

## **APPENDIX A**

### **WORK PLAN INVESTIGATIVE APPROACH**

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## LIST OF TERMS

bgs	below ground surface
CH2M HILL	CH2M HILL Hanford Group, Inc.
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
RCRA	Resource Conservation and Recovery Act
WAC	<i>Washington Administrative Code</i>
WMA	waste management area

## A.1.0 INTRODUCTION

This appendix summarizes the work plan for waste management area (WMA) B-BX-BY, *Site-Specific SST Phase 1 RFI/CMS Work Plan Addendum for WMA B-BX-BY* (Rogers and Knepp 2000). The activities defined in the work plan have been completed except for the near-surface characterization in the BX tank farm that is scheduled for May 2003.

Rogers and Knepp (2000) is intended to serve as guidelines for the work described and is designed to allow for changes depending on conditions encountered in the field. Any changes to the planned work were recorded on the appropriate field documentation, memoranda, or letters. Any modifications that did occur are addressed in Appendix B.

The activities performed in accordance with the work plan were as follows:

- Installation of new boreholes (299-E33-45 and 299-E33-46) near tanks BX-102 and B-110
- *Resource Conservation and Recovery Act* (RCRA) groundwater monitoring well sediment sampling and analyses.

The following sections discuss these activities.

## **A.2.0 BOREHOLES 299-E33-45 AND 299-E33-46**

Two new boreholes labelled 299-E33-45 and 299-E33-46 were installed northeast of tank BX-102 and north of tank B-110, respectively. The following activities were conducted at the new boreholes:

- Conducted borehole geophysical surveying and analyses (moisture, neutron, gross gamma, and spectral gamma) for stratigraphic correlation and selected contaminant distribution
- Obtained sediment samples to analyze for the presence and concentration of contaminants and to evaluate alterations of the sediments from waste chemistry effects
- Obtained sediment samples to support preparation of the borehole geologic logs and stratigraphic and lithologic contact correlation with other boreholes in the WMA B-BX-BY vicinity.

### **A.2.1 NEW BOREHOLE LOCATIONS**

A new borehole was drilled northeast of tank BX-102 within the BX tank farm. The location of this borehole is 30 m (100 ft) northeast of tank BX-102 as shown in Figure A.1. The boring extends from the surface to 79.9 m (262 ft) below ground surface (bgs) to allow for groundwater sampling.

An additional borehole was drilled north of tank B-110 within the B tank farm. The location of this borehole is 3 m (10 ft) north of tank B-110 as shown in Figure A.1. The boring extends from the surface to 80.6 m (264.4 ft) bgs to allow for groundwater sampling.

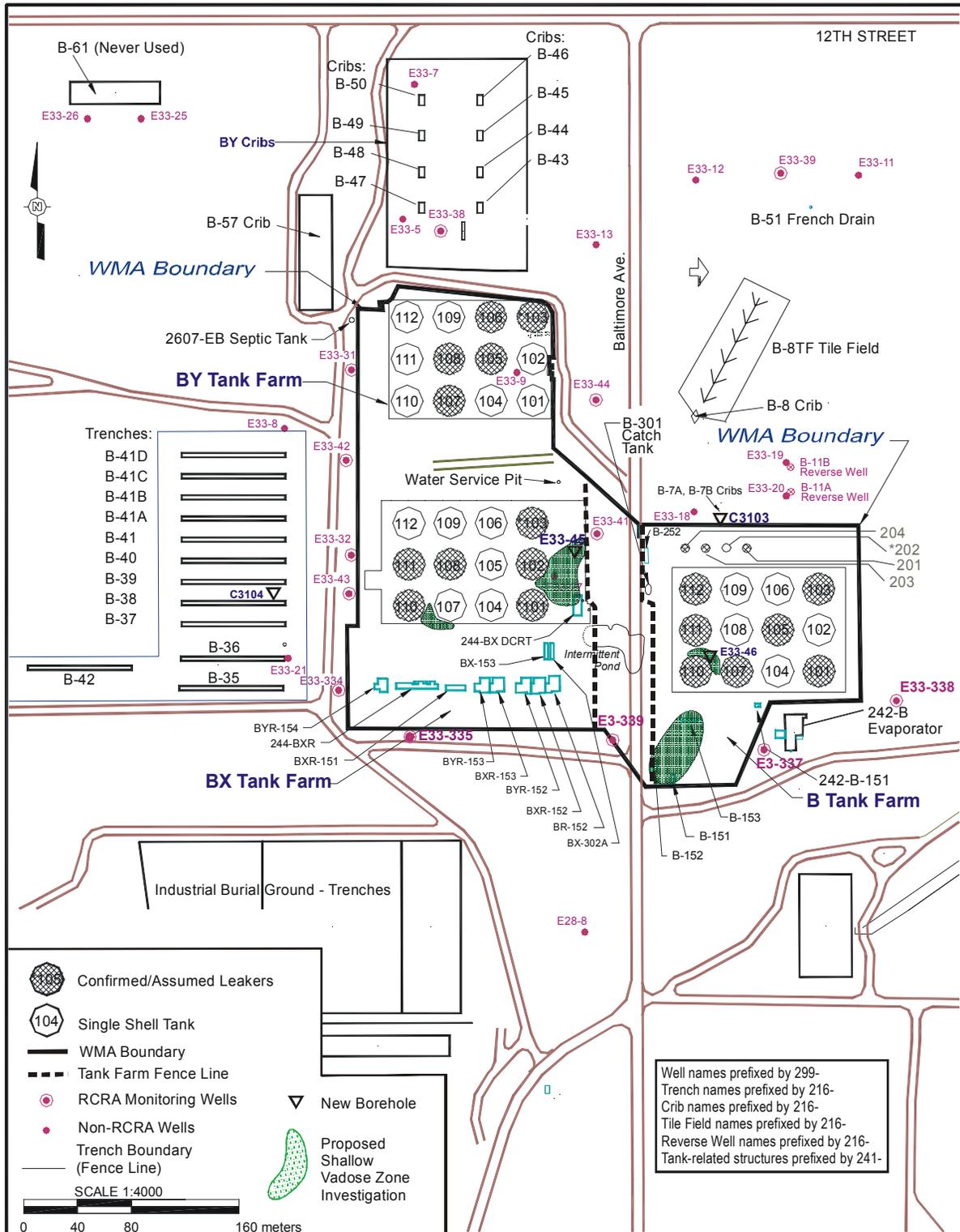
### **A.2.2 DRILLING AND SEDIMENT SAMPLING METHODS AND INTERVALS**

The following sections describe drilling and sediment sampling activities.

