PNNL-15731

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Post-Closure RCRA Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch

B. A. Williams
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March 2006

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, WA 99354

Summary

The purpose of this plan is to provide a post-closure groundwater monitoring program for the 216-S-10 pond and ditch (S-10) treatment, storage, and/or disposal (TSD) unit. The plan incorporates the sum of knowledge about the potential for groundwater contamination to originate from the S-10, including groundwater monitoring results, hydrogeology, and operational history. The S-10 has not received liquid waste since October 1991. The closure of S-10 has been coordinated with the 200-CS-1 source operable unit in accordance with the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement; Ecology et al. 1989) interim Milestones M-20-39 and M-15-39C.

The S-10 is closely situated among other waste sites of very similar operational histories. The proximity of the S-10 to the other facilities (216-S-17 pond, 216-S-11 pond, 216-S-5,6 cribs, 216-S-16 ditch and pond, and 216-U-9 ditch) indicate that at least some elevated chromium concentrations observed at upgradient and downgradient wells of S-10 could have originated from waste sites other than S-10. Hence, it may not be feasible to strictly discriminate between the contributions of each waste site to groundwater contamination beneath the S-10.

A post-closure groundwater monitoring network is proposed that will include the drilling of three new wells to replace wells that have gone dry. When completed, the revised network will meet the intent for groundwater monitoring network under WAC 173-303-645, and enable an improved understanding of groundwater contamination that may have originated at the S-10. Site-specific sampling constituents are based on the dangerous waste constituents of concern relating to *Resource Conservation and Recovery Act* TSD unit operations (TSD unit constituents) identified in the Part A Permit Application. Thus, a constituent is selected for monitoring if it is:

- A dangerous waste constituent identified in the Part A Permit Application, or
- A mobile decomposition product (e.g., nitrate from nitrite) of a Part A constituent, or
- A reliable indicator of the site-specific contaminants (e.g., specific conductance).

Using these criteria, the following constituent list and sampling schedule is proposed:

Constituent	Sampling Frequency
Site-Specific Parameters	
Hexavalent chromium[a]	Semiannual
Chloride	Semiannual
Fluoride	Semiannual
Nitrate	Semiannual
Nitrite	Semiannual
Specific conductance (field)[a]	Semiannual
Ancillary Parameters	
Anions	Annual
Alkalinity	Annual
Metals, (in addition to chromium)	Annual
pH (field)	Semiannual
Temperature (field)	Semiannual
Turbidity (field)	Semiannual

(a) These constituents will be subject to statistical tests after background is established.

It will be necessary to install new monitoring wells and accumulate background data on the groundwater from those wells before statistical comparisons can be made. Until then, the constituents listed above will be evaluated by tracking and trending concentrations in all wells and comparing these results with the corresponding drinking water standard (DWS) or Hanford Site background concentration for each constituent. If a comparison value (background or DWS) for a constituent is exceeded, the U.S. Department of Energy (DOE) will notify Washington State Department of Ecology (Ecology) per WAC 173-303-645(9)(g) requirements (within 7 days or a time agreed to between DOE and Ecology).

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1.0 Introduction

This document provides a *Resource Conservation and Recovery Act* (RCRA) post-closure groundwater monitoring plan for the 216-S-10 pond and ditch (S-10) prepared to final status standards pursuant to the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement; Ecology et al. 1989) Action Plan, Section 5.3. The S-10 is located south-southwest of the 200 West Area on the Hanford Site in Washington State. Since 1991, RCRA groundwater monitoring has been conducted in accordance with interim status requirements (40 CFR Part 265, Subpart F, which is incorporated into Washington State Department of Ecology [Ecology] regulations Washington Administrative Code [WAC 173-303-400] by reference). The S-10 is currently monitored under interim-status, indicator-evaluation as described in Williams and Chou (2002). The site is also within the 200-UP-1 Groundwater Operable Unit and 200-CS-1 source Operable Unit of the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA). The S-10 has not received liquid waste since October 1991.

The plan presented here describes a revised well network and updates the list of constituents based on the knowledge gained from monitoring data collected over the past 14 years for this site and the Part A Permit Application. The plan includes the current interpretation of groundwater flow and a summary of groundwater analytical results. Additionally, an updated conceptual model of contaminant transport through the vadose zone beneath the S-10 is presented in this plan to assist in developing appropriate monitoring for this facility.

1.1 Objectives and Scope

The purpose of this plan is to provide a RCRA post-closure groundwater monitoring program for the S-10. The plan incorporates the sum of knowledge about the potential for groundwater contamination to originate from the S-10, including groundwater monitoring results, hydrogeology, and operational history. A conceptual model is developed based on these attributes of the S-10 site and the data quality objective (DQO) process to be issued under a separate title. The groundwater monitoring program presented in this plan is intended specifically to satisfy monitoring requirements for treatment, storage, and/or disposal (TSD) facilities, as required by WAC 173-303-806 and WAC 173-303-645.

1.2 Regulatory Status and History

The S-10 has been regulated by WAC 173-303-400 and has been monitored under a RCRA interim status groundwater monitoring program since 1991 (Airhart et al. 1990; Williams and Chou 2002). The RCRA Part A Permit Application for this TSD unit was first submitted to Ecology in June 1987. Revisions to the Part A Permit Application have been submitted and approved over the years. RCRA groundwater monitoring at the S-10 was initially required because regulated waste from synthetic double-shell tank slurry was discharged to the site in 1983. The waste types comprising the slurry are those identified in the Part A Permit; these (and corresponding waste codes) are ignitability (D001), corrosivity (D002), chromium (D007), and state-only toxicity (WT01, WT02).

The S-10 is also within the boundary of the CERCLA 200-UP-1 Groundwater Operable Unit, which has the responsibility for groundwater cleanup activities. The Tri-Party Agreement requires that characterization and remediation of waste sites integrate the requirements of CERCLA and RCRA and provide a consistent, standard approach to cleanup activities to assure that applicable regulatory requirements are met. The 200 Areas Implementation Plan (DOE 1999) outlines a framework to provide for consistent, integrated cleanup actions (i.e., characterization and remediation) in the 200 Areas and integrates the requirements of RCRA and CERCLA into one standard approach for cleanup activities.

Besides the ongoing RCRA interim status groundwater monitoring, the S-10 is part of the CERCLA 200-CS-1 chemical sewer group of waste sites, based on waste-stream groupings. A remedial investigation, which included the S-10, was recently completed for the 200-CS-1 Operable Unit and the results presented by DOE (2004). Comprehensive chemical and radiological analyses were performed on soil samples from boreholes and trenches excavated within the S-10 during 1999-2003.

In accordance with Milestone M-15-00C, all characterization work in the 200 Areas is to be completed by December 31, 2008. An associated milestone, M-20-39C, requires submittal of the S-10 closure/post-closure plan to Ecology in March 2006. This groundwater monitoring plan also supports these milestones. Relevant sections of this groundwater monitoring plan (e.g., monitoring well network, constituent list and sample frequency, water level monitoring, sampling and analysis protocol, quality control, and data management, evaluation, and reporting) will be incorporated into Part VI, Post Closure Units, in the Hanford Facility RCRA Permit following completion of the notice of deficiency process in the Tri-Party Agreement, Action Plan Section 9.2.2.

2.0 Description of the 216-S-10

The information contained in this section came from several sources: Waste Information Data System (WIDS) General Summary Reports, Maxfield (1979), and DOE (1987), DOE/RL (1992, 2004).

2.1 Facility Description and Operational History

The S-10 is located south-southwest of the 200 West Area, directly outside the perimeter fence (Figure 2.1). Initially the S-10 consisted of an open, unlined ditch (216-S-10 ditch) that was approximately 1.2 m (4 ft) wide at its base, at least 1.8 m (6 ft) deep, and 686 m (2,250 ft) long. The ditch began receiving wastewater via pipeline from the Reduction-Oxidation (REDOX) facility in August 1951. The 216-S-10 pond (S-10 pond) was added to the southwest end of the S-10 in 1954; it covered 20,234 m^2 (5 acres) and included four finger-like leaching trenches when it was active. The pond was approximately 2.4 m (8 ft) deep at its deepest point. Like the ditch, the pond was unlined and, therefore, served as a percolation basin for liquid discharges. Water discharged into the S-10 ditch also flowed into the S-10 pond and infiltrated into the ground, which created perched water in the vadose zone and artificially recharged the underlying aquifer.

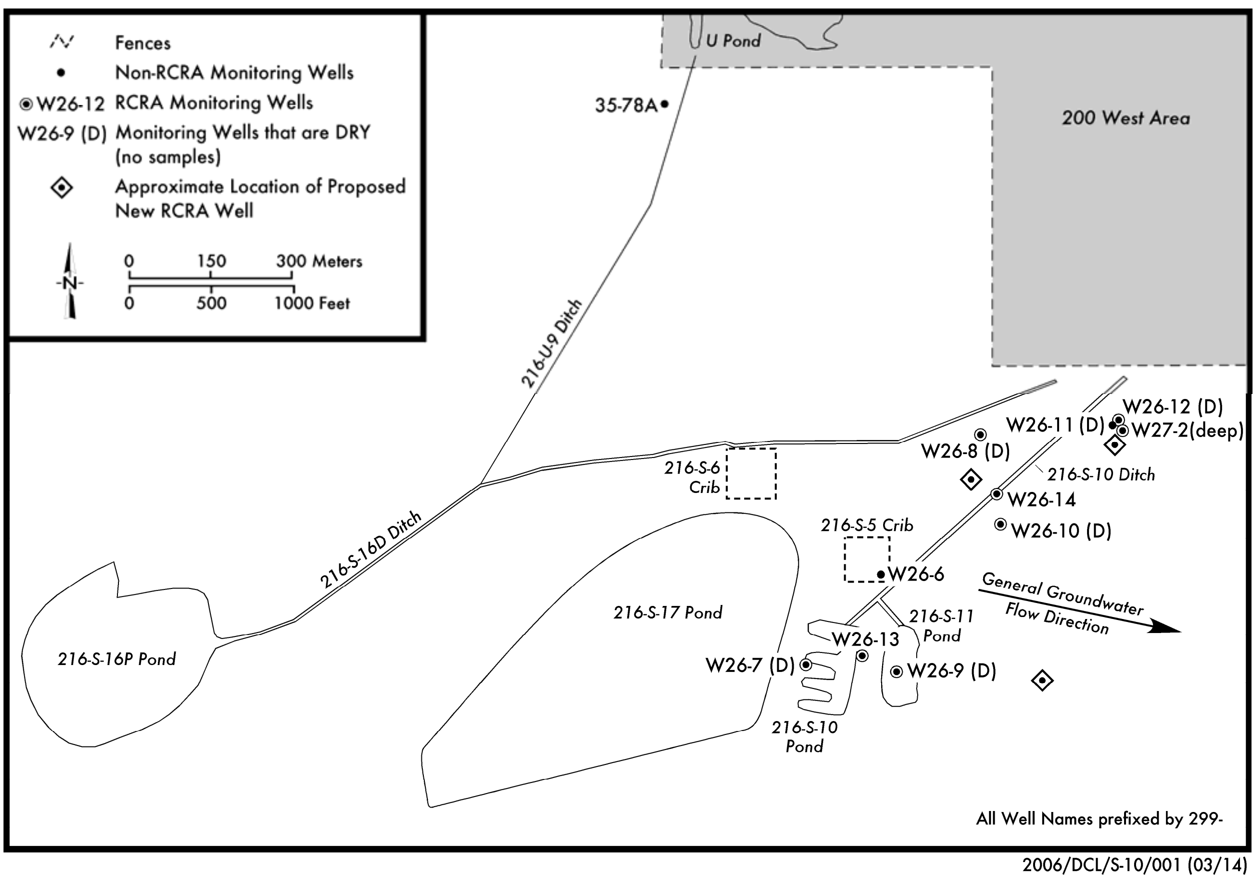


Figure 2.1. S-10 Site Map

As shown in Figure 2.1, several other waste disposal waste sites, which include cribs 216-S-5 and 216-S-6; ponds 216-S-11, 216-S-16, and 216-S-17 and associated ditches, are in the immediate vicinity of the S-10. The WIDS General Summary Reports give general descriptions, including descriptions of the site and the waste it received. It is important to note that historical discharges to these sites may influence the groundwater chemistry near the S-10. Currently, it is not possible to distinguish the potential effects of these surrounding waste sites from that of the S-10 due to the lack of monitoring wells in the area. The following paragraphs describe the operational history of the S-10.

In August 1951, the 216-S-10 ditch began receiving wastewater from the REDOX Plant chemical sewer. In February 1954, the 216-S-10 pond was dug at the southwest end of the ditch to provide more surface area for percolation. In May 1954, increases in discharge to the S-10 necessitated the digging of the two 216-S-11 leach ponds on the southeast side of the 216-S-10 ditch. An inadvertent release of ammonium nitrate non-hydrate reduced the infiltration capacity in the S-10 and in 1955, 0.6 m (2 ft) of sediment was dredged from the bottom of the 216-S-10 ditch to improve water percolation in the ditch. The contaminated sediment was buried in excavation pits along the sides of the ditch. The depth and location of the pits are unknown (RHO 1979). The 216-S-11 lobes were dammed in 1965, so that all of the effluent was diverted along the S-10 ditch to the 216-S-10 pond. The south lobe of the 216-S-11 pond was covered in the summer of 1975 and was free of radioactive contamination. The site as a whole was stabilized by September 30, 1983. The REDOX Plant was closed in 1967. At that time, effluent to the S-10 was reduced primarily to chemical sewer waste. When the REDOX Plant was deactivated in 1972, physical controls were administered to eliminate hazardous discharges from the REDOX Plant to the S-10. These controls reduced discharges from the REDOX Plant to non-hazardous chemical sewer effluent.

In September 1983, the S-10 received a hazardous waste discharge from the Chemical Engineering Laboratory. This laboratory produced synthetic slurry to test methods for recovering slurry from double-shell tanks (DOE 1987). This discharge is described in more detail in Section 2.2.

The 216-S-10 pond and southwest end of the 216-S-10 ditch were decommissioned, backfilled, and stabilized in October 1985; the northern portion of the ditch remained operational and received non-dangerous chemical sewer waste from the REDOX Plant until October 1991 (BHI 1995). The effluent supply pipeline was plugged with concrete near the outfall in July 1994. The remaining portion of the S-10 ditch was decommissioned in 1991. The sequence of important events surrounding operation and closure of the S-10 is summarized in Figure 2.2.

2.2 Waste Characteristics

The following section was adapted from the 200-CS-1 Operable Unit remedial investigation/ feasibility study (RI/FS) work plan and RCRA treatment, storage, and disposal unit sampling plan (DOE 2000).

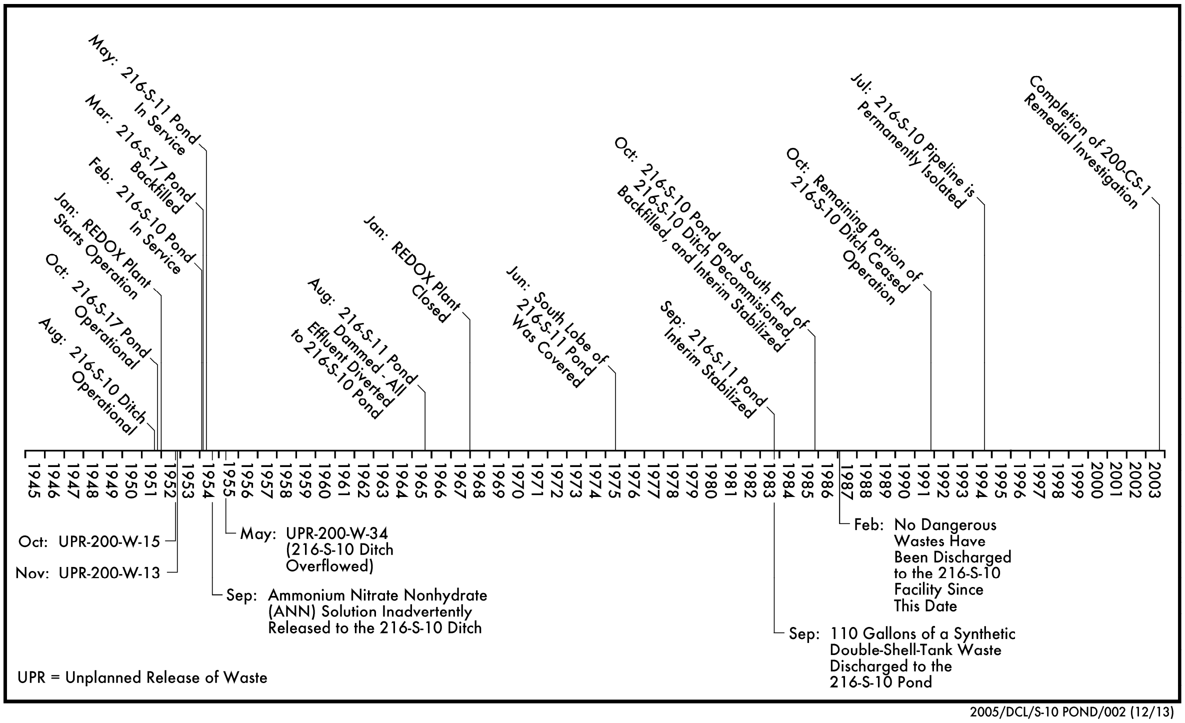


Figure 2.2. Timeline of Significant Events of the S-10

This section summarizes the chemical and physical characteristics of past discharges to the S-10. Most of the liquid waste discharged to the S-10 came from the REDOX Plant's chemical sewer and the Chemical Engineering Laboratory, both part of the S Plant Aggregate Area (DOE 1992). The chemical sewers were designed to be uncontaminated, but they often contained limited quantities of radionuclides and chemicals. Approximately 50 waste streams contributed to the 216-S-10 ditch (WHC 1990). The routine waste stream sources include the compressor cooling water from the REDOX Plant and the sanitary water overflow from the 2901-1-901 water tower. The remaining sources were infrequent additions and included waste from REDOX Plant floor drains and funnel drains; S Tank Farm pump drains, tank drains, station drains, chemical sewer line manholes; and 276-S Building floor drains.

In September 1983, a documented hazardous waste discharge to the S-10 occurred (DOE 1987). In this incident, 416.4 L (110 gal) of synthetic double-shell-tank slurry was discharged to the S-10. The waste consisted largely of $NaNO_3$ (46%) and NaOH (41%), with small quantities of Na_3PO_4, NaF, NaCl, and $K_2Cr_2O_7$. Samples of this slurry taken from the two feed tanks, TK-505 and TK-509, before the discharge occurred were analyzed; the results of these analyses are presented in Table 2.1. The synthetic tank slurry comprised the chemical compounds identified in the Part A Permit Application submitted for S-10.

The portion of the 216-S-10 ditch that was still in service after 1985 received chemical sewer discharge from the REDOX Plant. The waste stream entered the north end of the ditch through a vitrified clay pipe 30.5 cm (12 in.) in diameter. This waste stream was composed of cooling water from water-scrubbed air-conditioning filters, air-conditioning bearings, and seal loops; overflow from the sanitary-water tower; steam condensate from building heaters and station steam supply; and floor-drain effluent produced by pipe leaks and pump overflow (DOE 1987). As part of deactivation of the REDOX Plant in

Table 2.1. Composition of Synthetic Double-Shell-Tank Slurry

Component	Concentration (molarity)	
	TK-505	TK-509
Al	1.225	1.235
OH	3.40	3.42
NO_2	2.18	2.115
NO_3	2.54	2.50
CO_3	0.159	0.157
PO_4	0.041	0.027
SO_4	<0.052	<0.052
F	0.062	0.05
Cl	0.115	0.103
Cr_2O_7	0.106	0.0983

1972, the source streams from the plant were routed so that they would not come into contact with hazardous materials. Combined cumulative liquid discharges of 6.6×10^9 L (1.7×10^9 gal) went to the S-10 ditch and the S-11 pond.

During operations, the maximum volume of wastewater discharged to the S-10 was approximately 568,000 L (150,000 gal) per day. The annual volume of effluent discharged was approximately 1.9×10^8 L (5.0×10^7 gal). Standing water was present in the ditch and created conditions conducive to vegetation growth. Figure 2.3 illustrates the combined effluent volume discharged to the S-10 and S-11 pond. Wastewater from the REDOX Plant has been combined with the 200 West portion of the effluent collection system for disposal since 1995.

