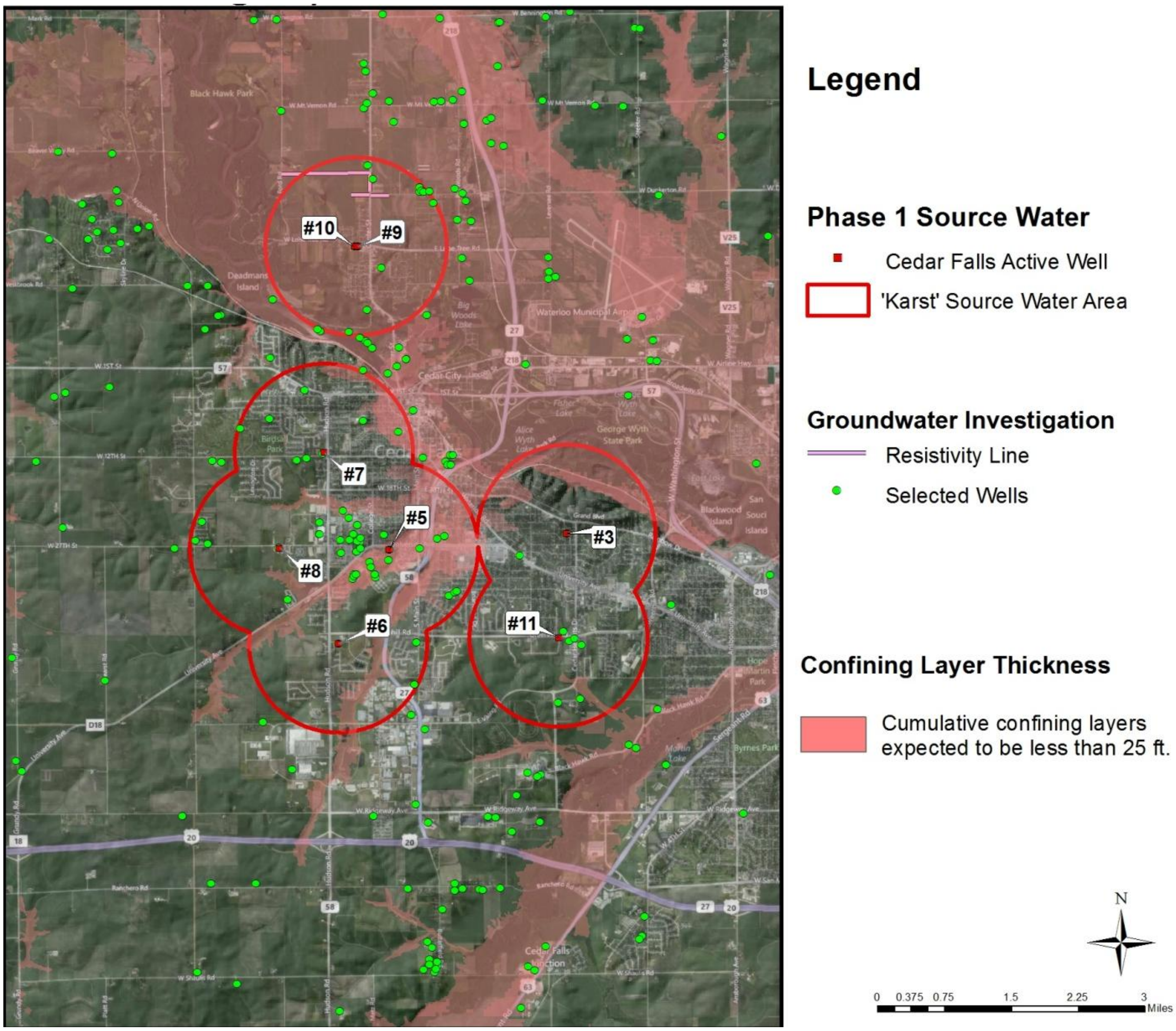

Figure 6. Map indicating the estimated confining layer (shale, till, clay) separating the land surface from the Silurian-Devonian bedrock aquifer. Confining layer thickness was estimated using geologic records, soils coverages, and bedrock elevation mapping.

Two previous studies have mapped groundwater elevation and direction in the Silurian-Devonian aquifer in the region: Horick, 1984 and Turco 2002. Horick, 1984 released a statewide regional map of the Silurian-Devonian aquifer throughout Iowa. Various properties of the Silurian-Devonian aquifer were mapped, including estimated yield potential, geologic formations, aquifer thickness, and potentiometric (i.e., groundwater elevation) surface. Horick used a total of 175 wells located throughout the eastern portion of the state to derive water levels in the Silurian-Devonian. Using values from these selected wells and a hydrogeologic understanding of groundwater movement near rivers, Horick produced a statewide groundwater elevation map of 50 ft. contours in the aquifer. Due to the low amount of data taken in the Cedar Falls region for Horick's study, the 1984 report was not included in the analysis of local groundwater flow conditions.

The U. S. Geological Survey study (Turco, 2002) monitored 63 wells for nearly a year from April 1998 to February 1999 for variations in static water levels. All selected wells had geologic or lithologic information available, and were open in the Silurian-Devonian bedrock aquifer. Additionally, each well had sufficiently detailed casing information that concluded the well was open only in the bedrock aquifer, and not additional geologic units. All wells were located around the Cedar Falls region and covered over a 400-square-mile area of Black Hawk, Bremer, Butler, and Grundy counties. Groundwater elevation measurements were taken from all wells on a bi-monthly basis. A resulting potentiometric surface was derived from average static water levels measured at the well sites during the sampling period. The potentiometric surface, along with hydrogeologic properties was then used in a USGS MODFLOW three-dimensional model of the aquifer (Turco, 2002).

An Iowa DNR 2011 supplementary groundwater elevation map was made for this study using water level measurement from existing databases in the area. This supplementary water level was designed to compare results with the previous USGS approach and provide more recent information on the water level maps. The water level map was also designed to check if any drastic change in water level has occurred in the region in the last 10 years.

For the supplementary Iowa DNR database elevation, LiDAR 1-meter high resolution elevation data were used with well location information to retrieve estimated surface elevation at the well site and static water level elevation above sea level. When available, well location information in the existing databases was augmented using available web resources such as Google Maps and Iowa Assessors Maps to accurately site the well in the correct plot of land. Location accuracy was assigned an estimated range from 1-mile (section only information) to 25 meters (gps or site located). Median, mean, and variation statistics were completed on elevation data within a buffer of the location estimate to provide a statistical approach to selecting groundwater elevation wells. Static water level elevations with variation higher than 10 ft were eliminated as groundwater elevation wells. Additionally, wells chosen for groundwater elevation measurements must be open in the Silurian-Devonian aquifer, and have a recent (post 1991) static water level measurement. A total of 119 wells were selected in the study area to evaluate groundwater elevations and movement. Wells included for groundwater elevations are in Appendix B.

The 119 wells used for groundwater elevation data were then interpolated into a coverage using the inverse distance weighted (IDW) interpolation method in ESRI ArcMap 10 Spatial Analyst software, and contoured manually from the IDW results.

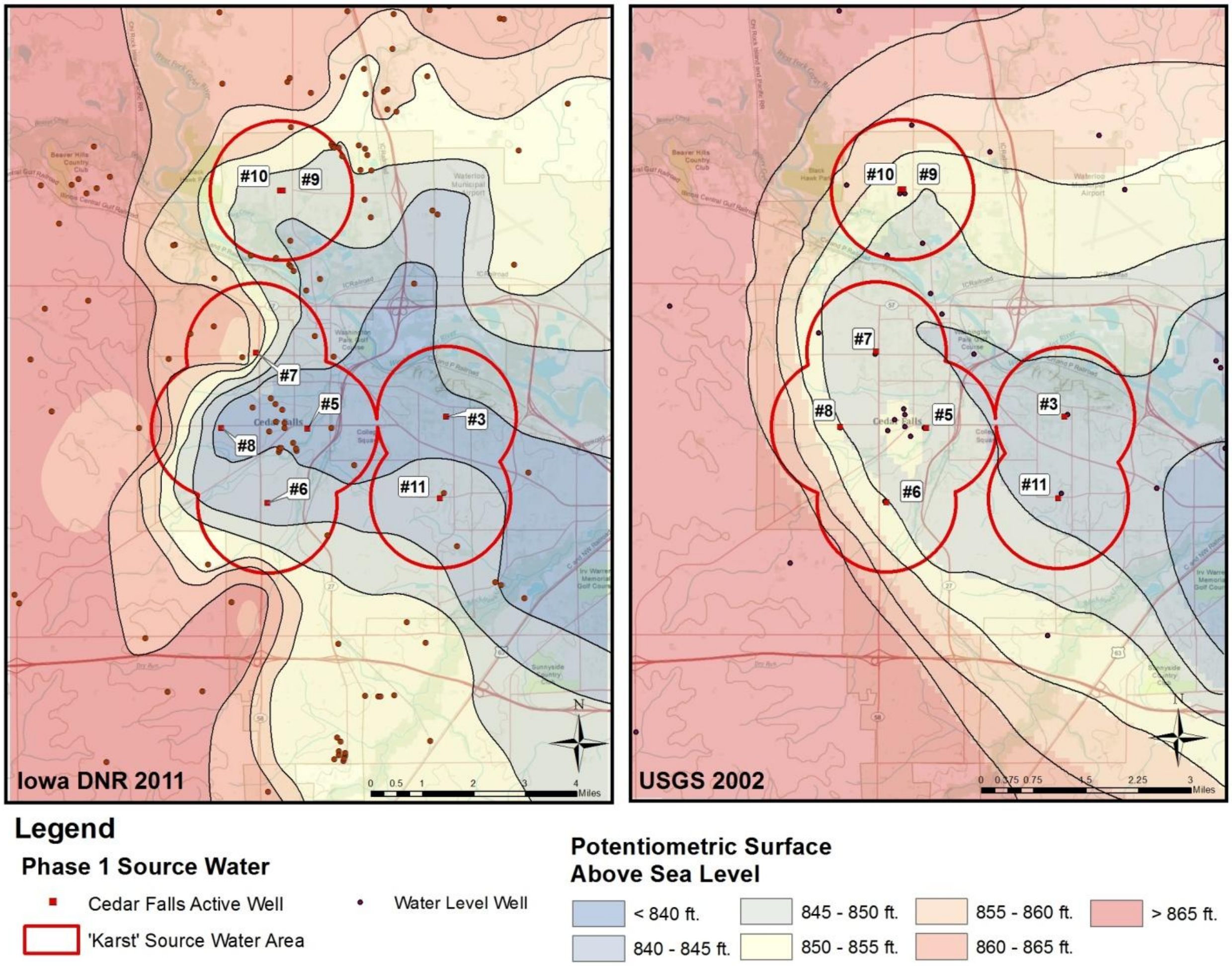

Figure 7. Map indicating the potentiometric surface from USGS 2002 study (Turco, 2002) and Iowa DNR 2011 study. The USGS approach included measuring a subset of distinct wells in the area over a period of time. The 2011 coverage included static water levels taken as the wells were drilled in the area.