#### **A.2.2.1 Drilling Activities**

Drilling was conducted using specifications and guidance in accordance with “Minimum Standards for the Construction and Maintenance of Wells” (*Washington Administrative Code* [WAC] 173-160). Drilling operations conformed to SP 4-1, “Soil and Sediment Sampling”; WP 2-2, “Field Cleaning and/or Decontamination of Equipment” (ES-SSPM-001); and the task-specific work package that was generated for these field activities. The work package contained such information as borehole construction, sampling technique, and radiation protection. All waste was handled in accordance with the requirements of “Dangerous Waste Regulations” (WAC 173-303) and/or the site-specific waste control plan. These techniques are based on minimizing the exposure of field personnel to both radiation and chemical pollutants to as low as reasonably achievable and in compliance with regulatory requirements.

**Figure A.1. WMA B-BX-BY Borehole Sampling Locations, Near-Surface Characterization, and RCRA Groundwater Monitoring Wells**



Note: All wells are preceded by 299-.

Note: The intermittent pond between the B and BX tank farms has been addressed by interim measures.

Drilling was conducted using specifications and guidance in accordance with WAC 173-160. The technique for collecting sediment samples was a removable tip in conjunction with a splitspoon sampler that allowed driven samples to be collected ahead of the casing. The splitspoon sampler was approximately 5 cm (2 in.) in diameter by 0.6 m (2 ft) long with a 10 cm (4 in.) diameter shielded lead casing around the sampler. The hole was 10 cm (4 in.) in diameter after the sample was collected, but only a 5 cm (2 in.) sample was collected and brought to the surface. The 0.6 m (2 ft) sample allowed for the depth of penetration to be beyond potential disturbed sediments below the end of the hole and brought sediments unable to be handled to the surface. This method collected enough sediment sample to be analyzed and provided the least amount of disturbance, therefore providing a sample that was as close as possible to being a representative sample. The samples were transported to the laboratory and analyzed for the contaminants of concern.

Appropriate permits and compliance with the Notice of Construction permit (DOE-ORP 2001) were maintained during the drilling operations for inside the tank farm. The selected drilling method complies with the requirements of the Washington State Department of Health for the Notice of Construction permit and other pertinent requirements and appropriate engineering systems to prevent the possible contaminated air from being released to the environment.

Contaminant dragdown during drilling and sampling activities is unavoidable and has been observed in past sampling activities. Different drilling and sampling techniques impact dragdown to varying degrees. Because the objective of the characterization activities identified in the data quality objectives (Knepp 2000) was to safely sample in and below the contaminated zone in a region of known leakage and not to tag the leading edge of a contaminant plume, the dragdown issue was a secondary concern.

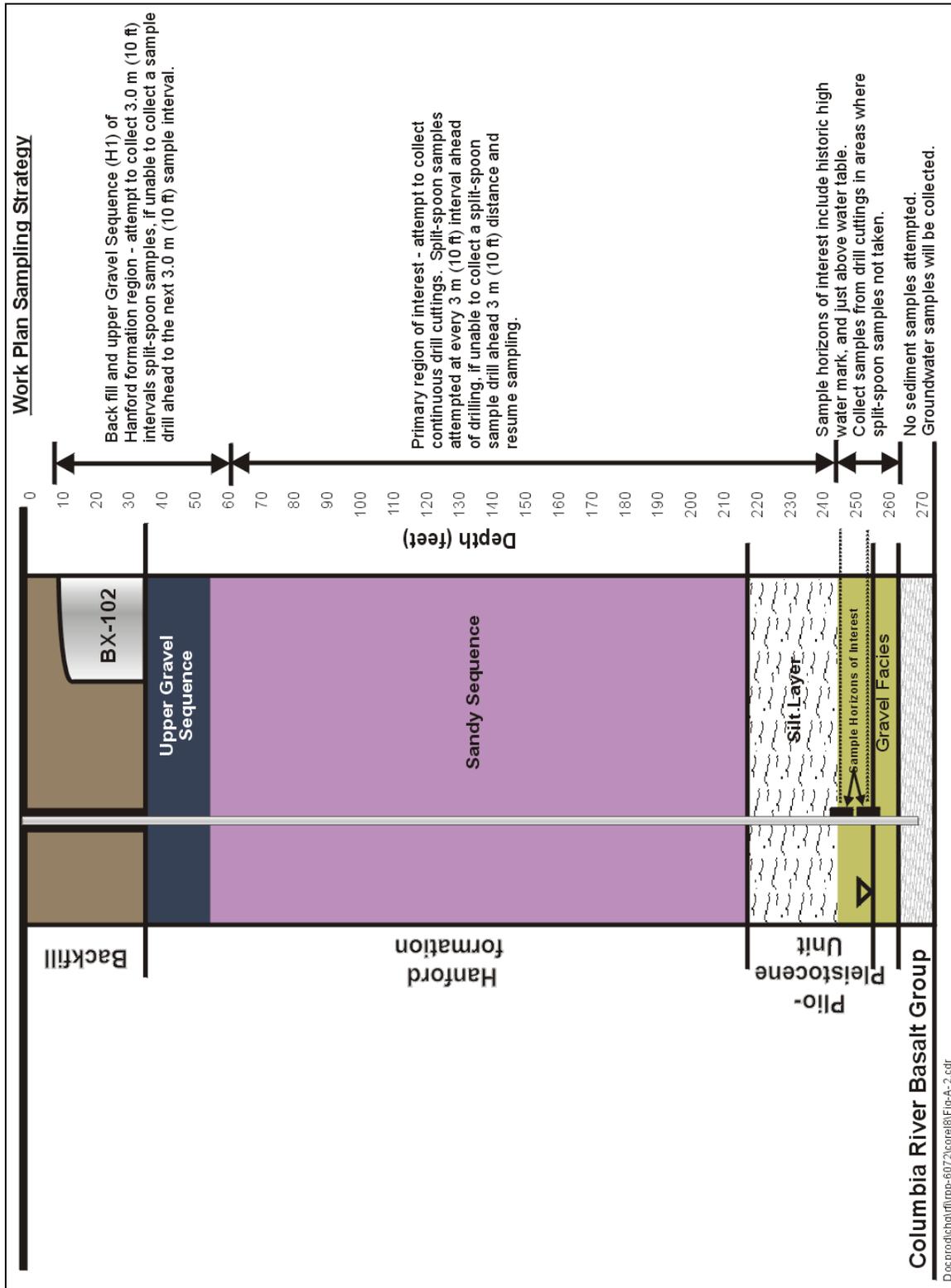
#### **A.2.2.2 Sediment Sampling Activities**

