PNNL-13486

Characterization Activities Conducted at the 183-DR Site in Support of an In Situ Gaseous Reduction Demonstration

E. C. Thornton, Project Manager
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March 2001

Prepared for the U.S. Department of Energy
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and Technology, within the U.S. Department
of Energy's Office of Environmental Management,
under the Subsurface Contaminants Focus Area

Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

In Situ Gaseous Reduction (ISGR) is a technology currently being developed by the U.S. Department of Energy for the remediation of soil waste sites contaminated with hexavalent chromium, Cr(VI). This approach involves the injection of a treatment gas mixture into a subsurface zone of contamination, resulting in the reduction and immobilization of chromium. The primary beneficial result of treatment is the elimination of a vadose zone source of contamination, thus potentially leading to the decline in hexavalent chromium concentration levels in local groundwater.

Prior work suggests that a candidate for application of this approach is the 183-DR site at Hanford, which is associated with a significant groundwater contaminant plume and was formerly a water treatment facility that utilized chromate as a corrosion inhibitor. This document presents the data collected during the excavation of trenches and the drilling of two vadose zone boreholes (C3040 and C3041) at the 183-DR site to obtain information regarding distribution of hexavalent chromium and other chemical and geological data that could support an ISGR demonstration. Laboratory geotechnical and treatment tests were also conducted to obtain information needed to support the design of an ISGR demonstration, if undertaken at the site.

Sediment samples obtained from the trenches and from nearly continuous split spoon cores from the boreholes were submitted for physical and chemical analysis. Although elevated total chromium was detected in sediment collected from one of the trenches and from the first borehole (C3040) at 68 ft depth, only trace levels of hexavalent chromium were detected in all other sediment samples. Hexavalent chromium was detected at elevated levels in groundwater samples obtained from the boreholes, as was expected. It is concluded that the two boreholes missed the vadose zone contaminant source that is responsible for the hexavalent chromium groundwater plume located downgradient of 183-DR. The well-defined nature of the groundwater plume suggests that an active vadose zone source may still exist in the vicinity of 183-DR, however. Borehole C3040 was completed as groundwater monitoring well 199-D2-8, which will help further define the upgradient configuration of the plume.

Further work is needed before a vadose zone source for the groundwater plume can be identified. The installation of additional groundwater wells in the vicinity of 183-DR could help to define the source. Split spoon core should be obtained from the vadose zone during the drilling of these wells and sediment samples collected and analyzed for hexavalent chromium. The chromate transfer lines and drain lines may also be sources of hexavalent chromium contamination. If a region of hexavalent chromium is identified at 183-DR, local excavation activities could be undertaken to define the source of contamination and potentially remove it. If contamination extends to significant depths, In Situ Gaseous Reduction can then be utilized for vadose zone treatment.

Acknowledgments

This work is funded by the Office of Science and Technology, within the U.S. Department of Energy's Office of Environmental Management, under the Subsurface Contaminants Focus Area. The authors wish to acknowledge the contributions of a number of individuals who participated in or supported the preparation of this document: Bill Bonner, Jim Bush, Joe Devary, Mark Freshley, John Fruchter, Mart Oostrom, and Bruce Williams of Pacific Northwest National Laboratory; Ron Jackson, Greg Mitchem, and Scott Petersen of Bechtel Hanford Inc.; and Jim Hanson, Scott McMullin, and Arlene Tortoso of the U.S. Department of Energy.

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1.0 Introduction and Objectives

This document describes field activities associated with excavation of trenches and installation of two boreholes to evaluate the distribution of hexavalent chromium, Cr(VI), in the vadose zone at the former location of the 183-DR facility in the 100-D/DR Area of the U.S. Department of Energy (DOE) Hanford Site, Washington. If a source of contamination can be identified in the vadose zone at 183-DR, treatment by injection of a reactive gas has been proposed, which would chemically reduce hexavalent chromium (Thornton et al. 2000a). This approach to remediation is referred to as In Situ Gaseous Reduction or ISGR (see Figure 1). The ISGR technology is expected to have a significant beneficial effect on local groundwater by immobilizing chromium in the vadose zone and thus eliminating the source responsible for contamination of the unconfined aquifer.

The 183-DR facility was constructed in 1950 to treat water from the Columbia River that was used for cooling water in the 100DR Reactor (WHC 1993). Primary treatment operations included coagulation/flocculation of sediment and chlorination (Figure 2). This facility stockpiled sodium dichromate solution, which was delivered by rail to a dichromate transfer station and transferred to 183-DR by chemical lines. Sodium dichromate was added to the processed cooling water as a corrosion inhibitor (Richards 1953) at concentrations of several parts per million (ppm or mg/l) after filtering and before going into clear wells. The treatment plant was decommissioned in 1978. This involved removal of surface structures and filling the sedimentation basins with debris and backfill. No significant contamination of soil by hexavalent chromium was described in historical reports. A large groundwater chromate plume presently exists downgradient of the 183-DR site, however, suggesting that the area around 183-DR is the source of the plume (Rohay et al. 1999, Thornton et al. 2000a). Thus, if a vadose zone source of hexavalent chromium can be identified and treated at 183-DR, it is anticipated that the groundwater plume will eventually dissipate.

The development and deployment of the ISGR technology has been funded by the U.S. Department of Energy's Office of Science and Technology Subsurface Contaminant Focus Area under Technical Task Plan (TTP) RL38SS42, In Situ Chemical Treatment of Soils by Gaseous Reduction, to Pacific Northwest National Laboratory (PNNL). This approach involves the preparation of the reactive gas mixture (diluted hydrogen sulfide in air or nitrogen) by a skid-mounted gas treatment system and injection of the treatment gas into chromate-contaminated soil through a borehole, as illustrated in Figure 1. The mixture is drawn through the soil by a vacuum applied to extraction wells situated at the periphery of the flow cell. As the gas mixture contacts the contaminated soil, hexavalent chromium is reduced to the trivalent oxidation state, which results in immobilization and detoxification of the chromium. Residual hydrogen sulfide is then scrubbed from the extracted gas mixture by the gas treatment system.

A small-scale field demonstration of this approach was previously completed by PNNL at a waste site located at the U.S. Department of Defense (DOD) White Sands Missile Range, New Mexico (Thornton et al. 1999). This pilot demonstration was effective in treating hexavalent chromium at the test site and was successfully completed without any measurable release of treatment gas to the environment.

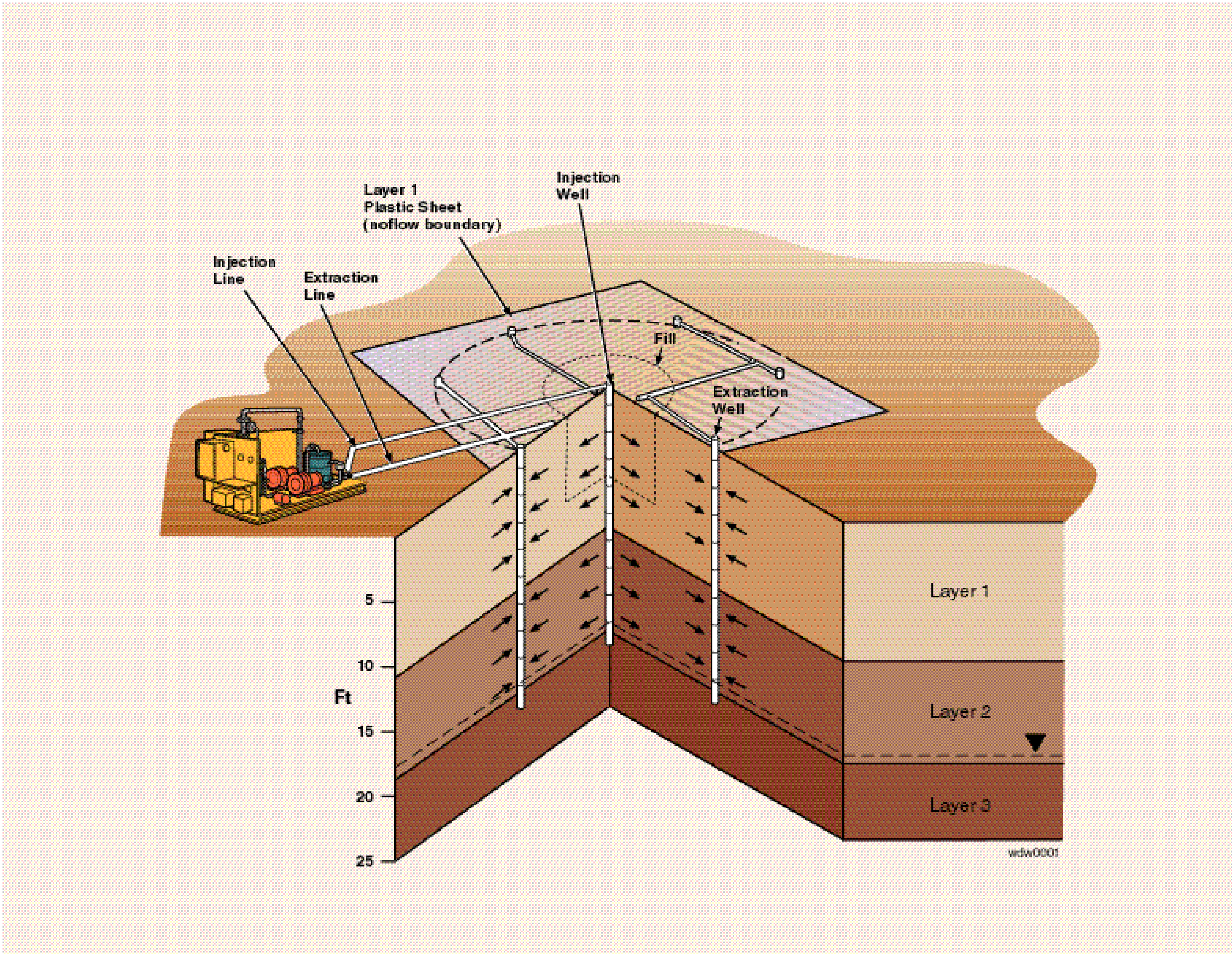

Figure 1. Conceptual Model of the In Situ Gas Treatment System and Wellfield Network

A larger scale demonstration of the ISGR technology within the 100 Areas at the Hanford Site could be utilized to support DOE's remediation goals and would represent the initial deployment of the ISGR technology at a DOE site. The need for the ISGR technology at the Hanford Site is formally recognized in Site Technology Coordinating Group (STCG), Need #RL-SS11, Cost-Effective, In Situ Remediation of Hexavalent Chromium in the Vadose Zone. The ISGR approach to soil remediation has been presented to stakeholders in meetings with the Hanford STCG and the performance of a treatability test at the Hanford Site has been endorsed by the STCG Management Council, provided a suitable demonstration site can be identified. A draft treatability test plan has also been prepared that describes technical activities and requirements associated with the gas treatment demonstration if it is undertaken.[1]

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[1] Thornton, E.C., K.B. Olsen, T.J Gilmore, R. Schalla, K. Cantrell, S.W. Petersen, and M. Oostrom. 2000. *Treatability Test Plan for In Situ Gaseous Reduction at the Hanford 183-DR Site*. Unpublished report, Pacific Northwest National Laboratory, Richland, Washington.

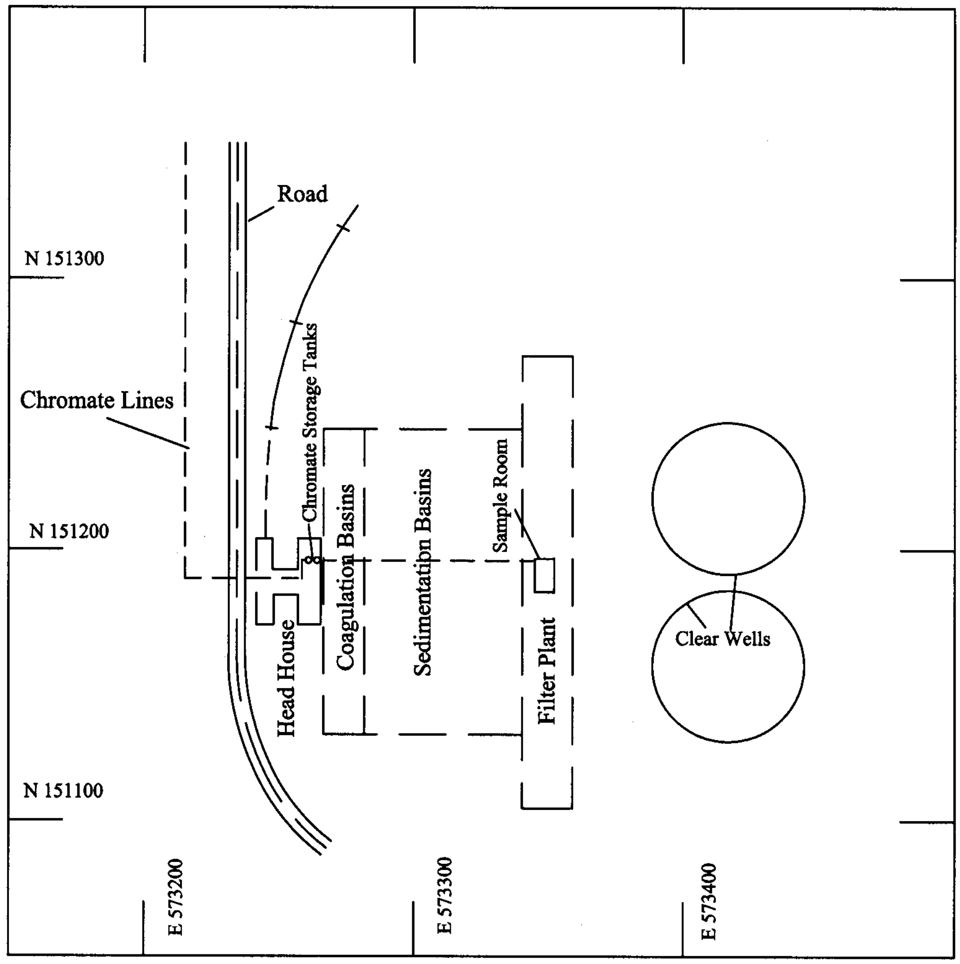

Figure 2. Layout of the 183-DR Facility. Coordinate System: State Plane NAD83 (meters).

English units are used in this report because they are used by drillers and geologists to measure and report depths and well construction details. The conversion to metric can be made by multiplying feet by 0.3048 to obtain meters or by multiplying inches by 2.54 to obtain centimeters.

2.0 Summary of Site Characterization Activities

Vadose zone characterization has been undertaken recently at 183-DR using Geoprobe™ and cone penetrometer equipment and by track hoe trenching (Thornton et al. 2000b). This work provided shallow (≤20 feet) stratigraphic information, but very little hexavalent chromium contamination was identified. However, minor levels of hexavalent chromium and high levels of total chromium (~650 ppm) were detected in soil samples collected in a trench on the northeastern corner of the head house and just north of the chromate storage tanks (see Figures 2 and 3). This area was characterized by soil discoloration (i.e., a slightly orange coloration suggestive of oxidation).

The characterization approach utilized in the evaluation of hexavalent chromium in the vadose zone at 183-DR by borehole drilling has been presented in a drilling description of work (DOW) prepared by PNNL (Thornton et al. 2000a) and implemented under a Bechtel Hanford Inc. drilling contract. The area of contamination north of the 183-DR head house was identified as the location for the first exploration borehole (C3040; Figure 3) needed to determine if hexavalent chromium contamination is present deeper in the vadose zone at 183-DR. Secondary drilling options specified by the DOW included a location near the former 183-DR filter plant and a location near a bend in the chromate chemical lines to the west of the 183-DR head house. Based on the results of drilling borehole C3040, which suggested that the source could be located downgradient of C3040, it was determined to drill the second borehole, C3041, near the bend in the chromate chemical lines (Figure 3). A detailed discussion of the criteria employed in determining the location of the second borehole is presented in the DOW. The DOW also indicated that geophysical logging would be performed in one of the boreholes.

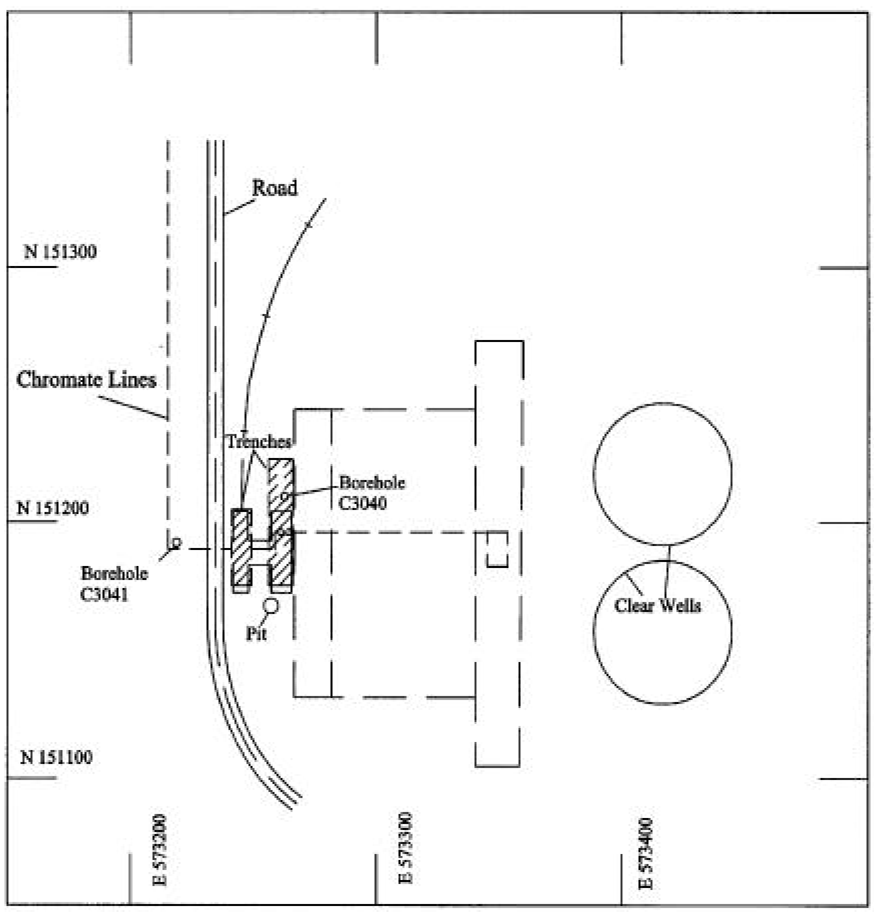

Figure 3. Location of Boreholes C3040 and C3041 and Excavation Trenches

2.1 Sampling Summary

The top 20 feet of sediment was sampled in the vicinity of the 183-DR head house in trenching operations conducted in January 2000 (Thornton et al. 2000b). This led to the discovery of an area of discolored soil at the northern end of the head house. Borehole C3040 was subsequently drilled at this location. The drilling of the two boreholes (C3040 and C3041) at 183-DR was initiated on July 20, 2000 (Table 1). Nearly continuous sediment core samples were collected from the boreholes for chemical and physical analysis from 20 feet to just below the water table at approximately 85 feet. The opportunity was taken during this work to complete one of the two boreholes, C3040, as a groundwater monitoring well, 199-D2-8.

Table 1. Drilling Summary

Well ID	Well Name	Start Date	Finish Date	Northing (m)	Easting (m)	Ground Surface Elevation (m)	Total Depth (ft)
C3040	199-D2-8	7/11/00	8/7/00	151208.864	573263.623	143.605	100.9
C3041	Abandoned	7/20/00	8/1/00	151191.699	573216.127	142.863	86.5

The boreholes were drilled from the surface to 20 feet using an air rotary drilling method and from 20 feet to the final depth using the cable tool method. The top 20 feet at the site contains areas of concrete and debris from the demolition of the former 183-DR water treatment facility. Air rotary drilling was determined to be the most efficient method of drilling this zone, because the debris made drilling conditions relatively difficult. Samples were not obtained in the top 20 feet; however, this interval has been previously sampled by trenching (see Thornton et al. 2000b). Continuous split spoon cores of sediment were collected from a depth of 20 feet in the boreholes to just below the groundwater table. The primary goal for the boreholes was to sample the unsaturated zone for chromium concentrations, but they also provided the opportunity to obtain groundwater data in an area of high chromium concentrations. For this reason, each borehole was advanced to approximately 10 feet into the upper unconfined aquifer. A temporary well screen was then installed with a sand pack, and a groundwater sample collected. The temporary well completion consisted of installing a 2-inch diameter PVC wire-wrap screen with casing. The 5-foot screen was placed approximately 5 feet below the static water level, and the annulus outside the casing was backfilled with filterpack sand. The temporary well was then pumped with a Grundfos Redi-Flo-2™ variable speed submersible pump until groundwater parameters stabilized. Groundwater samples were then collected (see Section 5.0).

Based on the analytical results for chromium, it was determined that borehole C3040 be deepened and completed as a RCRA groundwater well (199-D2-8) and C3041 be abandoned. Summary of the completion details are included in Appendixes A and B. Additional site-specific geologic descriptions are presented in Section 3.0.

2.2 Geophysical Logging Summary

Geophysical logging was conducted through the casing in borehole C3041 on July 25, 2000. Total gamma-ray and neutron moisture logs are included in Appendix B.

A total gamma survey was performed using a NaI (sodium iodide) spectral logging tool, which helped identify stratigraphic changes in the borehole. An increase in total gamma activity was detected at a depth of about 47 feet, near the base of the Hanford formation. The gamma ray response was somewhat erratic from a depth of 47 feet to about 60 feet. This may be a reworked zone at the top of the Ringold Formation and was characterized as a silty sandy gravel during geologic logging (see Section 3.0). A more stable total gamma-ray baseline below 60 feet suggests that this is the top of undisturbed Ringold Formation sediments. The total gamma response was judged to be related to concentrations of natural radionuclides.

Neutron moisture logging was also performed in borehole C3041. The neutron count rate was relatively constant through the vadose zone, although values decreased in a zone between 40 and 50 feet depth. The water level in the casing was evident at a depth of 76 feet on the log. A static water level depth of 78.2 feet was recorded during drilling activities (Appendix B).

3.0 Site Geology

The stratigraphic units associated with the vadose zone and unconfined aquifer in the vicinity of the 183-DR site in descending order from the surface to depth are: localized Holocene surficial deposits and backfill, the informally defined Hanford formation, and the Ringold Formation. Based on geological logging performed during the drilling of groundwater monitoring wells in the 100-D Area, the Hanford formation is generally present to a depth of about 55 feet; a coarse-grained unit of the Ringold is present from 55 to 98 feet; and a fine-grained unit of the Ringold Formation is present below 98 feet. Hanford formation sediment consists of 2 to 11 foot-thick interbedded sand and sandy gravel layers. Coarse-grained Ringold Formation Unit E deposits underlie the Hanford formation in the vicinity of 183-DR; these deposits consist of sandy gravels to sandy silty gravels. The Ringold Upper Mud Unit occurs locally at a depth of about 105 feet and acts as an aquitard that forms the base of the unconfined aquifer.

