SGW-51214
Revision 0

Borehole Summary Report for the Drilling, Sampling and Installation of 8 Monitoring Wells in the 100-N Area in Support of the Integrated 100 Area Remedial Investigation/Feasibility Study, FY2011

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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Terms

ags	above ground surface
bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M Hill Plateau Remediation Company
Ci	Curie(s)
cm	centimeter(s)
cpm	counts per minute
EPA	U.S. Environmental Protection Agency
DOE	U.S. Department of Energy
DOW	Description of Work
dpm	disintegrations per minute
DQO	Data Quality Objective
WA-DOE	Washington State Department of Ecology
°F	degrees Fahrenheit
Fm.	Formation (formal name)
fm.	formation (informal name)
ft	foot (feet)
ft^3	cubic foot (feet)
g	gram(s)
gpm	gallon(s) per minute
HCl	hydrochloric acid
HEIS	*Hanford Environmental Information System*
hp	horse power
IH	industrial hygiene
IHT	Industrial Hygiene Technician
ID	inner diameter
in.	inch(es)
L	liter(s)
LEL	lower explosive limit
LWDF	Liquid Waste Disposal Facility
m	meter
mg	milligram(s)
mg/L	milligram(s) per liter
min	minute(s)
mm	millimeter(s)
MSW	miscellaneous solid waste
NMLS	Neutron Moisture Logging System
NTU	nephelometric turbidity units
OD	outer diameter
OU	operable unit

pCi	picoCurie(s)
pCi/L	picocurie(s) per liter
pCi/g	picocurie(s) per gram
PID	photo-ionization detector
ppm	part(s) per million
PNNL	Pacific Northwest National Laboratory
Radcon	Radiological Control
RCRA	*Resource Conservation and Recovery Act of 1976*
RCT	Radiological Control Technician
RI/FS	Remedial Investigation/ Feasibility Study
ROD	Record of Decision
RUM	Ringold Formation, Upper Mud Unit
SAP	Sampling and Analysis Plan
SGLS	Spectral Gamma Logging System
TD	total depth
TOC	top of casing
µS/cm	microSiemen(s) per centimeter
VOA	volatile organic analyte
VOC	volatile organic compound
WAC	Washington Administrative Code
Well ID	Well identification
WP/LIS	Waste Packaging /Labeling Instruction Sheet

Metric Conversion Chart

Into Metric Units			Out of Metric Units		
If you know	*Multiply by*	*To get*	*If you know*	*Multiply by*	*To get*
Length			**Length**		
inches	25.40	millimeters	millimeters	0.0394	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles (statute)	1.609	kilometers	kilometers	0.621	miles (statute)
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.0929	sq. meters	sq. meters	10.764	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.591	sq. kilometers	sq. kilometers	0.386	sq. miles
acres	0.405	hectares	hectares	2.471	acres
Mass (weight)			**Mass (weight)**		
ounces (avoir)	28.349	grams	grams	0.0353	ounces (avoir)
pounds	0.454	kilograms	kilograms	2.205	pounds (avoir)
tons (short)	0.907	ton (metric)	ton (metric)	1.102	tons (short)
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.034	ounces
tablespoons	15	milliliters	liters	2.113	pints
ounces	29.573	milliliters	liters	1.057	quarts
cups	0.24	liters	liters	0.264	gallons
pints	0.473	liters	cubic meters	35.315	cubic feet
quarts	0.946	liters	cubic meters	1.308	cubic yards
gallons	3.785	liters			
cubic feet	0.0283	cubic meters			
cubic yards	0.764	cubic meters			
Radioactivity			**Radioactivity**		
picocurie	37	millibecquerel	millibecquerel	0.027	picocurie

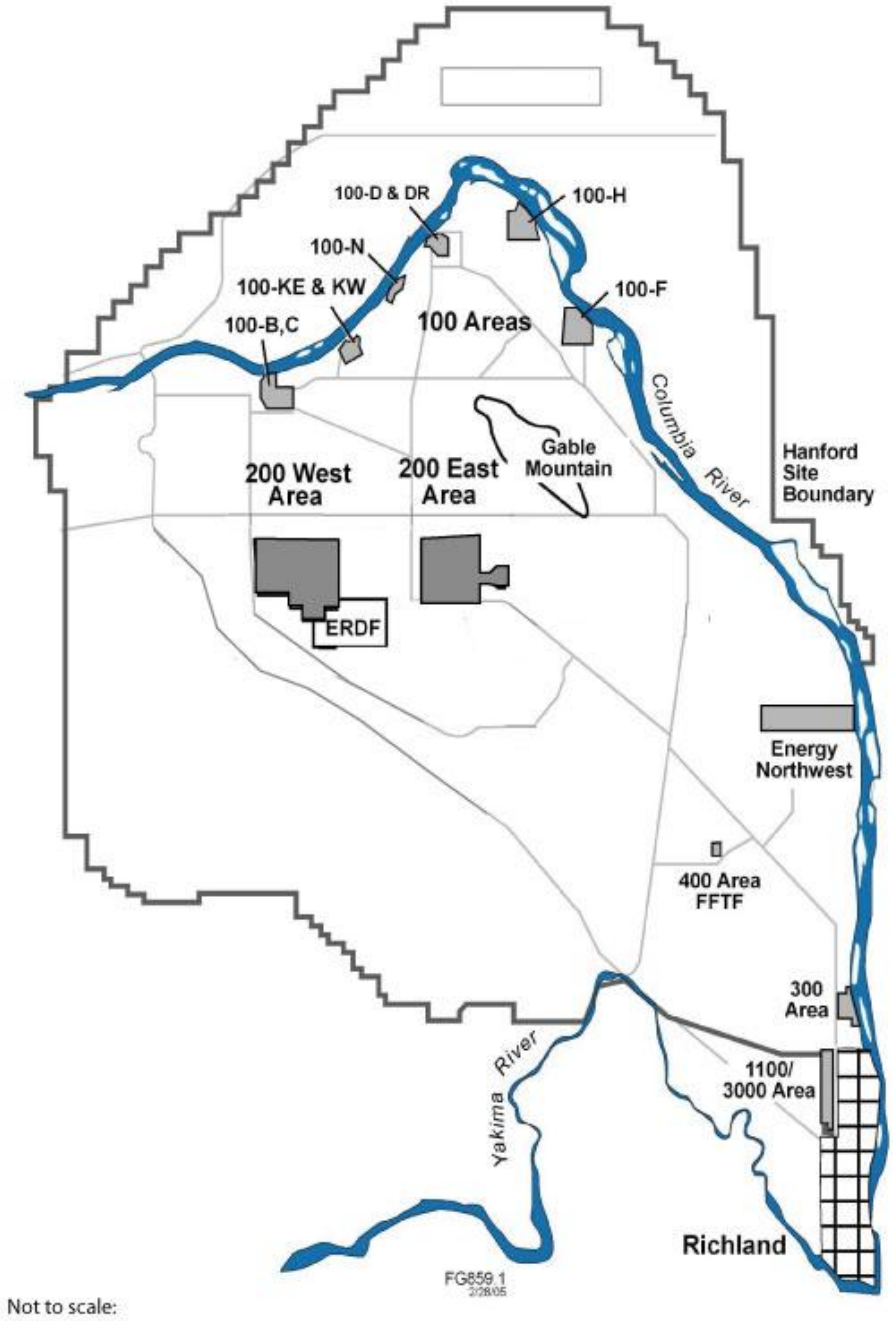
1 Introduction

This report describes the fiscal year 2011 (FY11) field activities associated with the drilling, sampling and installation of eight (8) monitoring wells in the 100-N Area for the 100-NR-1 and 100-NR-2 operable units (OUs). These OUs are located in the northern portion of the Hanford Site along the Columbia River, which is also known as the 100 Areas (Figure 1).

All of the monitoring wells were installed by CH2M Hill Plateau Remediation Company (CHPRC) in conjunction with Washington Closure Hanford (WCH) through an outside drilling contractor. This work supported the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) activities set forth by the U.S. Department of Energy (DOE) as approved by the Washington State Department of Ecology (WA-DOE). Monitoring well locations are presented in Figure 2 and monitoring well data is summarized in Table 1.

Technical information; including: drilling summaries, borehole geology descriptions, sampling summaries, geophysical logging results, well construction summaries and well development results are presented in Section 2. Environmental monitoring information is presented in Section 2. Waste management information is presented in Section 3. Civil Surveys performed are located in Section 4. Well acceptance is discussed in Section 5 and references cited are found in Section 6. Appendices include: (A) well summary/as-built sheets; (B) well construction summary sheets; (C) well development sheets/slug test responses; (D) borehole lithology sheets; (E) geophysical logging reports; and (F) survey data reports.

Figure 1. River Corridor Operational Areas



Not to scale:

Figure 2. 100-N Area Monitoring Well Location Map

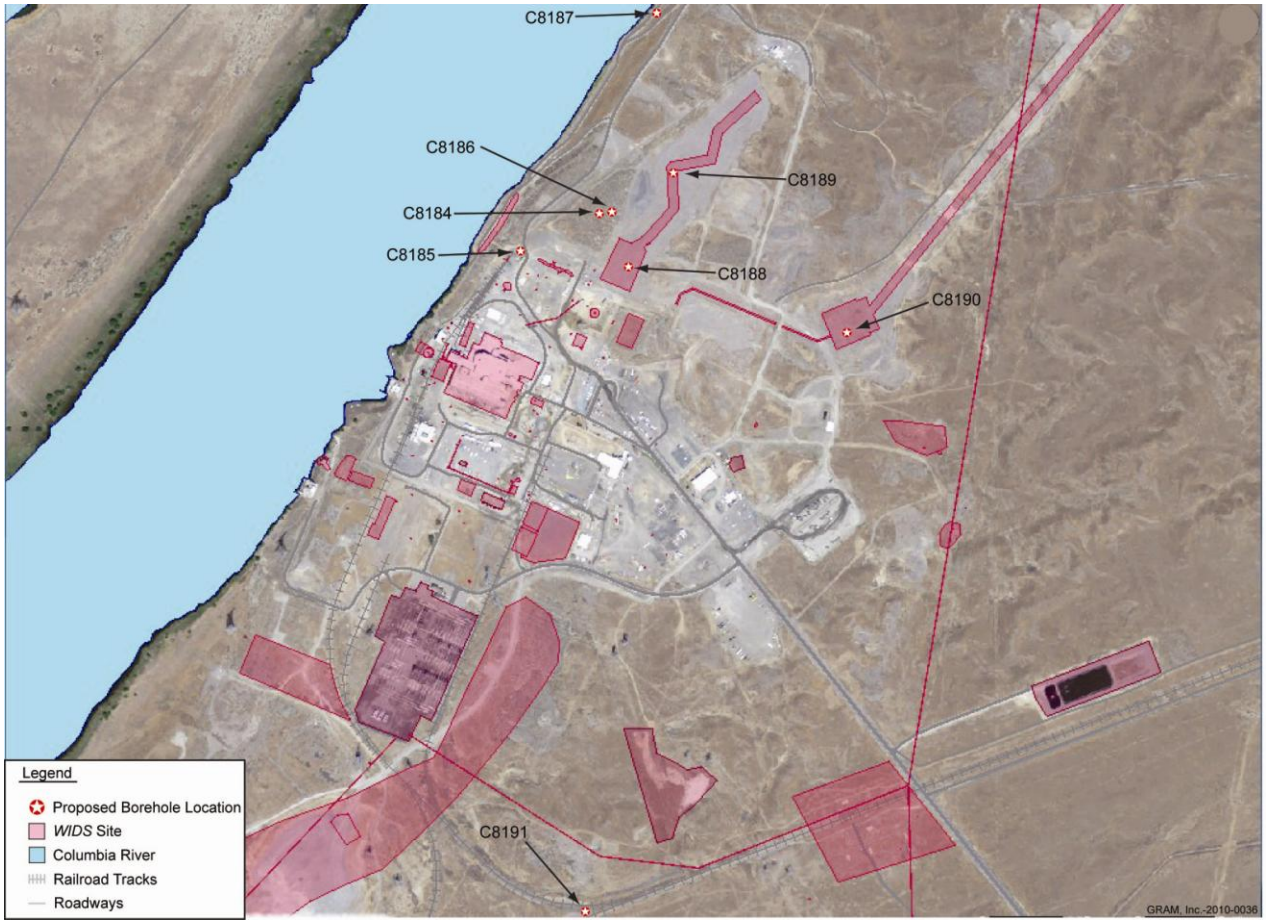


Table 1. Well Summary Information

Well Name	Well ID	Easting (m)[a]	Northing (m)[a]	Elevation – brass cap (m)[b]	Depth to Water (ft bgs)	Total Depth (ft bgs)
199-N-182	C8184	571428.71	149819.87	140.522	67.9	154.0
199-N-183	C8185	571269.69	149756.01	140.240	69.2	117.4
199-N-184	C8186	571430.74	149817.82	140.528	69.7	108.0
199-N-185	C8187	571546.33	150237.98	122.073	8.7	92.5
199-N-186	C8188	571480.87	149715.06	141.394	71.0	97.3
199-N-187	C8189	571565.90	149897.96	141.246	70.0	94.5
199-N-188	C8190	571906.94	149581.53	139.314	64.5	90.0
199-N-189	C8191	571431.65	148430.52	143.638	78.7	117.3

Notes:
[a] Measured at the staked proposed well location in Washington State Plane Coordinates, NAD83[91], North American Datum of 1983.
[b] Measured at the staked proposed well location, NAVD88, North American Vertical Datum of 1988.
ft bgs = feet below ground surface
ID = identification
m = meters

1.1 Purpose/Scope

The characterization results from the remedial investigation are intended to support final remedy selection under CERCLA for the 100-N Area at the Hanford Site. The 100-N Area is included in the 100 Area National Priorities List[1].

1.2 Background

This section describes the background and history of 100-N and includes information on the waste generated and known soil and groundwater contamination. Information used in this section was taken from DOE/RL-2008-46-ADD5, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 5: 100-NR-1 and 100-NR-2 Operable Units*; unless otherwise cited.

1.2.1 Process History

Between 1943 and 1963, nine nuclear reactors were built along the Columbia River with the core function of producing special nuclear materials for national defense. 100-N includes the N Reactor and its ancillary production and waste disposal facilities.

The ninth defense materials production reactor, N Reactor, operated from 1964 to 1986. N Reactor was built with two separate cooling loops, the primary cooling loop provided cooling to the fuel elements and the secondary cooling loop provided water to remove heat from the primary system and release heated water to the Columbia River. This two-loop system released significantly less radioactive effluent

[1] 40 CFR 300, "National Oil and Hazardous Substances Pollution Contingency Plan," Appendix B, "National Priorities List," *Code of Federal Regulations*.