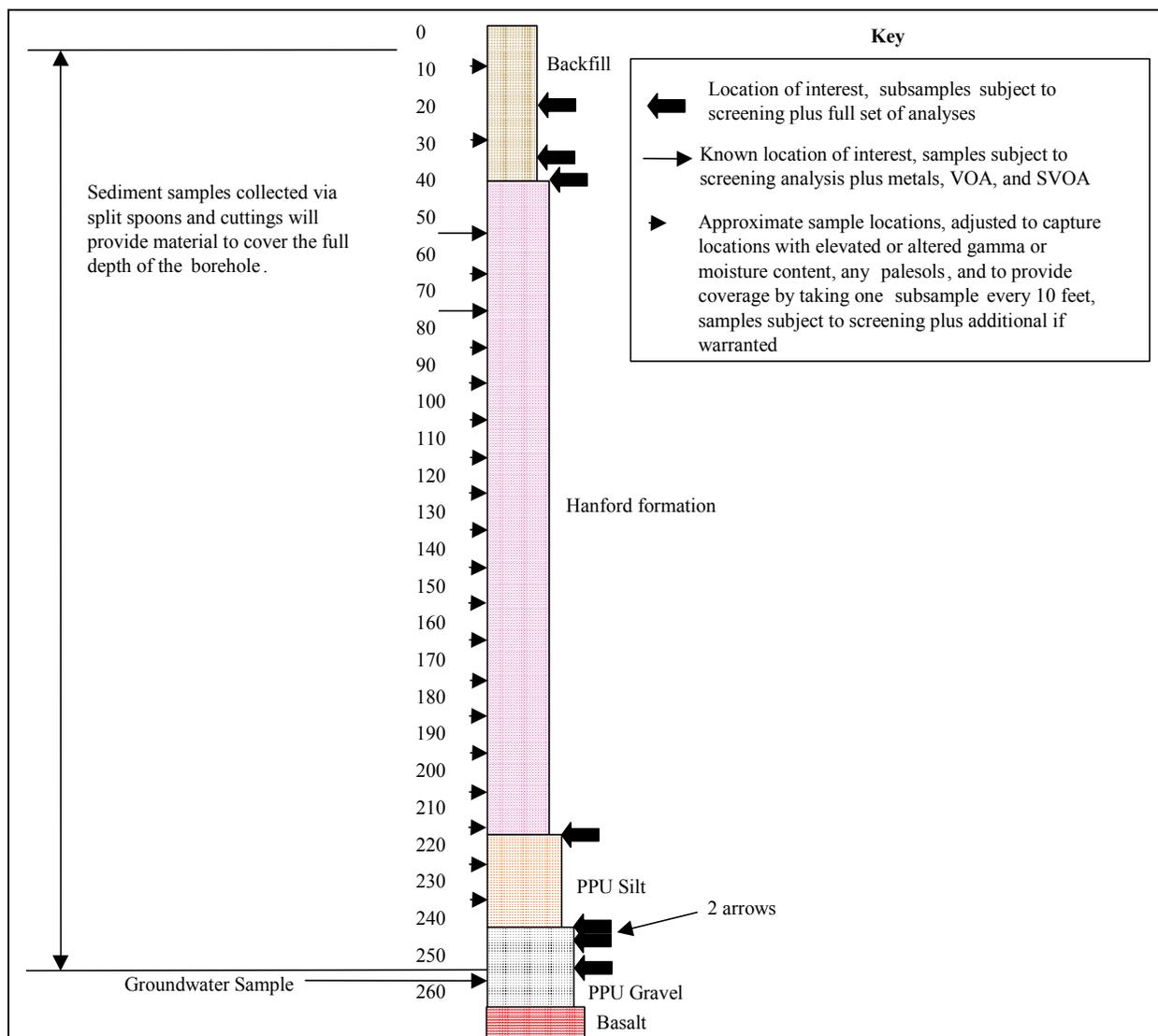
For borehole 299-E33-45, sediment sampling was conducted beginning at 3.0 m (10 ft) bgs and continued at discrete intervals of a minimum of 3.0 m (10 ft) to 79.9 m (262 ft) bgs. A total of 34 splitspoon samples were collected. For borehole 299-E33-46, sediment sampling was conducted beginning at 6.1 m (20 ft) bgs and continued at discrete intervals of a minimum of 3.0 m (10 ft) to 80.6 m (264.4 ft) bgs. Figure A.2 and Figure A.3 show the borehole location and sampling strategy.

After the sediment samples were screened, these samples were transported to the Pacific Northwest National Laboratory Applied Geology and Geochemistry Group for analysis. All material removed from the borehole was sent to the laboratory for possible future analysis. Samples were placed in airtight sample containers after their initial screening by health physics technicians and kept under refrigeration. This process was used to retain sediment moisture in as close to field condition as possible. All samples were transported to the laboratory under refrigeration to further limit alteration of sediment moisture.

Subsurface conditions are variable and the process of installing the vertical boreholes must be flexible. The work plan addendum (Rogers and Knepp 2000) served as a guideline and was designed to allow for changes depending on conditions encountered in the field. Any change was recorded on appropriate field documentation, memoranda, or letters. A complete documented record of activities was maintained for preparation of a final summary report.

Figure A.2. Sampling Strategy for New Boreholes



**Figure A.3. Boreholes BX-102 and B-110 Subsample Analyses Strategy**

Continuous drill cuttings were collected beginning after the first splitspoon sample was attempted. All splitspoon samples were collected in advance of the casing being driven. Standard techniques were used to remove that portion of the sediment column that remained in the drill casing once it was driven to the sample depth. The casing was driven to total sample depth at the end of the drilling effort each day to prevent potential borehole collapse. Splitspoon samplers were new or decontaminated before reuse. Procedures for decontamination of sampling equipment are contained in WP 2-2, "Field Cleaning and/or Decontamination of Equipment" (ES-WSPM-001).

A geologist prepared a geological log for the vertical boreholes based on the sediment samples. Borehole geologic logs were prepared in accordance with approved procedures. The geologic log included lithologic descriptions, sampling intervals, health physics technician hand-held instrument readings, screening results, evidence of any alteration of sediments, and general information and observations deemed relevant by the geologist to the characterization of

subsurface conditions. Sediment samples were screened with hand held instruments for radiation, as appropriate, using techniques and procedures defined in the work package. Screening results and general observations as to drilling progress and problems were included in each borehole log.

Waste containing unknown, low-level mixed radioactive material and/or hazardous material was contained, stored, and disposed of in accordance with Appendix D of *Phase 1 RCRA Facility Investigation/Corrective Measures Study Work Plan for Single-Shell Tank Waste Management Areas* (DOE-RL 2000) and specified in the quality assurance project plan (Appendix A of DOE-RL 2000). Waste was disposed of in accordance with Appendix D of DOE-RL (2000). All important information was recorded on field activity report forms according to approved procedures. The field activity report forms included borehole number, site location drawings, drawing of the downhole tool strings, site personnel, sampling types and intervals, zones noted by the health physics technician as elevated in radiological contaminants, instrument readings and the depth represented by those readings, and specific information concerning borehole completion.