The specific geology at the 183-DR site is summarized in Figures 4 and 5 and detailed geologic log descriptions are presented in Appendixes A and B. The interval from the surface to 15 to 20 feet depth at the site is composed of backfill material containing broken concrete, piping, and reinforcing steel near the former location of the 183-DR facility with areas of relatively undisturbed sandy gravel, as determined by track hoe trenching activities. In some areas around the demolished facility, a 3 foot-thick reinforced concrete floor is still intact at a depth of approximately 23 feet. In areas away from the facility at depths between 16 to 20 feet, the sediments consist of large cobbles in a clast-supported matrix (i.e., lacking a finer grained matrix). Between 23 to 32 feet, the sediments are predominantly sandy gravel with a layer

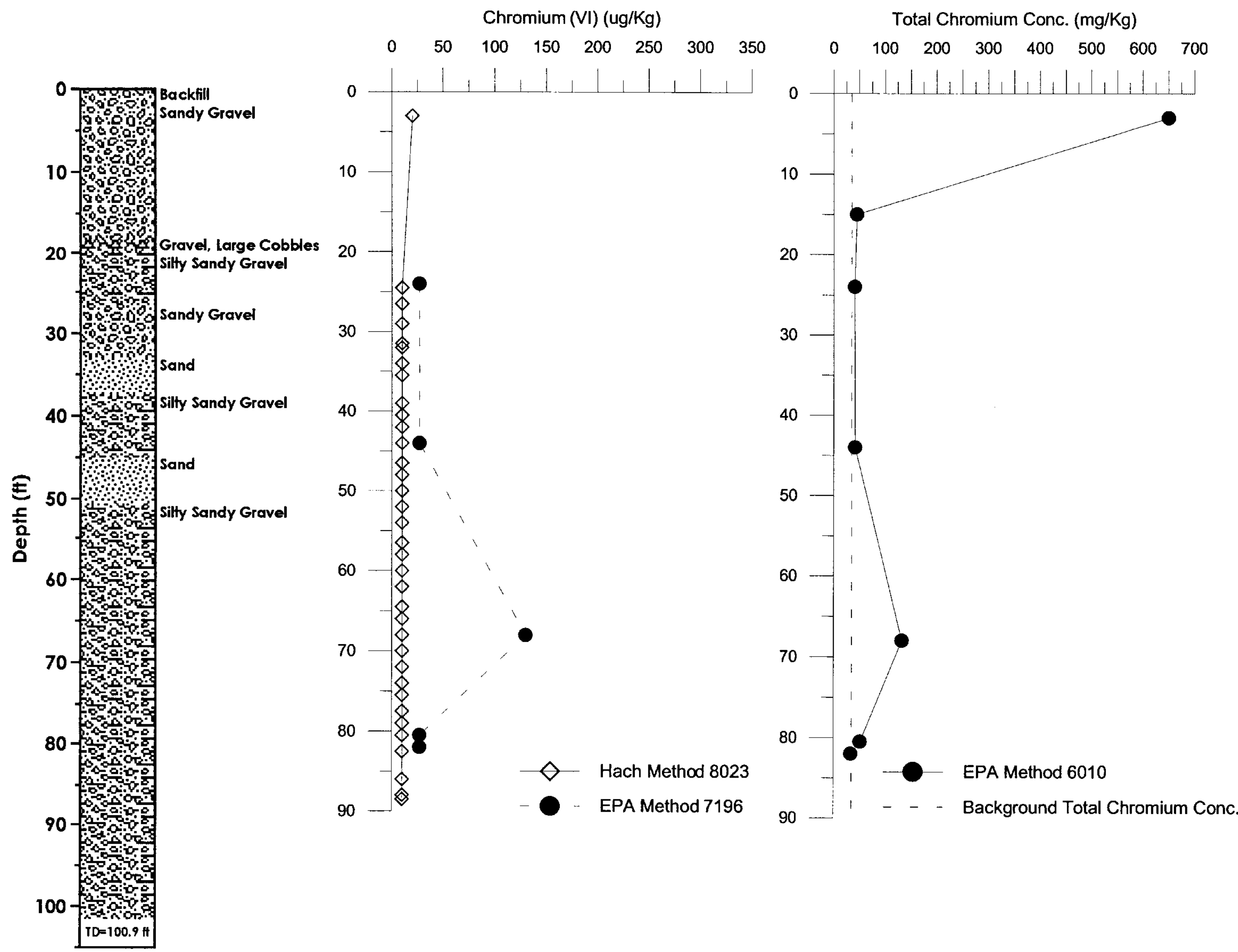

Figure 4. Generalized Geologic Logs and Cr Concentration versus Depth for Borehole C3040 and Trench

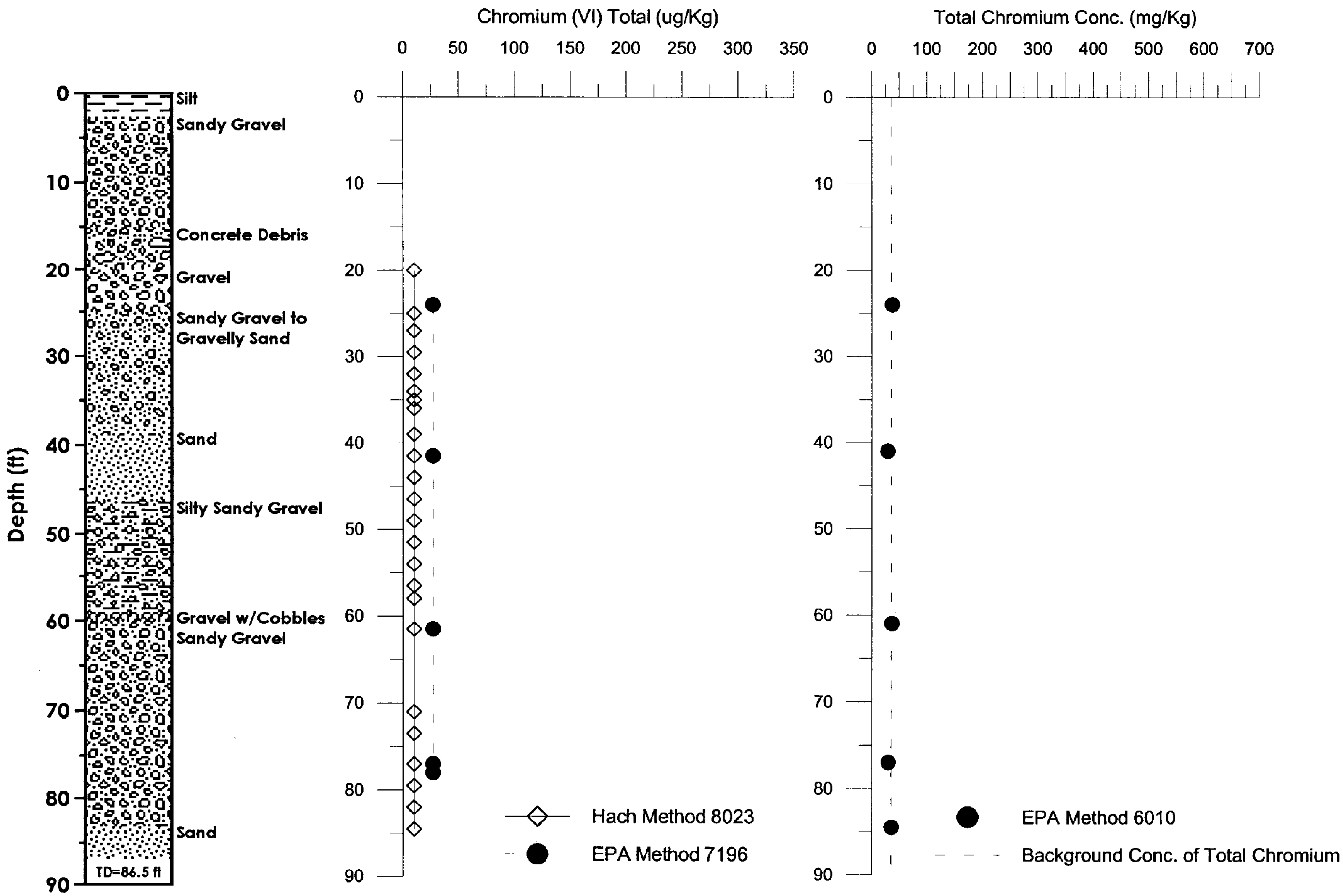

Figure 5. Generalized Geologic Logs and Cr Concentration versus Depth for Borehole C3041

of sand between 32 to 36 feet. It is then silty sandy gravel to approximately 46 feet with a sand layer just above the contact with the Ringold Formation at 50 feet. The Ringold Formation was differentiated from the Hanford during logging by the higher percentages of silica-rich minerals. The sediment between 50 feet and the final depth of 100.9 feet in well C3040 was predominantly silty sandy gravel. The top of the unconfined aquifer was located at about 80 feet below ground surface within the Ringold Formation. The Upper Mud unit was not encountered in drilling borehole C3040 (well 199-D2-8) probably because drilling was terminated at 100.9 feet (see Figure 4), whereas the Upper Mud unit should occur near 105 feet.

4.0 Vadose Zone Sediment Chemistry and Physical Properties

Sediment samples collected at 183-DR during trenching and borehole drilling activities were analyzed for chemical constituents and underwent selected geotechnical tests, primarily measurement of moisture content and performance of grain size analyses. The chemical analytical data were utilized primarily to determine the distribution of hexavalent chromium at the site. Moisture content is useful from the standpoint of identifying zones that may contain higher levels of saturation. The grain size analyses are useful in providing estimates of permeability, which is an important consideration in the design of a potential future ISGR demonstration at the site.

4.1 Sediment Analysis

Analytical data for hexavalent chromium is available for vadose zone sediment samples collected using Geoprobe™ and cone penetrometer equipment at 183-DR from July through October 1999 (Thornton et al. 2000b). All data obtained indicated hexavalent chromium concentrations at or below 0.5 ppm. Additional sampling was undertaken in January 2000 during the excavation of the two trenches along the head house foundation (see Figure 3). A total of 50 samples (including duplicates) were analyzed for hexavalent chromium with generally no significant concentrations detected, though an area of discolored soil located at the northern end of the head house contained a trace of hexavalent chromium in one sample collected. Ten of the soil samples collected by excavation were analyzed for total metals by x-ray fluorescence (XRF). Most were uncontaminated with a total chromium concentration of 20 to 30 ppm (i.e., background). However, a discolored soil sample collected at the northern end of the head house at a depth of 3 feet contained about 650 ppm total chromium, and was depleted in iron, manganese, and calcium and slightly enriched in lead. This area could have become contaminated as the result of drainage of water off the concrete slab associated with the chromate stock solution storage tanks. Another sample collected north of the head house at a depth of 15 feet had similar chemical characteristics and a total chromium content of 43 ppm, slightly above local background. This sample appeared to be associated with an area of alteration around a broken drain pipe.

The high level of total chromium content of the discolored soil thus suggests that chromium-bearing solutions may have entered the soil at the northern end of the head house, where chromate stock solution was stored in tanks, or by leakage of subsurface drainage pipes immediately to the north of the head house. Hexavalent chromium was apparently reduced to the trivalent oxidation state upon entering the soil and precipitated as Cr(III) oxyhydroxides (Rai et al. 1987) or other solid Cr(III)-bearing phases. This reaction could have been promoted by an acidic character of the solutions, which would have tended to accelerate reduction by ferrous-iron or organic matter in the soil and could also account for the slight orange-colored discoloration of the soil.

Borehole C3040 was drilled at the discolored soil location based on the evidence of release of chromium-bearing solutions from the head house. Continuous split spoon coring was conducted from a depth of 20 feet below the surface to 5 feet below the groundwater table in this borehole (see Figure 4 and Appendix A). Analysis of sediment samples from these cores was conducted for a variety of constituents as indicated in Appendix C for characterization and for waste designation purposes. In general, no significant indication of contamination was detected. However, a total chromium concentration of 132.8 ppm and a hexavalent chromium concentration of 130 ppb was reported for a sample collected in the depth interval of 68 to 68.5 feet in borehole C3040.

The second borehole, C3041, was located downgradient of C3040 because less than 2 ppm hexavalent chromium was detected in a groundwater sample collected from C3040 (Section 5; Thornton et al. 2000a). Specifically, C3041 was positioned at a bend in the chemical transfer lines coming into the head house (Figure 3). Split spoon sampling was conducted in this borehole and the sediment samples analyzed (Appendixes B and C). No indication of contamination was identified in the sediment samples from C3041 and all total chromium concentrations were near background levels (Figure 5).

4.2 Moisture Content Measurements

The moisture contents of vadose zone sediment samples obtained from cores retrieved during drilling of boreholes C3040 and C3041 are presented in Table 2. Values ranged from 2.6 to 4.6 wt% and averaged 3.3 wt% for C3040 and 3.7 wt% for C3041. No discernable trend with depth is apparent, although the moisture content of samples collected in the interval of 41.5 through 47 feet were highest in both boreholes. This corresponds to an interval of sand located at a depth of about 40 to 50 feet and could reflect an increase in saturation near the contact of the Hanford and Ringold formations.

Table 2. Moisture Content of Sediment Samples Collected from Boreholes C3040 and C3041

Borehole ID	Depth, ft	Moisture Content, wt%
C3040	24.5	3.50
C3040	46.5-47	4.40
C3040	68-68.5	2.60
C3040	80.5-81	2.60
C3041	25	3.40
C3041	41.5-42.5	4.60
C3041	61.5-62.5	3.10
C3041	77-78	3.60

4.3 Grain Size Analyses and Estimation of Vadose Zone Permeability

Three 5-gallon buckets of sandy gravel were collected at different locations during the trenching operations in intervals that were judged to be native undisturbed sediments. Grain size analysis by sieving (PNL 1993) was performed with this material, and the results were utilized to obtain estimates of permeability. This information is useful in ISGR design activities because vadose zone permeability determines gas flow rates.

Prior to the sieve analysis, the >3/8 inch fraction was removed from each sample and a portion of the <3/8 inch fraction submitted for analysis. The wt% greater than and less than 3/8 inch is indicated in Table 3 for each sample. The results of the sieve analysis for the <3/8 inch fractions is presented in Table 4. Grain size distribution plots of the three samples are presented in Figure 6.

Table 3. Weight Percent of Size Fraction Greater and Less than 3/8 inch for Excavated Sediment Samples

Sample ID	Wt% > 3/8 Inch	Wt% < 3/8Inch
N130 E130, depth = 15 feet	43.9	56.1
N131 E130, depth = 15 feet	62.3	37.7
N136 E130, depth = 25 feet	76.7	23.3

Table 4. Sieve Analyses of Less than 3/8 inch Fraction for Excavated Sediment Samples

Diameter (μm)	N130 E130 % < diameter	N131E130 % < diameter	N136E130 % < diameter
4,000	79.46	84.66	73.68
2,000	70.49	75.93	63.78
1,000	61.56	64.87	52.09
500	31.52	26.99	22.02
250	12.46	4.62	3.27
125	7.06	2.59	1.78
63	3.46	1.41	1.13
45	1.70	0.74	0.78

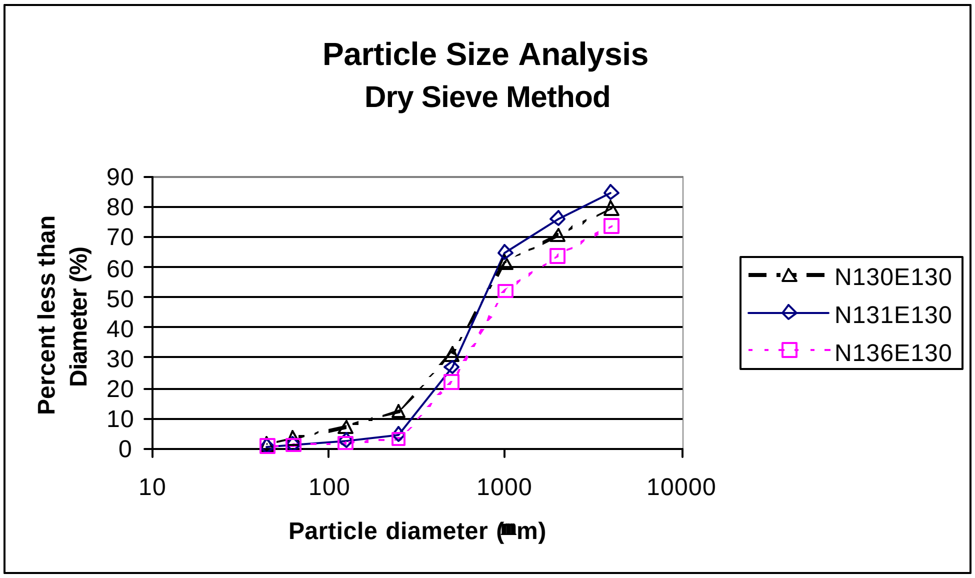

Figure 6. Grain Size Distributions of Less than 3/8 inch Fraction of Excavated Sediment Samples

Estimates of hydraulic conductivity of the samples were obtained from the grain size analyses using several theoretical models. An estimate of 700 m/day was obtained when the >3/8 inch fraction was included, and 200 m/day was obtained when only the <3/8 inch fraction was considered. This corresponds to intrinsic permeabilities of about 8.3 x 10^{-10} m^2 and 2.4 x 10^{-10} m^2, respectively, and provides a preliminary estimate of the range of permeabilities that could exist in the Hanford formation at the site. This information has been utilized to support initial modeling activities in support of a possible ISGR demonstration at 183-DR. Numerical simulations with the Subsurface Transport Over Multiple Phases (STOMP) simulator (White and Oostrom 1996) suggest that a high flow rate should be achievable (200 cfm at 2 psig pressure) owing to the high permeability of the vadose zone at the site. Good gas capture characteristics have been indicated with respect to STOMP pressure field and tracer simulations for an extraction to injection flow rate ratio (Q_{out}/Q_{in}) of 1.1 or greater.

5.0 Groundwater Chemistry and Well Development

Groundwater samples were collected from boreholes C3040 and C3041 for chemical analysis. Borehole C3041 was abandoned, but borehole C3040 was completed as a monitoring well. Presented below are aspects of the groundwater chemistry, especially chromium concentration levels, and information associated with development of the temporary and permanent well completions.

5.1 Groundwater Chemistry Summary

Groundwater samples were collected from temporary completions in boreholes C3040 and C3041 and analyzed for cations and anions and organic and radionuclide constituents. The results of these analyses are presented in Appendix C. The only contaminant noted was hexavalent chromium, which was reported at a concentration of 1,490 µg/L (ppb) in the sample collected from C3040 and 87 µg/L in the sample from C3041. Total chromium concentrations of 1,600 µg/L and 93.7 µg/L were reported for the C3040 and C3041 samples, respectively. Hexavalent chromium concentrations in the 100-D Area are commonly similar to total chromium concentrations, indicating that most of the dissolved chromium is in the hexavalent oxidation state as the chromate anion, CrO_4^{2-}.

The groundwater data for total chromium concentrations at 183-DR and other groundwater monitoring wells in the 100-D Area are presented in Figure 7, which illustrates the configuration of two major chromium plumes in mid-calendar year 2000. The configuration of the plume in the vicinity of 183-DR is generally similar to earlier interpretations (Rohay et al. 1999 and Thornton et al. 2000a). However, this more recent data plus the information from C3040 and C3041 indicates that the center of the plume is displaced slightly to the north relative to earlier work. This suggests that the vadose zone source of hexavalent chromium at 183-DR could be associated with the chromate chemical transfer lines to the west of the head house or a drainline located north of the head house. Analyses of soil samples collected at the 100-D Sodium Dichromate Transfer Station (Figure 7) suggest that significant concentrations of hexavalent chromium are not present at that location (Thornton et al. 2000b).

Hexavalent chromium concentrations in the 100-D Area groundwater plumes approach maximum values of about 2 mg/L (ppm) as indicated in Figure 7. This observation suggests that the aquifer may be saturated with respect to a chromate mineral phase that has previously precipitated and is now redissolving (i.e., hexavalent chromium concentrations may be solubility controlled). To assess this possibility, the analytical data presented for the C3040 groundwater sample was utilized to determine solution speciation and to calculate the saturation indices for various mineral phases. The MINTEQA2 geochemical equilibrium speciation model developed by EPA was employed for this purpose (Allison et al. 1991). In these calculations, alkalinity of the sample was calculated to be approximately 100 mg/L $CaCO_3$ based on charge balance considerations. Results obtained by the model indicated the sample was highly undersaturated with respect to nine different chromate minerals. The solid phase closest to saturation was $BaCrO_4$ (saturation index = log Q/K = -1.529). Thus, no common chromate mineral phase has yet been recognized that could provide a solubility control for hexavalent chromium concentration levels present in the aquifer. Solid solution of chromate in mineral phases such as calcite or gypsum could provide a solubility control but it is not possible at present to assess this potential mechanism.

5.2 Well Development Activities

There were two stages of well development at 183-DR. The first stage was to develop the well using a temporary well screen after the borehole was advanced 10 feet into the unconfined aquifer; this activity was undertaken for both boreholes. The second stage, installation of a permanent monitoring well, was conducted only in borehole C3040 after the well was completed at a depth of 20 feet into the unconfined aquifer.

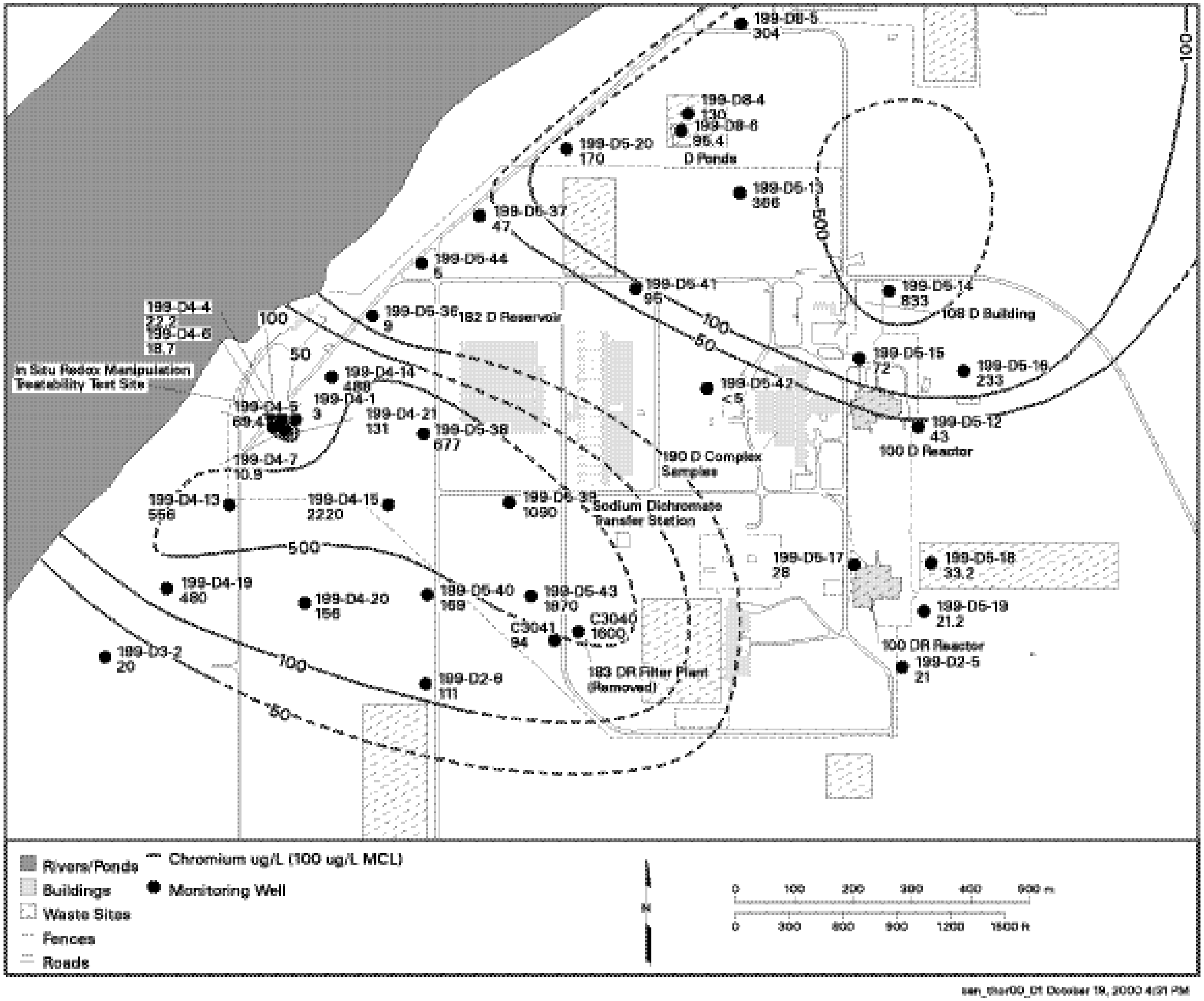

Figure 7. Facilities and Cr(total) Groundwater Plumes in the 100-D Area in mid-Calendar Year 2000

The first stage of development was conducted after a temporary PVC well casing and screen were placed in the borehole and then backfilled with filterpack sand after the borehole was advanced 10 feet into the aquifer. The temporary steel casing was then pulled back above the water table to expose the PVC well screen. Each well was pumped using an electric submersible pump until the groundwater parameters specific conductance, pH, and hexavalent chromium concentrations stabilized, and turbidity decreased to below 5 NTU. Additional groundwater samples were collected for chemical and radiological analysis after the groundwater parameters stabilized (Appendix C). The results for hexavalent chromium as determined in the field using Hach Method 8023, which is equivalent to EPA Method 7196 (EPA 1992), are shown in Figure 8. A total of 900 gallons of water were pumped in 180 minutes from borehole C3040 during development and a total of 583 gallons were pumped in 180 minutes from borehole C3041. The drawdown in C3041 was 1.2 feet after 180 minutes while pumping at 3.3 gallons per minute. Although an accurate drawdown was not measured in C3040, it can be qualitatively stated that the drawdown was less in C3040 in comparison to C3041 even while pumping at a higher discharge rate of 5 gpm. This indicated borehole C3040 was a better water producer.