(wastewater) on a daily basis as compared to the eight previously constructed reactors. Materials that passed through the reactor for the manufacturing of special nuclear materials or that contacted items passing through the reactor were considered radiologically contaminated and represented the majority of the wastes produced.

The irradiated fuel elements were shipped to the 200 Area for chemical processing. Unlike the single-pass reactors, N Reactor decontamination solutions were often piped to storage facilities before being transported to the 200 Area for disposal. During production, fuel element failures and infrastructure failures resulted in contaminated materials being released to the environment.

Burial grounds at 100-B/C, 100-K and 100-D were used to dispose contaminated solid wastes generated at 100-N; K Basins were used for long-term N Reactor spent fuel storage. Wastes resulting from supporting reactor operations were similarly disposed in each area according to phase, quantity, radioactivity, and composition.

1.2.2 Liquid Discharges

Liquid wastes were disposed to the 100-N soil column and to the Columbia River through a variety of disposal facilities including outfalls, spillways, cribs, ponds, pits, French drains, and septic systems. Two outfall structures were constructed in the 100-N Area. The outfalls were designed primarily for the return of raw river water used to remove heat from the secondary cooling system. It also provided an emergency disposal method for primary cooling water and fuel storage basin water, should it be needed. The outfalls were permitted under the Hanford Site National Pollutant Discharge Elimination System permit, and are still identified in the permit; however all discharges via these outfalls have been discontinued.

Wastewater collected from sumps and drains designed to manage radioactive wastes within the facility was discharged to crib and trench facilities. These drains contained effluent from water quality testing laboratories, personnel decontamination stations, waste transfer stations, and from floor drains located in controlled areas of the reactor building. Settling and percolation ponds were used in the 100-N Area to settle out solids from filter backwash, treat corrosive regeneration effluent, and dispose of backwash effluents. The ponds were generally unlined trenches and relied on infiltration of the liquid to the soil.

Primarily, radioactive effluents and wastes were generated within the N-Reactor building and the N-Heat Transfer building. The radioactive process effluent and waste streams ultimately were sent to the 116-N-1 Crib and Trench, the 116-N-3 Crib and Trench, or the 1314-N Liquid Waste Loadout Station. In order to maintain low dose rates and an efficient cooling system associated with the reactor core, the steam generator, and the fuel storage basin work areas, fresh demineralized water was added to these independent systems, and the wastewater was discharged to the 116-N-1 and 116-N-3 Cribs and Trenches. Water released to the 116-N-1 and 116-N-3 Cribs eventually reached the Columbia River through the groundwater system.

A major release (80,000 gal) of No. 6 fuel oil (diesel) occurred in 1966, when a line lost integrity through external corrosion in the 166-N Tank Farm. The diesel drained through the vadose zone to groundwater and moved towards the Columbia River. A trench was excavated along the riverbank to intercept the diesel before it could reach the river.

1.2.3 Waste Site Description

The two primary liquid waste disposal sites in 100-N are the 116-N-1 and 116-N-3 Crib and Trenches, also known as the 1301-N and 1325-N Liquid Waste Disposal Facilities (LWDF), respectively. The oldest is the 116-N-1 Crib, used from the time the reactor went online in 1963 until September 1985. The

trench was added in 1965 because the wastewater volume exceeded the capacity of the crib. The 116-N-3 Crib, built in 1983, was to augment the original 116-N-1 Crib. In 1985, a covered extension trench was added to the 116-N-3 Crib to increase the capacity of that facility. To enhance percolation, the 116-N-3 Crib and Trench were sited where geophysical logs indicated relatively high permeability. The newer facility was located approximately twice the distance from the river as the old facility, and was completely covered. Remedial action goals were achieved during remediation of the 116-N-1 and 116-N-3 Cribs and Trenches. Both waste sites were classified as "interim closed out" in accordance with the waste site reclassification guideline.

1.2.4 Conceptual Model

The conceptual model expresses the current understanding of site conditions and makes possible the identification of data gaps and data needs in conjunction with the planning process described in Section 4.4 of DOE/RL-2008-46-ADD5. The conceptual model identifies waste site key features, distills the known information, and captures decisions to be made. The conceptual model will evolve as new data and information are developed. The conceptual model is presented here as a discussion of known and potential contaminant sources.

This conceptual model focuses primarily on Sr-90, the contaminant for which the bulk of remediation efforts at 100-N have been directed. Specific discussions are provided for petroleum releases, sodium dichromate releases, tritium releases and nitrate releases.

1.2.4.1 Strontium-90 Releases

According to DOE/RL-2001-27, *Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit*; by the late 1970's, elevated levels of strontium -90, which moves more slowly than tritium, were detected in the groundwater near the river. To mitigate strontium-90 entry into the river, the 1325-N Liquid Waste Disposal Facility (LWDF) was constructed inland from the river and placed into partial service in 1983 and full service by 1985. Discharges to the 1325-N LWDF ceased in 1991. Approximately 2,997 Curies (Ci) of strontium-90 was contained in the liquid effluent discharged to the LWDF during N-reactor's operation. Of the estimated 2,997 Ci of strontium-90 initially present in the liquid effluent, approximately 46 Ci of strontium-90 (decayed to 1995) was estimated to have entered the Columbia River through groundwater flow. Based on the total inventory of strontium-90 discharged to the LWDF, less than that which entered the Columbia River, approximately 1,866 Ci (decayed to 1995) remained within the LWDF, vadose zone soil and the underlying unconfined aquifer.

DOE/RL-2001-27 also states that of the remaining estimated 1,500 Ci (decayed to 2003) of strontium-90 at 100-N, the majority resides in the vadose zone. Of the 72.8 Ci of strontium-90 present in the aquifer, an estimated 72 Ci are sorbed to the aquifer solids and approximately 0.8 Ci is present in the groundwater. Strontium-90 has a much greater affinity for sediment than for water (i.e., a high distribution coefficient), so its rate of groundwater transport to the Columbia River is considerably slower than the actual groundwater velocity. The relative velocity of strontium-90 to groundwater is approximately 1:100 or between 0.0005 and 0.009 m/day. Under current conditions, the estimated annual strontium-90 flux to the river from 100-N is 0.1 Ci per year. As a result of its low mobility, a majority of the strontium-90 present in the inland portions of 100-N will naturally decay before reaching groundwater and the river. With a half-life of 28.6 years, it will take approximately 300 years for the maximum concentration of strontium-90 present in the aquifer at 100-N to decay to a concentration less than the remedial action goal.

1.2.4.2 Petroleum Releases

Petroleum product releases occurred at fuel storage facilities (notably the 166-N Tank Farm and the 184-N Day Tanks) and connecting underground transfer lines on several occasions. The 166-N Tank Farm

consisted of one large fuel oil storage tank (1,375,000 gal) and four smaller diesel oil storage tanks (105,000 gal). From the 166-N Tank Farm, underground pipelines transferred fuel to the 184-N Day Tanks, which then supplied fuel to the N Reactor.

The first and largest known leak occurred in August 1966 when a 4-in. diesel fuel line leaked, due to corrosion, releasing an estimated 80,000 gallons of fuel. The leak (UPR-100-N-17) was detected through an observed discrepancy in the fuel inventory. The line was excavated and repaired. Subsequently, numerous smaller leaks and some tank overflows released estimated fuel volumes of more than 4,400 gallons. These lines were also repaired.

The 184-N Day Tank consists of two 35,000-gallon Number 6 fuel oil tanks and one 8,000 gallon diesel oil tank. These tanks had several spills over the life of the facility. On April 25, 1986, 800 gallons of diesel oil spilled (UPR-100-N-21), and 2,000 gallons of fuel oil were spilled on April 1987 (UPR-100-N-19).

1.2.4.3 Sodium Dichromate Releases

Sodium dichromate was stored in solid form at 105-N and mixed into cooling water as needed. Sodium dichromate was only used until 1973, and in small amounts after 1970. Only the 116-N-1 liquid waste disposal site received sodium dichromate waste. Documented sodium dichromate quantities are available over 4 years, 1965 and 1968 through 1970. For the purposes of this discussion, an average mass of 15,000 pounds of sodium dichromate is assumed for the two years (1966 and 1967) for which no documentation is readily available. Given the total discharges, average concentrations in the discharge wastewater are estimated between 0.5 and 0.9 mg/L.

1.2.4.4 Tritium and Nitrate Releases

Tritium, like Sr-90, Cs-137, and Co-60, was a primary radioactive contaminant in the wastewater discharged to 1301-N and 1325-N. Typical concentrations were 1E+05 pCi/L and approximately 6,500 Ci were released through 1301-N and 1325-N LWDFs.

The source of nitrate has never been clearly determined. The common source of nitrate in wastewater is nitric acid, which was used in many of the facilities. However, neither nitric acid nor nitrate was a reported component of the wastewater discharged to the 1301-N LWDF or the 1325-N LWDF. The current groundwater plume suggests that fluid losses from facilities around the N Reactor were at least partial sources. Given the lack of historical records about such losses, no inventory estimate can be determined.

2 Technical Data

This section provides details of methods used to drill/install eight wells in the 100-NR-2 OU. The drilling, construction and development of all eight wells were performed in accordance with DOE/RL-2009-42, *Sampling and Analysis Plan for the 100-NR-1 and 100-NR-2 Operable Units Remedial Investigation/Feasibility Study* and SGW-48469, *Description of Work for the Installation of 8 Groundwater Monitoring Wells in the 100-NR-2 Operable Unit to Support RI/FS Work for Fiscal Year 2011*. General well summary information is presented in Table 1.

2.1 Well 199-N-182 (C8184)

This section contains summarized descriptions of drilling, borehole geology, sampling, geophysical logging, well construction and well development activities performed during the installation of well 199-N-182 (C8184).

2.1.1 Drilling

Well 199-N-182 (C8184) was drilled using a 22-W Bucyrus Erie Cable Tool drill rig utilizing a drive barrel to remove cuttings from the ground between April 19, 2011 and July 13, 2011. Total depth of the borehole was 152 feet (ft) below ground surface (bgs). Three strings of temporary casing were utilized to maintain efficient drilling and to prevent cross contamination of aquifers. Casing strings included:

- 14-inch carbon steel casing to a depth of ~15 ft bgs
- 10-inch carbon steel casing to a depth of 106.3 ft bgs
- 8.5-inch carbon steel casing to a depth of 150.2 ft bgs.

All temporary casing was removed from the borehole during completion with 6-in stainless steel screen and casing.

2.1.2 Borehole Geology

The vadose zone at this site consists of Hanford formation sediments and Ringold Formation Unit E sediments made up mostly of sandy gravels, sands, and silty sandy gravels. The Hanford formation, Ringold Formation contact was at 46 ft bgs.

The Hanford formation was dominated by mafic basalt material. Gravels generally consisted of poorly sorted pebble and cobble sized material. Gravels were sub-round to round in shape. The sands associated with this formation consisted of poorly sorted fine to coarse grained particles. Sediment colors were recorded as light gray (2.5Y 7/2) and gray (2.5 Y 5/1).

The saturated zone of this borehole consisted of Ringold Formation Unit E sediments made up mostly of silty sandy gravels, sandy gravels, and gravels. The groundwater table was measured at 72.2 ft bgs. The depth to the top of the Ringold Upper Mud (RUM) was at 102 ft bgs surface and was made up of compacted silts and clay.

The Ringold Formation Unit E was dominated by felsic quartzite material. Gravels generally consisted of poorly sorted pebble and cobble sized material. Gravels were sub-angular to round in shape. The sands associated with this formation consisted of poorly sorted fine to coarse grained particles. Sediment colors were recorded as light brownish gray (2.5 Y 6/2) and gray (10 YR 5/1). No color readings were taken after 63 ft bgs as sediments exhibited radiological readings above those allowable limits for sampling.

The RUM was encountered at 102.0 ft bgs. This unit was comprised of dark gray clays, displayed moderate plasticity, and had no reaction to a 10% solution of HCl. One non-water bearing sand lens in the RUM was noted from 127 to 128.5 ft bgs. Sand material within this lens was medium sized, loosely to moderately consolidated, moderately sorted, and angular to sub angular. No water-bearing strata were observed in the RUM over the interval drilled.

The borehole reached a total depth of 154 ft bgs, 52 ft into the RUM.

The borehole log for this well location provides a more lithologically detailed description of the depositional strata and can be found in Appendix B.

2.1.3 Sampling

Geologic grab samples of drill cuttings were collected at 5-ft intervals or at significant lithologic changes throughout the drilling of this well, except when radiological contamination was higher than normal background levels. The grab samples were collected in glass pint mason jars and plastic chip trays for storage at the Hanford Geotechnical Sample Library (HGSL).

Soil samples for laboratory analysis were also collected at various intervals throughout the drilling of the well. The SAP planned for groundwater samples to be collected from the RUM if water-bearing strata were encountered. Since no water-bearing strata were observed in the RUM over the interval drilled, no groundwater samples were collected from this borehole during drilling. The soil samples are summarized in Table 2, below.

Table 2. Sample Summary Table for 199-N-182 (C8184)

Type	Media	Interval #	Depths (ft bgs)	HEIS #
Split Spoon	Soil	I-001	102.0 – 104.5	B2C1R2 (VOA), B2C1R6, B2C1P8, B2C1P4, B2C1T0, B2C1P0
Split Spoon	Soil	I-002	126.8 – 129.3	B2C1R3 (VOA), B2C1R7, B2C1P9, B2C1P5, B2C1T1, B2D1X0, B2C1P1
Split Spoon	Soil	1-002 DUP	126.8 – 129.3	B2C1R4 (VOA), B2C1R8, B2C1R0, B2C1P6, B2C1P2
Split Spoon	Soil	I-003	151.5 – 154.0	B2C1R5 (VOA), B2C1R9, B2C1R1, B2C1P7, B2C1T3, B2D1X1, B2C1P3

Notes:
# = number
DUP = duplicate
ft bgs = feet below ground surface
VOA = Volatile Organic Analysis

2.1.4 Geophysical Logging

Geophysical Logging was conducted at C8184 on June 30, 2011, July 1, 2011, and July 15, 2011. The geophysical logging contractor, S.M. Stoller, Corp. (Stoller), was directed to scan the borehole using the Spectral Gamma Logging System (SGLS) and the Neutron Moisture Logging System (NMLS). According to Stoller cobalt-60 was detected at 67 and 68 ft bgs with an approximate concentration of 0.16 pCi/g. More detailed geophysical logging results for this location can be found in Appendix D.