Borehole 299-E33-45 was abandoned following completion of the geophysical surveying. All steel casing was removed and transferred to an appropriate disposal facility or controlled decontamination facility. The borehole was pressure-grouted from the bottom up using a Portland cement/bentonite slurry or other appropriate material in accordance with WAC 173-160. Specific procedures for borehole abandonment were documented in the field work package. These procedures comply with U.S. Environmental Protection Agency requirements and WAC 173-160.

Borehole 299-E33-46 was completed as a vadose zone monitoring well to allow for vadose zone water samples to be collected and analyzed. Specific procedures for completion are provided in Appendix B and were conducted in accordance with WAC 173-160.

### **A.2.3 BOREHOLE GEOPHYSICAL SURVEYING**

Based on sampling and construction methods, downhole spectral gamma or gross gamma geophysical logging was conducted to ascertain the gamma-emitting radionuclide concentrations.

A full suite of geophysical logs was run any time the casing size was changed and at the completion of the borehole. Because the sampling method involved pulling splitspoon samples up through the borehole, there was a high probability that the inner bore of the casing would become contaminated. Following completion of the sampling, the contamination levels were evaluated and a determination was made on the utility of geophysically logging the borehole.

The following logging techniques were used for the boreholes:

- Gross gamma logging to support correlation of confining layers and stratigraphy
- Spectral gamma logging for measuring the distribution of selected radionuclides
- Neutron log for measuring the relative moisture content.

The existing equipment and procedures for gross gamma and spectral gamma logging in use at the Hanford Site provide acceptable data (DOE-GJPO 2000).

#### **A.2.4 GROUNDWATER SAMPLING AND ANALYSIS**

The sampling and analyses of groundwater were conducted by the Hanford Groundwater Program as described in *Groundwater Quality Assessment Plan for Single-Shell Waste Management Area B-BX-BY at the Hanford Site* (Narbutovskih 2000). The new boreholes penetrated the groundwater table; therefore, samples of groundwater were collected and analyzed in accordance with guidance provided in the sampling plan in Narbutovskih (2000).

#### **A.2.5 LABORATORY ANALYSES OF BOREHOLE SEDIMENT SAMPLES**

The following sections describe the laboratory analyses required for the samples collected from the new borehole. Samples for laboratory analysis were placed in appropriate containers and properly preserved.

Once sample material from the boreholes was received at the laboratory, it was geologically logged by an assigned geologist in conformance with standard procedures. The assigned geologist photographed the samples and described the geologic structure, texture, and lithology of the recovered samples. Special attention was paid to the presence of contaminant alteration. Any contaminant alteration was recorded in the laboratory notebook and those samples were preserved for more detailed physical, chemical, and mineralogic analyses.

Sediment samples for laboratory analysis were defined by location in the sample after the field screening and geologic logging were completed and indication of contamination locations was identified. Approximately 33 sediment samples from borehole 299-E33-45 and 34 sediment samples from borehole 299-E33-46 were chosen for screening analysis. The following criteria were used to identify subsamples for laboratory analysis based on concurrence with the Washington State Department of Ecology (Ecology).

- One background subsample taken at 6 m (20 ft) bgs.
- One subsample taken at 11.6 m (38 ft) bgs, at the level of the tank bottom.
- Two subsamples taken at the major lithology changes in the Hanford formation.
- One subsample taken at the Hanford formation/Plio-Pleistocene unit silt facies and Hanford formation contact at 66.5 m (218 ft) bgs, and one subsample obtained at the Hanford formation/Plio-Pleistocene unit silt facies and Hanford formation/Plio-Pleistocene unit gravel facies contact at 73.7 m (242 ft) bgs.
- One subsample taken just above the water table in the capillary fringe zone.
- One subsample taken at the historic high water table at approximately 74.4 m (244 ft) bgs.
- Subsamples taken of any paleosols seen in the splitspoon drive samples.

Figure A.2 shows the subsamples identified for laboratory analyses. All subsamples underwent screening analyses, which consisted of nitrate analysis by the colorimetric method, pH

measurement, electrical conductance measurement, and gamma energy analysis. These analyses, along with the gamma surveying and moisture content measurements performed during the field geophysical surveys and the laboratory geologic logging, were used to determine the extent of further subsample analysis. Table A.1 identifies the full complement of analyses and the respective laboratory preparation and analytical methods. This paragraph and the remainder of this section identify which analyses were conducted on each subsample. If more than one preparation or analytical method is listed, the laboratory geochemistry staff determined which methods would produce the best results and provide the best understanding of the chemistry involved. For those methods that produce multiple constituents (i.e., inductively coupled plasma or volatile organic analysis), all constituents identified were reported. Regulatory hold times were met where appropriate.

Because the purposes of the new borehole analyses were to gain an understanding of the nature and extent of contamination, understand the fate and transport of the contaminants in the vadose zone, and to produce RCRA-compliant data, the analysis of these subsamples consisted of two levels. The baseline level involved analysis of organic, inorganic, and radiochemical constituents in full conformance with *Hanford Analytical Services Quality Assurance Requirements Document* (DOE-RL 1998) and with no modifications to methods (as defined in DOE-RL 1998) without concurrence from the CH2M HILL Hanford Group, Inc. (CH2M HILL) technical representative and from Ecology. Substitutions and deviations to methods as defined in DOE-RL (1998) did not require concurrence from Ecology. The second level involved a research type approach to the analyses. In this level, procedures could be modified or developed to gain a more comprehensive understanding of the dynamics involved. Although specific quality control criteria did not apply to this level, compliance with the other quality assurance requirements of DOE-RL (1998) were met and research analysis was initiated only following review and approval of the activities by the CH2M HILL technical representative.