Pumping water level and static water level are typically very similar in this region, with pumping well water level drawdown noted to be around only one to two feet per thousand gallons of water production in many wells. Due to the small difference between pumping and non-pumping groundwater elevations, no attempt was made to differentiate pumping and non-pumping water flow directions in the study area.

Figure 7 details the water levels found in the Silurian-Devonian aquifer around Cedar Falls using the two different studies: 1) average water level from the 63 temporal well samples taken for the USGS study, and 2) 119 aggregated water levels taken from GeoSam and PWTS Iowa DNR online databases. In general, the two groundwater elevation and movement results were very similar. Both showed a clearly defined regional trend towards the Cedar River. However, wells 3 and 5 had inconclusive groundwater movement directions from each of the methods, and therefore no established groundwater path. All other wells indicated clear groundwater flow pathways.

When comparing the two methods wells 7, 9 and 10 had some variation in estimated groundwater movement between the two studies. Wells 9 and 10 are in an unconfined setting, and are directly connected to the alluvium and surface conditions of the river and climate. In wells that are unconfined and directly connected to the surface, water level/gradient can change drastically depending on the amount of rainfall, river flow, and freeze/thaw conditions. Water level measurements taken in unconfined aquifers change more significantly over time than in confined aquifer conditions. Despite these variables affecting the groundwater movement, wells 9 and 10 have a groundwater gradient that appears to be typically from the north.

The other difference noted between the two groundwater elevation studies is a noticeable 10 ft. drop in groundwater levels and gradient change in the middle region located between wells 5, 6, 7, and 8 at the University of Northern Iowa. This decrease is most likely not the result of more information, as both studies have numerous wells located in this region. The additional drawdown might be attributed to the high levels of geothermal wells being drilled in the area, or perhaps a gradual decrease from city pumping around this region.

Using static water level measurements from the Silurian-Devonian established decent groundwater elevations and gradient estimates on the majority of the region. Seven out of eight Cedar Falls public wells had conclusive estimates of groundwater movement to the well. Well 3 was the only well that did not have a clear groundwater gradient and flow path for water movement established using these methods.

WATER CHEMISTRY

Three different water analyses (nitrate, tritium, and isotopes of nitrogen and oxygen) were used in an attempt to 'fingerprint' the water from different public wells, as well as private wells and surface water throughout the study area. Nitrate is often found in surface water and younger groundwater. Nitrate is regularly monitored in drinking water wells as a contaminant, and is near ubiquitous in Iowa surface water due to its use in fertilizer and prevalence in human and animal waste (septic systems). Nitrate has been monitored in the Cedar Falls public wells for the past 50 years (Figure 2). The wells with consistently higher concentrations are wells 3, 9, and 10, all three of which average around 7-8 ppm. Wells 5 and 11 have nitrate-N concentrations hovering around 3-4 ppm, wells 6, 7, and 8 all have consistently lower nitrate-N concentrations that are at or near the detection limit of 0.5 ppm. Nitrate levels in wells 3, 9, and 10 indicate a significant connection to near surface water.

Wells 9 and 10 are north of the Cedar River, and drilled through substantial layers of alluvial sand and gravels, with little to no confining layers separating the aquifer from the land's surface. Well 3 is to the south of the river, and has significant (60 ft.) confining layers between the aquifer and land surface. To get a better understanding of nitrate levels with respect to surface water, an intensive two-month sampling regimen was put into place that involved sampling from wells 5, 9, 10, and 3, as well as sampling the Cedar River. This sampling scheme was put in place to detect any river influence on the water chemistry of the wells.

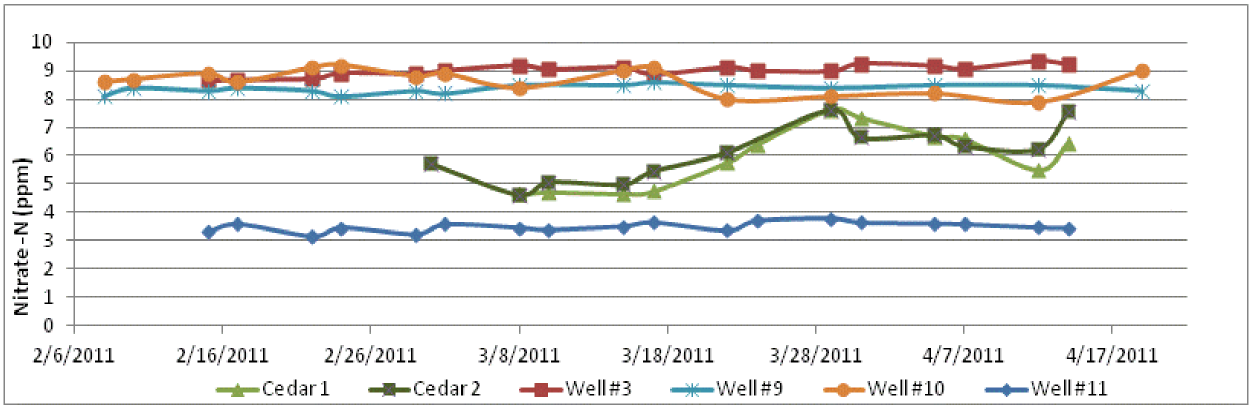

Figure 8. Nitrate-N results from the intensive two-month monitoring period. Monitoring included two stations in the Cedar River, as well as wells #3, #9, #10, and #11.

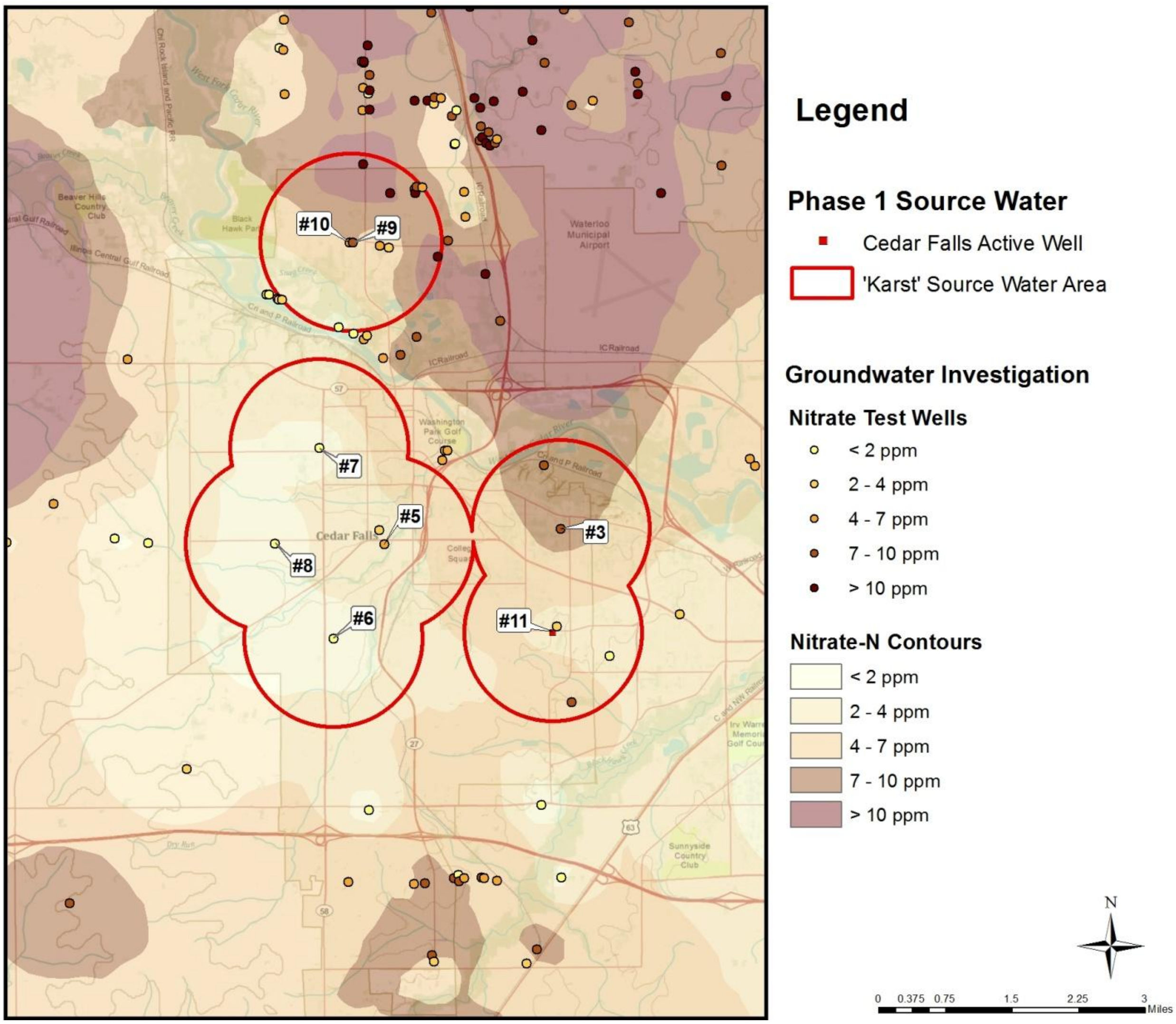

Figure 9. Nitrate-N well and interpolated concentrations from public wells sampled in Cedar Falls and as part of the "Grants to Counties" volunteer sampling program.