2.1.5 Well Construction

Well construction at 199-N-182 (C8184) was conducted in accordance with WAC 173-160 "*Minimum Standards for Construction and Maintenance of Wells*" (WAC-173-160). Construction started July 22, 2011 and was completed August 11, 2011. A straightness tester was run into the hole and extracted without binding on July 13, 2011. The completed monitoring well was constructed of 6 $^{9/16}$-inch OD/ 6 $^{7/16}$-inch ID schedule 10, type 316/316L stainless steel casing. Other completion materials included a 0.020 inch (20-slot) continuous wire wrap screen, 10-20 mesh filter pack, and a 5-ft sump. The screen is 20 ft in length. and is situated entirely under the water table. Specific well construction and associated depths are summarized in Table 3 below. It is specifically noted that this well was not completed with a screen in the RUM, as originally planned in the SAP, since no water-bearing strata were encountered in the RUM during the drilling of the borehole. Instead, the well was installed with a screen at the bottom of the unconfined aquifer. This change was agreed to in advance of the well construction by DOE and WA-DOE based on the field-conditions observed, as allowed by the SAP. More detailed well construction data for this location can be found in Appendix A.

Table 3. Well Construction Summary for 199-N-182 (C8184))

Total Depth (ft bgs)	RUM Depth (ft bgs)	Static Water Level (ft bgs)	6-inch Diameter, Sch. 10, Type 316/316L Well Materials			Annular Materials			
			Material	Interval (ft bgs)	Slot Size	Material	Interval (ft bgs)	Mesh/Type	Volume (cu. ft)
154.0	102.0	67.9	Sump	104.4-109.4	N/A	Portland Cement	0-9.25	I/II	5.78
			Screen	84.4-104.4	20	Bentonite Crumbles	9.25-69.8	#8	21.3
			Riser	+2.3-84.4	N/A	Bentonite Pellets	69.8-77.5	3/8”	2.76
						Silica Sand	77.5-112.0	10/20	13.38
						Bentonite Pellets	112.0-122.0	3/8”	3.45
						Portland Cement	122.0-154.0	I/II	6.43

Notes:

“ = inches
= mesh
cu. ft= cubic feet
ft bgs = feet below ground surface
Sch. = schedule

2.1.6 Well Development

Final well development at 199-N-182 (C8184) was started and completed on August 12, 2011. Development took place at two intervals no greater than 15 ft apart using a 0.75 horsepower (hp) submersible pump. The first interval, in the lower portion of the screen, was pumped at a rate of 25 gallons per minute (gpm) for 88 minutes. A total of 1,950 gallons of water was removed from the aquifer. The second development interval, near the top of the screen, was pumped at a rate of 25 gpm for 27 minutes. A total of 825 gallons of water was discharged from the aquifer. Water level recovery was also monitored at the end of development for each interval. Table 4 summarizes hydrologic and chemical parameters measured during well development at each of the intervals. More detailed information on this well-development work is presented in Appendix C, and the resulting drawdown and recovery data and plots will be documented in a future RI/FS Report.

Table 4. Well Development Summary for 199-N-182 (C8184)

Well Development					Hydrogeochemistry			
	Intake	Duration	Discharge	Drawdown	Turbidity	Specific Cond		
Test Number	(ft bgs)	(min)	(gpm)	(ft)	(NTU)	(µS/cm)	pH	Temp (°F)
1	101	88	25	10.88	2.43	390	9.19	65.66
2	86.7	27	25	8.97	2.78	389	8.91	67.1

Notes:
ft bgs = feet below ground surface
gpm = gallons per minute
NTU = nephelometric turbidity units
µS/cm = micro Siemens per centimeter
°F = degrees Fahrenheit

2.1.6.1 Slug Test

Slug testing for 199-N-182 (C8184) was started and completed on August 12, 2011. For this well two slugging rods of different volumes were used. The displacement volumes for these rods were 0.3276 ft^3 and 0.6877 ft^3. Both slugs were inserted and removed twice during separate tests and the subsequent water-level response recorded. More detailed information on this slug-testing work is presented in Appendix C, and the extensive data resulting from these tests will be documented in a future RI/FS Report.

2.1.6.2 Permanent Sampling Pump Installation

A permanent sampling pump was installed in this well on September 16, 2011. A 0.5 hp Grundfos Redi-Flo3 submersible pump was set with the intake at 97.9 ft bgs. The pump was tested prior to installation and re-tested at depth to ensure it was functioning properly.

2.1.7 Environmental Monitoring

Environmental monitoring included services provided by Radiological Control Technicians (RCTs) from CHPRC's Radiological Control (Radcon) department and Industrial Hygiene Technicians (IHTs) provided by an off-site contractor, PBS Engineering + Environmental.

2.1.7.1 Radiological Monitoring

Radiological monitoring was originally provided on an "AM/PM" basis, but switched to a continuous basis at this well location for both drilling and well construction activities once contamination was detected at elevated levels.

RCTs detected contamination of 6,000 cpm beta/gamma levels at 63 ft bgs within the soil from the drill cuttings. The highest concentration of the contamination was detected at 76.2 ft bgs at 15,000 disintegrations per minute [dpm] beta/gamma and 76.5 ft bgs at 10,000 dpm beta/gamma. Elevated levels of contamination declined to 380 cpm at 81 ft bgs and continued at that level to 97.5 ft bgs. From 97.5 ft bgs to total depth at 154 ft bgs contaminant levels were below background.

During well construction activities, RCTs detected contamination at 150 – 300 cpm beta/gamma fixed to the temporary 10" carbon steel while it was being back-pulled and removed from the subsurface.

2.1.7.2 Industrial Hygiene Monitoring

Industrial hygiene monitoring was provided on an "AM/PM" (morning and afternoon) basis at this well location for drilling and construction activities. The IHT monitored for volatile organic compound (VOC) vapors and potentially explosive vapors using a photo-ionization detector (PID) and a lower explosive limit detector (LEL). The IHT reported no anomalous readings during the drilling or construction of this well.

2.2 Well 199-N-183 (C8185)

This section contains summarized descriptions of drilling, borehole geology, sampling, geophysical logging, well construction and well development activities performed during the installation of well 199-N-183 (C8185).

2.2.1 Drilling

Well 199-N-183 (C8185) was drilled using a 22-W Bucyrus Erie Cable Tool drill rig utilizing a drive barrel to remove cuttings from the ground between March 29, 2011 and April 27, 2011. Total depth of the borehole was 117.4 ft bgs. One string of temporary casing was utilized during drilling. Casing string consisted of 10-inch carbon steel casing to a depth of 114.9 ft bgs. All temporary casing was removed from the borehole during well completion with the 6-inch stainless steel monitoring well.

2.2.2 Borehole Geology

The vadose zone of this borehole was comprised of Hanford formation sediments and Ringold Formation, Unit E sediments made up mostly of silty sandy gravels, sandy gravels, silty gravels, and gravelly sands. The Hanford formation, Ringold Formation contact was at 50 ft bgs.

The Hanford formation was dominated by mafic basalt material. Gravels generally consisted of poorly sorted pebble sized material. Gravels were sub-angular to round in shape. The sands associated with this formation consisted of very fine to coarse grained particles. Sediment colors were recorded as Greenish Gray (GLEY1 5/10Y) and reddish gray (2.5YR 7/5).

The saturated zone of this borehole was contained in Ringold Unit E sediments made up mostly of sandy gravels and gravelly sands. The groundwater table was measured at 69.2 ft bgs.

The Ringold Formation Unit E was dominated by felsic, quartzite material. Gravels generally consisted of poorly sorted pebble sized material. Gravels were sub-angular to rounded in shape. The sands associated with this formation consisted of very fine to very coarse grained particles. Sands appear to coarsen with increased depth. Sediment colors were recorded as weak red (10Y 5/2), reddish yellow (7.5YR 8/6), pinkish gray (7.5 YR 7/2), and reddish gray (2.5YR 7/5).

The RUM was encountered at 109.1 ft bgs and extended down to the total depth of 117.4 ft bgs. This unit was comprised of silts and clays and displayed high levels of plasticity. Recorded color was weak red (10R5/2).

The borehole log for this well location provides a more lithologically detailed description of the depositional strata and can be found in Appendix B.

2.2.3 Sampling

Geologic grab samples of drill cuttings were collected at 5-ft intervals or at significant lithology changes throughout the drilling of this well, except when radiological contamination was higher than normal background levels. The grab samples were collected in glass pint mason jars and plastic chip trays for storage at the HGSL.

Soil and groundwater samples for laboratory analysis were also collected at various intervals throughout the drilling of the well. These samples are summarized in Table 5.

Table 5. Sample Summary Table for 199-N-183 (C8185)

Type	Media	Interval #	Depths (ft bgs)	HEIS #
Split Spoon	Soil	I-001	47.9 – 50.4	B2C227 (RS), B2C211
Split Spoon	Soil	I-002	53.0 – 55.5	B2C212
Split Spoon	Soil	I-003	58.0 – 60.5	B2C285 (RS), B2C1Y7 (VOA), B2C214, B2CL46, B2C1X1
Split Spoon	Soil	I-004	62.6 – 65.1	B2C1Y8 (VOA), B2C215, B2CL47, B2C1X2
Split Spoon	Soil	I-005	68.2 – 70.7	B2C286 (RS), B2C200 (VOA), B2C216, B2CL48, B2C1X3
Split Spoon	Soil	I-005 DUP	68.2 – 70.7	B2C203 (VOA), B2C219, B2C1X6
Split Spoon	Soil	I-006	70.6 – 73.1	B2C202 (VOA), B2C218, B2CL49, B2C1X5
Split Spoon	Soil	I-013	74.2 – 76.7	B2C210 (VOA), B2C226, B2CL56, B2C1Y3
Pump	Water	I-013	74	B2C2C1 (VOA), B2C2B3, B2C292 (filtered), B2C291 (filtered), B2C290 (filtered), B2C3L5
Pump	Water	I-014	79.7	B2C2C2 (VOA), B2C2B4, B2C3L6
Pump	Water	I-014 DUP	79.7	B2C2C3 (VOA), B2C2B5
Pump	Water	I-015	84.5	B2C2C4 (VOA), B2C2B6, B2C3L8
Pump	Water	I-016	89.4	B2C2C5 (VOA), B2C2B7, B2C3L9
Split Spoon	Soil	I-020	89.4 – 91.9	B2C2B0 (VOA), B2C2B2, B2C298, B2C296, B2C294
Pump	Water	I-017	94.1	B2C2C6 (VOA), B2C2B8, B2C3M0
Pump	Water	I-018	99.0	B2C2C7 (VOA), B2C2B9, B5C6M1
Pump	Water	I-019	104.1	B2C2C8 (VOA), B2C2C0, B2C3M2
Split Spoon	Soil	I-026	106.7 – 109.2	B2D4K2 (VOA), B2D4K3, B2D4K1, B2D4K0, B2D4J9, B2D4K4
Split Spoon	Soil	I-021	114.9 – 117.4	B2C299 (VOA), B2C2B1, B2C297, B2C295, B2C293, B2C416

Notes:
# = number
DUP = duplicate
ft bgs = feet below ground surface
VOA = Volatile Organic Analysis
RS = Radiological Screen

2.2.4 Geophysical Logging

Geophysical Logging was conducted at C8185 on April 28, 2011. The geophysical logging contractor, Stoller, was directed to scan the borehole using SGLS and NMLS. Logging concluded that cobalt-60 was detected at a depth of 64 ft bgs at concentration of 0.1 pCi/g. More detailed geophysical logging results for this location can be found in Appendix D.

2.2.5 Well Construction

Well construction at 199-N-183 (C8185) was conducted in accordance with WAC-173-160. The construction was started May 2, 2011 and completed May 4, 2011. A straightness tester was run into the hole and extracted without binding on April 28, 2011. The monitoring well was constructed of 6 $^{9/16}$-inch OD/6 $^{7/16}$-inch ID schedule 10, type 316/316L stainless steel. Other construction materials included a 0.020 inch (20-slot) continuous wire wrap screen, 10-20 mesh filter pack, and a 3-ft sump. The screen is 20 ft in length and with approximately 3 ft above the water table. Well construction and associated depths are summarized in Table 6. More detailed well construction data for this location can be found in Appendix A.

Table 6. Well Construction Summary for 199-N-183 (C8185)

Borehole Total Depth (ft bgs)	RUM Depth (ft bgs)	Static Water Level (ft bgs)	6-inch Diameter, Sch. 10, Type 316/316L Well Materials			Annular Materials			
			Material	Interval (ft bgs)	Slot Size	Material	Interval (ft bgs)	Mesh/Size/Type	Volume (cu. ft)
117.4	109	69.2	Sump	86.5 – 90.1	N/A	Portland Cement	0 – 10.5	I/II	5.78
			Screen	66.5 – 86.5	20	Granular Bentonite	10.5 – 59.0	#8	26.27
			Riser	+2.0 – 66.5	N/A	Bentonite Pellets	59.0 – 62.2	3/8”	3.8
						Colorado Silica Sand	62.2 – 93.5	10-20	20.33
						Bentonite Pellets	93.5 – 98.3	3/8”	1.73
						Colorado Silica Sand	98.3 – 117.4	10-20	8.56

Notes:
“ = inches
= mesh
cu. ft = cubic feet
ft bgs = feet below ground surface
Sch. = schedule

2.2.6 Well Development

Final well development at 199-N-183 (C8185) was started and completed on May 9, 2011. Development took place at one interval using a 0.75 hp submersible pump. The well was pumped at a rate of 24 gpm for a little more than an hour and removed a total of 1,728 gallons of water from the aquifer. Water level recovery was also monitored at the end of development. Table 7 gives a summary of activities at the single interval. More detailed information on this well-development work is presented in Appendix C, and the resulting drawdown and recovery data and plots will be documented in a future RI/FS Report.

Table 7. Well Development Summary for 199-N-183 (C8185)

Well Development					Hydrogeochemistry			
	Intake	Duration	Discharge	Drawdown	Turbidity	Specific Cond		
Test Number	(ft bgs)	(min)	(gpm)	(ft)	(NTU)	(µS/cm)	pH	Temp (°F)
1	85.8	72	24	7.2	4.9	957	7.12	66.74

Notes:
ft bgs = feet below ground surface
gpm = gallons per minute
NTU = nephelometric turbidity units
µS/cm = micro-Siemens per centimeter
°F = degrees Fahrenheit

2.2.6.1 Slug Test

Slug testing for 199-N-183 (C8185) was started and completed on May 9, 2011. In this well two different rods of different volumes were used. The displacement volumes for these rods were 0.3276 $ft^3$and 1.0112 ft^3. Both slugs were inserted and removed twice during separate tests and the subsequent water-level response was then monitored. More detailed information on this slug-testing work is presented in Appendix C, and the extensive data resulting from these tests will be documented in a future RI/FS Report.

2.2.6.2 Permanent Sampling Pump Installation

A permanent sampling pump was installed into this well on August 4, 2011. A 0.5 hp Grundfos Redi-Flo3 submersible pump was installed with the intake at 70.1 ft bgs. The pump was tested prior to installation and re-tested at depth to ensure it was functioning properly.

2.2.7 Environmental Monitoring

Environmental monitoring included services provided by RCTs from CHPRC's Radcon department and IHTs provided by an off-site contractor, PBS Engineering + Environmental.