**Table A.1. Constituents and Methods for Sediment Sample Analyses and Near-Surface Characterization Samples for WMA B-BX-BY (7 pages)**

COPC	CAS #	ACTION LEVELS			NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTITATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL
		RR <sup>a</sup> pCi/g	C/I <sup>b</sup> pCi/g	GW <sup>c</sup>		WATER <sup>a</sup> high level pCi/L	SOIL- OTHER low level pCi/g	SOIL- OTHER high level pCi/g					
<b>RADIONUCLIDE</b>													
Americium-241	14596-10-2	31	210	TBD	Americium Isotopic - Alpha Energy Analysis (AEA)	1	400	1	4000		70-130%	+35%	70-130%
Carbon-14	14702-75-5	5.7 <sup>d</sup>	33100	TBD	Carbon-14 - Liquid Scintillation	200	NA	50	NA		70-130%	+35%	70-130%
Cesium-137	10045-97-3	6.2	25	TBD	Gamma Energy Analysis	15	200	0.1	2000		70-130%	+35%	70-130%
Cobalt-60	10198-40-0	1.4	5.2	TBD	Gamma Energy Analysis	25	200	0.05	2000		70-130%	+35%	70-130%
Europium-152	14683-23-9	3.3	1.2	TBD	Gamma Energy Analysis	50	200	0.1	2000		70-130%	+35%	70-130%
Europium-154	15585-10-1	3	11	TBD	Gamma Energy Analysis	50	200	0.1	2000		70-130%	+35%	70-130%
Europium-155	14391-16-3	125	449	TBD	Gamma Energy Analysis	50	200	0.1	2000		70-130%	+35%	70-130%
Hydrogen-3	10038-17-8	359 <sup>d</sup>	14,200	TBD	Tritium - Liquid Scintillation	400	400	400	400		70-130%	+35%	70-130%
Nepthunium-237	13904-20-2	2.5	62.2	TBD	Nepthunium-237 - AEA	1	NA	1	8000		70-130%	+35%	70-130%
Nickel-63	13981-37-8	4026	3008000	TBD	Nickel-63 - Liquid Scintillation	15	NA	30	NA		70-130%	+35%	70-130%
Plutonium-238	13981-16-3	37	483	TBD	Plutonium Isotopic - AEA	1	130	1	1300		70-130%	+35%	70-130%
Plutonium-239/240	PU-239/240	34	243	TBD	Plutonium Isotopic - AEA	1	130	1	1300		70-130%	+35%	70-130%
Total Radioactive Strontium	SR-RAD	4.5	2500	TBD	Total Radioactive Strontium - Gas Proportional Counting (GPC)	2	80	1	800		70-130%	+35%	70-130%
Techneium-99	14133-76-7	5.7 <sup>d</sup>	410000	TBD	Techneium-99 - Liquid Scintillation	15	400	15	4000		70-130%	+35%	70-130%
Thorium-232	TH-232	1	5.1	TBD	Thorium Isotopic - AEA (pCi) ICPMS (ug)	1	002 mg/L	1	0.02 mg/Kg		70-130%	+35%	70-130%
Uranium-234	13966-29-5	160	1200	TBD	Uranium Isotopic - AEA (pCi) ICPMS (ug)	1	002 mg/L	1	0.02 mg/Kg		70-130%	+35%	70-130%
Uranium-235	15117-96-1	26	100	TBD	Uranium Isotopic - AEA (pCi) ICPMS (ug)	1	002 mg/L	1	0.02 mg/Kg		70-130%	+35%	70-130%
Uranium-238	U-238	85	420	TBD	Uranium Isotopic - AEA (pCi) ICPMS (ug)	1	002 mg/L	1	0.02 mg/Kg		70-130%	+35%	70-130%

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COPC	CAS #	ACTION LEVELS		NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTIFICATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL
		Meth B mg/Kg	Meth C mg/Kg		WATER <sup>b</sup> low level	WATER <sup>b</sup> high level	SOIL- OTHER low level	SOIL- OTHER high level				
Organics					mg/L	mg/Kg	mg/L	mg/Kg				
Ethyl alcohol	64-17-5	none	none	Non-Halogenated VOA - 8015 <sup>c</sup> - GC	5	NA	NA	5	e	e	e	e
n-Butyl alcohol	71-36-3	8000	350	Non-Halogenated VOA - 8015 - GC	5	NA	NA	5	e	e	e	e
Methyl alcohol (methanol)	67-56-1	40000	160000	Non-Halogenated VOA - 8015M - GC modified for hydrocarbons	1	NA	NA	1	e	e	e	e
Kerosene (paraffin hydrocarbons)	8008-20-6	200000 <sup>b</sup>	200000 <sup>b</sup>	Non-Halogenated VOA - 8015M - GC modified for hydrocarbons	0.5	0.5	0.5	5	e	e	e	e
Carbon tetrachloride	56-23-5	7.69	2.24	Volatile Organics - 8260 - GCMS	0.005	0.0337	0.005	0.005	e	e	e	e
2-Propanone (Acetone)	67-64-1	8000	32000	Volatile Organics - 8260 - GCMS	0.02	80	0.02	0.02	e	e	e	e
Chloroform	67-66-3	164	3200	Volatile Organics - 8260 - GCMS	0.005	0.717	0.005	0.005	e	e	e	e
Benzene	71-43-2	34.5	1380	Volatile Organics - 8260 - GCMS	0.005	0.151	0.005	0.005	e	e	e	e
1,1,1-trichloroethane	71-55-6	72000	288000	Volatile Organics - 8260 - GCMS	0.005	720	0.005	0.005	e	e	e	e
Dichloromethane (methylene chloride)	75-09-2	133	5330	Volatile Organics - 8260 - GCMS	0.005	0.583	0.005	0.005	e	e	e	e
Carbon Disulfide	75-15-0	8000	32000	Volatile Organics - 8260 - GCMS	0.005	80	0.005	0.005	e	e	e	e
1,1-dichloroethane	75-34-3	8000	32000	Volatile Organics - 8260 - GCMS	0.01	80	0.01	0.01	e	e	e	e
1,1-dichloroethene	75-35-4	1.67	66.7	Volatile Organics - 8260 - GCMS	0.01	0.00729 <sup>f</sup>	0.01	0.01	e	e	e	e
1,2-dichloropropane	78-87-5	14.7	588	Volatile Organics - 8260 - GCMS	0.005	0.0643	0.005	0.005	e	e	e	e
2-butanone	78-93-3	48000	192000	Volatile Organics - 8260 - GCMS	0.01	480	0.01	0.01	e	e	e	e
1,1,2-trichloroethane	79-00-5	17.5	702	Volatile Organics - 8260 - GCMS	0.005	0.0768	0.005	0.005	e	e	e	e
1,1,2-trichloroethylene	79-01-6	90.9	3640	Volatile Organics - 8260 - GCMS	0.005	0.398	0.005	0.005	e	e	e	e
1,1,2,2-tetrachloroethane	79-34-5	5	200	Volatile Organics - 8260 - GCMS	0.005	0.0219	0.005	0.005	e	e	e	e