Water samples were taken on a bi-weekly basis by Cedar Falls Utilities water operators for all wells, and University of Northern Iowa student Alison Schell. All water samples were analyzed for nitrate-N by a Dionex Ion Chromatograph.

Figure 8 details the intensive nitrate level measurements monitored taken in this study. No groundwater wells used by Cedar Falls indicate a direct surface water influence as indicated by the lack of seasonal response seen in the surface nitrate-N trends reflected in the well nitrate-N trends. Furthermore, nitrate levels in the groundwater were 1-3 ppm higher than in the river water, indicating a source of higher nitrates than the river, as opposed to the nitrates traveling from the river to the wells. Nitrate levels in well 3 did not indicate a river source for water. Wells 9, 10, and 3 all showed similar levels throughout the sampling period, indicating similar chemistry.

In addition to public well required monitoring, nitrate and bacteria are also regularly voluntarily sampled and inventoried though a private well sampling program administered by the state. A subset of these wells was chosen to estimate nitrate-N concentration in the Silurian-Devonian aquifer. Selected well were estimated to be completed in the Silurian-Devonian aquifer through either lithology or well depth, had at least one measured nitrate-N value, and had accurate location information. Results from the wells were then analyzed by IDW and contoured at discreet increments to draw an interpolated concentration map. Wells included in the nitrate-N concentration map are in Appendix C.

Figure 9 shows the interpolated nitrate-N contours and well locations used for the interpolation. In the study area, the highest nitrate-N concentrations are located in the area to the north of the Cedar River. This area is characterized geologically by Cedar River alluvium and thin confining layer thickness separating the Silurian-Devonian aquifer from the land surface. One area not typical of this is a group of wells to the south of Cedar Falls wells 9 and 10. These wells consistently measured low nitrate-N. This could be due to the effects of denitrification commonly found along surface water bodies (McMahon and Bohlke, 1996), or local land use practices reducing the input of nitrogen on the local source water area. Nitrate-N is consistently low or absent in most of the southwestern region of the study area, despite the high percentage of row crop agriculture in the region. This is most likely due to the extensive confining layers protecting the aquifer in the southwest.

Isotopes from both nitrogen and oxygen were analyzed to typify, compare and contrast the different public wells with private wells and locations. Figure 10 shows results from the isotope sampling as well as the sample locations. The results indicate that the source of nitrate in groundwater is not from animal or human waste. The $d^{15}N_{Air}$ results from all of the samples are below $11^{0}/_{00}$, and in the range where fertilizer or soil nitrate, not manure, is expected to be the main contributor (GeoLogics, 2004). Well 5 and well C were the only locations with results high enough to be considered slightly impacted by either septic or manure sources (around $9^{0}/_{00}$). Other sampled wells were within range of each other.

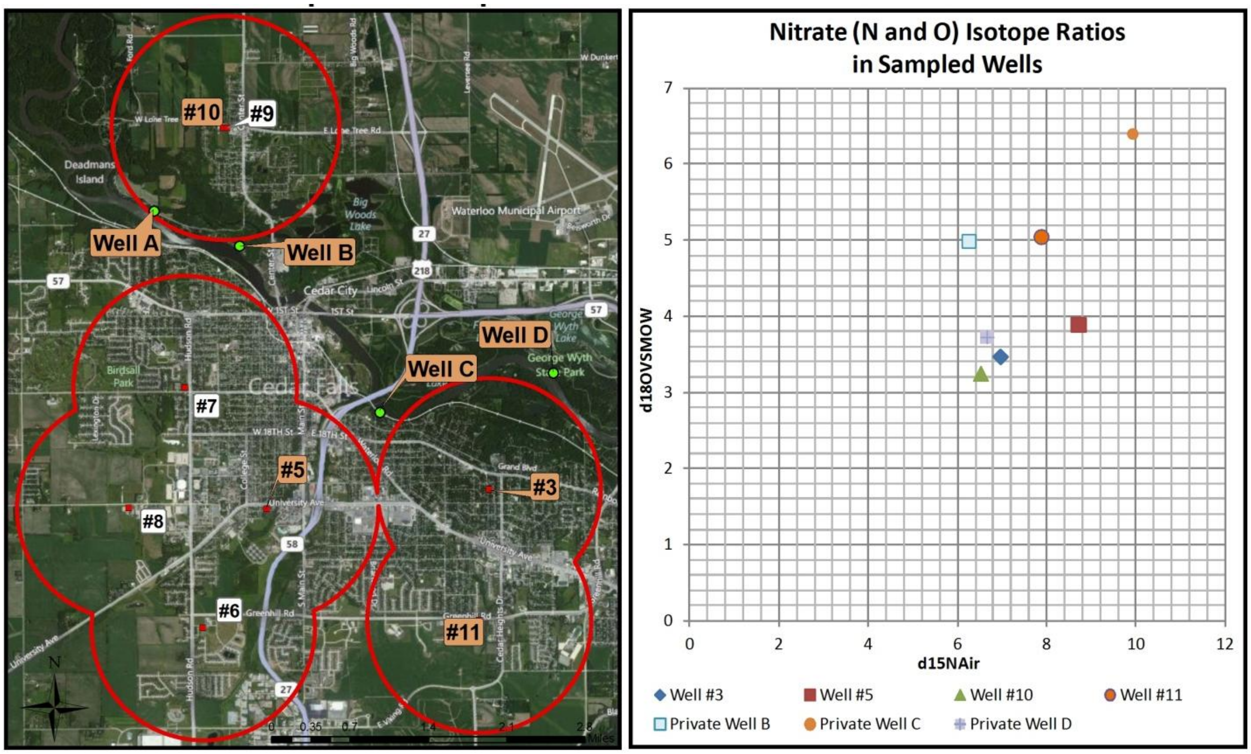

Figure 10. Sample locations and results for Nitrogen and Oxygen Isotopes. Isotopes were measured in four public wells (3, 5, 10, 11), and four private wells (A, B, C, D).

Plotting nitrogen and oxygen isotope composition from all sites indicate isotopically similar traits between wells 3, 10, and well D. All three have between 6-7 $^{0}/_{00}$ d^{15}N, and 3-4$^{0}/_{00}$ d^{18}O (Figure 10; Table 1). Additionally, nitrate levels were similar in all three of these wells at 8-10 ppm (Table 1). This is despite the fact that well D and 10 are located across the Cedar River hydrologic boundary from well 3.

Tritium sampling was also completed on wells 3 and 10 from the city (Figure 10; Table 1). Tritium is a naturally occurring radioactive isotope of hydrogen found in the Earth's atmosphere. Tritium levels in the atmosphere increased greatly after WWII during the cold war as increased levels of nuclear testing occurred. Since testing has stopped however, tritium levels have decreased in the

Table 1. Tritium and nitrate isotope sampling results.

Tritium				
Sample Name	**Run Date**	**Tritium**	**Std. Dev.**	
Well #3	6/1/2011	5.66	0.19	
Well #10	6/1/2011	5.41	0.19	
Nitrate Isotopes				
Sample Name	**Run Date**	**NO3 Conc. (ppm)**	**$d^{15}N_{Air}$ (‰)**	**$d^{18}O_{VSMOW}$ (‰)**
Well 3 3/15/11	7/5/2011	9.23	6.92	3.33
Well 3 4/12/11	7/5/2011	9.51	6.87	3.36
Well 3 5/17/11	7/5/2011	9.49	7.10	3.70
Well 5 5/17/11	7/5/2011	3.79	8.70	3.89
Well 10 5/17/11	7/5/2011	8.32	6.51	3.25
Well 11 3/15/11	7/5/2011	3.57	7.72	5.08
Well 11 4/12/11	7/5/2011	3.54	8.23	4.95
Well 11 5/17/11	7/5/2011	3.60	7.65	5.12
Site A	7/5/2011	0.02	n/a	n/a
Site B	7/5/2011	3.06	6.24	4.99
Site C	7/5/2011	8.98	9.91	6.40
Site D	7/5/2011	9.92	6.66	3.73

environment. This necessitates ‘concentrating’ the tritium sample in order to read the values. Table 1 indicates radioactivity in tritium units (TU) monitored during the study. Both wells indicate younger water (post 1950s), which is to be expected with the area’s lack of geologic confining layers and known higher nitrates. Tritium levels from both wells are also within a standard deviation of each other, indicating very similar water chemistry between the two wells.

Well water nitrate concentrations, tritium levels, and isotope ratios all indicate that wells 3, 9, and 10 share a similar water chemistry signature. This conclusion is reached despite the fact a river lies between the well 3 and wells 9 and 10, and well 3 has a thick confining layer separating the land surface from the bedrock in the region. The similar water chemistry in well 3 with groundwater in wells north of the river lead to evidence supporting a source water area for well 3 that is north of the river, under the alluvium and shallow bedrock of the thin confining layers, as opposed to a source location south of the river near the region of well 5. Although rivers are typically a hydrologic barrier to groundwater movement, open conduits can cross surface hydrologic barriers. Also, water piracy, such as from a high production well, can shift groundwater divides and groundwater recharge zones from one region to another (White, 2002).

CEDAR FALLS VULNERABILITY MAP

Using the results from the Source Water Phase 1 Assessment, local geology, water levels, and water chemistry, a Cedar Falls Source Water groundwater vulnerability map was generated. The use of the word vulnerability should be distinguished from susceptibility. Susceptibility is used within the Iowa Source Water Protection program to denote a capture zone’s risk of contamination through estimated confining layer thickness. The susceptibility ranking is only derived through lithology of geologic layers above the source aquifer. The Cedar Falls Vulnerability Map (Figure 11) incorporates geology, water movement, and chemistry, to delineate the previous 1-mile radius capture zones into separate vulnerability categories.

