

2. STUDY AREA INVESTIGATIONS

This section describes the field and analytical methods implemented during the Phase I RI to collect and analyze data needed to meet the DQOs developed for 11 high-priority AOCs in the *RVAAP Phase I RI SAP Addendum for High Priority AOCs* (USACE 1996d). The field and analytical programs were conducted in accordance with the *RVAAP Facility-Wide SAP* (USACE 1996c) and the *Phase I RI SAP Plan Addendum for High Priority AOCs at RVAAP* (USACE 1996d). Investigation objectives, rationale, sampling methods, and sampling locations as implemented during the Phase I RI are discussed in this section. The results of previous investigations are also presented for each AOC in **Table 2.1** for reference in understanding the Phase I RI approach.

The Phase I RI field activities were conducted during July and August of 1996. Field investigation activities included surface soil and ditch sediment sampling, subsurface soil sampling, pond sediment sampling, geophysical surveying, and sampling of groundwater through the installation of monitoring wells and temporary well points. Sample locations were based on available as-built drawings and maps provided by the facility and, for the most part, correspond to the sample locations presented in the work plans. Aquifer testing was also conducted on the monitoring wells installed for this RI. The rationales and methods for each component of the field program are described in the following sections.

2.1 SOIL AND VADOSE ZONE INVESTIGATIONS

Surface soils [0 to 0.6 m (0 to 2 feet)] and drainage ditch sediments were sampled at all AOCs during Phase I RI to evaluate potential surface releases of munitions assembly and demilitarization wastes associated with process facilities, and the discharge of pink water effluent from process operations into open ditches. Subsurface [>0.6 m (2 feet) below ground surface (BGS)] soil sampling was also included in the field program at selected AOCs where potential subsurface releases of munitions waste are suspected as a result of former wastes disposal operations at RVAAP. All soil and sediment samples collected are documented in soil boring and sediment sampling logs presented in Appendix C.

2.1.1 Surface Soil and Sediment

The release of explosive compounds onto surface soils and ditch sediments occurred adjacent to process buildings at each load line (RVAAP-08, -09, -10, -11, -12, and -18), from building washout operations, and as process effluent was discharged from buildings through concrete settling tanks into drainage ditches and unlined settling ponds. Open burning and detonation of munitions and explosive wastes at Winklepeck Burning Grounds (RVAAP-05) and Demolition Area #2 (RVAAP-04) also resulted in the release of explosive compounds and other chemicals at the surface based on the nature of these operations. Surface water runoff from these AOCs may also have conveyed explosive compounds and heavy metals to drainage ditches bounding these AOCs. At the Landfill North of Winklepeck Burning Grounds (RVAAP-19), buried refuse is a potential source of contaminants that may be released to soils and adjacent stream sediments.

Table 2.1. Summary of Previous Investigations of High-Priority AOCs

AOC	Date	Media	Investigation Results (Maximum Concentrations)				Comments	
			Soil	Sediment	Surface Water	Groundwater		
Demolition Area #2 (RVAAP-04)	1983	Soil	TNT (238.0 µg/g)	—	—	—	RCRA Horseshoe Area - Surface soil investigation	
			RDX (535.0 µg/g)					
			HMX (19,598.0 µg/g)					
			DNT (2.4 µg/g)					
			Ba (25.3 mg/L)					EP Toxicity Leachate
			PB (535.0 mg/L)					EP Toxicity Leachate
	1992	Soil	TNT (10.7 mg/kg)	—	—	—	RCRA Area (outside horseshoe) - Soil borings to 15 feet	
			RDX (72.6 mg/kg)				Explosives found in surface soils only	
			HMX (7.05 mg/kg)				Metals generally <2 × background	
			Ba (170.0 mg/g)					
			Cd (3.4 µg/g)					
			Hg (0.28 µg/g)					
			Pb (69.0 mg/g)					
			As (42.0 mg/g)					

Table 2.1 (continued)

AOC	Date	Media	Investigation Results (Maximum Concentrations)				Comments
			Soil	Sediment	Surface Water	Groundwater	
	1995 ^a	Groundwater		—	—	Indicator parameters exceeded	4 RCRA monitoring wells - Quarterly sampling for metals and SVOCs is ongoing at Demolition Area #2
						HMX & RDX detected in duplicate sample	
						1,2-DCA detected	
Winklepeck Burning Grounds (RVAAP-05)	1983	Soil	TNT (2263.0 µg/g)	—	—	—	70 surface soil samples from 11 active burning pads
			HMX (2976.0 µg/g)				34 samples detected explosives
			HMX (686.1 µg/g)				12 samples detected metals
			Cd (3.6 mg/L)				EP Toxicity Leachate
			Pb (5.1 mg/L)				EP Toxicity Leachate
			Ba (197.0 mg/L)				EP Toxicity Leachate
	1992	Soil/ Groundwater	TNT (6.03 mg/kg)	COD (53,000 µg/g)	TNT (4.0 µg/L)	No contamination detected	RCRA Area (Pad #38)

Table 2.1 (continued)

AOC	Date	Media	Investigation Results (Maximum Concentrations)				Comments
			Soil	Sediment	Surface Water	Groundwater	
			RDX (39.0 mg/kg)	TOC (17,000 µg/g)	RDX (120.0 µg/L)		4 RCRA Monitoring wells - Sampled for metals and explosives
			HMX (2.65 mg/kg)		DNT (2.8 µg/L)		9 surface soil samples and 5 soil borings to 10 feet
			DNT (2.1 mg/kg)		Cd (0.016 mg/L)		Explosives detected in surface soil interval only
			Ba (350 µg/g)		Cu (0.05 mg/L)		All metals detected in soils <6 × background
			Pb (350 µg/g)		Pb (0.01 mg/L)		
			Cr (46 µg/g)		Zn (0.22 mg/L)		
			Se (3.1 µg/g)		Fe (4.6 mg/L)		
			As (53.0 µg/g)				
	1995 ^a	Groundwater	—	—	—	Indicator parameters exceeded	4 RCRA monitoring wells - Quarterly sampling for metals and SVOCs is ongoing at Demolition Area #2
						1,2-DAC detected	
Load Line 1 and Dilution Settling Pond (RVAAP-08)	1981	Sediment/ Groundwater	—	TNT (0.3 µg/ml)	—	As (0.063 mg/L)	Sampling locations unknown

Table 2.1 (continued)

AOC	Date	Media	Investigation Results (Maximum Concentrations)				Comments
			Soil	Sediment	Surface Water	Groundwater	
				RDX (1.6 µg/ml)			
Load Line 2 and Dilution Settling Pond (RVAAP-09)	1981	Sediment	—	TNT (0.6 µg/ml)	—	—	Sampling locations unknown
				RDX (1.75 µg/ml)			
Load Line 3 and Dilution Settling Pond (RVAAP-10)	1982	Sediment	—	TNT (0.17 µg/ml)	—	—	Upper Cobbs Pond
				RDX (1.16 µg/ml)			
Load Line 4 and Dilution Settling Pond (RVAAP-11)	1982	Sediment	—	TNT (0.06 µg/ml)	—	—	Sampling locations unknown
				RDX (0.54 µg/ml)			
Load Line 12 and Dilution Settling Pond (RVAAP-12)	1982	Sediment	—	TNT (0.17 µg/ml)	—	—	Upper Cobbs Pond
				RDX (1.16 µg/ml)			
Building 1200 and Dilution Settling Pond (RVAAP-13)	—	—	—	—	—	—	No known characterization data

Table 2.1 (continued)

AOC	Date	Media	Investigation Results (Maximum Concentrations)				Comments
			Soil	Sediment	Surface Water	Groundwater	
Load Line 12 Pink Wastewater Treatment Plant (RVAAP-18)	—	—	—	—	—	—	No known characterization data
Landfill North of Winklepeck Burning Grounds (RVAAP-19)	—	—	—	—	—	—	No known characterization data
Upper and Lower Cobbs Ponds (RVAAP-29)	1982	Sediment	—	TNT (0.17 µg/ml)	—	—	Sampling locations unknown
				RDX (1.16 µg/ml)			

Source: Phase I SAP (USACE 1996c).