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		Meth B mg/kg	Meth C mg/kg		WATER <sup>b</sup> low level	WATER <sup>b</sup> high level	SOIL- OTHER low level	SOIL- OTHER high level				
CHEMICAL												
Ethyl benzene	100-41-4	8000	32000	80	mg/kg	0.005	0.005	0.005	0.005	e	e	e
1,2-dichloroethane	107-06-2	11	440	0.0481		0.005	0.005	0.005	0.005	e	e	e
4-methyl-2-pentanone	108-10-1	6400	25600	64		0.01	0.01	0.01	0.01	e	e	e
Toluene	108-88-3	16000	64000	160		0.005	0.005	0.005	0.005	e	e	e
Chlorobenzene	108-90-7	1600	6400	16		0.005	0.005	0.005	0.005	e	e	e
1,1,2,2-tetrachloroethane	127-18-4	19.6	784	0.0858		0.005	0.005	0.005	0.005	e	e	e
2-hexanone	591-78-6	none	none	64		0.02	0.02	0.02	0.02	e	e	e
cis-1,3-dichloropropene	10061-01-5	5.56	96	0.0243 <sup>1</sup>		0.005	0.005	0.005	0.005	e	e	e
Trans-1,3-dichloropropene	10061-02-6	5.56	96	0.0243 <sup>1</sup>		0.005	0.005	0.005	0.005	e	e	e
Xylene (total)	1330-20-7	160000	640000	1600		0.005	0.005	0.005	0.005	e	e	e
Dibenz[a,h]anthracene	53-70-3	0.137 <sup>f</sup>	5.48	0.0012 <sup>g</sup>		0.01	0.05	0.33	1	e	e	e
Hexachloroethane	67-72-1	71.4	320	0.625		0.01	0.05	0.33	1	e	e	e
Hexachlorobutadiene	87-68-3	12.8	64	0.0561 <sup>f</sup>		0.01	0.05	0.33	1	e	e	e
Penta-chlorophenol	87-86-5	8.33	333	0.0729 <sup>f</sup>		0.01	0.05	0.33	1	e	e	e
2-methylphenol (o-cresol)	95-48-7	4000	16000	80		0.01	0.05	0.33	1	e	e	e
1,2-dichlorobenzene	95-50-1	7200	28800	72		0.01	0.05	0.33	1	e	e	e
Nitrobenzene	98-95-3	40	160	0.8		0.01	0.05	0.33	1	e	e	e
4-methylphenol (p-cresol)	106-44-5	400	1600	8		0.01	0.05	0.33	1	e	e	e
1,4-dichlorobenzene	106-46-7	41.7	1670	0.0182 <sup>f</sup>		0.01	0.05	0.33	1	e	e	e

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		Meth B mg/kg	Meth C mg/kg		WATER <sup>b</sup> low level ng/L	WATER <sup>b</sup> high level ng/L	SOIL- OTHER low level mg/kg	SOIL- OTHER high level mg/kg				
CHEMICAL												
Pyridine	110-86-1	80	320	1.6	Semi-Volatiles - 8270 - GCMS	0.02	0.1	0.66	2	e	e	e
Hexachlorobenzene	118-74-1	0.625	25	0.00547 <sup>o</sup>	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e
1,2,4-trichlorobenzene	120-82-1	800	3200	8	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e
2,4-Dinitrotoluene	121-14-2	160	640	3.2	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e
Tributyl phosphate	126-73-8	none	none	none	Semi-Volatiles - 8270 - GCMS	0.1	0.5	3.3	5	e	e	e
1,3-dichlorobenzene	541-73-1	41.7	167 <sup>d</sup>	0.018 <sup>d</sup>	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e
Benzo(a)pyrene	50-32-8	0.137 <sup>f</sup>	5.48	0.0012 <sup>o</sup>	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e
2,4,5-Trichlorophenol	95-95-4	8000	32000	160	Semi-Volatiles - 8270 - GCMS	0.01	0.05	0.33	1	e	e	e
gamma-BHC(Lindane)	58-89-9	0.769	30.8	0.00673	Pesticides - 8081 - GC	0.0005	NA	0.00165	NA	e	e	e
Dieldrin	60-57-1	0.0625	2.5	0.000547 <sup>o</sup>	Pesticides - 8081 - GC	0.0001	NA	0.0033	NA	e	e	e
Endrin	72-20-8	24	96	0.48	Pesticides - 8081 - GC	0.0001	NA	0.0033	NA	e	e	e
Heptachlor	76-44-8	0.222	8.89	0.00194	Pesticides - 8081 - GC	0.0005	NA	0.00165	NA	e	e	e
Aldrin	309-00-2	0.0588	2.35	0.000512 <sup>o</sup>	Pesticides - 8081 - GC	0.0005	NA	0.00165	NA	e	e	e
Alpha-BHC	319-84-6	0.159	6.35	0.00139 <sup>f</sup>	Pesticides - 8081 - GC	0.0005	NA	0.00165	NA	e	e	e
Beta-BHC	319-85-7	0.556	2.22	0.00486	Pesticides - 8081 - GC	0.0005	NA	0.00165	NA	e	e	e
Toxaphene	8001-35-2	0.909	36.4	0.00795 <sup>o</sup>	Pesticides - 8081 - GC	0.005	NA	0.165	NA	e	e	e
Total Organic Carbon	TOC	N/A	N/A	none	TOC - 9060 - Combustion	1	1	100	100	+20%	70-130%	70-130%
Polychlorinated biphenyls (PCBs)	1336-36-3	0.13	5.19	0.00114 <sup>o</sup>	PCBs - 8082 - GC	0.0005	0.005	0.0165	0.1	e	e	e
Inorganics												
Ammonia/ammonium	7664-41-7	2720000	10900000	27100	Ammonia - 350N <sup>d</sup>	0.05	800	0.5	8000	e	e	e
Phosphate	14265-44-2	N/A	N/A	none	Anions - 9056 - IC	0.5	15	5	40	e	e	e
Nitrate	14797-55-8	128000	512000	2560	Anions - 9056 - IC	0.25	10	2.5	40	e	e	e
Nitrite	14797-65-0	8000	32000	160	Anions - 9056 - IC	0.25	15	2.5	20	e	e	e
Sulfate	14808-79-8	25000 <sup>f</sup>	25000 <sup>f</sup>	25000	Anions - 9056 - IC	0.5	15	5	40	e	e	e
Chloride	16887-00-6	25000 <sup>f</sup>	25000 <sup>f</sup>	25000	Anions - 9056 - IC	0.2	5	2	5	e	e	e

**Table A.1. Constituents and Methods for Sediment Sample Analyses and Near-Surface Characterization Samples for WMA B-BX-BY (7 pages)**

