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SGW-44089
Revision 0

ARRA FY2010 Description of Work for the Installation of 18 Scenario 5 Remedial Process Optimization Wells for the 100-D Area, 100-HR-3 Operable Unit

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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Document Type: TR Program/Project: S&GRP

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GRAM, Inc.

Date Published
January 2010

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Release Approval Date

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SGW-44089, REV.0

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ACRONYMS

ags	above ground surface
APE	area of potential effect
bgs	below ground surface
BTR	Buyer's Technical Representative
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	*Code of Federal Regulations*
CRR	Cultural Resources Review
CHPRC	CH2M Hill Plateau Remediation Company
DOE	U.S. Department of Energy
DOW	Description of Work
EPA	U.S. Environmental Protection Agency
ETF	effluent treatment facility
ft	foot (feet)
FY	Fiscal Year
gpm	gallons per minute
GPR	Ground Penetrating Radar
HASQARD	Hanford Analytical Services Quality Assurance Requirements Document
HGET	Hanford General Employee Training
ID	Identification
ISRM	In-Situ Redox Manipulation
m	meter(s)
MSW	miscellaneous solid waste
NPE	no potential effect
NPL	National Priorities List
NTU	nephelometric turbidity units
OU	Operable Unit
PSTF	Purgewater Storage and Treatment Facility
QA	Quality Assurance
RAO	remedial action objectives
RI	Remedial Investigation
ROD	Record of Decision
RPO	Remedial Process Optimization
RUM	Ringold Upper Mud (Unit)
SAP	Sampling Analysis Plan
SHPO	State Historic Preservation Officer
TBD	to be determined
TD	total depth
WAC	*Washington Administrative Code*
WP/LIS	Waste Packaging/Labeling Instruction Sheet
QAPjP	Quality Assurance Project Plan

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 (U.S., liquid)
tablespoons	15	milliliters	Liters	2.113	Pints
ounces (U.S., liquid)	29.573	milliliters	Liters	1.057	quarts (U.S., liquid)
cups	0.24	liters	Liters	0.264	gallons (U.S., liquid)
pints	0.473	liters	cubic meters	35.315	cubic feet
quarts (U.S., liquid)	0.946	liters	cubic meters	1.308	cubic yards
gallons (U.S., liquid)	3.785	liters			
cubic feet	0.0283	cubic meters			
cubic yards	0.764	cubic meters			
	Temperature			**Temperature**	
Fahrenheit	(°F-32)*5/9	Centigrade	Centigrade	(°C*9/5)+32	Fahrenheit
	Radioactivity			**Radioactivity**	
picocurie	37	millibecquerel	millibecquerel	0.027	Picocurie

1 PURPOSE/SCOPE OF WORK

This description of work (DOW) describes the drilling, construction, development, and sampling activities associated with the installation of 18 new groundwater wells at the 100-D Area of the Hanford Site (Figure 1-1). The location of the new wells is shown in Figure 1-2, staked at the coordinates shown in Table 1-1. All drilling activities and well construction/development will be performed by a drilling subcontractor.

The wells are being installed to expand the size and efficiency of the 100-HR-3 groundwater Operable Unit (OU) pump and treat system operating to remediate hexavalent chromium contamination in the groundwater. The new wells will facilitate Remedial Process Optimization (RPO) in the 100-HR-3 groundwater OU, an ongoing process operating in support of the Year 2012 and Year 2020 Plume Remediation Goals set forth by the U.S. Department of Energy (DOE) and CH2M Hill Plateau Remediation Company (CHPRC). This work is conducted pursuant to the Hanford Site's 1989 listing on the Environmental Protection Agency's (EPA) National Priorities List (NPL) for the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA).

Many of the well sites are situated in and around areas that are potentially cultural and ecological sensitive. A Cultural Resource Review (CRR) is in progress to determine which prospective well sites are located in Areas of Potential Effect (APE) or in areas of No Potential Effect (NPE) on cultural resources. Work activities on sites undergoing CRR will not be initiated until such activities have been approved by the State Historical Preservation Officer (SHPO), Tribal Confederation, and/or other interested parties.

Currently 16 of the 18 well sites discussed in this DOW have been designated NPE in the CRR process (Table 1-1) and are ready for work to begin upon contract release. The remaining two well sites are still under review. If any of the well locations are determined to be APE, they will require a more lengthy cultural review period.

Table 1-1. Scenario 5 Well Location Summary Table

Well ID	Well Name	Type	Easting (m)	Northing (m)	Elevation (m)	CRR Status
C7580	199-D4-101	Extraction	572800.30	151425.75	143.24	NPE
C7582	199-D8-97	Extraction	573859.59	152087.60	140.19	NPE
C7583	199-D5-101	Extraction	572942.78	151521.29	143.48	NPE
C7589	199-D8-95	Extraction	573611.76	152160.76	141.30	NPE
C7590	199-D5-130	Extraction	574039.43	151928.16	141.97	NPE
C7591	199-D5-127	Extraction	572992.87	151428.66	143.33	NPE
C7592	199-D6-1	Injection	574129.64	151691.50	143.85	NPE
C7593	199-D8-99	Injection	574006.34	152363.99	136.20	NPE
C7594	199-D7-4	Injection	574376.96	152369.54	133.36	NPE
C7599	199-D7-3	Extraction	574151.35	152364.06	135.12	NPE
C7600	199-D5-129	Injection	573728.41	151443.19	143.26	NPE
C7601	199-D5-131	Extraction	573684.30	152007.01	143.24	NPE
C7602	199-D8-98	Extraction	574012.53	152122.67	137.29	NPE
C7603	199-D8-96	Extraction	573705.88	152152.59	140.22	NPE
C7607	199-D6-2	Injection	574545.22	151970.55	133.32	NPE
C7608	199-D7-5	Injection	574434.21	152678.57	130.96	APE
C7611	199-D7-6	Extraction	574428.64	152980.21	124.57	APE
C7612	199-D5-128	Injection	573622.04	151237.06	142.88	NPE

Notes:

APE = Area of Potential Effect (highlighted gray for clarity); requires additional CRR prior to start of field work