^a At the time of this report, 1995 was the most recent complete year of groundwater data. Groundwater data from RCRA monitoring wells are also available for years prior to 1995.

The Phase I RI objectives for the surface soil sampling program are to determine (1) if releases of explosive compounds and associated chemicals have occurred, and (2) the nature and current levels of any potential contamination. The Phase I RI objectives for the ditch sediment sampling program are to (1) determine if residual explosive compounds and associated chemicals currently exist in the drainage ditches receiving surface water runoff and past process effluent and (2) characterize the nature and current levels of any potential residual contamination.

Surface soil and ditch sediment samples were collected using the same methods and procedures. All surface soil and ditch sediment samples were analyzed for explosives and process-related metals. Explosive compounds analyzed were: HMX, RDX, Trinitrobenzene (TNB), Dinitrobenzene (DNB), Tetryl, Nitrobenzene, TNT, Dinitrotoluene (DNT), and Nitrotoluene. The process-related metals are those metals known to be associated with process operations conducted at RVAAP. The process-related metals consist of aluminum, arsenic, barium, cadmium, chromium, lead, manganese, mercury, selenium, silver, and zinc. Twenty percent of all samples were additionally analyzed for EPA Target Analyte List (TAL)/Total Compound List (TCL) volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides/PCBs, cyanide, and additional TAL metals. The expanded analyses were performed on 20 percent of the samples collected to evaluate the potential for unknown process-related chemicals. Samples analyzed for the full suite of chemicals were selected at potential source areas based on process knowledge, or on a random statistical basis where no process knowledge existed to guide biased sampling. Sediment samples were additionally analyzed for two geotechnical parameters, Total Organic Carbon (TOC) and grain size.

2.1.1.1 Rationale

Surface soils were evaluated at Load Lines 1, 2, 3, 4, and 12, Building 1200, and Winklepeck Burning Grounds during the Phase I RI. The exact sampling locations were finalized in the field based on observations (e.g., staining, effluent pipes, drainage, etc.) to ensure that the most representative locations were sampled. The rationale for biased surface sampling at the load lines is based on the operational histories and similarities in design of the load lines. The strategy was to sample surface soils in and/or near the former process buildings. The buildings formally associated with processing raw explosives into munitions were of primary importance in the strategy. These buildings are known as the Melt/Pour, Washdown, Drilling and Boostering, Propellant Charge, and High Explosive Buildings. Vacuum pumps associated with process wastes (Drilling and Boostering and Melt/Pour Buildings) and concrete settling tanks associated with process building effluent (Melt/Pour, Washdown, and High Explosive Buildings) are also of primary concern. Ancillary process support buildings, such as the Paint and Oils Storage and Mixing Buildings and Truck Service Buildings, are of concern in terms of the other hazardous materials that were used therein. Figures 4.7, 4.13, 4.18, 4.23, and 4.29 show the sampling locations for each load line.

At Building 1200, the surface soil sampling strategy focused on biased sampling adjacent to the former process building. The primary concern is from process effluent discharged into the adjacent drainage ditch. Figure 4.35 shows the surface soil sampling locations for Building 1200.

At Winklepeck Burning Grounds, the sampling rationale focused on sampling of the center or "burn area" of each of the known burning pads. In addition, surface soil and sediment samples

were collected from the ditches adjacent to Road D, East and Road E, East where previous studies documented contamination in surface soils at 11 recently active burning pads along Road D, East (USAEHA 1983) and at Burning Pad #37 (USAEHA 1992). These results are summarized in Table 2.1. At burning pads where the results of previous investigations indicate contamination is present, two surface soils were collected from these locations; at Burning Pad #37, four surface soil samples were collected from the area adjacent to the burning pad, but outside of the RCRA permit area. Figure 4.4 shows the surface soil sampling locations for Winklepeck Burning Grounds.

Drainage ditches associated with the above AOCs received either direct discharge of pink water effluent from former process operations (Load Lines 1, 2, 3, 4, and 12, Building 1200) or surface water runoff and groundwater discharge from Demolition Area #2, Winklepeck Burning Grounds, and the Landfill North of Winklepeck Burning Grounds. As such, sediment samples were located in each of the major drainage ditches exiting these AOCs, as identified from engineering drawings, and site walkovers. Sampling locations were placed at known effluent discharge points, at the points where drainage exited the former facility, and along the upstream reaches of ditches prior to their outfall to settling ponds (Sediment sampling locations are shown on the same maps as soil sampling locations, above).

Surface water streams at Demolition Area #2 and the Landfill North of Winklepeck Burning Grounds received surface water runoff and likely shallow groundwater discharge from these AOCs. Sediment sampling stations were located in the streams upstream, adjacent to, and downstream of both AOCs to characterize the nature of the sediments and any potential contamination that may exist. Figures 4.1 and 4.37 show the locations of these sampling points.

The analytical results of the surface soil and ditch sediment samples are presented in Section 4 of the Phase I RI Report, and analytical data are provided in Appendix G.

2.1.1.2 Field Sampling Methods

All surface soil and ditch sediment samples were collected using hand augers with 7.62-cm (3-inch) diameter stainless-steel buckets, from the surface to a maximum depth of 0.6 m (2 feet) BGS. Soil was collected in continuous 15.24-cm (6-inch) increments over this interval and composited, except for VOC samples. At locations where VOC sample fractions were collected, the auger bucket was first advanced to a depth of 30.48 cm (1 foot) BGS, with material filling the bucket collected in a stainless-steel bowl. Material collected from the 30.48-cm (1-foot) to 45.72-cm (1.5-foot) interval was used to fill the VOC sample fraction containers. Excess material not used to fill VOC sample containers was added to the stainless-steel bowl for compositing for additional sample fractions. Soil collected from each interval was composited to form a single sample. Material collected in the auger bucket cylinder during augering of each interval was removed using a stainless-steel spoon.

Shallow refusal of the hand augers occurred before the target depth [0.6 m (2 feet)] was obtained at a number of surface soil and sediment sampling locations. Refusal commonly occurred at 24.39-cm (0.8 foot) BGS. In such instances, the VOC fraction was collected from the material at the bottom of the borehole, and the excess material not used in the VOC sample was added to the stainless-steel bowl for compositing for the remaining analytical fractions.

Organic vapors were monitored in both the soil/ditch sediment boring and in headspace gases, using field instruments. Each soil sample collected from a boring was placed in a glass jar, leaving some air space, then sealed with aluminum foil. The headspace sample was placed in an empty cooler and allowed to volatilize for a minimum of 15 minutes. The seal on the jar was then punctured with the instrument probe and headspace gas monitored until the meter reading was stable. Ambient air and headspace gas concentrations were recorded in project logbooks to the nearest 0.1 ppm.

Following collection of the sample, the surface soil or sediment lithologies and/or general soil characteristics were recorded in the project logbooks. After completion, each borehole was staked with a 60.96-cm (2-foot), high-visibility rebar stake, labeled, and then plugged with coarse grade bentonite hole plug and water. Excess soil from the borehole was placed in lined, labeled 242-L (55-gallon) drums that were sealed after each use and staged within the AOC of origin. Investigation-derived waste (IDW) practices for all media are presented in Appendix J.