COPC	CAS #	ACTION LEVELS		NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTIFICATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL
		Meth B mg/Kg	Meth C mg/Kg		WATER <sup>b</sup> low level	WATER <sup>b</sup> high level	SOIL- OTHER low level	SOIL- OTHER high level				
<b>CHEMICAL</b>												
Fluoride	16984-48-8	96 <sup>a</sup>	300 <sup>b</sup>	96	0.5	5	5	e	e	e	e	e
Bromide	24959-67-9	N/A	N/A	none	0.25	N/A	2.5	e	e	e	e	e
Chromium VI	18540-29-9	400	1600	8	0.01	4	0.5	e	e	e	e	e
Mercury	7439-97-6	24	96	0.48	0.0005	0.0005	NA	e	e	e	e	e
Mercury	7439-97-6	24	96	0.48	NA	NA	0.2	e	e	e	e	e
Lead	7439-92-1	25000 <sup>b</sup>	25000 <sup>b</sup>	N/A	0.1	0.2	10	e	e	e	e	e
Nickel	7440-02-0	1600	6400	32	0.04	0.04	4	e	e	e	e	e
Silver	7440-22-4	400	1600	8	0.02	0.02	2	e	e	e	e	e
Antimony	7440-36-0	32 <sup>1</sup>	128 <sup>1</sup>	6	0.06	0.12	6	e	e	e	e	e
Arsenic	7440-38-2	6.5 <sup>a</sup>	66.7	0.00583 <sup>g</sup>	0.1	0.2	10	e	e	e	e	e
Barium	7440-39-3	5600	22400	112	0.2	0.2	20	e	e	e	e	e
Beryllium	7440-41-7	0.233	9.3	0.00203 <sup>g</sup>	0.005	0.01	0.5	e	e	e	e	e
Cadmium	7440-43-9	40	160	0.8	0.005	0.01	0.5	e	e	e	e	e
Chromium (total)	7440-47-3	1600	3500	None	0.01	0.01	1	e	e	e	e	e
Copper	7440-50-8	2960	11800	59.2	0.025	0.025	2.5	e	e	e	e	e
Selenium	7782-49-2	400	1600	8 <sup>g</sup>	0.1	0.2	10	e	e	e	e	e
Lead	7439-92-1	25000 <sup>b</sup>	25000 <sup>b</sup>	N/A	0.01	NA	1	e	e	e	e	e
Silver	7440-22-4	400	1600	8	0.005	NA	0.5	e	e	e	e	e
Antimony	7440-36-0	32 <sup>1</sup>	128 <sup>1</sup>	6	0.01	NA	1	e	e	e	e	e
Arsenic	7440-38-2	6.5 <sup>a</sup>	66.7	0.00583 <sup>g</sup>	0.01	NA	1	e	e	e	e	e
Barium	7440-39-3	5600	22400	112	0.005	NA	0.5	e	e	e	e	e
Cadmium	7440-43-9	40	160	0.8	0.005	NA	0.5	e	e	e	e	e
Chromium (total)	7440-47-3	1600	3500	None	0.01	NA	1	e	e	e	e	e
Selenium	7782-49-2	400	1600	8	0.01	NA	1	e	e	e	e	e
pH	pH	N/A	N/A	none	NA	NA	NA	e	e	e	e	e
Sulfides	18496-25-8	N/A	N/A	none	0.5	NA	5	e	e	e	e	e

**Table A.1. Constituents and Methods for Sediment Sample Analyses and Near-Surface Characterization Samples for WMA B-BX-BY (7 pages)**

COPC	CAS #	ACTION LEVELS		NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTIFICATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL
		Meth B mg/Kg	Meth C mg/Kg		mg/Kg	WATER <sup>b</sup> high level mg/L	SOIL- OTHER low level mg/Kg	SOIL- OTHER high level mg/Kg				
CHEMICAL												
Cyanide	57-12-5	1600	6400	mg/Kg	Total Cyanide - 9010 - Colorimetric	32	0.005	0.005	0.5	0.5	e	e
Uranium (total)	7440-61-1	240 <sup>a</sup>	960 <sup>b</sup>	4.8	Uranium Total - Kinetic Phosphorescence Analysis	None	0.0001	0.02	1	0.2	+20%	70-130%
Cation exchange capacity	CEC	N/A	N/A	None	Cation exchange capacity/Methods of Soil Analysis Part 2, 9-3.1	None	N/A	N/A	N/A	N/A	p	p
Particle size distribution	N/A	N/A	N/A	None	Particle size distribution/ASTM D 422-63, ASTM D 854-83	None	N/A	N/A	N/A	N/A	p	p
Mineralogy	N/A	N/A	N/A	None	XRD/SEM/TEM/JEA-3, Rev. 0	None	N/A	N/A	N/A	N/A	p	p
Electrical conductance	EC	N/A	N/A	None	Electrometh of PNL-MA-567- FA-2	None	N/A	N/A	N/A	N/A	p	p
Moisture content	N/A	N/A	N/A	None	Moisture content/PNL-MA-567- SA-7	None	N/A	N/A	N/A	N/A	p	p
Matrix potential	N/A	N/A	N/A	None	Matrix potential/PNL-MA-567- SA-10	None	N/A	N/A	N/A	N/A	p	p
Distribution coefficient	K <sub>d</sub>	N/A	N/A	None	Methods for determining radioisotope retardation factors, 1980/PNL-3349 USC-70	None	N/A	N/A	N/A	N/A	p	p
Bulk density	N/A	N/A	N/A	None	Bulk density/PNL-MA-567- SA-8	None	N/A	N/A	N/A	N/A	p	p
Moisture retention	θ <sub>r</sub>	N/A	N/A	None	Moisture retention/ASTM D 3325-68	None	N/A	N/A	N/A	N/A	p	p
Saturated hydraulic conductivity	K <sub>s</sub>	N/A	N/A	None	Saturated hydraulic conductivity/ASTM D18.21 (draft in review) Methods of Soil Analysis, Part 2, 13-3.2 and 13-3.3	None	N/A	N/A	N/A	N/A	p	p

**Table A.1. Constituents and Methods for Sediment Sample Analyses and Near-Surface Characterization Samples for WMA B-BX-BY (7 pages)**

COPC	CAS #	ACTION LEVELS			NAME/ANALYTICAL TECH.	TARGET REQUIRED QUANTIFICATION LIMITS				PRECISION WATER	ACCURACY WATER	PRECISION SOIL	ACCURACY SOIL	
		Meth B mg/kg	Meth C mg/kg	mg/kg		WATER <sup>b</sup> low level	WATER <sup>b</sup> high level	SOIL- OTHER low level	SOIL- OTHER high level					mg/kg
CHEMICAL														

<sup>RR</sup> - Rural Residential, C/I - Commercial Industrial, GW - Groundwater Protection. Radionuclide values from WDOH "Hanford Guidance for Radiological Cleanup", WDOH/330-015.