2.2.7.1 Radiological Monitoring

Radiological monitoring was provided on a continuous basis at this well location until it was determined by Radcon that continuous coverage was no longer necessary; as no elevated radiation levels had been detected well past the zone of suspected contamination. Radiological monitoring was then switched to an "AM/PM" basis.

RCTs reported no elevated readings from ground surface to the total depth of the borehole (117.4 ft bgs).

2.2.7.2 Industrial Hygiene Monitoring

Industrial hygiene monitoring was provided on an "AM/PM" basis at this well location for drilling and construction activities.

The IHT monitored for VOC vapors using PID and potentially explosive vapors using a LEL within the casing annulus and within the general breathing area of the people working in the drilling zone.

The IHT reported 16 parts per million (ppm) with the PID inside the casing and zero ppm within the breathing zone at 68 ft bgs during drilling. The IHT also reported between 80 and >100 ppm with the PID inside the casing, zero ppm within the breathing zone, when the well was being constructed at depths around the water table (69.2 ft bgs).

2.3 Well 199-N-184 (C8186)

This section contains summarized descriptions of drilling, borehole geology, sampling, geophysical logging, well construction and well development activities performed during the installation of well 199-N-184 (C8186).

2.3.1 Drilling

Well 199-N-184 (C8186) was drilled using a 22-W Bucyrus Erie Cable Tool drill rig utilizing a drive barrel to remove cuttings from the ground between August 17, 2011 and September 19, 2011. Total depth was reached at 108 ft bgs. One string of temporary casing driven during drilling; 10-inch carbon steel to a depth of 101 ft bgs.

Several sections of the 10-in casing used were radiologically regulated, and confirmed by Radcon prior to use at this borehole. All temporary casing was removed from the borehole during well completion during installation of the permanent 6-inch stainless steel screen, casing, sump, and annular materials.

2.3.2 Borehole Geology

The vadose zone at this borehole was comprised of Hanford formation sediments and Ringold Unit E sediments made up mostly of gravelly silty sands, silty sandy gravels, and gravelly sands. The Hanford formation, Ringold Formation contact was at 62.4 ft bgs.

The Hanford formation was dominated by mafic basalt material. Gravels generally consisted of poorly sorted pebble and cobble sized material. Gravels were sub-angular to round in shape. The sands associated with this formation consisted of very fine to very coarse grained particles. Sediment colors were recorded as very dark grayish brown (2.5Y 3/2), olive gray (5Y 5/2), light brownish gray (2.5Y 6/2), gray (5Y 6/2), gray (5Y 5/1), light brownish gray (2.5Y 5/2), dark grayish brown (2.5Y 4/2).

The saturated zone of this borehole was comprised of Ringold, Unit E sediments made up mostly of silty sandy gravels, sands, sandy gravels, and gravelly sands. The groundwater table was measured at 69 ft bgs.

The Ringold Formation Unit E was dominated by felsic quartzite material. Gravels generally consisted of moderately sorted pebble sized material. Gravels were sub-angular to round in shape. The sands associated with this formation consisted of fine to medium grained particles. Sediment colors were recorded as light gray, dark gray, dark brown and dark grayish brown.

The Ringold Upper Mud (RUM) was encountered at 100 ft bgs to a total depth of 108 ft bgs. This unit was comprised of silts and clays and no records plasticity were recorded. Recorded color was white to dark gray.

The borehole log for this well location provides a more lithologically detailed description of the depositional strata and can be found in Appendix B.

2.3.3 Sampling

Geologic grab samples of drill cuttings were collected at 5-ft intervals or at significant lithologic changes throughout the drilling of this well, except when radiological contamination was higher than normal background levels. The grab samples were collected in glass pint mason jars and plastic chip trays for storage at the HGSL.

Soil and groundwater samples for laboratory analysis were also collected at various intervals throughout the drilling of the well. These samples are summarized in Table 8.

Table 8. Sample Summary Table for 199-N-184 (C8186)

Type	Media	Interval #	Depths (ft bgs)	HEIS #
Split spoon	Soil	I-001	20.0 – 22.5	B2C3Y3 (RS), B2C3P6 (VOA), B2C3T8, B2C3M4
Split spoon	Soil	I-002	25.5 – 28.0	B2C3P7 (VOA), B2C3T9, B2C3M5
Split spoon	Soil	I-003	29.8 – 32.3	B2C3Y4 (RS), B2C3P8 (VOA), B2C3V0, B2C3M6
Split spoon	Soil	I-004	35.2 – 37.7	B2C3P9 (VOA), B2C3V1, B2C3M7
Split spoon	Soil	I-005	39.5 – 42.0	B2C3Y5 (RS), B2C3R1 (VOA), B2C3V3, B2C3M9
Split spoon	Soil	I-006	45.6 – 48.1	B2C3R2 (VOA), B2C3V4, B2C3N0
Split spoon	Soil	I-007	50.6 – 53.1	B2C3Y6 (RS), B2C3R3 (VOA), B2C3V5, B2C3N1
Split spoon	Soil	I-008	55.4 – 57.9	B2C3R4 (VOA), B2C3V6, B2C3N2
Split spoon	Soil	I-009	57.3 – 59.8	B2C3Y7 (RS), B2C3X0, B2C3N3
Split spoon	Soil	I-010	59.8 – 62.3	B2C3R6 (VOA), B2C3V8, B2C3N4
Split spoon	Soil	I-011	62.4 – 64.9	B2C3Y8 (RS), B2C3R7 (VOA), B2C3V9, B2C3X1, B2C3N5
Split spoon	Soil	I-011 DUP	62.4 – 64.9	B2C3R8 (VOA), B2C3W0, B2C3N6
Split spoon	Soil	I-012	65.0 – 67.5	B2C3R9 (VOA), B2C3W1, B2C3N7
Split spoon	Soil	I-013	67.5 – 70.0	B2C3Y9 (RS), B2C3T0 (VOA), B2C3W2, B2C1W9, B2C3N8
Split spoon	Soil	I-020	74.0 – 76.5	B2C3T7 (VOA), B2C3W9, B2C3X9, B2C3P5
Pump	Water	I-020	75.5	B2C427 (VOA), B2C418, B2C404, B2C406, B2C405, B2C440
Pump	Water	I-021	81.0	B2C428 (VOA), B2C419, B2C441
Pump	Water	I-021 DUP	81.0	B2C429 (VOA), B2C420
Pump	Water	I-022	86.0	B2C430 (VOA), B2C421, B2C442
Pump	Water	I-023	91.0	B2C431 (VOA), B2C422, B2C443
Pump	Water	I-024	96.0	B2C432 (VOA), B2C423, B2C444
Split spoon	Soil	I-028	98.0 – 100.5	B2C411, B2C409, B2C414, B2C407
Pump	Water	I-025	99.0	B2C433 (VOA), B2C424, B2C445
Split spoon	Soil	I-029	105.5 – 108.0	B2C412, B2C410, B2C413, B2C415, B2C408

Notes:

#	=	number
DUP	=	duplicate
ft bgs	=	feet below ground surface
VOA	=	Volatile Organic Analysis
RS	=	Radiological Screen

2.3.4 Geophysical Logging

Geophysical Logging was conducted at C8186 on September 19, 2011 and September 20, 2011. The geophysical logging contractor, Stoller, was directed to scan the borehole using SGLS and NMLS. Cesium-137 was detected at 4 ft bgs at a concentration of 0.4 pCi/g. Cobalt-60 was also detected at 61 ft bgs, 62 ft bgs and 67 ft bgs with a maximum concentration of 0.1 pCi/g at 61 ft bgs. More detailed geophysical logging results for this location can be found in Appendix D.

2.3.5 Well Construction

Well construction at 199-N-184 (C8186) was conducted in accordance with WAC 173-160. The construction was started on September 22, 2011 and completed by September 23, 2011. A straightness tester was run into the hole and extracted without binding on September 22, 2011. The monitoring well was constructed of 6 $^{5/8}$-inch OD/6 $^{3/8}$-inch ID schedule 10, type 316/316L stainless steel permanent casing and 0.020 inch (20-slot) continuous wire wrap screen, 10-20 filter sand, and a 3-ft sump. The screen is 20 ft in length and is situated so that 8 ft of it sits above the water. Well construction and associated depths are summarized in Table 9. More detailed well construction data for this location can be found in Appendix A.

Table 9. Well Construction Summary for 199-N-184 (C8186)

Borehole Total Depth (ft bgs)	RUM Depth (ft bgs)	Static Water Level (ft bgs)	6-inch Diameter, Sch. 10, Type 316/316L Well Materials			Annular Materials			
			Material	Interval (ft bgs)	Slot Size	Material	Interval (ft bgs)	Mesh/Size/Type	Volume (cu. ft)
108	100	69.7	Sump	81.9 – 84.9	N/A	Portland Cement	0.0 – 10.0	I/II	7.07
			Screen	61.8 – 81.9	20	Granular Bentonite	10.0 – 54.0	#8	17.04
			Riser	+2.05 – 61.8	N/A	Bentonite Pellets	54.0 – 56.5	3/8”	0.69
						Colorado Silica Sand	56.5 – 90.0	10-20	17.66
						Bentonite Pellets	90.0 – 108.0	3/8”	2.07

Notes:

“	=	inches
#	=	mesh
cu. ft	=	cubic feet
ft bgs	=	feet below ground surface
Sch.	=	schedule

2.3.6 Well Development

Final well development at 199-N-184 (C8186) was started and completed on September 26, 2011. Development took place at a single interval using a 0.75 hp submersible pump. The single interval, at the lowest portion of the screened area, was pumped at a rate of 12 gpm for 80.5 minutes and pumped a total of 612 gallons of water from the aquifer. Water level recovery was also monitored at the end of development. Table 10 gives a summary of activities at the single interval. More detailed information on this well-development work is presented in Appendix C, and the resulting drawdown and recovery data and plots will be documented in a future RI/FS Report.

Table 10. Well Development Summary for 199-N-184 (C8186)

Well Development					Hydrogeochemistry			
	Intake	Duration	Discharge	Drawdown	Turbidity	Specific Cond		
Test Number	(ft bgs)	(min)	(gpm)	(ft)	(NTU)	(µS/cm)	pH	Temp (°F)
1	80.5	51	12	0.1	2.99	433	7.99	63.626

Notes:
ft bgs = feet below ground surface
gpm = gallons per minute
NTU = nephelometric turbidity units
µS/cm = mico-Siemens per centimeter
°F = degrees Fahrenheit

2.3.6.1 Slug Test

Slug testing for 199-N-184 (C8186) was started and completed on September 26, 2011. In this well two different rods of different volumes were used. The displacement volumes for these rods were 1.0112 $ft^3$and 0.6877 ft^3. Both slugs were inserted and removed, twice during separate tests, and the subsequent water-level response was then monitored. More detailed information on this slug-testing work is presented in Appendix C, and the extensive data resulting from these tests will be documented in a future RI/FS Report.

2.3.6.2 Permanent Sampling Pump Installation

A permanent sampling pump was installed into this well on September 27, 2011. A 0.5 submersible Grundfos Redi-Flo3 pump was installed with intake depth of 78.5 ft bgs. The pump was tested prior to installation and re-tested at depth to ensure it was functioning properly.

2.3.7 Environmental Monitoring

Environmental monitoring included services provided by RCTs from CHPRC's Radcon department and IHTs provided by an off-site contractor, PBS Engineering + Environmental.

2.3.7.1 Radiological Monitoring

Radiological monitoring was provided on a continuous basis at this well location for both drilling and well construction activities.

RCTs detected 50,000 dpm beta/gamma direct, < 1000 dpm beta/gamma smearable, < 20 dpm alpha within the soil from the drill cuttings at 62.6 ft bgs. The highest concentration of contamination was detected between 62.4 ft bgs and 70 ft bgs at 90,000 dpm beta/gamma direct, no alpha and 10,000 dpm beta/gamma removable. Elevated levels of contamination decreased at 74 ft bgs to 25,000 dpm

beta/gamma, no alpha and no removable contamination. Levels continued to decrease and at 79 ft bgs values of 10,000 dpm beta/gamma, no alpha, and no removable were recorded. Levels were back at background from 80 ft bgs to total depth (108 ft bgs).

During well construction activities, RCTs detected levels of contamination between 40,000 dpm beta/gamma and 2,500 dpm beta/gamma fixed to some of the already regulated sticks of temporary 10" carbon steel while it was being back-pulled through the formation.

2.3.7.2 Industrial Hygiene Monitoring

Industrial hygiene monitoring was provided on an "AM/PM" basis at this well location for drilling and construction activities.

The IHT monitored for VOC vapors and potentially explosive vapors using a PID and a LEL in the morning hours and again in the afternoon hours on a daily basis. The IHT reported a single supposedly anomalous reading between the depths of 74 and 76.5 ft bgs within the annulus of the temporary casing (0.2 ppm) using the PID.

2.4 Well 199-N-185 (C8187)

This section contains summarized descriptions of drilling, borehole geology, sampling, geophysical logging, well construction and well development activities performed during the installation of well 199-N-185 (C8187).

2.4.1 Drilling

Well 199-N-185 (C8187) was drilled using a Speedstar 71 Cable Tool drill rig utilizing a drive barrel to remove cuttings from the ground between March 17, 2011 and April 6, 2011. Total depth was 92.5 ft bgs. Two strings of casing were utilized to maintain efficient drilling. Casing strings included were:

- 10-inch carbon steel casing to a depth of 43.32 ft bgs
- 8-inch carbon steel casing to a depth of 87.5 ft bgs

All temporary casing was removed from the borehole during well completion with the 6-inch stainless steel monitoring well.

2.4.2 Borehole Geology

The vadose zone at this borehole was comprised of Hanford formation sediments and Ringold Formation, Unit E sediments made up mostly of gravelly sands. The Hanford formation, Ringold Formation contact was at 23 ft bgs.

The Hanford formation was dominated by mafic basalt material. Gravels generally consisted of moderately sorted pebble sized material. Gravels were sub-angular to round in shape. The sands associated with this formation consisted of fine to medium grained particles. Sediment colors were recorded as brown (10YR 4/3) and dark grayish brown (2.5Y 4/2).

The saturated zone of this borehole was comprised of Ringold Unit E sediments made up mostly of sands and sandy gravels. The groundwater table was measured at 13.0 ft bgs

The Ringold Formation Unit E was dominated by felsic quartzite material. Gravels generally consisted of poorly sorted pebble sized material. Gravels were sub angular to round in shape. The sands associated with this formation consisted of fine to medium grained particles. Sediment colors were recorded as olive (2.5Y 4/3).

The RUM was encountered from 41 ft bgs to a total depth of 92.5 ft bgs. This unit was comprised of silts and clays and no plasticity was recorded. Recorded color was light brownish gray (2.5Y 6/2) . No water-bearing strata were observed in the RUM over the interval drilled.