2.1.1.3 Background Soil Sampling

Three background soil sampling locations were established at each of the five load lines addressed during the Phase I RI (15 total sampling stations) to assess background concentrations of process-related metals at each of these AOCs. The background sampling locations were selected in areas believed to represent native soil conditions at each AOC at locations within AOC boundaries clear of known process operations and, generally, at locations upgradient of surface water runoff, process effluent discharge, and prevailing wind directions. Background soil sample locations are designated by xxxss-xxx(b) on the AOC location maps in Section 4. One composite soil sample was collected using a bucket hand auger from the surface to 0.9 m (3 feet) from each background sample station.

Background soil samples were collected using the hand auger methods described in Section 2.1.1.2, and were analyzed for process-related metals. See Section 4.1 for additional discussion of background rationale. All background soil borings were staked, labeled, and plugged as described in Section 2.1.1.2. Lithologies and general soil characteristics were recorded in the project logbooks. Field screening for organic vapors followed the procedures described in Section 2.1.1.2. Background sampling locations are shown on Figures 4.7, 4.13, 4.18, 4.23, 4.29, and 4.35.

2.1.1.4 Previous Studies

Summary results of previous surface soil and sediment sampling in the 11 high priority AOCs are presented in Table 2.1.

2.1.2 Subsurface Soils

Subsurface soils were collected at Demolition Area #2 (RVAAP-04) and the Landfill North of Winklepeck Burning Grounds (RVAAP-19) to investigate potential subsurface contamination occurring as a result of open detonation of explosives and munitions and landfilling of general plant and sanitary refuse. Of the 11 high priority AOCs, these two AOCs are the only ones investigated where potential subsurface release mechanisms [i.e., open detonation from 1.2 m (4 feet) deep pits,

potentially buried unexploded ordnance (UXO), and landfilling of possible munitions wastes] are documented. Subsurface soil sampling at Demolition Area #2 was conducted using shallow soil borings, and at the Landfill North of Winklepeck Burning Grounds using shallow trench excavations. All subsurface soil samples were analyzed for explosives and process-related metals. Explosive compounds analyzed were: HMX, RDX, TNB, DNB, Tetryl, Nitrobenzene, TNT, DNT, and Nitrotoluene. The process-related metals are those metals known to be associated with process operations conducted at RVAAP. The process-related metals consist of aluminum, arsenic, barium, cadmium, chromium, lead, manganese, mercury, selenium, silver, and zinc. Ten percent of all subsurface soil samples collected at Demolition Area #2 and all samples collected from the Landfill North of Winklepeck Burning Grounds were additionally analyzed for EPA TAL/TCL VOCs, SVOCs, pesticides/PCBs, cyanide, and additional TAL metals. The expanded analyses were performed to evaluate the potential for unknown process-related chemicals. Samples analyzed for the full suite of chemicals were selected at potential source areas based on process knowledge, or on a random statistical basis where no process knowledge existed to guide biased sampling. No samples were collected for geotechnical analysis (i.e., grain size and TOC).

The objectives of subsurface soil sampling at Demolition Area #2 were to (1) confirm the presence or absence of soil contamination and (2) characterize the nature of potential contamination. Characterization of the RCRA area within the Demolition Area #2 is not an objective of the Phase I RI. The objectives of the subsurface soil sampling at the Landfill North of Winklepeck Burning Grounds were to (1) evaluate the nature of buried materials, (2) confirm the presence or absence of contamination in the soils adjacent to burials, and (3) characterize the nature of potential contamination.

Analytical results of the subsurface soil sampling are presented in Section 4 of the Phase I RI Report, and analytical data are provided in Appendix G.

2.1.2.1 Rationales

Demolition Area #2

Subsurface soils in this AOC were investigated by installing 30 shallow soil borings to a depth of 1.2 m (4 feet), using a hand-operated power auger and hand auger bucket. Because of the potential for UXO at this site, the area immediately surrounding each soil boring location was surveyed before drilling by a UXO-certified technician using a magnetometer. During drilling, each soil boring was monitored downhole at 0.6-m (2-foot) intervals using the magnetometer.

Soil borings were located in the area north of Sand Creek adjacent to areas of suspected munitions burials, and in the areas reported to contain former shallow [1.2-m (4 feet)] detonation pits. Former detonation pits were reported by former employees to have been near the roads traversing the AOC. Map sketches (USAEHA 1983) show six elongated areas (two to the west, and four to the east of the road) parallel to the RCRA area. Soil borings were concentrated in these areas and spaced outwardly from these areas on approximately 30.5-m (100-foot) spacings. The locations of these subsurface soil samples are shown in Figure 4.1.

Landfill North of Winklepeck Burning Grounds

A geophysical survey of the former landfill area was conducted to locate probable burial trenches and/or buried metal objects. Based on the results of the geophysical investigation (Section 2. 4), five trench locations were selected to characterize the nature of the buried wastes and associated soils. Before any trenching was performed, four temporary well points were installed to determine the elevation of the water table, so that all trench excavations could be terminated above the water table to mitigate the potential for cross contamination should contamination be encountered. The trenches were approximately 4.5 m (15 feet) long \times 0.6 m (2 feet) wide \times 0.9 m (3 feet) deep and did not intersect groundwater. Locations of landfill trenches and trench sampling locations are presented in Figure 4.37.

2.1.2.2 Field Sampling Methods

Demolition Area #2

Two composite soil samples were collected from each soil boring, one from the surface interval [0 to 0.6 m (0 to 2 feet)] and one from the subsurface [0.6 to 1.2 m (2 to 4 feet)], for a total of 30 surface and 30 subsurface soil samples. The 0 to 0.6 m (0 to 2 feet) interval was sampled using the bucket hand auger, as described in Section 2.1.1.2. A hand-operated power auger was then used to overdrill the 0 to 0.6-m (0 to 2-foot) interval. The power auger flights, 15.2 cm (6 inches) in diameter, were attached to and rotated by a gasoline-powered hydraulic drive. By increasing the diameter of the borehole in the 0 to 0.6-m (2-foot) interval, the bucket hand auger was more easily advanced to the total depth. The remainder of the borehole 0.6 to 1.2 m (2 to 4 feet) was drilled using the bucket hand auger. Where subsurface conditions permitted, the hand auger method was used to complete the boring without the use of the power auger. In several sampling locations, early refusal of either the hand or power auger prevented reaching the target sampling depth. In such cases, samples were collected from the surface interval and the deepest subsurface interval achieved.

The soil samples were collected from each interval by compositing in a stainless-steel bowl before filling sample containers except where VOCs were required. Material collected from the 0.15 to 0.3-m (0.5 to 1-foot) interval was used to fill the VOC sample fraction containers. Excess material not used to fill VOC sample containers was added to the stainless-steel bowl for compositing for additional sample fractions. Soil collected from each interval was composited to form a single sample. Material collected in the auger bucket cylinder during augering of each interval was removed using a stainless-steel spoon.

Organic vapors were monitored in both the subsurface soil boring and in headspace gases, using field instruments. Each soil sample collected from a boring was placed in a glass jar, leaving some air space, then sealed with aluminum foil. The headspace sample was placed in an empty cooler and allowed to volatilize for a minimum of 15 minutes. The seal on the jar was then punctured with the instrument probe and headspace gas monitored until the meter reading was stable. Breathing zone and headspace gas concentrations were recorded in project logbooks to the nearest 0.1 ppm.