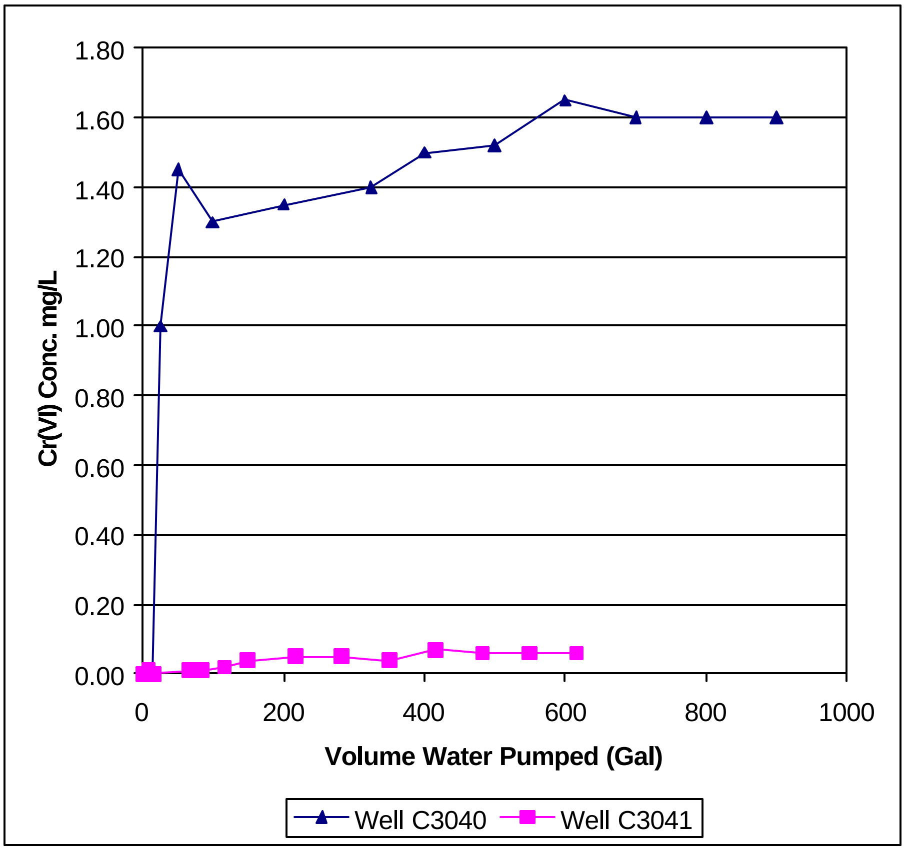

Figure 8. Cr(VI) Concentration in Development Water from Boreholes C3040 and C3041

Owing to its higher potential flow rates, borehole C3040 was completed as a permanent groundwater monitoring well. The hole was deepened to 100.9 feet to accommodate a 20-foot well screen. The well was again developed after the final completion with stainless steel well casing and screen. During this second stage of development, sand was placed around the screen, and the well was initially developed using a bailer to settle the sandpack. After the annulus was backfilled with bentonite and grout to the surface, the well was developed using an electric submersible pump. A total of 1,882 gallons of water were pumped in 174 minutes. The total drawdown after 174 minutes of pumping at 10.8 gpm was 12 feet. The development proceeded in steps where the flow rate was slowly increased to 10.8 gallons. At this flow rate the water level was approximately 1 foot above the pump intake. The pumping continued until the groundwater temperature, pH, specific conductance, and the concentration of hexavalent chromium stabilized and the turbidity decreased to below 5 NTU. The well fully recovered to static water level approximately 30 minutes after the pump was turned off.

6.0 Laboratory Treatment Tests

A number of laboratory treatment tests have been conducted to date that indicate diluted hydrogen sulfide is very efficient in reducing hexavalent chromium in soil. However, it is important to conduct site-specific treatment tests for each location where ISGR may be applied. The objectives of these site-specific treatment tests are to verify that an acceptable level of reduction can be achieved and to obtain an estimate of treatment gas consumption that is expected as hydrogen sulfide interacts with site sediment. These tests typically involve packing contaminated soil into columns and passing a diluted hydrogen sulfide gas mixture through the column at a known flow rate and concentration. Treatment progress can be monitored by recording the concentration of hydrogen sulfide at the column exit (i.e., the degree of breakthrough achieved). After treatment is complete, leaching of the column is undertaken and the mass of hexavalent chromium recovered is determined by analysis of leachate samples. An untreated soil column is also leached to determine the total mass of hexavalent chromium originally present. Comparison of the mass of hexavalent chromium recovered from the two columns provides a basis for determination of the degree of immobilization achieved during the gas treatment test.

Early experimental activities conducted during the development of the ISGR approach included treatment of sediments from the Hanford formation that were spiked with hexavalent chromium at the 200 ppm level (Thornton and Jackson 1994). Treatment with 2,000 and 100 ppm hydrogen sulfide treatment gas mixtures were undertaken and the treated soil columns leached with groundwater. Leachate analyses indicated that 94.6% and 98.4% immobilization of chromium was achieved, respectively. More recently, a sample of soil from the 183-KW site at Hanford has been tested that contains about 203 ppm hexavalent chromium, as determined by leaching of an untreated soil column. Leaching of the soil after treatment with a 200 ppm hydrogen sulfide mixture indicated essentially 100% reduction of hexavalent chromium in the soil. The higher degree of immobilization observed in this test compared to earlier tests can be attributed to a longer period of treatment. These results thus indicate that a minimum of 95% immobilization should be achievable by gas treatment at 183-DR under ideal conditions. Treatment operations may be less effective in the field in many cases, depending on gas flow characteristics and the extent of stratigraphic heterogeneity. As indicated in Section 4.3, however, the high permeability of this site makes it an ideal candidate for the ISGR approach.

Drilling activities at several Hanford Site locations have indicated that generation of hydrogen gas can occur (e.g., Bjornstad et al. 1994). This appears to result from the reduction of water. This may be attributed to the breakage of basalt cobbles, with resulting exposure of ferrous-iron bearing surfaces, or by introduction of metal shavings from a drill bit or drive casing. It has been suggested that hexavalent chromium in the vadose zone at Hanford may be reduced during drilling as the result of hydrogen generation or by direct reduction by basalt or shavings. The split spoon sediment sampling undertaken in the vadose zone at 183-DR was conducted ahead of the cable tool drive casing, however, and thus reduction of hexavalent chromium by broken rock or metal shavings would not be expected. However, the potential for the diffusion of hydrogen ahead of the drive casing should be considered as a possible mechanism for reduction of hexavalent chromium. To test this hypothesis, two more columns were packed with the Cr(VI)-contaminated soil collected at the 183-KW site. One of these columns was treated with a mixture of 4% H_2 in N_2 at a flow rate of 100 cc/min for more than 29 hours. The treated and untreated columns were then leached with deionized water and the leachate samples analyzed for hexavalent chromium. No significant difference in hexavalent chromium concentrations were observed between the two sets of leachate samples, indicating that H_2 did not reduce any of the chromate present in the treated column. Thus, it is concluded that hydrogen generation by drilling is probably not an important process for reducing hexavalent chromium in the vadose zone. It is concluded that the cored sediments recovered at 183-DR were probably not significantly altered by drilling activities.

Gas treatment tests have also been completed on the <3/8 inch fraction of soil collected during the trench excavations (Section 4.3). The purpose of these tests was to determine the extent of treatment gas consumption by the soil matrix and to obtain information regarding the specific reactions between H_2S/N_2 and H_2S/air gas mixtures and soil components. Mixtures of 200 ppm hydrogen sulfide in nitrogen and in air were employed in two column treatment tests. Both tests were run until a high degree of breakthrough was achieved ($C/C_o > 0.8$). The consumption ratio of hydrogen sulfide to soil by mass was determined to be 1.0×10^{-3} for the H_2S/N_2 test and 0.3×10^{-3} for the H_2S/air test. However, as indicated above, the >3/8 inch fraction of the soil was removed before packing into the columns. This gravel-sized material would likely consume less hydrogen sulfide on a mass basis owing to the lower specific surface area. A breakthrough of less than 80% should also be adequate for reduction of hexavalent chromium by hydrogen sulfide at the site, since the rate of this reaction appears to be fast (i.e., most of the treatment gas is consumed by slower reactions of hydrogen sulfide with soil iron oxides). Thus, a consumption ratio of about 1×10^{-4} should be adequate for the application of ISGR at 183-DR.

The time required to achieve treatment during an ISGR demonstration at 183-DR can be estimated on the basis of the mass associated with the treatment zone, the mass of hydrogen sulfide required per unit mass of soil, and the concentration and flow rate of treatment gas through the site flow cell. Assuming the zone targeted for treatment is 15 feet thick and 60 feet in diameter, the volume of soil involved is 42,412 cubic feet. Based on a bulk density of about 100 lb/ft^3 measured in laboratory column tests, approximately 4.24×10^6 pounds of soil is located in the treatment interval. As indicated above, a gas consumption ratio of 1×10^{-4} should be adequate to treat hexavalent chromium within the flow cell. Thus, approximately 424 pounds of hydrogen sulfide will be needed to treat the zone. If the treatment gas is injected into the site as a 200 ppm hydrogen sulfide mixture at a flow rate of 200 cfm, the time required to achieve a moderate level of breakthrough is expected to be roughly 78 days. However, because the treatment time required is inversely proportional to gas concentration and flow rate, the time associated with amount of time needed for treatment could be reduced by increasing the hydrogen sulfide concentration of the injection gas stream or by injecting at a higher flow rate.

7.0 Conclusions and Recommendations

Characterization activities conducted at 183-DR in the course of this study did not locate the vadose zone source of hexavalent chromium that has contaminated the underlying aquifer. Thus, it is not possible to proceed with an ISGR demonstration at 183-DR at this time. However, the groundwater data collected from boreholes C3040 and C3041, combined with that available from other monitoring wells in the area, has provided a better understanding of the geometry of the groundwater plume. The chromate chemical transfer lines located to the west of the 183-DR head house or a drainline north of the head house could be areas for future site investigations and a potential ISGR deployment.

Additional upgradient groundwater monitoring wells could help to identify the vadose zone source of hexavalent chromium at 183-DR. In particular, completion of a monitoring well near the former 183-DR filter plant would be useful in helping to establish the upgradient configuration of the plume. It is recommended that split spoon sampling of vadose zone sediments be undertaken as described in this study during installation of wells and sediments be analyzed for hexavalent and total chromium in the event that the source is encountered during drilling.

One or more vadose zone sources of hexavalent chromium may be discovered in the future at 183-DR. If a region of hexavalent chromium is identified, excavation can be undertaken to define the source and potentially remove it. Application of ISGR can then be considered for remediation of hexavalent chromium contamination if it is present above action levels at significant depths in the vadose zone.

8.0 References

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Appendix A

Well Construction Summary Report and Borehole Log for Borehole C3040

WELL CONSTRUCTION SUMMARY REPORT

Start Date: **July 11, 2000**	Finish Date: **August 7, 2000**
Page 1 of 1	

Specification No.:	Rev. No.:	Well Name: **199-D2-8**	Temp. Well No.: **C3040**
ECNs: N/A		Approximate Location: **Near demolished 183DR Facility, D Area**	
Project: **In Situ Gaseous Reduction**		Other Companies: **Pacific NW National Laboratory and Bechtel**	
Drilling Company: **Resonant Sonic International**		Geologist(s): **Tyler Gilmore, Ron Schalla, Ed Thornton**	
Driller: **Morris Wraspir**			

TEMPORARY CASING AND DRILL DEPTH

*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.
Nominal 14-in. Steel	surface – 20 ft	
Nominal 11-in. Steel	20 ft – 100.9 ft	
	-	
Temporary PVC 2-in. casing	+5.4 ft – 89.2 ft	
Temporary PVC 2-in. screen	69.1 ft – 89.2 ft	

Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design

Note: Temporary PVC casing used to obtain water samples and then removed. Final Stainless Steel casing placed after removing PVC casing and drilling an additional 15.5 ft

DRILLING METHOD/HOLE DIAMETER

Auger:	Diameter From ___ to ___
Cable Tool: **20 ft – 104.7 (TD)**	11" Diameter From 20 to 100.9
Air Rotary: **Surface – 20 ft**	14" Diameter From 0 to 20
A.R. w/Sonic:	Diameter From ___ to ___
	Diameter From ___ to ___
	Diameter From ___ to ___
	Diameter From ___ to ___

Drilling Fluid: **Water**

Total Drilled Depth: **100.9 ft**	Hole Dia @ TD: **11-in.**	Total Amt. Of Water Added During Drilling: **~130 gallons**	
Well Straightness Test Results:		Static Water Level: **81.25**	Date: **July 18, 2000**

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
No Geophysical Logging	-			-	
	-			-	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annual Seal/Filter Pack	Volume	Mesh Size
316 Stainless Steel (SS) tail pipe (sump)	100.1 - 97.08		N/A	Natural Fill	100.9 - 100.25	0.5 ft³	N/A
316 SS screen; 20 slot wire wrap	97.08 - 77.1		20 slot	Silica Sand; 10-20 mesh	100.25 - 71.66	31.03 ft³	10-20
316 SS casing 20 ft (3 pieces)	77.1 - 17.06		N/A	Bentonite Crumbles	71.66 - 10.0	41.89 ft³	
304 SS casing 20 ft (1 piece)	17.06 - +2.96		N/A	Cement Grout	10.0 - surface	10.69 ft³	

OTHER ACTIVITIES

Aquifer Test: **(2) Development Tests; one after temporary PVC installed, and one after final stainless steel casing installed.**	Date: **July 26, 2000**	Well Abandoned:	Yes:	No: **X**	Date:
Description: **PVC development; Pumped 900 gallons in 180 minutes; Sampled for Cr(VI) in time series; Stainless steel development, pumped 1882 gal in 174 minutes.**		Description:			

WELL SURVEY DATA

Date:	Protective Casing Elevation:
Washington State Plane Coordinates:	Brass Cap Elevation:

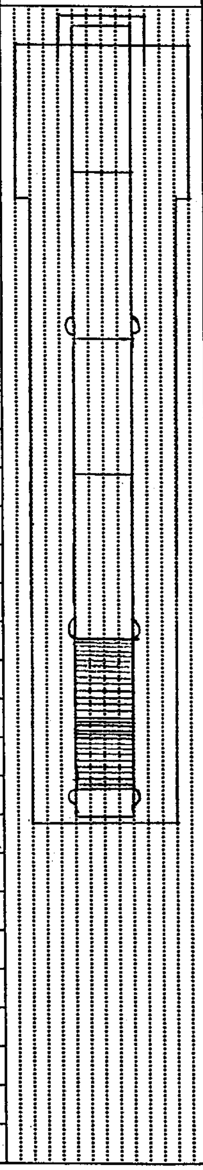
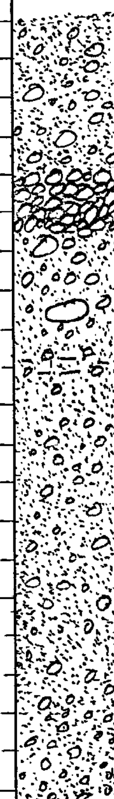
COMMENTS/REMARKS

Well completed as a RCRA well

Reported By: **Tyler Gilmore**		Reported By:	
Title: **Senior Research Scientist**	Date: **August 22, 2000**	Title:	Date:
Signature:		Signature:	

WELL SUMMARY SHEET

Page 1 of 1		Date: Aug 22 2000	
Well ID: C3040		Well Name: 199-D2-8	
Location: 100 D Area near demolished 183 DR		Project: In Situ Gaseous Reduction	
Prepared By: Tyler Gilmore	Date: Aug 22, 2000	Reviewed By: Ronald Schalla	Date: 8-31-2000
Signature: [signature]		Signature:	

CONSTRUCTION DATA			GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description
Temporary 14" Carbon Steel				
casing Surface - 20 ft		0		Backfill Sandy Gravel
(removed from ground)				
Protective Steel casing to +3ft				
Temporary 11" Carbon Steel				Gravel; large Cobbles
Casing 20ft - 101.01		25		
(removed from ground)				Sandy Gravel
316 Stainless steel 4" dia Casing				Sand (Boulder at 37ft)
77.1 - 17.06ft (20 ft lengths)				Silty Sandy Gravel
304 Stainless Steel 4" dia casing		50		Sand Ringold contact 50.5 ft
17.06 - +2.96 ft				Silty Sandy Gravel
316 Stainless Steel wire wrap				
screen 20 slot 97.08 - 77.1 ft				
316 Stainless steel tail pipe		75		
100.1 - 97.08 ft				
Sandpack 10-20 silica sand				
100.25 - 71.66		100		TD 100.9 ft
Bentonite Crumbles 71.66-100ft				
Cement Grout 10.0 - Surface				

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No: C3040 Depth: 0 to 24′ Sheet 1 of ~~#6~~ 23

Location: 100-D Area, 183-DR in 100H Project: ISGR

Logged by Ronald Schalla (Print) Ronald Schalla (Sign) Date 7-11-2000 to 7-12-2000

Reviewed by Ronald Schalla (Print) Ronald Schalla (Sign) Date 8-31-2000

Lithologic Class. Scheme USCS Procedure ______ Rev ____

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor Resonant Sonic International

Driller Kelly Cowden

Rig/Method Dresser XT 70F / Air Rotary + Cable

Depth Control Point Ground Surface

DEPTH ft	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	Driven CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
0	0930	cuttings drummed.			None	N/A	Fill	Sandy Gravel with cobbles	1+2 gpm	~14-in.	Began Driving casing at 0930 hrs
	↓							and a few small boulders. Some		Steel.	drove casing 10 feet then drilled
								concrete debris, steel parts +		Actual 13 3/8 OD	~~70~~ feet by air rotary with H_2O
								insulated electrical wire (Fill).		12 3/8 ID	added to reduce dust a cyclone
								Wire from approximately 16 feet			separator. Problems with threading
								in depth. Boulders or concrete			second 5′ section of casing. Stopped at
								from 18 to 19.5′. Drilling			1200 hrs for lunch; then resumed air
								easier from 19.5 to 20′. Cuttings			rotary drilling @ 1235 hrs.
20	1335	July 11, 2000						from 0-16′ contained in drum 100H-00-0079.			Actual Drill rate 10 ft/hour or less.
	0620	July 12, 2000						Driller informed me that he think			Telescoping with 11 3/4" O.D. +
								some cuttings were lost to the formation			10 1/4" I.D. threaded casing for
								in the first 20 feet of drilling. The			cable tool drilling.
								14" borehole should create about 1 cuft			Mucked out drill hole using
								per foot or 20 cubic feet. However			core barrel driven by cable
								only 8 cubic feet were collected			
								+ drummed. Water lost also			
20	0700							Silty, Sandy GRAVEL (GM)			Dump cuttings into
								40% gravel, 50% sand, 10% silt,			drum 100H-00-0078 from
								gravel is 20% v.cs-cs, 20% med, 40%			16′ to 22′ in depth
								fine, 20% vf. Sand is 40% vcs-cs,			
								30% med; 30% fine, dark grayish			
								brown (2.5Y-4/2), wet to v. moist,			
								poorly sorted, gravel subrounded to subang.			
23.9	0845							75% basalt, 25% granitic + quartz			

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040	Depth: 24´ to 32.5´	Sheet 2 of ~~16~~ 23
		Location: 100-D Area, 183-DR in 100-H OU	Project: ISGR	

Logged by Ronald Schalla (Print) Ronald Schalla (Sign) Date 7-12-2000

Reviewed by Ronald Schalla (Print) Ronald Schalla (Sign) Date 8-31-2000

Lithologic Class. Scheme USCS Procedure ______ Rev ____

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor Resonant Sonic International

Driller Kelly Cowden + Moe Wruspér

Rig/Method Dresser XT 70E, Cable Tool

Depth Control Point Ground Surface

DEPTH ft	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	Driven CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
24.0	0900	SPLIT SPOON	C3040-24.5	GM	Background	dry		Sandy GRAVEL (GW) with 5%	None	11,750.D	Drove sampler from 24 ~~ft~~ to
24.5		MOIST VOA	C3040-24.5	GM	"			or less silt. 50% gravel, 45%	↓	10,25 I.D.	26.5 ft. % recovery was 40%.
24.5-25.0		6" liner	C3040-24.5	GM	"			sand and 5% silt. Gravel is			Casing advanced after sampling
25 to		No	Recovery					similar in particle size as			+ borehole cleaned out to 26.5´
26.5			↓					above. dark grey (10YR-4/1)			All drilling by corebarrel
26.5	0940	SPLIT SPOON	C3040-26.5	GM	background	dry		dry to slightly moist			cable tool.
27.0		6" Lexan	C3040-27	"	"			@ 26.5 similar to above			Next sample 26.5´ to 29.0´
27.5		Liners	C3040-27.5	"	"			but somewhat coarser and			only recovery 1.5´ of sample
28.0								slightly more moist.			or 60%. Large cobble
28		No	Recovery								probably blocked end.
29			↓								
29-	1027	Split	C3040-29	GM	Background			Silty Sandy ~~GRAVEL~~ (GM)			Sampled at 29.0 to 31.5´
29.5		Spoon	C3040-29.5	"	"			40% gravel, 40% sand, 20% silt			Only recovered 1.5´ of sample
30.0		Lexan Liners	C3040-30	"	"			silt decreasing to 10% by			or 60% recovery. Some sand
30.5								30.5 ft. gravel is 10% v.csc, cs,			fell out of bottom of the 4"
30.5-		No	Recovery					30% med, 40% fine, 20% vf.			Lexan liner at the bottom.
31.5			↓					Sand is generally finer than			
31.5	1120	6" Lexan	C3040-31.5	GM	Background			above samples. Large increase			Sampled from 31.5 to 34 ft
32.0		Liners	C3040-32	"	"			in silt content from 29.5 to			recovered 1.8 ft or 70%.
32.5			C3040-32.5	"	"			30.5 feet. Dry, gray (10YR-5/1)			
33.0								70% basalt, 30% other including			
33 to		No	Recovery					about 10% quartz, chert, etc.			
34								same to 32.5 ft.			
								32.5´	↓		

W = Wet, M = Moist, D = Dry

A.4

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040	Depth: 32.5 – 41 ft	Sheet 3 of ~~76~~ 23
		Location: 100-D Area, 183DR in 100H OU	Project: ISGR	