The borehole log for this well location provides a more lithologically detailed description of the depositional strata and can be found in Appendix B.

2.4.3 Sampling

Geologic grab samples of drill cuttings were collected at 5-ft intervals or at significant lithologic changes throughout the drilling, except when radiological contamination was at higher than normal background levels. The grab samples were collected in glass pint mason jars and plastic chip trays for storage at the HGSL.

Soil and groundwater samples for laboratory analysis were also collected at various intervals throughout the drilling of the well. These samples are summarized in Table 11.

Table 11. Sample Summary Table for 199-N-185 (C8187)

Type	Media	Interval #	Depths (ft bgs)	HEIS #
Split spoon	Soil	I-001	2.4 – 4.4	B2C4F3 (RS), B2C466, B2C477, B2C1Y4
Split spoon	Soil	I-002	5.0 – 7.5	B2C467, B2C478, B2C1Y5
Split spoon	Soil	I-003	9.7 – 12.2	B2C4F4 (RS), B2C469, B2C479, B2C403
Split spoon	Soil	I-003 DUP	9.7 – 12.2	B2C470, B2C438
Split spoon	Soil	I-008	12.4 – 14.9	B2C475, B2C484, B2C464
Split spoon	Soil	I-007	17.0 – 19.5	B2C4F6 (RS), B2C474, B2C483, B2C463
Pump	Water	I-009	17.7	B2C4C7 (VOA), B2C448, B2C541, B2C543, B2C542
Split spoon	Soil	I-010	20.0 – 22.5	B2C499
Pump	Water	I-010	24.7	B2C4C8 (VOA), B2C449
Split spoon	Soil	Contingency	25.6 – 28.1	B2C7X1
Pump	Water	I-011	28.0	B2C4C9 (VOA), B2C450
Pump	Water	I-011 DUP	28.0	B2C4D0 (VOA), B2C4B6
Pump	Water	I-012	34.0	B2C4D1 (VOA), B2C4B7, B2C528
Split spoon	Soil	I-013	39.4 – 41.9	B2C495, B2C490
Pump	Water	I-013	38.4	B2C4D2 (VOA), B2C4B8, B2C529
Split spoon	Soil	I-017	49.7 – 52.2	B2C496, B2C4B0, B2C4B3, B2C491
Split spoon	Soil	I-018	69.7 – 72.2	B2C497, B2C4B4, B2C492
Split spoon	Soil	I-019	90.0 – 92.5	B2C498, B2C4B5, B2C493

Notes:

#	=	number
DUP	=	duplicate
ft bgs	=	feet below ground surface
VOA	=	Volatile Organic Analysis
RS	=	Radiological Screen

2.4.4 Geophysical Logging

Geophysical Logging was conducted at C8187 on March 30, 2011. The geophysical logging contractor, was directed to scan the borehole using SGLS and NMLS. According to Stoller, cobalt-60 was detected at a depth of 8 ft bgs with an approximate concentration of 0.07 pCi/g. More detailed geophysical logging results for this location can be found in Appendix D.

2.4.5 Well Construction

Well construction at 199-N-185 (C8187) was conducted in accordance with WAC 173-160. The construction was started April 11, 2011 and completed April 13, 2011. The monitoring well was constructed of 6 $^{5/8}$-inch OD/6 $^{3/8}$-inch ID schedule 10, type 316/316L stainless steel with a 0.020 inch (20-slot) continuous wire wrap screen, 10-20 mesh filter pack, and a 4-ft sump. The screen is 5 ft in length and is situated below the water by approximately 23.5 ft. Well construction and associated depths are summarized in Table 12. It is specifically noted that this well was not completed with a screen in the RUM, as originally planned in the SAP, since no water-bearing strata were encountered in the RUM during the drilling of the borehole. Instead, the well was installed with a screen at the bottom of the unconfined aquifer. This change was agreed to in advance of the well construction by DOE and WA-DOE based on the field-conditions observed, as allowed by the SAP. More detailed well construction data for this location can be found in Appendix A.

Table 12. Well Construction Summary for 199-N-185 (C8187)

Borehole Total Depth (ft bgs)	RUM Depth (ft bgs)	Static Water Level (ft bgs)	6-inch Diameter, Sch. 10, Type 316/316L Well Materials			Annular Materials			
			Material	Interval (ft bgs)	Slot Size	Material	Interval (ft bgs)	Mesh/Size/Type	Volume (cu. ft)
92.5	41	8.7	Sump	41.5 – 45.4	N/A	Portland Cement	0 – 3.3	I/II	3.85
			Screen	36.5 – 41.5	20	Granular Bentonite	3.3 – 16.2	#8	2.84
			Riser	0 – 36.5	N/A	Bentonite Pellets	16.2 – 32.4	3/8”	8.51
						Colorado Silica Sand	32.4 – 44.8	10-20	5.89
						Bentonite Pellets	44.8 – 49.0	3/8”	2.53
						Portland Cement	49.0 – 92.5	I/II	12.85

Notes:

“	=	inches
#	=	mesh
cu. ft	=	cubic feet
ft bgs	=	feet below ground surface
Sch.	=	schedule

2.4.6 Well Development

Final well development at 199-N-185 (C8187) was started and completed on April 14, 2011. Development took place at a single interval using a 0.75 hp submersible pump. The well was pumped at a rate of 10 gpm for 85 minutes and a total of 850 gallons was removed from the aquifer. Water level recovery was also monitored at the end of development. Table 13 gives a summary of activities at the single interval. More detailed information on this well-development work is presented in Appendix C, and the resulting drawdown and recovery data and plots will be documented in a future RI/FS Report.

Table 13. Well Development Summary for 199-N-185 (C8187)

Well Development					Hydrogeochemistry			
	Intake	Duration	Discharge	Drawdown	Turbidity	Specific Cond		
Test Number	(ft bgs)	(min)	(gpm)	(ft)	(NTU)	(µS/cm)	pH	Temp (F)
1	31.7	85	10	19.43	3.15	364	8.71	N/R

Notes:

ft bgs	=	feet below ground surface
gpm	=	gallons per minute
NTU	=	nephelometric turbidity units
µS/cm	=	micro-Siemens per centimeter
F	=	Fahrenheit
N/R	=	not recorded

2.4.6.1 Slug Test

Slug testing for 199-N-185 (C8187) was started and completed on April 14, 2011. In this well two slugging rods of different volumes were used. The displacement volumes for these rods were 0.3276 ft^3 and 1.0112 ft^3. Both slugs were inserted and removed, twice during separate tests, and the subsequent water-level response was then monitored. More detailed information on this slug-testing work is presented in Appendix C, and the extensive data resulting from these tests will be documented in a future RI/FS Report.

2.4.6.2 Permanent Sampling Pump Installation

A permanent sampling pump was installed into this well on August 17, 2011. A 0.5 Grundfos Redi-Flo3 submersible pump was installed with the intake at a depth of 38.2 ft bgs. The pump was tested prior to installation and re-tested at depth to ensure it was functioning properly.

2.4.7 Environmental Monitoring

Environmental monitoring included services provided by RCTs from CHPRC’s Radcon department and IHTs provided by an off-site contractor, PBS Engineering + Environmental.

2.4.7.1 Radiological Monitoring

Radiological monitoring was provided on a continuous basis at this well location. However, RCTs reported no elevated readings while drilling the borehole from ground surface to the total depth of the borehole or while back-pulling the temporary casing from the ground.

2.4.7.2 Industrial Monitoring

Industrial hygiene monitoring was provided on an "AM/PM" basis at this well location for drilling and construction activities.

The IHT monitored for VOC vapors and potentially explosive vapors using a PID and an LEL in the morning hours and again in the afternoon hours on a daily basis. The IHT reported no anomalous readings during the drilling or construction of this well.

2.5 Well 199-N-186 (C8188)

This section contains summarized descriptions of drilling, borehole geology, sampling, geophysical logging, well construction and well development activities performed during the installation of well 199-N-186 (C8188).

2.5.1 Drilling

Well 199-N-186 (C8188) was drilled using a 22-W Bucyrus Erie Cable Tool drill rig utilizing a drive barrel to remove cuttings from the ground between May 10, 2011 and August 17, 2011. The total depth of the borehole was 97.3 ft bgs. One string of temporary casing was utilized during drilling; 10-inch carbon steel casing to a depth of 97.4 ft bgs

All temporary casing was removed from the borehole during well completion with the 6-inch stainless steel monitoring well.

2.5.2 Borehole Geology

The vadose zone at this borehole was comprised of Hanford formation sediments and Ringold Formation, Unit E sediments made up mostly of silty gravels, silty sandy gravels, sandy gravels, gravelly sands, and sands. The Hanford formation, Ringold Formation contact was at 50 ft bgs.

The Hanford formation was dominated by mafic basalt material. Gravels generally consisted of poorly sorted pebble and cobble sized material. Gravels were sub-angular to sub-round in shape. The sands associated with this formation consisted of medium to coarse grained particles. Sediment colors were recorded as 10R 6/1 (reddish gray). Munsell Color Chart readings were not taken after 18 ft bgs as radiation levels were above limits for archive sampling.

The saturated zone of this borehole was comprised of Ringold Unit E sediments made up mostly of silty sandy gravels, gravelly sands, and sandy gravels. The groundwater table was measured at 72.3 ft bgs.

The Ringold Formation Unit E was dominated by felsic quartzite material. Gravels generally consisted of moderately sorted pebble and cobble sized material. Gravels were sub-angular to sub-round in shape. The sands associated with this formation consisted of medium to very coarse grained particles with some pockets of fine grained material intermixed.

As planned in the SAP, the RUM was not encountered in this borehole and the borehole reached a total depth of 97.3 ft bgs.

The borehole log for this well location provides a more lithologically detailed description of the depositional strata and can be found in Appendix B.

2.5.3 Sampling

Geologic grab samples of drill cuttings were collected at 5-ft intervals or at significant lithology changes throughout the drilling of this well, except when radiological contamination was higher than normal background levels. The grab samples were collected in glass pint mason jars and plastic chip trays for storage at the HGSL.

Soil and groundwater samples for laboratory analysis were also collected at various intervals throughout the drilling of the well. These samples are summarized in Table 14.

Table 14. Sample Summary Table for 199-N-186 (C8188)

Type	Media	Interval #	Depths (ft bgs)	HEIS #
Split spoon	Soil	I-001	19.8 – 22.3	B2C6V8 (RS), B2C7P9, B2C6X1 (VOA), B2C709, B2C6T3
Split spoon	Soil	I-002	25.2 – 27.7	B2C7R0, B2C6X2 (VOA), B2C710, B2C6T4
Split spoon	Soil	I-003	29.7 – 32.2	B2C6W0 (RS), B2C7R3, B2C6X3 (VOA), B2C711, B2C6T5
Split spoon	Soil	I-004	35.1 – 37.6	B2C7R5, B2C6X5 (VOA), B2C713, B2C6T7
Split spoon	Soil	I-005	40.2 – 42.7	B2C6W2 (RS), B2C7R6, B2C6X6 (VOA), B2C714, B2C6T8
Split spoon	Soil	I-006	45.2 – 47.7	B2C7R7, B2C6X7 (VOA), B2C715, B2C6T9
Split spoon	Soil	I-007	50.0 – 52.5	B2C743 (RS), B2C7R8, B2C6X8 (VOA), B2C716, B2C6V0
Split spoon	Soil	I-007 SPLIT	50.0 – 52.5	B2C6X9
Split spoon	Soil	I-008	55.2 – 57.7	B2C744 (RS), B2C7R9, B2C6Y0 (VOA), B2C717, B2C6V2
Split spoon	Soil	I-008 DUP	55.2 – 57.7	B2C7T7, B2C702 (VOA), B2C726, B2C6W4
Split spoon	Soil	I-009	60.2 – 62.7	B2C745 (RS), B2C7T1, B2C6Y2 (VOA), B2C719, B2C6V4
Split spoon	Soil	I-010	62.5 – 65.0	B2C746 (RS), B2C7T2, B2C6Y3 (VOA), B2C720, B2C733, B2C6V5
Split spoon	Soil	I-011	65.3 – 67.8	B2C747 (RS), B2C7T3, B2C6Y5 (VOA), B2C722, B2C6V7
Split spoon	Soil	I-011 SPLIT	65.3 – 67.8	B2C6Y6, B2C721 (VOA)
Split spoon	Soil	I-012	67.5 – 70.0	B2C748(RS), B2C7T4, B2C6Y7(VOA), B2C723, B2C734, B2C6V9
Split spoon	Soil	I-012 SPLIT	67.5 – 70.0	B2C6Y8
Split spoon	Soil	I-013	70.0 – 72.5	B2C749(RS), B2C7T5, B2C6Y9(VOA), B2C724, B2C6W1

Table 14. Sample Summary Table for 199-N-186 (C8188)

Type	Media	Interval #	Depths (ft bgs)	HEIS #
Split spoon	Soil	I-013 SPLIT	70.0 – 72.5	B2C6V1, B2C6V6
Split spoon	Soil	I-019	72.5 – 75.0	B2C755(RS), B2C7V2, B2C707(VOA), B2C731, B2C485, B2C6W9
Split spoon	Soil	I-020	78.0 – 80.5	B2C7V3, B2C708(VOA), B2C732, B2CL34, B2C6X0
Pump	Water	I-020	77.3	B2C6R3(VOA), B2C6P9, B2C738, B2C741, B2C740, B2C7V6
Split spoon	Soil	I-021	83.0 – 85.5	B2C6P3(VOA), B2C6P5, B2C6P7, B2C6P1, B2C6N9, B2C6N7
Pump	Water	I-021	82.4	B2C6R4(VOA), B2C6R0, B2C7V7
Pump	Water	I-021 DUP	82.4	B2C6R5(VOA), B2C6R1
Split spoon	Soil	I-022	87.5 – 90.0	B2C6P4(VOA), B2C6P6, B2C6P8, B2C6P2, B2C6P0, B2C6N8
Pump	Water	I-022	87.0	B2C6T2(VOA), B2C6R6(VOA), B2C6R2

Notes:
# = number
DUP = duplicate
ft bgs = feet below ground surface
VOA = Volatile Organic Analysis
RS = Radiological Screen
SPLIT = split

2.5.4 Geophysical Logging

Geophysical Logging was conducted at C8188 on August 18, 2011. The geophysical logging contractor, Stoller, was directed to scan the borehole using SGLS and NMLS. Cesium-137 was detected continuously from 18 ft bgs to 51 ft bgs with a maximum concentration of 2,420 pCi/g at 22 ft bgs. Cobalt-60 was also detected between 18 and 54 ft bgs, with a maximum concentration of 30 pCi/g at a depth of 20 ft bgs. More detailed geophysical logging results for this location can be found in Appendix D.