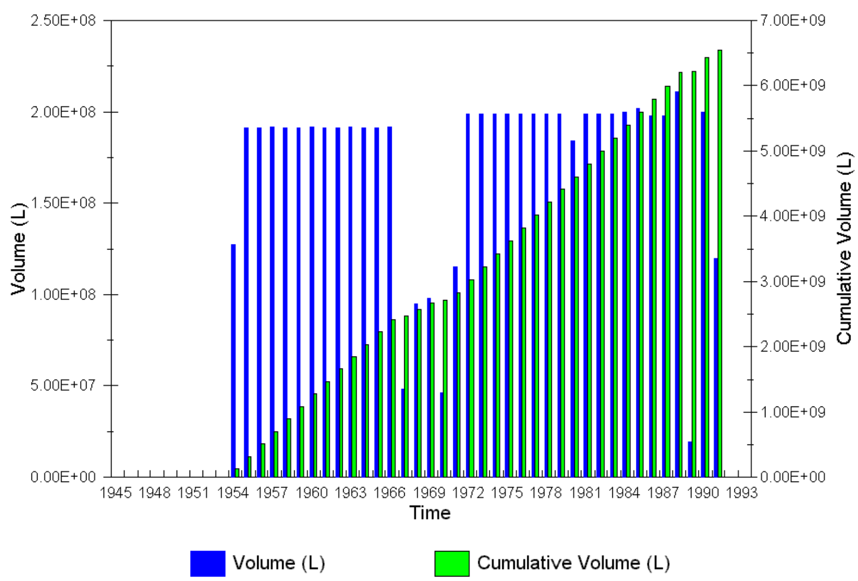


Figure 2.3. Effluent Volume Discharged to the 216-S-10 Ditch (216-S-10D), 216-S-10 Pond, and 216-S-11 Pond

2.3 Soil Contamination Characterization Activities

Past-practice spills and documented hazardous waste releases to the S-10 have required an evaluation of soil contamination to evaluate and develop waste site specific cleanup/closure options. An integrated process for characterization of the RCRA regulated units within the CERCLA 200-CS-1 Operable Unit combines an RI/FS work plan with the Implementation Plan (DOE 1999).

Based on this approach, a two-phased remedial investigation was completed in 2003 for the S-10. The first phase of characterization was completed in 2000 and involved deep sediment sampling in one borehole drilled at the S-10 pond (Figure 2.4). The borehole was later completed as a RCRA downgradient monitoring well (299-W26-13) to replace well 299-W26-9 that had gone dry. A second phase of field characterization, which was completed in 2003 (DOE 2004), included seven test pit excavations for soil sampling along the ditch and pond, and one characterization borehole (later completed as downgradient well 299-W26-14) midway between the head of the S-10 ditch and where the ditch meets the S-10 Pond. Preliminary results (DOE 2004) indicate that the Part A constituent chromium was detected significantly above background levels in soil at the S-10, as was nitrate, a possible derivative of the Part A constituent nitrite.

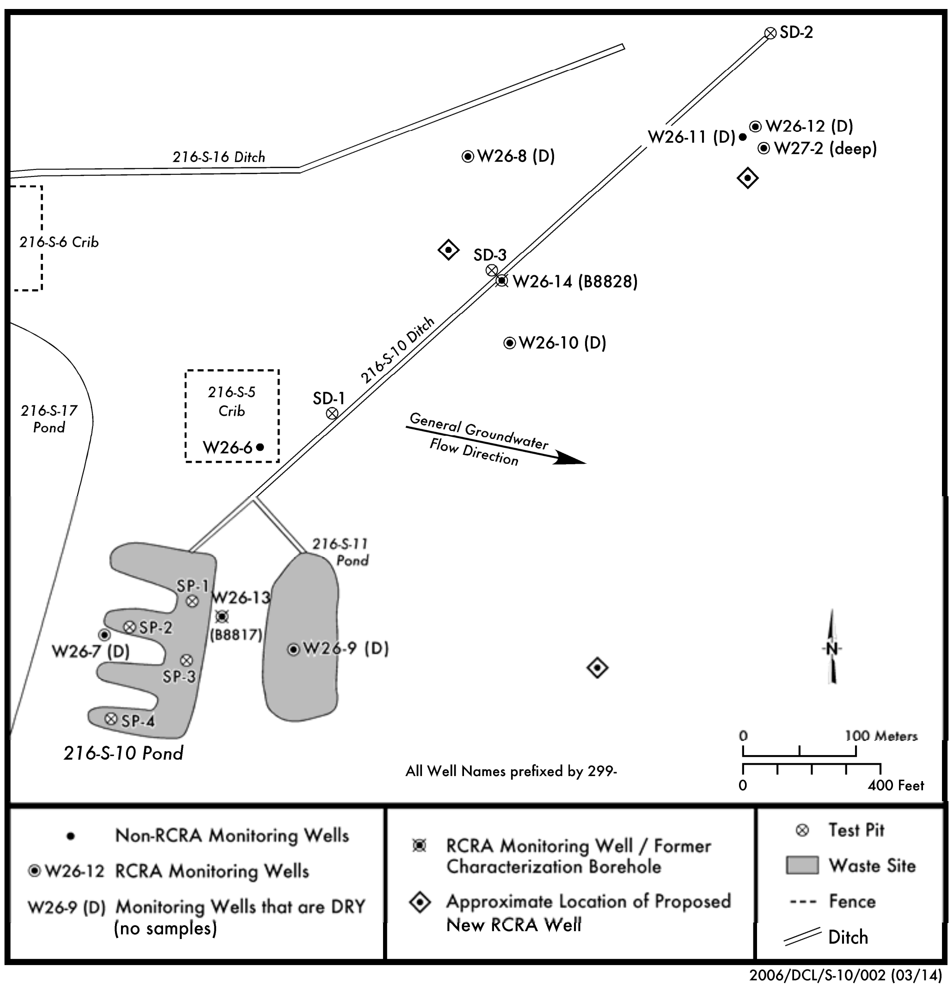


Figure 2.4. The S-10 Site, Showing Locations of Soil Sampling Test Pits and Boreholes

3.0 Hydrogeology

This section summarizes recent interpretations of the hydrogeology of the S-10. Data on physical characteristics of the S-10 and the surrounding area (e.g., boreholes) are used to refine understanding of the local hydrogeology beneath the site and the potential contaminant transport pathways from the subsurface, toward groundwater and toward potential receptors. These data are used to develop the conceptual model beneath the waste site (Section 5.0). In addition, the data also are needed to provide engineering information to develop and screen remedial action alternatives. Early studies relied on limited borehole and well data to describe the stratigraphy and groundwater hydrogeology of the area. More wells have been drilled in recent years in the surrounding area specifically targeted to collect more characterization data. As a result, the quantity and quality of the geologic data has been enhanced, which improves hydrogeologic model development and its interpretation.

The S-10 is located south-southwest of the 200 West Area on the Central Plateau, a broad, flat area that constitutes a local topographic high around the 200 Areas. The plateau is one of the flood bars (i.e., Cold Creek Bar) formed during the cataclysmic flooding events of the Missoula floods that occurred over 13,000 years ago. The northern boundary of the flood bar is defined by an erosional channel, and present day topographic low, that runs northwest-southeast near Gable Butte just north of the 200 West Area boundary (Williams et al. 2002). Most of the 200 West Area, including the S-10, is situated on the flood bar (Figure 3.1).

The geology of the Central Plateau, and particularly the Pasco Basin, has been studied in great detail. The focus of this section is on the sediment above the basalt bedrock, or the suprabasalt sediment, contained within the Hanford formation, Cold Creek unit (formerly Plio-Pleistocene unit), and Ringold Formation, because these strata comprise the uppermost aquifer system and vadose zone in the area. Detailed descriptions of these geologic units are available in Bjornstad (1984, 1985), Tallman (1979), Myers and Price (1981), Graham et al. (1981), and Lindsey (1995), and more recently by DOE (2002). The most detailed description of the stratigraphy beneath the S-10 could be found in Airhart et al. (1990).

Williams et al. (2002) provides an updated re-interpretation of the hydrogeology in the 200 West Area and vicinity that includes characterization of the entire suprabasalt aquifer system. The most recent description of the groundwater contamination in the region of the Hanford Site surrounding the S-10 is presented in Hartman et al. (2006).

3.1 Stratigraphy

Hanford Site stratigraphic classifications account for lithologic and hydrogeologic units. The hydrogeologic classification is more applicable to groundwater movement in the suprabasalt sediment. This hydrogeologic nomenclature and its lithostratigraphic relationship are illustrated in Figure 3.2. The uppermost suprabasalt aquifer system is contained in the Ringold Formation, and the Hanford formation and Cold Creek unit comprise the vadose zone. The Ringold Lower Mud Unit (hydrogeologic unit 8) separates the supra basalt aquifer system into a confined and unconfined aquifer (Williams et al. 2002). The uppermost surface of the Elephant Mountain member basalt is considered the base of the suprabasalt aquifer system (bedrock) because of its dense, low permeability interior, relative to the overlying sediments. This surface is considered to be a groundwater no-flow boundary. The basalt surface beneath the S-10 dips south-southwest forming the southern limb of the Gable Mountain-Gable Butte anticline and the northeast flank of the Cold Creek syncline (after Fecht et al. 1987). Figures 3.3 (south-north) and Figure 3.4 (east-west), illustrate the stratigraphic position and relationship of these hydrogeologic units as they exist beneath the southern 200 West Area and the S-10. Figure 3.5 provides a more detailed hydrogeologic profile beneath the S-10.

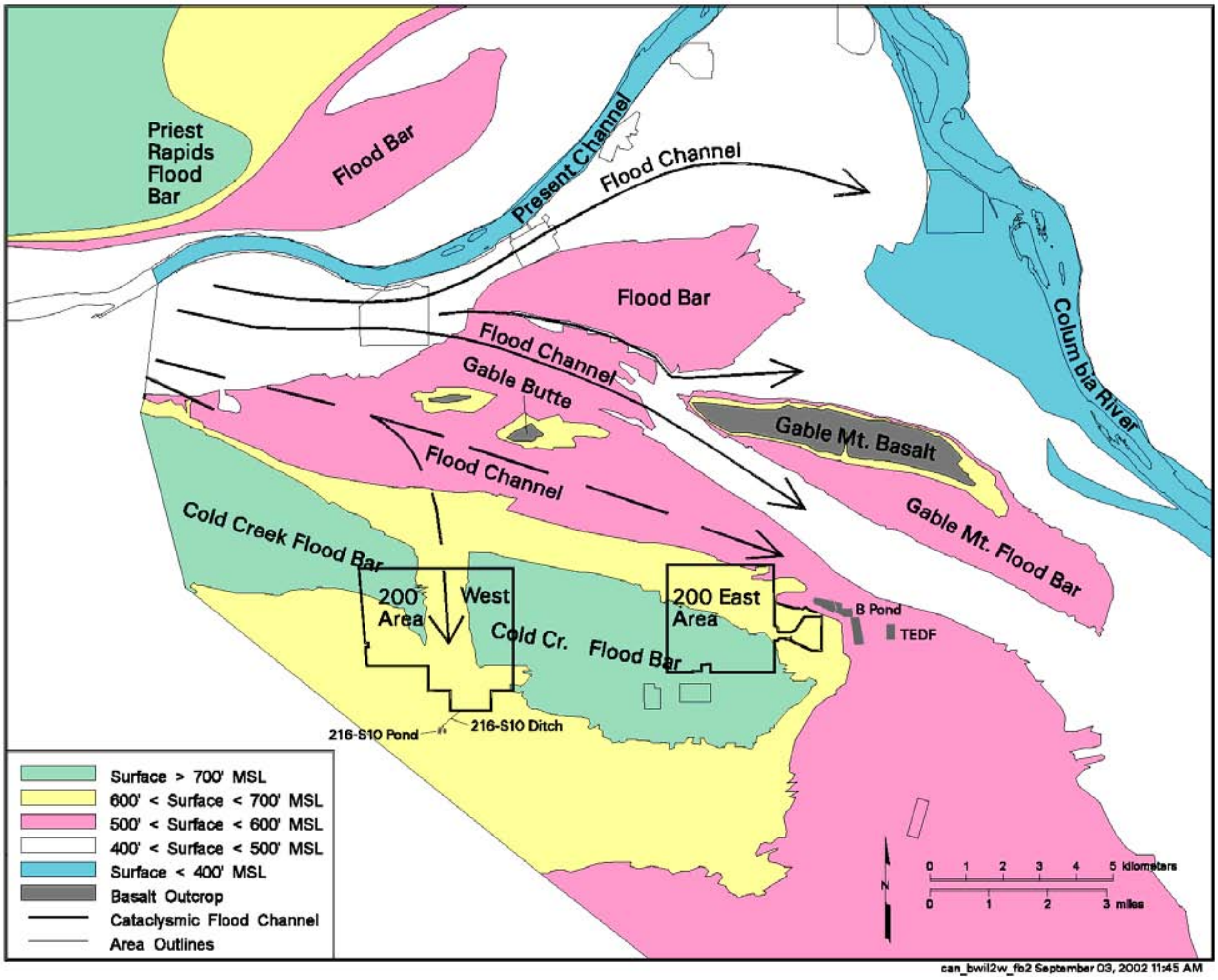


Figure 3.1. Topographic Illustration of Pleistocene Flood Channels and the Present-Day Columbia River Channel Pathways, with Outlines of the 200 West and East Areas, Hanford Site, Washington (after Williams et al. 2002)

The S-10 lies at an elevation of about 200 m (~650 ft) above mean sea level. The three major, supra-basalt stratigraphic units beneath the S-10 are (from oldest to youngest) the Ringold Formation, the Cold Creek unit, and the Hanford formation.

Geology beneath the S-10 is described in detail in the following paragraphs.

3.1.1 Ringold Formation (Units 4 through 9)

Units 4 through 9 correspond to the Ringold Formation (see Figure 3.2) and consist of continental fluvial and lacustrine sediments deposited on the Elephant Mountain member basalt by ancestral

Columbia and Clearwater-Salmon Rivers during late Miocene to Pliocene time (DOE 1988). From the oldest to youngest, the stratigraphic intervals are the Unit 9 fluvial gravel, Unit 8 composed of the paleosol/overbank facies beneath lacustrine fine-grained facies (Bjornstad 1984; DOE 1988; Last et al. 1989; Bjornstad 1990), Unit 5 fluvial gravel, and Unit 4 fines.

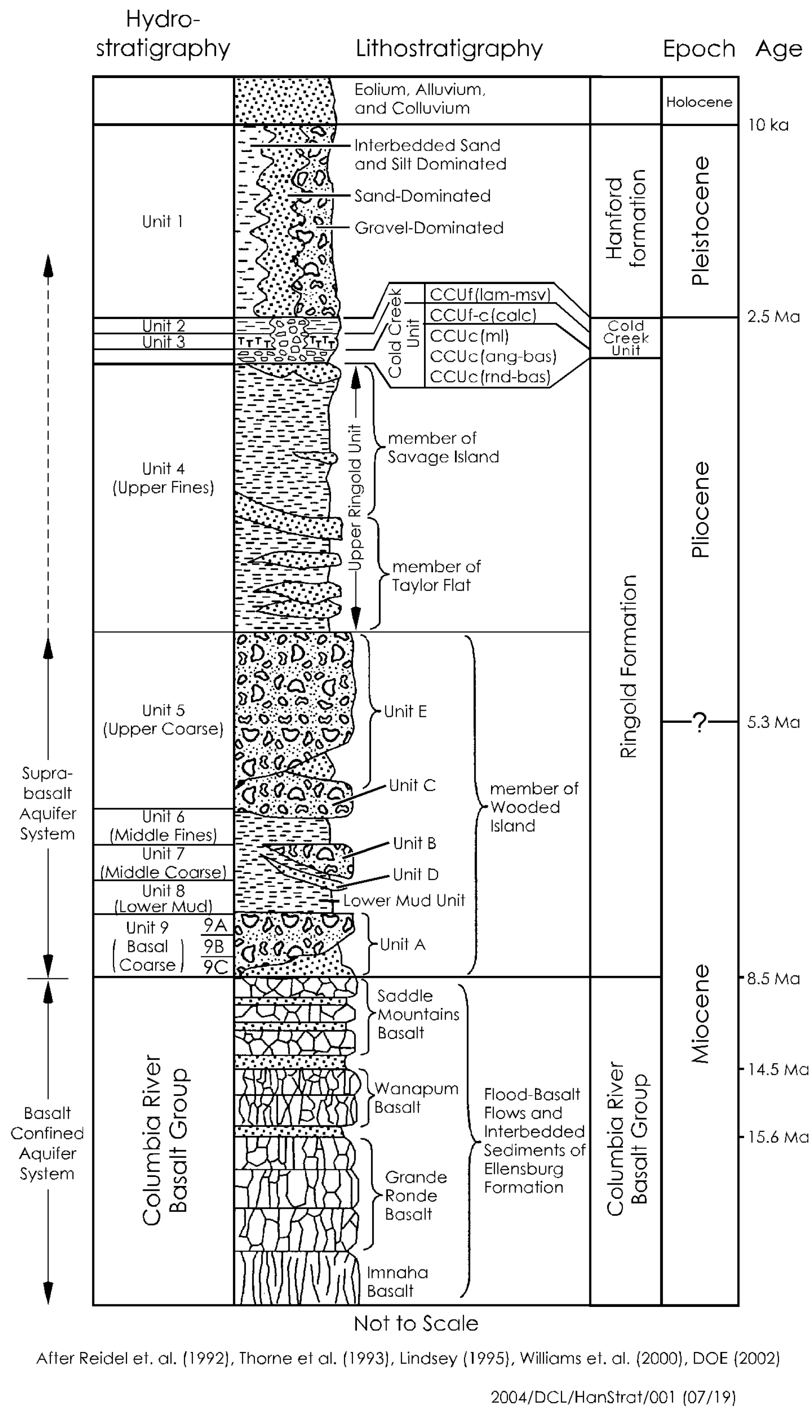


Figure 3.2. Hydrostratigraphy of the Hanford Site (comparison of hydrogeologic and geologic classifications)

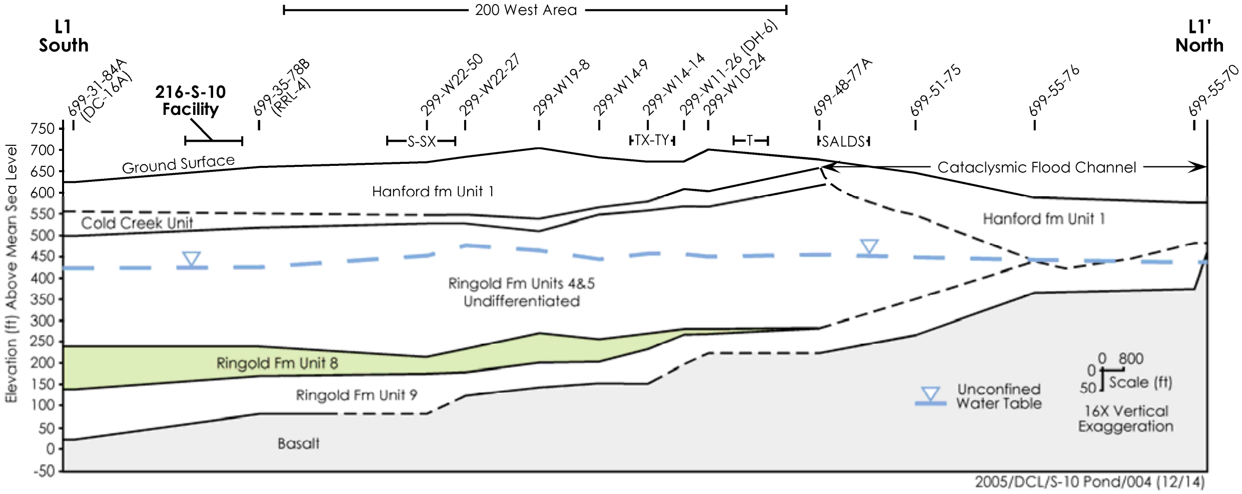


Figure 3.3. Hydrogeologic South-North Cross Section in the 200 West Area and Near S-10

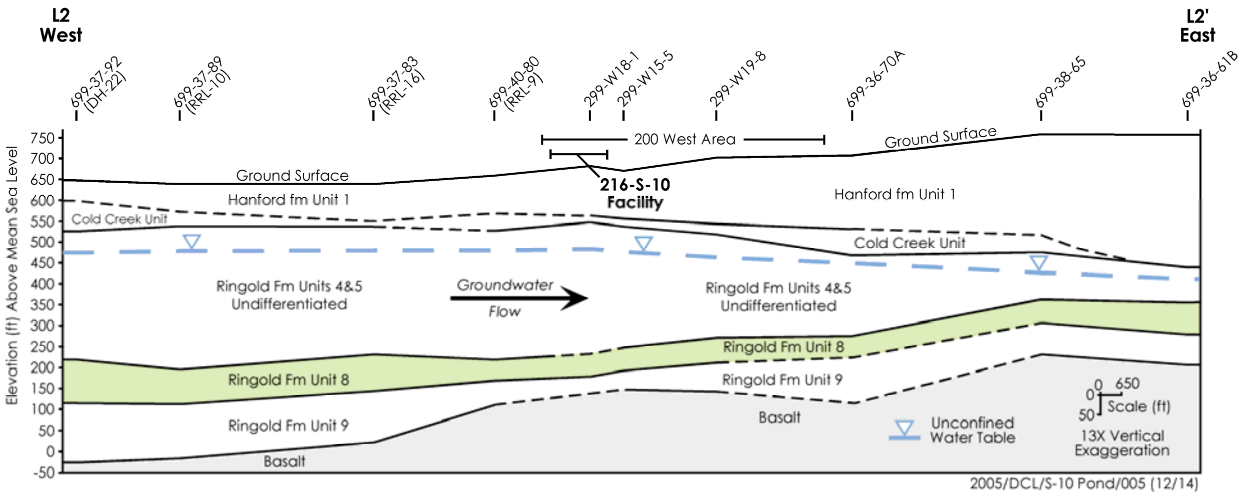


Figure 3.4. Hydrogeologic East-West Cross Section in the 200 West Area and Near S-10

Ringold Units 4 through 9 consist of intercalated layers of indurated to semi-indurated and/or pedogenically altered sediment, including clay, silt, fine-to-coarse grained sand, and granule-to-cobble gravel. Within the area of the S-10, this sequence consists of only three distinct stratigraphic intervals designated Units 5, 8, and 9. Units 5, 8, and 9 correspond generally to Lindsey's Ringold Formation fluvial gravel Unit E, lower mud unit and fluvial gravel Unit A, respectively (see Figure 3.2).