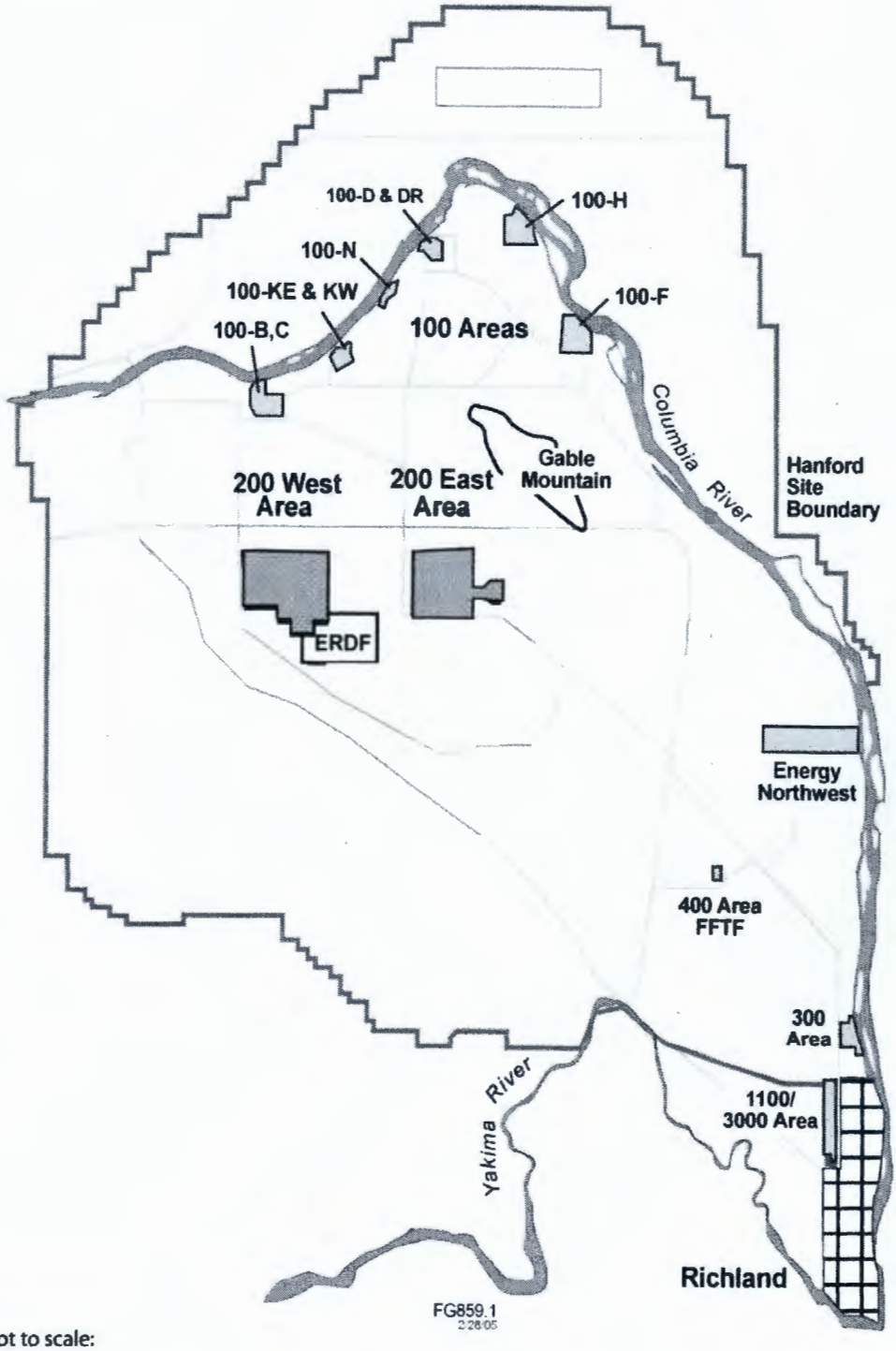
CRR = Cultural Resources Review

m = meter(s)

ID= Identification

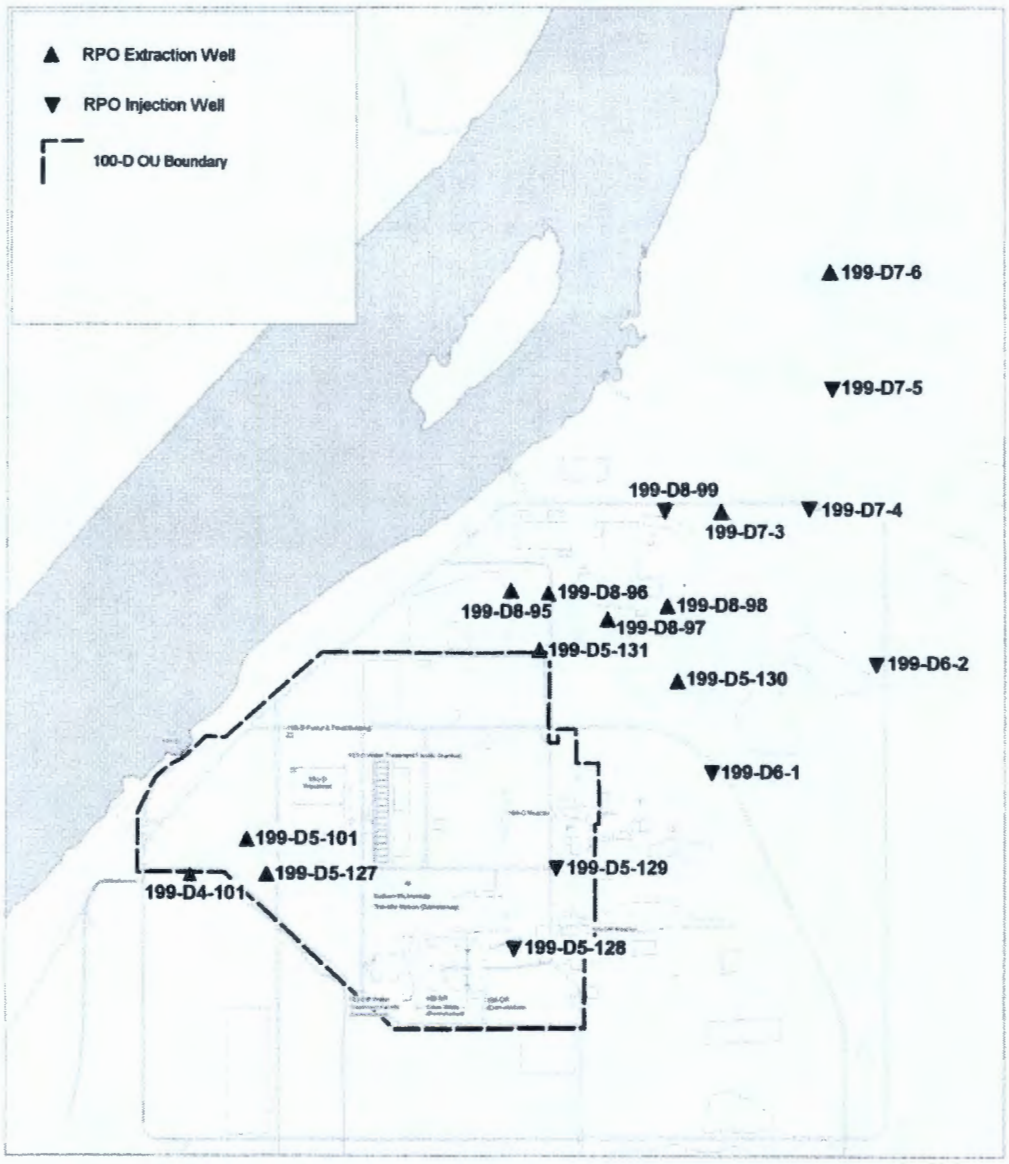
NPE = No Potential Effect; field work ready under CRR

Figure 1-1. 100-D Area Location Map



Not to scale:

Figure 1-2. Well Location Map



2 BACKGROUND

The following section discusses previous work activities and regulatory decisions associated with the 100-HR-3 groundwater OU and 100-D Area. General summaries of the site geology and hydrogeology and contaminants of concern relevant to the planned are presented.

2.1.1 Historic Site Operations and Resulting Contamination

The 100-HR-3 groundwater OU is located in the north-central part of the Hanford Site approximately 28 miles north-northwest of the city of Richland, Washington. It includes all groundwater impacted by the operation of four nuclear reactors in the 100-D and 100-H Areas from 1944 through 1967, encompassing an area informally referred to as "the Horn" due to the shape formed by the Columbia River between 100-D and 100-H Areas (Figure 1-1). The 100-D Area is located on the west side of the Horn and includes the 105-D and 105-DR Reactors and their associated former support facilities.

As discussed in SGW-38338, *Remedial Process Optimization for the 100-D Area Technical Memorandum Document,* most groundwater contamination in the 100-D Area is a result of the cooling system used in the reactors, which pumped water from the Columbia River to cool the reactor core, treated it, and returned it to the soil column. Sodium dichromate salts and aqueous solutions of varying concentrations were routinely added to the cooling water stream in order to reduce the corrosivity of the water, typically to concentrations of approximately 2 mg/L hexavalent chromium. After passing through the reactor, the spent cooling water was discharged to unlined basins, where it was held for a number of hours before being piped back to the Columbia River. This discharge of cooling water to unlined basins led to widespread mounding of the aquifer up to 3 m (~10 ft) above natural static water level, which contributed to the growth of the contamination plume extending from 100-D Area (SGW-40781).