2.5.5 Well Construction

Well construction at 199-N-186 (C8188) was conducted in accordance with WAC 173-160. The construction was started August 19, 2011 and completed August 26, 2011. A straightness tester was run into the hole and extracted without binding on August 19, 2011. The monitoring well was constructed of 6 $^{5/8}$-inch OD/6 $^{3/8}$-inch ID schedule 10, type 316/316L stainless steel with a 0.020 inch (20-slot) continuous wire wrap screen, a 10-20 filter pack, and a 3-ft sump. The screen is 20 ft in length with approximately 2 ft of it extending above the water table. Well construction and associated depths are summarized in Table 15. More detailed well construction data for this location can be found in Appendix A.

Table 15. Well Construction Summary for 199-N-186 (C8188)

Borehole Total Depth (ft bgs)	RUM Depth (ft bgs)	Static Water Level (ft bgs)	6-inch Diameter, Sch. 10, Type 316/316L Well Materials			Annular Materials			
			Material	Interval (ft bgs)	Slot Size	Material	Interval (ft bgs)	Mesh/Size/Type	Volume (cu. ft)
97.3	N/A	71	Sump	88.7 – 91.7	N/A	Portland Cement	0 – 11.5	I/II	9
			Screen	68.7 – 88.7	20	Granular Bentonite	11.5 – 60.0	#8	22.37
			Riser	+2.0 – 68.7	N/A	Bentonite Pellets	60.0 – 63.0	3/8”	1.38
						Colorado Silica Sand	63.0 – 97.3	10-20	15.52

Notes:
“ = inches
= mesh
cu. ft = cubic feet
ft bgs = feet below ground surface
Sch. = schedule

2.5.6 Well Development

Final well development at 199-N-186 (C8188) was started and completed on August 29, 2011. Development took place at a single interval using a 0.75 hp submersible pump. The single interval, at the lowest portion of the screened area, was pumped at a rate of 25 gpm for 126 minutes and pumped a total of 3,150 gallons of water from the aquifer. Water level recovery was also monitored at the end of development. Table 15 gives a summary of activities at the single interval. More detailed information on this well-development work is presented in Appendix C, and the resulting drawdown and recovery data and plots will be documented in a future RI/FS Report.

Table 15. Well Development Summary for 199-N-186 (C8188)

Well Development					Hydrogeochemistry			
	Intake	Duration	Discharge	Drawdown	Turbidity	Specific Cond		
Test Number	(ft bgs)	(min)	(gpm)	(ft)	(NTU)	(µS/cm)	pH	Temp (°F)
1	85.7	126	25	5.97	3.24	713	6.93	70.16

Notes:
ft bgs = feet below ground surface
gpm = gallons per minute
NTU = nephelometric turbidity units
µS/cm = mico-Siemens per centimeter
°F = degrees Fahrenheit

2.5.6.1 Slug Test

Slug testing for 199-N-186 (C8188) was started and completed on August 30, 2011. In this well two different slug rods of different volumes were used. The displacement volumes for these rods were 0.3276 ft^3 and 0.6877 ft^3. Both slugs were inserted and removed, twice during separate tests, and the subsequent water-level response was then monitored. More detailed information on this slug-testing work is presented in Appendix C, and the extensive data resulting from these tests will be documented in a future RI/FS Report.

2.5.6.2 Permanent Sampling Pump Installation

A permanent sampling pump was installed into this well on September 1, 2011. A 0.5 Grundfos Redi-Flo3 submersible pump was installed at an intake depth of 87.7 ft bgs. The pump was tested prior to installation and re-tested at depth to ensure it was functioning properly.

2.5.7 Environmental Monitoring

Environmental monitoring included services provided by RCTs from CHPRC's Radcon department and IHTs provided by an off-site contractor, PBS Engineering + Environmental.

2.5.7.1 Radiological Monitoring

Radiological monitoring was provided on a continuous basis at this well location for both drilling and well construction activities.

RCTs detected readings of 310,000 dpm beta/gamma direct with no alpha at 19 ft bgs within the soil from the drill cuttings. The highest concentration of contamination was detected between 19 ft bgs and 22.3 ft bgs at 310,000 dpm beta/gamma direct, no alpha and 200,000 dpm beta/gamma, respectively. Levels of contamination declined at 29 ft bgs to 120,000 dpm beta/gamma with no alpha. At 78 ft bgs 1,300 dpm beta/gamma was detected with no alpha. Contamination levels were at background from 83 ft bgs to total depth.

During well construction activities, RCTs detected levels of contamination between 10,000 dpm beta/gamma and 65,000 dpm beta/gamma fixed on some temporary 10-in carbon steel casing while it was being back-pulled through the formation.

2.5.7.2 Industrial Hygiene Monitoring

Industrial hygiene monitoring was provided on an "AM/PM" basis at this well location for drilling and construction activities.

The IHT monitored for VOC vapors and potentially explosive vapors using a PID and an LEL in the morning hours and again in the afternoon hours on a daily basis. The IHT reported no anomalous readings during the drilling or construction of this well.

2.6 Well 199-N-187 (C8189)

This section contains summarized descriptions of drilling, borehole geology, sampling, geophysical logging, well construction and well development activities performed during the installation of well 199-N-187 (C8189).

2.6.1 Drilling

Well 199-N-187 (C8189) was drilled using a Speed-star 71 Cable Tool Drill Rig drill rig utilizing a drive barrel to remove cuttings from the ground between July 19, 2011 and 6 September, 2011. Total depth

was 94.5 ft bgs. One string of temporary casing was utilized during drilling; 10-inch carbon steel casing to 95.0 ft bgs.

All temporary casing was removed from the borehole during well completion during installation of the 6-inch stainless steel screen and casing.

2.6.2 Borehole Geology

The vadose zone at this borehole was comprised of Hanford formation sediments and Ringold Formation, Unit E sediments made up mostly of sandy gravel, gravelly sand, clay, clayey gravel and clayey silt. The Hanford formation, Ringold Formation contact was at 40.0 ft bgs.

The Hanford formation was dominated by mafic basalt material. Gravels generally consisted of poorly sorted pebble and cobble sized material. Gravels were sub-rounded to round in shape. The sands associated with this formation consisted of medium to coarse grained particles.

The saturated zone of this borehole was comprised of Ringold Unit E sediments made up mostly of sandy gravel, clayey gravel, clayey silt and gravelly sand. The groundwater table was measured at 70.0 ft bgs.

The Ringold Formation Unit E was dominated by felsic quartzite material. Gravels generally consisted of moderately sorted pebble and cobble sized material. Gravels were angular to round in shape. Smaller, pebble sized material exhibited more angular characteristics, while larger cobbles appeared rounded. The sands associated with this formation consisted of fine to medium grained particles. A 10 cm layer of clay was recorded at 40.0 ft bgs and from 43.0 ft bgs to 45.0 ft bgs.

As planned in the SAP, the RUM was not encountered in this borehole and the borehole reached a total depth of 94.5 ft bgs.

The borehole log for this well location provides a more lithologically detailed description of the depositional strata and can be found in Appendix B.

2.6.3 Sampling

Geologic grab samples of drill cuttings were collected at 5-ft intervals between 0ft and 25ft. Collection of grab samples was halted at 25ft, as radiological contamination was higher than normal background levels. The grab samples were collected in glass pint mason jars and plastic chip trays for storage at the HGSL.

Soil and groundwater samples for laboratory analysis were also collected at various intervals throughout the drilling of the well. These samples are summarized in Table 16.

Table 16. Sample Summary Table for 199-N-186 (C8189)

Type	Media	Interval #	Depths (ft bgs)	HEIS #
Split spoon	Soil	I-001	19.5-22.0	B2C7M4, B2C7H9, B2C784, B2C784, B2C7C2, B2C756
Split spoon	Soil	I-002	24.5-27.0	DISCARDED DUE TO RAD LEVELS
Split spoon	Soil	I-003/I-004 (combined)	31.6-33.1	B2C786, B2C7J1, B2C758, B2C7C4, B2C7M5, B2C7C6
Split spoon	Soil	I-005	34.6-37.1	B2C7M6, B2C7J4, B2C789, B2C7C7, B2C761
Split spoon	Soil	I-006	37.5-40.0	B2C7C8

Table 16. Sample Summary Table for 199-N-186 (C8189)

Type	Media	Interval #	Depths (ft bgs)	HEIS #
Split spoon	Soil	I-007	40.0-42.5	B2C7M7, B2C7J6, B2C791, B2C7C9
Split spoon	Soil	I-008	42.4-44.9	B2CYD0
Split spoon	Soil	I-009	44.8-47.3	B2C7M8, B2C7J8, B2C793, B2C7D1, B2C765
Split spoon	Soil	I-010	47.7-50.2	B2C7D2
Split spoon	Soil	I-011	50.0-52.5	B2CL27, B2C7K0, B2C795, B2C7D3, B2C767
Split spoon	Soil	I-012	55.0-57.5	B2C7M9, B2C7K1, B2C796, B2C7D4, B2C768
Split spoon	Soil	I-013	60.5-63.0	B2C7N0, B2C7K2, B2C798, B2C7D6, B2C770
Split spoon	Soil	I-014	72.5 – 75.0	B2C7N1, B2C7K3, B2C799, B2C7D7, B2C7H0, B2C771
Split spoon	Soil	I-015	78.0 – 80.5	B2C7N2, B2C7K4, B2C7B1, B2C7D9, B2C773
Split spoon	Soil	I-016	67.0-69.5	B2C7N3, B2C7K5, B2C7B2, B2C7F0, B2C7H1, B2C774
Split spoon	Soil	I-017	69.9-72.4	B2C7N4, B2C7K6, B2C7B3, B2C7F1, B2C775
Split spoon	Soil	I-018	71.5-74.0	B2C7N5, B2C7K7, B2C7B4, B2C7F2, B2C7H2, B2C776
Split spoon	Soil	I-018DUP	71.5-74.0	B2C7K8, B2C7B5, B2C7F3, B2C777
Split spoon	Soil	I-024	76.2-78.7	B2C7L4, B2C7C1, B2C7F9, B2C7H8, B2C783
Pump	Water	I-024	77.7	B2C7X7, B2C7X3, B2C7R2, B2C7R1, B2C742, B2C7Y3
Split spoon	Soil	I-025	82.0-84.5	B2C7W5, B2C7W7, B2C7W9, B2C7W3, B2C7W1, B2C7V9
Pump	Water	I-025	84.5	B2C7X8, B2C7X4, B2C7Y4
Pump	Water	I-025	84.5	B2C7X9, B2C7X5
Split spoon	Soil	I-026	87.6-90.1	B2C7W6, B2C7W8, B2C7X0, B2C7W4, B2C7W2, B2C7W0
Pump	Water	I-026	87.5	B2C7Y0, B2C7X6, B2C7Y5

Notes:
# = number
DUP = duplicate
ft bgs = feet below ground surface
VOA = Volatile Organic Analysis
RS = Radiological Screen

2.6.4 Geophysical Logging

Geophysical Logging was conducted at C8189 between September 9, 2011 and September 12, 2011. The geophysical logging contractor, Stoller, was directed to scan the borehole using SGLS and NMLS as well as High Rate Logging System (HRLS). Cesium-137 was detected continuously from 22 ft bgs to 60 ft bgs and from 64 ft bgs to 70 ft bgs and at 91 ft bgs with a maximum concentration of approximately 97,100 pCi/g at 27 ft bgs. Cobalt-60 was also detected continuously from 22 ft bgs to 25 ft bgs, 30 ft bgs to 45 ft bgs, 52 ft bgs to 62 ft bgs and 92 ft bgs to 94 ft bgs with a maximum concentration of approximately 38 pCi/g at 25 ft bgs. Europium-154 was also detected at 37 ft bgs at an approximate concentration of 0.3 pCi/g. More detailed geophysical logging results for this location can be found in Appendix D.

2.6.5 Well Construction

Well construction at 199-N-187 (C8189) was conducted in accordance with WAC 173-160. The construction was started 16 September, 2011 and completed 21 September, 2011. The monitoring well was constructed of 6 $^{9/16}$-inch OD/6 $^{7/16}$-inch ID schedule 10, type 316/316L stainless steel with a 0.020 inch (20-slot) continuous wire wrap screen, 10-20 mesh filter pack, and a 3-ft sump. The screen is 20 ft in length and is completely submerged. Well construction and associated depths are summarized in Table 17. More detailed well construction data for this location can be found in Appendix A.

Table 17. Well Construction Summary for 199-N-187 (C8189)

Borehole Total Depth (ft bgs)	RUM Depth (ft bgs)	Static Water Level (ft bgs)	6-inch Diameter, Sch. 10, Type 316/316L Well Materials			Annular Materials			
			Material	Interval (ft bgs)	Slot Size	Material	Interval (ft bgs)	Mesh/Size/Type	Volume (cu. ft)
94.5	N/A	70	Sump	91.69-94.7	N/A	Silica Sand	30.3-94.5	10-20	24.61
			Screen	71.69-91.69	20	Coated Bentonite	28.6-30.3	3/8”	1.38
			Riser	71.69 - +1.8	N/A	Bentonite Crumbles	9.9-28.6	#8	23.79
						Portland Cement PT	0.0-9.9	I/II	7.39

Notes:

“	=	inches
#	=	mesh
cu. ft	=	cubic feet
ft bgs	=	feet below ground surface
Sch.	=	schedule

2.6.6 Well Development

Final well development at 199-N-187 (C8189) was started and completed on 23 September, 2011. Development took place at one interval using a Franklin electric submersible pump. The interval was pumped at a rate of 30 gpm for 58 minutes with a total of 1740 gallons of water removed from the aquifer. Water level recovery was also monitored at the end of development. Table 18 gives a summary of activities at each of the intervals. More detailed information on this well-development work is presented in Appendix C, and the resulting drawdown and recovery data and plots will be documented in a future RI/FS Report.

Table 18. Well Development Summary for 199-N-187 (C8189)

Well Development					Hydrogeochemistry			
	Intake	Duration	Discharge	Drawdown	Turbidity	Specific Cond		
Test Number	(ft bgs)	(min)	(gpm)	(ft)	(NTU)	(µS/cm)	pH	Temp ((°F)
1	83.5	52	30	10.58	4.58	554	8.07	64.508

Notes:
ft bgs = feet below ground surface
gpm = gallons per minute
NTU = nephelometric turbidity units
µS/cm = mico-Siemens per centimeter
°F = degrees Fahrenheit

2.6.6.1 Slug Test

Slug testing for 199-N-187 (C8189) was started and completed on 23 September, 2011. In this well two different slugging rods of different volumes were used. The displacement volumes for these rods were 1.0112 ft^3 and 0.6877 ft^3. Both slugs were inserted and removed, twice during separate tests, and the subsequent water-level response was then monitored. More detailed information on this slug-testing work is presented in Appendix C, and the extensive data resulting from these tests will be documented in a future RI/FS Report.