Radionuclide values are calculated using parameters from WDOH guidance.

<sup>a</sup>Water values for sampling QC (e.g. equipment blanks/rinses) or drainable liquid (if recovered)

<sup>d</sup>All 4 digit numbers refer to "Test Methods for Evaluating Solid Waste" (EPA SW-846)

<sup>e</sup>Methods of Analysis of Water and Waste" (EPA-600/4-79-010)

<sup>f</sup>Precision and Accuracy Requirements as identified and defined in the referenced EPA procedures.

<sup>g</sup>If quantitation to action level lower than nominal RDL is required, prior notification/concurrence with the laboratory will be required to address special low level detection limits

<sup>h</sup>The 100 times GW rule does not apply to residual radionuclide contaminants. GIV protection is demonstrated through technical evaluation using RESRAD (DOE/RL-96-17, Rev. 2)

<sup>i</sup>This value is based upon MPCA Method A values.

<sup>j</sup>T Value based upon most restrictive dichloropropene 1,3

<sup>k</sup>Value based upon most restrictive dichlorobenzene compound

<sup>l</sup>Value based upon soil concentration for groundwater protection R.A.G.s.

<sup>m</sup>Value based upon most restrictive antimony compound

<sup>n</sup>Default to be airground.

<sup>o</sup>Value based upon uranium soluble salts value.

<sup>p</sup>Detection limits below this value not achievable by listed technology. No routine technology likely available to achieve this detection limit

<sup>q</sup>Precision and accuracy for these measurements are not required because of the nature of the measurement

- AEA - alpha energy analysis
- ASTM - American Society for Testing and Materials
- CVAA - cold vapor atomic absorption
- IC - ion chromatography
- ICP - inductively coupled plasma
- ICPMS - inductively coupled plasma mass spectrometry
- N/A - not applicable
- NA - not available
- SEM - scanning electron microscopy
- TEM - transmission electron microscopy
- TOTC - total organic carbon/total carbon
- WDOH - Washington Department of Health
- XRD - x-ray diffraction

The following samples were analyzed for the constituents and properties identified in Table A.1:

- Background subsample
- Backfill and Hanford formation contact subsample
- Hanford formation H1 unit and Hanford formation H2 unit contact sample
- Peak gamma concentration sample
- Two subsamples obtained at the Hanford formation/Plio-Pleistocene unit silt facies contact
- Hanford formation/Plio-Pleistocene unit silt facies and Hanford formation/Plio-Pleistocene unit gravel facies contact
- Subsample obtained just above the water table in the capillary fringe zone.

It was recognized that conditions could occur when all of the analyses identified in Table A.1 were not warranted (e.g., limited potential for useful data) and these occurrences were evaluated on a case by case basis.

The remaining subsamples were analyzed for specific constituents listed in Table A.1 depending on the results of the nitrate, electrical conductivity, and pH screening analyses. A review of the screening analyses results with CH2M HILL and U.S. Department of Energy (DOE) technical representatives and Ecology was conducted before performing additional analyses. Screening analysis may have been used to determine whether alternative analytical techniques with lower detection limits should be used for specific radionuclides of concern.

### **A.3.0 RESOURCE CONSERVATION AND RECOVERY ACT GROUNDWATER MONITORING WELL SEDIMENT SAMPLE ANALYSIS**

Continuous splitspoon driven samples and drill cutting samples were collected in conjunction with the installation of two RCRA groundwater monitoring wells. The monitoring wells are located along the southern and western boundaries of the BX tank farm (Figure A.1). From these wells, continuous sediment splitspoon driven samples from about 6 m (20 ft) bgs to refusal were collected. Drill cuttings were collected from refusal to the total depth of the water table. The other RCRA groundwater monitoring wells are located west of BX tank farm. Drill cuttings were collected from these wells. Selected portions of the driven samples and cuttings were analyzed for chemical and physical characteristics. Only details associated with analysis of sediment splitspoon driven samples and cuttings are addressed in this appendix.

Near-continuous, driven samples were taken from the vadose zone during construction of well 299-E33-338 (Figure A.1), and the samples were made available for hydrologic properties analysis. The analyses required for this sample are listed in Table A.2. Samples for analysis were from each stratigraphic unit, stratigraphic contacts, weathered bedding structures, and lithologic facies changes.

**Table A.2. Required Analyses on Resource Conservation  
and Recovery Act Well Sediment Samples**

<b>Analysis/ Constituent</b>	<b>Preparation Method</b>	<b>Preparation Procedure Number</b>	<b>Analytical Method</b>	<b>Analytical Procedure Number<sup>(a)</sup></b>
PH	Water extract	Methods of Soil Analysis, Part 2; 62-1.3.2.2	Electrometric	Methods of Soil Analysis; 60-3.4
Particle size distribution	Bulk sediment	NA	Particle size distribution	ASTM D 422-63 ASTM D 854-83
Moisture content	Gravimetric	NA	Moisture content	PNL-MA-567-SA-7
Matric potential	Filter paper suction	NA	Matric potential	PNL-MA-567-SA-10
Bulk density	Gravimetric/volume	NA	Bulk density	PNL-MA-567-SA-8
Moisture retention	Bulk sediment	NA	Moisture retention	ASTM D 2325-68
Saturated hydraulic conductivity	Bulk sediment	NA	Saturated hydraulic conductivity	ASTM D 18.21 (draft in review) Methods of Soil Analysis, Part 2; 13-3.2 and 13-3.3
Anions	Water extract	Methods of Soil Analysis, Part 2; 62-1.3.2.2	IC  ISE Colorimetric	PNL-ALO-212 US EPA Method 300.0A Orion-720a Hach procedure
Metals	Water extract  Acid leach  Fusion	Method of Soil Analysis, Part 2; 62-1.3.2.2  PNL-ALO-106  PNL-ALO-235	ICPMS	PNL-ALO-211
Cation exchange capacity	Bulk sediment	NA	Cation exchange capacity	Methods of Soil Analysis Part 2; 9-3.1

<sup>(a)</sup> The procedures are addressed in EPA (1983), EPA (1986), and ASTM (1998).

IC = ion chromatography  
ICPMS = inductively coupled plasma mass spectrometry  
ISE = ion selective electrode  
NA = not applicable

#### **A.4.0 NEAR-SURFACE CHARACTERIZATION**

Near-surface characterization to be conducted in the BX tank farm was postponed until fiscal year 2003 because of CH2M HILL safety issues. These activities will be conducted in fiscal year 2003 and involve deployment of a truck mounted, direct push vehicle to collect the data.

## A.5.0 REFERENCES

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

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