Contamination is also associated with a large scale infiltration test that was conducted in the 100-D Area from March through June 1967 (BNWL-CC-1352, *Ground Disposal of Reactor Coolant Effluent*). Approximately 3.4 billion gallons of reactor coolant effluent was disposed directly to the ground at the 100-D emergency crib trench. This test raised the water level in the unconfined aquifer an additional 0.3 to 3 m (1 to 10 ft) and may have significantly contributed to migration of hexavalent chromium from the 100-D Area towards the central Horn and the 100-H Area (SGW-40781). Groundwater mounding may also have contributed to the separation of contamination in the 100-D Area into distinct northern and southern plumes.

Hexavalent chromium concentrations in the 100-D Area are locally much higher than 2 mg/L. This suggests that there may have been unknown leaks or spills of concentrated hexavalent chromium solutions that are continuing to contaminate 100-D Area groundwater 40 years after the termination of reactor operations. Current conceptual models suggest that the vadose zone contains significant amounts of hexavalent chromium which continue to feed the groundwater contamination plumes. However, the exact causes of the continued high concentrations are unknown and part of the ongoing remedial investigation for the 100-HR-3 groundwater OU.

Currently, the hexavalent chromium groundwater plumes in the 100-D Area are both discharging to the Columbia River and potentially impacting the river's ecosystem. Hexavalent

chromium is locally upwelling into potential salmon redds, and shoreline seeps are discharging into riparian habitat during low-river stages (SGW-38338).

2.1.2 Remedial Action Goals & Previous Work Activities

Interim remedial actions for the 100-D Area were initiated to address the three remedial action objectives (RAO) required by the interim remedial action Record of Decision (ROD) (EPA et al. 1996; amended 1999), listed below:

Protect aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River.

Protect human health by preventing exposure to contaminants in the groundwater.

Provide information that will lead to a final remedy.

The 100-HR-3 pump and treat system was installed to reduce the levels of hexavalent chromium in groundwater discharging to the Columbia River in 1997. Between 2000 and 2003, the 100-HR-3 system was augmented by the phased installation of the In Situ Redox Manipulation (ISRM) treatment zone. Active treatment of the 100-D Area was further expanded in 2004 with the addition of a second pump and treat system, the DR-5 system. The DR-5 system was designed to supplement the 100-HR-3 system by capturing contamination from the southern portion of the northern 100-D hexavalent chromium plume.

The pump and treat systems continue to operate but are in the process of receiving upgrades to increase their capacity and area of influence through the RPO process (DOE/RL-2008-46). The primary objectives for the RPO design are to (1) prevent the discharge of hexavalent chromium to the Columbia River substrate at concentrations exceeding those considered protective of aquatic life in the river and riverbed sediments by the year 2012, and (2) restore the aquifer by attaining target cleanup levels in the 100-HR-3 aquifer area by the year 2020 (SGW-40041).

The 18 wells in this document are part of the RPO design expansion to the 100-HR-3 pump and treat system. 'Scenario 5' refers to the multiple iterations of groundwater modeling and planning gone through before arriving at a pump and treat expansion deemed appropriately broad to the meet the 2020 target cleanup goals discussed above. 'Scenario 5' adds 33 additional wells to the 37 already planned for a total of 70 new RPO wells planned for the 100-HR-3 groundwater OU.

2.2 Site Stratigraphy and Hydrogeology

The following section summarizes the stratigraphic setting and hydrogeologic conditions in the vicinity of the new wells. Table 2-1 provides a listing of estimated contact depths for each borehole planned in this document, based on contour maps developed from the nearest available well logs.

2.2.1 Stratigraphic Setting

The stratigraphy of the Horn area is consistent with the regional geologic setting, composed of unconsolidated sedimentary deposits overlying the Columbia River Basalt Group and associated Ellensburg Formation interbeds. Units overlying the basalt include Holocene alluvial, eolian, and

anthropogenic deposits, the Pleistocene Hanford formation, and the Miocene-Pliocene Ringold Formation.

The ground surface in the 100-HR-3 groundwater OU reflects the influence of the Pleistocene Missoula Floods (discussed below) and subsequent reestablishment and migration of the Columbia River through the Hanford Area. Surface features that reflect the catastrophic Missoula floods in the area include giant ripple marks and gravel bars. Well-defined curvilinear channel trace features are visible on both sides of the existing river, indicating that the channel has repeatedly migrated across the valley floor (SGW-38338). Additionally, eolian sands may be present to depths of less than 10 ft. Contact depths in the Horn area depend greatly on the degree of Pleistocene flood and Holocene river erosion that has taken place.

Depending on proximity to former facilities and/or remediation sites, the ground surface of the 100-D Area has been extensively disturbed by grading, construction, and demolition work. Disturbed sediments can extend more deeply, but in general range from 1 to 15 ft below ground surface (bgs) in disturbed areas. Due to many of the wells' locations, most surficial sediments will most likely show very little anthropogenic influence.

Underlying any Holocene deposits, the Hanford formation is a Pleistocene, cataclysmic flood and inter-flood deposit unit resulting from the Missoula Floods 15,000 to 12,000 years ago (SGW-38338). The Hanford formation can be loosely divided into three facies: gravel-dominated, sand-dominated, and slackwater (WCH-SD-EN-TI-011). In the 100 Areas, the gravel facies is most common. The gravel-dominated Hanford formation is highly basaltic, ranging from approximately 50% to 80% basalt (WHC-SD-EN-TI-011). Limited examples of in-situ Hanford formation (from outcrop or excavations have shown common open-framework textures.

Discrete sand lenses are present in the 100-D Area, which may form preferential flow paths or collection zones for vadose-zone contaminants (SGW-38338). Borehole logs have reported these sand lenses to be nearly 100% basalt (for example, at well 199-D4-96). However, WHC-SD-EN-TI-132 reports that in general, Hanford formation matrix sands in the vicinity of 100-HR-3 are less basaltic than elsewhere on the site.

Sediments of the Hanford formation within the 100-D Area are expected to extend to between 52 ft and 58 ft below bgs near the river and to between 43 and 47 ft bgs towards the southern end of the 100-D Area. North of the 100-D Area, the Hanford formation has been extensively eroded by the modern day Columbia and is expected to extend to only 8-12 ft bgs.

Disconformably underlying the Hanford formation, the Ringold Formation Unit E is composed of fluvial matrix-supported gravels and sands with intercalated fine to coarse sand and silt lenses. Unit E lithology is between 35% and 90% felsic consisting mainly of metamorphic, intermediate volcanics and felsic volcanics (WHC-SD-EN-TI-011). Silica and/or carbonate cementation is/are highly variable depending on depth and location.

The contact between the Hanford formation and Ringold Unit E can be difficult to distinguish. Borehole logs suggest that the Hanford forms a disconformable, gradational (i.e. reworked) contact with the Ringold Unit E, with felsic content and cementation increasing with depth. In general, Ringold Unit E gravels are more rounded, may be more cemented, and show a distinct oxidized brown color as compared to the Hanford formation (WCH-SD-EN-TI-132). Ringold Unit

E is mostly absent east of the 100-D Area, except for isolated erosional remnants throughout the Horn area. Where Unit E does not exist, the Hanford formation sediments directly overlay the Ringold Upper Mud (RUM).

The RUM is primarily composed of variably cemented overbank flood deposits and paleosols. Primarily composed of silt and clay, the RUM is typically described as various shades of brown to olive-brown. Within the RUM, thin sand-to-gravel lenses form discontinuous confined-to-semi-confined aquifers. The RUM is expected to be encountered between 90 and 110 ft bgs in the vicinity of 100-D Area. North of the 100-D Area, the RUM unit is expected to be encountered between 40 and 60 ft bgs (Table 2-1). At some locations in the 100-HR-3 area, the lower Hanford formation contains isolated but numerous rip-up clasts of the RUM (WCH-SD-EN-TI-132). Drilling 7 ft into the RUM should confirm that the lower confining layer has been reached, as opposed to an isolated rip-up clast.