Following collection of a sample, each borehole location was staked with a 60.96-cm (2-foot), high-visibility rebar stake, labeled, and then plugged with bentonite hole plug and water. Excess soil from the borehole was placed in lined, labeled 242-L (55-gallon) drums that were sealed after each use. Subsurface soil boring lithologies and/or general soil characteristics were recorded in the project logbooks on soil boring logs.

Landfill North of Winklepeck Burning Grounds

Five trenches were excavated in the Landfill North of Winklepeck Burning Grounds using a backhoe at the location of geophysical anomalies indicated by Electromagnetic (EM)-31 and EM-61 surveys conducted prior to intrusive field work (Section 2.4). Ten trenches were originally planned, however, the results of the geophysical surveys indicated the burials to be much smaller than originally thought. Based on groundwater elevations determined at four temporary well points in the landfill, the trenches were limited to a maximum depth of approximately 1 m (approximately 3 feet) BGS to ensure that groundwater would not be intersected by a trench excavation. Soil was removed in layers measuring approximately 15 cm (0.5 foot) in thickness, until the required depth was reached. All soil and solid waste removed from trenches was placed beside each trench on plastic sheeting and segregated by the layers in which it was excavated. This prevented the commingling of non-hazardous and potentially hazardous materials, and allowed for placement of the material back into the trench in the position in which it was excavated. There was no field evidence indicating that potentially hazardous materials were present, consequently, all soil and materials were returned to the trench after excavation was complete.

Three samples were initially scoped to be collected from each trench: one from 0 to 0.3 m (1 foot), one within the refuse, and one from below the buried materials. However, because of the presumed shallow occurrence of the water table within the landfill, no trench excavations were advanced below the base of the refuse. Refuse was generally present within the upper 0.3 m (1 foot) of the soil. Therefore, only one composite sample was collected from each trench.

Each trench was sampled using soil collected in the backhoe bucket. Soil was scooped using a stainless-steel spoon from each bucket of excavated material. This soil collected from each bucket was placed in a stainless-steel bowl. When buried refuse was encountered, a new bowl and spoon were used to collect soil from each bucket. Material collected from the zone of buried refuse was used to fill the VOC sample containers. A single sample was then composited from the two bowls for the remaining analytical fractions.

Organic vapors were monitored in both the ambient air around the backhoe bucket and in headspace gases, using field instruments. Each soil sample collected from a trench was placed in a glass jar, leaving some air space, then sealed with aluminum foil. The headspace sample was placed in an empty cooler and allowed to volatilize for a minimum of 15 minutes. The seal on the jar was then punctured with the instrument probe and headspace gas monitored until the meter reading was stable. Breathing zone and headspace gas concentrations were recorded in project logbooks to the nearest 0.1 ppm.

After completion, each trench location was staked with a 60.96-cm (2-foot), high-visibility rebar stake and labeled, pending topographic surveying.

2.2 SEDIMENT SAMPLING

2.2.1 Rationale

Sediment from unlined settling ponds receiving pink water effluent from former process operations associated with Load Lines 1 (RVAAP-08), 2 (RVAAP-09), 3 (RVAAP-10) [Upper and Lower Cobbs Ponds (RVAAP-29)], 4 (RVAAP-11), 12 (RVAAP-12), and Building 1200 (RVAAP-13) were evaluated during the Phase I RI. Eight settling ponds have been identified as receiving process effluent and surface water runoff via open ditches from former operations at these AOCs. Samples were collected from locations at the receiving end (inlet) and discharge end (outlet) along the main drainage axes of these ponds to evaluate the residual effects from the discharge of process effluent to these receptacles. In addition, sediment sampling locations were placed immediately downstream of each settling pond outfall to evaluate potential contaminant discharge from the settling ponds. Three sediment sampling locations were established for each settling pond, except for Lower Cobbs Pond and the Load Line 1 settling pond complex, where additional sampling stations were needed to cover a larger area. Pond sampling locations are shown on the site sample location figures for each AOC in Section 4.

All sediment samples were analyzed for explosives and process-related metals. Explosive compounds analyzed were: HMX, RDX, TNB, DNB, Tetryl, Nitrobenzene, TNT, DNT, and Nitrotoluene. The process-related metals are those metals known to be associated with process operations conducted at RVAAP. The process-related metals consist of aluminum, arsenic, barium, cadmium, chromium, lead, manganese, mercury, selenium, silver, and zinc. Between five and ten percent of all samples were additionally analyzed for EPA TAL/TCL VOCs, SVOCs, pesticides/PCBs, cyanide, and additional TAL metals. The expanded analyses were performed to evaluate the potential for unknown process-related chemicals. Samples analyzed for the full suite of chemicals were selected on a random basis. Pond sediment samples were additionally analyzed for two geotechnical parameters, TOC and grain size.

The analytical results of the pond sediment samples are discussed in Section 4 of the Phase I RI Report, and the analytical results presented in Appendix G.

2.2.2 Field Sampling Methods

Pond sediment sampling was conducted using a core sampler, in accordance with the *Phase I RI SAP Addendum for High-Priority Areas of Concern* (USACE 1996d). The sampler consists of a stainless-steel, 8.26-cm (3.25-inch) outside diameter, 30.48-cm (1.0-foot) long capped tube that was fitted with a core sampling attachment. Extension rods were attached to the handle to attain greater depths. The device was pushed rapidly into the sediment by hand, to a depth that allowed the core tube to fill with sediment. Upon retrieval, the sediment was removed from the tube and placed in a stainless-steel bowl. The VOC sample fraction was collected immediately and the remainder of the sample composited for the remaining analytical fractions. After sample collection, any remaining sediment material was placed back in the pond. The amount of residual sediment from sampling activities was small (<0.5 lb), and no greater than the amount of sediment resuspended in the water during retrieval of the sample, so the sediment sampler was rinsed off with native water at each sample point, allowing resuspension of particulate.

Organic vapors were monitored in headspace gases, using field instruments. Each sample collected from a pond was placed in a glass jar, leaving some air space, then sealed with aluminum foil. The headspace sample was placed in an empty cooler and allowed to volatilize for a minimum of 15 minutes. The seal on the jar was then punctured with the instrument probe and headspace gas monitored until the meter reading was stable. Headspace gas concentrations were recorded in project logbooks to the nearest 0.1 ppm.

2.2.3 Previous Studies

The results of previous pond and stream sediment investigations are summarized in Table 2.1.

2.3 GROUNDWATER SAMPLING

Groundwater at 7 of RVAAP's 11 high-priority AOCs was investigated during the Phase I RI to assess groundwater conditions and the potential impacts from munitions and waste operations at Load Lines 1 (RVAAP-08), 2 (RVAAP-09), 3 (RVAAP-10) [and Upper and Lower Cobbs Ponds (RVAAP-29)], 4 (RVAAP-11), and 12 (RVAAP-12); and the Landfill North of Winklepeck Burning Grounds. The objectives of the groundwater investigation were to (1) evaluate the potential impact to groundwater downgradient from the most likely release points by screening for the presence or absence of potential groundwater contamination at the perimeter of the AOC, (2) evaluate the nature and concentration of any potential contamination occurring in shallow groundwater, (3) collect preliminary hydrogeologic information for future characterization of these areas, if necessary, and (4) evaluate the potential for migration of contamination outside of the RVAAP boundaries via groundwater.

Two different sampling strategies were employed during Phase I RI to collect preliminary groundwater information. Groundwater was collected (1) from six newly installed monitoring wells and (2) from 14 temporary well points installed in the shallow water table zone. All groundwater samples were intended to be analyzed for explosives and EPA TAL/TCL VOCs, SVOCs, pesticides/PCBs, cyanide, and metals; however, in some instances there was insufficient recharge in the well points, resulting in a reduced analytical suite of constituents. Explosive compounds analyzed were: HMX, RDX, TNB, DNB, Tetryl, Nitrobenzene, TNT, DNT, and Nitrotoluene. The results of groundwater analyses performed are presented in Section 4 of the Phase I RI Report, and the analytical data are presented in Appendix G.