Logged by Ronald Schalla (Print) / Ronald Schalla (Sign)	Date 7-12-2000	Drilling Contractor	Resonant Sonic International
Reviewed by Ronald Schalla (Print) / Ronald Schalla (Sign)	Date 8-31-2000	Driller	~~Kelly Gouden~~ Moe Wrasper
Lithologic Class. Scheme USGS	Procedure ____ Rev ____	Rig/Method	Dresser XT-70E, Cable Tool
Steel Tape/E-Tape ____ / ____	Field Indicator Equip. 1) ____ 2) ____	Depth Control Point	Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
32.5	1120	See	previous log	—	—	—		Sand (SP) and (SW) sand 98%,	None	11.75 O.D. 10.25 I.D.	Dumped waste soil into
								2% silt, ~~no~~ 0% gravel.	↓		drum 100H-00-00~~8E~~80
								Sand is 15% vcs-c, 60% med,			from samples to 34' in depth
								20% fine, 5% very fine, dry to			drum contains cuttings from
								slightly moist, gray (10YR-5/1) to			22 to 34' in depth.
								dark gray with white speckles			
								(10YR-4/1), 60% basalt 40%			
								other minerals primarily subrounded			
34.0	1300 ~~0700~~							to subangular.			Sampled from 34 to 36.5'
34-								Gravelly SAND (SW) sand			recovered nearly 2.0 ft, or 80%.
35	1320	12" Lexan	C3040-34	GM	Background	[illegible]		is 30% vcs-cs, 50% med, 15%			
36	1320	12" Lexan	C3040-35	GM	Background			fine, 5% vf. Traces of silt,			
↓		No	Recovery					slightly moist, dark gray (10YR-4/1)			
			↓					Gravel 50% fine, 40% med,			
36.5	1415							10% coarse. Basalt & quartz.			
36.8	1415	6" Lexan	C3040-36.5	GM	Background			Coarsening with depth.			Sampled from 36.5 to 39 ft,
	Boulder damaged steel							Boulder composed of basalt.			recovered only 3" or about 10%.
	drive shoe. No Recovery							Estimated to be 8 to 12-in. dia.			Boulder at 36.8 feet prevent
39.0	from 36.8 to 39'										additional recovery.
39.5	1515	6" Lexan	C3040-39.5	GM	Background	slightly moist		Silty Sandy Gravel (GM) 50% gravel,			Sampled from 39 to 41.5 ft,
40.0	1515	Liner "	C3040-40	"				40% sand, 10% silt or less. Gravel			recovered 2.0 ft or 80%.
40.5	1515	"	C3040-40.5	"				is 40% vcs-cs, 40% med., 20% fn-vf,			
41.0	1515	"	C3040-41	"				dark gray (10YR-4/1). 75% basalt			
								25% other, (quartz, feldspar)	↓		

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040	Depth: 41 – 49 ft,	Sheet 4 of ~~46~~ 23
		Location: 100-D Area, 183DR in 100H OU	Project: ISGR	

Logged by Ronald Schalla (Print) [signature] (Sign)	Date 7-12-00 to 7-13-00	Drilling Contractor Resonant Sonic International
Reviewed by Ronald Schalla (Print) [signature] (Sign)	Date 8-31-2000	Driller ~~Kelly Gowder~~ Moe Wrasper
Lithologic Class. Scheme USCS	Procedure ______ Rev ____	Rig/Method Dresser XT 70E, Cable Tool
Steel Tape/E-Tape ______ / ______	Field Indicator Equip. 1) ______ 2) ______	Depth Control Point Ground Surface

DEPTH ft	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
41.0	1610	No	Recovery	41	to 41.5			Same as above	None	11.75" OD 10.25" ID	Sampled from 41.5' to 44 ft
41.5	1610	6"	C3040-42	GM	Background			which is Sandy Gravel but			recovered 2.0' or 80%
42.0	Lexan	liner	C3040-425	"	"	Sl. Moist		less silt ~5%			
42.5	"		C3040-43	"	"			Gravel is rounded to well			
43.0	"		C3040-435	"	"			rounded for very coarse and			On 7-12-00
43.5-		No	Recovery					subrounded to subangular for finer.			Drilling ceased @ 1630 hrs
44.0			↓					Same as			Cleaned + loaded up + left site @ 1650 hrs.
~~44.5~~								above, but			7-13-00 Drilling resumed at
44.5	0810	6" liner	C3040-445	GM	Background			less silt ~2%			0745 this morning.
45.0	0810	"	C3040-45					Gravels (GW) fine to coarse.			Sampled from 44 to 46.5'
45.5	0810	"	C3040-45.5					coarser gravels igneous granitic			Recovered 2.0 ft or 80% recovery
46.0	0810	"	C3040 46	2 VOAs + Moisture Sample		Moist.		SAND (SP) sand 98%, 2%			Collected Moisture Samples + 2
46.0-		No Recovery						silt, 0% gravel. Sand is			VOA VIALS, C3040-46.
46.5			↓					25% v.CRS to crs, 60% med, and			
								15% fine to v.fine. moist			
								sample dark gray (10YR-4/1)			
46.5	0930							80% basalt 20% other (~~quartz~~)			
47.0	0930	6" liner	C3040-47			Moist		gravelly SAND (SP-SM)			Sampled from 46.5' to 49'
47.5	0930	"	C3040-47.5			to		with silt at certain layers up to			Recovered 2.0 ft or 80% recovery
48.0	0930	"	C3040-48			v. moist		20%, gravel 30%, Sand 50 to 70%			4, 6" long 4-in dia Lexan
48.5	0930	"	C3040-48.5					sand v.cs to cs 20%, 60% med			Liners capped + sealed.
48.5	No	Recovery						20% fine to v.f. (10YR-4/1) dark			
49.0			↓					gravel both rounded to subrounded			
								80% basalt + granitic gravel, sand 80% basalt	↓		

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040	Depth: 49' to	Sheet 5 of ~~? 62~~ 23
		Location: 100D Area, 183DR in 100H OU	Project: ISGR	

Logged by: Ronald Schalla [signature]	Date 7-13-00	Drilling Contractor: Resonant Sonic Int.	
Reviewed by: Ronald Schalla [signature]	Date 8-31-00	Driller: Morris "Moe" Wrasper	
Lithologic Class. Scheme: USCS	Procedure:	Rev:	Rig/Method: Dresser XT70E, Cable Tool
Steel Tape/E-Tape: /	Field Indicator Equip. 1) 2)		Depth Control Point: Ground Surface

DEPTH ft	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
49.0	1118					↑		~~Sa~~ same as above, but	None	11.75" OD 10.25" ID	Sampled from 49' to 51.5'
49.5	1118	6" Liner	C3040-49.5	GM	Background			gravel very fine and	↓		Recovered 2.0 ft or 80% of
50.0	1118	"	C3040-50			Moist		less than 10%, & >2% silt			sample. 4 6" long, 4-in.
50.5	1118	"	C3040-50.5	Hanford		↓		Possible contact with Hanford			dia ~~tubes~~ Lexan liners were
51.0	1118	"	C3040-51	Ringold		Dry		Ringold Formation, silty			capped & sealed.
51.5	No	Re	covery	Fm.				GRAVEL with some Sand (GP			All sampling from 24 feet to
								or GM. Iron stained quartz			total depth or water is to
51.5								gravel prominent & other			be done by split spoon only.
52.0	1155	6"	C3040-52	GM	None	Dry		minerals, very dry, color			Sampled from 51.5' to 54'
52.5	1155	liner	C3040-52.5	GM	"	Dry		light gray (10YR-7/2)			Recovered 2 ft or 80% but
52.5-	No		Recovery	because of				Rounded to Well rounded			1 foot was sediment that
54.0	sand	sloughing	from	above.				quartz gravel & subrounded			fall in from above. Primarily
								to rounded basalt gravel.			dark gray sand.
								colored sediments sometime			
								light brownish gray (10YR-6/2).			
54.0	1310	6" liner				Slight		Silty Sandy GRAVEL (GM)			Split spoon Sampled from
54.5	1310	"	C3040-54.5	GM	None	Moist		50% gravel, 40% sand, 10% silt			54 to 56.5' Recovered 4
55.0	1310	"	C3040-55	"	"	Moist		gravel 5% or less crs, 20% medium,			6" long 4" dia Lexan Liners
55.5	1310	"	C3040-55.5	"	"			35% fine and 40% very fine.			full, ~80% recovery. 54 to 56'.
56.0	1310	"	C3040-56	"	"			gravel subrounded to well rounded			
56.5	No	Recovery.						in fine to coarse size. Primary			
								color gray (10YR-6/1) but small			
								powdered silt colored reddish			
								yellow ~~6~~ (7.5YR-6/8).	↓		

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No: C3040 Depth: ______ Sheet 6 of ~~76~~ 23

Location: 100 D Area, 183-DR in 100A OU Project: ISGR

Logged by: Ronald Schalla (Print) Ronald Schalla (Sign) Date 7-13-00

Reviewed by: Ronald Schalla (Print) Ronald Schalla (Sign) Date 8-31-2000

Lithologic Class. Scheme: USCS Procedure ______ Rev ______

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor: Resonant Sonic International

Driller: Morris "Moe" Wraspir

Rig/Method: Dresser XT70E, Cable Tool

Depth Control Point: Ground Surface

DEPTH	TIME	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
		TYPE	ID NUMBER	INSTR.	READING						
56.5	1450							Same as above,	None		Split spoon sampled from 56.5'
57.0	1450	6" Liner	C3040-57			slightly moist		but more silt perhaps			to 58.0'. Recovered four
57.5	1450	"	C3040-57.5			or		as much as 30% at			6-in. long Lexan liners full,
58.0	1450	"	C3040-58			dry		certain layers. May be			~80% recovery 56.5' to 58.5'
58.5	1450	"	C3040-58.5					slightly cemented			
59.0	No	Recovery-58.		5 to	59'						
59.0	1520										
59.5	1520	6"	C3040-60					Same as above but			Sample by split spoon 4"
60.0	1520	Lexan Liner	C3040-60.5			sl.		less silt perhaps 10%			dia. 6" long Lexan liner.
60.5	1520	"	C3040-61			Moist		or less.			Collected four 6-in sample
61.0	1520	"	C3040-61.5								or 80% recovery.
61.5	No	Recovery	61	to 6	1.5 ft.						
61.5											
62.0		6"	C3040-62			sl.		Same as above,			
62.5		Lexan Liner	C3040-62.5			Moist					
63.0		"	C3040-63								
63.5		"	C3040-63.5								
64.0		No	Recovery								

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040	Depth: 64 to 74'	Sheet 7 of ~~16~~ 23
		Location: 100 D Area, 183-DR	Project: ISGR	

Logged by: Edward C. Thornton (Print) / Edward C. Thornton (Sign)	Date 7-14-00	Drilling Contractor	Resonant Sonic International
Reviewed by: Ronald Schalla (Print) / Ronald Schalla (Sign)	Date 8-31-2000	Driller	Morris "Moe" Wcaspir
Lithologic Class. Scheme	Procedure / Rev	Rig/Method	Dresser XT 70E, Cable Tool
Steel Tape/E-Tape /	Field Indicator Equip. 1) 2)	Depth Control Point	Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
64.0	700							Same as above but 5%	None		on site at 700, split spoon
64.5	700	6" liner	C3040-64.5 6030					or less silt			obtained from 64-66.5'
65.0	700	"	C3040-65.0								Recovered four 6-in Lexan
65.5	700	"	C3040-65.5								liners full ~80% recovery
66.0	700	"	C3040-66.								from 64.0' to 66.0'
66.5	No recovery 66.0-66.5'										Dumped waste soil into drum
66.5	0850										1004-00-0077 (59'-67')
67.0	0850	6"	C3040-67					same as above but			Split spoon obtained
67.5	0850	Lexan liner	C3040-67.5					more cemented			from 66.5-69.0'
68.0	0850	"	C3040-68								Recovered four 6-in Lexan
68.5	0850	"	C3040-68.5	2 VOAs & Moisture		s. Moist					liners full ~80% recovery
69.0	No recovery 68.5-69.0'										from 66.5-68.5'
69.0											
69.5	0950		C3040-69.5					Same as above but more			split spoon obtained
70.0	0950		C3040-70.0					gravel 60-65%,			from 69.0-71.5'
70.5	0950		C3040-70.5	s. moist				more cementation, more			Recovered four 6-in lexan
71.0	0950		C3040-71.0	GM	background			light-colored materials			liners full ~80% recovery
71.5	No recovery 71.0-71.5'							especially in fine-grained			from 69.0-71.0'
71.5								(quartzite & granitics)			
72.0			C3040-72								split spoon obtained
72.5			C3040-72.5					Same as above			from 71.5-~~73.5'~~ 74.0' ECT
73.0			C3040-73	GM	background			hit large rock?			Recovered four 6in lexan
73.5			C3040-73.5	sl. moist				bent end of shoe			Liners ~70% recovery
74.0	No recovery 73.5-74.0'										from 71.5-73.5'

W = Wet, M = Moist, D = Dry

Dumped waste soil into drum 1004-00-0087 (67-~~77'~~ 74' ECT)

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040	Depth: 74 to 84'	Sheet 8 of ~~18~~ 12 23
		Location: 100 D Area, 183-DR	Project: ISGR	

Logged by: Edward C. Thornton (Print) Edward C. Thornton (Sign) Date 7-14-00

Reviewed by: Ronald Schalla (Print) Ronald Schalla (Sign) Date 8-31-2000

Lithologic Class. Scheme ______ Procedure ______ Rev ____

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor: Resonant Sonic International

Driller: Morris "Moe" Wraspir

Rig/Method: Dresser XT 70E, Cable Tool

Depth Control Point: Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
74.0								gravely sand, lt. gray			split spoon obtained
74.5	1300		C3040-74.5					w/ minor silt cobbles/			from 74.0-76.5'
75.0	1300		C3040-75.0					pebbles of quartzite &			Recovered four 6 in lexan
75.5	1300		C3040-75.5					metamorphics, occasional rust			liners ~80% recovery
76.0	1300		C3040-76.0	GM background				or oxide coatings, well			from 74.0-76.0'
76.5	No recovery 76.0-76.5'							consolidated			
76.5	~~1405~~		~~C3040~~								split spoon obtained
77.0	1405		C3040-77.0					cemented/consolidated			from 76.5 - 79.0'
77.5	1405		C3040-77.5					gravel			Recovered four 6 in lexan
78.0	1405		C3040-78								liners 70-80% recovery
78.5	1405		C3040-78.5								from 76.5-78.5'
79.0	No recovery 78.5-79.0'										
79.0											
79.5	1505		C3040-79.5					same as above			split spoon obtained
80.0	1505		C3040-80								from 79.0-81.5'
80.5	1505		C3040-80.5								Recovered four 6 in lexan
81.0	1505		C3040-81	2 VOAs & moisture							liners ~80% recovery
81.5	No recovery & 81.0-81.5'										from 79.0-81.0'
81.5								brownish sand at 82', flakes of mica,			Dumped waste soil into drum 100H-00-0082 (74-80')
82.0	1620		C3040-82		wet			~~82~~ with gravel			split spoon obtained
82.5	1620		C3040-82.5					water level at ~82'			from 81.5 - 84.0'
83.0	1620		C3040-83		wet			82.5-83.5 gravely			recovered four 6 in lexan
83.5	1620		C3040-83.5					sand wet			liners full ~80% recovery
84.0	No recovery 83.5-84.0'										from 81.5-83.5'

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040	Depth: 84 - 89(90)	Sheet 9 of ~~2~~ 18
		Location: 100-D Area	Project: ISGR	R-23

Logged by: Tyler Gilmore (Print) [signature] (Sign)	Date 7/17/00	Drilling Contractor	Resonant Sonic International
Reviewed by: Ronald Schalla (Print) [signature] (Sign)	Date 8-31-2000	Driller	Marvin "Moe" [illegible]
Lithologic Class. Scheme ______ Procedure ______	Rev ____	Rig/Method	Dresser XT70F Cable tool
Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______	2) ______	Depth Control Point	Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
81'	0600							Water estimated at 81-82 ft will			At drill site; discuss work;
								take e-tape reading this morning			Safety meeting
	0723							Measure depth to water			
								water at 81.0' (w chalked tape)			Drive barrel drilling
								Casing at 80.37' Bottom of			hole sloughed in about 3' over
								hole at 81.2'; just below			weekend
								casing			
81'	0757							Add 10 ft piece of casing			
	0830										Drilling out cave-in back to
86'	0950	Soil	C3040 84.5	GM	bkgrnd	wet		Sandy Gravel 65% gravel 32% Sand			84' will split spoon after
		Soil	C3040 85	VOA	bkgrnd			3% Silt/Mud poorly sort bslts			Splitspoon driven from 84-86.5
		Soil	C3040 85.5					qtzites sl consol			
		Soil	C3040 86					+(4) 6" lexan liners ~80% recovery			
								drove splitspoon to 86' - very difficult			
								to open splitspoon — lexan liners full			
	955										Drilling clean out hole for
								Dump waste into drum 100-H-00-~~0086~~ TG			next splitspoon
								0083			Splitspoon driven from 86.5-89
89	1020	Soil	C3040 87.5	GM	bkgrnd	wet		Gravelly Sand 30% Gravel 65% Sand			Will clean hole out to 89'
		|	88	VOA	bkgrnd			5% Mud Nice sand looks permeable			TD at 89' drive casing to
		|	88.5					poor-mod ~~sort~~ sort sl consol lt colored			90' to allow some sediments to
		Soil	C340 89					qtz and qtzites + bslt 72% recovery			come-up inside hole then will
								+waste to drum 100H-00-0083			set casing - will not bail due to
											sloughing sands

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040	Depth: 89 - 90	Sheet ~~2~~ 10 of ~~2~~ 16
		Location: 100-D Area	Project: ISGR	P223

Logged by: Tyler Gilmore (Print)	[signature] (Sign)	Date 7/17/00	Drilling Contractor: Resonant Sonic
Reviewed by: Ronald Schalla (Print)	Ronald Schalla (Sign)	Date 8-31-2000	Driller: Morris Wraspir
Lithologic Class. Scheme	Procedure	Rev	Rig/Method: Dresser XT 70 E/Cabletool
Steel Tape/E-Tape /	Field Indicator Equip. 1)	2)	Depth Control Point: Ground surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
	1050										Drive Casing to 90 ft and
											drill casing out
	12:00 - 1230										Lunch
								Add 20 gal water to keep			Sands coming in to casing
								Sand out of pipe			continue to clean out
90'		1430									Down to 90 ft will stop
											for day. Wait to determine
											if we need to log the well
											(Geophysical Logs)

W = Wet, M = Moist, D = Dry

E tape add 0.27
Steel tape 0.7

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3040	Date 7/18/00	Sheet No. 11 of 16 23
	Location C3040 100-D Area	Project ISGR	

Logged by Tyler Gilmore	Date 7/18/00	Drilling Contractor Resonant Sonic
Reviewed by Ronald Schalla, Ronald Schalla	Date 8-31-2000	Driller Morris Wraspir
Measuring Equip. Solinst 300' ETape	Procedure	Rig/Equipment Dresser XT 70E

Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Overlap	Comments
830	Temporary		95.4'	5.4'	90'					DW = 86.65 - 5.4 = 81.25'
										DB = 94.5 - 5.4 = 89.1'
										Pull pipe off; stickup will change
0957										Wait to move jacks on
12-12:30										Lunch
PVC	20 slot Screen	2"	10.22'			PVC				Measure casing PVC
	5' Casing		4.95							DB = 89.22'
	10' Casing		9.95							will set casing on bottom and
			9.95							then pull up approx 0.5'
			9.95							
			9.95							Temporary casing still at 95.4'
			9.95							stick-up
			9.95							
			9.95							
			9.95							
			9.95							
PVC	10' Casing		9.95			PVC				PVC Set at 88.17
			94.47						0.8	Top of PVC 6.3 aboveground
			95.4	5.4	90	Natural Fill	—		~~1.5~~	Add sand (0.7 add on to tape)
1320						10-20 Sand	1 bag	89.2	2.9	(2.1 ft came up from 1 bag
		11"	95.4	7.3	87.2	Colo Silica Sand		~~8~~		
							1 bag			

A.13

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3040 Location 100-D Area	Date 7/18/00 Sheet No. 12 of ~~2~~ 23 Project ISGR

Logged by Tyler Gilmore Date 7/18/00 Reviewed by Ronald Schalla [signature] Date 8-31-2000 Measuring Equip. Procedure	Drilling Contractor Resonant Sonic Driller Morris Wraspir Rig/Equipment Pump Rig

Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Overlap	Comments
1349		11"	95.4	7.3	88.1		(92.5)	85.2	2.9	Pull casing
1353		11"	95.4	8.8	86.6		94.5	85.7	0.9	(2.47' screen covered)
										~~PVC stickup 6.8~~
		11"	91.4	4.6	86.8					Take piece casing off 4'
										PVC stickup 6.4'; 88.07'
1416						~~Re~~ 10-20 Sand	(90.5)	85.9	0.9	
						Colo Silica Sand	1 bag (88.6)	84.0	2.8	Add Sand; Pull casing
			91.4	6.1	85.3		(90.5)	84.4	0.9	Add Sand; Pull casing
						10-20 Sand	1 bag (88.5)	82.4	2.9	
1429			91.4	6.95	84.45	10-20 Sand	(90.0)	83.05	1.4	Pipe "popped" did it break?
							(90.9)	83.3	0.5	
			91.4	7.6	83.8		1.75 bags (87.4)	79.8	4.0	Add sand
1453			91.4	10.1	81.3		(90.8)	80.7	0.6	Remove casing
		11"	85.4	4.1	81.3	10-20 Sand	1 bag (83.2)	79.1	2.2	Add Sand
							~~(84.7)~~	~~80.3~~		Pull casing
			85.4	6.6	78.8	10-20 sand	1 bag (82.9)	76.3	2.5	Add sand
1538			85.4	7.1	78.3		(83.4)	76.3	2	Stop
										Total Sand 7.75 bags
						Set up to pump well				

lost end of tape
steel bar w/ electric tape at 76.3 ft

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040	Depth: 89 (TD)	Sheet 13 of 23
		Location: 100-D Area	Project: ISGR	

Logged by Tyler Gilmore (Print) Tyler Gilmore (Sign)	Date 7/18/00	Drilling Contractor Resonant Sonic	
Reviewed by Ronald Schalla (Print) Ronald Schalla (Sign)	Date 8-31-2000	Driller Morris Wrasp...	
Lithologic Class. Scheme	Procedure	Rev	Rig/Method Dresser XT 70E
Steel Tape/E-Tape /	Field Indicator Equip. 1) 2)		Depth Control Point Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
0600								Driller setting up to pull casing and complete well. Needs casing jacks, materials etc.			
	0830										Water level 81.25 Depth to bottom 89.1
								Driller will move drill rig off and complete with smaller pump setting rig			
								Checked coordinates of borehole from a local GPS grid N129 E71 (where E100 is almost in line with power pole across street)			
								See Well Completion Logs 2 pages dated 7/18/00			
1400								Set "Rediflow" pump in well and begin pumping at 4:25 to do time series sampling. Sampling for conductivity and Cr VI			Set pump 2 ft off bottom of well at 86'

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040	Depth: 88 ft	Sheet ~~2~~ 14 of ~~2~~ ~~16~~ 23
		Location: 100-D Area	Project: ISGR	

Logged by Tyler Gilmore (Print) [signature] (Sign) Date 7/18/00

Reviewed by Ronald Schalla (Print) [signature] (Sign) Date 8-31-2000

Lithologic Class. Scheme ______ Procedure ______ Rev ______

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor —

Driller —

Rig/Method —

Depth Control Point —

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOIS-TURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
	1825							Sampled water at Time = 100 min			
								500 gal pumped			
		Water						(1) 500 ml (P) Metals			
								(1) 500 ml (G) Mercury			
								(1) 20 ml (P) Activity scan			
								(1) 500 ml (G/P) Hex Cr outside Lab			
								(1) 1000 ml (P) Alpha Beta			
								(1) 4000 ml (P) Gamma			
								(1) 20 ml (P) Activity Scan			
								(2) 40 ml (g) VOA PNL			
								(1) 500 ml (p) Lab			
								COC X 00-021-2			
								X 00-021-5			
								X 00-021-1			
								No chain for PNL Labs			
								other than this document			
								Will leave well to drill next			
								well C3041			

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040	Depth: 90 - 103.5	Sheet 15 of ~~16~~ 23 pz
		Location: 183 DR	Project: ISGR	

Logged by Tyler Gilmore (Print) [signature] (Sign) Date 7/31/00 8/1/00

Reviewed by Ronald Schalla (Print) ~~8-31~~ [signature] (Sign) Date 8-31-2000

Lithologic Class. Scheme ______ Procedure ______ Rev ____

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor ~~Max~~ Resonant Sonic Intl.