Delineation of the vulnerability map was determined using the following criteria:

- Bedrock within 50 ft. of the land surface as determined through geophysics, soils coverages, and well records
- Limited (<25 ft.) confining layer thickness between land surface and source aquifer as determined through well records, geophysics, and soil coverages.
- Groundwater movement direction as determined through water levels, and water chemistry (e.g., nitrate, tritium, nitrate isotopes).
- Existing contaminant water chemistry in Cedar Falls public wells.

Additionally, local sinkholes in the area were attempted to be mapped, as sinkholes represent a direct connection between the land surface and source aquifer. No sinkholes were found in the Cedar Falls study area. Known quarry locations and depths were mapped, with none showing up in the study area. Geophysical methods were used in an attempt to locate subsurface channels near wells 9 and 10 in the north part of the study area. Bedrock channel mapping through geophysical methods was inconclusive due to the highly variable and fractured nature of the Devonian bedrock.

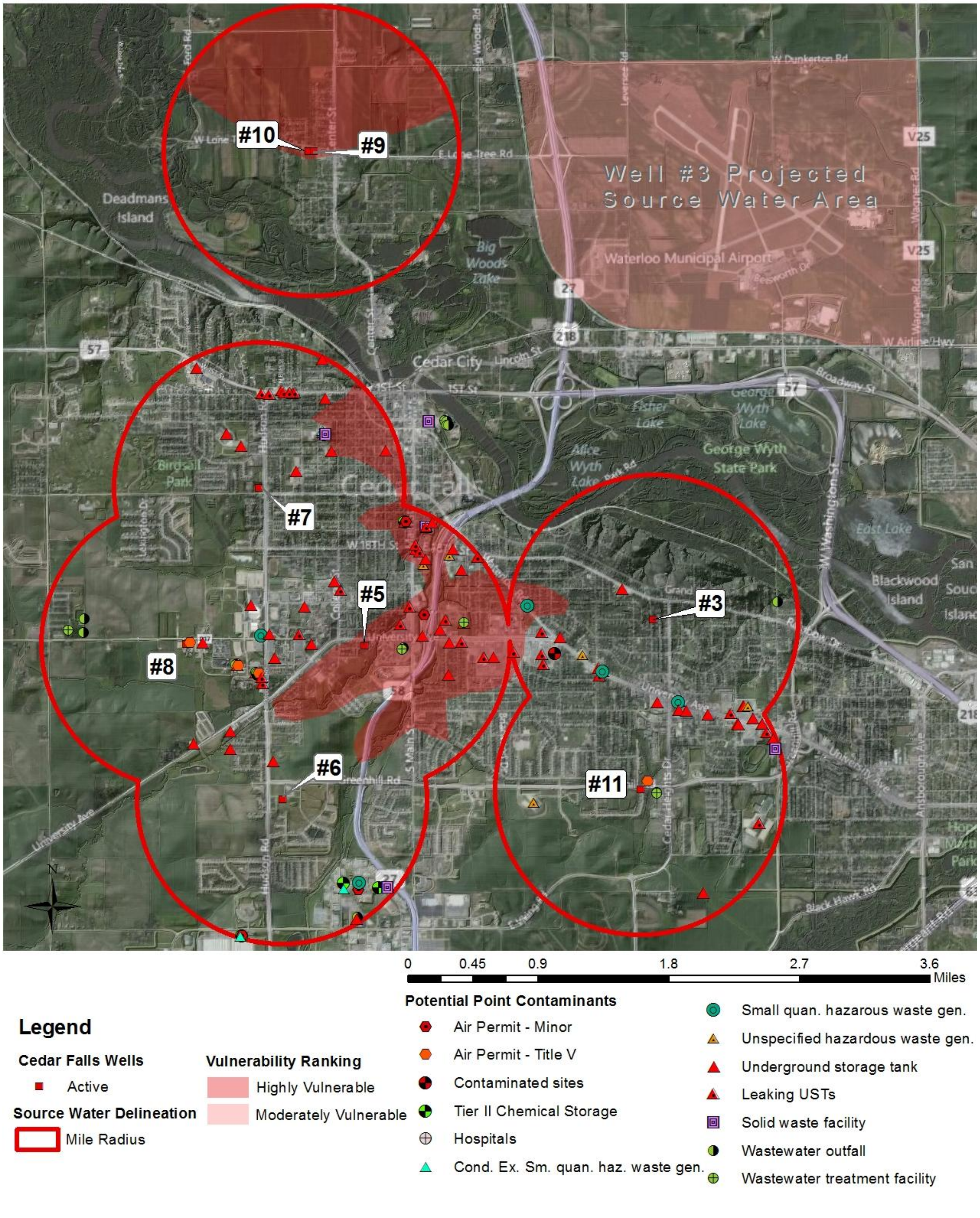

Figure 11. Vulnerability map and revised point contaminant source inventory map for the Cedar Falls study area.

Figure 11 shows the various vulnerability zones for the Cedar Falls region. The highest vulnerability is in areas that have 1) been shown to have little or no confining layers between the aquifer and land surface, either through the bedrock being close to the surface or the limited amount of confining layers between the bedrock and land surface, 2) groundwater direction is assumed to be moving toward the well, and 3) known impacted water chemistry in the public well. Land use changes within these areas have the greatest and most immediate potential to impact the water quality of the Silurian-Devonian aquifer and subsequently the nearby public (and private) wells retrieving water from that aquifer.

The medium vulnerability area is to the north of the Cedar River, and is currently believed to be the recharge area for well 3 based on information from water chemistry data and potentiometric surface maps. Because of uncertainty between these methods this vulnerability area is large. Land use changes within this region have a chance of affecting the water quality in the Silurian-Devonian aquifer, and could also positively affect the water quality in well 3. Further research could be completed to refine and/or change the medium vulnerability area for well 3, including further geophysical earth resistivity for bedrock conduit mapping, intensive static water level measurements from wells in the 1-mile capture zone on both sides of the river, and time series water level measurements coinciding with Cedar River stream measurements.

The low vulnerability area generally has good protection of the aquifer from the land surface, such as thick confining layers), no impacted groundwater moving toward a well, and therefore has less need of land use changes to affect water quality. These areas still should be addressed, however minimum the effort should be. Abandoned or improperly constructed wells often serve as conduits for contaminant migration to otherwise well protected aquifers. Keeping a proper inventory of wells drilled in the area, along with construction specifications can often help if or when a contaminant issue does arise.

POTENTIAL POINT SOURCE CONTAMINANTS

As part of this study, all potential point sources noted in the Source Water Phase 1 report were checked for proper location. Figure 11 shows the potential point sources mapped in the Cedar Falls Groundwater Investigation. Out of a total 115 potential point source contaminants—69 were significantly different from the location mapped in the existing Source Water Phase 1 Assessment and associated database. All of the improperly located potential contaminant sources were moved to a more accurate location through GPS.

Appendix D lists the location and type of potential contaminant sources reviewed in this study. As a result of the location edits to the changes, six potential contaminant sites now plot outside the capture zone. Four are classified as wastewater outfall, one as a wastewater treatment facility, and one as a solid waste facility.

Potential point contaminant sources listed in the Source Water Phase 1 Assessment include commonly known groundwater contaminants such as leaking underground gas storage tanks, wastewater treatment outfalls, and hazardous waste generators. However, many potential contaminants are unique to each community. This list changes for each community, but the list often includes above ground storage tanks, old business and old agricultural chemical facilities such as local cooperatives. Therefore the listing addressed in this report needs to be more fully extended and edited to fully reflect the potential contaminants in the area.

CONCLUSIONS

The Cedar Falls Groundwater Investigation completed an inventory of available research and data resources, with additional data through geophysical methods and water chemistry to better define the source water areas for the city's eight wells. A total of 277 wells were used to better define the depth to the Silurian-Devonian bedrock aquifer used as the main source of drinking water. LiDAR high resolution elevation data were used to better define the well elevation, and subsequent layer elevation beneath the surface. Additional two dimensional data on the extent of the aquifer was gathered through four geophysical methods transects north of wells 9 and 10 on Fitkin Road. A total of 119 wells were also employed for defining the water levels and water movement through the aquifer. Data from previous U.S. Geological Survey reports and models were utilized for comparison purposes. Water chemistry results were analyzed for nitrate-N trends through time, tritium levels in wells, and nitrogen and oxygen isotope levels. Nitrate-N sample results were averaged and plotted from 147 local wells to define areas of high nitrate concentrations near Cedar Falls.

Results from all of the gathered information were analyzed to create a vulnerability map for the city. The vulnerability map is the best estimate of where land use changes and conservation practices have the best chance of impacting the water chemistry due to the aquifer's direct connection to the land surface. Well 3 was shown to have a capture zone on the north side of the Cedar River through isotope analysis, and a rough area of recharge was delineated as a vulnerability zone.

Additionally, 115 potential point source contaminants were field-located within the Phase 1 source water capture zone. A total of 69 of the 115 were moved due to a significant change in location. These potential point source contaminants will be ranked and prioritized, along with nonpoint source contaminants when a Source Water Planning process is completed for the city.

Due to the research done in the Cedar Falls Source Water Groundwater Investigation, additional research will be conducted for the U.S. Geological Survey STATEMAP program. Geologists from the Iowa Geological and Water Survey will be conducting field work and data collection that might be utilized to help even further refine the geology, hydrogeology, and subsequently the vulnerability map.

The research done in this Groundwater Investigation is intended to help the city of Cedar Falls have a more manageable Source Water Protection Area. This in turn should focus more time and resources where land use change will be the most cost-effective. The city is strongly encouraged to take the results from this study and incorporate them into a Source Water Protection Plan. Assistance is also available though the Source Water Protection Guidebook and Workbook, available free of charge at www.iowasourcewater.org. Additional staff assistance is also provided to willing communities through the program.

REFERENCES

Canter, L.W., 1997, *Nitrates in Groundwater.* CRC Press, 263p.

GeoLogics Corporation, 2004, Nitrogen Source Tracking, Workshop Review Draft, 18p.

Hallberg, G.R. and Hoyer, B.E., 1982, Sinkholes, hydrogeology and groundwater quality in northeast Iowa: Iowa Department of Natural Resources Geological Survey Bureau, Open File Report 82-3, 120p.