Unit 9. The Ringold Unit 9 gravel is located between 140 to 149.5 m (460 to 490 ft) beneath the S-10 and ranges up to 30.5 m (100 ft) thick. This unit dips to the south-southwest and lies uncomfortably on top of the Columbia River Basalt. Unit 9 is composed primarily of semi-consolidated and cemented silty sandy gravel with secondary lenses and interbeds that can consist of gravel, gravely sand, sand, muddy sand, and/or silt/clay.

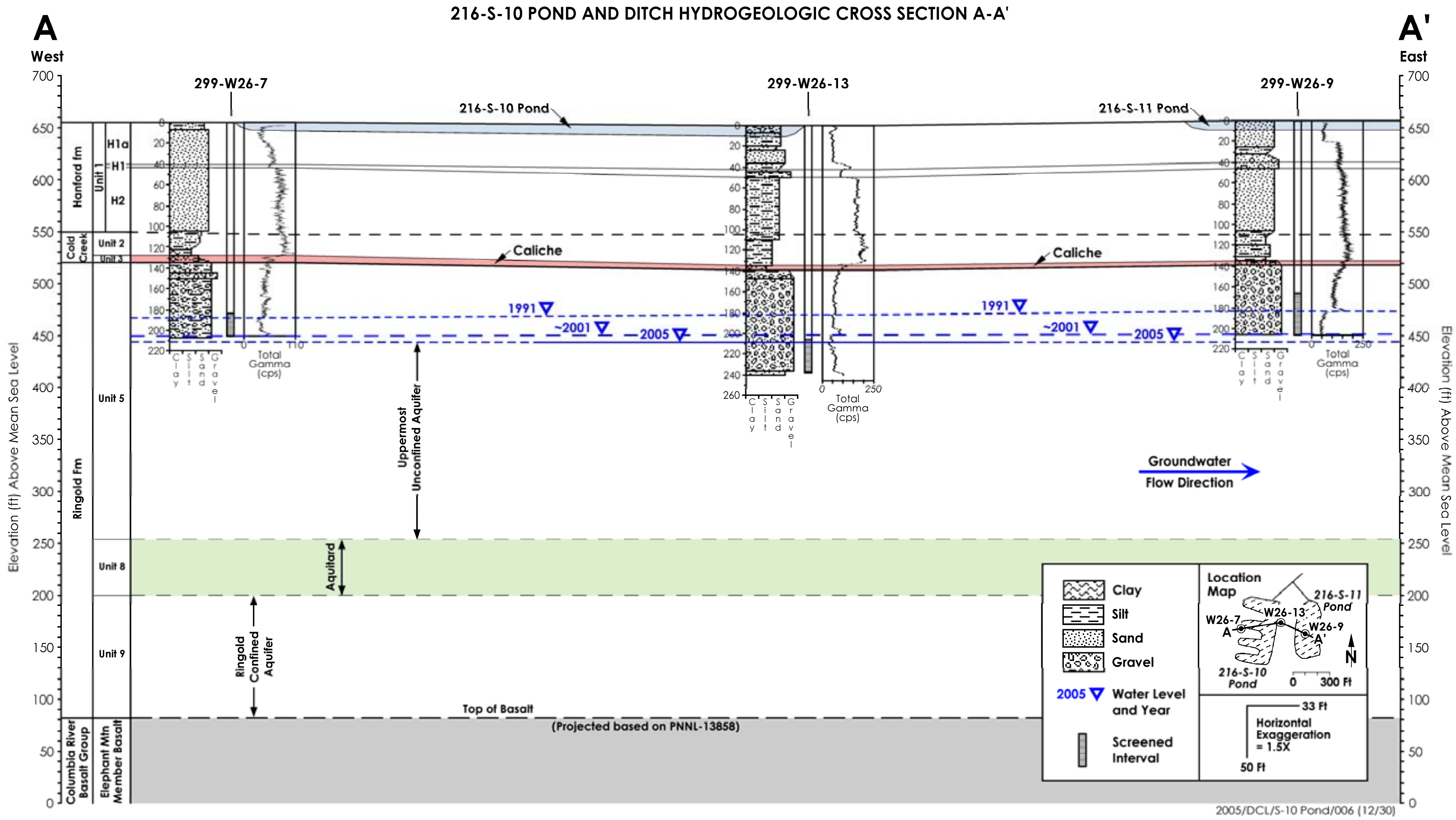


Figure 3.5. Detailed Hydrogeologic Cross Section at the S-10

Unit 8 (Lower Mud Unit). Unit 8 is composed of a thick sequence of fluvial overbank, paleosol, and lacustrine silts and clay with minor sand and gravel. Unit 8 forms the most significant and extensive confining unit within the suprabasalt aquifer system at the Hanford Site (Williams et al. 2000). More detailed descriptions of Unit 8 (the lower mud unit) can be found in Lindsey (1995). This unit is between 12 to 21 m (40 to 70 ft) thick and located approximately 129 m (423 ft) beneath the S-10.

Unit 5. The Ringold Unit 5 gravel is a relatively thick unit, ranging up to 76 m (250 ft) thick, composed primarily of indurated fluvial gravel to silty sandy gravel and sand that grades upward into Unit 4 (interbedded fluvial sand and silt). Unit 5 has not been subdivided further due to the lack of distinctive and correlatable stratigraphy or lithologic units. The saturated portion of Unit 5 comprises the uppermost unconfined aquifer and is over 58 m (190 ft) thick beneath the S-10. Unit 5 overlies the Unit 8 (Ringold lower mud unit).

Unit 4. The Ringold Unit 4 is only locally present in the 200 West Area, and consists of fluvial sand and silt that overlies the Ringold Unit 5 gravel. This unit is not present in the wells surrounding the S-10. More information on the areal extent and details of this unit can be found in Lindsey (1995).

3.1.2 Cold Creek Unit (Units 2 and 3)

Units 2 and 3 represent relatively thin but significant depositional units that are post-Ringold and pre-Hanford sedimentation. Unit 3 is a calcic paleosol horizon that has developed on the eroded Ringold Formation (either Unit 4 or 5). Unit 3 is commonly referred to as the calcic sequence (or "caliche" zone) and is also referred to as the lower Cold Creek unit (CCU_{cp}). Unit 2 is described as an overlying fine-grained overbank-eolian sequence considered to belong to the upper portion of the Cold Creek unit (CCU_{oe}). It is equivalent to what has been called the early "Palouse" soil (Connelly et al. 1992) in previous reports. Unit 3 is easily differentiated from the underlying (Unit 5) and overlying overbank-eolian sequence (Unit 2) because it is highly weathered, heavily cemented with calcium carbonate, poorly sorted, and shows a distinct decrease in natural gamma activity compared to the upper Unit 2, which is very fine grained, un-cemented, consisting of alternating thin lenses (typically less than 15.2 cm [6 in.]) of very fine sand to silt and clay, and has a relatively high natural gamma activity. The stratigraphic contact between the Unit 3 and the Ringold Unit 5 is fairly distinct and sharp, whereas the contact between the Unit 2 and the overlying Hanford Unit 1 is gradational, dependent on grain size. In most cases, geophysical gamma logs greatly improve the accuracy of these correlations. Figure 3.5 illustrates these contacts near the southern end of the facility.

At the S-10, Unit 3 is less than 1 m (3.3 ft) thick. Unit 2 ranges from 10 to 15 m (33 to 50 ft) thick. Unit 2 is located from approximately 33 to 43 m (110 to 140 ft) in depth below the surface.

3.1.3 Hanford Formation (Unit 1)

The Hanford formation is the informal name given to Pleistocene-age cataclysmic flood deposits in the Pasco Basin (Lindsey et al. 1994). It consists predominantly of unconsolidated sediments, which cover a wide range in grain size from pebble- to boulder-gravel, fine- to coarse-grained pebbly sand to sand, silty sand, and silt. Gravel clasts are composed of mostly subangular to subrounded basalt. Beneath the S-10, the Unit 1 consists of essentially three facies, the lower facies (Hanford H_2 unit) is composed of fine-grained sand to sandy silt that ranges from 12 to 18 m (40 to 60 ft) in thickness. This fine-grained facies is overlain with a fine to coarse sand to sandy gravel sequence that ranges from 1 to 3 m (3 to 10 ft) in thickness. This coarse grained interval is designated the Hanford H_1 unit and is similar to the same zone described at Johnson and Chou (1999, Figure B.8). The uppermost fine grained sequence is designated the Hanford H_{1a} unit.

3.2 Groundwater Hydrology

Information on the vadose zone and the suprabasalt aquifer system at the S-10 is obtained from well-log data for wells and boreholes surrounding the facility and from published reports. In the 200 West Area and vicinity of S-10, Williams et al. (2002) use data from boreholes and groundwater monitoring to subdivide the suprabasalt sediments into two aquifers, an upper unconfined (Hanford/Ringold) aquifer and a lower confined (Ringold confined aquifer). The hydrogeology beneath the S-10 is adequately explained by this interpretation.

The uppermost aquifer beneath the S-10 is unconfined; the aquifer comprises the saturated portion of the Ringold Unit 5 and is approximately 57 m (187 ft) thick (2005 measurement). Groundwater flow direction is approximately east to southeast in the vicinity of S-10, and is calculated based on water-level measurements taken in network and surrounding wells (e.g., Figure 2.8-2 in Hartman et al. 2006).

Site-specific hydraulic conductivity values, derived from constant discharge test data at two wells near the S-10, range from 10 to 150 m (33 to 492 ft) per day (Williams and Barnett 1993; Kipp and Mudd 1973). Based on these values, a March 2005 hydraulic gradient of 0.0015, an effective porosity of 0.1 to 0.2, the groundwater flow rate (Darcy velocity) ranges from 0.075 to 2.25 m (0.25 to 7.4 ft) per day.

Throughout the 200 West Area, including the S-10, the water table is declining rapidly due to site-wide cessation of past liquid effluent disposal practices. Hydrographs for monitoring wells near the S-10 are presented in Figure 3.6. The falling water table is causing wells in the S-10 network and surrounding monitoring wells to go dry, but the rate of decline appears to be slowing over the past ~2 years (see Figure 3.6).

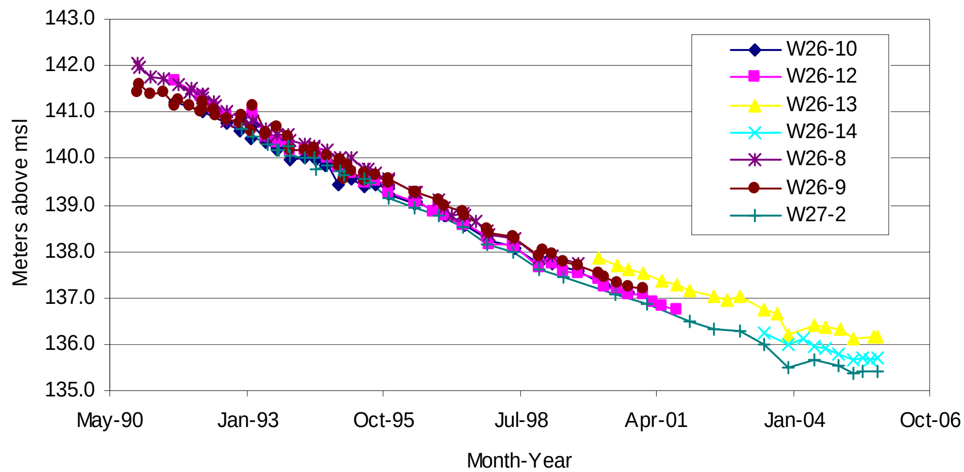


Figure 3.6. Hydrographs of Wells Monitoring the S-10 through September 2005

Beneath the S-10, groundwater in the uppermost unconfined aquifer is assumed to be isolated from groundwater in the confined Ringold aquifer by Unit 8 (lower mud unit). Intercommunication between Units 5 and 9 is assumed to be insignificant because groundwater flow through Unit 8 is extremely low due to the thickness and relative permeability of the confining unit.

The top of Unit 8 (lower mud unit) comprises the base of the uppermost-unconfined aquifer (Williams et al. 2002). Beneath the S-10, the vertical hydraulic conductivity of Unit 8, as measured from a split-spoon soil sample collected in well 299-W27-2, is 0.051 m (0.17 ft) per day and falls within the expected range reported by Thorne and Newcomer (1992).

The Unit 8 (lower mud unit) is an aquitard and separates and confines groundwater in the underlying Ringold Unit 9 gravel (confined Ringold aquifer) from the unconfined aquifer in Unit 5. Groundwater in the confined Ringold aquifer is interpreted to flow laterally through Unit 9 gravel due to the thickness and relatively low vertical hydraulic conductivity of the overlying confining Unit 8.

Regionally, groundwater in the confined Ringold aquifer flows from west to east similar to groundwater in the uppermost unconfined aquifer. In the 200 West Area and around the S-10, it is more difficult to determine flow direction because there are currently no wells completed within the confined Ringold aquifer. Limited data are available below the confining Unit 8 (lower mud unit) for the 200 West Area; however, groundwater heads measured in several deep/shallow well pairs, and deep wells drilled into the Ringold Unit 9 confined aquifer (e.g., Johnson and Horton 2000) indicate a downward vertical hydraulic gradient beneath the 200 West Area from the unconfined Unit 5 into the confined Unit 9 (Williams et al. 2002).

The vadose zone beneath the S-10 is up to 72 m (236 ft) thick. The vadose zone includes hydrogeologic Units 1, 2, 3 and the upper, unsaturated portion of Unit 5 (see Figure 3.2). Figure 3.5 provides input to the conceptual model for the area near the S-10 and S-11 ponds and includes depths, relative thicknesses, and hydraulic relationship of the hydrogeologic units beneath the facility.

Recharge to the unconfined aquifer beneath the S-10 is from artificial and possibly natural sources. Natural recharge from precipitation is the only source of recharge since discharges ceased in 1991. A likely range of average recharge for the S-10 is between 5 and 25.4 cm/year, and is probably toward the higher end of this range because of the surface covering of coarse sand and sparse vegetation at the site (Rockhold et al 1995).

While the local liquid waste disposal facilities were operating, many localized areas of saturation or near saturation were created in the soil column. Artificial recharge from years of liquid effluent disposal accounts for most of the liquid influx to the aquifer and is the main driver and transport medium for potential contaminants disposed at the facility. Perched water, created due to liquid effluent disposal to the S-10 ditch, was observed above the Cold Creek unit 3. Well 299-W26-11, located near the pipeline inlet end of the S-10 ditch (north end), monitored this perched water interval until the well went dry after liquid effluent disposal ceased at the waste site.

The downward flux of moisture in the vadose zone decreased with the cessation of artificial recharge in the S-10 area. Areas with high residual water saturation in the sediment will continue gravity drainage for an unknown period of time. When stable unsaturated conditions are reached, the moisture flux into the aquifer becomes less significant.

4.0 Summary of Groundwater Monitoring Results

Prior to RCRA groundwater monitoring, the S-10 was monitored by various means including effluent stream sampling, surface radiation surveys, aerial radiation surveys, composite weekly water quality samples from the ditch, and sediment and vegetation samples (DOE 2000). Sampling and analysis of groundwater at the S-10 has been conducted under RCRA interim status requirements since the third quarter of 1991. RCRA monitoring at the S-10 has not detected an impact to groundwater based on upgradient-downgradient indicator parameter statistical comparisons. This section summarizes significant historical results of groundwater analyses for the S-10 through December 2005, using all the RCRA-compliant (WAC 173-160 as referenced by WAC 173-303-645(8)(c)) groundwater monitoring wells, including those that have gone dry. Hanford Site groundwater background concentrations of constituents discussed here are those determined by DOE (1997).

Wells 299-W26-7, 299-W26-8, 299-W26-9, 299-W26-10, and 299-W26-12 monitored the upper 4.5 to 6 m (15 to 20 ft) of the uppermost aquifer. Well 299-W26-11 was completed in a perched water zone above the Cold Creek unit 2 and 3 to monitor apparent perched effluent recharging to the aquifer. Well 299-W27-2 was installed in 1992 and monitors the lower 3 m (10 ft) of the uppermost aquifer, just above unit 8. Due to declining water levels, none of the original six upper aquifer monitoring wells remains in service today. Not including the perched aquifer well, four wells have gone dry, at an average rate of one well per year starting in early 1998; the last upgradient well, 299-W26-7, went dry in 2003. Two replacement wells, 299-W26-13 and 299-W26-14 (completed in 2000 and 2003, respectively), have been added to the network near the S-10. These and the deep well are the only wells remaining in service at this time. These two wells monitor the upper portion of the uppermost aquifer downgradient of the S-10.

4.1 Contamination Indicator Parameters

Required statistical evaluations of the contamination indicator parameters (specific conductance, pH, total organic carbon, and total organic halides) have been conducted since 1992, immediately after background values were established. Since then, background values have been revised several times to reflect the changes in site conditions (e.g., wells gone dry). Statistical evaluations of indicator parameters have not indicated that the S-10 has affected the groundwater quality in the uppermost aquifer beneath the site.

4.2 Metals

Concentrations of filtered (dissolved) metals have been measured by inductively coupled plasma (ICP) method. Cadmium, copper, mercury, selenium, and silver are essentially not detected. Detection of lead in S-10 wells is problematic. Several low-level (~2 to 8 µg/L) detections of lead are reported, but these coincide with duplicate samples that were non-detects and are suspect. Concentrations-versus-time plots for chromium are presented in Figure 4.1.

Chromium concentrations, especially in well 299-W26-7, increased above the 100-µg/L drinking water standard (DWS) (highest value = 576 µg/L) and then dropped below the DWS between October 1995 and July 1998, suggesting a transient release event. Historical records indicate the release to the S-10 of a high-salt waste (simulated tank waste) containing hexavalent chromium. For example, a one-time release of 416.4 L (110 gal) of synthetic double-shell tank waste was released to the ditch and pond system in September 1983 (see Section 2.2). Assuming a transport time of several years through the vadose zone to groundwater, and considering the volume of water and mass of chromium (~3,000 g as chromium), the observed transient and approximate chromium concentrations are consistent with the 416.4-L (110-gal) release event. Although well 299-W26-7 is an upgradient well, it is located very close to one lobe of the pond system. Wastewater from the S-10 may have reached this well by spreading laterally in the subsurface.

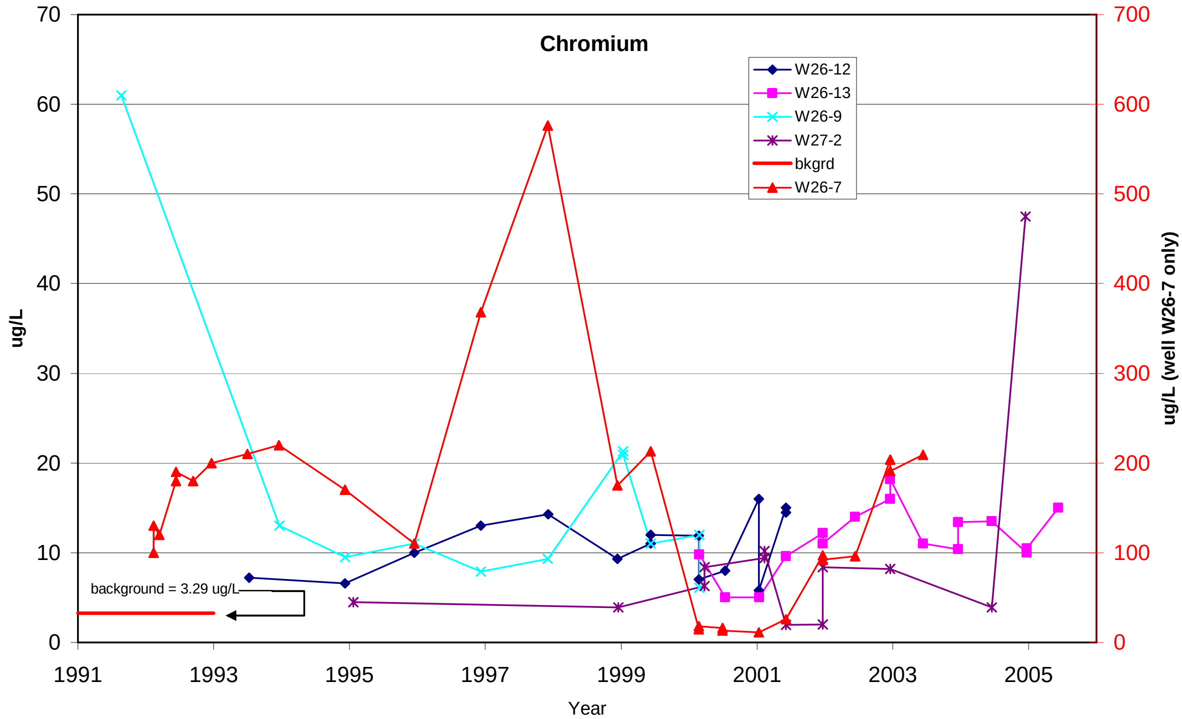


Figure 4.1. Chromium Concentrations in S-10 Wells (filtered; Note: Different scale for well 299-W26-7.)