2.6.6.2 Permanent Sampling Pump Installation

A permanent sampling pump was installed into this well on 28 September, 2011. A 0.5 horsepower Grundfos Redi-Flo3 submersible pump was installed at an intake depth of 84.5. The pump was tested prior to installation and re-tested at depth to ensure it was functioning properly.

2.6.7 Environmental Monitoring

Environmental monitoring included services provided by RCTs from CHPRC's Radcon department and IHTs provided by an off-site contractor, PBS Engineering + Environmental.

2.6.7.1 Radiological Monitoring

Radiological monitoring was provided on a continuous basis at this well location for both drilling and well construction activities.

RCTs recorded 1,000,000 dpm beta/gamma direct with no alpha contamination levels at 25 ft bgs within the soil from the drill cuttings. This decreased at 26 ft bgs to levels of contamination between 800,000 dpm beta/gamma direct and 180,000 beta/gamma direct until 43 ft bgs. At 43 ft bgs depth, levels were recorded at 60,000 beta/gamma, direct. Contamination levels ranged between 70,000 dpm beta/gamma and 2,500 dpm beta/gamma from 43 ft bgs to a total depth at 94.5' bgs.

During well construction activities, RCTs detected levels of contamination between 1,000 dpm beta/gamma and 60,000 dpm beta/gamma which was fixed to the temporary 10" carbon steel casing. Some lengths of casing exhibited transferable beta/gamma contamination less than 1,000 dpm. These pieces were tagged as radiological and handled according to procedures laid out in the radiological work permit.

2.6.7.2 Industrial Hygiene Monitoring

Industrial hygiene monitoring was provided on an "AM/PM" basis at this well location for drilling and construction activities.

The IHT monitored for VOC vapors and potentially explosive vapors using a PID and an LEL in the morning hours and again in the afternoon hours on a daily basis. The IHT reported no anomalous readings during the drilling or construction of this well.

2.7 Well 199-N-188 (C8190)

This section contains summarized descriptions of drilling, borehole geology, sampling, geophysical logging, well construction and well development activities performed during the installation of well 199-N-188 (C8190).

2.7.1 Drilling

Well 199-N-188 (C8190) was drilled using a Speed-star 71 Cable Tool Drill Rig drill rig utilizing a drive barrel to remove cuttings from the ground between 8 August, 2011and 26 September, 2011. Total depth was 90 ft bgs. One string of temporary casing was utilized during drilling; 10-inch carbon steel to a depth of 91.0 ft bgs.

All temporary casing was removed from the borehole during well completion with the 6-inch stainless steel monitoring well

2.7.2 Borehole Geology

The vadose zone at this borehole was comprised of Hanford formation sediments and Ringold Formation, Unit E sediments made up mostly of gravelly sandy silt, silty sandy gravel, gravelly sand, and sandy gravel. The Hanford formation/Ringold formation contact was at 30.0 ft bgs.

The Hanford formation was dominated by mafic basalt material. Gravels generally consisted of poorly sorted pebble and cobble sized material. Gravels were sub-angular to sub-round in shape. The sands associated with this formation consisted of very fine to very coarse grained particles. Sediment colors were recorded as gray (7.5YR 5/1).

The saturated zone of this borehole was comprised of Ringold Unit E sediments made up mostly of silty sandy gravel, gravelly sand, sandy gravel, and sand. The groundwater table was at 65.6 ft bgs.

The Ringold Formation Unit E was dominated by felsic quartzite material. Gravels generally consisted of moderately sorted pebble sized material. Gravels were angular to sub-angular in shape. The sands associated with this formation consisted of fine to medium grained particles.

As planned in the SAP, the RUM was not contacted in this borehole and the borehole reached a total depth of 90.0 ft bgs.

The borehole log for this well location provides a more lithologically detailed description of the depositional strata and can be found in Appendix B.

2.7.3 Sampling

Geologic grab samples of drill cuttings were collected at 5-ft intervals between 0 and 25 ft bgs. Collection of grab samples was halted at 15 ft, as radiological contamination was higher than normal background levels. The grab samples were collected in glass pint mason jars and plastic chip trays for storage at the HGSL.

Soil and groundwater samples for laboratory analysis were also collected at various intervals throughout the drilling of the well. These samples are summarized in Table 19.

Table 19. Sample Summary Table for 199-N-188 (C8190)

Type	Media	Interval #	Depths (ft bgs)	HEIS #
Split spoon	Soil	I-001	14.7-17.2	B2CKT3, B2CKP4, B2CB60, B2CKL5, B2C7P2
Split spoon	Soil	I-002	21.0-23.5	B2CKP5, B2CB61, B2CKL6, B2C7P3
Split spoon	Soil	I-003	25.5-28.0	B2CKT4, B2CKP6, B2CB62, B2CKL7, B2C7P4
Split spoon	Soil	I-004	30.0-32.5	B2CKP7, B2CB63, B2CKL8, B2C7P5
Split spoon	Soil	I-005	35.3-37.8	B2CKT5, B2CKP9, B2CB65, B2CKM0, B2C7P7
Split spoon	Soil	I-006	39.8-42.3	B2CKR0, B2CB66, B2CKM1, B2C7P8 DUP: B2CKR8, B2CB76, B2CKN1, B2C803
Split spoon	Soil	I-007	44.8-47.3	B2CKT6, B2CKR1, B2CB67, B2CKM2, B2C7V4
Split spoon	Soil	I-008	50.2-52.7	B2CKT7, B2CKR2, B2CB68, B2CKM3, B2C7V5
Split spoon	Soil	I-009	55.3-57.8	B2CKT8, B2CKR3, B2CB69, B2CKM4, B2D283, B2C7Y6
Split spoon	Soil	I-010	59.7-62.2	B2CKT9, B2CKR4, B2CB71, B2CKM6, B2D284, B2C7Y8
Split spoon	Soil	I-011	62.3-64.8	B2CB73, B2CKV0, B2CKR5, B2CB72, B2CKM7, B2C7Y9
Split spoon	Soil	I-012	65.0-67.5	B2CKV1, B2CKR6, B2CB74, B2CKM9, B2D285, B2C801
Split spoon	Soil	I-018	67.7-70.2	B2D287, B2CB81, B2CKN6, B2D286, B2C808
Split spoon	Soil	I-019	71.0-73.5	B2D289, B2CB82, B2CKN7, B2D288, B2CB59
Pump	Water	I-019	71.4	B2CKX6, B2CKX2, B2CKV9, B2CKV8, B2CKV7, B2CKY1
Split spoon	Soil	I-020	75.7-78.2	B2CKW6, B2C1T4, B2CKW4, B2CKW2, B2CKW0
Pump	Water	I-020	75.5	B2CKX7, B2CKX3, B2CKY2 DUP: B2CKX8, B2CKX4,
Split spoon	Soil	I-021	81.0-83.5	B2CKW7, B2C1T5, B2CKW5, B2CKW3, B2CKW1
Pump	Water	I-021	81.0	B2CKY0, B2CKX9, B2CKX5, B2CKY3

Notes:
# = number
DUP = duplicate
ft bgs = feet below ground surface
VOA = Volatile Organic Analysis
RS = Radiological Screen

2.7.4 Geophysical Logging

Geophysical Logging was conducted at C8190 on September 15, 2011. The geophysical logging contractor, Stoller, was directed to scan the borehole using SGLS and NMLS. According to Stoller, cesium-137 was detected continuously from 15 to 26 ft bgs, with a maximum concentration of 319 pCi/g at 17 ft bgs. Stoller also detected cobalt-60 continuously from 18 to 50 ft bgs and between 55 and 59 ft bgs, with a maximum concentration of 170 pCi/g at 20 ft bgs. More detailed geophysical logging results for this location can be found in Appendix, E.

2.7.5 Well Construction

Well construction at 199-N-188 (C8190) was conducted in accordance with WAC 173-160 "*Minimum Standards for Construction and Maintenance of Wells*." The construction was started 15 September, 2011 and completed 21 September, 2011. A straightness tester was run into the hole and extracted without binding on 15 September, 2011. The monitoring well was constructed of 6 $^{9/16}$-inch OD/6 $^{7/16}$-inch ID schedule 10, type 316/316L stainless steel with a 0.020 inch (20-slot) continuous wire wrap screen, 10-20 mesh filter pack, and a 3-ft sump. The screen is 20.04 ft in length and approximately 3.7 ft of it sits above the water. Well construction and associated depths are summarized in Table 20. More detailed well construction data for this location can be found in Appendix A.

Table 20. Well Construction Summary for 199-N-188 (C8190)

Borehole Total Depth (ft bgs)	RUM Depth (ft bgs)	Static Water Level (ft bgs)	6-inch Diameter, Sch. 10, Type 316/316L Well Materials			Annular Materials			
			Material	Interval (ft bgs)	Slot Size	Material	Interval (ft bgs)	Mesh/Size/Type	Volume (cu. ft)
90	N/A	64.5	Sump	80.8-83.8	N/A	Silica Sand	55.7-90.0	10-20	23.54
			Screen	60.8-80.8	20	Bentonite Pellets	52.5-55.7	3/8"	1.38
			Riser	-58.8	N/A	Bentonite Crumbles	11.2-52.5	#8	14.91
						Portland Cement PT	0.0-11.2	I/II	8.99

Notes:
" = inches
= mesh
cu. ft = cubic feet
ft bgs = feet below ground
surfaceSch. = schedule

2.7.6 Well Development

Final well development at 199-N-188 (C8190) was started and completed on 22 September, 2011. One development test took place for a single interval using a Franklin electric submersible pump. The well was pumped at a rate of 10 gallons per minute for 44 minutes which removed a total of 440 gallons of water from the aquifer. Water level recovery was also monitored at the end of development for each interval. Table 21 gives a summary of activities at each of the intervals. More detailed information on this well-development work is presented in Appendix C, and the resulting drawdown and recovery data and plots will be documented in a future RI/FS Report.

Table 21. Well Development Summary for 199-N-188 (C8190)

Well Development					Hydrogeochemistry			
	Intake	Duration	Discharge	Drawdown	Turbidity	Specific Cond		
Test Number	(ft bgs)	(min)	(gpm)	(ft)	(NTU)	(µS/cm)	pH	Temp (°F)
1	74	44	10	1.88	3.81	462	8.08	68.72

Notes:
ft bgs = feet below ground surface
gpm = gallons per minute
NTU = nephelometric turbidity units
µS/cm = mico-Siemens per centimeter
°F = degrees Fahrenheit

2.7.6.1 Slug Test

Slug testing for 199-N-188 (C8190) was started and completed on 22 Sept 2011. In this well two different slugging rods of different volumes were used. The displacement volumes for these rods were 1.0112 ft^3 and 0.6877 ft^3. Both slugs were inserted and removed, twice during separate tests, and the subsequent water-level response was then monitored. More detailed information on this slug-testing work is presented in Appendix C, and the extensive data resulting from these tests will be documented in a future RI/FS Report.

2.7.6.2 Permanent Sampling Pump Installation

A permanent sampling pump was installed into this well on 26 September, 2011. A 0.5 hp Grundfos Redi-Flo3 submersible pump was installed at an intake depth of 77.5 ft bgs. The pump was tested prior to installation and re-tested at depth to ensure it was functioning properly.

2.7.7 Environmental Monitoring

Environmental monitoring included services provided by RCTs from CHPRC's Radcon department and IHTs provided by an off-site contractor, PBS Engineering + Environmental.

2.7.7.1 Radiological Monitoring

Radiological monitoring was provided on a continuous basis at this well location for both drilling and well construction activities.

RCTs began detecting 2,000 dpm beta/gamma direct with no alpha contamination levels at 17 ft bgs within the soil from the drill cuttings. Concentration levels peaked at 1.2 million dpm beta/gamma with no alpha at 19 ft bgs. Rad levels dropped to 60,000 dpm beta/gamma at 20 ft bgs. Contamination levels steadily declined from 20 ft bgs and dropped to background at 78 ft bgs.

2.7.7.2 Industrial Hygiene Monitoring

Industrial hygiene monitoring was provided on an "AM/PM" basis at this well location for drilling and construction activities.

The IHT monitored for VOC vapors and potentially explosive vapors using a PID and an LEL in the morning hours and again in the afternoon hours on a daily basis. The IHT reported no anomalous readings during the drilling or construction of this well.

2.8 Well 199-N-189 (C8191)

This section contains summarized descriptions of drilling, borehole geology, sampling, geophysical logging, well construction and well development activities performed during the installation of well 199-N-189 (C8191).

2.8.1 Drilling

Well 199-N-189 (C8191) was drilled using a Speed-star 71 Cable Tool Drill Rig drill rig utilizing a drive barrel to remove cuttings from the ground between June 14, 2011 and July 18, 2011. Total depth was 117.3 ft bgs. One string of temporary casing was utilized during drilling; 10-inch carbon steel casing to 110.0 ft bgs.

All temporary casing was removed from the borehole during well completion with the 6-inch stainless steel screen and casing.

2.8.2 Borehole Geology

The vadose zone at this borehole was comprised of Hanford formation sediments and Ringold Formation, Unit E sediments made up mostly of sandy gravel and gravelly sand. The Hanford formation, Ringold Formation contact was at 59.0 ft bgs.

The Hanford formation was dominated by mafic basalt material. Gravels generally consisted of pebble and cobble sized material. Gravels were sub-rounded to round in shape. The sands associated with this formation consisted of medium to coarse grained particles. Sediment colors were recorded as very dark gray (10YR 3/2), gray (10YR 5/1), dark gray (10 YR 4/1), and very dark gray brown (10 YR 3/2).

The saturated zone of this borehole was comprised of Ringold Unit E sediments made up mostly of gravel, gravelly sand, and clay. The groundwater table was measured at 79.4 ft bgs.

The Ringold Formation Unit E was dominated by felsic quartzite material. Gravels generally consisted of poorly sorted pebble and cobble sized material. Gravels were angular to round in shape. Smaller material appeared angular in shape, while larger clasts were more rounded in nature. The sands associated with this formation consisted of fine to medium grained particles.

The Ringold Upper Mud (RUM) was contacted at 105 ft bgs. This unit was comprised of very dense silts and clays and no plasticity was recorded. Recorded color was light brownish gray (10YR 6/2).

The borehole reached a total depth of 117.3 ft bgs.

The borehole log for this well location provides a more lithologically detailed description of the depositional strata and can be found in Appendix B.

2.8.3 Sampling

Geologic grab samples of drill cuttings were collected at 5-ft intervals or at significant lithologic changes throughout the drilling of this well, except when radiological contamination was higher than normal background levels. The grab samples were collected in glass pint mason jars and plastic chip trays for storage at the HGSL.

Soil and groundwater samples for laboratory analysis were also collected at various intervals throughout the drilling of the well. These samples are summarized in Table 22.