Driller Morris Wespiv

Rig/Method Bucyrus Erie 22W/Cable tool

Depth Control Point ground surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
	1400-1530							Drilling out casing. Very difficult			Decision made to complete this
								Need to get back to original depth			well (C3040) as RCRA well; will
								89.1 ft			deepen and complete.
	0615						8/1/00	Continue drilling; use sand pump			Note: No activity (or Logs)
								still difficult.			between 7/19 and 7/30/00
	1000							Switch to hard tool drill			
	1130							Approx 91' but have not bailed			
95	1430	Soil	C3040-95			N/A		Gravelly Sand - Sample from			
								hard tool and is crushed; drilled			
								very hard, texture and sorting classification			
								is not applicable Color greenish brown			
								mixture of basalt and quartz minerals			
100	1600	Soil	C3040-100			N/A		Gravelly Sand - description as			
								above. Silt/Clay layer in Ringold			
								was not hit; still gravels and			
								Sands	~200 gal		Water added many times for drilling
103.5	1630		—					No sample still Sands and Gravels			Drill to 103.5
								as above			Sediment settling back to 102
											bottom of casing at 101.5

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG

Boring/Well No: C3040 Depth: TD 103.5 Sheet 16 of ~~16~~ 23

Location: 100 D Area 183 DR Project: ESGR

Logged by Tyler Gilmore (Print) [signature] (Sign) Date 8/2/00

Reviewed by Ronald Schalla (Print) Ronald Schalla (Sign) Date 8-31-2000

Lithologic Class. Scheme ______ Procedure ______ Rev ______

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor Resonant Sonic

Driller Morris Weeper

Rig/Method Bucyrus Erie 22W/cable tool

Depth Control Point Ground Surface

DEPTH	TIME	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
		TYPE	ID NUMBER	INSTR.	READING						
	0600							Clean hole out with bailer			Casing materials have not arrived
								Prepare to set casing			yet
	0840							DB = 100.9 ft after settling			Wait on Casing
	1040										Casing Arrived

W = Wet, M = Moist, D = Dry

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3040 Location 100 D Area 183 DR	Date 8/2/00 Sheet No. 17 of 23 Project ISGR

Logged by Tyler Gilmore *(signature)* Date 8/2/00 Reviewed by Ronald Schalla *(signature)* Date 8-31-00 Measuring Equip. ____ Procedure ____		Drilling Contractor Resonant Sonic International Driller Morris Wespir Rig/Equipment Bucyrus Erie 22W / Cable Tool

Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Over lap	Comments
1115	Stainless steel	Sch 055	.316	Centralizers welded at bottom (male)						
	side of each casing; Screen is 20 slot Manufacturer Roscoe Moss									
	We are short (1) 20 ft piece. will need to find one and/or make Change Request									
	SS 316 Sump	4"	3.02	Centralizer						
	SS 316 20 slot Scr	4"	19.98	Screen	no centralizer (blank)					
	SS 316 Casing	4"	20.02	Centralizer						
	SS 316 Casing	4"	20.01	blank						
	SS 316 Casing	4"	20.01	Centralizer						
	SS 304 Casing	4"	20.02	blank						Note 304 SS 20 foot casing
			103.06	Total						
1249	Temporary Steel	11"	105.46	4.45	101.01	Natural Fill			0.76	DB 104.7 − 4.45 = 100.25
										Run 4" Stainless Steel in Well
1441			105.46	4.45	101.01	Colo Silica Sand 10-20	1 bag (102)	97.55	3.46	Hold stainless at 2.81' above ground
			105.46	5.89	99.61		(105.50)	99.61	0.0	
						Colo Silica Sand	1 bag (102.16)	96.31	3.3	
			105.46	7.55	97.91		(104.58)	97.03	0.88	
						Colo Silica Sand	1 bag (102.5)	94.95	2.96	Take off 4.0' casing
1514	Temp Steel	11"	101.46	4.3	97.16		(99.5)	95.2	1.96	Stainless casing at 2.8' above grnd
						Colo Silica Sand	1 bag (98.3)	94	3.16	(Stnls did not move)
				6.2	95.26	Colo Silica	1 bag (97.8)	91.46	3.8	
				8.25	93.21		(100.5)	92.25	0.96	

199-D2-8

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3040	Date 8/2/00	Sheet No. 18 of 23
	Location 100 D Area 183 DR	Project TSGR	

Logged by Tyler Gilmore	Date 8/2/00	Drilling Contractor Resonant Sonic
Reviewed by Ronald Schalla	Date 8-31-2000	Driller Morris Wespiv
Measuring Equip.	Procedure	Rig/Equipment BE 22W Cable Tool

Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Overlap	Comments
1525	Temp Steel	11"	101.46	8.25	93.21	Colo Silica Sand	1 bag (98.3)	90.05	3.16	Target for Sand = 72.25 for 5' above
		11"	96.44	4.2	92.24		(94.6)	90.4	1.84	screen – Remove 5.02 casing
		11"	96.44	4.8	91.64		(95.5)	90.7	0.94	Stainless casing holding at 2.8 above grnd
		11"				Colo Silica Sand	1 bag (93.5)	88.7	2.94	
							(95.4)		1.0	100 lb bags Sand
						Colo Silica Sand	1 bag (93)		3.44	
							(95.58)		0.86	
						Colo Silica Sand	1 bag (93.25)		3.19	
1600	Temp Steel	11"	91.42	4.3	87.12		(95.25)		1.19	Remove 5.02 casing
1625										Quit for Day

A.21

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3040 (199-D2-8) Location 100 D Area	Date 8/3/00 Project ISGR	Sheet No. 19 of 23

Logged by Tyler Gilmore [signature] Date 8/3/00
Reviewed by Ronald Schalla [signature] Date 8-31-2000
Measuring Equip. ______ Procedure ______

Drilling Contractor Resonant Sonic
Driller Morris Wesper
Rig/Equipment BE 22'W / (Cable tool)

Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Over lap	Comments Inside Stainless Steel
0615	Temporary Steel	11"	91.42	4.3	87.12	~~50lb bags~~		(90.25) 85.95	1.17	DW = 83.8 - 2.8 = 81.0'
						Colo Silica Sand	1 bag	(88.5) 84.2	2.92	DB = 102.9 - 2.8 = 100.1'
			91.42	5.7	85.72			(90.5) 84.8	0.92	50lb bags today
						Colo Silica Sand	2 bags	(88.6) 82.9	2.82	Target for sand 72.2
				7.4				(90.50)	0.92	
			91.42	7.4	84.02	Colo Silica Sand	3 bags	(87.0) 79.6	4.42	
			91.42	9.15	82.27			(89.50) 80.35	1.92	Pull 5.02 casing off
0700	Temp Steel	11"	86.4	4.3	82.1	Colo Silica Sand	3 bags	(81.50) 77.2	4.9	
			86.4	7.4	79			(85.50)	0.9	
						Colo Silica Sand	3 bags	(82.25) 74.85	4.15	
		11"	81.38	4.2	77.18			(84.50)	1.9	Pull 5.02 casing off
								(79.50) 75.3	1.88	
0722						Colo Silica Sand	3 bags	(76.05) 72.05	5.13	Hold sand - will surge block
0730-930										Break for Driller's mtg
1000						Subtotal 24 bags Sand		(77.33) 73.13	4.05	Surge well w/ bailer to settle sand
1030								(78.3) 72.13	3.05	dropped ~1ft after 10 min surging
										dropped 1ft after 1/2 hour
								(78.5)		dropped 0.2 after 15 min
1135								(78.6)		dropped 0.1 after 15 min
										Stainless steel at 2.65 above ground
										dropped maybe 0.15 ft
1200				4.2				(78.75) 74.55		dropped 0.15 after ~25 min

6.78 lost
4.59 pulled

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3040 (199-D2-8) Location 100 D	Date 8/3/00 Sheet No. 20 of 23 Project ISGR

Logged by Tyler Gilmore [signature] Date 8/3/00 Reviewed by Ronald Schalla [signature] Date Measuring Equip. Procedure	Drilling Contractor Resonant Sonic Morris Wespir Driller Rig/Equipment BE 22w Cabletool

Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Over lap	Comments
1240	Temp Steel	11"	81.38	4.2	77.18			74.55	2.63	Need 72.2 ft for Sand
						50 lb bags Colo Silica Sand	3 bags (74.50)	72.3		50 lb bags bentonite
		11"	81.38	7.6	73.78		(81.0)	73.4	0.38	
1301						Colo Silica Sand	2 bags (78.83)	71.23		29 bags Sand total
			81.38	9.84	71.54		(81.50)	71.66	-0.12	Switch to Bentonite; Avg 1.3 ft/bag
1341						Casing-Seal bentonite	10 bags (66.0)	56.16	15.38	on Well C3041
	Temp Steel	11"	71.35	4.4	66.95		(62.75)	58.35	8.6	Remove 10.03 casing
			71.35	4.4	66.95	Casing-Seal bentonite	10 bags (47.5)	43.1	23.85	
1403	Temp Steel	11"	61.33	4.4	58.93		(51.1)	46.7	12.23	Remove 10.02 Casing
						Casing-Seal bentonite	6 bags (42.0)	37.6	21.33	
		11"	51.32	4.35	46.97		(45.12)	40.77	6.2	Remove 10.01 casing
1442	Temp Steel	11"				Casing-Seal bentonite	11 bags (27.9)	23.55	23.42	
			41.31	4.4	36.91		(32.16)	27.76	9.15	Remove 10.01 Casing
1501						Casing-Seal bentonite	8 bags (19.9)	15.5	21.41	
	Temp Steel Casing		31.30	4.5	26.8		(24.5)	20	6.8	Remove 10.01 Casing
1527						Granular Bentonite	12 bags (5.45)	0.95	25.85	50 lb bag CETCO
				Ø			(9.15)	9.15'		inside 14" casing ~ 11'
										All 11" out of well
1602										End of Day

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3040 Location 100D	Date 8/4/00 Sheet No. 21 of 23 Project

Logged by Ed Thornton Date 8/4/00 Reviewed by Ronald Schalla [signature] Date 8-31-2000 Measuring Equip. Procedure	Drilling Contractor Resonant Sonic Driller Morris Wespir Rig/Equipment Cable tool

Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Over lap	Comments
700	temporary surface casing	14"		10.00	21.5	granular bentonite	2 bgs			pulling temporary surface casing
				11.10	19.5					
735								10'		measured depth to bentonite
1130										broke for lunch - will
										pour cement in annular
										space this afternoon
										will return Monday for
										development
										59 bags of bentonite

A.23

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040 199-D2-8	Depth: Development	Sheet 22 of 23
		Location: 100 D	Project: ISGR	

Logged by Tyler Gilmore (Print) [signature] (Sign)	Date 8/7/00	Drilling Contractor	Resonant Sonic
Reviewed by Ronald Schalla (Print) Ronald Schalla (Sign)	Date 8-31-2000	Driller	Morris Wespic
Lithologic Class. Scheme ____ Procedure ____ Rev ____		Rig/Method	Pump Rig
Steel Tape/E-Tape ____ / ____ Field Indicator Equip. 1) ____ 2) ____		Depth Control Point	Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
	0700							Waiting to set up Well			Well Development / Step draw-
								development test			down
								Pump Intake at 3 ft			
								off bottom - base of well			
								screen - Transducer at			
								~3.5' off bottom (above			
								pump intake)			
								DW = 83.98 - 2.965 = 81.015			T=0
								Transducer = 12.721			
	1106							Start pump - Leaks Stop; Repair Leaks			
								let recover to static			
								87.9 - 2.965 = 84.935			T= 3 min into test
								8.82 Transducer			DW / Trans
								88.03 - 2.965 = 85.065			T= 6
								8.64 Transducer			Flow rate = 5 gal/min (by bucket)
								at T=15 Sample then incr flow drawdown to 25 ft approx 15 gpm (by flow meter)			
	1143							then back off at T=17 to approx 10 gpm (by bucket) below flow meter range			
								Cloudy water after incr flow rate			

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3040 (199-D2-8)	Depth: Development	Sheet 23 of 23
		Location: 100D, 183DR	Project: ISGR	

Logged by: Tyler Gilmore (Print) / [signature] (Sign)	Date 8/7/00	Drilling Contractor	Resonant Sonic
Reviewed by: Ronald Schalla (Print) / Ronald Schalla (Sign)	Date 8-31-2000	Driller	Morris Wesp
Lithologic Class. Scheme	Procedure ___ Rev ___	Rig/Method	Pump Rig
Steel Tape/E-Tape ___ / ___	Field Indicator Equip. 1) ___ 2) ___	Depth Control Point	Ground surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
	1151							DW=93.46 - 2.965 = 90.495			T=28
								Trans = 3.220			
								DW 93.58-2.965=90.61 T=1:40			Samples at T= 0,5,10,15,20,25
								Trans 3.13			30,40,60,80,100,120
	1306							At T=100 (after sample)			
								incr flow - Water turned brown			
	1311							DW 96.05 - 2.965= 93.085			Flow rate 5gal/27sec 11.1 gal
								Trans 0.659			drawdown 10.9 ft
	1318							DW 95.45-2.965 = 91.485			
								Trans 1.176			
	1416							T=174			Recovery Data
								Note no check valve but all			
								valves shut down looks like its			
								holding			
								DW 84.28 - 2.965= 81.315			T=5 Recovery
								Trans 12.41			
								DW 84.05 - 2.965 = 81.085			T=12
								Trans 12.458			
	1452							Recovered to Static			~T=30 End test

W = Wet, M = Moist, D = Dry

GROUNDWATER SAMPLE REPORT

Project: 183-DR GW, Drilling Samples, July					Date:	Page 1 of 1
Task Order/Month: JULY 2000		QC Type:			Calculations:	
Well Number: C3040-GW		A# :				
Total Purge Volume (gal): 500		Purge Flow Rate (gal/min): 5gpm				
Pump Type: Redi-flow	Time on:	Water:	Purge:	Samp.:	Off:	

SAMPLES COLLECTED

B0YN88 Severn Trent Incorporated COC No.: X00-021-1

1;500mL;G/P 7196_CR6: Hexavalent Chromium (1) (Cool 4C)

B0YN89 Severn Trent Incorporated COC No.: X00-021-2

1;20mL;P Activity Scan (None)
1;4000mL;G/P GAMMA_GS: List-1 (9) (HNO3 to pH <2)
1;1000mL;P 9310_ALPHABETA_GPC: Alpha + Beta (2) (HNO3 to pH <2)

B0YN92 Severn Trent St. Louis COC No.: X00-021-5

1;20mL;P Activity Scan (None)
1;500mL;G 7470_HG_CVAA: Mercury (1) (HNO3 to pH <2)
1;500mL;P 6010_METALS_ICP: List-1 (19) (HNO3 to pH <2)

Total No. Bottles: 7 Containment Code: Collector:

FIELD MEASUREMENTS

Water Level (TOC): | Drawdown (TOC): | Oil Sheen Yes ☐ No ☐

Prev. pH: | Prev. DTW: | E-Tape No.:

Time										
pH										
Temp. (°C)										
Cond. (μs/cm)	550									
Turb. (NTU)										
D. O. (mg/L)										

FIELD OBSERVATIONS

Weather: Hot

Field Comments:

Pre Check: Post Check:

Comments: GROUNDWATER - C3040

Well capped and locked: ☐ Yes ☐ No Logbook/Pg# :

Samples Surveyed for Gamma Radiation by RPTs: ☐ Yes ☐ No

Data Recorded by: Tyler Gilmore [signature]
Print and sign name

Data Checked by: Ronald Schalla [signature] Date 8-31-2000
Print and sign name Date

PNNL

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. # **X00-021-2**

Page 1 of 1

Collector Tyler Gilmore	**Contact/Requester** DL STEWART	**Telephone No.** (509) 376-5056 **MSIN** **FAX**
SAF No. X00-021	**Sampling Origin** HANFORD SITE	**Purchase Order/Charge Code**
Project Title 183-DR GW Drilling Samples, July 2000	**Logbook No.** Field logs 7/18/00 C3046	**Ice Chest No.** **Temp.**
Shipped To (Lab) Severn Trent Incorporated	**Method of Shipment** GOVT. VEHICLE	**Bill of Lading/Air Bill No.**
Protocol Other	**Data Turnaround** 45 Days	**Offsite Property No.**

POSSIBLE SAMPLE HAZARDS/REMARKS
** **

SPECIAL INSTRUCTIONS **Hold Time** Total Activity Exemption: Yes ☑ No ☐
Batch all samples submitted under this SAF into one SDG, not to exceed SDG closure of 14 days. Submit invoices & deliverables to DL Stewart, PNNL.

Sample No.	Lab ID	*	Date	Time	No/Type Container	Sample Analysis	Preservative
B0YN89		W			1x1000-mL P	9310_ALPHABETA_GPC: Alpha + Beta (2)	HNO3 to pH <2
B0YN89		W			1x4000-mL G/P	GAMMA_GS: List-1 (9)	HNO3 to pH <2
B0YN89		W			1x20-mL P	Activity Scan	None

Relinquished By	Print	Sign	Date/Time	Received By	Print	Sign	Date/Time
	Tyler Gilmore	[signature]	7/18/00 20:56				
Relinquished By			Date/Time	Received By			Date/Time
Relinquished By			Date/Time	Received By			Date/Time
Relinquished By			Date/Time	Received By			Date/Time

Matrix *

S = Soil		DS = Drum Solid
SE = Sediment		DL = Drum Liqui
SO = Solid		T = Tissue
SL = Sludge		WI = Wipe
W = Water		L = Liquid
O = Oil		V = Vegetation
A = Air		X = Other

FINAL SAMPLE DISPOSITION	Disposal Method (e.g., Return to customer, per lab procedure, used in process)	Disposed By	Date/Time

Cr VI
Groundwater
7/18/00 Pump Test C3040

4:30 pm ran 0.5 mg/l Cr VI std — read 0.45 mg/l

4:38	To	(filtered)	0.01 mg/l Cr VI
:55 No turbidity 0.00	T5	filtered	> 0.66 mg/l
	T5	filtered 10x dilution	0.10 x 10 = 1.0 mg/l Cr VI
:25 pm	T_{10}	filtered 5x dilution	~~0.28 x 5 = 1.40~~ mg/l Cr VI
			0.29 x 5 = 1.45
:30 pm	T_{20}	filtered 5x dilution	0.26 x 5 = 1.30
:45 pm turb = 0.00	T40	filtered 5x dilution	~~0.26 x 5 = 1.30~~
			0.27 x 5 = 1.35
:00 pm	T65	filtered 5x dilution	0.28 x 5 = 1.40
:20 pm	T80	filtered 5x dilution	0.30 x 5 = 1.50
:40	T100	20.3/4.0 x filtered dilution	0.30 x 20.3/4.0 = 1.52
:55 pm	T120	20.6/4.0 x filtered dilution	0.32 x 20.6/4.0 = 1.65
:10 pm	T140	filtered 5x dilution	0.32 x 5 = 1.60
7:45 pm	T~~180~~ 160	filtered 5x dilution	0.32 x 5 = 1.60
7:55 pm	T180	filtered 5x dilution	0.32 x 5 = 1.60

PNNL

CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST

C.O.C. # **X00-021-1**

Page 1 of 1

Collector Tyler Gilmore	Contact/Requester DL STEWART	Telephone No. (509) 376-5056 MSIN FAX
SAF No. X00-021	Sampling Origin HANFORD SITE	Purchase Order/Charge Code
Project Title 183-DR GW, Drilling Samples, July 2000	Logbook No. Fieldnotes 7/18/00 C3040	Ice Chest No. Temp.
Shipped To (Lab) Severn Trent Incorporated	Method of Shipment GOVT. VEHICLE	Bill of Lading/Air Bill No.
Protocol Other	Data Turnaround 45 Days	Offsite Property No.

POSSIBLE SAMPLE HAZARDS/REMARKS
** **

SPECIAL INSTRUCTIONS Hold Time Total Activity Exemption: Yes ☑ No ☐
Batch all samples submitted under this SAF into one SDG, not to exceed SDG closure of 14 days. Submit invoices & deliverables to DL Stewart, PNNL.

Sample No.	Lab ID	*	Date	Time	No/Type Container	Sample Analysis	Preservative
B0YN88		W			1x500-mL G/P	7196_CR6: Hexavalent Chromium (1)	Cool 4C

Relinquished By	Print	Sign	Date/Time	Received By	Print	Sign	Date/Time
	Tyler Gilmore	Tyler Gilmore	7/18/00 20:56				
Relinquished By			Date/Time	Received By			Date/Time
Relinquished By			Date/Time	Received By			Date/Time
Relinquished By			Date/Time	Received By			Date/Time

Matrix *

S = Soil		DS = Drum Solid	
SE = Sediment		DL = Drum Liqui	
SO = Solid		T = Tissue	
SL = Sludge		WI = Wipe	
W = Water		L = Liquid	
O = Oil		V = Vegetation	
A = Air		X = Other	

FINAL SAMPLE DISPOSITION	Disposal Method (e.g., Return to customer, per lab procedure, used in process)	Disposed By	Date/Time

PNNL	CHAIN OF CUSTODY/SAMPLE ANALYSIS REQUEST	C.O.C. # X00-021-5
		Page 1 of 1

Collector Tyler Gilmore	Contact/Requester DL STEWART	Telephone No. (509) 376-5056 MSIN FAX
SAF No. X00-021	Sampling Origin HANFORD SITE	Purchase Order/Charge Code
Project Title 183-DR GW, Drilling Samples, July 2000	Logbook No. 7/18/00 C3040	Ice Chest No. Temp.
Shipped To (Lab) Severn Trent St. Louis	Method of Shipment GOVT. VEHICLE	Bill of Lading/Air Bill No.
Protocol Other	Data Turnaround 45 Days	Offsite Property No.

POSSIBLE SAMPLE HAZARDS/REMARKS	SPECIAL INSTRUCTIONS Hold Time Total Activity Exemption: Yes ☑ No ☐
** **	Batch all samples submitted under this SAF into one SDG, not to exceed SDG closure of 14 days. Submit invoices & deliverables to DL Stewart, PNNL.