4.3 Anions

Anions are analyzed by the ion chromatography method. Nitrate concentrations (Figure 4.2) have been historically covariate with chromium concentrations in downgradient wells 299-W26-9, 299-W26-10, and 299-W26-12 and also in the upgradient well 299-W26-7 that is located adjacent to, and upgradient of the S-10 pond (Figures 4.3 through 4.6). The peak concentration was observed in December 1997 in wells 299-W26-7, 299-W26-10, and 299-W26-12, but peak concentrations of chromium and nitrate in well 299-W26-9 were observed in January 1999. Nitrate in wells 299-W26-7 (now dry) and 299-W26-14 has shown recent upward trends, but the actual concentrations of nitrate in these wells are far below Hanford Site background (26,871 µg/L). Hence, it is possible that these trends reflect a recovery of groundwater to natural levels of nitrate after being diluted by relatively clean effluent for several years.

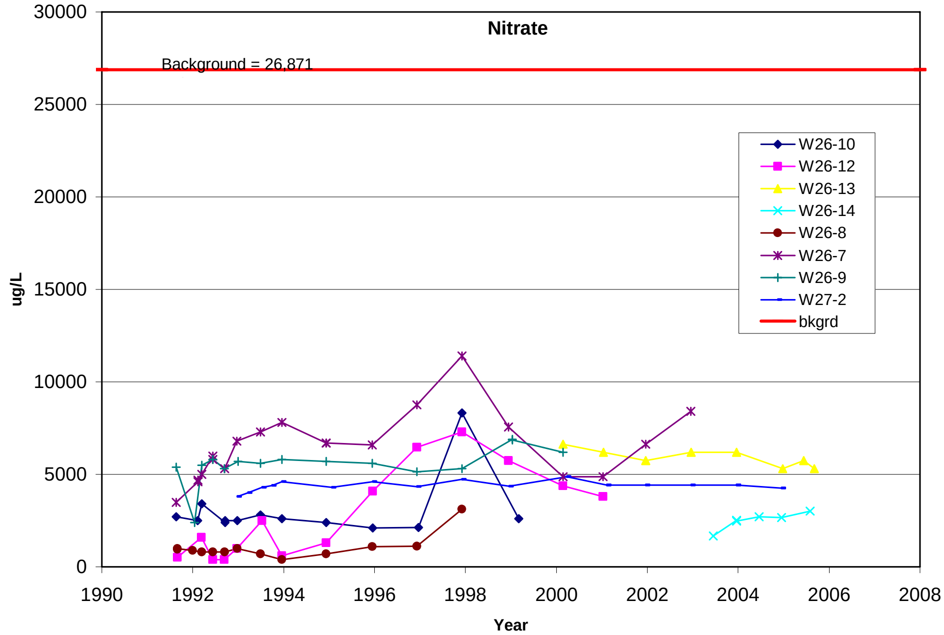


Figure 4.2. Nitrate Concentrations versus Time (Note: Hanford Site-wide nitrate background 26,871 µg/L is the 90th percentile per DOE 1997.)

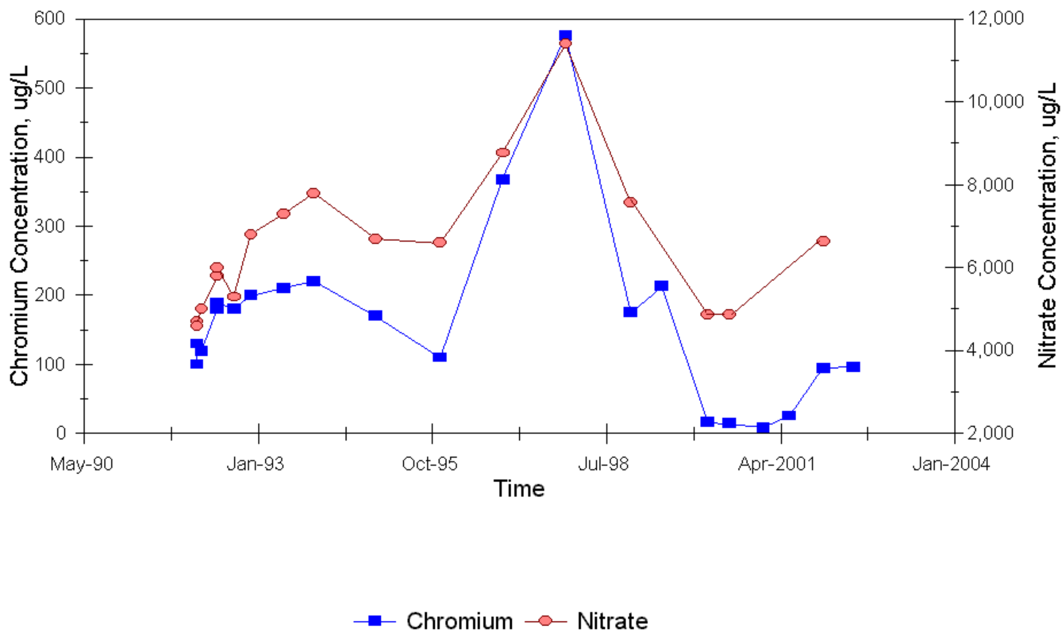


Figure 4.3. Chromium (filtered) and Nitrate Concentrations in Well 299-W26-7

Chloride, fluoride, and nitrite are also listed in the Part A Permit Application. Trends for chloride and fluoride are shown in Figures 4.7 and 4.8. Nitrite, a possible source of nitrate by decomposition, has been detected only once (174 µg/L in 2004 in well 299-W26-14) in the S-10 network out of 108 analyses since RCRA monitoring began in 1991. This result is suspect because of laboratory spike samples that were out of the acceptable range.

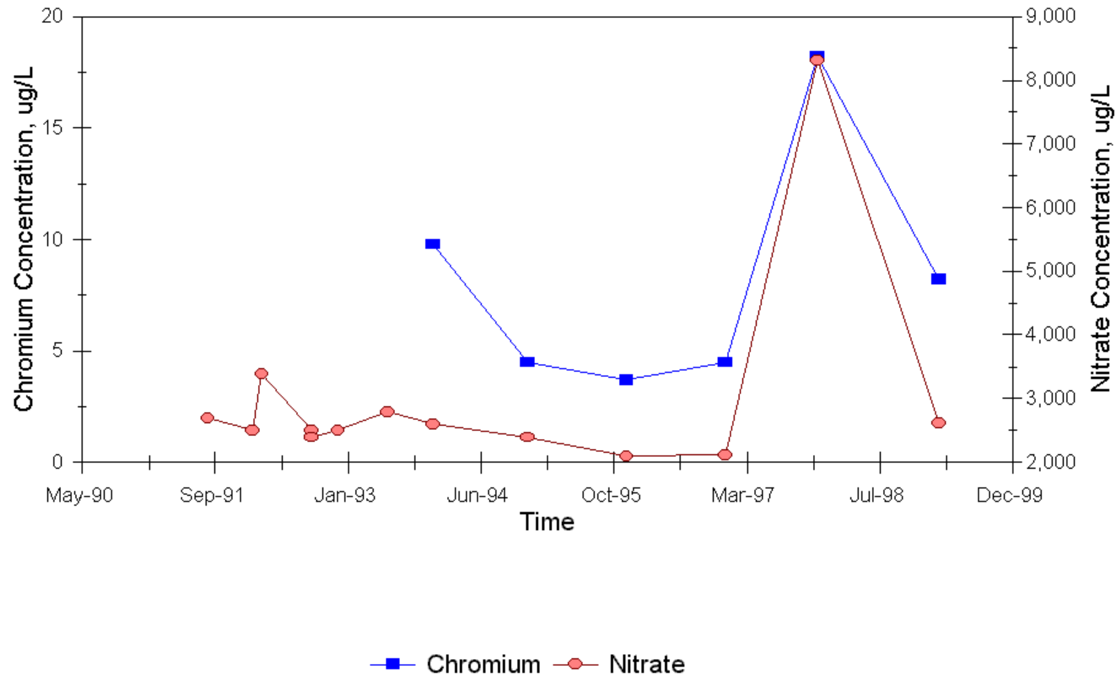


Figure 4.4. Chromium (filtered) and Nitrate Concentrations in Well 299-W26-10

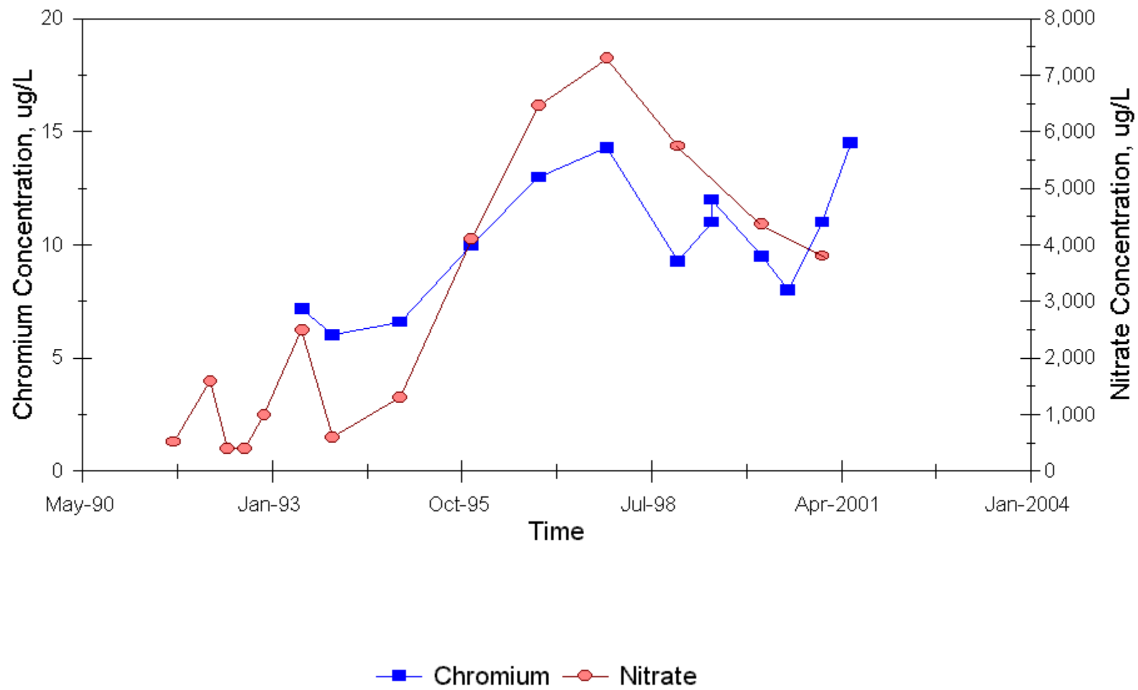


Figure 4.5. Chromium (filtered) and Nitrate Concentrations in Well 299-W26-12

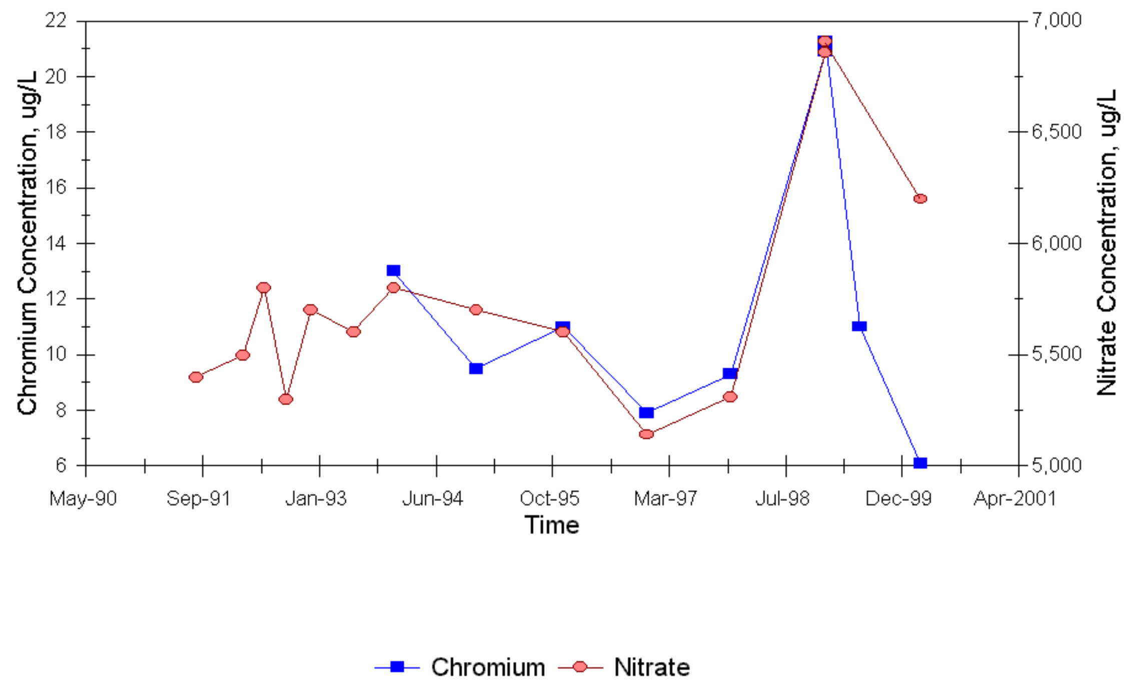


Figure 4.6. Chromium (filtered) and Nitrate Concentrations in Well 299-W26-9

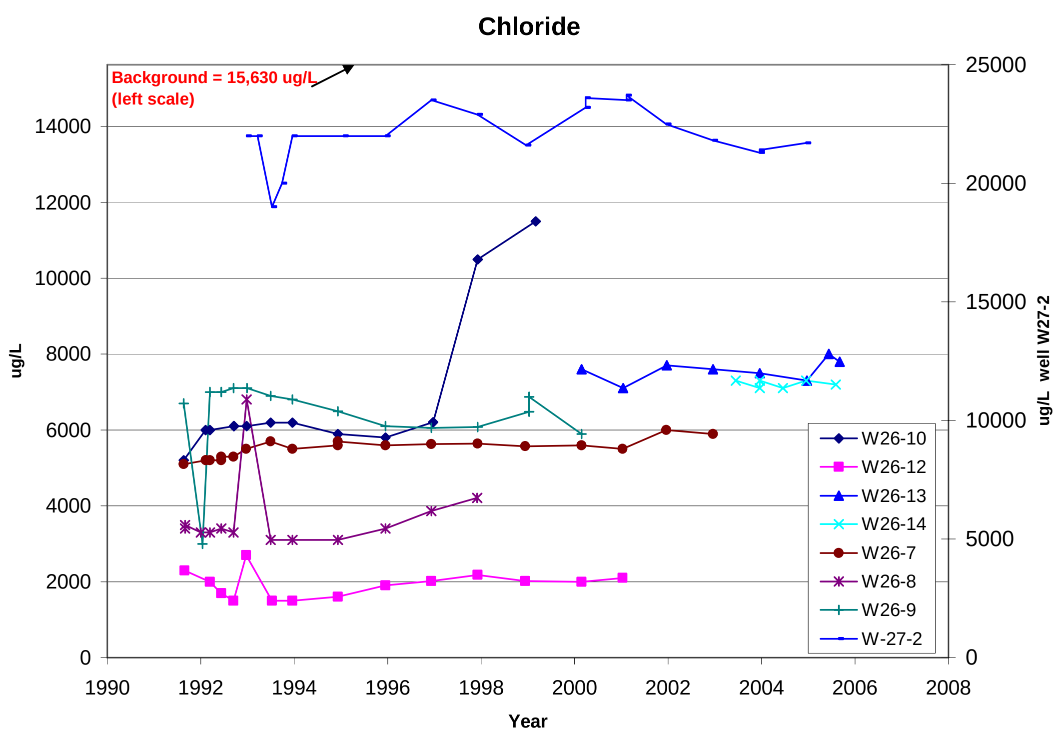


Figure 4.7. Chloride Concentrations in the S-10 Wells (Note: Right-hand scale for well 299-W27-2; the site-wide background for chloride per DOE 1997 is 15,630 µg/L at the 90th percentile.)

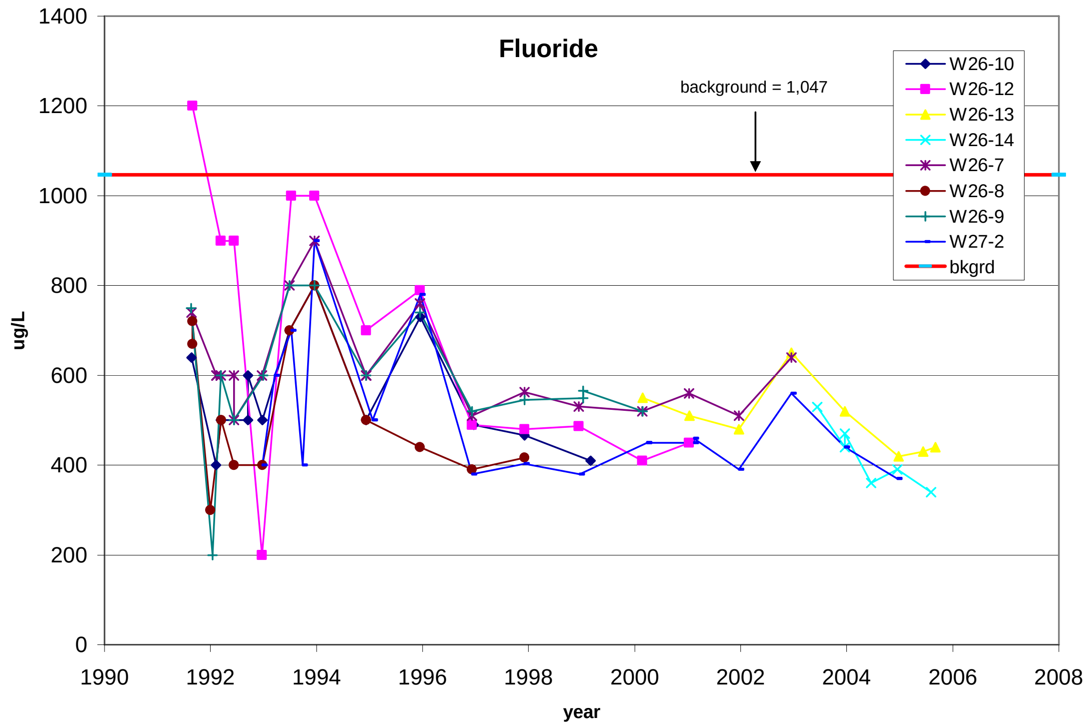


Figure 4.8. Fluoride Concentrations in S-10 Wells (The site-wide background per DOE 1997 is 1,047 µg/L at the 90th percentile.)

4.4 Constituents Exceeding Drinking Water Standards

The only constituents exceeding DWS occurred in the shallow upgradient well 299-W26-7 for hexavalent chromium (maximum 576 µg/L in 1997) and in wells 299-W27-2 and 299-26-12 for carbon tetrachloride. Well 299-W27-2 has had results for carbon tetrachloride slightly above the 5-µg/L DWS, the highest of which was 6.4 µg/L in 2001. The only other result above DWS occurred in well 299-W26-12 in 1999 (6.0 µg/L) before the well went dry. All other wells in the network have produced at least one detectable result of carbon tetrachloride. This compound is believed to have originated from a source upgradient of the S-10. Carbon tetrachloride is not a constituent related to TSD unit activities and will be addressed by actions attending the 200-UP-1 Operable Unit RI/FS. Section 4.2 discusses the elevated hexavalent chromium that exceeded primary DWS.

5.0 Conceptual Model

A conceptual model of contaminant transport through the vadose zone to groundwater beneath the 216-S-10 ditch and pond system is used to develop an appropriate and cost-effective monitoring plan. The conceptualization begins with a summary of physical and chemical conditions at the disposal site and related assumptions. The most important of these are:

- The large volume of water (6.6 x 109 L [1.7 x 109 gal]) discharged to the S-10 was sufficient to wet the soil column down to groundwater beneath both the unlined ditch and the pond.

- Waste streams discharged to this waste site were classified as neutral to basic, low ionic strength, and low organic content (WHC 1990, Appendix C). These effluent chemical characteristics are favorable for sorption of certain heavy metals (see bullets below) by vadose zone sediment.

- Fine-grained and/or low permeability sedimentary layers in the vadose zone (i.e., the Cold Creek unit) created perched water conditions and allowed subsurface, lateral spreading, possibly beyond the boundary of the ditch and pond system. As a result, wastewater may have reached upgradient monitoring wells.

- Mobile contaminants associated with residual wastewater pore fluid are distributed over the entire soil column beneath the ditch and pond. Based on a two-layer model, wastewater transport time through the vadose zone to groundwater by a conservative species (e.g., a metal with retardation factor of 10, or distribution coefficient of ~4.0) during the active discharge period was previously estimated to be 2.7 years at this facility during operation. Movement of water to groundwater from operation was estimated to take approximately 0.27 years (99 days) using the same model (WHC 1990, Appendix B; Cantrell et al. 2003). Thus, mobile contaminants released during the operating period had adequate time to break through to groundwater during the operational period.

- There is no surface barrier to natural infiltration. A likely range of average recharge for the S-10 is between 5 to 25.4 cm/year, and is probably toward the higher end of this range because of the surface covering of coarse sand and sparse vegetation at the site (Rockhold et al. 1995; Vermeul et al. 2001).

- The contaminants of concern, chloride, fluoride, nitrate, and nitrite, are assumed to be mobile (relatively non-sorbing) because they are anions (including the oxymetal anion, chromate).