2.3.1 Rationale

Groundwater samples were collected from the shallow water table zone at locations immediately downgradient from settling ponds, including Upper and Lower Cobbs Ponds, receiving process effluent from the major load lines, and from the Landfill North of Winklepeck Burning Grounds. These locations were considered to have a higher relative potential for groundwater contamination because of the convergence of all load line drainage ditches in settling ponds, and because of the proximity of buried refuse to the water table in the landfill. Four monitoring wells and 18 temporary well points were planned during the Phase I RI; however, due to hydrogeologic conditions encountered and changes to the trenching (Section 2.1.2.1) work scope, seven monitoring wells and 17 well points were installed during the Phase I RI.

Four monitoring wells (LL1mw-064 and -065, and LL2mw-59 and -060) were installed at the facility boundary (inside the perimeter fence) in Load Lines 1 and 2, and two monitoring wells (LL1mw-063 and -067) were installed within the Load Line 1 AOC adjacent to a potential major source area (main concrete settling tanks). The seventh monitoring well borehole (LL1mw-066) had to be abandoned prior to well installation due to silt problems. Because of the long history of operation and the location of these AOCs near the facility boundary, the location of monitoring wells along the facility perimeter at Load Lines 1 and 2 were considered optimum locations for evaluating the potential for off-site migration of groundwater contamination. The monitoring wells installed within the Load Line 1 complex were placed to evaluate the groundwater quality near a major potential source of contaminant release to provide source area water quality and upgradient geologic data (because of the preliminary nature of the Phase I RI groundwater assessment, no background monitoring well installation and groundwater sampling was conducted). Groundwater samples were collected from these wells, and in situ permeability tests were conducted to evaluate the aquifer characteristics. All monitoring wells installed during Phase I are summarized in Table 2.2 and are shown on the sample location figures for each AOC in Section 4.

Table 2.2. Summary of Monitoring Well Depths, Groundwater Depth, and Screen Interval

Well ID	Ground Surface Elevation	Boring Depth (BGS)	Depth to Water (BGS) (July 1997)	Screen Interval (BGS)
LL1mw-063	992.14	27.4 feet	22.58 feet	17.1 - 27.1 feet
LL1mw-064	932.35	18.35 feet	2.98 feet	8.02 - 18.02 feet
LL1mw-065	941.71	20.5 feet	13.03 feet	10.2 - 20.2 feet
LL1mw-067	977.40	23.4 feet	17.66 feet	12.77 - 22.8 feet
LL2mw-059	964.19	22.9 feet	12.88 feet	9.34 - 19.14 feet
LL2mw-060	959.07	19.2 feet	10.2 feet	8.08 - 17.94 feet

Seventeen temporary well points were installed in the Load Lines 1, 2, 3 (Upper and Lower Cobbs Ponds), 4, and 12 complexes, and the Landfill North of Winklepeck Burning Grounds. Well points were installed in a crescent array along the downgradient sides of each settling pond to evaluate the potential for a contaminant plume emanating from each of these locations. The ponds are considered the most probable release points of explosives and related compounds from discharged process effluent to groundwater. General shallow groundwater flow direction was inferred from the local topography and drainage pattern in each area. At the Landfill North of Winklepeck Burning Grounds, infiltration of precipitation and groundwater movement has the potential to result in shallow groundwater contamination. Well points were installed in four locations along the eastern and southern sides of the former landfill area, but not on the northern side, where topography was steep and shallow occurrence of bedrock would have made well points impossible. Two well points were installed at Load Line 1 near the perimeter fence and between monitoring wells LL1mw-064 and LL1mw-065, in order to further characterize the hydrogeology

in that portion of the AOC and the potential for off-site contaminant migration. Table 2.3 summarizes the well point locations and groundwater sampling, and the well point locations are shown on the sample location figures for each AOC in Section 4.

2.3.2 Field Sampling Methods

2.3.2.1 Monitoring Well Installation, Development, and Sampling

Monitoring wells were installed using hollow-stem auger and air-rotary drilling methods under the direct supervision of a professional geologist. A 16.5-cm (6.5-inch) inside diameter, hollow-stem auger was used to advance the borehole through unconsolidated materials. Soil samples were collected continuously from the surface to bedrock refusal or planned borehole termination using a split-barrel sampler. Soil sampling was conducted for lithologic evaluation only. Where bedrock was encountered before the target depth was reached, the bedrock interval was drilled using air rotary methods with a 15.8-cm (6.25-inch) to 16.5-cm (6.5 inch) tricone roller bit. Rock cuttings produced during bedrock drilling were collected for lithological evaluation only. A borehole log, including lithologic information, was developed and entered into the project logbook for each monitoring well boring. Monitoring well logs are provided in Appendix A.

Organic vapors were monitored from soil and rock cutting samples collected using field instruments from each borehole to evaluate the potential occurrence of organic chemicals. In addition, ambient air conditions were also monitored for organic vapors throughout the drilling process. All readings were recorded to the nearest 0.1 ppm in the project logbooks.

Following drilling of monitoring well boreholes to target depths in the water table zone, monitoring wells were constructed using pre-cleaned 5.0-cm (2.0-inch), Schedule 40 polyvinyl chloride (PVC) pipe. Well screens were commercially fabricated with slot widths of 0.125 cm (0.005 inch) or 0.025 cm (0.010 inch). Monitoring wells LL1mw-063, -064, -065 were constructed using 0.025 cm (0.010 inch) screens and exhibited minor silting problems during well development; therefore, subsequent wells (LL1mw-067, LL2mw-59, and LL2mw-060) were installed with a 0.125 cm (0.005 inch) screen to reduce silting problems. The screen length in each well was 3 m (10 feet), with a threaded end PVC cap. For wells completed in unconsolidated material, the well casing and screen were assembled and lowered through the drill stem augers into the boreholes for completion. Where wells were completed in bedrock, the well casing and screen were assembled and lowered in the open borehole. Following placement of the well pipe and screen, a pre-washed sand filter pack, consisting of Global Supply No. 7 [well screens 0.125 cm (0.005 inch)] or No. 5 sand [0.025 cm (0.010 inch) well screens], was tremied in place from the bottom of the borehole to approximately 0.6 m (2 feet) above the top of the well screen in each well. A 0.6 m (2 foot) or 0.9 m (3 foot) bentonite pellet annular seal was then poured and tamped into the borehole on top of the filter pack. A 0.9 m (3 foot) annular seal was used in each monitoring well construction except where shallow groundwater conditions prevented its use; in these wells (LL1mw-064) a 0.6 m (2 foot) annular seal was used. A grout mixture consisting of Type I portland cement and 5 percent bentonite was then tremied from the top of the annular seal to the ground surface, followed by the placement of a protective steel casing and construction of a mortar collar and cement pad. Four steel posts were installed around the well, painted, and labeled. The monitoring well installation procedures are provided in Section 4.3.2. of the *Facility-Wide SAP* (USACE 1996c). Monitoring well construction diagrams are provided in Appendix B.