Sample No.	Lab ID	*	Date	Time	No/Type Container	Sample Analysis	Preservative
B0YN92		W			1x500-mL P	6010_METALS_ICP: List-1 (19)	HNO3 to pH <2
B0YN92		W			1x500-mL G	7470_HG_CVAA: Mercury (1)	HNO3 to pH <2
B0YN92		W			1x20-mL P	Activity Scan	None

Relinquished By Print Sign	Date/Time	Received By Print Sign	Date/Time
Tyler Gilmore [signature]	7/18/00 20:50		
Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time
Relinquished By	Date/Time	Received By	Date/Time

Matrix *

S = Soil		DS = Drum Solid	
SE = Sediment		DL = Drum Liquid	
SO = Solid		T = Tissue	
SL = Sludge		WI = Wipe	
W = Water		L = Liquid	
O = Oil		V = Vegetation	
A = Air		X = Other	

FINAL SAMPLE DISPOSITION	Disposal Method (e.g., Return to customer, per lab procedure, used in process)	Disposed By	Date/Time

Appendix B

Well Construction Summary Report, Borehole Log, and Geophysical Logs for Borehole C3041

WELL CONSTRUCTION SUMMARY REPORT

Start Date: **July 20, 2000**
Finish Date: **August 1, 2000**
Page 1 of 1

Specification No.:	Rev. No.:	Well Name: **N/A**	Temp. Well No.: **C3041**
ECNs: N/A		Approximate Location: **Near demolished 183DR Facility, D Area**	
Project: **In Situ Gaseous Reduction**		Other Companies: **Pacific NW National Laboratory and Bechtel**	
Drilling Company: **Resonant Sonic International**		Geologist(s): **Tyler Gilmore, Ron Schalla**	
Driller: **Morris Wraspir**			

TEMPORARY CASING AND DRILL DEPTH			DRILLING METHOD/HOLE DIAMETER	
***Size/Grade/Lbs. Per Ft.**	**Interval**	**Shoe O.D./I.D.**	Auger:	Diameter From ___ to ___
Nominal 14-in. Steel	**surface – 20 ft**		Cable Tool: **20 ft – 86.5 (TD)**	**11" Diameter From 20 to 86.5**
Nominal 11-in. Steel	**20 ft – 87.36 ft**		Air Rotary: **Surface – 20 ft**	**14" Diameter From 0 to 20**
	-		A.R. w/Sonic:	Diameter From ___ to ___
Temporary PVC 2-in. casing	**+3 ft – 76.1 ft**			Diameter From ___ to ___
Temporary PVC 2-in. screen	**76.1 ft – 86.42 ft**			Diameter From ___ to ___
Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design				Diameter From ___ to ___
Note: Temporary PVC casing used to obtain water samples and then removed				
			Drilling Fluid: **Water**	
Total Drilled Depth: **86.5 ft**	Hole Dia @ TD: **11-in.**		Total Amt. Of Water Added During Drilling: **30 gallons**	
Well Straightness Test Results: Good			Static Water Level: **78.2**	Date: **July 26, 2000**

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
Relative Moisture (Nuetron)	**0 - 76**	**7/25/00**		-	
Total Gamma-Ray	**0 - 84**	**7/25/00**		-	
	-			-	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annual Seal/Filter Pack	Volume	Mesh Size
N/A	-			**N/A**	-		
	-				-		
	-				-		
	-				-		
	-				-		

OTHER ACTIVITIES

Aquifer Test: **Development Test**	Date:**July 26, 2000**	Well Abandoned:	Yes: **X**	No:	Date:**August 1, 2000**
Description: **Pumped 577 gallons in 180 minutes; Sampled for Cr(VI) in time series**		Description: **Abandoned after development test. Borehole was never completed as a well. Sand (from PVC casing) 86.5-74.6 ft; Bentonite crumbles 74.6-9.3 ft; and Cement Grount 9.3 ft-surface.**			

WELL SURVEY DATA

Date:	Protective Casing Elevation:
Washington State Plane Coordinates:	Brass Cap Elevation:

COMMENTS/REMARKS

Well abandoned

Reported By: **Tyler Gilmore**		Reported By:	
Title: **Senior Research Scientist**	**August 23, 2000**	Title:	Date:
Signature:		Signature:	

WELL SUMMARY SHEET

Page 1 of 1

Date: Aug 22, 2000

Well ID: C3041	Well Name: C 3041
Location: 100 D Area Near demolished 183 DR	Project: InSitu Gaseous Reduction
Prepared By: Tyler Gilmore — Date: August 22, 2000	Reviewed By: Ronald Schalla — Date: 8-31-2000
Signature: [signature]	Signature: [signature]

CONSTRUCTION DATA

Description

Temporary 14" Carbon Steel casing surface - 20ft (removed from ground)

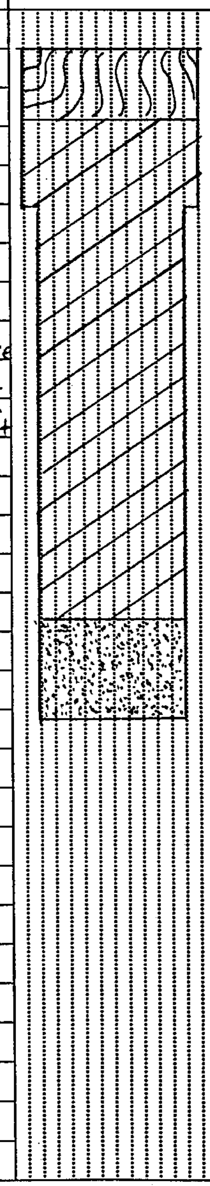
Temporary 11" Carbon Steel casing 20ft - 87.36ft (removed from ground)

Cement Grout 9.3ft - surface
Bentonite Crumbles 74.6-9.3 ft
Sand 10-20 Mesh 86.5 - 74.6ft

Borehole Abandoned

All depths measured from Ground Surface

Diagram

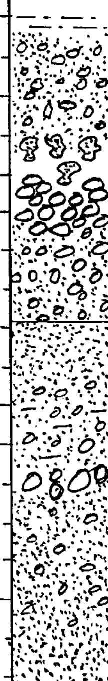


Depth in Feet

0
25
50
75
86.5

GEOLOGIC/HYDROLOGIC DATA

Graphic Log



Lithologic Description

Silt 0-2.5 ft
Sandy Gravel 2.5-15
Concrete debris 15-20ft
Gravel - 20-25
Sandy Gravel to Gravelly Sand 25-39
Sand 39-46
Possible Ringold Contact at 39
Silty Sandy Gravel 46-59
Gravel 59-60 with Cobbles
Sandy Gravel 60-83
Sand 83-86.5

TD 86.5
W.L. = 78.0 July 31, 2000

Pacific Northwest National Laboratory

DAILY BOREHOLE LOG

Boring/Well No: C3041 Depth: 0 - 20 ft Sheet 1 of 17

Location: 100 D Area 183 DR Project: ISGR

Logged by Tyler Gilmore (Print) [signature] (Sign) Date 7/20/00

Reviewed by Ronald Schalla (Print) [signature] (Sign) Date 8-31-2000

Lithologic Class. Scheme ______ Procedure ______ Rev ______

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor Resonant Sonic

Driller Kelly Cowden

Rig/Method Dresser XT 70E Air Rotary

Depth Control Point Groundsurface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
	0600							Drill location is at borehole 2b			Rig over drill location; preparing to
								west of paved road, located near			drill
								turn in piping entering 183 DR			
	0840									10'	Drilling Casing 10'
	0940							About 10 ft - Rig head jumping			water added to cyclone
								up and down like it is in cobbles		10'	Add casing 10'
								and boulders. Some water added			
								to Cyclone to knock dust down			
								Samples are brown in color no			
								concrete or debris hit so far			
10	1120	Soil	C3041-10					10' Groundup sediment brown			drier sediment than previous
								Sample 11:18 Ran Hach kit for Cr^{+6}			less water added
								and had a 0.01 mg/L result; no visible paint			
15	1140	Soil	C3041-15					15' Ground sediment clasts to			Hard spot at 12' driller
								15cm that are whole; green			thinks it might be concrete
								tint, could be some concrete			
								Sample 11:25		5'	Add casing 5'
20	1410	Soil	C3041-20					Cement - no cobbles green color			
								when wet - concrete gray when dry			
								fine grained			
								Will tear down Rotary Rig and		-5'	Take 5' off 20 ft of
								move cabletool on			Starter casing

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3041	Depth: ~20ft - 28	Sheet 2 of ~~10~~ 17
		Location: 100 D 183 DR	Project: ISGR	

Logged by: Tyler Gilmore (Print) / [signature] (Sign) Date: 7/21/00

Reviewed by: Ronald Schalla (Print) / Ronald Schalla (Sign) Date: 8-31-2000

Lithologic Class. Scheme: ______ Procedure: ______ Rev: ______

Steel Tape/E-Tape: ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor: Resonant Sonic

Driller: Morris Wraspir

Rig/Method: Bucyrus Erie 22W

Depth Control Point: Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOIS-TURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
	0630							New Rig - will need to fine tune		(20) 14'	Cable tool set up over borehole. Will
								set up			need to drill out ~ 6 feet of slough
	0930							Drilling - use drive barrel to			Driller speculates other driller may not have
								Clean out casing			drilled to 20' - may have made it to
											14' ?
								Concrete Coming out of casing			
	0950							At bottom of casing - out of surface			Measure DB = 19.2 ft
								Cobbles and sediment at base of core			Setup for splitspoon
	1020							barrel			
19-21.5		Soil	C3041-19			dry		Sandy Gravel 45% Gravel 45% Sand			drove splitspoon 19-21.5
	(4)	6"	Core					10% Mud gravels to 20cm rounded			117 blow count
								smooth basalts w/ some quartzite			
								dry sediments, Field screen w/ Hach		12"	Casing catching on 14" Casing
								kit 0.00 Cr+6 70% Recovery			need to drill slough out to ~22.5'
1200	23.5-25	Soil	C3041-25			Moist		Gravelly Sand · Sand increases			23.5-25 Splitspoon
	(2)	VOA		PAH	Bkgrnd			not good recovery ~25%			
	(1)	Moisture						Sampled for full suite, VOA moisture			
	(1)	Cr						Cr.			Casing dropped in hole
	(1)		Core								21' casing in a 25' hole
1400	25.5-28	soil	C3041-28			dry		Gravelly Sand layer at			25.5-28 Splitspoon
	(4)	6"	Core					25.5 Gravel support matrix;			
								mostly sand at 26; Cobble jammed			
								in barrel at at about 27.5			
								that stopped more sample 60% Recovery			

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3041	Depth: 28-35.5'	Sheet ~~2~~ 3 of 17
		Location: 100 D 183-DR	Project: ISGR	

Logged by: Tyler Gilmore (Print) / [signature] (Sign)	Date 7/21/00	Drilling Contractor	Resonant Sonic
Reviewed by: Ronald Schalla (Print) / Ronald Schalla (Sign)	Date 8-31-2000	Driller	Moe Whaspir
Lithologic Class. Scheme ____ Procedure ____	Rev ____	Rig/Method	Bucyrus Erie 22W
Steel Tape/E-Tape ____ / ____ Field Indicator Equip. 1) ____	2) ____	Depth Control Point	Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
1430	28-30.5	Soil	C3041			Dry		Sandy Gravel large Clasts			28-30.5 Splitspoon
	(2)	12"	Core					coming out of drive barrel			only had 12" lexan liners left
								very loose likely matrix			(no 6")
								Supported Gravel 70% Recovery			
1500	30.5-33	Soil	C3041			Dry		Gravelly Sand			30.5-33 Splitspoon
	(2)	12"	Core					As above 60% Recovery			
										10.01	Add casing
1555	33-35.5	Soil	C3041			Moist ~~Dry~~ TG		Sand, drilled tighter. More			33-35.5 Splitspoon
	~~(2)~~	~~12"~~	~~Core~~ TG					consolidated moist good recovery			
	(4)	6"	Core					80%			
1630											End of Day

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3041	Depth: 35.5 – 45.5	Sheet 4 of ~~18~~ 17
		Location: 100 D-Area, 183-DR	Project: ISGR	

Logged by Ronald Schalla (Print) Ronald Schalla (Sign) Date 7-24-00
Reviewed by Ronald Schalla (Print) Ronald Schalla (Sign) Date 8-31-2000
Lithologic Class. Scheme USCS Procedure ______ Rev ____
Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor Resonant Sonic Int.
Driller Morris "Moe" Wraspir
Rig/Method Bucyrus Erie 22W
Depth Control Point Ground Surface

DEPTH ft	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
35.5	0740	Split Spoon	C3041-36.5	GM		Sl. moist		Gravelly SAND (SW) sand is	None	11.75" O.D.	Sampled from 35.5 to 38'
to 36.5	"	12"	∅					30% vcs-cs, 50% med, 20% fn to v.fn		10.25"	recovered only 80% overall,
37.5	"	long	C3041-37.5					trace amounts of silt, Slightly		ID	but each 12" long tube 95%
37.5	"	No	recovery from Section					moist, dark gray (10YR-4/1)			full.
38.0	"	of	Sampler below basket					Gravel 80% fine, 20% med.			
								Basalt & quartz. no cementation			
38.0	0835	Split	C3041-39								
39.0	"	Spoon									
39.0-	"	"	C3041-40			Sl. Moist		SAND (SP [redacted]) 98%, 2% silt			Sampled from 38.0–40.5'
40.	"	"						or less, 0% gravel to traces of			Nearly 100% recovery 38 to 40'.
40.5	No	recovery 40	–40.5'					fine to very fine gravel. Less			No recovery from 40–40.5' because
								than 5% vcs.-cs sand,			below basket.
40.5-	0930	Split Spoon				Sl.		80% medium, 15% fine to v.fn.			Sampled from 40.5'–43'
41.5	"	12"	C3041-41.5	2 VOA vials		Moist		Basalt & quartz sand. Dark			95% recovery from 40.5 to 42.5
41.5-	"	long		& one moisture tin				gray (10YR-4/1).			No Recovery from 42.5 to 43.0'
42.5	"		C3041-42.5					No Cementation.			2 VOA vials filled with methanol
42.5	to 43.0'	No Recovery									+5 grams of soil. Also, moisture tin.
43.0-			"					Slightly more silty about			Sampled from 43'–45.5'
44.0	1000	Split Spoon	C3041-44			Sl.		2–3% than above			95 to 100% recovery in two lexan
44.0-		"				Moist					12", 4 in dia tubes. No Recovery
45.0	1000	12"	C3041-45								from 45.0 to 45.5 (below basket).
45.0	–45.5	No Recovery									
below		basket									

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3041	Depth: 45.5'–55.5'	Sheet ~~4~~5 of 17~~0~~
		Location: 100 D, 183-DR	Project: ISGR	

Logged by Ronald Schalla (Print) Ronald Schalla (Sign) Date 7-24-00

Reviewed by Ronald Schalla (Print) Ronald Schalla (Sign) Date 8-31-2000

Lithologic Class. Scheme USCS Procedure ______ Rev ____

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor Resonant Sonic Int.

Driller Morris "Moe" Wraspir

Rig/Method Bucyrus Erie 22W

Depth Control Point Ground Surface

DEPTH ft	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
45.5-	1032	Split Spoon	C3041-46.5	GM		Sl. Moist		Less silt 0-2% and traces	None		Sampled from ~~45~~ 45.5 to 46.5 ft.
46.5		12"						of very fine gravel			recovered ~~45~~ 45.5 to 47.5 ft
46.5-	1032	Long Lexan	C3041-47.5			Moist		Sl. Silty, Sandy GRAVEL (GP-GM)			about 90%. No recovery from
47.5		Liners						dark gray to gray (10YR-4/1			47.5 to 48 feet.
47.5 to 48.0 No Recovery								to 5/1. 50% gravel, 40% sand			
								10% or less silt. Moist to			
48.0-								49 feet. Fine to med. gravel.			
49.0	1100	Split Spoon	C3041-49			Moist					
49.0-		Lexan Liner				Dry		Silty Sandy GRAVEL (GM)			Sampled from 48-50.5'
50.0	1100	"	C3041-50					60% gravel, 25 to 30% sand, and			90% to 95% recovery in
50.0 to 50.5 No Recovery								10-15% silt. Gravel is 20%			two Lexan 12", 4-inch dia tubes.
								Coarse to very coarse, ~~4~~0% medium 40%			No recovery from 50 to 50.5'
50.5-	1132	Split	C3041-51.5					fine to v.fn.. Gravel subrounded			Sampled from 50.5 to 53'
51.5	"	Spoon Liners				Dry		to well rounded in all sizes.			90% recovery in two
51.5-	1132	"	C3041-52.5					light brownish gray (10YR-6/2)			12" long Lexan liners (tubes).
52.5	"	"						same as above but only			No recovery from 52.5 to 53 ft.
52.5 to 53 No Recovery								slightly silty. 2 to 5%.			
								~~Same~~			
53 to	1205	Split				Dry		Same as above, but			Sampled from 53.0 to 55.5
54	"	Spoon	C3041-54			to		5 to 10% silt and small			70 to 80% recovery in two 12"
54 to	1205					Slight		siltrich areas colored			Lexan Liners from 53 to 55 ft
55	"		C3041-55			Moist		reddish yellow (7.5YR-6/8)			No Recovery from 55 to 55.5 ft
55 to 55.5 No Recovery											

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3041	Depth: 55.5'-65.5'	Sheet 6 of ~~10~~ ~~8~~ 17
		Location: 100D Area, 183-DR	Project: ISGR	

Logged by Ronald Schalla (Print) [signature] (Sign) Date 7-24-00

Reviewed by Ronald Schalla (Print) [signature] (Sign) Date 8-31-2000

Lithologic Class. Scheme USCS Procedure ______ Rev ____

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor Resonant Sonic Int.

Driller Morris "Moe" Wraspir

Rig/Method Bucyrus Erie 22W

Depth Control Point Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
55.5-	1330	Split	C3041-565	GM	Nothing	slight		Same as above, but			Sampled from 55.5 to 58 ft
56.5	"	Spoon		PAM	Background	Moist		cementation evident.			80-90% recovery in two 12"
56.5-	1330	4" Dia	C3041-575			to					long Lexan® liners from
57.5	"					dry					55.5 ft to 57.5 ft. No Recovery from
57.5 to 58 No Recovery											57.5 ft to 58 ft, except one
											small jar.
58 to	1410	Split	C3041-59	GM		slight		Same as above but less silt			Sampled from 58 to 60.5 ft
59	"	Spoon				Moist		cementation.			0% to 99% recovery in two 12"
59 to	1410	"	~~C3041-60~~			Dry		Cobbles Large to small boulders			Long Lexan® liners from 58' to 60'.
60	"	"	No Recovery					gravel and sand			No recovery from ~~58~~ 59 to 60.5' because
60 to 60.5 No Recovery											of large cobble up to 8 inches
											Long & 6" in diameter.
60.5 to	1440	Split Spoon	C3041-61.5			Dry		Sandy GRAVEL (GW-GP) with			Sampled from 60.5 to 63 ft
61.5	1440	"						minor amounts of silt less than 5%,			80% recovery in two 12"
61.5 to	1440	"	C3041-62.5					Sand 30-50% and GRAVEL more			Long Lexan liners from 60.5 to 62.5
62.5	1440	"	2 VOAs & 1 moisture					than 50%. GRAVEL is 25%			Collected 2 VOAs & 1 moisture jar
62.5 to 63.0 ft. No Recovery								coarse to very crs, 40% medium			from 62.5 ft.
								35% fine gravel to v. fine. Gravels			
63 to	1520	Split	C3041-64			Dry		are subrounded to well rounded.			Sampled from 63 to 65.5 two
64	"	Spoon						primarily light brownish gray			12" Long tubes from 63 to 65'; no
64 to	"	"	C3041-65					(10YR-6/2). V. Fine gravels			recovery from 65.0 to 65.5 ft.
65	"	"						may be subangular or broken			80% to 90% recovery.
65 to	65.5	No	Recovery					fragments of larger particles			

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3041	Depth: 65.5 - 70.5	Sheet 7 of 17
		Location: 100D, 183DR	Project: ISGR	

Logged by Ronald Schalla (Print) Ronald Schalla (Sign) Date 7-24-00

Reviewed by Ronald Schalla (Print) Ronald Schalla (Sign) Date 8-31-2000

Lithologic Class. Scheme USCS Procedure ______ Rev ____

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor Resonant Sonic Int.

Driller Morris "Moe" Wraspir

Rig/Method Bucyrus Erie 22W

Depth Control Point Ground Surface

DEPTH	TIME	SAMPLES		CONTAMINATION		MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
		TYPE	ID NUMBER	INSTR.	READING						
65.5 to	1550	Split	C3041-66.5	GM				same as above			Sampled from 65.5 to 68 ft.
66.5	"	Spoon									Two 12" long Lexan liners from
66.5 to	"	"	C3041-67.5								65.5 to 67.5. No recovery from
67.5	"	"									67.5 to 68 ~~ft~~ ft. 80% recovery
67.5 to 68.		No	Recovery								on both samples
68 to		Split	C3041-69	GM							Sampled from 68 to 70.5
69		Spoon									Two 12" long, 4-in dia. Lexan liners
69 to		"	C3041-70								from 68 to 70 ft. No recovery
70		"									from 70 to 70.5 feet, which is
70 to	70.5	No	Recovery								the 5" long sampling tip below
											the catch basket. Recovery in
											the upper foot long liner was %
											and in the lower (69 to 70') %.

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3041	Depth: 70.5 - 78	Sheet 8 of 17
		Location: 100D 183DR	Project: ISGR	

Logged by Tyler Gilmore (Print) [signature] (Sign) Date 7/25/00

Reviewed by Ronald Schalla (Print) [signature] (Sign) Date 8-31-2000

Lithologic Class. Scheme ______ Procedure ______ Rev ______

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor Resonant Sonic

Driller Morris "Moe" Wraspir

Rig/Method Bucyrus Erie 22W

Depth Control Point Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
	0600							Last Sample interval was to 70.5			
	0638										Drilling
70.5	0725	Soil	C3041-71 (71-72)								Split spoon 70.5-73
|			C3041-72 (72-73)								
73	(2)	Core	6"			Moist		Sandy Gravel to Gravelly Sand	None	5'	Add casing total casing now
								Gravels to 6cm in Core			76.48'
								30-50% Gravels 60-40% Sand			
								some silt - sediment binds together			Drilled "easier" between 70.5-73
								when rolled gray colored blk bslt			
								w/ wht quartzite Sand fraction			
								from v fine to v coarse			
								Good recovery liners filled 80% Recovery			
73	0800		C3041-73.5		51	Moist		Gravelly Sand 40% Gravel -			Split spoon 73-75.5
|			C3041-74.5					50% Sand 10% Silt poorly sorted			
75.5	(2)	Core	6"					all fractions from v fine snd to			
								v Coarse sand pebbles to 2cm			
								gravels gray color Good Recovery			
								liners full 80% Recovery			
								Some yel-brn staining on grains			
								at 75.5			
75.5	0829		C3041-76			Dry to		Gravelly Sand to Sand			Split spoon 75.5-78
|			C3041-77		51	moist		at 78' Nice well sorted coarse			
78	(2)	6"	Core					Sand blk & wht (salt & Pepper color)			
								Cobble at 77 ~8cm rounded			

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3041	Depth: 78 - 85.5	Sheet 9 of 17
		Location: 100D 183DR	Project: ISGR	

Logged by Tyler Gilmore (Print) [signature] (Sign)	Date 7/25/00	Drilling Contractor Resonant Sonic	
Reviewed by Ronald Schalla (Print) [signature] (Sign)	Date 8-31-2000	Driller Morris Wraspir	
Lithologic Class. Scheme	Procedure Rev	Rig/Method Bucyrus Erie 22W	
Steel Tape/E-Tape /	Field Indicator Equip. 1) 2)	Depth Control Point Ground Surface	

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
								Cont at 77 more silt drier			Split spoon 75.5-78 (cont.)
								sample some yel-brn staining		4.95	Add 4.97 casing 81.45' total
78	0900				Sl-	moist		Water table ~78.5-79		81.45	Split spoon 78-80.5
|	(1)	Moisture			to	Wet		Sampled VOAs moisture just			
80.5	(2)	VOA						above water table			
	(1)	Cr (clr jar)									
	(2)	6" core		C3041-78.5				Sand Gravel 45% Gravel 45% Sand			Split spoon
				C3041-79.5				10% Silt/Mud clasts to 3cm			Water at ~78.5-79 ft
								well rounded Nice break at water table			
								Sand poorly sorted See saturation profile			
80.5	0939										
|	(2)	6" core									
83		C3041-81				Wet		Sandy Gravel to Sand			Split spoon 80.5-83
		C3041-82						Sand at 81 well sorted coarse			
								sand Grades to Sandy Gravel			Depth to Water 79.5'
								at 82 Clasts to 6cm, well			w/ e-tape
								rounded, some muds and gravels			
								poorly sorted at 81-82		5.02	Will drill to ~86.5
										86.47	Add 5.02 casing; total 86.47'
83	1045					Wet		Sloughing sands - sample representativeness			Split spoon 83-85.5
|	(2)	6" Core						is questionable well sorted fine sands			
85.5		C3041-83.5									Drilling Difficult flowing Sand
		C3041-84.5									will add 10 gal water
											add 10 gal water (20 total)

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3041	Depth: 85.5	Sheet 3/10 of 3/17
		Location: 100D 183DR	Project: ISGR	

Logged by Tyler Gilmore (Print) [signature] (Sign) Date 7/25/00
Reviewed by Ronald Schalla (Print) [signature] (Sign) Date 8-31-2000
Lithologic Class. Scheme ______ Procedure ______ Rev ______
Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor Resonant Sonic
Driller Morris Wrosper
Rig/Method Bucyrus Erie 22W
Depth Control Point Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOIS-TURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
								Water at 73.5 after adding			Add 10gal water (5gal total)
								10gal for hydrostatic head			Put on smaller core barrel because
	1215							Loggers on site; Driller need to attend mtg.		4.0	no sample coming up; Difficult drilling
								D.B = 84.5'		90.47	Total casing
								Will log well even though about			
								1.5 ft short of TD			
	1230							Set up to Log well w/ neutron			
								and gamma tools			
								Well logged			Difficulty w/ logging truck
	2130							Finish logging			Switch trucks