- Adjacent disposal waste sites (see Figure 2.1) are subject to similar hydrogeologic controls and received similar waste streams during operational life. Hence, distinguishing between contamination contributions from these waste sites and the S-10 may be difficult, particularly without extensive well coverage.

- Groundwater flow direction beneath S-10 is to the east-southeast, and will retain that general direction (east-northeast) even after water levels have fallen to pre-Hanford levels.

Based on the hydrogeology of the site, operational history, and the assumptions and conditions as noted above, a schematic representation of contaminant transport through the vadose zone to groundwater was constructed as illustrated in Figure 5.1.

During operation, the conceptual model shows that saturated or semi-saturated flow conditions prevailed beneath the ditch and pond system. Contaminants from periodic releases migrated through the soil column to groundwater. Lateral spreading may have brought waste constituents to the upgradient well (299-W26-7). This could account for the occurrence of chromium in this well, but does not eliminate upgradient waste sites as possible sources.

The coincidence of peak concentrations of chromium and nitrate in groundwater at this facility may reflect the release of potassium dichromate (hexavalent chromium) in chemical waste discharged to the ditch in September 1983 from a simulated double-shell tank waste associated with the Chemical Engineering Laboratory. Hexavalent chromium (filtered samples) in both upgradient and downgradient monitoring wells at the S-10 demonstrates that this constituent reached groundwater from the S-10 or an upgradient source. Chromium is assumed to be present as a highly mobile oxymetal anion. The presence of chromium in these wells is consistent with this expectation.

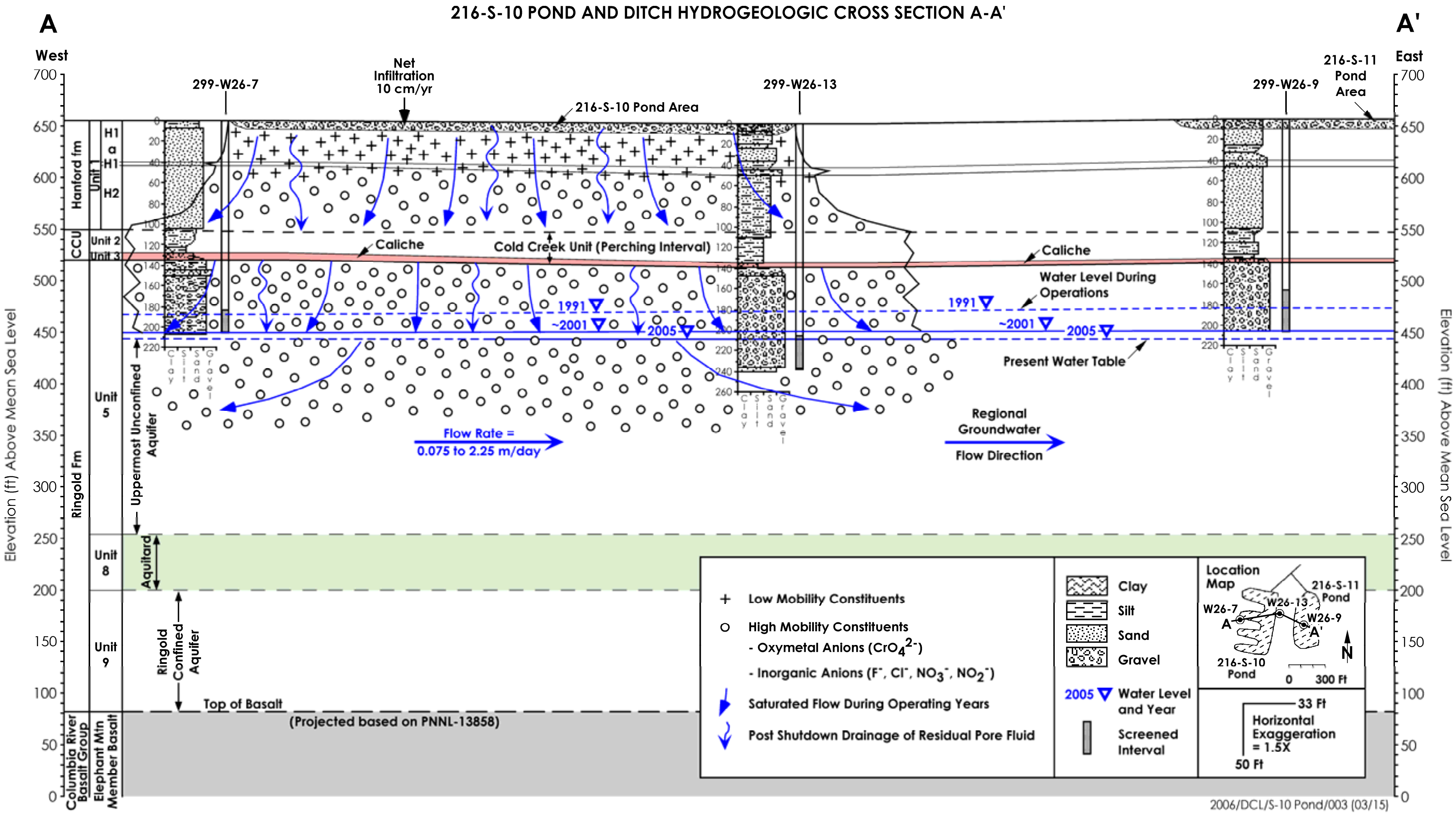


Figure 5.1. Conceptual Model of Infiltration of Effluent at the 216-S-10 Pond and Ditch

6.0 Groundwater Monitoring Program

This section describes a post-closure groundwater monitoring program for the S-10 consisting of monitoring well network, target constituents, sampling and analysis protocol, and quality assurance (QA) and quality control (QC). This plan will replace the existing RCRA interim status groundwater monitoring plan following approval by Ecology and implementation of the closure plan. This new plan is expected to be effective until the post-closure care period has expired or other agreement is reached between DOE and Ecology on groundwater monitoring for this TSD unit. Relevant sections of this plan (i.e., 6.3 and 7.0) are expected to be incorporated into the post closure monitoring plan in the Hanford Facility RCRA Permit (Ecology 1994) for post closure of S-10. All applicable aspects of the plan are adherent to provisions of the Detection Monitoring Program (D-10e) in the *Hanford Facility RCRA Permit General Information Portion, Attachment 33* (DOE 2003). Specific procedures are described in more detail in the following paragraphs.

6.1 Objectives of RCRA Monitoring

The objectives of RCRA groundwater monitoring at the S-10 are:

- To detect and assess sources of groundwater contamination relating to S-10 TSD unit constituents.
- To improve upon the ability to demonstrate whether the source(s) of elevated chromium concentrations at upgradient and downgradient wells originate from the S-10 or an upgradient source.
- To fulfill post-closure care requirements for S-10 TSD unit groundwater monitoring.

The ultimate goal is to design a technically sound and cost-effective monitoring program that is capable of protecting human health and the environment.

6.2 Special Conditions at the 216-S-10 Pond and Ditch

The S-10 is closely situated among other disposal waste sites of very similar operational histories. The proximity of the S-10 to the other waste sites (216-S-17 pond, 216-S-11 pond, 216-S-5,6 cribs, 216-S-16 ditch and pond, and 216-U-9 ditch) indicate that at least some observed groundwater contamination beneath and downgradient of S-10 could have originated from waste sites other than S-10. Hence, it may be infeasible to strictly discriminate between the contributions of each waste site to groundwater contamination beneath the S-10, despite the installation of new groundwater monitoring wells. In addition, the declining water table in the 200 West Area, especially in the vicinity of the S-10, caused many RCRA-compliant wells to go dry in a short period, including the only upgradient well, 299-W26-7. The foreshortened life of these wells greatly restricted their usefulness for interpretation purposes. Furthermore, the upgradient well was emplaced so close to the 216-S-10 pond as to draw into question whether the observed groundwater quality was affected by the pond itself or an upgradient source (e.g., the 216-S-17 pond). These circumstances add to the difficulty in determining if a contaminant originates from the S-10 waste site or other site.

6.3 Sampling and Analysis Plan

A post-closure groundwater monitoring network is proposed that will include the drilling of three new wells to replace wells that have gone dry. When completed, the revised network will meet the intent of RCRA network requirements for a post-closure detection groundwater monitoring according to WAC 173-303-645(9) and may help to shed light on the origin(s) of certain contaminants at the S-10.

6.3.1 Monitoring Well Network

The declining water table in the 200 West Area, especially in the vicinity of the S-10, caused many wells to go dry. None of the original upper aquifer monitoring wells remains in service due to declining water levels (see Figure 3.6). Well 299-W27-2 was installed in 1992 and monitors the lower 3 m (10 ft) of the uppermost aquifer, just above Unit 8. Two replacement wells, 299-W26-13 and 299-W26-14 were added to the network (completed in January 2000 and 2003, respectively) near the S-10 Pond. Both of these wells were constructed with a 11-m (35-ft) well screen. The locations of existing and proposed wells are shown in Figure 6.1.

The well network (Table 6.1; Figure 6.1) is designed to:

- Represent the background quality groundwater at S-10 [WAC 173-303-645(8)(a)(i)]
- Determine the quality of groundwater passing the point of compliance[WAC 173-303-645(8)(a)(ii)]
- Allow for the detection of contamination if dangerous waste or dangerous constituents have migrated from the S-10 to the uppermost aquifer [WAC 173-303-645(8)(a)(iii)].

Currently, only two downgradient wells, 299-W26-13 and 299-W26-14, monitor the S-10. One deep RCRA well, 299-W27-2, which monitors groundwater conditions at the base of the uppermost unconfined aquifer, is sampled for auxiliary information.

Three additional wells (one upgradient, two downgradient) are currently planned. The proposed network for groundwater monitoring will be evaluated annually to determine if it is adequate to provide groundwater monitoring through the post-closure period. These wells are prioritized under the Tri-Party Agreement milestone M-24-57 well drilling activities.

6.3.2 Constituent List and Sample Frequency

Site-specific constituents of concern are selected based on these criteria:

- Constituent is a dangerous waste constituent identified in the Part A Permit Application, or
- Constituent is a mobile decomposition product (e.g., nitrate from nitrite) of a Part A constituent, or
- Constituent is a reliable indicator of the site-specific contaminants (e.g., specific conductance).

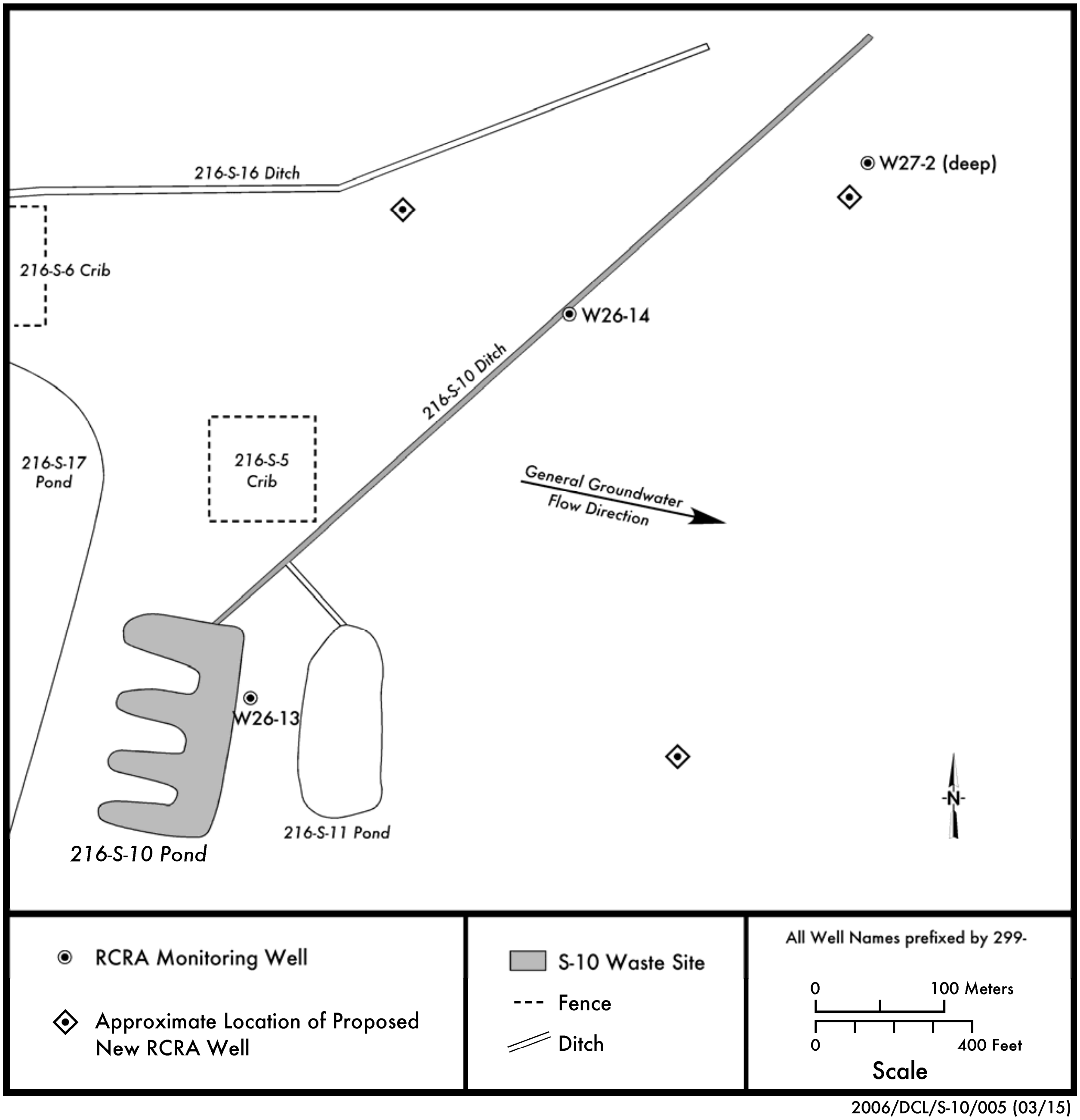


Figure 6.1. Well Location Map at the 216-S-10 Pond and Ditch

Based on these criteria, the constituent list of Table 6.2 is derived for the S-10. Major dissolved ions, alkalinity, turbidity, and temperature are included as indicators of sample and analytical quality, and general aquifer/well background conditions. Groundwater samples from the newly installed upgradient wells will be sampled at least quarterly for one year to obtain the minimum number of samples needed to establish background. Groundwater will be sampled at the downgradient wells for all constituents on a semiannual basis except the groundwater quality parameters, which will be sampled annually.

Table 6.1. Revised Monitoring Well Network for the 216-S-10 Pond and Ditch

Well ID	Well Name	Purpose	WAC Compliant	Constituents of Interest						Supporting Constituents						
				Hexavalent Chromium, filtered	Chloride	Fluoride	Nitrate	Nitrite	Specific Conductance[(a)]	Alkalinity	Anions[(b)]	Metals, filtered[(c)]	pH[(a)]	Temperature[(a)]	Turbidity[(a)]	Water Level
B8817	299-W26-13	Downgradient	C	S	S	S	S	S	S	A	A	A	S	S	S	S
B8828	299-W26-14	Downgradient	C	S	S	S	S	S	S	A	A	A	S	S	S	S
N/A	3 new wells[(d)]	1 upgradient, 2 downgradient	C	S	S	S	S	S	S	A	A	A	S	S	S	S
A5410	299-W27-2	Base of unconfined aquifer; information only	C	S	S	S	S	S	S	A	A	A	S	S	S	S

(a) Field measurement.
(b) Anions - Analytes include but not limited to chloride, fluoride, nitrate, and nitrite.
(c) Metals - Analytes include but not limited to calcium, potassium, magnesium, and sodium.
(d) At least quarterly for one year to establish background.
A = To be sampled annually.
C = Well is constructed as a WAC 173-160 resource protection well.
S = To be sampled semiannually.

6.3.3 Sampling and Analysis Protocol

Monitoring of the S-10 is part of the Hanford Groundwater Performance Assessment Project (groundwater project). Procedures for groundwater sampling, documentation, sample preservation, shipment, and chain-of-custody requirements are described in DOE (2003). Samples generally are collected after three casing volumes of water have been purged from the well or after field parameters (pH, temperature, specific conductance, and turbidity) have stabilized. For routine groundwater samples, preservatives are added to the collection bottles before their use in the field. Samples to be analyzed for metals are filtered in the field so that results represent dissolved metals.

Procedures for field measurements are also specified in DOE (2003) and the subcontractor's or manufacturer's manuals. Analytical methods are specified in contracts with laboratories, and most are standard methods from *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA 1986a, as amended).

6.3.4 Quality Assurance and Quality Control

The groundwater monitoring project's QA/QC program is directed by the DOE contractor's Quality Assurance Plan and is designed to assess and enhance the reliability and validity of groundwater data. Groundwater sampling and analysis activities for DOE also adhere to *EPA Requirements for Quality Assurance Project Plans* QA/R-5 (EPA 2001). The primary quantitative measures or parameters used to assess data quality are accuracy, precision, completeness, and the method detection limit. Qualitative measures include representativeness and comparability. Goals for data representativeness for groundwater monitoring are addressed by the specification of well locations, well construction, sampling intervals, and sampling and analysis techniques in the groundwater monitoring plan for each TSD unit. Comparability is the confidence with which one data set can be compared to another. The QC parameters are evaluated through laboratory checks (e.g., matrix spikes, laboratory blanks), replicate sampling and analysis, analysis of blind standards and blanks, and inter-laboratory comparisons. Acceptance criteria have been established for each of these parameters in the project QA plan based on guidance from the U.S. Environmental Protection Agency (EPA 1986a). When a parameter is outside the criteria, corrective actions are taken to prevent a future occurrence and affected data are flagged in the database.

Table 6.2. Constituent List, Schedule, and Evaluations for the 216-S-10 Pond and Ditch

Constituent (DWS or SDWS in μg/L unless noted)	Sampling Frequency	Type of Comparison (Value)	Action if Result Exceeds Comparison Value
Site-Specific Parameters			
Hexavalent chromium (**100 for total Cr**)[(a)]	Semiannual	Trending and comparison to **DWS**[(a)]	Verification/Notification
Chloride (**250,000**)	Semiannual	Trending and comparison to **SDWS**	Notification
Fluoride (**2,000**)	Semiannual	Trending and comparison to **SDWS**	Notification
Nitrate as NO_3 (**45,000**)	Semiannual	Trending and comparison to **DWS**	Notification
Nitrite as nitrogen (**1,000**)	Semiannual	Trending and comparison to **DWS**	Notification
Specific conductance (field)[(a)]	Semiannual	Trending and comparison to **site-wide background**[(a,b)]	Verification/Notification
Additional Parameters			
Alkalinity	Annual	Used for calculation of charge balance	NA
Metals, in addition to chromium	Annual	Trending and comparison to **DWS** and/or background[(b)]	Notification only if a metal exceeds a primary DWS
pH (field) (**6.5 to 8.5**)	Semiannual	Trending and comparison to **DWS**	Notification only if a value falls outside DWS range for two consecutive sampling events
Temperature (field)	Semiannual	Information and sample quality screening	NA
Turbidity (field)	Semiannual	Information and sample quality screening	Project Scientist notified if turbidity exceeds 5.0 NTU

(a) These constituents will be subject to statistical tests after background is established.
(b) Background is defined as unfiltered results in the 90^{th} percentile confidence level in DOE (1997). "New site-wide" values are used where available. Otherwise, historical background is used.
DWS = Primary Drinking Water Standard (U.S. Environmental Protection Agency).
SDWS = Secondary Drinking Water Standard (U.S. Environmental Protection Agency).

QC data are evaluated based on established acceptance criteria for each QC sample type. For field and method blanks, the acceptance limit is generally two times the method detection limit. Groundwater samples that are associated (i.e., collected on the same date and analyzed by the same method) with out-of-limit field blanks are flagged with a "Q" in the database to indicate a potential contamination problem.

Field duplicates must agree within 20%, as measured by the relative percent difference (RPD), to be acceptable. Only those field duplicates with at least one result greater than five times the appropriate detection limit are evaluated. Unacceptable field duplicate results are also flagged with a "Q" in the database.

The acceptance criteria for laboratory duplicates, matrix spikes, matrix spike duplicates, surrogates, and laboratory control samples are generally derived from historical data at the laboratories in accordance with EPA (1986a, as amended). Typical acceptance limits are within 25% of the expected values, although the limits may vary considerably with the method and analyte. These values are subject to change if the contract is modified or replaced.

Holding time is the elapsed time period between sample collection and analysis. Exceeding recommended holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Recommended holding times depend on the analytical method, as specified in EPA (1986a, as amended) or *Methods for Chemical Analysis of Water and Wastes* (EPA 1983). Data associated with exceeded holding times are flagged with an "H" in the Hanford Environmental Information System (HEIS) database. Flagged data generally are suitable for use in plume maps and trend plots, but may not be suitable for decision-making.

Additional QC measures include laboratory audits and participation in nationally based performance evaluation studies. The contract laboratories participate in national studies such as the EPA-sanctioned Water Pollution and Water Supply Performance Evaluation studies. The groundwater project periodically audits the analytical laboratories to identify and solve quality problems, or to prevent such problems. Audit results are used to improve performance. Summaries of audit results and performance evaluation studies are presented in the annual groundwater monitoring report (e.g., Hartman et al. 2006).