Hallberg, G.R., Kross, B.C., Libra, R.D., Burmeister, L.F., Weih, L.M.B., Lynch, C.F., Bruner, D.R., Lewis, M.Q., Cherryholmes, K.L., Johnson, J.K., and Culp, M.A., 1990, The Iowa state-wide rural well-water survey: design report: a systematic sample of domestic drinking water quality: Iowa Department of Natural Resources, Technical Information Series 17, 135p.

Horick, P.J., 1984, Silurian-Devonian Aquifer of Iowa, Miscellaneous Map Series 10, 4p.

Iowa Department of Natural Resources, 2009, Source Water Report for Cedar Falls Iowa: Iowa Department of Natural Resources Geological Survey Bureau 10p.

McMahon, P.B., and Bohlke, J.K., 1996, Denitrification and mixing in a stream--aquifer system: effects on nitrate loading to surface water: Journal of hydrology: 186: 105-108.

Prior, J.C., Boekhoff, J.L., Howes, M.R., Libra, R.D., and VanDorpe, P.E., 2003, *Iowa's Groundwater Basics*, Iowa Department of Natural Resources, 83p.

Prior, J.C., 1991, *Landforms of Iowa*. University of Iowa Press, 154p.

Turco, M.J., 2002, Simulation of Ground-Water Flow in the Silurian-Devonian Aquifer, Cedar Falls, Iowa: U.S. Geological Survey, Water-Resources Investigations Report 02-4081, 33p.

White, W.B., 2002, Karst hydrology: recent developments and open questions: Engineering Geology 65: 85-105.

Witzke, B.J., Anderson, R.R. and Pope, J.P., 2010, Bedrock Geologic Map of Iowa: Iowa Department of Natural Resources Geological Survey Bureau, Map 22.

APPENDIX A

Wells used for Bedrock measurements.

Well ID	Well Source	Well Depth (ft)	Drill Date	Depth to bedrock (ft)	Bedrock (ft above sea level)
43766	IGS well database	140	4/30/1997	112	778
27589	IGS well database	257	6/26/1985	116	801
29494	IGS well database	112	11/7/1988	84	784
30117	IGS well database	110	6/3/1989	80	790
42876	IGS well database	120	2/24/1997	76	891
42874	IGS well database	140	2/26/1997	125	731
56729	IGS well database	144	9/18/2002	125	743
53545	IGS well database	226	3/1/2001	189	821
41529	IGS well database	165	10/17/1996	128	730
32780	IGS well database	140	9/23/1991	116	750
29703	IGS well database	95	7/8/1988	44	823
56723	IGS well database	118	11/22/2002	80	849
51043	IGS well database	116	10/20/1999	47	805
2717	IGS well database	60	12/28/1946	41	826
2079671	Private well tracking system	126	6/7/2002	62	810
10605	IGS well database	150	1/1/1958	115	758
28290	IGS well database	130	4/3/1987	110	768
54573	IGS well database	135	8/2/2001	96	828
46616	IGS well database	205	9/9/1998	184	821
48484	IGS well database	156	2/5/1999	109	831
30119	IGS well database	120	6/20/1989	100	762
2107288	Private well tracking system	126	3/21/2005	19	876
39817	IGS well database	130	10/11/1996	114	742
57113	IGS well database	70	11/26/2002	53	844
51676	IGS well database	125	8/13/1999	115	743
29875	IGS well database	149	1/7/1987	144	788
29644	IGS well database	103	10/6/1988	101	772
48190	IGS well database	145	11/20/1998	115	740
41523	IGS well database	120	12/6/1996	96	775
8459	IGS well database	117	8/9/1968	95	786
51044	IGS well database	152	10/26/1999	111	854
29088	IGS well database	172	10/28/1985	88	892
36121	IGS well database	340	4/10/1995	157	827
25726	IGS well database	315	1/14/1980	45	902
35858	IGS well database	160	3/2/1995	120	839
64786	IGS well database	145	2/27/2008	91	820

22760	IGS well database	160	5/9/1968	115	860
46220	IGS well database	120	4/30/1998	84	825
50711	IGS well database	116	9/23/1999	65	794
18712	IGS well database	195	7/21/1966	90	837
48475	IGS well database	120	1/15/1999	105	760
57496	IGS well database	170	5/30/2003	69	871
33495	IGS well database	175	7/8/1992	138	802
2103145	Private well tracking system	99	12/3/2004	75	815
46222	IGS well database	140	5/1/1998	109	800
53164	IGS well database	140	10/24/2000	106	771
51045	IGS well database	164	10/22/1999	75	904
35104	IGS well database	120	5/25/1994	74	824
7447	IGS well database	278	7/20/1955	145	786
29884	IGS well database	130	9/19/1985	114	742
25352	IGS well database	105	5/12/1978	73	829
29730	IGS well database	125	4/9/1985	107	772
2111705	Private well tracking system	125	8/19/2005	22	847
2139489	Private well tracking system	80	11/15/2008	43	807
56158	IGS well database	86	7/9/2002	65	817
54139	IGS well database	120	6/5/2001	82	776
39810	IGS well database	140	10/1/1996	68	808
29645	IGS well database	133	10/3/1988	100	877
37334	IGS well database	140	9/22/1995	77	825
60783	IGS well database	138	8/5/2005	98	770
32342	IGS well database	144	5/18/1989	102	818
52316	IGS well database	116	7/7/2000	13	858
2122236	Private well tracking system	175	9/28/2006	117	835
2134740	Private well tracking system	83	5/23/2008	82	797
29627	IGS well database	104	2/16/1989	95	780
17624	IGS well database	158	4/3/1965	113	803
57885	IGS well database	196	9/8/2003	125	784
44418	IGS well database	120	7/9/1997	98	818
29725	IGS well database	208	6/9/1988	191	819
55098	IGS well database	215	11/30/2001	117	832
30118	IGS well database	115	6/13/1989	90	784
57712	IGS well database	160	8/7/2003	121	814
44557	IGS well database	140	9/27/1997	112	820
50714	IGS well database	136	9/10/1999	13	882
39156	IGS well database	90	7/18/1996	73	849
33496	IGS well database	135	8/14/1992	94	806
29606	IGS well database	195	8/29/1988	115	852
53181	IGS well database	255	11/15/2000	171	826
48135	IGS well database	173	9/19/1997	65	882

33494	IGS well database	155	7/9/1992	126	822
29726	IGS well database	119	7/7/1986	44	824
66767	IGS well database	100	4/23/2009	46	843
34496	IGS well database	140	3/16/1994	100	762
32783	IGS well database	120	1/7/1992	26	847
50715	IGS well database	135	9/9/1999	87	872
43831	IGS well database	140	6/2/1997	108	812
29886	IGS well database	180	5/24/1985	35	852
34454	IGS well database	120	12/8/1993	70	797
35180	IGS well database	140	7/30/1994	71	861
46224	IGS well database	250	4/14/1998	93	883
60456	IGS well database	125	5/23/2005	100	762
25058	IGS well database	222	5/1/1974	120	821
57573	IGS well database	96	6/24/2003	60	814
33497	IGS well database	150	8/12/1992	116	813
57698	IGS well database	136	7/11/2003	21	871
57263	IGS well database	130	3/24/2003	115	755
60153	IGS well database	141	3/17/2005	42	817
57105	IGS well database	150	12/20/2002	25	875
18306	IGS well database	148	1/1/1966	110	739
2086369	Private well tracking system	105	7/19/2000	76	799
52853	IGS well database	170	8/4/2000	123	805
2089640	Private well tracking system	200	4/17/1997	105	843
16167	IGS well database	135	8/1/1962	115	816
43768	IGS well database	180	4/16/1997	95	845
11272	IGS well database	281	8/1/1959	162	770
46291	IGS well database	140	7/6/1998	103	770
2103095	Private well tracking system	136	8/26/2004	97	824
17884	IGS well database	150	7/1/1965	85	826
2131066	Private well tracking system	187	3/14/2008	123	792
58588	IGS well database	80	1/12/2004	40	831
56442	IGS well database	70	8/26/2002	13	866
19622	IGS well database	170	6/1/1967	71	862
28499	IGS well database	210	1/26/1982	80	847
57743	IGS well database	135	8/14/2003	20	870
2123944	Private well tracking system	145	12/18/2006	97	771
2139241	Private well tracking system	186	10/1/2008	112	866
37620	IGS well database	220	1/1/1971	100	840
14446	IGS well database	128	4/15/1963	90	782
32724	IGS well database	200	8/27/1991	105	795
11653	IGS well database	160	7/3/1959	70	846
2093342	Private well tracking system	100	8/12/2003	64	824
58705	IGS well database	118	11/22/2002	80	852

5781	IGS well database	77	10/9/1951	75	792
2089313	Private well tracking system	85	6/3/1993	60	811
18612	IGS well database	205	7/11/1966	82	847
61360	IGS well database	130	1/16/2006	98	768
30061	IGS well database	125	2/8/1945	83	837
2112050	Private well tracking system	159	7/29/2005	32	852
2146481	Private well tracking system	324	7/1/2010	121	832
4216	IGS well database	175	8/27/1949	39	818
2084080	Private well tracking system	144	9/15/2002	80	831
2139716	Private well tracking system	116	2/27/1987	115	752
22188	IGS well database	168	8/20/1968	117	856
18273	IGS well database	80	7/8/1965	75	783
37622	IGS well database	275	1/1/1975	90	785
37621	IGS well database	275	1/1/1975	90	785
73475	IGS well database	96	4/4/2011	67	793
17610	IGS well database	175	6/1/1965	70	858
35857	IGS well database	200	3/6/1995	13	843
2107300	Private well tracking system	141	3/17/2005	42	818
2148916	Private well tracking system	120	7/28/2010	37	850
52638	IGS well database	120	7/28/2010	37	850
67798	IGS well database	212	7/14/2009	29	846
18103	IGS well database	120	9/1/1965	105	832
67822	IGS well database	160	9/16/2009	124	821
4413	IGS well database	125	1/7/1950	54	808
8694	IGS well database	218	8/19/1957	125	807
38482	IGS well database	250	4/2/1971	85	769
2116344	Private well tracking system	125	3/20/2006	92	779
29867	IGS well database	153	6/17/1988	137	802
17632	IGS well database	145	5/1/1965	102	867
16320	IGS well database	170	1/1/1963	110	852
26594	IGS well database	200	8/20/1980	65	865
34037	IGS well database	147	8/18/1942	142	816
2115714	Private well tracking system	200	2/15/2006	70	849
2086257	Private well tracking system	235	1/27/1999	159	801
38591	IGS well database	112	12/16/1975	42	819
32324	IGS well database	167	7/24/1990	156	830
41250	IGS well database	110	2/24/1972	40	810
33500	IGS well database	196	6/10/1992	107	827
30120	IGS well database	195	6/10/1989	61	836
52637	IGS well database	120	7/23/2010	36	853
19443	IGS well database	123	2/24/1967	80	786
34159	IGS well database	177	6/25/1993	138	835
33594	IGS well database	178	2/24/1993	36	849