No boreholes in this project are expected to encounter any units below the RUM.

Table 2-1. Estimated Depths to Contacts.

Well ID	Well Name	Depth to Water (ft bgs)	Depth to Ringold Upper Mud (ft bgs)	Planned Total Depth (ft bgs)
C7580	199-D4-101	80.5	99.0	106.0
C7582	199-D8-97	71.6	92.5	99.5
C7583	199-D5-101	81.7	100.0	107.0
C7589	199-D8-95	74.8	96.0	103.0
C7590	199-D5-130	78.3	93.0	100.0
C7591	199-D5-127	81.8	100.5	107.5
C7592	199-D6-1	84.8	98.0	105.0
C7593	199-D8-99	58.4	81.0	88.0
C7594	199-D7-4	49.7	69.0	76.0
C7599	199-D7-3	55.2	77.5	84.5
C7600	199-D5-129	82.4	94.0	101.0
C7601	199-D5-131	82.0	103.0	110.0
C7602	199-D8-98	62.3	82.0	89.0
C7603	199-D8-96	71.3	92.0	99.0
C7607	199-D6-2	50.6	67.0	74.0
C7608	199-D7-5	42.2	61.5	68.5
C7611	199-D7-6	21.2	40.5	47.5
C7612	199-D5-128	80.8	103.0	110.0

Table 2-1. Estimated Depths to Contacts.

Well ID	Well Name	Depth to Water (ft bgs)	Depth to Ringold Upper Mud (ft bgs)	Planned Total Depth (ft bgs)

Notes:

bgs = below ground surface
ft = feet
ID = Identification

Hydrogeology

The vadose zone at the project location is composed of Holocene material and the sands, gravels and boulders of the Hanford formation. The unconfined aquifer beneath the project area is found within the Hanford formation and within Unit E of the Ringold Formation. Unit E pinches out east of the 100-D Area and reappears as thin remnants throughout the remainder of the "Horn" area. The base of the unconfined aquifer is silt and silty clay of the RUM.

Depths to groundwater for the new wells are specified in Table 2-1. The depth to groundwater at the new wells is expected to range from 50 ft to 85 ft bgs throughout the 100-D Area and 20 ft and 25 bgs north of the 100-D Area. All depths and thicknesses are estimates and may vary due to the nature of the depositional/erosional environment along the riverbank as well as seasonal and diurnal fluctuations in the water table.

2.3 Contaminants of Potential Concern

The primary contaminant of concern identified in the ROD for 100-HR-3 is hexavalent chromium (EPA et al. 1996). Concentrations of hexavalent chromium measured in the groundwater of the unconfined aquifer for the area northeast of the 100-D Area range from 27 to 33 µg/L.

Besides hexavalent chromium, known groundwater contaminants in the 100-HR-3 OU include strontium-90, technetium-99, nitrate, and tritium (Hanford Site Groundwater Monitoring for Fiscal Year 2005 [PNNL-15670]). Sulfate is monitored in the vicinity of the ISRM barrier in the 100-D Area because it is a by-product of the redox reaction, but is not considered a contaminant. Table 2-2 lists the contaminants of potential concern for both the soil and groundwater related to the RPO expansion.

Table 2-2. List of Contaminants of Potential Concern.

Soil			
Radionuclides	Non-radionuclides		
Barium-133 Cesium-137 Cobalt-60 Europium-152 Europium-154 Europium-155 Strontium-90	Antimony Arsenic Barium Beryllium Boron Cadmium Chromium (VI)	Chromium (III) Copper Lead Lithium Manganese Molybdenum Nickel	Selenium Silver Thallium Vanadium Zinc
Groundwater			
Radionuclides	Non-radionuclides		
Strontium-90 Technetium-99 Tritium Total alpha Total beta Total gamma	Antimony Barium Beryllium Cadmium Chloride Chromium (VI) Chromium (III) Calcium	Copper Cobalt Fluoride Iron Magnesium Manganese Potassium Nickel	Nitrate Nitrite Sodium Silver Strontium Sulfate Vanadium Zinc

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3 DESCRIPTION OF WORK ACTIVITIES

Activities to be conducted at each well site include site preparation, drilling, sampling, well construction, and well development. All activities described in this document will be conducted in accordance with the guidelines and requirements set forth in Drilling, Remediating, and Decommissioning Resource Protection Wells, and Geotechnical Soil Borings (GRP-EE-02-14) and shall conform to minimum resource protection well standards as defined in Washington Administrative Code (WAC) 173-160, "Minimum Standards for Construction and Maintenance of Wells" (WAC 173-160). A legal record of well site activities will be maintained by a third-party field geologist and recorded in daily field activity reports.

3.1 Well Site Preparation

Each well site will be surveyed, staked and assigned a unique well number. A preliminary cultural resource and ecologic site assessment will be performed for each well site prior to commencement of work, as described in Section 1. Radiological soil surveys will be performed prior to drill pad and access road construction. Ground penetrating radar (GPR) surveys will also be conducted as necessary and excavation permits will be obtained as part of site preparation prior to drilling. A drill pad of sufficient size for operations and limited access roads will be constructed as necessary for each well. Due to the cultural and biological sensitivities adjacent to planned drill sites, all vehicle traffic will be restricted to existing roads and gravel pads.

3.2 Drilling

Prior to the start of the project and between each well, all down-hole equipment will be high temperature/pressure washed (180° F at >1000 psi) to minimize potential cross-contamination. The nominal casing diameter for the boreholes at total depth (TD) shall be no less than 10 inches to allow completion of a 6-inch diameter well. This assures that the wells retain a minimum 2-inch annulus as called for under WAC 173-160.

All wells will be drilled 7 ft into the RUM to allow completion of an injection or extraction well that screens the entire thickness of the unconfined aquifer. Estimated total drilling and construction depths are presented in Table 3-1 in Section 3.4. The actual TD of the wells will be determined by CHPRC's field geologist or hydrogeologist and may vary from anticipated depths depending on the hydrogeologic conditions encountered.

Drilling aids such as bentonite, other clay-based agents, water, or any foreign matter capable of affecting the characteristics of the sediment samples or ground water will not be placed in the well without prior approval of CHPRC. Lubricants used on down-hole equipment shall be environmentally compatible; hydrocarbon based lubricants are not acceptable.

The drilling contractor will be responsible for performing a straightness test prior to beginning well completion as called for under WAC 173-160. The test will be conducted by running a 20-ft-long section of pipe that is a diameter 1-in smaller than the inner diameter of the temporary

casing to the bottom of the boring. The pipe must freely pass without binding to declare the well straight. The test for straightness shall be made in the presence of the CHPRC Buyer's Technical Representative (BTR) or delegate.

Drilling activities for all RPO wells have been evaluated to pose both low radiological and chemical risk based on the site history, sampling of nearby waste sites and existing wells. Radiological-control and industrial hygiene support are anticipated to consist of daily "AM/PM" checks as long as current radiological and chemical risks remain unchanged.

3.3 Sampling Requirements

All data collection requirements for this project meet the requirements established by DOE/RL-2009-09, *Sampling and Analysis Plan for Installation of 100-HR-3 Groundwater Operable Unit Remedial Process Optimization Wells*. A summary of planned sampling is presented in Table 3-1.

Grab samples for archive purposes will be collected from drill cuttings every 5 feet and at changes in lithology or at depths where unusual conditions are encountered (as determined by the field geologist) for lithologic descriptions from surface to total depth. Archive grab samples will be collected in one-pint glass jars and chip trays. Borehole logs shall follow the specifications in GRP-EE-01-7.0, *Geologic Logging*.

Two geologic samples of aquifer soils will be collected during borehole installation for physical property of grain-size distribution (sieve analysis) testing to provide location-specific soil property data. Samples will be collected from the upper and lower halves of the aquifer at depths determined by CHPRC's field geologist. A split-spoon for collecting sieve analysis samples will only be necessary if the drilling method prevents an accurate sample of the lithology to be sampled.