Following the initial quarterly sampling in the new upgradient and downgradient wells to establish background, groundwater data on each constituent of interest (Table 6.2) will be collected from the background well and downgradient wells. The number and kinds of samples collected to establish background must be appropriate for the form of statistical test employed (e.g., four to eight samples to establish background). Sampling procedure will be appropriate for the test selected after establishment of background. An alternative sampling procedure may also be proposed in accordance with WAC 173-303-645 (8)(g)(ii).

7.0 Data Management, Evaluation, and Reporting

This chapter summarizes how groundwater data are stored, retrieved, evaluated, and interpreted. Evaluation methods and reporting requirements also are described.

7.1 Data Management

The contract laboratories report analytical results electronically. The results are loaded into the HEIS database. Field-measured parameters are entered manually or through electronic transfer. Paper data reports and field records are considered to be the record copies and are stored at the DOE contractor's place of business.

The data undergo a validation/verification process according to a documented procedure as described in the project QA plan. QC data are evaluated against the criteria listed in the project QA plan and data flags are assigned when appropriate. In addition, data are screened by scientists familiar with the hydrogeology of the unit, compared to historical trends or spatial patterns, and flagged if they are not representative. Other checks on data may include comparison of general parameters to their specific counterparts (e.g., conductivity to ions), calculation of charge balances, and comparison of calculated versus measured conductivity. If necessary, the laboratory may be asked to check calculations or re-analyze the sample, or the well may be re-sampled.

7.2 Data Evaluation and Interpretation

The goal of RCRA detection monitoring is to determine if the S-10 pond and ditch has adversely impacted groundwater quality in the uppermost aquifer beneath the site. This may be determined after data are validated and verified, based on the results of a statistical test or other methods as allowed by WAC 173-303-645(8)(h). Because there is currently no upgradient well for S-10, the calculation of appropriate background or baseline values is deferred until a new upgradient well is drilled and a sufficient body of groundwater data become available for the evaluation of the parameters described below.

When the new upgradient well data set is complete, background or baseline values will be used to determine whether the S-10 has adversely affected the groundwater quality in the uppermost aquifer beneath the site. This is accomplished by testing for statistically significant changes in concentrations of constituents of interest in a downgradient monitoring well relative to baseline levels. These baseline levels could be obtained from upgradient (or background) wells and are referred to as inter-well (or between-well) comparisons. Alternatively, if baseline values are obtained from historical measurements from that same well, the comparisons are referred to as intra-well (or within-well) comparisons. The number and kinds of samples collected to establish background (or baseline values) will be appropriate for the form of statistical test employed (WAC 173-303-645 8(g)). Data transformations, if any, will be identified; generally accepted statistical procedures for screening outliers and/or accounting for non-detects will be followed (ASTM 1998; EPA 1989, 1992).

Statistical methods appropriate for a final status detection monitoring program include parametric or non-parametric analysis of variance, tolerance intervals, predication intervals, control charts, or other statistical methods approved by Ecology [WAC 173-303-645(8)(h)]. The type of monitoring, the nature of the data, the proportions of non-detects, site hydrogeological condition, and temporal/spatial variation are some of the important factors to be considered for the selection of appropriate statistical methods. The statistical evaluation procedures chosen will be based on the EPA guidance documents and *Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs* developed by American Society for Testing and Materials (ASTM 1998).

Statistical assumptions (e.g., normally distributed data, homogeneity of variance, temporal/spatial variations) will be assessed prior to performing the statistical test. The background (or baseline values) and the statistical approach will be evaluated and updated periodically. If changes in groundwater flow directions result in changes in definition of upgradient well(s) or changes in site conditions, background (or baseline) values will be re-established. If statistical evaluation methods are no longer effective to achieve the objective because of changing site conditions, a new statistical approach will be proposed in the unit-specific groundwater monitoring plan.

In addition to statistical testing procedures, verification sampling and geochemical and hydrological considerations are integral parts of the decision-making process. It is of critical importance to realize that on the basis of a statistical analysis alone, it can never be concluded that a waste site has impacted groundwater (ASTM 1998, Section 1.6). A statistically significant exceedance over background (or baseline) levels indicates that the new measurement in a particular monitoring well for a particular constituent is inconsistent with chance expectations based on the available sample of background measurements. Hence, in the event of a statistical exceedance (confirmed by verification sampling), non-statistical evaluations should be conducted to determine if the exceedance is due to an impact from upgradient sources or from the waste site in question.

Because of the current inadequacies in the well network, it will be necessary to install new monitoring wells and accumulate background data on the groundwater from those wells. Assessment of temporal and spatial variation, as well as the percentages of non-detects before statistical comparisons to local background conditions can then be made. In the interim, the constituents in Table 6.2 will be evaluated by tracking and trending concentrations in all S-10 wells and comparing these results with the corresponding primary or secondary DWS or Hanford Site background concentration for each constituent. If a comparison value for a constituent (Hanford site-wide background or DWS) is exceeded as shown in Table 6.2, Ecology will be notified as described in Section 7.3. In the case of chromium and specific conductance, verification sampling may be employed to confirm initial results.

In addition to the comparisons, a more rigorous evaluation is conducted to interpret groundwater conditions at the site. Interpretive techniques may include:

- Hydrographs – plot water levels versus time to determine decreases, increases, seasonal, or man-made fluctuations in groundwater levels.

- Water-table maps – use water-table elevations from multiple wells to construct contour maps to estimate flow directions. Groundwater flow is assumed to be perpendicular to equipotentials.

- Trend plots – graph concentrations of constituents versus time to determine increases, decreases, and fluctuations. These may be used in tandem with hydrographs and/or water-table maps to determine if concentrations relate to changes in water level or in groundwater flow directions.

- Plume maps – areal distributions of chemical or radiological constituents in the aquifer to determine extent of contamination. Changes in plume configuration over time aid in determining movement of plumes and direction of flow.

- Contaminant ratios – can sometimes be used to distinguish between different sources of contamination. Trends for two or more constituents are plotted to check for co-varying behavior.

7.3 Reporting

Reporting requirements of DOE (2003, Section 5.5.4.8) will be followed for groundwater monitoring at the S-10. Specific types of reporting and actions are described below. Groundwater chemistry and water-level data will be reviewed at least semiannually and made available in HEIS. The results of the statistical evaluation will be submitted to Ecology in RCRA quarterly reports and in the annual *Hanford Site Groundwater Monitoring* report (e.g., Hartman et al. 2006). In addition, groundwater analytical and hydrologic data from nearby facilities such as the single-shell tank farm S-SX Waste Management Area will be examined for results that may lend understanding to the hydrogeologic system and will be discussed in the Hanford Site annual groundwater report, as appropriate. This discussion will be accompanied by recommendations for modifications of the well network and/or constituent list, as necessary.

If groundwater analytical data indicate evidence of contamination by applying the criteria described in Section 7.2 and in Table 6.2, Ecology will be notified of the finding as per DOE (2003), specifying which parameter(s) have exceeded DWS or Hanford Site groundwater background concentrations. These criteria will be applied until background groundwater quality is established in a new upgradient well.

Requirements per WAC 173-303-645(9) will be implemented after appropriate background values for chromium and specific conductance are established. Subsequent to establishing background, reporting will occur according to WAC 173-303-645(9)(g) if groundwater data show there is statistically significant evidence of contamination by chemical parameters (e.g., specific conductance) or dangerous constituents specified in the permit at any downgradient monitoring well.

The exception to the adherence to the WAC, is that 40 CFR Part 264, Appendix IX parameters will not be analyzed. Instead, the selection of any additional constituents to be analyzed will be based on potential contaminants agreed to between Ecology and DOE. Notification, as indicated in Table 6.2, will occur according to regulatory requirements of DOE (2003) and WAC 173-303-645 by reference, or as otherwise agreed to between DOE and Ecology.

8.0 References

40 CFR 264, Appendix IX. "Ground-Water Monitoring List." *Code of Federal Regulations*, U.S. Environmental Protection Agency.

40 CFR 265, Subpart F. "Interim Status Standards for Owners of Hazardous Waste Treatment, Storage, and Disposal Facilities; Ground-Water Monitoring." *U.S. Code of Federal Regulations*, U.S. Environmental Protection Agency.

Airhart SP, JV Borghese, and S Dudziak. 1990. *Interim Status Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch.* WHC-SD-EN-AP-018, Rev. 0, prepared by Pacific Northwest Laboratory for Westinghouse Hanford Company, Richland, Washington.

ASTM. 1998. *Standard Guide for Developing Appropriate Statistical Approaches for Ground-Water Detection Monitoring Programs.* Designation D 6312 – 98, American Society for Testing and Materials, West Conshohocken, Pennsylvania.

BHI. 1995. *S Plant Aggregate Area Management Study Technical Baseline Report.* BHI-00176, Rev. 00, Bechtel Hanford, Inc., Richland Washington.

Bjornstad BN. 1984. *Suprabasalt Stratigraphy Within and Adjacent to the Reference Repository Location.* SD-BWI-DP-039, prepared by Rockwell Hanford Operations for the U.S. Department of Energy, Richland, Washington.

Bjornstad BN. 1985. "Late-Cenozoic Stratigraphy and Tectonic Evolution Within a Subsiding Basin, South-Central Washington." *Geological Society of America, Abstract with Programs* 17(7):524.

Bjornstad BN. 1990. *Geohydrology of the 218-W-5 Burial Ground, 200 West Area, Hanford Site.* PNL-7336, Pacific Northwest Laboratory, Richland, Washington.

Cantrell KJ, RJ Serne, and GV Last. 2003. *Hanford Contaminant Distribution Coefficient Database and Users Guide*. PNNL-13895, Rev. 1, Pacific Northwest Laboratory, Richland, Washington.

Comprehensive Environmental Response, Compensation, and Liability Act. 1980. Public Law 96-150, as amended, 94 Stat. 2767, 42 USC 9601 et seq.

Connelly MP, BH Ford, and JV Borghese. 1992. *Hydrogeologic Model for the 200 West Groundwater Aggregate Area*. WHC-SD-EN-TI-014, Westinghouse Hanford Company, Richland, Washington.

Corbin RA, BC Simpson, MJ Anderson, WF Danielson III, JG Field, TE Jones, and CT Kincaid. 2005. *Hanford Soil Inventory Model, Rev. 1*. RPP-26744, Rev. 0, CH2M HILL Hanford Group, Inc., Richland, Washington.

DOE. 1987. *216-S-10 Ditch and Pond Preliminary Closure/Post Closure Plan.* U.S. Department of Energy, Richland, Washington.

DOE. 1988. *Consultation Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Washington*. DOE/RW-0164, Vol. 1, U.S. Department of Energy, Richland, Washington.

DOE. 1992. *S Plant Aggregate Area Management Study Report*. DOE/RL-91-60, Rev. 0, U.S. Department of Energy, Richland, Washington.

DOE. 1995. *Hanford Site Background: Part 1, Soil Background for Inorganics*. DOE-RL-92-24, Rev. 3, U.S. Department of Energy, Richland, Washington.

DOE. 1997. *Hanford Site Background: Part 3, Groundwater Background*. DOE/RL-96-61, Rev. 0, U.S. Department of Energy, Richland, Washington.

DOE. 1999. *200 Area Remedial Investigation/Feasibility Study Implementation Plan - Environmental Restoration Program*. DOE/RL-98-28, Rev. 0, U.S. Department of Energy, Richland, Washington.

DOE. 2000. *200-CS-1 Operable Unit RI/FS Work Plan and RCRA TSD Unit Sampling Plan.* DOE/RL-99-44, Rev. 0, U.S. Department of Energy, Richland, Washington.

DOE. 2002. *Standardized Stratigraphic Nomenclature for Post-Ringold-Formation Sediments Within the Central Pasco Basin*. DOE/RL-2002-39, Rev. 0, U.S. Department of Energy, Richland, Washington.

DOE. 2003. *Hanford Facility RCRA Permit General Information Portion, Attachment 33*. DOE/RL-91-28, Rev. 6, U.S. Department of Energy, Richland, Washington.

DOE. 2004. R*emedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit*. DOE/RL-2004-17, U.S. Department of Energy, Richland, Washington.

Ecology - Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy. *Hanford Federal Facility Agreement and Consent Order*. Document No. 89-10, as amended (The Tri-Party Agreement), Olympia, Washington.

Ecology. 1994. *Dangerous Waste Portion of the Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste*, as amended. Permit Number 7890008967, effective September 28, 1994. Washington State Department of Ecology, Olympia, Washington.

EPA. 1983. *Methods for Chemical Analysis of Water and Wastewater*. EPA-600/4-79-020, Office of Research and Development, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.

EPA. 1986a. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, SW-846, Third Edition*. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C., as amended.

EPA. 1986b. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document*. OSWER-9950.1, U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1989. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Interim Final Guidance*. EPA/530-R-93-003, U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1992. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Draft Addendum to Interim Final Guidance*. EPA/530-R-93-003, U.S. Environmental Protection Agency, Washington, D.C.

EPA. 2001. *EPA Requirements for Quality Assurance Project Plans.* EPA/240/B-01/003 (EPA QA/R-5), as revised, U.S. Environmental Protection Agency, Washington, D.C.

Fecht KR, SP Reidel, and AM Tallman. 1987. *Paleodrainage of the Columbia River System on the Columbia Plateau of Washington State – A Summary, in Washington Division of Geology and Earth Resource Bulletin 77.* Basalt Waste Isolation Project, Westinghouse Hanford Company, Richland, Washington.

Graham MJ, MD Hall, SR Strait, and WR Brown. 1981. *Hydrology of the Separation Area*. RHO-ST-42, prepared by Rockwell Hanford Operations for the U.S. Department of Energy, Richland, Washington.

Hartman MJ, LF Morasch, and WD Webber (eds.). 2006. *Hanford Site Groundwater Monitoring for Fiscal Year 2005*. PNNL-15670, Pacific Northwest National Laboratory, Richland, Washington.

Johnson VG and CJ Chou. 1999. *RCRA Assessment Plan for Single-Shell Tank Waste Management Area S-SX at the Hanford Site*. PNNL-12114, Pacific Northwest National Laboratory, Richland, Washington.

Johnson VG and DG Horton. 2000. *Borehole Data Package for Wells 299-W22-48, 299-W22-49, and 299-W22-50 at Single-Shell Tank Waste Management Area S-SX*. PNNL-13200, Pacific Northwest National Laboratory, Richland, Washington.

Kipp KL and RD Mudd. 1973. *Collection and Analysis of Pump Test Data for Transmissivity Value*s. BNWL-1709, Battelle Northwest Laboratory, Richland, Washington.

Last GV, BN Bjornstad, MP Bergeron, DW Wallace, DR Newcomer, JA Schramke, MA Chamness, CS Cline, SP Airhart, and JS Wilbur. 1989. *Hydrogeology of the 200 Areas Low-Level Burial Grounds – An Interim Report*. PNL-6820, Vol. 1, Pacific Northwest Laboratory, Richland, Washington.

Lindsey KA. 1995. *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*. BHI-00184, Bechtel Hanford, Inc., Richland, Washington.

Lindsey KA, SP Reidel, KR Fecht, JL Slate, AG Law, and AM Tallman. 1994. "Geohydrologic Setting of the Hanford Site, South-Central Washington." In *Geologic Field Trips of the Pacific Northwest*, DA Swanson and Haugerud (eds.), Geological Society of America Annual Meeting, Department of Geological Sciences, University of Washington, Seattle, Washington, Chapter 1C, pp 1C-1 to 1C-16.

Maxfield HL. 1979. *200 Areas Waste Sites*. RHO-CD-673, handbook compiled by Rockwell Hanford Operations for the U.S. Department of Energy, Richland, Washington.

Myers CW and SM Price (eds.). 1981. *Subsurface Geology of the Cold Creek Syncline*. RHO-BWI-ST-14, Rockwell Hanford Operations, Richland, Washington.

Reidel SP, KA Lindsey, and KR Fecht. 1992. *Field Trip Guild to the Hanford Site*. WHC-MR-0391, Westinghouse Hanford Company, Richland, Washington.

Resource Conservation and Recovery Act. 1976. Public Law 94-580, as amended, 90 Stat. 2795, 42 USC 6901 et seq.

RHO. 1979. *Handbook 200 Area Waste Sites.* RHO-CD-798, Vols. II and III, Rockwell Hanford Operations, Richland, Washington.

Rockhold ML, MJ Fayer, CT Kincaid, and GW Gee. 1995. *Estimation of Natural Ground Water Recharge for the Performance Assessment of a Low-Level Waste Disposal Facility at the Hanford Site.* PNL-10508, Pacific Northwest Laboratory, Richland, Washington.

Tallman AM, KR Fecht, MC Marratt, and GV Last. 1979. *Geology of the Separation Areas, Hanford Site, South-Central Washington*. RHO-ST-23, Earth Sciences Group Research Department, Rockwell International, Richland, Washington.

Thorne PD and DR Newcomer. 1992. *Summary and Evaluation of Available Hydraulic Property Data for the Hanford Site Unconfined Aquifer System*. PNL-8337, Pacific Northwest Laboratory, Richland, Washington.

Thorne PD, MA Chamness, FA Spane, Jr., VR Vermeul, and WD Webber. 1993. *Three-Dimensional Conceptual Model for the Hanford Site Unconfined Aquifer System, FY93 Status Report*. PNL-8971, Pacific Northwest Laboratory, Richland, Washington.

Vermeul VR, CR Cole, MP Bergeron, PD Thorne, and SK Wurstner. 2001. *Transient Inverse Calibration of Site-Wide Groundwater Model to Hanford Operational Impacts from 1943 to 1996—Alternative Conceptual Model Considering Interaction with Uppermost Basalt Confined Aquifer.* PNNL-13623, Pacific Northwest National Laboratory, Richland, Washington.

WAC 173-160. "Minimum Standards for Construction and Maintenance of Wells." *Washington Administrative Code*, Olympia, Washington.

WAC 173-303-400. "Interim Status Facility Standards." *Washington Administrative Code*, Olympia, Washington.

WAC 173-303-645. "Releases from Regulated Units." *Washington Administrative Code*, Olympia, Washington.

WAC 173-303-806. "Interim Status Permits." *Washington Administrative Code*, Olympia, Washington.

WHC. 1990. *Liquid Effluent Study Final Project Report*. WHC-EP-0367, prepared by Westinghouse Hanford Company for the U.S. Department of Energy Richland, Washington.

Williams BA and DB Barnett. 1993. *Borehole Completion Data Package for the 216-S-10, CY-1992*. WHC-SD-EN-DP-052, Westinghouse Hanford Company, Richland, Washington.

Williams BA and CJ Chou. 2002. *Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch*. PNNL-14070, Pacific Northwest National Laboratory, Richland, Washington.

Williams BA, BN Bjornstad, R Schalla, and WD Webber. 2000. *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*. PNNL-12261, Pacific Northwest National Laboratory, Richland, Washington.

Williams BA, BN Bjornstad, R Schalla, and WD Webber. 2002. *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-West Area and Vicinity, Hanford Site, Washington*. PNNL-13858, Pacific Northwest National Laboratory, Richland, Washington.

Appendix A

Post-Closure Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch Data Quality Objectives

Appendix A

Post-Closure Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch Data-Quality Objectives

A.1 Introduction

This document addresses the planning of data collection and developing appropriate data collection design to support decision making for post-closure groundwater monitoring for the *Resource Conservation and Recovery Act* (RCRA) treatment, storage, and/or disposal (TSD) unit designated the 216-S-10 pond and ditch (S-10) following U.S. Environmental Protection Agency (EPA) guidance for conducting the data quality objectives (DQO) process (EPA 2000 as amended). Each step draws upon current knowledge of the TSD unit and the closure process at the Hanford Site, existing DQO examples (e.g., Sweeney and Chou 2003), and adheres to the applicable requirements of state and federal regulation (Washington Administrative Code [WAC] 173-303). Elements of each DQO step that apply to a groundwater monitoring plan, prepared to WAC 173-303-645 standards at this TSD unit, are discussed here.

A.1.1 Step 1: Problem Statement

To formulate the problem statement, it is necessary to examine the study objective from a regulatory standpoint. The *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement; Ecology et al. 1989) Milestone M-20-39 requires submittal of the 216-S-10 pond and ditch closure plan. The draft closure plan concludes that the TSD unit cannot achieve clean closure for groundwater based on review of groundwater data in the Hanford Environmental Information System (HEIS). Because clean closure cannot be achieved, a post-closure groundwater monitoring plan will be prepared for the TSD unit based on WAC 173-303-610(8)(b). A post-closure plan covers "a description of the planned groundwater monitoring activities and frequencies at which they will be performed." The post-closure period is established in WAC 173-303-610(7).

A.1.1.1 Study Objective

Develop a post-closure groundwater monitoring program in accordance with WAC 173-303-645(9) for the S-10 TSD unit.

A.1.1.2 Members and Roles of the DQO Team

Team Members. Participants in deriving the final groundwater monitoring plan includes staff from Pacific Northwest National Laboratory, U.S. Department of Energy Richland Operations Office (DOE/RL), and Fluor Hanford, Inc. Objectives, requirements, and concerns will be further refined and addressed through consultation first with DOE (decision makers, owner/operator) and Fluor Hanford Inc. (current co-operator for the TSD unit). Following the incorporation of DOE and Fluor comments/ recommendations, the monitoring plan will be transmitted to the Washington State Department of Ecology (Ecology) by DOE.