9401	IGS well database	55	1/1/1957	40	864
2081580	Private well tracking system	80	8/19/2002	14	864
37618	IGS well database	145	5/5/1961	30	847
2103297	Private well tracking system	145	9/12/2004	75	855
9405	IGS well database	105	1/1/1957	30	847
49944	IGS well database	175	8/27/1949	39	819
49946	IGS well database	200	12/1/1961	45	813
49945	IGS well database	150	11/3/1956	25	829
2144033	Private well tracking system	212	7/30/2009	25	851
6618	IGS well database	130	1/1/1953	105	838
8675	IGS well database	205	4/24/1957	165	797
5004	IGS well database	200	5/17/1951	162	801
2153248	Private well tracking system	140	4/1/2011	88	777
65662	IGS well database	150		103	804
19068	IGS well database	215	10/17/1966	160	772
51042	IGS well database	180	8/12/1999	128	745
65470	IGS well database	95	8/12/2008	49	821
34039	IGS well database	142		127	804
8641	IGS well database	204	5/7/1957	100	754
23780	IGS well database	170	10/26/1970	125	750
22673	IGS well database	155	9/8/1970	115	843
2664	IGS well database	157	5/6/1946	83	856
28201	IGS well database	161	8/24/1987	60	803
6940	IGS well database	140	1/1/1954	135	795
38513	IGS well database	200	10/17/1975	92	846
20805	IGS well database	191	7/24/1968	60	831
33501	IGS well database	200	6/25/1992	69	834
38516	IGS well database	194	7/26/1985	76	836
2121273	Private well tracking system	135	9/5/2006	120	744
20806	IGS well database	165	6/17/1968	55	850
2148915	Private well tracking system	120	7/23/2010	36	853
9207	IGS well database	113	4/19/1957	85	838
72706	IGS well database	167	5/16/2007	70	839
38498	IGS well database	228	10/28/1968	156	809
72704	IGS well database	160	5/9/2007	55	855
2125946	Private well tracking system	160	5/16/2007	55	852
44558	IGS well database	140	9/29/1997	112	804
25278	IGS well database	275	9/11/1975	180	734
29727	IGS well database	135	5/20/1986	110	753
25271	IGS well database	275	7/18/1975	178	733
22549	IGS well database	215	5/3/1970	150	760
11888	IGS well database	140	10/30/1959	50	835
38499	IGS well database	160	9/30/1974	46	827

30057	IGS well database	206	1/22/1942	152	764
12674	IGS well database	147	1/1/1960	120	791
2100121	Private well tracking system	195	6/8/2004	117	879
8576	IGS well database	235	4/10/1957	160	837
2124806	Private well tracking system	145	12/1/2006	97	770
2111498	Private well tracking system	200	10/17/1975	92	843
66011	IGS well database	190	8/20/2008	28	822
2077758	Private well tracking system	110	3/26/2002	90	779
31203	IGS well database	200		83	820
21058	IGS well database	195	8/20/1968	95	837
37619	IGS well database	227	1/1/1967	127	831
2114332	Private well tracking system	180	11/14/2005	31	846
4019	IGS well database	125	9/30/1949	35	821
1923	IGS well database	141	10/3/1944	90	850
64787	IGS well database	150	2/29/2008	81	839
29728	IGS well database	135	9/20/1986	112	751
52219	IGS well database	195	7/14/2000	178	752
58570	IGS well database	95	2/24/2004	58	810
8185	IGS well database	162	1/1/1956	138	765

APPENDIX B

Wells used for Silurian-Devonian groundwater elevation measurements.

Well ID	Well Source	Well Depth (ft)	Drill Date	Static Water Level (ft below surface)	Static Water Level (ft above sea level)
48484	IGS well database	156	2/5/1999	65	875
32780	IGS well database	140	9/23/1991	14	852
50715	IGS well database	135	9/9/1999	60	899
2116344	Private well tracking system	125	3/20/2006	0	871
35858	IGS well database	160	3/2/1995	83	876
33496	IGS well database	135	8/14/1992	40	860
33497	IGS well database	150	8/12/1992	65	864
33494	IGS well database	155	7/9/1992	79	869
33495	IGS well database	175	7/8/1992	75	865
29088	IGS well database	172	10/28/1985	110	870
35104	IGS well database	120	5/25/1994	35	865
2100121	Private well tracking system	195	6/8/2004	115	881
17632	IGS well database	145	5/1/1965	98	871
39156	IGS well database	90	7/18/1996	62	860
56723	IGS well database	118	11/22/2002	75	854
46616	IGS well database	205	9/9/1998	136	869
2089313	Private well tracking system	85	6/3/1993	10	861
58705	IGS well database	118	11/22/2002	75	857
35180	IGS well database	140	7/30/1994	55	877
39810	IGS well database	140	10/1/1996	20	856
53164	IGS well database	140	10/24/2000	10	867
51044	IGS well database	152	10/26/1999	105	860
26594	IGS well database	200	8/20/1980	71	859
46224	IGS well database	250	4/14/1998	118	858
46291	IGS well database	140	7/6/1998	12	861
48190	IGS well database	145	11/20/1998	10	845
51676	IGS well database	125	8/13/1999	5	853
50711	IGS well database	116	9/23/1999	11	848
39817	IGS well database	130	10/11/1996	15	841
2134740	Private well tracking system	83	5/23/2008	12	867
51045	IGS well database	164	10/22/1999	96	862
52316	IGS well database	116	7/7/2000	7	864
36121	IGS well database	340	4/10/1995	120	864
2086369	Private well tracking system	105	7/19/2000	20	855
34496	IGS well database	140	3/16/1994	6	856
2124806	Private well tracking system	145	12/1/2006	30	836

60783	IGS well database	138	8/5/2005	14	854
73475	IGS well database	96	4/4/2011	10	850
48475	IGS well database	120	1/15/1999	10	855
60456	IGS well database	125	5/23/2005	10	852
30119	IGS well database	120	6/20/1989	20	842
57263	IGS well database	130	3/24/2003	24	846
2115714	Private well tracking system	200	2/15/2006	78	841
2111705	Private well tracking system	125	8/19/2005	20	849
48135	IGS well database	173	9/19/1997	90	857
58588	IGS well database	80	1/12/2004	18	853
35857	IGS well database	200	3/6/1995	12	844
2086257	Private well tracking system	235	1/27/1999	108	852
20805	IGS well database	191	7/24/1968	50	841
32324	IGS well database	167	7/24/1990	117	869
33501	IGS well database	200	6/25/1992	67	836
2107300	Private well tracking system	141	3/17/2005	14	846
2077758	Private well tracking system	110	3/26/2002	19	850
38516	IGS well database	194	7/26/1985	75	837
18712	IGS well database	195	7/21/1966	80	847
57743	IGS well database	135	8/14/2003	30	860
31203	IGS well database	200		89	814
33500	IGS well database	196	6/10/1992	95	839
56729	IGS well database	144	9/18/2002	22	846
34454	IGS well database	120	12/8/1993	12	857
57105	IGS well database	150	12/20/2002	45	855
2121273	Private well tracking system	135	9/5/2006	16	848
57698	IGS well database	136	7/11/2003	40	852
2112050	Private well tracking system	159	7/29/2005	42	842
61360	IGS well database	130	1/16/2006	20	846
30120	IGS well database	195	6/10/1989	76	821
2107288	Private well tracking system	126	3/21/2005	40	855
2148916	Private well tracking system	120	7/28/2010	44	843
52637	IGS well database	120	7/23/2010	42.25	847
2148915	Private well tracking system	120	7/23/2010	42	847
52638	IGS well database	120	7/28/2010	44	845
30117	IGS well database	110	6/3/1989	30	840
57496	IGS well database	170	5/30/2003	75	865
50714	IGS well database	136	9/10/1999	31	864
2146481	Private well tracking system	324	7/1/2010	70	883
42874	IGS well database	140	2/26/1997	20	836
34159	IGS well database	177	6/25/1993	103	870
33594	IGS well database	178	2/24/1993	45	840
2081580	Private well tracking system	80	8/19/2002	44	834

2139241	Private well tracking system	186	10/1/2008	96	882
56442	IGS well database	70	8/26/2002	42	837
2103297	Private well tracking system	145	9/12/2004	65	850
32783	IGS well database	120	1/7/1992	31	844
2114332	Private well tracking system	180	11/14/2005	37	840
30118	IGS well database	115	6/13/1989	30	844
2089640	Private well tracking system	200	4/17/1997	85	863
57885	IGS well database	196	9/8/2003	58	851
55098	IGS well database	215	11/30/2001	100	849
72706	IGS well database	167	5/16/2007	70	839
43768	IGS well database	180	4/16/1997	80	860
2103145	Private well tracking system	99	12/3/2004	46	844
2122236	Private well tracking system	175	9/28/2006	88	864
37334	IGS well database	140	9/22/1995	48	854
54573	IGS well database	135	8/2/2001	68	856
42876	IGS well database	120	2/24/1997	75	892
44557	IGS well database	140	9/27/1997	80	852
44418	IGS well database	120	7/9/1997	64	852
2153248	Private well tracking system	140	4/1/2011	11	854
44558	IGS well database	140	9/29/1997	80	836
2093342	Private well tracking system	100	8/12/2003	35	853
2103095	Private well tracking system	136	8/26/2004	77	844
46222	IGS well database	140	5/1/1998	72	836
2084080	Private well tracking system	144	9/15/2002	60	851
57113	IGS well database	70	11/26/2002	28	869
56158	IGS well database	86	7/9/2002	45	837
46220	IGS well database	120	4/30/1998	55	854
32724	IGS well database	200	8/27/1991	56	844
2079671	Private well tracking system	126	6/7/2002	20	852
52219	IGS well database	195	7/14/2000	80	850
57573	IGS well database	96	6/24/2003	20	854
53545	IGS well database	226	3/1/2001	144	866
11888	IGS well database	140	10/30/1959	40	845
51042	IGS well database	180	8/12/1999	10	863
2139489	Private well tracking system	80	11/15/2008	13	837
58570	IGS well database	95	2/24/2004	14	854
34039	IGS well database	142		93	838
51043	IGS well database	116	10/20/1999	11	841
41529	IGS well database	165	10/17/1996	22	836
64788	IGS well database	250	<Null>	143	872

APPENDIX C

Well Nitrate Samples in the Silurian-Devonian aquifer.