Table 22. Sample Summary Table for 199-N-189 (C8191)

Type	Media	Interval #	Depths (ft bgs)	HEIS #
Split Spoon	Soil	I-001	42.4 – 44.9	B2C4N5, B2C4K9
Split Spoon	Soil	I-002	47.3 – 49.8	B2C4L0
Split Spoon	Soil	I-003	58.0 – 60.5	B2C4N6, B2C4L1
Split Spoon	Soil	I-005[a]	59.5 – 62.0	B2C4N7, B2C4L4, B2C4M5, B2C4J8
Split Spoon	Soil	I-004[a]	62.4 – 64.9	B2C4L2
Split Spoon	Soil	I-006/I-006 DUP	64.7 – 67.2	B2C4L5, B2C4M6, B2C4J9/ B2C4L6[d], B2C4K0[d],
Split Spoon	Soil	I-007	69.5 – 72.0	B2C4N8, B2C4L7, B2C4M7, B2C4K1
Split Spoon	Soil	I-008	72.2 – 74.7	B2C4L8, B2C4M8, B2C4K2
Split Spoon	Soil	I-009	74.8 – 77.3	B2C4N9, B2C4L9, B2C4M9, B2C4K3
Split Spoon	Soil	I-010	77.5 – 80.0	B2C4M0, B2C4N0, B2C4K4
Split Spoon	Soil	I-013	79.9 – 82.4	B2C4M3, B2C4N3, B2C4K7
Split Spoon	Soil	I-014	85.0 – 87.5	B2C4M3, B2C4N3, B2C4K7
Pump	Water	I-014	85.0	B2C4T3, B2C4W4, B2C4P3, B2C4P8, B2C4P1, B2C4P2, B2C4X9
Pump	Water	I-015	90.0	B2C4T4, B2C4W5, B2C4P9, B2C4Y0
Pump	Water	I-016	95.0	B2C4T5, B2C4W6, B2C4R0, B2C4Y1
Pump	Water	I-017/I-017 DUP	100.0	B2C4T6, B2C4W7, B2C4R1, B2C4Y2/ B2C4W8[d], B2C4T7[d], B2C4R2[d]
Pump	Water	I-018	105.0	B2C4W0, B2C4T8, B2C4W9, B2C4R3, B2C4Y3
Split Spoon	Soil	I-028	108.0 – 110.5	B2C4P7, B2C4W3, B2C4P5
Split Spoon	Soil	I-029	114.8 – 117.3	B2C4P6, B2C4P4, B2C4W1, B2C4W2

Notes:
[a] During the course of drilling these samples were taken out of order.
[d] Denotes duplicate sample.
# = number
DUP = duplicate

ft bgs = feet below ground surface

2.8.4 Geophysical Logging

Geophysical Logging was conducted at C8191 on July 19, 2011. The geophysical logging contractor, Stoller, was directed to scan the borehole using SGLS and NMLS. No manmade radionuclides were detected at this borehole. More detailed geophysical logging results for this location can be found in Appendix D.

2.8.5 Well Construction

Well construction at 199-N-189 (C8191) was conducted in accordance with WAC 173-160 "*Minimum Standards for Construction and Maintenance of Wells*." The construction was started August 1, 2011 and completed August 4, 2011. A straightness tester was run into the hole and extracted without binding on July 29, 2011. The monitoring well was constructed of 6 $^{9/16}$-inch OD/6 $^{7/16}$-inch ID schedule 10, type 316/316L stainless steel with a 0.020 inch (20-slot) continuous wire wrap screen, 10-20 mesh filter pack, and a 3-ft sump. The screen is 45 ft in length and approximately 16.5 ft of it sits above the water. Well construction and associated depths are summarized in Table 23. More detailed well construction data for this location can be found in Appendix A.

Table 23. Well Construction Summary for 199-N-189 (C8191)

Borehole Total Depth (ft bgs)	RUM Depth (ft bgs)	Static Water Level (ft bgs)	6-inch Diameter, Sch. 10, Type 316/316L Well Materials			Annular Materials			
			Material	Interval (ft bgs)	Slot Size	Material	Interval (ft bgs)	Mesh/Size/Type	Volume (cu. ft)
117.3	107	78.7	Riser	+2.86 – 62.1	N/A	Portland Cement	0 – 11.6	I/II	6.43
			Screen	62.1 – 107.1	20	Bentonite Crumbles	11.6 – 53.0	#8	17.4
			Sump	107.1 – 110.1	N/A	Bentonite Pellets	53.0 – 56.0	3/8"	2
						Colorado Silica Sand	56.0 – 112.0	10-20	23.54
						Natural Fill	112.0 – 117.3	N/A	N/A

Notes:
" = inches
= mesh
cu. Ft = cubic feet
ft bgs = feet below ground surface
Sch. = schedule

2.8.6 Well Development

Final well development at 199-N-189 (C8191) was started and completed on August 5, 2011. Development took place at three intervals using a 2.5 hp submersible pump. The first interval, at 108.16 ft bgs, was pumped at a rate of 15 gpm for 156.3 minutes and pumped a total of 2,345 gallons of water from the aquifer. The second interval, at 98.1 ft bgs, was pumped at a rate of 15 gpm for 31 minutes and pumped a total of 465 gallons of water from the aquifer. The third interval, at 88.14 ft bgs, was pumped at

a rate of 15 gpm for 28 minutes and removed a total of 420 gallons of water from the aquifer. Water level recovery was also monitored at the end of development for each interval. Table 24 gives a summary of activities at each of the intervals. More detailed information on this well-development work is presented in Appendix C, and the resulting drawdown and recovery data and plots will be documented in a future RI/FS Report.

Table 24. Well Development Summary for 199-N-189 (C8191)

Well Development					Hydrogeochemistry			
	Intake	Duration	Discharge	Drawdown	Turbidity	Specific Cond		
Test Number	(ft bgs)	(min)	(gpm)	(ft)	(NTU)	(µS/cm)	pH	Temp (F)
1	108.16	156.3	15	N/R	2.54	302	N/R	61.47
2	98.1	31	15	N/R	4.24	298	N/R	61.44
3	88.14	28	15	N/R	1.53	304	N/R	61.70

Notes:
ft bgs = feet below ground surface
NR = not recorded
gpm = gallons per minute
NTU = nephelometric turbidity units
µS/cm = mico-Siemens per centimeter
F = Fahrenheit

2.8.6.1 Slug Test

Slug testing for 199-N-189 (C8191) was started and completed on August 8, 2011. In this well two different slugging rods of different volumes were used. The volumes for these rods were 0.3276 ft^3 and 0.6877 ft^3. Both slugs were inserted and removed, twice during separate tests, and the subsequent water-level response was then monitored. More detailed information on this slug-testing work is presented in Appendix C, and the extensive data resulting from these tests will be documented in a future RI/FS Report.

2.8.6.2 Permanent Sampling Pump Installation

A permanent sampling pump was installed into this well on 2 September, 2011. A 0.5 horsepower Grundfos Redi-Flo3 submersible pump was installed at an intake depth of 107.5 ft bgs. The pump was tested prior to installation and re-tested at depth to ensure it was functioning properly.

2.8.7 Environmental Monitoring

Environmental monitoring included services provided by RCTs from CHPRC's Radcon department and IHTs provided by an off-site contractor, PBS Engineering + Environmental.

2.8.7.1 Radiological Monitoring

Radiological monitoring was provided on an AM/PM basis at this well site. RCTs reported no elevated readings while drilling the borehole from ground surface to the total depth of the borehole or while back-pulling the temporary casing from the ground.

2.8.7.2 Industrial Hygiene Monitoring

Industrial hygiene monitoring was provided on an "AM/PM" basis at this well location for drilling and construction activities.

The IHT monitored for VOC vapors and potentially explosive vapors using a PID and an LEL in the morning hours and again in the afternoon hours on a daily basis. The IHT reported no anomalous readings during the drilling or construction of this well.

3 Waste Management

This section presents the management and disposition of waste generated during the drilling, sampling, construction and development of the eight new wells. Waste streams generated include: (1) investigation derived waste (IDW) consisting of vadose zone derived drill cuttings and saturated zone drill cuttings; (2) purgewater and aquifer water; and (3) miscellaneous solid waste (MSW). Waste streams are fully described and managed in compliance with strategies documented in:

- DOE/RL-2000-41, *Interim Action Waste Management Plan for the 100-NR-2 Operable Unit.*
- HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria.*

3.1 Investigation Derived Waste

3.1.1 Vadose Zone Cuttings

Vadose zone soils (i.e., drill cuttings collected from above the highest historical water table) were contained at the drill pad in 55-gallon non-lined waste drums. The drums were labeled with the borehole ID, well name, date, and depth from which the waste was derived. These cuttings were then sampled and analyzed for the appropriate designation of method of disposal. If the cuttings were found to meet return-to-earth (RTE) criteria then the cuttings were spread across the drilling pad, if the cuttings did not meet the RTE criteria, but met the criteria (HNF-EP-0063) for disposal at the Environmental Restoration Disposal Facility (ERDF), then they were sent to the disposal facility instead. Sediments identified as contaminated were dealt with in accordance with site specific waste packaging/labeling instruction sheets (WP/LIS).

3.1.2 Saturated Zone Cuttings

All drill cuttings produced at or below the historic high water table are considered to be from the zone of saturation and were containerized in lined 55-gallon waste drums. Free liquid from the containerized saturated sediments was transferred from the 55-gallon drums to purgewater trucks and managed as purgewater. All saturated sediments are to be profiled and disposed of at the ERDF facility, providing ERDF disposal criteria (HNF-EP-0063) are met. Saturated soils are not eligible for RTE under any circumstances.

3.2 Miscellaneous Solid Waste

Miscellaneous Solid Waste (MSW) generated during the installation of each well consists of materials that have contacted potentially contaminated media. MSW consisted of disposable sampling equipment and personal protective equipment. All MSW generated during the drilling and sampling of all eight monitoring wells was handled and disposed of in a manner consistent with guidelines set forth in the:

- DOE/RL-2008-46-ADD5, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 5: 100-NR-1 and 100-NR-2 Operable Units*
- DOE/RL-2009-42, *Sampling and Analysis Plan for the 100-NR-1 and 100-NR-2 Operable Units Remedial Investigation/Feasibility Study.*
- SGW-48469, *Description of Work for the Installation of 8 Groundwater Monitoring Wells in the 100-NR-2 Operable Unit to Support RI/FS Work for Fiscal Year 2011*.

Saturated or moistened MSW was containerized and disposed of based on field screening results as stated in the site-specific WP/LIS. MSW generated at all well sites was sealed in clearly labeled bags and placed in on-site, 55-gal barrels which were sent to ERDF providing the waste met disposal criteria (HNF-EP-0063).

3.3 Purgewater and Aquifer Water

Purgewater from each well was collected and temporarily stored near the respective wellhead in open top modular tanks and/or purgewater trucks. Purgewater produced during all phases of drilling sampling and development of each well was transferred from the site via purge water truck to the Modular Storage Units in the 200 East Area.

All purgewater generated during the drilling and sampling of the eight monitoring wells was handled and disposed of in a manner consistent with guidelines set forth in:

90-ERB-040, "*Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington.*"

GRP-EE-01-1.11, "*Purgewater Management.*"

4 Civil Survey

Civil surveys were performed on October 11, 2011 on the eight new monitoring wells. The surveys were performed under the supervision of a licensed professional land surveyor registered in the state of Washington. Table 25 was compiled with information obtained from the survey report (Request No. 114-561, File No. 1NT14R26).

Table 25. Final Civil Survey for 100-NR-2 RI/FS Monitoring Wells

Well ID	Well Name	Easting (m)[a]	Northing (m)[a]	Elevation (m)[b]
C8184	199-N-182	571428.71	149819.87	140.522
C8185	199-N-183	571269.69	149756.01	140.240
C8186	199-N-184	571430.74	149817.82	140.528
C8187	199-N-185	571546.33	150237.98	122.073
C8188	199-N-186	571480.87	149715.06	141.394
C8189	199-N-187	571565.90	149897.96	141.246
C8190	199-N-188	571906.94	149581.53	139.314
C8191	199-N-189	571431.65	148430.52	143.638

Notes:
[a] Measured at the center of the well casing in Washington State Plane Coordinates, NAD83[91], North American Datum of 1983.
[b] Measured at the brass survey marker on the north side of the well in Washington State Plane Coordinates, NAVD88, North American Vertical Datum of 1988.

ID = identification
m = meters

5 Well Acceptance

A final well acceptance walk down was conducted by representatives of the drilling contractor, the field geology contractor, and CHPRC on September 29, 2011, and all of the wells were accepted. The well inspections and well acceptance activities included representatives from Carpenter Drilling Company, CHPRC's Buyer's Technical Representative, CHPRC's Well Drilling Management and CHPRC's Quality Assurance/Quality Control, as well as GRAM, Inc. All eight monitoring wells received a walk down with all involved parties. The final acceptance walk downs included verification of attributes such as surface protection, well identification, well functionality, and site cleanup. Work Site Assessment, SGRP-2012, WSA-11681 documents acceptance of these wells.

6 References

40 CFR 300, National Oil and Hazardous Substances Pollution Contingency Plan *Code of Federal Regulations*, as amended

90-ERB-040, 1990, "*Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington,"* (letter, to P.T. Day, U.S. Environmental Protection Agency, and T.L. Nord, Washington State Department of Ecology, from R.D. Izatt.) U.S. Department of Energy, Richland Operations Office, Richland, Washington. July 19, 1990.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601, et seq.

DOE/RL-2000-41, 2000, *Interim Action Waste Management Plan for the 100-NR-2 Operable Unit*, Rev.0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2001-27, 2011, *Remedial Design/Remedial Action Work Plan for the 100-NR-2 Operable Unit*, Rev. 1, Draft A, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2008-46-ADD5, 2010, *Integrated 100 Area Remedial Investigation/Feasibility Study Work Plan, Addendum 5: 100-NR-1 and 100-NR-2 Operable Units*, Rev.0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-2009-42, 2010, *Sampling and Analysis Plan for the 100-NR-1 and 100-NR-2 Operable Units Remedial Investigation/Feasibility Study*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement), 2 volumes, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

GRP-EE-01-1.11, "*Purgewater Management*"

GRP-EE-01-7.0, Rev. 1, "*Geologic Logging*"

HNF-EP-0063, **"***Hanford Site Solid Waste Acceptance Criteria"*

NAD83, 1991, *North American Datum of 1983*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland, as revised.

NAVD88, 1988, *North American Vertical Datum of 1988*, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland, as revised.

SGW-48469, 2010, *Description of Work for the Installation of 8 Groundwater Monitoring Wells in the 100-NR-2 Operable Unit to Support RI/FS Work for Fiscal Year 2011*, Rev. 0, CH2M Hill Plateau Remediation Company, Richland, Washington.

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