A.1.1.3 Site Conceptual Model

A description and history of the S-10 is provided by Williams and Chou (2002). The history of operations at waste sites adjacent to S-10, particularly those upgradient of, or very near this TSD unit, indicate that some observed groundwater contamination beneath S-10 could have originated from waste sites other than S-10. This circumstance forces the realization that discriminating between the contributions of each waste site to groundwater contamination beneath this cluster of disposal sites may not be possible. For the S-10 specifically, the release mechanisms, fate and transport parameters, contaminant distribution, and receptors are described by DOE (2004). It is likely that this set of properties also applies to the waste sites adjacent to S-10 that received liquid waste in roughly the same volumes and from the same source. Hence, these adjacent sites are considered in the DQO process for determining contaminants of concern. For chromium, it is problematic to what extent the S-10 has affected groundwater quality versus the adjacent waste sites. If contamination is detected in downgradient wells at the S-10, it may have originated at other waste sites upgradient of S-10. Hence, Table A.1 is presented as a means for showing the potential overlap of waste streams from nearby waste sites that may have contributed to groundwater contamination detected at the S-10. Because chromium has been detected above background in recent soil analyses (DOE 2004), it is assumed in this model that the S-10 is a contributor to chromium contamination of groundwater.

Other aspects of the conceptual model are taken from Williams and Chou (2002) as follows:

- The large volume of water (6.6×10^9 L [1.7×10^9 gal]) discharged to the S-10 was sufficient to wet the soil column down to groundwater beneath both the unlined ditch and the pond.

- Waste streams discharged to this facility were classified as neutral to basic, low ionic strength, and low organic content (WHC 1990, Appendix C). These effluent chemical characteristics are favorable for sorption of certain heavy metals (see bullets below) by vadose zone sediment.

- Fine textured sedimentary layers allowed subsurface, lateral spreading beyond the boundary of the pond system. As a result, wastewater may have affected both upgradient and downgradient monitoring wells.

- Many of the contaminants of concern are assumed to be mobile (non-adsorbed) because they are either anions (including the oxymetal anions, e.g., chromate) or are non-charged chemical species (volatile and non-volatile organics).

- There is no surface barrier to natural infiltration. An average net natural infiltration rate of 10 cm (3.9 in.) per year is assumed for the surface covering of coarse sand and sparse vegetation (located in a recharge zone designated as 5 to 10 cm [1.97 to 3.9 in.] per year).

Table A.1. Constituents of Potential Concern for Groundwater at the S-10 and Adjacent Facilities

	Non-radiological Constituents of Potential Concern in Facilities Adjacent to the 216-S-10 Pond and Ditch [1]																									
Disposal Facility	Arsenic	aluminum	Barium	Cadmium	chromium	copper	lead	mercury	nickel[3]	silver	vanadium	zinc	chloride	nitrate	nitrite	phosphate	sodium	sulfate	fluoride	carbon tetrachloride	Halogenated hydrocarbons	organic compounds	**Relative Location[2]**	**Discharge Volume (liters x 10^6)**	**Comments**	**References**
216-S-10 Ditch	**S**	P	N	P	S,G	S	S	**S**	S,G	**S**	S	S	P	S	P	P	P	W	P	**G**	**S**	**S**		6.6E+03 (combined)	(see references and text)	DOE/RL-2004-17, PNNL-14070; PNNL-15070; Kaiser Eng. 1991
216-S-10 Pond	N	P	S	P	S,G	P	S	S	S,G	S	S	S	P	S	P	S	P	W	P	G	**S**	P			(see references and text)	DOE/RL-2004-17, PNNL-14070
216-S-11 Pond	N	P	N	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	N	P	P	DG	3.22E+03	This facility is ~50 m to the east of S-10 pond; Corbin et al. estimate S-10 and S-11 total Q as 6.73E+09 L (202 CS) "The S-11 Pond was credited with all S-10D and P wastes for years."	RHO-CD-673; Shearer (2005)
216-S-5 Crib	N	W	N	P	P	P	P	P	P	P	P	P	P	W	P	P	W	P	P	N	P	P	UG	4.10E+03	"Acidic process cooling water"	DOE/RL-91-60, WIDS, RHO-CD-673
216-S-6 Crib	N	P	N	P	P	P	P	P	P	P	P	P	P	W	P	P	P	P	P	N	P	W	UG	4.50E+03	"Low salt, neutral/basic"	DOE/RL-91-60, WIDS, RHO-CD-673; Shearer (2005)
216-S-16 Pond	N	P	N	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	N	P	P	UG	4.07E+04 (combined)	"202-S process cooling water"	RHO-CD-673; Shearer (2005)
216-S-16 Ditch	N	P	N	P	P	P	P	P	P	P	P	P	P	W	P	P	P	P	P	N	P	P	UG			DOE/RL-91-60, RHO-CD-673
216-S-17 Pond	N	P	N	P	P	W	P	P	P	P	P	P	W	W	P	P	P	W	P	N	W	W	UG	6.43E+03	naphtha, 2,4-D, and copper sulfate applied as herbicides "Grossly contaminated."	DOE/RL-91-60, WIDS, RHO-CD-673; Shearer (2005); Kaiser Eng. 1991
216-U-9 Ditch	N	P	N	P	P	P	P	P	P	P	P	P		P	P	P	P	P	P	N	P	P	UG	unknown	Overflow from U-10 pond- "no radioactivity detected"	RHO-CD-673

G = Constituent present in groundwater above background or **MCL (bold)** (background defined by DOE/RL-96-61)

S = constituent present in soil above background or **screening level (bold)**(background defined by DOE/RL-92-24; screening level defined by WAC 173-340-747)

W = Constituent known or suspected in waste stream

P = Potential source of this constituent, based on source processes (DOE-RL. 1991).

N = Constituent is not detected above background, screening level, or MCL in soil or groundwater, and is not listed as a potential constituent of a waste stream.

(1)The selection of constituents for this table are based on constituents list in Table 6.4 of PNNL-14070 and other references as noted in this table.

(2)Locations are: UG = hydraulically upgradient of S-10 facility; DG = hydraulically downgradient of S-10 facility

(3) Nickel-59 and Nickel-63 were produced and discharged from S Plant processing. These nuclides have half lives of 7.6E+04 years and ~100 years, respectively.

(4)Includes mercuric thiocyanate and mecuric nitrate

A.1.1.4 Problem Statement

Historical records indicate that the release to the S-10 of high-salt waste (simulated tank waste) containing hexavalent chromium and other regulated wastes is the basis for the waste site being identified as a TSD unit. A one-time release of 416.4 L (110 gal) of synthetic double-shell tank waste was released to the S-10 pond and ditch system in September 1983 (DOE 1987). Chromium concentrations, especially in the well 299-W26-7, increased above the maximum contaminant level (MCL) (highest value = 576 μg/L) and then dropped below the MCL between October 1995 and July 1998, suggesting a transient release event (Williams and Chou 2002). Although well 299-E26-7 is an upgradient well, it is located very close to one lobe of the pond system. Wastewater from the pond may have intersected this well by spreading laterally in the subsurface. Detailed results from groundwater monitoring activities are discussed in Williams and Chou (2002, Section 4). The history of operations at waste sites adjacent to S-10, particularly those upgradient of, or very near this TSD unit, indicate that some observed groundwater contamination beneath S-10 could have originated from waste sites other than S-10 (see Table A.1). In addition, the declining water table in the 200 West Area, especially in the vicinity of the S-10, caused many RCRA-compliant wells to go dry. Initially, there were six compliant (WAC 173-160) groundwater monitoring wells installed in 1990 and 1991. Two upgradient wells (299-W26-7 and 299-W26-8) and three downgradient wells (299-W26-9, 299-W26-10, and 299-W26-12) monitored the upper 4.5 to 6 m (15 to 20 ft) of the uppermost aquifer and one perched water well 299-W26-11. Another well (299-W27-2) was installed in 1993 and monitors the lower 3 m (10 ft) of the uppermost aquifer. All of the original six upper aquifer monitoring wells have gone dry. A replacement well (299-W26-13) was added to the network (completed in January 2000) downgradient of the S-10 pond. Another downgradient well (299-W26-14) was installed in April 2003 downgradient of the mid-point along the ditch as a replacement well for well 299-W26-10, which went dry in 1999. Hence, the site currently only has two downgradient wells (299-W26-13 and 299-W26-14) that monitor the top of the unconfined aquifer. Well 299-W27-2 monitors the bottom of the unconfined aquifer and is used for supplemental information only.

Because clean closure cannot be achieved for this TSD unit regarding groundwater at this time, the closure plan requires development of a post-closure groundwater monitoring plan as part of post-closure care for the S-10. *Hence, this DQO documents the process necessary to derive the appropriate groundwater monitoring approach under the assumption that clean closure cannot be achieved.* Additionally, because of the proximity of the S-10 to other waste sites, particular care is needed to formulate a groundwater monitoring network and sampling and analysis plan.

A.2.1 Step 2: Identification of the Decisions

Because it is assumed that clean closure cannot be achieved for the TSD unit regarding groundwater, the process to monitor the TSD unit as a land disposal unit (surface impoundment) will be carried out in accordance with applicable requirements described in WAC 173-303-610 and WAC 173-303-645. WAC 173-303-610(7) and (8) identifies the post-closure plan requirements. WAC 173-303-806(4)(a)(xx) further specify one of two distinct approaches to protection of groundwater through monitoring:

- A detection monitoring program which meets the requirements of WAC 173-303-645(9) if presence of dangerous constituents in groundwater have not been detected at the point of compliance at the time of the permit application

- A compliance monitoring program which meets the requirements of WAC 173-303-645(10) if dangerous constituents have been detected in the groundwater at the point of compliance.

However, alternative requirements for groundwater monitoring may be granted (by Ecology) in accordance with WAC-173-303-645(1)(e) if a dangerous waste unit is situated among other waste management units or area of concern, a release has occurred, and both dangerous waste unit and one or more of the solid waste management units or areas of concern are likely to have contributed to the release.

The principal study questions (PSQ) to resolve whether a detection monitoring program or a compliance monitoring program should be implemented during the post-closure care period for the S-10 and the alternative actions are presented in Table A.2. This table also provides a relative estimate of the severity of the consequences of taking an alternative action if it is inappropriate.

A.3.1 Step 3: Inputs to the Decisions

This step is to identify the information inputs and/or supporting evidence required to resolve the PSQs.

- Discharge history/inventory for the S-10.
- Constituents identified in the Part A Permit Application for the S-10 TSD unit.
- Discharge histories/inventories of adjacent waste sites that may have affected groundwater beneath 216-S-10 (e.g., 216-S-17 swamp).
- Groundwater monitoring that has been conducted at this site since 1991, with voluminous data available for interpretation, with results indicating:
  - Elevated chromium above drinking water standards in well 299-W26-7.
  - Presence of hexavalent chromium in some wells
  - No primary or secondary drinking water standard (DWS) or constituents given in WAC 173-303-645(4) have been exceeded.
  - Current and historical interpretations of groundwater flow rates (travel times) and directions since the 1960s indicate that discharges to nearby facilities could also account for contamination upgradient and downgradient of the S-10.
  - Distribution of other groundwater contaminants in the vicinity of S-10
- Updated hydrostratigraphic interpretations for the 200 West Area (e.g., Williams et al. 2002).
- Timing of arrival of contamination in downgradient wells at S-10.

Table A.2. Summary of Data Quality Objective Step 2 Information

PSQ/AA #	Alternative Action	Consequences of Implementing the Wrong Alternative Action	Severity of Consequences (Low/Moderate/Severe)
PSQ #Is detection monitoring appropriate for post closure care period?			
1-1	No action - proceed with detection monitoring (i.e., "*the presence of dangerous constituents at the point of compliance for 216-S-10 Pond and Ditch has not been detected*")	Implement an incorrect groundwater monitoring program	Moderate
1-2	Implement compliance monitoring (i.e., "*the presence of dangerous constituents at the point of compliance for 216-S-10 Pond and Ditch has been detected*")	Resources misused by excessive sampling/analysis	Moderate
1-3	Implement alternative groundwater monitoring requirements (e.g., coordinating with CERCLA and/or AEA)	• Resources misused by excessive sampling/analysis • Contamination may be incorrectly attributed to S-10.	Severe
PSQ #2 Are the constituents of concern necessary and sufficient for the selected mode of monitoring?			
2-1	Use existing constituents (CIPs + site-specific parameters) semiannually per Williams and Chou (2002).	Unnecessary cost of data analyses/management, or the list of constituents is incomplete	Moderate
2-2	Reduce less mobile site-specific parameters to less frequent sampling frequency	May initially miss trends for some constituents of concern, but due to lower head in the aquifer flow rates are slowing	Low
2-3	Determine if constituents are appropriate, based on Part A Permit Application constituents	Unnecessary cost of data collection, analysis/management if constituents do not yield additional insight.	Moderate
PSQ #3: Is the monitoring network adequate for purposes of determining whether TSD unit constituents (e.g., chromium, nitrate) from the TSD unit have impacted the groundwater?			
3-1	Use existing network per Hartman et al. (2006, p. B.17)	Monitoring network is inadequate unless new wells are installed	Severe
3-2	Drill and install new monitoring wells to supplement existing well network.	If the wells do not add to understanding of contaminant source(s): Unnecessary cost of drilling new monitoring wells. Unnecessary cost of analyzing and managing data. However, new wells are necessary for compliance.	Low

- Soil sampling and analyses at the S-10 (DOE/RL 2004), which indicate:
  - Arsenic, mercury, and silver above groundwater protection levels in soil in the 216-S-10 ditch. However, these constituents are not S-10 TSD unit constituents on the Part A Permit Application
  - Chromium, copper, lead, nickel, vanadium, zinc, nitrate, halogenated hydrocarbons, and organic compounds above background levels. Except for chromium and nitrate (an assumed byproduct of nitrite), these constituents are not pertinent to S-10 TSD unit constituents on the Part A Permit Application
- Conceptual model that integrates the above considerations.

A.1.4 Step 4: Definition of the Study Boundaries

Boundaries are dictated in general by regulations (WAC 173-303-610(7) and (8) and others by reference). The following bounding parameters constrain the *scope* of the study for *detection* monitoring:

- Spatial boundaries
  - Areal boundaries are defined by the upgradient (background) and downgradient, and as defined in WAC 173-303-645(6) monitoring wells surrounding the TSD unit.
  - Additional spatial boundaries may be identified on the basis of constituent trends and spatial variability in concentrations reflected by individual wells and the proximity of other waste sites.
  - A vertical surface located at the hydraulically downgradient limit of the S-10 that extends down into the uppermost aquifer underlying the S-10.
- Temporal boundaries
  - After closure of S-10, through the post-closure care period (The post-closure period may be 30 years, but can be shortened or lengthened by Ecology at any time in accordance with WAC 173-303-610(7).)

A.1.5 Step 5: Develop Decision Rules

Questions 1 and 2 are intended to address PSQ-1.

1. **If** the decision inputs indicate that "*the presence of dangerous constituents at the point of compliance for S-10 has not been detected*" is accepted, **then** apply a detection monitoring program to the S-10.
2. **If** the assertion that "*the presence of dangerous constituents at the point of compliance for S-10 has been not detected*" is NOT accepted, **then** develop a compliance monitoring program for the S-10.

Questions 3, 4 and 5 are intended to address PSQ-2.

3. **If** conditions specified in WAC-173-303-645 (1)(e) are met (i.e., if S-10 is situated among other solid waste management units or area of concern, a release has occurred, and both the S-10 and one or

more of the solid waste management units or areas of concern are likely to have contributed to the release), **then** an alternative requirement that replaces all or part of the requirements of WAC 173-303-645 may be sought for the post closure care groundwater monitoring program for the S-10.

4. **If** evaluation of groundwater, soils, and waste streams at the site indicates that current constituents (i.e., Williams and Chou 2002) are insufficient for post-closure monitoring, **then** derive an appropriate constituents list for the post-closure monitoring program using other data, such as Table A.1.

5. **If** the constituents of concern (or derivatives, such as nitrate) listed in the Part A Permit Application are appropriate for post-closure monitoring, **then** apply these to the constituents list.

   Question 6 is intended to address PSQ-3.

6. **If** the monitoring network is inadequate for purposes of tracking constituents that have potential of impacting groundwater, **then** add new wells through selection of existing wells or drilling of new wells.

A.1.6 Step 6: Not Applicable

A.1.7 Step 7: Optimize the Design

Optimization of the S-10 post-closure groundwater monitoring plan design will occur by integrating information from the above steps. The purpose of this step is to identify a resource-effective field investigation sampling design that generates data expected to meet the decision performance criteria specified in previous steps. The PSQs embody the primary decisions to be made in the development and maintenance (as needed) of the plan. Below are the types of activities for development and maintenance that may occur to optimize the plan. Additional iterations of this step may be needed to arrive at the optimum design.

A.1.7.1 Monitoring Program Type

At present, and based on decision inputs, it is recommended that a detection-level monitoring program be implemented. Thus far, no dangerous constituents have been identified at concentrations of concern, nor have any primary drinking water parameters been exceeded at the S-10 TSD unit in *down-gradient* wells with the exception of carbon tetrachloride in deep well 299-W27-2—interpreted to originate from a source to the northwest of the S-10. Should these conditions change, the level of monitoring will be re-evaluated.

A.1.7.2 Constituents of Concern

Groundwater constituents list for the S-10 consists of the site-specific parameters identified on the Part A Permit Application and ancillary surrogate parameters for sampling and analytical quality assurance. Selection of the site-specific constituents is based on:

- Constituent is a dangerous waste constituent identified in the Part A Permit Application, or

- Constituent is a mobile decomposition product of constituents in (1) (i.e., nitrate from nitrite) of a Part A constituent, or

- Constituent is a reliable indicator of constituents in (1) (e.g., specific conductance).

Based on the above criteria, the parameters and sampling frequencies shown in Table A.3 are those selected for groundwater monitoring at the S-10.

Table A.3. Wells, Constituents, and Sampling Schedule for the 216-S-10 Pond and Ditch

				Constituents of Interest						Supporting Constituents						
Well ID	Well Name	Purpose	WAC Compliant	Hexavalent Chromium, filtered	Chloride	Fluoride	Nitrate	Nitrite	Specific Conductance[a]	Alkalinity	Anions[b]	Metals, filtered[c]	pH[a]	Temperature[a]	Turbidity[a]	Water Level
B8817	299-W26-13	Downgradient	C	S	S	S	S	S	S	A	A	A	S	S	S	S
B8828	299-W26-14	Downgradient	C	S	S	S	S	S	S	A	A	A	S	S	S	S
N/A	3 new wells[d]	1 upgradient, 2 downgradient	C	S	S	S	S	S	S	A	A	A	S	S	S	S
A5410	299-W27-2	Base of unconfined aquifer; information only	C	S	S	S	S	S	S	A	A	A	S	S	S	S

(a) Field measurement.
(b) Anions - Analytes include but not limited to chloride, nitrate, and sulfate.
(c) Metals - Analytes include but not limited to calcium, potassium, magnesium, and sodium.
(d) At least quarterly for one year to establish background.
A = To be sampled annually.
C = Well is constructed as a WAC 173-160 resource protection well.
S = To be sampled semiannually.

A.1.7.3 Evaluation of Data

Site-specific parameters will eventually be evaluated according to one of the alternatives described in WAC 173-303-645(8)(h). Because of the current inadequacies in the well network, it will be necessary to install new monitoring wells and accumulate background data on the groundwater from those wells before statistical comparisons can be made. In the interim, the constituents in Table A.3 will be evaluated by tracking and trending concentrations in all wells and comparing these results with the corresponding DWS or Hanford Site background concentration for each constituent. If a comparison value (background or DWS) is exceeded as described in Table A.4 for each constituent, Ecology will be notified.

Notification of the conditions indicated in Table A.4 will normally occur through the regular reporting procedures of the Hanford Groundwater Performance Assessment Project (PNNL 2005). In exceptional cases, at the discretion of project management, results may be reported to DOE as soon as a result is evaluated.

Table A.4. Constituent List and Comparisons

Constituent (DWS or SDWS in µg/L unless noted)	Sampling Frequency	Type of Comparison (Value)	Action if Result Exceeds Comparison Value
Site-Specific Parameters			
Hexavalent chromium (**100 for total Cr**)[(a)]	Semiannual	Trending and comparison to **DWS**[(a)]	Verification/Notification
Chloride (**250,000**)	Semiannual	Trending and comparison to **SDWS**	Notification
Fluoride (**2,000**)	Semiannual	Trending and comparison to **SDWS**	Notification
Nitrate as NO_3 (**45,000**)	Semiannual	Trending and comparison to **DWS**	Notification
Nitrite as nitrogen (**1,000**)	Semiannual	Trending and comparison to **DWS**	Notification
Specific conductance (field)[(a)]	Semiannual	Trending and comparison to **site-wide background**[(a,b)]	Verification/Notification
Additional Parameters			
Alkalinity	Annual	Use for calculation of charge balance	NA
Metals, in addition to chromium	Annual	Trending and comparison to **DWS** and/or background[(b)]	Notification only if a metal exceeds a primary DWS
pH (field) (**6.5 to 8.5**)	Semiannual	Trending and comparison to **DWS**	Notification only if a value falls outside DWS range for two consecutive sampling events
Temperature (field)	Semiannual	Information and sample quality screening	NA
Turbidity (field)	Semiannual	Information and sample quality screening	Project Scientist notified if turbidity exceeds 5.0 NTU

(a) These constituents will be subject to statistical tests after background is established.
(b) Background is defined as unfiltered results in the 90th percentile confidence level in DOE (1997). "New site-wide" values are used where available. Otherwise, historical background is used.
DWS = Primary Drinking Water Standard (U.S. Environmental Protection Agency).
SDWS = Secondary Drinking Water Standard (U.S. Environmental Protection Agency).