W = Wet, M = Moist, D = Dry

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3041	Date 7/26/00	Sheet No. 11 of 17
	Location 100 D Area 183DR Facility	Project ISGR	

Logged by Tyler Gilmore *Tyler Gilmore* Date 7/26/00	Drilling Contractor Resonant Sonic
Reviewed by Ronald Schalla 8-31-2000 Date *Ronald Schalla*	Driller Morris Wrasp[illegible]
Measuring Equip. Procedure →	Rig/Equipment Bucyrus Erie 22W

Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Overlap	Comments
										Beginning depth 86.1 ft Target 74.1
0920	Temp steel casing	11"	~~90.91~~ 90.47	3.55	87.36		(87.8)	84.3	3.11	(100 lb Bag Sand)
						10-20 Sand	1 bag		3.11	Pull 1 foot casing
			90.47	5.0	85.47		(89.6)	85.95	0.97	Pull Casing
						10-20 Sand	1 bag (87.4)	82.4	3.07	
			90.47	6.5	83.97		(89.6)	83.1	0.87	Pull casing
						10-20 Sand	1 bag (87.6)	81.1	2.87	
			90.47	7.95	82.52		(89.6)	81.65	0.87	Pull casing
						10-20 Sand	1 bag (87.6)	79.65	2.87	
			90.47	8.5	81.97		(88.4)	79.9	2.07	Remove 4.0 ft casing
	Temp Steel casing	11"	86.47							PVC casing stickup 4.1 ft was 4.4
										dropped 0.3 ft New depth 86.4
	Temp Steel casing	11"	86.47	4.5	81.97		~~(85.80)~~			Continue to pull
			86.47	5.35	81.12	~~10-~~	(85.5)	80.15	0.97	
						10-20 Sand	1 bag (83.6)	78.25	2.87	
			86.47	6.8	79.67		(85.7)	78.9	0.77	Pull casing
						10-20 Sand	1 bag (83.9)	77.1	2.57	
			86.47	8.15	78.32		(85.5)	77.35	0.97	Pull casing
						10-20 Sand	1 bag (83.9)	75.75	2.57	
			86.47	9.2	77.27		(85.3)	76.1	1.19	Pull Casing
	Temp Steel casing		81.45	4.35	77.1					Remove 5.02' Casing — 81.45

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3041 Location 100 D Area 183 DR Facility	Date 7/26/00 Sheet No. 12 of 17 Project ISGR

Logged by Tyler Gilmore [signature] Date 7/26/00 Reviewed by Ronald Schalla [signature] Date 8-31-2000 Measuring Equip. ____ Procedure ____	Drilling Contractor Resonant Sonic Driller Morris Wraspir Rig/Equipment Bucyrus Erie 22 W

Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Overlap	Comments
										Target 74.4 ft
	Temp Steel Casing	11"	81.45	4.35	77.1	10-20 Sand	1 bag	(76.5) 74.15	2.95	
										Pull casing
			81.45	6.05	75.4			(80.6) 74.55	0.85	
						10-20 Sand	1 bag	(78.9) 72.85	2.55	
	Temp Steel Casing	11"	81.45	6.75	74.7			(79.7) 72.95	1.75	End Pulling
										Prepare to sample water
										9 Sacks sands total
1050	Temp Steel Casing	11"	76.48							Remove casing 4.97 Total 76.48
			.37 76.11	1.35	74.76					Will not include 0.37' head
										Sand 74.2' TOC (in annulus)

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3041	Depth: 84.5 -	Sheet 13 of 17
		Location: 100 D Area 183DR Facility	Project: ISGR	

Logged by: Tyler Gilmore (Print) / Tyler Gilmore (Sign) — Date 7/26/00

Reviewed by: Ronald Schalla (Print) / Ronald Schalla (Sign) — Date 8-31-2000

Lithologic Class. Scheme ______ Procedure ______ Rev ____

Steel Tape/E-Tape ______ / ______ Field Indicator Equip. 1) ______ 2) ______

Drilling Contractor: Resonant Sonic

Driller: Morris "Moe" Wraspir

Rig/Method: Bucyrus Erie 22W

Depth Control Point: Ground Surface

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	CASING	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
	0615										Drilling out last 2ft; TD will
	0700							Depth to bottom 86.5 ft			be approx 86.5-87 ft
								Depth to water 78.2 ft; this may			
								be a good static level, well was			Prepare to set screen and PVC
								advanced past casing			casing
	1100							PVC Casing:			Set casing
								PVC Screen 20 slot 10.22'			
								(Centralizer) PVC Casing 4.95			Measure depth to bottom inside
								9.95			PVC 90.5' Casing tally off
								9.95			
								9.95			
								9.95			
								9.95			
								9.95			
								9.95			
								4.95			
								(measured 90.5) 89.77 ft			4.4' Stickup DB 86.1 ft
											4.1' Stickup DB 86.4 ft
								See Completion Log 7/26/00			after pulling casing
								From Top of Casing DW = 83.30			Set up to Sample Water
								(PVC) DB = 90.22			

W = Wet, M = Moist, D = Dry

Pacific Northwest National Laboratory	DAILY BOREHOLE LOG	Boring/Well No: C3041	Depth: TD - Water	Sheet 14 of 17
		Location: 100 D	Project: Sampling ISGR	

Logged by Tyler Gilmore (Print) [signature] (Sign)	Date 7/26/00	Drilling Contractor Resonant Sonic	
Reviewed by Ronald Schalla (Print) [signature] (Sign)	Date 8-31-2000	Driller —	
Lithologic Class. Scheme	Procedure ___ Rev ___	Rig/Method 22W	
Steel Tape/E-Tape ___ / ___	Field Indicator Equip. 1) ___ 2) ___	Depth Control Point Surface	

DEPTH	TIME	SAMPLES TYPE	SAMPLES ID NUMBER	CONTAMINATION INSTR.	CONTAMINATION READING	MOISTURE	GRAPHIC LOG	LITHOLOGIC DESCRIPTION (particle size distribution, sorting, mineralogy, roundness, color, reaction to HCl, etc.)	WATER ADDED	~~CASING~~ in ppb	DRILLING COMMENTS (drilling rate, down time, blow counts, water level, drill fluid, etc.)
	2:16							Start Pumping		Cr6+ conc. 0	Samples T=0 (Start 2:16pm)
								Flow rate from T0 - T10		10	1.66gpm T=5
								= 1.66 gal/min		0	Flowrate > T=10
								At T10 Flow rate increased		10	3.3gpm T=15
								to 3.33 gal/min		10	T=20
										20	T=30
								Draw down 0.7ft at 3.3gpm	after 30mins.	40	T=40
								After 2hrs drawdown 1.13 ft		50	T=60
								at 3.3 gpm.		50	T=80
								After 3 hrs drawdown 1.20ft		40	T=100
								at 3.3 gpm		70	T=120
										60	T=140
										60	T=160
										60	T=180
								Groundwater samples			
								collected while pumping			
								at 3.3 gpm			
								Total of 582.7 gallons pumped			
								in 180minutes			

W = Wet, M = Moist, D = Dry

48 bags on Pallet

-2' from tape

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3041	Date 7/31/00	Sheet No. 15 of 17
	Location 183 DR	Project ISGR	

Logged by Tyler Gilmore [signature]	Date 7/31/00	Drilling Contractor Resonant Sonic	
Reviewed by Ronald Schalla [signature]	Date 8-21-2000	Driller Wes Worth	
Measuring Equip.	Procedure	Rig/Equipment Pump Rig	

Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Over lap	Comments (Hot 108°F)
1430	Temporary Steel	11"	80.11	5.5	74.6					Add 4.0' Casing
										Abandon Well
						Volclay Pure Gold	1 bucket	(80) 72.9	2.3	Add 1/2 Bentonite pellets Volclay
			80.11	7.1	73.0	50lb bag Baroid Casing Seal	5 bags	(74) 66.9	6.0	DW = 78 DB was about 86'
										so there is ~12' Sand (to above
			76.48	4.55	71.93			(72.2) 67.7	4.23	Water table)
						Baroid Casing Seal	5 bags	(69.5) 65.0	6.93	
			71.48	4.3	67.1			(67.6) 63.3	4.0	Casing Seal Baroid 50lb Random Sized
								(70.5) 64.0	0.98	Pull
			71.48	6.5	64.98	Baroid Casing Seal	5 bags	(64.5) 58.0	6.0	5.02 Casing removed
	Temporary Steel		66.46	4.3	62.16			(63.2) 58.9	3.2	
			66.46	5.8	60.66			(65.0) 59.2	1.46	
1600						Baroid Casing Seal	5 bags	(58.9) 53.1	7.56	
			61.46	4.25	57.21			(58.7) 54.45	2.76	Remove 5.0 Casing
			61.46	5.8	55.66			(60.7) 55.8	0.2	
						Baroid Casing Seal	5 bags	(54.7) 48.9	4.5	
						Baroid Casing Seal	3 bags	(50.8) 45.0	9.3	
			56.44	4.3	52.14			(50.8) 46.5	5.64	Remove 5.02 Casing
			56.44	7.5	48.9	Baroid Casing Seal	5 bags	(48.8) 41.3	7.6	
			51.42	4.35	47.07			(46.5) 42.15	4.9	Remove 5.02 Casing
1640										End Day
						Total	33 bags			

B.17

B.18

1.3 bag / ft

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3041 Location D Area 183 DR	Date 8/1/00 Project ISGR	Sheet No. 16 of 17

Logged by Tyler Gilmore *Tyler Gilmore*	Date 8/1/00	Drilling Contractor Resonant Sonic
Reviewed by Ronald Schalla *Ronald Schalla*	Date 8-31-2000	Driller Wes Worth
Measuring Equip. Driller's Nylon tape	Procedure	Rig/Equipment Pump Rig

Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Over lap	Comments
0615		11"	51.42	4.25	47.17		(46.3)	42.05	5.12	Measure depth to Bentonite w/ e-tape to
										confirm
0755										Build pullerhead
		11"	51.42	6.9	44.52		(50)	43.10	1.42	
						Baroid Casing Seal	5 bags (43.6)	36.7	7.8	
0806			46.4	4.2	42.2		(44.5)	40.3	1.9	Remove 5.02 Casing
			46.4	5.0	41.4		(46.5)	41.5	-0.1	
						Baroid Casing Seal	5 bags (39.8)	34.8	6.6	
0810						Baroid Casing Seal	5 bags (33.4)	28.4	13.0	Pull Casing 48 bags total 1 pallet
										New Pallet of bentonite
			41.38	4.4	36.98		(34.4)	30	6.98	Remove 5.02 casing
			41.38	7.9	33.48		(38)	30.1	3.38	
						Baroid Casing Seal	10.5 bags (27.9)	20.0	13.48	
			31.36	4.6	26.76		(25.2)	20.6	6.16	Remove 10.02 casing
						Baroid Casing Seal	10 bags (12.6)	8	18.76	Remove 10.02 Casing
			21.34	4.5	25.84		(16.0)	11.5	14.34	Surface casing to 20 ft so pull rest
0930		13"	20'	0	20'			12.9	7.1	of 11" casing
			20	1.6	18.4	Baroid Casing Seal	3 bags	10.4	8.0	
0952			20	4.4	15.6		(10)	11.6	4.0	
			20	7.6	12.4		(20)	12.4	0	
						Baroid Casing Seal	4 bags (16.3)	8.7	3.7	
			20	9.7	10.3		(19)	9.3	1.0	

DAILY BOREHOLE/WELL COMPLETION LOG	Boring or Well Number C3641 Location D Area 183DR	Date 8/1/00 Project ISGR	Sheet No. 17 of 17

Logged by Tyler Gilmore [signature] Date 8/1/00 Reviewed by Ronald Schalla [signature] Date 8-31-2000 Measuring Equip. Procedure	Drilling Contractor Resonant Sonic Driller Wes Worth Rig/Equipment Pump Rig

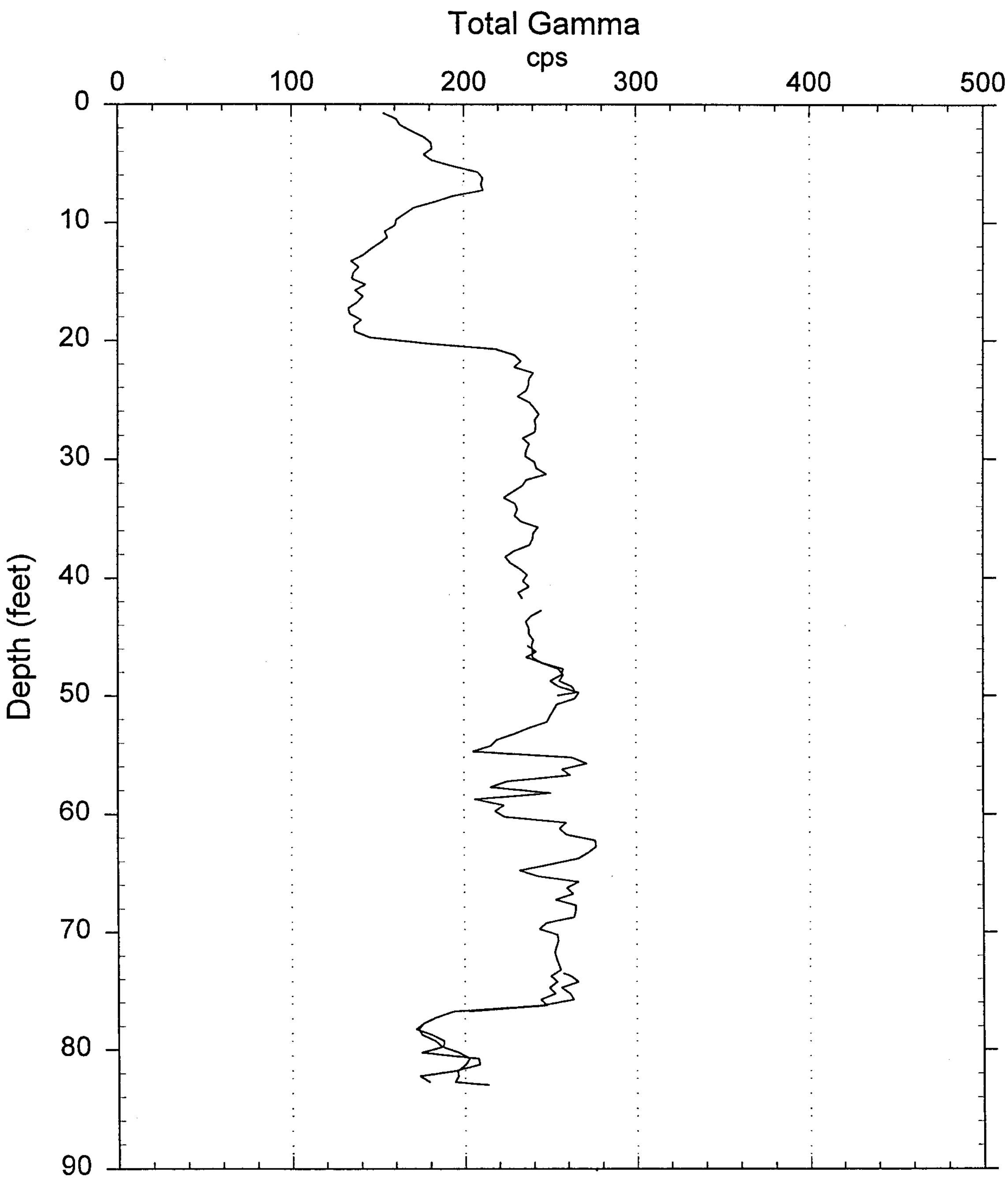
Time	Casing/Screen Type	Dia	Length	Stickup	Depth	Annular Fill Type	Quantity	Depth	Over lap	Comments
1006	Temp Steel	13"	20'	10.7	9.3		(20)	9.3	∅	Bentonite crumbles to 9.3'
										Prepare to Mix grout
						Bentonite and Portland cement Type I & II				(94lb bags Cement)
						mix ~5% Bentonite w/ cement; mix as thick as possible				
1103						½ bag bentonite	~80gal			Calculate ~86 gal to fill casing
						7 bags Cement				
										Pull casing Grout to near surface
						Grout		3'	N/A	Pull all casing out of hole
										Mix rest of cement in tough w/ water
						Grout		~1'	N/A	and put in hole – will let settle out
										Cement settled to ~2.5ft below ground surface
										Clean up site
										Will top off well after a brass marker is aquired

Note: PVC casing used for water sampling well was removed; bottom of hole from about 74.4 to 86 is filled with Colorado Silica Sand

RLS Total Gamma-Ray

Waste Management Technical Services

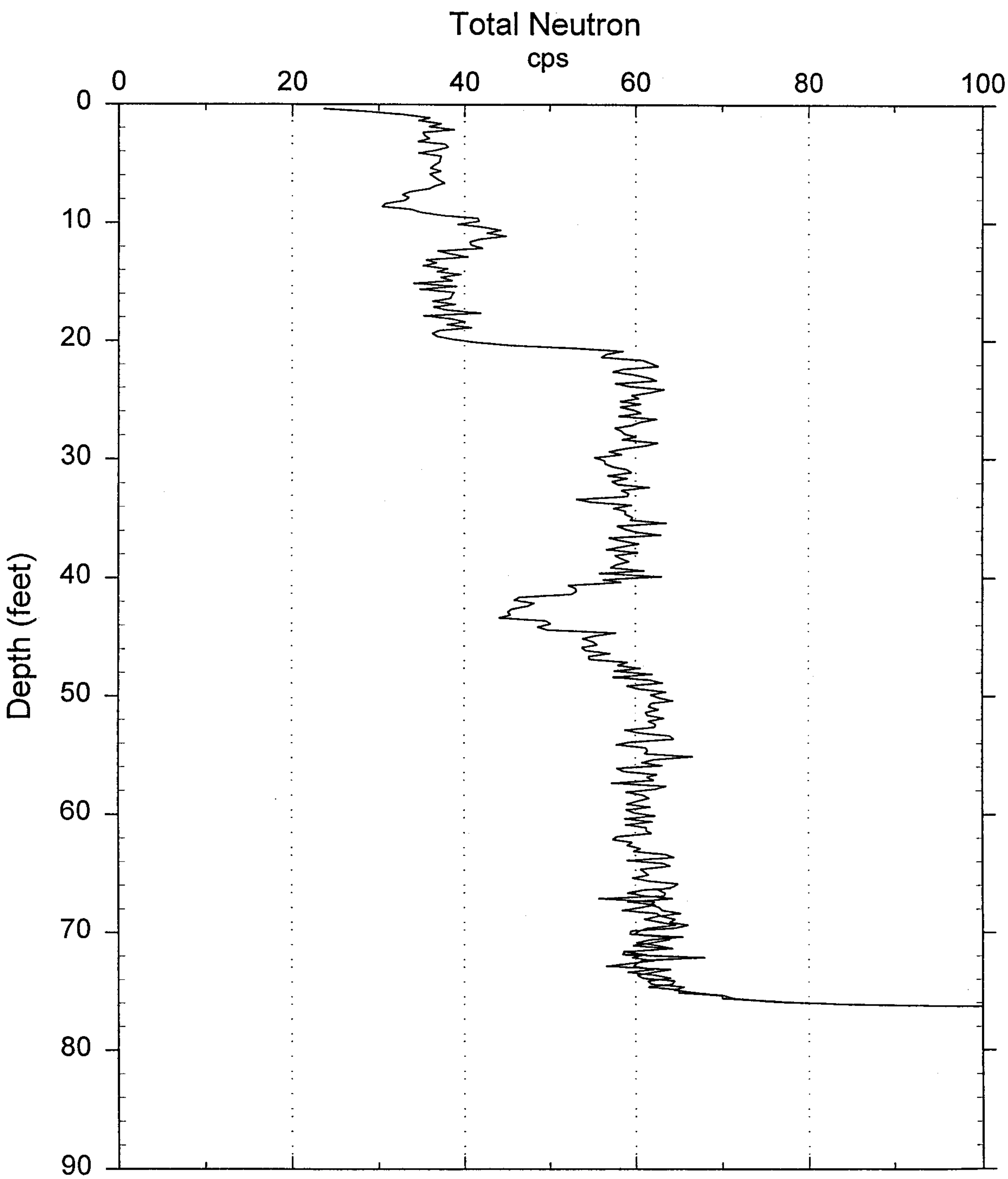
Project: ISGR-183DR
Log Date : July 25, 2000
Borehole: C-3041
Depth Datum: Ground Level



RLS Relative Moisture

Waste Management Technical Services

Project: ISGR-183DR
Borehole: C-3041
Log Date : July 25, 2000
Depth Datum: Ground Level



Appendix C

Sediment and Groundwater Sampling and Analysis for 183-DR Boreholes C3040 and C3041

Appendix C

Sediment and Groundwater Sampling and Analysis for 183-DR Boreholes C3040 and C3041

C.1 Sample Collection

Core Samples – Drilling of the characterization boreholes at the 183-DR site began on July 20, 2000. Drilling was initiated by air rotary, but sampling was conducted while drilling with a cable tool rig. Pre-drilling characterization was conducted at the C3040 borehole site previously (Thornton et al. 2000) to a depth of 20 feet below ground surface (bgs). Sampling during C3040 borehole installation was initiated at 20 feet bgs and continued to 5 feet below the water table. Sampling during C3041 borehole installation was initiated at 10 feet bgs and continued to 5 feet below the water table. All core samples were collected with a 2 feet by 4 inch diameter split spoon sampler equipped with either 6-inch or 12-inch long lexan liners and were collected ahead of the driven casing. Upon insertion of the split spoon sampler to its full length into the undisturbed subsurface sediment sampling interval, the sampler was removed from the borehole and opened. The lexan liners were transferred to a worktable and screened with a portable beta/gamma meter. If a sediment volatile organic sample was to be collected from a specific core-segment, the 1 to 5 gram sample was collected immediately from the core with a stainless steel spatula and deposited into a pre-weighed 40 ml volatile organic analysis (VOA) vial containing 10 ml of purge and trap grade methanol stored at or below 4°C. Immediately after sampling, the vials were stored into an ice chest with blue ice. The lexan liner core samples were capped and placed in an ice chest with ice bags. At the end of the day, the VOA vial and core samples were placed into a walk-in cooler at 4°C. Cores were stored at 4°C at all times, except when being processing.

Groundwater Samples – Groundwater samples were collected from a temporary well completion within the boreholes. The temporary well completion consisted of installing a 2-inch PVC liner with a 5-foot screened interval 5 feet below the groundwater table. Sand was backfilled around the screened interval and the wells pumped with a Grundfos Redi-Flo-2 variable speed submersible pump. Each well was purged for several hours until pH, conductivity, and hexavalent chromium concentrations stabilized and turbidity decreased to below 5 NTU. Groundwater samples were collected for VOA, filtered metals, hexavalent chromium, anions, gross alpha and beta, and gamma scans.

C.2 Sample Analysis

Table C.1 identifies the number of samples analyzed, the constituents analyzed, analytical methods used, and the laboratory conducting the analysis for the sediment and groundwater samples collected.