One split spoon sample will be collected from each borehole from the uppermost RUM, at the contact between the aquifer and confining layer. Additionally, to support 100-D decision area remedial investigation (RI) needs, two of the eighteen wells will undergo more extensive sampling (Table 3-1). In addition to the split spoon collected at the RUM contact, four supplementary split spoons will be collected from wells 199-D7-5 (C7608) and 199-D5-128 (C7612). The five samples will be collected from the following intervals:

- Approximately 2 ft above the water table. This sample is targeted at the periodically re-wetted zone, which may be an area where contamination migrates.
- The upper half of the aquifer
- The lower half of the aquifer
- The uppermost RUM soil (common to all boreholes)
- Approximately 5 ft into the RUM to TD (approximately 7 ft into the RUM)

If a split spoon sample cannot be successfully collected due to the drilling conditions (i.e., the presence of oversize cobbles, etc), a field decision to collect a grab sample (in addition to the previously collected split-spoon sample) can be made by the CHPRC project lead. Alternatively, an additional split-spoon may be driven at the next available depth interval. Supplementary geologic split-spoon samples may be requested by CHPRC's field geologist at any time in order to better catalog the lithology of the borehole, particularly to clarify the depth of contacts.

A pumped groundwater sample will be collected from each completed well following final development as determined by the onsite geologist. If the well is developed in multiple intervals, the sample will be collected from the final interval. The sample may not be collected before three well volumes have been purged and water chemistry has stabilized within 10% variance over three consecutive measurements (GRP-EE-01-4.1, *Groundwater Sampling)*.

No geophysical logging will be performed at these boreholes.

Table 3-1. Summary of 100-D Well Sampling (2 sheets).

Well ID	Geologic Grab Sample	Sieve Analysis Grab Sample	Split-Spoon Sample Location	Water sample
C7580	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7582	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7583	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7589	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7590	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7591	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7592	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7593	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7594	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7599	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7600	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7601	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7602	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development

Table 3-1. Summary of 100-D Well Sampling (2 sheets).

Well ID	Geologic Grab Sample	Sieve Analysis Grab Sample	Split-Spoon Sample Location	Water sample
C7603	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7607	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7608[RI]	5 ft intervals	Upper Aquifer Lower Aquifer	2 ft above WT upper aquifer lower aquifer RUM contact 5 ft into RUM	post-development
C7611	5 ft intervals	Upper Aquifer Lower Aquifer	RUM contact	post-development
C7612[RI]	5 ft intervals	Upper Aquifer Lower Aquifer	2 ft above WT upper aquifer lower aquifer RUM contact 5 ft into RUM	post-development

Notes:

[RI] Remedial Process Optimization well sampled to meet 100-D/H decision unit remedial investigation (RI) data needs

ft = foot

ID = identification

RUM = Ringold Upper Mud unit

WT= Water Table

3.4 Well Construction

Well construction shall meet the minimum standards for resource protection wells required by WAC 173-160 unless a state approved variance is obtained. Table 3-2 provides a summary of anticipated well construction parameters. The proposed well design is illustrated in Figure 3-1.

3.4.1 Well Specifications

All wells shall be constructed of nominal 6-in, Schedule 10, Type 304/304L or 316/316L stainless steel with flush-joint design and Viton[1] O-rings. The length of casing and screen in each well will vary based on the TD and static water level in each boring. Well screens shall be of V-slot, continuous-wire-wrap design. Screen slot size will be determined by CHPRC's Science Lead based on sieve analysis. Anticipated screen lengths are 20 ft, but will be determined by CHPRC's science lead. Final screen placement will be at the direction of the BTR and/or CHPRC's field geologist. The sump will be 5 ft with a closed end cap.

An environmentally-compatible non-petroleum lubricant, such as Jet-Lube Well-Guard® thread compound [2] or an equivalent may be used for lubricating the stainless steel threads. Stainless steel centering guides (centralizers) shall be placed both above and below the well screen and at 40-foot intervals above the top of the screen, unless dual-wall temporary casing is used.

3.4.2 Annular Seal and Filter Pack

The filter pack will be of Colorado silica sand and extend from below the sump to 5 ft above the top of the screen. Mesh size will correspond to the chosen screen size. The filter pack shall be placed in no more than 10 ft intervals and surged aggressively, as described in Section 3.5, "Well Development."

Overlying the filter pack will be a seal of bentonite pellets a minimum of 1.5 ft thick. Granular bentonite will be used to fill the remaining annular space to 10 ft bgs, the contact with the surface seal. A non-shrinking surface seal consisting of neat grout cement will be installed from 10 ft bgs to ground surface.

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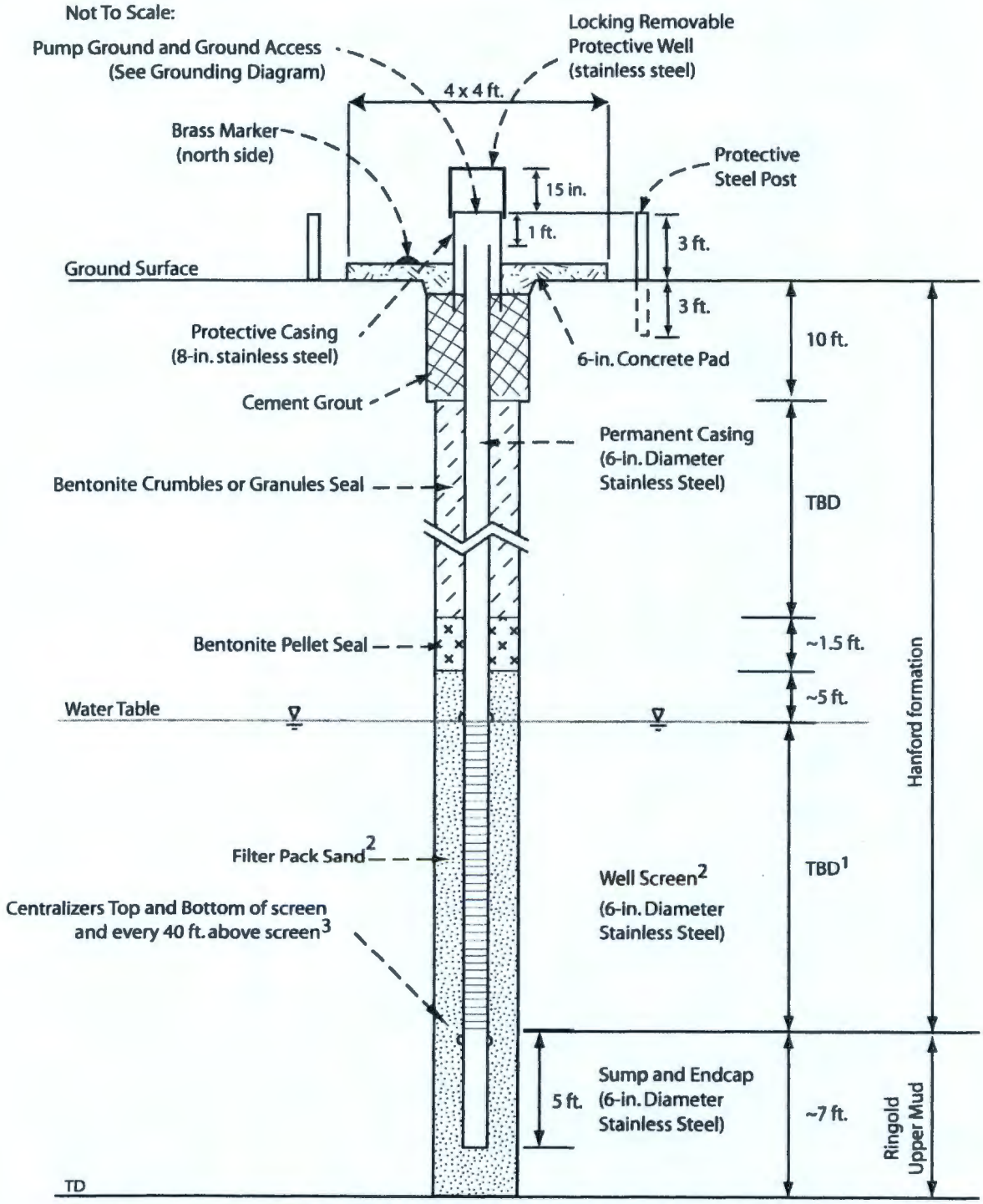
[1] Viton is a registered trademark of E.I. du Pont de Nemours and Company, Wilmington, Delaware.