OBJECTID	Well ID Match (GeoSam)	Samples Taken	Estimated Depth (ft)	Average Nitrate-N (ppm)
1	unknown	1	150	15.4
2	unknown	1	180	4.7
3	unknown	1	170	8.8
4	unknown	1	140	1.7
5	unknown	1	100	2.0
6	unknown	1	60	3.1
7	unknown	1	65	1.3
8	37620	20	220	0.6
9	unknown	1	60	5.0
10	unknown	1	77	2.3
11	unknown	1	120	1.6
12	unknown	1	60	2.7
13	unknown	1	130	4.8
14	unknown	1	120	4.8
15	unknown	1	150	4.5
16	unknown	1	125	19.3
17	19622	20	170	0.4
18	37619	21	227	0.4
19	unknown	1	160	0.3
20	unknown	1	100	13.2
21	unknown	1	99	5.2
22	37622	73	275	6.6
23	37621	90	275	7.6
24	unknown	1	80	1.8
25	unknown	1	100	13.0
26	unknown	1	125	9.8
27	unknown	1	100	6.5
28	60170	1	90	12.2
29	unknown	1	90	11.8
30	unknown	1	87	4.9
31	unknown	1	80	10.3
32	unknown	1	100	6.5
33	unknown	1	100	11.4
34	unknown	1	90	4.0
35	unknown	1	80	16.5
36	unknown	1	120	11.7

37	unknown	1	120	1.2
38	38498	1	190	0.6
39	unknown	1	125	7.2
40	unknown	1	101	10.3
41	unknown	1	100	11.8
42	9401	2	202	3.4
43	unknown	1	90	5.6
44	37618	28	141	4.0
45	37618	1	136	4.0
46	unknown	1	120	13.3
47	unknown	1	180	3.0
48	60769	1	88	10.8
49	60153	1	141	9.6
50	unknown	1	120	5.7
51	unknown	1	145	8.8
52	unknown	1	120	10.2
53	60783	1	138	10.3
54	63808	1	145	9.1
55	60456	1	125	5.5
56	unknown	1	120	9.8
57	unknown	1	105	10.4
58	unknown	1	120	12.2
59	unknown	1	100	12.1
60	unknown	1	120	9.3
61	unknown	1	144	9.2
62	unknown	1	125	2.4
63	57113	1	70	2.5
64	unknown	1	80	7.8
65	unknown	1	65	12.2
66	unknown	1	100	11.0
67	unknown	1	105	6.8
68	49946	2	145	4.8
69	4216	3	175	5.1
70	4019	5	143	5.9
71	unknown	1	140	7.6
72	unknown	1	132	9.8
73	unknown	1	80	5.4
74	unknown	1	100	1.9
75	unknown	1	125	0.6
76	unknown	1	200	1.0
77	59330	1	136	9.6
78	unknown	1	100	6.5
79	unknown	1	150	4.8

80	62782	1	135	4.7
81	unknown	1	92	11.5
82	unknown	1	140	13.2
83	unknown	1	90	8.3
84	unknown	1	75	12.0
85	unknown	1	100	8.6
86	unknown	1	100	13.6
87	unknown	1	80	8.1
88	unknown	1	100	10.4
89	unknown	1	100	5.0
90	unknown	1	125	10.7
91	57743	1	135	10.3
92	unknown	1	131	12.8
93	unknown	1	110	9.9
94	unknown	1	100	10.4
95	unknown	1	147	12.7
96	unknown	1	173	14.2
97	unknown	1	60	11.9
98	60183	1	126	8.9
99	unknown	1	110	13.6
100	unknown	1	100	16.7
101	57573	1	96	4.1
102	unknown	1	100	13.4
103	unknown	1	100	12.2
104	unknown	1	72	6.9
105	unknown	1	110	12.8
106	57698	1	136	12.4
107	unknown	1	100	15.0
108	unknown	1	100	11.8
109	unknown	1	75	3.7
110	unknown	1	90	11.7
111	unknown	1	90	9.9
112	unknown	1	100	13.9
113	unknown	1	120	13.6
114	unknown	1	100	13.9
115	unknown	1	120	11.4
116	43048	3	225	0.1
117	unknown	1	120	13.7
118	unknown	1	100	8.8
119	unknown	1	125	14.4
120	unknown	1	110	9.8
121	unknown	1	100	16.6
122	32724	24	200	3.6

123	8694	65	218	8.0
124	unknown	1	100	1.1
125	unknown	1	160	7.1
126	unknown	1	150	5.3
127	unknown	1	200	10.0
128	unknown	1	120	10.3
129	13835	1	205	2.5
130	unknown	1	140	8.8
131	unknown	1	126	9.2
132	unknown	1	110	11.3
133	8641	1	204	5.0
134	43045	1	191	5.7
135	unknown	1	60	20.0
136	unknown	1	100	9.9
137	unknown	1	100	10.2
138	unknown	1	100	1.8
139	unknown	1	100	7.3
140	unknown	1	100	6.1
141	unknown	1	126	7.4
142	unknown	1	110	11.0
143	unknown	1	120	9.5
144	unknown	1	70	9.8
145	unknown	1	60	14.0
146	unknown	1	128	5.3
147	unknown	1	136	2.5

APPENDIX D

Potential Point Source Contaminant Inventory.

Program ID	Site Type	Facility Name	Location
709600	Wastewater treatment facility	Cedar Falls Mobile Home Village	3825 West 27th Street
709600	Wastewater treatment facility	Cedar Falls Mobile Home Village	3825 West 27th Street
709600	Wastewater outfall	Cedar Falls Mobile Home Village	3825 West 27th Street
709600	Wastewater outfall	Cedar Falls Mobile Home Village	3825 West 27th Street
709600	Wastewater outfall	Cedar Falls Mobile Home Village	3825 West 27th Street
709600	Wastewater outfall	Cedar Falls Mobile Home Village	3825 West 27th Street
200000002	Underground storage tank	Thunderidge Ampride	2425 Whitetail Dr
198605648	Underground storage tank	Cedar Falls Comm. Schools	505 Holmes Dr
198605646	Underground storage tank	Cedar Falls Comm. Schools	616 Holmes Dr
8LTN02	Leaking USTs	First Street Amoco	1704 W 1st
7LTW44	Leaking USTs	Fisca Oil Co Inc	1612 West 1st
8LTQ34	Leaking USTs	Schuerman's Auto Repair	1505 West 1st St
07-02-005-02	Air Permit - Title V	Cedar Falls Municipal Electric Utility - Cts	2506 W 27th St
07-02-005-02	Air Permit - Title V	Cedar Falls Municipal Electric Utility - Cts	2506 W 27th St
9LTM27	Leaking USTs	The Music Station	1420 W First St
7LTS58	Leaking USTs	The Music Station	1420 W First St
8LTD46	Leaking USTs	Willabby, Inc.	1310 W 1st St
9LTJ63	Leaking USTs	Video Store	1408 W First Street
198602971	Underground storage tank	Wayne Engineering Corp	2412 W 27th St
198605763	Underground storage tank	Physical Plant Department	Uni-Dome
	Cemeteries	Greenwood Cemetery	T89N, R14W, Sec. 11, NE, NE
198915542	Underground storage tank	The Rasmusson Co	2525 State Street
9LTF97	Leaking USTs	Sartori Hospital	515 College Street
198605650	Underground storage tank	Cedar Falls School Administration	1002 W 1st Stt
709501	Wastewater outfall	University Of Northern Iowa	30th Street And Nebraska
709501	Wastewater treatment facility	University Of Northern Iowa	30th Street And Nebraska
709501	Wastewater outfall	University Of Northern Iowa	30th Street And Nebraska
198605354	Underground storage tank	University Of Northern Iowa	1932 W 31st St
198605758	Underground storage tank	Physical Plant Department	Physical Plant Bldg
198605643	Underground storage tank	Cedar Falls Comm. Schools	Tenth & Division Streets
	Hospitals	SARTORI MEMORIAL HOSPITAL	515 COLLEGE STREET
198605759	Underground storage tank	Physical Plant Department	Gilchrist
1.10001E+11	Cond. Ex. Sm. quan. haz. waste gen.	Sartori Hosp	515 College Street