Table C.1. Groundwater and Sediment Analysis Associated with Borehole Installations at the 183-DR Site

Sample Type	Number of Samples	Analytical Constituents	Laboratory	Laboratory Method
Borehole Sediments	10	NA	STL	EPA Method 1311 TCLP Leaching
TCLP Leachate	10	Metals	STL	EPA Method 6010
TCLP Leachate	10	Mercury	STL	EPA Method 7470
TCLP Leachate	10	Volatile Organics	STL	EPA Method 8260
Borehole Sediments	66	Chromium (VI)	In-House	Hach Method 8023
Borehole Sediments	66	PH	In-House	Electrometric
Borehole Sediments	7	Anions	In-House	PNL Method IC-1
Borehole Sediments	10	Chromium (VI)	STL	EPA Method 7196
Borehole Sediments	10	Total Metals	KLM	KLM-XRF Procedure XRF-1
Borehole Sediments	4	Soil VOA	In-House	PNL Method VOA-3
Borehole Sediments	10	Alpha, Beta, and Gamma	STL	STL-RC-5014 STL-RC-5017
Groundwater	2	Alpha, Beta, and Gamma	STL	STL-RC-5014 STL-RC-5017
Groundwater	2	Metals	STL	EPA Method 6010
Groundwater	2	Anions	In-House	PNL Method IC-1
Groundwater	2	VOA	In-House	PNL Method VOA-3
Groundwater	2	Chromium (VI)	STL	EPA Method 7196

In-House = Pacific Northwest National Laboratory, Richland, Washington.
KLM = KLM Analytical Laboratory, Richland, Washington.
STL = Severn Trent Laboratory, Richland, Washington.

Upon receipt of the sediment samples in the laboratory, hexavalent chromium analysis was conducted on aliquoted core samples at 2-foot intervals. These samples were leached with a sediment/distilled water ratio of 1:10. Extraction was accelerated with the aid of microwave heating. After cooling the leachate was analyzed for hexavalent chromium according to Hach Method 8023, which is based on EPA

Method 7196 (EPA 1992). pH was measured on each sample electrometrically. Anions were measured in the leachate solutions from 7 of the leachate samples according to procedure PNL-IC-1. This method is based on EPA Method 300.0 (EPA 1992).

After all sampling was completed from boreholes C3040 and C3041, core segments were selected and prepared for subsequent analysis. Each selected core segment was sieved through a 2 mm stainless steel sieve. The <2 mm sieved fraction was aliquoted into three sub-samples. One 500 ml aliquot was prepared for STL Laboratory for TCLP leaching, chromium(VI), and radiological analysis. In addition, two 60 ml aliquots were also prepared. One aliquot was sent for total metal analysis by x-ray fluorescence. The second 60-ml aliquot was retained as an archive sample for follow up analysis, if necessary.

Groundwater samples were collected in the field following development of the temporary wells. Filtered samples were collected for metals analysis. The remainder of the samples was collected unfiltered. PNNL conducted analysis for anions and volatile organic compounds. Severn Trent Laboratory conducted the remainder of the analysis.

Presented below is a summary of each analytical procedure used for the analysis of sediment and groundwater samples.

Sediment TCLP Leaching: The Toxicity Characteristic Leaching Procedure (TCLP) is a test designed to simulate the leaching a waste will undergo if disposed of in a sanitary landfill. The extraction fluid employed is a function of the alkalinity of the solid phase of the waste. A subsample of a waste is extracted with the appropriate buffered acetic acid solution for 18 ± 2 hours, as prescribed in EPA Method 1311 (EPA 1992). A solid/leachate ratio of 1:20 is used for the extraction. The extract obtained from the sediment material is then analyzed to determine if any of the thresholds values established for the 40 Toxicity Characteristic (TC) constituents have been exceeded or if the treatment standards established for the constituents specified by the Land Disposal Restrictions (LDR) program have been met. If the TCLP extract contains any one of the TC constituents in an amount equal to or exceeding the concentrations specified by the LDR program, the waste possesses the characteristic of toxicity and is a hazardous waste. The resulting TCLP extracts in this study were analyzed for RCRA Metals according to EPA Method 6010 (ICAP analysis), volatile organic compounds according to EPA Method 8260, and mercury according to EPA Method 7470. A total of ten sediment samples underwent TCLP leaching and subsequent analysis at Severn Trent Laboratory.

Sediment VOA: Refrigerated methanol preserved VOA samples were allowed to warm to room temperature. The 40-ml vial was centrifuged to settle the particles and a 0.5 ml aliquot was removed and diluted to 40 ml with boiled Mill-Q water in a VOA vial. The sample was then analyzed according to PNL Method VOA-3. PNL Method VOA-3 is based on EPA Method 502.2, which measures a total of 58 volatile and semi-volatile compounds using a tandem photoionization and electrolytic conductivity detector in series. A total of eight samples and two duplicates samples were analyzed from selected core segments at PNNL.

Sediment X-Ray Fluorescence: A sample aliquot was removed from the core segment and sieved to obtain the <2 mm fraction. An aliquot of this fraction was dried at 105°C, coned and quartered, and ground in a mortar and pestle. A 600-mg sample was analyzed using iron, zirconium, and silver secondary sources according to KLM procedure XRF-1 (KLM 2000). A total of 31 elements were reported for each sample analyzed. KLM Analytical Laboratory, Richland, Washington, analyzed a total of ten samples by XRF corresponding to the same samples submitted to STL for TCLP analysis.

Sediment Chromium (VI): A sample aliquot was removed from the 500 ml aliquoted prepared for STL Laboratory for TCLP leaching. The sample was leached using a 1:10 sediment/distilled water ratio. The samples were analyzed according to EPA Method 7196 as independent verification of PNNL's in-house hexavalent chromium measurement. A total of ten samples corresponding to the same samples submitted for TCLP leaching were analyzed at Severn Trent Laboratory for hexavalent chromium.

Sediment Alpha, Beta, and Gamma: Sediment analysis for alpha, and beta emitting radionuclides were analyzed according to STL's method RC-5014. Sediment samples were digested with nitric acid and the digestates analyzed for alpha and beta radionuclides using appropriate alpha and beta counting techniques. Analysis of gamma emitting radionuclides was conducted according to STL's method RC-5017. Gamma emitting radionuclides were measured directly on aliquots of the sediment samples using high-resolution gamma-ray spectroscopy. A total of ten samples corresponding to the same samples submitted for TCLP leaching were analyzed at Severn Trent Laboratory for alpha, beta, and gamma.

Sediment PCB Screening: Screening of selected sediment samples was conducted using the SDI EnvironGard PCB test kit. This screening test is based on enzyme immunoassay that enables sediment samples to be screened reliably. The test method measures the concentrations of Aroclors 1016, 1242, 1248, 1254, and 1260 to 1 ppm in sediment. Sediment samples are extracted with methanol at a 1:1 soil/methanol volume ratio. An aliquot of the extract is exposed to a treated test tube, which is activated with an enzyme conjugate. The concentration is determined colorimetrically by comparing the absorption of the sample tube to known concentrations of PCBs. A total of ten samples corresponding to the same samples submitted for TCLP leaching were analyzed at PNNL for PCBs.

Groundwater Metals and Radiological Analysis: Groundwater samples were analyzed for filtered metal concentrations according to EPA Method 6010. Analysis of groundwater samples for alpha and beta emitting radionuclides were measured according to STL's method RC-5014. Analysis of gamma emitting radionuclides was conducted according to STL's method RC-5017. A total of two water samples were analyzed at Severn Trent Laboratory.

Groundwater Anions: Groundwater samples were analyzed for fluoride, chloride, bromide, nitrate, phosphate, sulfite, sulfate, formate, and oxalate anions according to PNL Method IC-01. This analysis is based on ion chromatograph separations of anions according to EPA Method 300.0 (EPA 1992). Two groundwater samples were analyzed at PNNL.

Groundwater VOA: Groundwater samples were analyzed for volatile organic compounds according to PNL Method VOA-3. PNL Method VOA-3 is based on EPA Method 502.2 (EPA 1992), which measures a total of 58 volatile and semi-volatile compounds using a tandem photoionization and electrolytic conductivity detector in series. Two groundwater samples were analyzed at PNNL.

C.3 Sample Results

Table C.2 contains field-screening results for selected C3040 and C3041 borehole sediment samples that were water leached and analyzed for hexavalent chromium, pH, and anion concentrations. Table C.3 contains the results of the TCLP leachate analysis for volatile organic compounds, TCLP RCRA metals, PCBs, total metal concentrations of the sediment samples by XRF for arsenic, chromium, lead, and selenium, and analysis of selected sediment samples for hexavalent chromium. Table C.4 contains the groundwater analytical results for anions, alpha, beta, and gamma emitting radionuclides, VOC, and filtered metal concentrations collected from borehole C3040 and C3041.

Reviewing the data present in Table C.2 revealed no hexavalent chromium to be present in any of the sediment samples. pH ranged from 8.8 to 9.2 in the sediment leachate samples. Anion analysis of selected sediments samples identified the presence of formate and oxalate. Other common anions identified in the leachate solutions included fluoride, chloride, nitrate, phosphate, sulfate, and traces of sulfite identified in one sample.

The TCLP leachate data presented in Table C.3 indicates that no volatile organic compounds were present above the detection limit of the method. This result was expected because of the sample preparation activities involved. In anticipation of this problem, sediment samples were also collected in the field using the methanol preservation method (Liikala et al. 1996). The results of this analysis found trichloroethylene (TCE), chloroform (CCl_3H), benzene, toluene, o-xylene, and ethylbenzene present in the samples. In all cases except for chloroform, there was a significant blank problem within the methanol used to extract the samples. A “B” identifies analyte compounds suspected of have a significant blank contribution. There was a trace of chloroform identified in the methanol but this did not contribute significantly to the high concentrations measured in several samples. The high chloroform concentrations appear to be real. However, if 100% of the chloroform was extracted into the TCLP leachate solution, its concentrations would only be 1900 ppb, significantly below the allowable limit of 6,000 ppb for the TCLP leachate solutions.

Results of the RCRA metals analysis of the TCLP leachate solutions found all the target metals below the TCLP action levels. The results of the XRF analysis found total arsenic and selenium at or below the detection limit of the method. Total chromium and lead concentrations were observed at typical Hanford background concentrations for sediment samples with the exception of 132.8 ppm chromium found in sample C3040 68-68.5. This sample also had 130 ppb of leachable hexavalent chromium. All other hexavalent chromium concentrations were below the method detection limit.

Results of radiochemical analysis on the sediments found normal Hanford background activities. Total alpha activity ranged from below the method detection limit to 11 pCi/g. Beta activity ranges from 12.9 to 31.9 pCi/g. All the cobalt-60 and cesium-137 concentrations were below the method detection limits. Potassium-40 ranged from 10.1 pCi/g to 21.9 pCi/g, which is normal for Hanford sediments.

Table C.2. Chromium (VI), pH, and Anion Results for Water Leachates of Sediment Samples Collected from Boreholes C3040 and C3041

Sample ID	Depth (ft)	Sediment [Cr+6] (ppm)	pH	Fluoride (ppm)	Chloride (ppm)	Bromide (ppm)	Nitrate (ppm)	Phosphate (ppm)	Sulfite (ppm)	Sulfate (ppm)	Formate (ppm)	Oxalate (ppm)
C3040	24.5	0.00	9.1	2.5	11.3	0.2	7.5	0.3	nd	59	2.4	10.6
C3040	24.5dup	0.00	9.1									
C3040	26.5-27	0.00	8.9									
C3040	29-29.5	0.00	9.1									
C3040	31.5-32	0.00	9.0									
C3040	32-33	0.00	9.0									
C3040	34-35.1	0.00	9.1									
C3040	35.5-36.8	0.00	9.0									
C3040	39-39.5	0.00	9.1									
C3040	40.5-41	0.00	9.1									
C3040	42-42.5	0.00	9.1									
C3040	44-44.5	0.00	9.0	0.8	10.4	< 0.05	5.2	< 0.05	< 0.05	16	1.2	3.7
C3040	46.5-47	0.00	9.0									
C3040	48-48.5	0.00	8.9									
C3040	48-48.5dup	0.00	8.8									
C3040	50-50.5	0.00	9.0									
C3040	52-52.5	0.00	9.0									
C3040	54-54.5	0.00	9.0									
C3040	56.5-57	0.00	8.9									
C3040	58-58.5	0.00	9.0									
C3040	60-60.5	0.00	9.0									
C3040	62-62.5	0.00	8.9									
C3040	62-62.5dup	0.00	9.0									
C3040	64.5-65	0.00	9.1	1.2	14.1	< 0.05	3	< 0.05	< 0.05	22.7	0.9	0.4
C3040	64.5-65dup	0.00	8.9									
C3040	66.5-67	0.00	8.8									
C3040	68-68.5	0.00	8.8									
C3040	70.5-71	0.00	8.8									
C3040	72-72.5	0.00	8.8									
C3040	74-74.5	0.00	8.8									
C3040	75.5-76	0.00	8.8									
C3040	77.5-78	0.00	8.8									
C3040	79-79.5	0.00	8.8									
C3040	80.5-81	0.00	8.9	0.16	1.12	< 0.05	0.45	< 0.05	0.03	3.42	0.1	0.03
C3040	82.5-83	0.00	9.2									
C3040	86	0.00	9.3									
C3040	88-87.5	0.00	8.9									
C3040	88.5-90	0.00	9.1									
C3041	10-AR	0.00	9.2									
C3041	15-AR	0.00	9.2									
C3041	20-AR	0.00	9.0									
C3041	20	0.00	8.9									
C3041	25	0.00	8.9									
C3041	25dup	0.00	8.9									
C3041	27-27.5	0.00	8.9									
C3041	29.5-30.5	0.00	9.0									
C3041	32-33	0.00	8.9									
C3041	35-35.5	0.00	9.0									
C3041	34-34.5	0.00	9.0									
C3041	36.5-37.5	0.00	9.0									
C3041	39-40	0.00	9.0									
C3041	39-40dup	0.00	9.0									
C3041	41.5-42.5	0.00	9.0	0.7	6.3	< 0.05	3.5	0.6	< 0.05	9.1	0.3	nd
C3041	44-45	0.00	9.0									
C3041	46.5-47.5	0.00	9.1									
C3041	49-50	0.00	9.1									
C3041	51.5-52.5	0.00	9.1									
C3041	54-55	0.00	9.3									
C3041	56.5-57.5	0.00	9.0									
C3041	58-59	0.00	9.0									
C3041	61.5-62.5	0.00	9.0	1.4	6.7	< 0.05	2.7	0.8	< 0.05	11.7	0.7	0.4
C3041	71-72	0.00	9.0									
C3041	73.5-74.5	0.00	8.9									
C3041	73.5-74.5	0.00	8.8									
C3041	77-78	0.00	9.1	1.3	18.8	< 0.05	3.2	0.7	< 0.05	8.8	4.3	0.2
C3041	79.5-80.5	0.00	8.8									
C3041	82-83	0.00	8.9									

Table C.3. Analytical Results for Sediment Samples Collected from 183-DR Boreholes C3040 and C3041

Sample ID	Depth (ft)	TCLP Volatiles: Vinyl Chloride (ppb)	1,1 DCE (ppb)	2-Butanone (ppb)	Chloroform (ppb)	Carbon Tetrachloride (ppb)	1,2 DCA (ppb)	Benzene (ppb)	TCE (ppb)	PCE (ppb)	Chloro-benzene (ppb)	PCBs (ppm)
Action Levels		**200**	**700**		**6000**	**500**	**500**	**500**	**500**	**700**	**100,000**	
C 3040	24-24.5	< 14	< 12	< 25	< 8.2	< 12	< 9.8	< 13	< 12	< 15	< 17	< 1 ppm
C 3040	44.0-44.5	< 14	< 12	< 25	< 8.2	< 12	< 9.8	< 13	< 12	< 15	< 17	< 1 ppm
C 3040	68-68.5	< 14	< 12	< 25	< 8.2	< 12	< 9.8	< 13	< 12	< 15	< 17	< 1 ppm
C 3040	80.5-81.5	< 14	< 12	< 25	< 8.2	< 12	< 9.8	< 13	< 12	< 15	< 17	< 1 ppm
C 3040	82-82.5	< 14	< 12	< 25	< 8.2	< 12	< 9.8	< 13	< 12	< 15	< 17	< 1 ppm
C 3041	24-24.5	< 14	< 12	< 25	< 8.2	< 12	< 9.8	< 13	< 12	< 15	< 17	< 1 ppm
C 3041	41.5-42.5	< 14	< 12	< 25	< 8.2	< 12	< 9.8	< 13	< 12	< 15	< 17	< 1 ppm
C 3041	61.5-62.5	< 14	< 12	< 25	< 8.2	< 12	< 9.8	< 13	< 12	< 15	< 17	< 1 ppm
C 3041	77-78	< 14	< 12	< 25	< 8.2	< 12	< 9.8	< 13	< 12	< 15	< 17	< 1 ppm
C 3041	84.5-85.5	< 14	< 12	< 25	< 8.2	< 12	< 9.8	< 13	< 12	< 15	< 17	< 1 ppm

Sample ID	Depth (ft)	TCLP Metals: Mercury (ppb)	Arsenic (ppb)	Barium (ppb)	Cadmium (ppb)	Chromium (ppb)	Lead (ppb)	Selenium (ppb)	Silver (ppb)	X-Ray Fluorescence: Total As (ppm)	Total Cr (ppm)	Total Pb (ppm)	Total Se (ppm)	Cr +6 (ppb)
Action Levels		**200**	**5,000**	**100,000**	**1,000**	**5,000**	**5,000**	**1,000**	**5,000**					
C 3040	24-24.5	0.75 B	< 49	63.2 B	< 2.0	< 2.7	33.1 B	< 46	< 8.0	< 3.5	40.8	15.9	< 2.6	< 54
C 3040	44.0-44.5	0.54 B	< 49	279 B	< 2.0	< 2.7	41.0 B	< 46	< 8.0	< 3.6	41.5	9.7	< 2.7	< 54
C 3040	68-68.5	0.58 B	< 49	1080	< 2.0	3.2 B	68.4 B	< 46	< 8.0	< 3.1	132.8	8	< 2.4	130
C 3040	80.5-81.5	0.60 B	< 49	1210	< 2.0	< 2.7	48.8 B	< 46	< 8.0	< 3.2	51.6	10.8	< 2.4	< 54
C 3040	82-82.5	0.75 B	< 49	403 B	< 2.0	< 2.7	195 B	< 46	< 8.0	3.9	33.4	9.9	< 2.0	< 54
C 3041	24-24.5	0.49 B	< 49	245 B	< 2.0	< 2.7	69.5 B	< 46	< 8.0	< 3.6	37.3	5.2	< 2.6	< 54
C 3041	41.5-42.5	0.50 B	< 49	302 B	< 2.0	< 2.7	68.5	< 46	< 8.0	< 3.6	29	5.3	< 2.6	< 54
C 3041	61.5-62.5	0.66 B	< 49	387 B	< 2.0	< 2.7	101 B	< 46	< 8.0	< 3.5	36.6	5.7	< 2.5	< 54
C 3041	77-78	1.5	< 49	481 B	< 2.0	< 2.7	108 B	< 46	< 8.0	< 3.5	30	13.3	< 2.5	< 54
C 3041	84.5-85.5	0.75 B	< 49	280 B	< 2.0	3.5 B	208 B	< 46	< 8.0	< 2.7	35.8	15.7	< 2.0	< 54

TCE = Trichloroethylene
PCE = Tetrachloroethylene
1,1 DCE = 1,1 Dichloroethyene
1,2 DCA = 1,2 Dichloroethane
B = Target Analyte found in blank

Sample ID	Depth (ft)	Soil VOA: TCE (ng/g)	CCl_3H (ng/g)	Benzene (ng/g)	Toluene (ng/g)	O-Xylene (ng/g)	Ethyl-benzene (ng/g)	Radiochemical Analysis: Alpha (pCi/g)	Beta (pCi/g)	Gamma: Co-60 (pCi/g	Cs-137 (pCi/g)	K-40 (pCi/g
C 3040	24-24.5	129 B	4246	289 B	414B	3.5 B	111 B	< 7.73	17.3	< 0.08	< 0.08	15.6
C 3040	44.0-44.5	91 B	888	182 B	319B	4.8 B	93 B	< 8.02	13.1	< 0.1	< 0.08	10.9
C 3040	68-68.5	132 B	1151	313 B	509B	12.3 B	168 B	< 7.14	21.7	< 0.09	< 0.09	15.3
C 3040	68-68.5 Dup	139 B	1171	296 B	473B	13.9 B	163 B	NM	NM	NM	NM	NM
C 3040	80.5-81.5	167 B	2360	374 B	569B	15.9 B	206 B	< 7.76	20.3	< 0.1	< 0.09	14.1
C 3040	80.5-81.5 Dup	257 B	2286	533 B	842B	17.2 B	303 B	NM	NM	NM	NM	NM
C 3040	82-82.5	NM	NM	NM	NM	NM	NM	11.3	23.1	< 0.1	<0.09	16.8
C 3041	24-24.5	< 29	38458	2342 B	< 29	< 29	< 29	< 8.85	15.7	< 0.1	<0.09	10.1
C 3041	41.5-42.5	< 41	1286	<	< 41	< 41	< 41	< 9.73	12.9	< 0.1	<0.08	11.6
C 3041	61.5-62.5	< 63	519	63 B	< 63	< 63	< 63	< 8.71	15	< 0.08	< 0.07	11.1
C 3041	77-78	NM	NM	NM	NM	NM	NM	< 8.01	14.1	< 0.1	< 0.08	11.2
C 3041	79.5-80.5	< 34	396	297 B	< 34	< 34	< 34	NM	NM	NM	NM	NM
C 3041	84.5-85.5	NM	NM	NM	NM	NM	NM	< 9.74	31.9	< 0.1	< 0.07	21.9

TCE = Trichloroethylene
CCl_3H = Chloroform
B = Target Analyte found in blank
NM = Not Measured

Table C.4. Results for Groundwater Samples Collected from 183-DR Boreholes C3040 and C3041

	Anions											Gamma		
Sample	Fluoride (ppm)	Chloride (ppm)	Bromide (ppm)	Nitrate (ppm)	Phosphate (ppm)	Sulfite (ppm)	Sulfate (ppm)	Formate (ppm)	Oxalate (ppm)	Alpha (pCi/L)	Beta (pCi/L)	Co-60 (pCi/L)	Cs-137 (pCi/L)	K-40 (pCi/L)
C3040	0.1	12.5	0.12	48.7	0.03	nd	113	nd	nd	2.88	5.77	< 3.28	< 4.16	< 91
C3041	0.12	11.3	0.11	46.4	0.02	nd	95.9	0.01	nd	4.16	7.38	< 5.58	< 5.18	< 130

	Filtered Metals													
Sample	Hg (ppb)	Al (ppb)	Sb (ppb)	Ba (ppb)	Be (ppb)	Cd (ppb)	Ca (ppm)	Cr +6	Cr (ppb)	Co (ppb)	Cu (ppb)	Fe (ppb)	Mg (ppm)	Mn (ppb)
C 3040	< 0.20	181 B	< 39	67.9 B	< 0.6	< 2.8	76.7	1490	1600	< 4.6	< 6.4	269	18.4	65.5
C 3041	< 0.20	2500	< 39	103	< 0.6	< 2.8	71.6	87	93.7	6.5 B	< 6.4	3950	17.3	184

	Filtered Metals							Volatiles	Organics
Sample	Ni (ppb)	K (ppm)	Ag (ppb)	Na (ppm)	Sr (ppb)	V (ppb)	Zn (ppb)	CCl_3H (ppb)	Benzene (ppb)
C 3040	< 13.3	5.7	< 7.4	10.4	441	12.5 B	< 4.2	9.33	0.05
C 3041	15.6 B	7.8	< 7.4	13.7	417	17.3 B	10.3 B	1.01	< 0.05

Reviewing the groundwater data presented in Table C.4 indicates elevated nitrate and background concentrations of the other common anions. Total alpha and beta activity were at background levels for the Hanford Site. Cobalt-60, cesium-137, and potassium-40 were all below the method detection limits. Results from filtered metals analysis found elevated chromium in the groundwater from C3040 and slightly elevated chromium in groundwater from C3041. The hexavalent chromium concentrations measured in the groundwater from both wells strongly suggest most if not all of the chromium measured by EPA Method 6010 was hexavalent chromium. Comparing the aluminum, iron, and manganese results from both groundwater samples suggest there may have been some fine particulate matter (sediment) present in the sample from C3041. Those aforementioned elements were significantly higher in C3041. Of the 58 volatile and semi-volatile compounds measured in two groundwater samples only chloroform and a trace of benzene were found in the samples.

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