Table 2.3. Well Point Installation and Sampling Summary

Well Point ID	Total Depth (m)	Depth to Water (before sampling) (m)	Samples Collected
LNWwp-019	2.40	1.15	Full suite
LNWwp-020	3.45	2.06	VOCs, explosives, part metals
LNWwp-021	6.31	3.80	VOCs only
LNWwp-022	7.36		VOCs only
LL2wp-056	3.00	dry	Not sampled
LL2wp-057	2.19	dry	Not sampled
LL2wp-058	3.21	dry	Not sampled
LL12wp-058	4.35	2.85	Not sampled, insufficient recharge
LL12wp-057	5.20	3.13	VOCs only
CPCwp-011	2.85	1.83	Full suite
CPCwp-013	1.95	0.49	Full suite
LL4wp-059	5.56	3.93	Full suite
LL4wp-060	4.05	1.88	Full suite
LL4wp-061	6.76	3.90	Full suite
LL1wp-067	5.26	0.19	Full suite
LL1wp-068	1.95	0.36	Full suite
LL1wp-069	7.96	2.76	Partial explosives and metals

At least 48 hours after installation, each monitoring well was developed so that representative groundwater samples could be collected. Well development was accomplished by purging at least five well volumes of groundwater using a submersible pump or bailer until the development water was visually clear, and the sediment thickness remaining in the well was less than 3.0 cm (0.1 foot). Well development records were included in project logbooks. Table 2.2 summarizes the monitoring wells installed during the Phase I RI along with wells depths, screened intervals, and groundwater elevations.

Following well development, one groundwater sample was collected from each monitoring well installed during the Phase I RI. The procedure for sampling of groundwater is described in Sections 4.3.4 and 4.3.5 of the *Facility-Wide SAP* (USACE 1996c). Monitoring wells were first purged until readings of pH, conductivity, and temperature of the well water reached equilibrium. Groundwater sampling was conducted using a dedicated Teflon bailer. All monitoring well

groundwater samples were submitted for analyses as unfiltered samples, except for the metals fraction which were filtered using a manually operated filtration kit. No unfiltered metals fractions were submitted for analysis.

2.3.2.2 Temporary Well Point Installation and Sampling

A hydraulic direct-push subsurface probe system was used to install temporary well points and collect groundwater samples. A screened groundwater sampling tube fixed to probe rods was hydraulically pushed to the required sample depth. Additional probe rods were added to advance the sampler to greater depths. The target depth for temporary well points was first occurrence of groundwater so there is little possibility of cross contamination from shallow depths as the probe rods are pushed deeper. The total depths of the well points ranged from 1.95 to 7.96 m (6.5 to 26.5 feet) based on the occurrence of groundwater or refusal, whichever occurred first. The occurrence of groundwater was determined by the equipment operator based on observed abrupt changes in the push friction (weight). The probe assembly was advanced to 0.6 m (2 feet) beyond the depth at which groundwater was encountered for sampling purposes. Then the probe rods were pulled up approximately 45.72 cm (1.5 feet), opening the groundwater sampler and allowing water to enter the probe sampler. The groundwater sample was collected from the inside of the sampler using a peristaltic pump or bailer.

During temporary well point installation, unfavorable geologic conditions were encountered that impaired the collection of groundwater samples from all of the well points installed. Three well points at Load Line 2 encountered bedrock refusal before encountering groundwater and, therefore, were not successful (Table 2.3). In addition, low formation hydraulic conductivity and the resulting slow groundwater recharge was a common problem observed due to the widespread occurrence of groundwater in supersaturated, low-permeability, silty clay loam glacial till. This condition resulted in unsuccessful sampling at one well point (LL12wp-058) and only partially successful (analysis of partial sample fractions, commonly VOCs only due to the small volume of sample recovered) groundwater sampling from five additional temporary well points (LNWwp-020, -021, -022; LL12wp-057; and LL1wp-069). In order to hasten the recharge of the sampler and mitigate the infiltration of fine material into the sampler, artificial sand packs were placed around the probe assembly in five well points in an effort to improve recharge and collect a groundwater sample.

Where groundwater samples were collected from well points, samples submitted for metals analysis were filtered first. All other groundwater sample analytical fractions collected (e.g., explosives, VOCs, SVOCs, pesticides/PCBs, and cyanide) were unfiltered. Table 2.3 summarizes the Phase I RI well point installation and groundwater sampling.

2.3.3 Previous Studies

Groundwater analytical data exist from four previously installed monitoring wells in the RCRA open burning area at the Winklepeck Burning Grounds (RVAAP-05) and four existing RCRA monitoring wells located at Demolition Area #2 (RVAAP-04). The analytical results from the RCRA monitoring wells have not been used in the Phase I RI Report to evaluate the potential impact to groundwater at these AOCs. The monitoring wells in Demolition Area #2 are sampled quarterly for indicator parameters such as pH, conductivity, turbidity, total Kjeldahl nitrogen

(TKN), and anions, as well as SVOCs and metals. The monitoring wells at Winklepeck Burning Grounds are also sampled for similar indicator parameters, metals, and explosives. Significant results of the RCRA monitoring program are summarized here.

TNB and/or TNT have been found in concentrations from 1.9 to 15 $\mu\text{g/L}$ sporadically in three of the four monitoring well locations in Winklepeck Burning Grounds. Oil and grease compounds were present in each of the four wells in concentrations in the thousands of $\mu\text{g/L}$ from 1992 to 1994. Phenols were also detected in OBG-3, in concentrations from 8 to 14 $\mu\text{g/L}$, from 1994 to March of 1996. In Demolition Area #2, isolated occurrences of RDX and TNB were observed in 1992 and 1994. Oil and grease compounds and phenols were detected at similar concentrations and with similar frequency as those observed in Winklepeck Burning Ground.

2.3.4 In Situ Permeability Testing

In situ permeability tests (slug tests) were conducted in each of the six new monitoring wells with the objective of estimating the hydraulic conductivity of the geologic material surrounding each well. The tests were initiated after the monitoring wells had stabilized after well development or groundwater sampling (LL2mw-059, LL2mw-060, and LL1mw-067 were slug tested after sampling; LL1mw-063, -064, and -065 were slug tested 48 to 72 hours before groundwater sampling).

“Rising-head” slug tests were conducted by removing a cylinder (slug) from the well and monitoring the return to pretest static water level over time, via pressure transducer. Static water level was measured with an electronic water level indicator, and recorded to the nearest 0.003 m (0.01 foot) below the top of casing prior to the test. The cylinder was inserted into the well and the water level allowed to equilibrate to static conditions. The slug was designed to displace 0.3 m (1 foot) of water. To begin the test, the slug was withdrawn quickly from the well, and water level measurement began at that moment. A pressure transducer and data logger were programmed to record measurements on a logarithmic time scale. Water level was monitored for a period of six hours or until the well re-equilibrated to 90 percent of the pretest water level.

Test data were evaluated using the Bouwer and Rice method. The test results are presented in Section 3.2.2 of Phase I RI Report, and test data are presented in Appendix A.

2.4 GEOPHYSICS

Geophysical surveys were performed at the Landfill North of Winklepeck Burning Grounds (RVAAP-19) as part of the Phase I RI. The objectives of the geophysical surveys were to (1) identify the locations of buried materials and possible burial trenches, (2) identify the locations of buried metal objects, and (3) select locations for trenching through buried materials and soils to determine the nature of the materials and their potential impacts on soils.

2.4.1 Rationale

Landfill activities were conducted at this AOC from 1966 to 1976 to dispose of sanitary waste, potentially including explosive and munitions wastes from Winklepeck Burning Grounds.

Information suggests that the burial method was random trench and fill with a native soil cover. The location of the trenches and the volume and nature of the buried materials are not known. EM surveys lend themselves to the detection of buried wastes and metal objects. Geophysical surveys were conducted using EM-31 (frequency-domain electromagnetics) to locate burial trenches, and EM-61 (time-domain EM) to detect metal objects.