A.1.7.4 Adequacy of the Well Network

The TSD unit currently has only two downgradient wells and no upgradient well. Three new wells are currently in the planning stage and, when installed, will bring the S-10 into compliance with regulatory requirements. If groundwater flow direction changes or additional wells go dry, the network will be re-evaluated for adequacy. The installation of new wells is subject to prioritization through the Tri-Party Agreement and documented in Tri-Party Agreement Milestone M-24-57.

Because of the proximity of the S-10 to surrounding cribs, ponds, and ditches, special care must be taken in attributing contamination to the S-10. As an example, upgradient well 299-W26-7 (now dry) has produced chromium (predominantly hexavalent chromium) concentrations significantly above DWS. However, this well is so close to the western side of the S-10 pond that the S-10 pond itself may have been the source of chromium. Alternatively, the source may have been the "grossly contaminated" 216-S-17 pond (swamp) immediately upgradient of both S-10 and well 299-W26-7. Likewise, other upgradient waste sties (e.g., S-5 and S-6 cribs) may have contributed contamination to groundwater that is now flowing beneath the S-10 TSD. Some of the difficulty in resolving the source of contamination may be ameliorated by the installation of the new wells.

A.2 References

Atomic Energy Act. 1954. Chapter 1073, 68 Stat. 919, 42 USC 2011 et seq.

Comprehensive Environmental Response, Compensation, and Liability Act. 1980. Public Law 96-150, as amended, 94 Stat. 2767, 42 USC 9601 et seq.

DOE. 1987. *216-S-10 Ditch and Pond Preliminary Closure/Post Closure Plan.* U.S. Department of Energy, Richland, Washington.

DOE. 1992. *S Plant Aggregate Area Management Study Report*. DOE/RL-91-60, Rev. 0, U.S. Department of Energy, Richland, Washington.

DOE. 1995. *Hanford Site Background: Part 1, Soil Background for Inorganics*. DOE-RL-92-24, Rev. 3, U.S. Department of Energy, Richland, Washington.

DOE. 1997. *Hanford Site Background: Part 3, Groundwater Background*. DOE/RL-96-61, Rev. 0, U.S. Department of Energy, Richland, Washington.

DOE. 2004. R*emedial Investigation Report for the 200-CS-1 Chemical Sewer Group Operable Unit*. DOE/RL-2004-17, U.S. Department of Energy, Richland, Washington.

Ecology - Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy. *Hanford Federal Facility Agreement and Consent Order*. Document No. 89-10, as amended (The Tri-Party Agreement), Olympia, Washington.

EPA. 2000 (as amended). *Guidance for the Data Quality Objectives Process.* EPA/600/R-96/055 (QA/G-4), U.S. Environmental Protection Agency, Washington, D.C.

Hartman MJ, LF Morasch, and WD Webber (eds.). 2005. *Hanford Site Groundwater Monitoring for Fiscal Year 2004.* PNNL-15070, Pacific Northwest National Laboratory, Richland, Washington.

Hartman MJ, LF Morasch, and WD Webber (eds.). 2006. *Hanford Site Groundwater Monitoring for Fiscal Year 2005.* PNNL-15670, Pacific Northwest National Laboratory, Richland, Washington.

Kaiser Engineers. 1991. *Site Safety Plan 216-S-10 Ditch and 216-S-17 Pond*. Correspondence No. 0502122. Kaiser Engineers Hanford Company, Richland, Washington.

Maxfield HL. 1979. *Handbook 200 Areas Waste Sites* (Volumes I-III). RHO-CD-673, Rockwell Hanford Operations, Richland, Washington.

PNNL. 2005. *The Groundwater Performance Assessment Project Quality Assurance Plan.* PNNL-15014, Pacific Northwest National Laboratory, Richland, Washington

Resource Conservation and Recovery Act. 1976. Public Law 94-580, as amended, 90 Stat. 2795, 42 USC 6901 et seq.

Shearer JP. 2005. *Hanford Site Waste Management Units Report*. DOE-RL-88-30, U.S. Department of Energy, Richland, Washington.

Sweeney MD and CJ Chou. 2003. *Data Quality Objectives Summary Report - Designing a Groundwater Monitoring and Assessment Network for the 100-BC-5 and 100-FR-3 Operable Units*. PNNL-14287, Pacific Northwest National Laboratory, Richland, Washington.

WAC 173-160. "Minimum Standards for Construction and Maintenance of Wells." *Washington Administrative Code*, Olympia, Washington.

WAC 173-303. "Dangerous Waste Regulations." *Washington Administrative Code*, Olympia, Washington.

WAC 173-303-610. "Closure and Post-Closure." *Washington Administrative Code*, Olympia, Washington.

WAC 173-303-645. "Releases from Regulated Units." *Washington Administrative Code*, Olympia, Washington.

WAC 173-340-747. "Deriving Soil Concentrations for Ground Water Protection." *Washington Administrative Code*, Olympia, Washington.

WHC. 1990. *Liquid Effluent Study Final Project Report*. WHC-EP-0367, prepared by Westinghouse Hanford Company for the U.S. Department of Energy Richland, Washington.

Williams BA and CJ Chou. 2002. *Groundwater Monitoring Plan for the 216-S-10 Pond and Ditch.* PNNL-14070, Pacific Northwest National Laboratory, Richland, Washington.

Appendix B

Well Construction and Completion Summaries

0515345

WELL SUMMARY SHEET	Page 1 of 1
	Date: 14 Dec 99

Well ID: B8817		Well Name: 299-W26-13	
Location: 216-S-10 Pond		Project: 200-CS-1/RCRA	
Prepared By: T.A. Lee	Date: 14 Dec 99	Reviewed By: DCWeekes	Date: 12/29/99
Signature: [signature]		Signature: [signature]	

CONSTRUCTION DATA

Description

SS 304 Riser Pipe, 4½" OD, 4" ID, from +2.9 to 202.2 ft. bgs.

Temporary casings: 11¾" carbon steel 0'-36.3' 8⅝" carbon steel 0'-240.0'

Portland cement from 0' to 10.3'

Bentonite crumbles from 10.3 to 185.2 ft bgs

Bentonite holeplug from 185.2 to 190.7 ft bgs.

20-40 Colorado Silica Sand from 190.7 to 237.8 ft bgs.

W.L. = 200.1' bgs, 13 Dec 99, 0800 hrs

SS 304 Screen, 4½" OD, 4" ID, 0.010" slot, from 202.2 to 237.3 ft bgs.

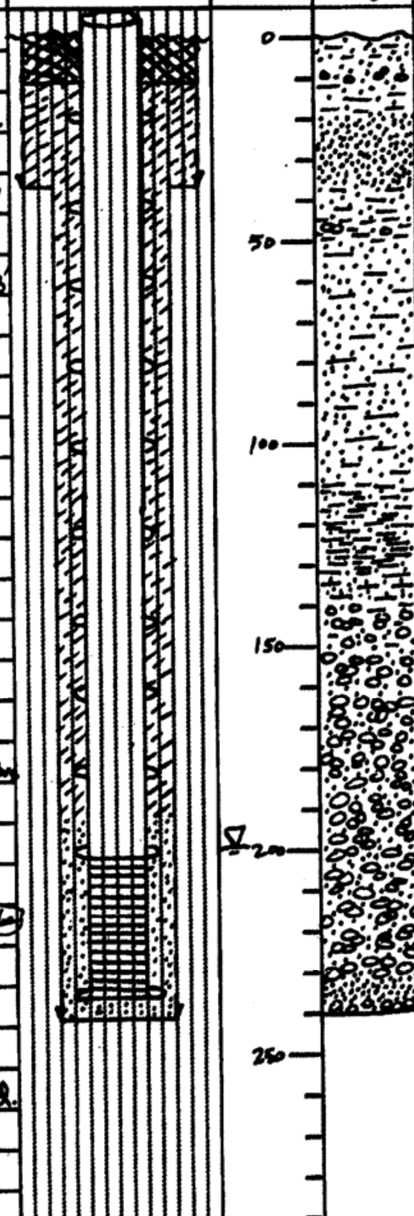
~~Sand from 237.3 to 240.7 ft~~ (TAL)

PVC Schedule 40 tail pipe from 237.3 to 237.8 ft bgs.

All depths in ft. below ground.

All Temporary casings removed.

Diagram / **Depth in Feet** / **Graphic Log**



GEOLOGIC/HYDROLOGIC DATA

Lithologic Description

0.0'-7.5' Slightly Silty SAND

7.5'-12.0' Gravelly SAND

12.0'-22.0' Silty SAND

22.0'-36.5' SAND

36.5'-47.0' Silty SAND

47.0'-51.0' Gravelly Sandy SILT

51.0'-110.0' Silty SAND

110.0'-134.0' Sandy SILT

134.0'-139.0' CALICHE ZONE

139.0'-148.0' Silty Sandy GRAVEL

148.0'-234.0' Sandy GRAVEL

Water level = 200.05' (12/13/99)

234.0'-237.0' SAND

237.0'-240.7' Sandy GRAVEL

T.D. = 240.7' bgs.

AS-BUILT WELL CONSTRUCTION AND COMPLETION SUMMARY

Drilling Method:	Cable Tool	Sample Method:	Grab/Split Spoon	WELL NUMBER:	299-W26-14 B8828 TEMPORARY WELL NO: Not Allowed
Drilling Fluid Used:	N/A	Additives Used:	potable water	Coordinates: N	Not documented
Driller's Name:	M Wraspar	WA State Lic Nr:	1909	Coordinates: E	Not documented
Drilling Company:	Blue Star	Company Location:	Rchld, Wa	Start Card #:	Not Available
Date Started:	06Mar03	Date Completed:	03Apr03	Elevation Ground Surface:	

Depth to Water: **223 ft 31Mar03**
(Ground surface)

Elevation of Reference Point: m

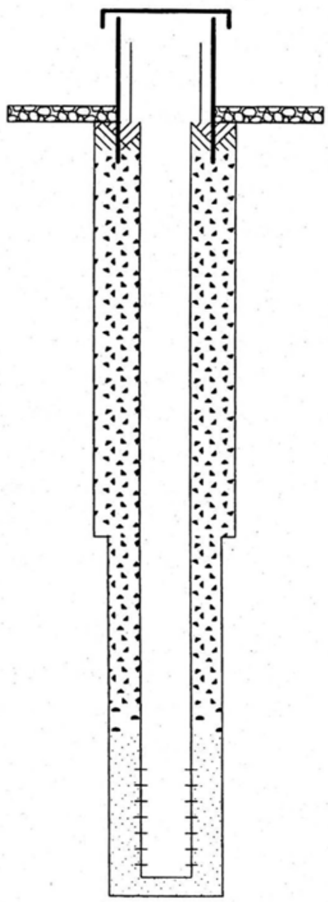
Height of Reference Point Above Ground Surface:

Depth of Surface Seal: **9.65 ft**

Type of Surface Seal: **4x4 Concrete Pad**

GENERALIZED STRATIGRAPHY **Geologist's Log**

0 - 1 ft : Fill
1 - 22 ft : slightly silty Sand (m)S
22 - 24 ft : Sand S
24 - 25 ft : silty Sand mS
25 - 26 ft : slightly silty Sand (m)S
26 - 35.5 ft : Sand S
35.5 - 40 ft : slightly silty Sand (m)S
40 - 48 ft : silty Sand mS
48 - 60 ft : sandy Silt sM
60 - 74 ft : silty Sand mS
74 - 76 ft : gravelly Silt gM
76 - 77 ft : gravelly sandy Silt gsM
77 - 78.5 ft : gravelly Sand gS
78.5 - 83 ft : slightly silty Sand (m)S
83 - 103.5 ft : Sand S
103.5 - 108 ft : slightly silty Sand (m)S
108 - 115 ft : Sand S
115 - 118 ft : slightly silty Sand (m)S
118 - 131 ft : sandy Silt sM
131 - 135 ft : Silt M
135 - 135.5 ft : Sand S
135.5 - 163 ft : Silt M
163 - 168 ft : sandy Gravel sG
168 - 182 ft : gravelly Sand gS
182 - 183 ft : slightly silt gravelly Sand (m)gS
183 - 190 ft : gravelly silty Sand gmS
190 - 192 ft : silty Sand mS
192 - 214 ft : gravelly silty Sand gmS
214 - 217 ft : gravelly Sand gS
217 - 219 ft : silty sandy Gravel msG
219 - 220 ft : Sand S
220 - 224 ft : sandy Gravel sG
224 - 257 ft : silty sandy Gravel msG
257 - 258 ft : Sand S
258 - 259 ft : silty sandy Gravel msG
259 - 260 ft : sandy Gravel sG
260 - 267 ft : Sand S
267 - ft : silty sandy Gravel msG



Fill	Casing	Screen
0 - 9.65 ft : 10.75-inch hole Cement surface seal	0 - 223.37 ft : 4 inch 304 SS sch 5 csg	
9.65 - 143 ft : 10.75-inch hole Bentonite crumbles		
143 - 200.98 ft : 8.625-inch hole Bentonite crumbles		
200.98 - 211.05 ft : 8.625-inch hole Bentonite pellets		223.37 - 258.37 ft : 4 inch 304 SS Wire Wrap .020 slot scrn
211.05 - 260.47 ft : 8.625-inch hole 10/20 Silica Sand		
260.47 - 267 ft : 8.625-inch hole 10/20 Silica Sand	258.37 - 260.47 ft : 4 inch 304 SS sump	

267 ft : Borehole drilled depth

0 - 143 ft : 10.75-in. Cable Tool 10-3/4" CS Temp csg to 143 ft
143 - 267 ft : 8.625-in. Cable Tool 8-5/8" CS Temp csg to 267 ft

Drawing By:	JEA
Reference:	Hanford Wells
Revision:	0
Revision Date:	29Apr03
Print Date:	23Jul03

Report Form: WELLS Project File: WELLS.GPJ

WELL SUMMARY SHEET

0500615

Boring or Well No. 299-W27-2

Sheet 1 of 3

Location South of S tank farm
Project W017H / S-10 Ditch
Elevation
Drilling Contractor K.E.H.
Driller G. Howell / G. Lydin
Drilling Method and Equipment Cable tool B.E. 22W
Prepared By [signature] / Brett Thompson (Sign/Print Name) Date 10-8-92
Reviewed By [signature] / Edward C. Rafuse (Sign/Print Name) Date 12/20/92

CONSTRUCTION DATA

Description

16" ⌀ C.S Casing set at 9.85'

12" ⌀ C.S casing set at 179.88

10" ⌀ CS CASING SET @ 302.82

8" ⌀ CS CASING SET @ 426.56

4" STAINLESS STEEL PERMANENT CASING - SET @ 416.56'

SCREENED INTERVAL SET @ ~~415.46~~ 416.56 - ~~405.46~~ 406.14

STICKUP = 3.7 W/CAP ON 12/05/92.

Diagram

GEOLOGIC/HYDROLOGIC DATA

Graphic Log

Depth in Feet	Lithologic Description
0	Silty Sand with occasional pebble.
5	" "
10	" "
15	" "
20	Pebble or Gravell loose
25	Silty Sand
30	" "
35	" "
40	" "
45	" "
50	" "
55	" "
60	" "
65	" "
70	silt clay ripup clasts
75	silty Sandy Gravel
80	Gravel silty Sand
85	" " "
90	" " "
95	silty Sand
100	" "
105	" "
110	" "
115	" "
120	" "
125	" "
130	" "
135	silt clay
140	silty Sand
145	" "
150	" "
155	" "

A-6000-384 (04/90)

WELL SUMMARY SHEET

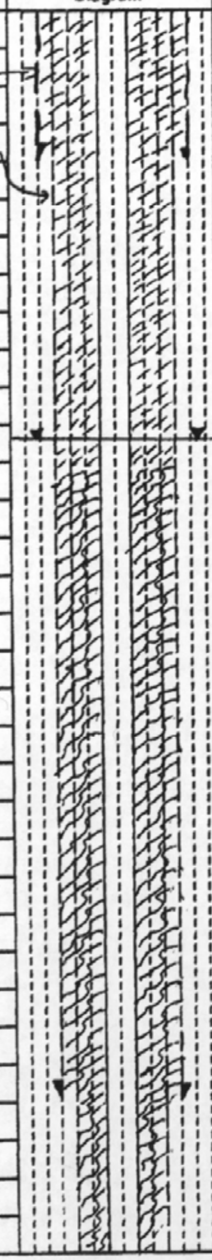
Boring or Well No. 299-W27-2

Sheet 2 of 3

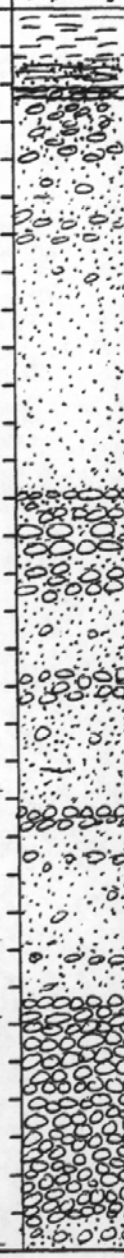
Location: South of S Tank farm
Project: W017H / S-10
Elevation:
Drilling Contractor: K.E.H
Driller: G. Lydin
Drilling Method and Equipment: Cable tool BE. 22W
Prepared By (Sign/Print Name): Brett R. [signature] Date 11/3/92
Reviewed By (Sign/Print Name): Edward C. Hagne [signature] Date 12/20/92

CONSTRUCTION DATA — **GEOLOGIC/HYDROLOGIC DATA**

Diagram:



Graphic Log:



Description (Construction Data)	Depth in Feet	Lithologic Description
	165	Silt clay
12" Ø CS CASING SET @ 179.88'	170	Silty Sandy Gravel
	175	" " "
10" Ø CS CASING SET @ 303.82'	180	
	185	SILTY GRAVELLY SAND
	190	SILTY SANDY GRAVEL
	195	GRAVELLY SAND
	200	" "
	205	" "
	210	" "
SWL @ 217.5 12/15/92	215	" "
	220	SAND SWL @ 217.5 ON 12/15/92
	225	GRAVEL
	230	" "
	235	SILTY SANDY GRAVEL
	240	" " "
	245	GRAVELLY SAND.
	250	SILTY SANDY GRAVEL
		" " "
	255	GRAVELLY SAND.
	260	
	265	SILTY SAND
		GRAVEL.
	270	
	275	GRAVELLY SAND W/ GRAVEL
	280	INTERBEDS
		" "
	285	" "
	290	" "
	295	" "
	300	
	305	GRAVEL.
	310	"
	315	"
		"
	320	"
	325	

A-6000-384 (04/90)

WELL SUMMARY SHEET

Boring or Well No. 299-W27-2

Sheet 3 of 3

Location: SOUTH OF "S" TANK FARM | Project: W017H/S-10

Elevation: | Drilling Contractor: JENSEN

Driller: D. MINOR | Drilling Method and Equipment: CP650/AIR ROTARY

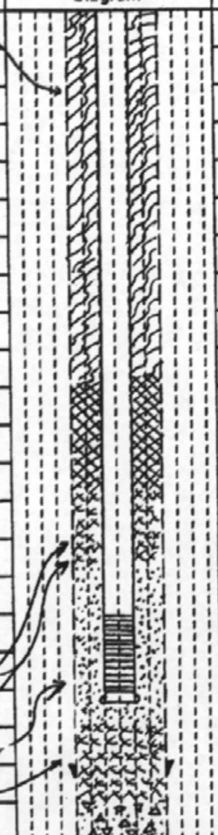
Prepared By: MOSWEENEY (Sign/Print Name) | Date: 12/18/92 | Reviewed By: EDWARD C. RATHE (Sign/Print Name) | Date: 12/20/92

CONSTRUCTION DATA

Description

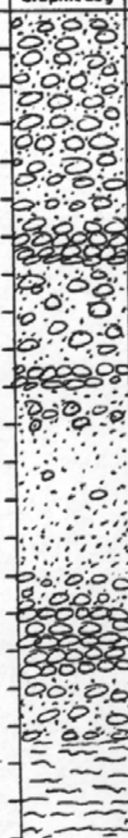
- 8" Ø CS CASING SET @ 426.8
- SCREEN SET @ 416.56 to 406.14
- PORTLAND CEMENT 9.7' - 20'
- BENTONITE CRUMBLES (8-20) 221.8 - 9.7'
- BENTONITE SLURRY 374.5 - 221.8
- PORTLAND CEMENT 389.4 - 374.5
- BAROID HOLE PLUG 399.4 - 389.4
- 10/20 SAND 420 - ~~399.4~~ 420.0 - 399.4
- BENTONITE PLUG 428.2 - 420.0
- HOLE COLLAPSED TO 428.2

Diagram



GEOLOGIC/HYDROLOGIC DATA

Graphic Log



Depth in Feet	Lithologic Description
330	SANDY GRAVEL
335	" "
340	" "
345	" "
350	" "
355	" "
360	GRAVEL
365	SANDY GRAVEL
370	" "
375	GRAVEL
380	SANDY GRAVEL
385	" "
390	GRAVELLY SAND
395	" "
400	SAND
405	SANDY GRAVEL
410	GRAVEL
415	"
420	SANDY GRAVEL
425	" "
430	CLAY/SILT
435	
440	

TD = 435.0' 11/20/92

REDRILLED FROM 376' TO 414.5 12/4/92 - 12/9/92 w/ BEEZW RIG # U-12.

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