[2] Jet-Lube Well-Guard® is a registered trademark of Jet-Lube, Inc. of Houston, TX.

Table 3-2. Well Construction Parameters

Well ID	Well Name	Depth to Water (ft bgs)	Drill depth (ft bgs)	Screen Interval (ft bgs)	Filter Pack Interval (ft bgs)	Bentonite Pellet Seal Interval (ft bgs)	Bentonite Crumble Seal Interval (ft bgs)	Concrete Surface Seal Interval (ft bgs)
C7580	199-D4-101	80.5	106.0	99.0 - 80.5	106.0 - 75.5	75.5 - 74.0	74.0 - 10.0	10.0 - 0.0
C7582	199-D8-97	71.6	99.5	92.5 - 71.6	99.5 - 66.6	66.6 - 65.1	65.1 - 10.0	10.0 - 0.0
C7583	199-D5-101	81.7	107.0	100.0 - 81.7	107.0 - 76.7	76.7 - 75.2	75.2 - 10.0	10.0 - 0.0
C7589	199-D8-95	74.8	103.0	96.0 - 74.8	103.0 - 69.8	69.8 - 68.3	68.3 - 10.0	10.0 - 0.0
C7590	199-D5-130	78.3	100.0	93.0 - 78.3	100.0 - 73.3	73.3 - 71.8	71.8 - 10.0	10.0 - 0.0
C7591	199-D6-127	81.8	107.5	100.5 - 81.8	107.5 - 76.8	76.8 - 75.3	75.3 - 10.0	10.0 - 0.0
C7592	199-D6-1	84.8	105.0	98.0 - 84.8	105.0 - 79.8	79.8 - 78.3	78.3 - 10.0	10.0 - 0.0
C7593	199-D8-99	58.4	88.0	81.0 - 58.4	88.0 - 53.4	53.4 - 51.9	51.9 - 10.0	10.0 - 0.0
C7594	199-D7-4	49.7	76.0	69.0 - 49.7	76.0 - 44.7	44.7 - 43.2	43.2 - 10.0	10.0 - 0.0
C75991	199-D7-3	55.2	84.5	77.5 - 55.2	84.5 - 50.2	50.2 - 48.7	48.7 - 10.0	10.0 - 0.0
C76001	199-D5-129	82.4	101.0	94.0 - 82.4	101.0 - 77.4	77.4 - 75.9	75.9 - 10.0	10.0 - 0.0
C76011	199-D5-131	82.0	110.0	103.0 - 82.0	110.0 - 77.0	77.0 - 75.5	75.5 - 10.0	10.0 - 0.0
C76021	199-D8-98	62.3	89.0	82.0 - 62.3	89.0 - 57.3	57.3 - 55.8	55.8 - 10.0	10.0 - 0.0
C76031	199-D8-96	71.3	99.0	92.0 - 71.3	99.0 - 66.3	66.3 - 64.8	64.8 - 10.0	10.0 - 0.0
C76071	199-D6-2	50.6	74.0	67.0 - 50.6	74.0 - 45.6	45.6 - 44.1	44.1 - 10.0	10.0 - 0.0
C76081	199-D7-5	42.2	68.5	61.5 - 42.2	68.5 - 37.2	37.2 - 35.7	35.7 - 10.0	10.0 - 0.0
C76111	199-D7-6	21.2	47.5	40.5 - 21.2	47.5 - 16.2	16.2 - 14.7	14.7 - 10.0	10.0 - 0.0
C76121	199-D5-128	80.8	110.0	103.0 - 80.8	110.0 - 75.8	75.8 - 74.3	74.3 - 10.0	10.0 - 0.0

Figure 3-1. Generalized Well Design for New Wells



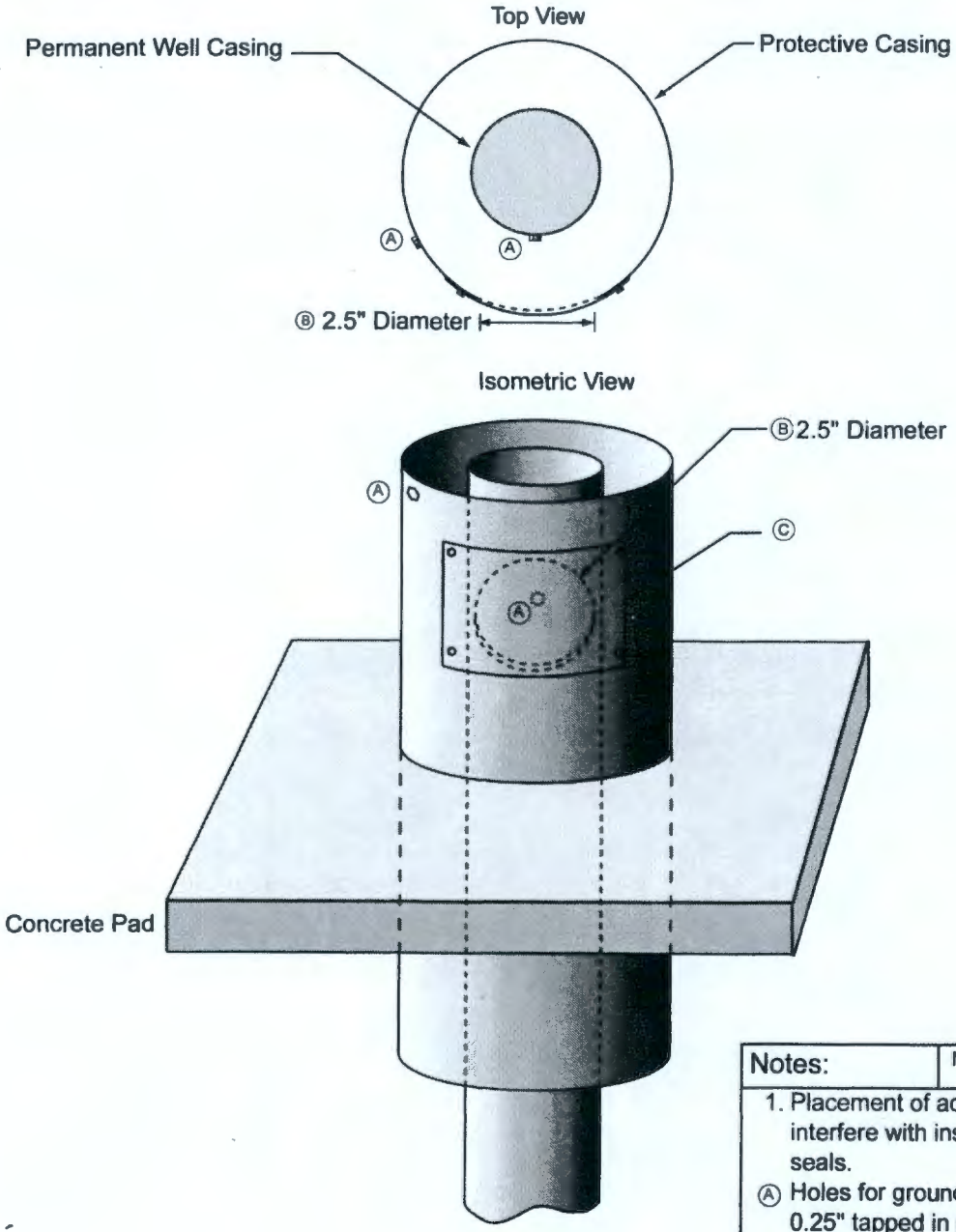
1 = Screened interval and filter pack interval will be determined upon field screening results; Screen length will be 20 feet unless determined otherwise by CHPRC Science Lead.
2 = Screen slot size and filter pack mesh will be determined upon field sieve results.
3 = Centralizers shall be placed at the top and bottom of the screen in addition to every 40 feet above the screen; however, if the screen is greater then or equal to 35 ft long, then centralizers shall be placed at the top and bottom of the screen and at 20 ft intervals throughout the screen.