2.4.2 Field Methods

The field procedures for geophysical surveys followed provisions in Section 4.1 of the *Phase I SAP Addendum* (USACE 1996d), and are presented in the Geophysical Survey report included as Appendix D of the Phase I RI Report. A 3-m (10-foot) survey grid was established on the suspected landfill area. Continuous profiles using EM instruments and data loggers were collected by an operator walking the survey grid. A test profile near the site was surveyed with each instrument, in a location where no buried debris was suspected, prior to surveying the actual survey grid.

Data reduction and analysis was performed in the field, and survey results were presented as contour maps showing subsurface anomalies. The results of the geophysical investigation are included in Appendix D. The survey results were used to establish locations for landfill trenching (Section 2.1.2.1). Not all EM anomalies identified were trenched, but those that were did encounter buried debris.

2.5 ANALYTICAL PROGRAM OVERVIEW

2.5.1 Laboratory Analysis

All analytical procedures were completed in accordance with applicable professional technical standards, EPA requirements, government regulations and guidelines, and specific project goals and requirements. The sampling and analysis program conducted during the Phase I RI for RVAAP's high-priority AOCs involved the collection and analysis of surface soil, subsurface soil, sediment, and groundwater. Field screening for organic vapors was conducted at each sampling location using an organic vapor meter (OVM). All samples were analyzed by an independent analytical laboratory under contract for the investigation.

All samples collected during the investigation activities were analyzed by Southwest Laboratory of Oklahoma, Inc., Broken Arrow, Oklahoma. This facility has been reviewed and validated by the USACE Missouri River Division (MRD) Hazardous, Toxic, and Radioactive Waste (HTRW) Mandatory Center of Expertise (MCX), Omaha, Nebraska. Quality assurance (QA) samples were collected of soil, sediment, and groundwater, and analyzed by the USACE Ohio River Division (ORD) Laboratory in Cincinnati, Ohio. Laboratories supporting this work have statements of qualifications including organizational structures, QA Manuals, and standard operating procedures, which can be made available on request.

Samples were collected and analyzed according to the *RVAAP Phase I RI Sampling and Analysis Plan Addendum for High-Priority Areas of Concern* (USACE 1996d). Prepared in accordance with USACE and EPA guidance, the SAP outlines the organization, objectives,

intended data uses, and quality assurance/quality control (QA/QC) activities to achieve the desired DQOs and maintain the defensibility of the data. Criteria for establishing sample locations for soil, sediment, and groundwater are outlined in the SAP. Project DQOs were established in accordance with EPA Region V guidance, and requirements for sample collection, handling, analysis criteria, target analytes, laboratory quality, and data validation criteria for the high-priority AOCs are consistent with EPA requirement for NPL sites. DQOs for this project included analytical precision, accuracy, representativeness, completeness, comparability, and sensitivity for the measurement data. Appendix F presents an assessment of those objectives as they apply to the analytical program.

Strict adherence to the requirements set forth in the SAP was required of the analytical laboratory so that conditions adverse to quality would not arise. The laboratory was required to perform all analyses in compliance with EPA SW-846 (EPA 1990), Test Methods for Evaluating Solid Waste, Physical/Chemical Methods analytical protocols. SW-846 chemical analytical procedures were followed for the analyses of metals, VOCs, SVOCs, pesticides, PCBs, explosives, and cyanide. Geotechnical parameters including grain size and TOC were determined employing American Society for Testing and Materials (ASTM) and EPA protocol, respectively. Laboratories were required to comply with all methods as written; recommendations were considered requirements. **Table 2.4** provides a summary of the analytical program.

All soil and sediment samples were analyzed for explosives and 11 site-related metals, with the exception of background soil samples being analyzed for metals only. In each AOC, 20 percent of the soil and ditch sediment sampling locations were analyzed for an expanded list of metal analytes to include the TAL metals, VOCs, SVOCs, pesticides, PCBs, and cyanide. Sediments were analyzed for explosives and site-related metals, TOC, and grain size distribution. Ten percent of these samples received the full suite of analyses. All groundwater samples with sufficient sample volume collected from both temporary well points and monitoring wells were analyzed for explosives, TAL metals, VOCs, SVOCs, pesticides, PCBs, and cyanide. A listing of all metals, explosives, and other chemicals evaluated in the Phase I RI environmental samples is provided in **Table 2.5**.

The requisite number of QA/QC samples were obtained during the Phase I RI (refer to Appendix F, Table F-1). QC samples for this project included field blanks, trip blanks, field duplicates, laboratory method blanks, laboratory control samples, laboratory duplicates, and matrix spike/matrix spike duplicate (MS/MSD) samples. Field blanks, consisting of potable water used in the decontamination process, equipment rinsate blanks, and trip blanks, were submitted for analysis along with field duplicate (co-located) samples to provide a means to assess the quality of the data resulting from the field sampling program. Field blank samples were analyzed to determine procedural contamination at the site that may contribute to sample contamination. Equipment rinsate blanks were used to assess the adequacy of equipment decontamination processes for groundwater sample collection. Trip blanks were used to assess the potential for contamination of samples due to contaminant migration during sample shipment and storage. Field duplicate samples were analyzed to determine sample heterogeneity and sampling methodology reproducibility. Laboratory method blanks and laboratory control samples were employed to determine the accuracy and precision of the analytical method as implemented by the laboratory. MSs provided information about the effect of the sample matrix on the measurement methodology. Laboratory sample duplicates and MSDs assisted in determining the analytical reproducibility and

Table 2.4. RVAAP Analytical Program Summary

Media	Data Use	Sample Type	Analyte Group	Analytical Method	SW Lab ^a Procedure
Soil	Screening for sample site selection	Discrete	Volatile Organics	FID/PID	
Soil/Sediment	Confirmation and nature of contamination	Discrete	Volatile Organics	SW-846, -8060A	MS326
		Discrete or Composite	Semivolatile Organics	SW-846, -8270B	MS500
			Pesticide/PCB	SW-846, -8081	GC800
			Explosive	SW-846, -8330	GC200
			Metals (list of 11)	SW-846, -6010A/7000	MT900/MT310
			Metals (TAL)	SW-846, -6010A/7000	MT900/MT310
			Cyanide	SW-846, -9013	IN660
Sediment	Determination of Geological Regimes	Discrete	Grain Size	AT-D422	
		Discrete	TOC	EPA 415.1	IN045
Groundwater	Determination of basic water characteristics		Conductivity	EPA-120.1	
			pH	EPA-150.1	
			Temperature	EPA-170.1	
			Dissolved Oxygen	EPA-360.1	
	Confirmation and nature of contamination	Discrete	Volatile Organics	SW-846, -8260A	MS500
		Discrete or Composite	Semivolatile Organics	SW-846, -8270B	MS500
			Pesticide/PCB	SW-846, -8081	GC800

Table 2.4 (continued)

Media	Data Use	Sample Type	Analyte Group	Analytical Method	SW Lab ^a Procedure
			Explosives	SW-846, -8330 ^b	GC200
			Metals (TAL)	SW-846, -6010A/7000	MT900/MT310
			Cyanide	SW-846, -9013	IN660

^a Southwest Laboratory of Oklahoma.

^b Low concentration methodologies to include "salting out."

precision of the analysis for the samples of interest. Evaluation of these QC measures and their contribution to documenting the project data quality is provided in Appendix F as the project Quality Control Summary Report (QCSR).