198607419	Underground storage tank	Greenwood Cemetery	N College St
07-SDP-10-89	Solid waste facility	Sartori Memorial Hospital	
1.10006E+11	Small quan. hazarous waste gen.	University Of Northern Iowa	1225 West 27th Street
	Cemeteries	Fairview Cemetery	T89N, R14W, Sec. 14, NE, NW
709004	Wastewater treatment facility	University Of Northern Iowa, Ms4	1801 W 31st St Street
198604028	Underground storage tank	St John American Lutheran Church	715 College
FAIDSIT2A000017	Tier II Chemical Storage	University Of Northern Iowa, Ms4	1801 W 31st St Street
07-02-006-02	Air Permit - Title V	University Of Northern Iowa - Power Plant	1901 W 30th St
198605757	Underground storage tank	Physical Plant Department	Animal Lab
07-02-006-01	Air Permit - Title V	University Of Northern Iowa - Main Campus	31st & Hudson Rd
7LTE84	Leaking USTs	Former Rudy's Taco	3205 Hudson Rd
7LTS49	Leaking USTs	B & B West	3105 Hudson
198607418	Underground storage tank	Brookside Vets Center	9305 University Ave
198605762	Underground storage tank	Physical Plant Department	Arts Bldg
198605760	Underground storage tank	Physical Plant Department	Bartlett
7LTC07	Leaking USTs	Uni	Art 2
FAIDSIT2A000018	Tier II Chemical Storage	Trugreen Chemlawn	5701 West Minster Drive
7LTV08	Leaking USTs	Kwik Star #726	2125 College Ave
198605761	Underground storage tank	Physical Plant Department	Noehren Hall
198608134	Underground storage tank	Mc Caskey Co	4112 S Hudson Rd
198605645	Underground storage tank	Lincoln Elementary School	Seventh & Franklin Streets
7LTI09	Leaking USTs	Kum & Go #431	2128 College
199517778	Underground storage tank	Kwik Star #726	2019 College
FAIDSIT2A000023	Tier II Chemical Storage	Target Corporation	2200 Viking Rd
07-02-049-01	Air Permit - Minor	Target Corporation	2200 Viking Rd
FAIDSIT2A000009	Tier II Chemical Storage	Qwest - Cedar Falls Co	1504 Washington Street
198811715	Underground storage tank	Us West	1504 Washington
07-02-047	Air Permit - Minor	Qwest Communications - Cedar Falls	1504 Washington St
709801	Wastewater outfall	Nazareth Lutheran Church	7401 University Avenue
9LTH69	Leaking USTs	Coastal Mart #1015	1810 Main
9LTH85	Leaking USTs	Coastal Mart #1015	1810 Main
7LTE10	Leaking USTs	Cedar Falls Fire Dpt	1718 Main St
07-SDP-06-82	Solid waste facility	City Of Cedar Falls Transfer Station	215 East 15th St
8LTN09	Leaking USTs	City Of Cedar Falls Transfer Station	215 East 15th St
709003	Wastewater treatment facility	Cedar Falls, City Of Ms4	City Of Cedar Falls

8LTX24	Leaking USTs	18th Street Conoco	123 East 18th
	Vineyards	UNI Biological Preserve for Teaching and Research	29th & Tremont (Davis L
198606275	Underground storage tank	Wastewater Treatment Plant	215 East 15th Street
1.10006E+11	Unspecified hazardous waste gen.	Curbmaster Former Cmi Metro Pave	115 East 19th Street
8LTW11	Leaking USTs	Prime Mart	2323 Main St
8LTW02	Leaking USTs	Dan Deery Motor Co	7404 University Ave
198811515	Underground storage tank	Dennis C Christensen and Sons Concrete and Masonry Construction	1910 State St
709801	Wastewater treatment facility	Nazareth Lutheran Church	7401 University Avenue
709109	Wastewater outfall	Viking Pump, Inc. - Viking Road Facility	711 Viking Road
709108	Wastewater outfall	Quad State Gauging & Measurement	622 Enterprise Drive
1.10006E+11	Unspecified hazardous waste gen.	H & H Machine Tool Co- former site of	525 East 18th Street
198609820	Underground storage tank	Stationmart #446	7216 University Ave
07-02-025	Air Permit - Minor	Deery Brothers Collision Center	210 E Seerley Blvd
198915595	Underground storage tank	Dennys Body Shop	522 E 18th St
198602165	Underground storage tank	Viking Pump	Viking Rd
198915569	Underground storage tank	Former Legend Car	7026 University Ave
8LTO60	Leaking USTs	Residential	2504 Grove Street
9LTN52	Leaking USTs	Dell Oil Ltd	809 East 18th Street
7LTW66	Leaking USTs	Dell Oil Ltd	809 East 18th Street
07-02-048	Air Permit - Minor	Casting Cleaning, Inc	5604 Westminster Dr
198915614	Underground storage tank	John Deery Motors Inc	6823 University Ave
198605651	Underground storage tank	Central Services Facility	2001 Fairview Dr
198605649	Underground storage tank	Peet Jr. High School	525 East Seerly Blvd
1.10023E+11	Cond. Ex. Sm. quan. haz. waste gen.	Keystone Automotive	5658 Westminster Dr
709502	Wastewater treatment facility	Peet Jr. High School	525 East Seerly Blvd
7LTW59	Leaking USTs	Saturn	6719 University Ave
07-SDP-12-89	Solid waste facility	Viking Pump Foundry Sand Landfill	406 State St
198605755	Underground storage tank	Physical Plant Department	Golf Course
1.10012E+11	Small quan. hazarous waste gen.	Cedar Valley Electroplating	5611 Westminster Dr
FAIDSIT2A000041	Tier II Chemical Storage	Totaline Central Plains Distributing	5529 Nordic Dr
7LTE89	Leaking USTs	Hy-vee, Inc.	6527 University
9LTK88	Leaking USTs	Hy-vee, Inc.	6527 University
07-ADP-04-02	Solid waste facility	Dalton Plumbing	5526 Nordic Dr

198710428	Underground storage tank	College Square Mall	6301 University Blvd
9LTE77	Leaking USTs	Former Montgomery Ward Auto Center	College Square Mall
1.10025E+11	Small quan. hazarous waste gen.	Arnold Motor Supply	2408 Waterloo Rd
9LTD30	Leaking USTs	Clarion Inn	5826 University
7LTO97	Leaking USTs	Fast Track #72	2915 Mc Clain Drive
9LTK62	Leaking USTs	Black Hawk Village Shopping	2415 Mcclain Drive
198604586	Underground storage tank	Pony Express	3205 Waterloo Rd
928	Contaminated sites	Econofoods Property	5901 University Ave
709001	Wastewater outfall	Cedar Falls City Of Stp	501 E. 4th St.
1.10006E+11	Unspecified hazardous waste gen.	Ace Fogdall Inc - Former Site Of	5424 University Ave
8LTL75	Leaking USTs	Casey's General Store #2630	5226 University Ave
198605647	Underground storage tank	Cedar Falls Comm. Schools	2417 Rainbow Dr
8LTQ19	Leaking USTs	Casey's Corner Store	5223 University Ave
709001	Wastewater outfall	Cedar Falls City Of Stp	501 E. 4th St.
1.10006E+11	Unspecified hazardous waste gen.	Sherwin-Williams Store 3171	5212 University Ave
1.10006E+11	Small quan. hazarous waste gen.	Sherwin-Williams Store 3171	5212 University Ave
709001	Wastewater outfall	Cedar Falls City Of Stp	501 E. 4th St.
198602980	Underground storage tank	Community Motors	4521 University Avenue
07-02-005-03	Air Permit - Title V	City Of Cedar Falls - Municipal Water Utility	2618 Greenhill Rd
1.10015E+11	Cond. Ex. Sm. quan. haz. waste gen.	Target Distribution Center T-590	2200 Viking Rd
7LTI32	Leaking USTs	L & M Transmission	4326 University Ave
1.10016E+11	Small quan. hazarous waste gen.	L & M Trans	4326 University
198912472	Underground storage tank	Holdiman Motors Inc	4325 University Avenue
709201	Wastewater outfall	Cedar Valley Foot and Ankle Center	4508 Chadwick Drive
709201	Wastewater treatment facility	Cedar Valley Foot and Ankle Center	4508 Chadwick Drive
199617901	Underground storage tank	Suzuki	4227 University Ave
198914911	Underground storage tank	Best Rental	4051 University Ave
	Cemeteries	Pet Haven Cemetery	T89N, R13W, Sec. 29, NW, SW
8LTU57	Leaking USTs	Former Midway Bank & Trust	3910 University Ave
9LTG97	Leaking USTs	Former Crouse Cartage	3841 University Ave
9LTG97	Leaking USTs	Former Crouse Cartage	3841 University Ave
198710734	Underground storage tank	City Of Cedar Falls Water Reclamation Division	5602 Prairie Street
790001	Wastewater outfall	Waterloo City Of Stp	3505 Easton Avenue
198603282	Underground storage tank	The General Store	3821 University Ave

198606022	Underground storage tank	K Mart #4158	3810 University Ave
198603282	Underground storage tank	The General Store	3821 University Ave
198606022	Underground storage tank	K Mart #4158	3810 University Ave
1.10001E+11	Unspecified hazardous waste gen.	Penske Auto Centers Incorporated	3810a University Drive
1.10001E+11	Unspecified hazardous waste gen.	Penske Auto Centers Incorporated	3810a University Drive
199617909	Underground storage tank	Osco #18-856	3715 University Ave
199617909	Underground storage tank	Osco #18-856	3715 University Ave
199117320	Underground storage tank	Platts Inc	3700 University Avenue
9LTG01	Leaking USTs	U-haul Company	3633 University
199117320	Underground storage tank	Platts Inc	3700 University Avenue
9LTG01	Leaking USTs	U-haul Company	3633 University
8LTK75	Leaking USTs	Waterloo Community School District	1350 S Hackett Rd
8LTK75	Leaking USTs	Waterloo Community School District	1350 S Hackett Rd
198601885	Underground storage tank	University Motor Co	722 S Hackett
198601885	Underground storage tank	University Motor Co	722 S Hackett
07-ADP-07-03	Solid waste facility	Young Plumbing & Heating	750 S Hackett Rd
07-ADP-07-03	Solid waste facility	Young Plumbing & Heating	750 S Hackett Rd
1.10006E+11	Unspecified hazardous waste gen.	Heartland Vineyard Christian Fellowship	1405 Greenhill Rd
1.10006E+11	Unspecified hazardous waste gen.	Heartland Vineyard Christian Fellowship	1405 Greenhill Rd
	Above ground storage	Black Hawk Co. Shop	2602 Union Rd
	Confined Animal Feeding Operation	Dietrick Enterprise	415 West Dunkerton Rd

Iowa Department of Natural Resources
Geological Survey
109 Trowbridge Hall
Iowa City, Iowa 52242-1319
(319) 335-1575
www.igsb.uiowa.edu