3.4.3 Surface Construction

Surface protection for each well will be installed in accordance with WAC 173-160-420, GRP-EE-02-14.1, and the design specified in the Contract Release. As shown in Figure 3-1, a minimum 8-in diameter stainless steel protective casing will be placed from 3 ft above ground surface (ags) to 2 ft bgs with a lockable cap extending 15 in above the protective casing. The protective casing will have a grounding access port with removable cover installed on its north side and other features as designated in Figure 3-2 and by the Contract Release. The permanent casing will rise approximately 2 ft ags, or to 1 ft below the top of the protective casing.

A 4- by 4- by 0.5-ft concrete pad will be placed around the well monument. This pad will be labeled on the north side by a 3-in domed brass survey marker stamped with the well identification number, well name, and completion date. Four protective posts will surround the pad, extending to 3 ft ags. The fourth post will be removable for well access. Posts will be painted yellow as specified in the Contract Release.

Figure 3-2. Well Head Design: Access Panel and Grounding Lug Placement



Notes:	Not to Scale

1. Placement of access must not interfere with installation of well seals.

Ⓐ Holes for ground lugs to be 0.25" tapped in permanent and protective casings.

Ⓑ Access hole to be cut into permanent casing.

Ⓒ Access cover of sheet metal to be be fastened with bolts or screws.

3.5 Well Development

The objectives of well development are to settle the filter pack, prevent uncontrolled infiltration of fines and ensure communication of the well with the surrounding formation. Well development will be conducted in two stages with initial development performed during well completion and final development performed after the wells have been constructed. Well development activities are directed toward ensuring adequate aquifer communication without causing excessive agitation of the aquifer to avoid potential aeration of the formation.

3.5.1 Initial Well Development

Initial development will be performed during well completion in conjunction with placement of the filter pack. Surging using a dual-flange surge block both settles the filter pack and begins to pull drilling-generated fines from the borehole wall to develop communication with the aquifer. Combining surging with the sand pack placement will provide an abrasive action on the borehole wall that will enhance borehole efficiency.

Surging should be carried out in no greater than 10-ft intervals. Fines will be removed from the well as necessary using a sand pump or similar apparatus. A dart bailer is not recommended for this process because the use of a dart bailer runs an increased risk of puncturing the bottom the well. As a general guide, surging can be considered complete when the filter pack sand level settles no more than 0.1 feet within 15 minutes. Surging will continue until CHPRC's field geologist confirms completion of the initial development.

3.5.2 Final Well Development

Final well development and pump installation will not be started sooner than 12 hours following placement of the surface seal and protective casing are, but must take place within two weeks of installation of the well screen/casing.

Prior to setting the pump, the well should be bailed of any fill present. A pump capable of producing 10 to 100 gallons per minute (gpm) at the well head should be installed at a depth chosen by CHPRC's field geologist and/or science lead; generally, the pump should be installed as low as possible to maximize the available water column. The drilling subcontractor must provide a valve for water sampling at the pump manifold and an accurate flow meter. The on-site geologist will monitor the development using a pressure transducer and data logger or similar device and/or an electronic probe, depending on circumstances encountered during the development process.

If the screen is greater than 20 ft long, the well should be developed in 2 or more intervals. Development should ideally take place at the highest sustainable pumping rate depending on constraints like purgewater disposal capacity. Fifty percent or greater drawdown is desirable. Pumping will continue until physical parameters including pH, conductivity, and temperature have stabilized and the turbidity has decreased to $\leq$5 nephelometric turbidity units (NTU), based on measurement using calibrated field instruments. During recovery monitoring, the pump and all down-hole monitoring equipment must remain in place. Recovery monitoring generally takes at least 30 minutes per final development stage.

The field geologist shall determine when development is complete in accordance with GRP-EE-01-6.3, "*Well Development and Testing*." Should these conditions not be met, CHPRC's field geologist, sampling lead, and BTR shall consult with CHPRC's science lead to determine the conditions for adequate development.

4 WASTE MANAGEMENT

Waste generated during the activities described in this document will be managed according to the *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units* (DOE/RL-97-01), [WASTE DQO], and a site-specific Waste Packaging/Labeling Instruction Sheet (WP/LIS). Vadose- and saturated-zone miscellaneous waste will be placed in containers and disposed based on field-screening results as stated in the site-specific WP/LIS.

4.1 Vadose Zone Waste

Vadose zone cuttings will be placed on plastic sheeting near the well head and periodically surveyed for radiological contamination. If surveys detect contamination, the soil will be sampled and analyzed prior to disposition; otherwise, the soil will be released to the environment and spread at the well head in accordance with the site-specific WP/LIS.

Vadose zone miscellaneous solid waste (MSW) will be placed in containers and disposed of based on field-screening results as stated in the site-specific WP/LIS.

4.2 Groundwater-Contacted Waste

Groundwater-contacted waste, defined as any cuttings below the historic high water mark for each well, will be containerized in drums and periodically surveyed in order to verify that the cuttings are not contaminated at levels greater than the instrument(s) sensitivity. Purgewater from containerized cuttings will be decanted and stored at the wellhead until transported to the Purgewater Storage and Treatment Facility (PSTF). The saturated soils will be sampled and analyzed prior to disposition in accordance with the site-specific WP/LIS; however, at no time will saturated soils be eligible for release to the environment, regardless of survey results.

Groundwater-contacted MSW will be placed in containers and disposed of based on field-screening results as stated in the site-specific WP/LIS.

4.3 Purgewater

Purgewater will be designated based on process knowledge and collected and contained at the well head until it is either transported to the PSTF, or, if waste acceptance criteria can be met, the Effluent Treatment Facility (ETF). Purgewater, groundwater samples, and decontamination fluids generated during well drilling, sample screening, and analysis will be managed as Purgewater in accordance with the guidance provided in "Strategy for Handling and Disposing of Purgewater at the Hanford Site, Washington" (90-ERB-040).

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5 QUALITY ASSURANCE

CHPRC-issued document "Quality Assurance Program" (PRC-MP-QA-599), describes how CHPRC implements the quality assurance (QA) requirements conveyed in U.S. Department of Energy Order 414.1C (*Quality Assurance*) and "Nuclear Safety Management" (10 *Code of Federal Regulations* [CFR] 830.121). PRC-MP-QA-599 also shows how the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) and *Hanford Analytical Services Quality Assurance Requirements Document (HASQARD)* (DOE/RL-96-68) apply to Environmental QA Program Plans. CHPRC has also issued *Environmental Quality Assurance Plan* (CHPRC-00189). All CHPRC employees and subcontractors performing environmental cleanup activities are responsible for performing work in accordance with the requirements set forth in CHPRC-00189.

All work performed under this DOW will be performed in compliance with Project Hanford Management System overall QA program design (PRC-MP-QA-599). A project specific QA Program plan for the Soil & Groundwater Remediation Project scope is presented in Appendix C of CHPRC-00189.

All operations including drilling, sampling and well completion/decommissioning, testing and associated documentation are subject to surveillance by CHPRC, CHPRC's authorizing agent and/or owner. This surveillance shall in no way relieve the contractor of any contractual responsibilities. Note the term "surveillance" as used here may include inspection, survey, and/or assessment. The drilling contractor will implement a QA program as submitted and approved under the drilling master agreement.