SAIC is the custodian of the project file and will maintain the contents of the files for this investigation, including all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, correspondence, and chain-of-custody (COC) forms. These files will remain in a secure area under the custody of the SAIC Project Manager, until they are transferred to the USACE Nashville District and RVAAP. Analytical data reports from Southwest Laboratory of Oklahoma have been forwarded to the USACE ORD Laboratory for QA review and comparison. Southwest Laboratory will retain all original raw data information (both hard copy and electronic) in a secure area under the custody of the Laboratory Project Manager.

2.5.2 Data Review, Validation, and Quality Assessment

Samples were properly packaged for shipment and dispatched to Southwest Laboratory for analysis. A separate signed custody record was enclosed with each shipment. Samples are accompanied by properly completed COC forms, with sample numbers and locations listed. When transferring the possession of samples, the individuals relinquishing and receiving signed, dated, and noted the time on the record. All shipments were in compliance with applicable Department of Transportation regulations for environmental samples.

All samples collected for investigations at RVAAP were sent to Southwest Laboratory of Oklahoma, a USACE MRD-qualified laboratory. Data were produced, reviewed, and reported by the laboratory in accordance with specifications outlined in the project SAP and the laboratory's QA manual. Laboratory reports included documentation verifying analytical holding time compliance.

Table 2.5. RVAAP Analytical Parameters

Volatile Organic Compounds (VOCs)		
Chloromethane	Bromomethane	Vinyl chloride
Chloroethane	Methylene chloride	Acetone
Carbon disulfide	1,1-Dichloroethene	1,1-Dichloroethane
1,2-Dichloroethene (total)	Chloroform	1,2-Dichloroethane
2-Butanone	1,1,1-Trichloroethane	Carbon tetrachloride
Bromodichloromethane	1,2-Dichloropropane	cis-1,3-Dichloropropene
Trichloroethene	Dibromochloromethane	1,1,2-Trichloroethane
Benzene	trans-1,3-Dichloropropene	Tribromomethane
4-Methyl-2-pentanone	2-Hexanone	Tetrachloroethene
Toluene	1,1,2,2-Tetrachloroethane	Chlorobenzene
Ethylbenzene	Styrene	Xylenes (total)
Semivolatile Organic Compounds (SVOCs)		
Phenol	bis(2-Chloroethyl) ether	2-Chlorophenol
1,3-Dichlorobenzene	1,4-Dichlorobenzene	1,2-Dichlorobenzene
2-Methylphenol	2,2'-oxybis(1-Chloropropane)	4-Methylphenol
N-nitroso-di-n-dipropylamine	Hexachloroethane	Nitrobenzene
Isophorone	2-Nitrophenol	2,4-Dimethylphenol
bis(2-chloroethoxy) methane	2,4-Dichlorophenol	1,2,4-Trichlorobenzene
Naphthalene	4-Chloroaniline	Hexachlorobutadiene
4-chloro-3-methylphenol	2-Methylnaphthalene	Hexachlorocyclopentadiene
2,4,6-Trichlorophenol	2,4,5-Trichlorophenol	2-Chloronaphthalene
2-Nitroaniline	Dimethylphthalate	Acenaphthylene
2,6-Dinitrotoluene	3-Nitroaniline	Acenaphthene
2,4-Dinitrophenol	4-Nitrophenol	Dibenzofuran
2,4-Dinitrotoluene	Diethylphthalate	4-Chlorophenyl-phenyl ether
Fluorene	4-Nitroaniline	4,6-Dinitro-2-methylphenol
N-nitrosodiphenylamine	4-bromophenyl-phenylether	Hexachlorobenzene
Pentachlorophenol	Phenanthrene	Anthracene
Carbazole	Di-n-butylphthalate	Fluoranthene
Pyrene	Butylbenzylphthalate	3,3'-Dichlorobenzidine
Benzo(a)anthracene	Chrysene	bis(2-Ethylhexyl)phthalate
Di-n-octylphthalate	Benzo(b)fluoranthene	Benzo(k)fluoranthene
Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenzo(a,h)anthracene
Benzo(g,h,i)perylene		

Table 2.5 (continued)

Pesticides/PCBs		
alpha-BHC gamma-BHC (Lindane) Heptachlor epoxide 4,4'-DDE 4,4'-DDD Methoxychlor alpha-Chlordane Aroclor-1016 Aroclor-1242 Aroclor-1260	beta-BHC Heptachlor Endosulfan I Endrin Endosulfan sulfate Endrin ketone gamma-Chlordane Aroclor-1221 Aroclor-1248	delta-BHC Aldrin Dieldrin Endosulfan II 4,4'-DDT Endrin aldehyde Toxaphene Aroclor-1232 Aroclor-1254
Explosive Compounds		
HMX Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine 1,3,5-Trinitrobenzene Tetryl 2,4,6-Trinitrotoluene 2,6-Dinitrotoluene m-Nitrotoluene	RDX (cyclonite) Hexahydro-1,3,5-trinitro-1,3,5-triazine 1,3-Dinitrobenzene Nitrobenzene 2,4-Dinitrotoluene o-Nitrotoluene p-Nitrotoluene	
Metals (Target Analyte List)	Metals (11 Site-related)	
Aluminum Antimony Arsenic Barium Beryllium Cadmium Calcium Chromium Cobalt Copper Iron Lead Magnesium Manganese Mercury Nickel Potassium Selenium Silver Sodium Thallium Vanadium Zinc	Aluminum Arsenic Barium Cadmium Chromium Lead Manganese Mercury Selenium Silver Zinc Cyanide Geotechnical Analyses Grain Size (sieve) Total Organic Carbon (TOC)	

Southwest Laboratory performed in-house analytical data reduction under the direction of the Laboratory Project Manager and QA Officer. These individuals were responsible for assessing data quality and informing SAIC and USACE of any data which are considered "unacceptable" or required caution on the part of the data user in terms of its reliability. Data were reduced, reviewed, and reported as described in the laboratory QA manual and standard operating procedures. Data reduction, review, and reporting by the laboratory were conducted as follows:

- Raw data produced by the analyst were turned over to the respective area supervisor.
- The area supervisor reviewed the data for attainment of QC criteria as outlined in the established methods and for overall reasonableness.
- Upon acceptance of the raw data by the area supervisor, a report was generated and sent to the Laboratory Project Manager.
- The Laboratory Project Manager completed a thorough review of all reports.
- Final reports were generated by the Laboratory Project Manager.
- Data were then delivered to SAIC for data validation.
- Subsequent to SAIC data validation, copies of all data packages were forwarded to Ohio River Division Laboratory for evaluation and preparation of QA documents.

Southwest Laboratory prepared and retained full analytical and QC documentation for the project. Such retained documentation is in both hard (paper) copy and electronic storage media (e.g., magnetic tape) as directed by the analytical methodologies employed. Southwest Laboratory provided the following information to SAIC in each analytical data package submitted:

- cover sheets listing the samples included in the report and narrative comments describing problems encountered in analysis;
- tabulated results of inorganic and organic compounds identified and quantified; and
- analytical results for QC sample spikes, sample duplicates, initial and continuing calibration verifications of standards and blanks, method blanks, and laboratory control sample information.

Comprehensive analytical information will be retained by Southwest Laboratory.

A systematic process for data verification and validation was performed by SAIC to ensure that the precision and accuracy of the analytical data were adequate for their intended use. Analytical data validation was performed to minimize the potential of using false positive or false negative results in the decision-making process (i.e., to ensure accurate identification of detected versus non-detected compounds). This approach was consistent with the DQOs for the project and with the analytical methods, and appropriate for determining contaminants of concern and calculating risk.

Samples were analyzed through implementation of "definitive" analytical methods. "Definitive Data" were reported consistent with the deliverables identified in the project SAP. These "Definitive Data" were then validated through the review process outlined in the SAP and are presented in Appendix F.

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