Commercially available tape measures and electronic depth sounders shall have an accuracy of +/- 0.1 ft in 300 ft as required by CHPRC procedure GRP-FS-04-G-005, *Control of Monitoring Instruments* and will be used to make depth and length measurements to +/- 0.01 ft tolerance while drilling and completing the well. The surface of the ground adjacent to the borehole will be used as the "ground surface" reference for depth measurements. The elevation of the brass marker on the concrete well pad and the top of the protective casing will be surveyed after the well has been completed. A correlation of the measurements made while drilling to the surveyed elevation will be included in the final report (Section 8.0).

Technical procedures to be followed are listed in Section 7.2 of this document.

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6 SCHEDULE

Drilling, sampling, and well construction operations for those wells deemed NPE by the SHPO are scheduled to begin by DATE. Activities for the remaining wells will occur at a later date upon well location approval from the CRR process.

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7 GENERAL REQUIREMENTS

Field work for the wells will be conducted in accordance with existing CHPRC procedures and protocols and the specifications set forth in this DOW. The applicable procedures are discussed in the following sections.

7.1 SAFETY AND HEALTH

All personnel working at the drilling sites addressed by this plan will have completed, at a minimum:

- Occupational Safety and Health Administration Act 40-hour Hazardous Waste Site Worker training program (29 CFR 1910.120).
- CHPRC General Employee Training (CGET).
- Hanford Radiation Worker II training.

Work will be performed in accordance with the following procedures:

- CHPRC-00073, *"CHPRC Radiological Control Manual"*
- Site specific plans, as applicable:
  - Health and safety plans
  - Radiological evaluation/radiation work permits
  - Activity hazard analysis/job safety analysis
  - Site-specific Waste Packaging Instruction
- CHPRC procedures
- Soil and Groundwater Remediation Project Radiological Control Procedures
- CHPRC Environmental Procedures

7.2 TECHNICAL PROCEDURES/SPECIFICATIONS

This section identifies technical procedures/specifications applicable to field activities performed under this DOW. Activities associated with the drilling and installation of these wells and management of waste generated by these activities will adhere to, at a minimum, the following procedures and requirements:

- GRP-EE-01-1.11, *"Purgewater Management"*
- GRP-EE-01-3.0, *"Chain of Custody"*
- GRP-EE-01-3.1, *"Sample Packaging and Shipping"*
- GRP-FS-04-G-029, *"Non VOC Soil and Sediment Sampling"*
- GRP-FS-04-G-030, *"VOC Soil and Sediment Sampling"*
- GRP-EE-01-4.1, *"Groundwater Sampling"*

- GRP-FS-04-G-028, *"Field Characterization & Treatment Monitoring Activities Groundwater Sampling"*
- GRP-EE-01-6.2, *"Field Cleaning and/or Decontamination of GeoProbe® and Drilling Equipment"*
- GRP-EE-01-6.3, *"Well Development and Testing"*
- GRP-EE-01-7.0, *"Geologic Logging"*
- GRP-EE-02-14.1, *"Drilling, Remediating, and Decommissioning Resource Protection Wells, and Geotechnical Soil Borings"*
- GRP-EE-05-1.21, *Particle Size Distribution of Soil-Wet Sieve Analysis*
- HNF-EP-0063, *"Hanford Site Solid Waste Acceptance Criteria"*
- PRC-PRO-IRM-10863, *"Control of Notebooks and Logbooks"*
- PRC-PRO-EP-15333, *"Environmental Protection Processes"*
- PRC-PRO-EP-15334, *"Effluent and Environmental Monitoring"*
- PRC-PRO-EP-15335, *"Environmental Permitting and Document Preparation"*
- PRC-RD-EP-15332, *"Environmental Protection Requirements"*
- WAC 173-160, *"Minimum Standards for Construction and Maintenance of Wells"*

8 PROJECT DOCUMENTATION

Documentation requirements for these activities are separated into scoping documents, field activity documents, and reporting documents. The following documents will be prepared to support the well drilling activity:

Scoping Documents

- DOW (this document)
  - Drilling specifications/subcontractor scope of work (procurement package)
  - Excavation permit
  - Site-specific WPLIS
  - Additional waste management documents, as required
- Field Documentation
  - Well Drilling/Decommissioning Planning form
  - Daily Field Activity Reports
  - Sample collection, custody, and shipment documentation for waste samples
  - Well logs (borehole, lithologic, and completion)
  - Field Logbook
  - Well Construction summary report
  - Well Summary sheet
  - Field Cleaning and/or Decontamination sheets
  - Well Development and Test data sheets
  - Sieve Analysis sheets
  - Well Survey Data Report
  - Well Acceptance Report
- Reporting Documents
  - Field documentation will be transmitted to Geoscience Support for incorporation into the well database
  - Borehole Summary Report
  - State of Washington Resource Protection Well Report (generated by driller)

The records produced for this project will undergo technical and management review in accordance with CHPRC practices and procedures. The required reviewers will be identified prior to document completion, and the review time will be established as soon as practical.

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9 REFERENCES

Groundwater Protection Program Procedures:

- GRP-FS-04-G-029, *"Non VOC Soil and Sediment Sampling"*
- GRP-FS-04-G-030, *"VOC Soil and Sediment Sampling"*
- GRP-FS-04-G-028, *"Field Characterization & Treatment Monitoring Activities Groundwater Sampling"*
- HNF-EP-0063, *"Hanford Site Solid Waste Acceptance Criteria"*
- PRC-PRO-IRM-10863, *"Control of Notebooks and Logbooks"*
- PRC-PRO-EP-15333, *"Environmental Protection Processes"*
- PRC-PRO-EP-15334, *"Effluent and Environmental Monitoring"*
- PRC-PRO-EP-15335, *"Environmental Permitting and Document Preparation"*
- PRC-RD-EP-15332, *"Environmental Protection Requirements"*
- GRP-FS-04-G-005, *"Control of Monitoring Instruments"*
- PRC-MP-QA-599, *"Quality Assurance Program"*
- GRP-EE-01-3.0, *"Chain of Custody"*
- GRP-EE-01-7.0, *"Geologic Logging"*
- GRP-EE-01-1.11, *"Purgewater Management"*
- GRP-EE-02-14.1, *"Drilling, Remediating, and Decommissioning Resource Protection Wells, and Geotechnical Soil Borings"*
- GRP-EE-05-1.21, *Particle Size Distribution of Soil-Wet Sieve Analysis*
- GRP-EE-01-3.1, *"Sample Packaging and Shipping"*
- GRP-EE-01-4.1, *"Groundwater Sampling"*
- GRP-EE-01-6.2, *"Field Cleaning and/or Decontamination of GeoProbe® and Drilling Equipment"*
- GRP-EE-01-6.3, *"Well Development and Testing"*

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DOE/RL-2009-09, Sampling and Analysis Plan for Installation of 100-HR-3 Groundwater Operable Unit Remedial Process Optimization Wells, Rev. 2, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-96-68, 2007, *Hanford Analytical Services Quality Assurance Requirements Document (HASQARD)*, Rev. 3, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL-97-01, 2005, *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units*, Rev. 5, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=91&parent=0.

EPA, Ecology, and DOE, 1996, *Declaration of the Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units at the Hanford Site (Interim Remedial Action)*, U.S. Environmental Protection Agency, Washington State Department of Ecology, and U.S. Department of Energy, Olympia, Washington.

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ARRA FY2010 Description of Work for the Installation of 18 Scenario 5 Remedial Process Optimization Wells for the 100-D Area, 100-HR-3 Operable Unit	S&GRP

Document Number: SGW-44089 **Revision/Change Number:** 0

DOCUMENT TYPE *(Check Applicable)* [ ] Plan [X] Report [ ] Study [ ] Description Document [ ] Other

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