

### 3. STUDY AREA INVESTIGATIONS

This chapter describes the field and analytical methods implemented during the Phase II RI to collect and analyze data needed to meet the DQOs developed for this project in the SAP Addenda Nos. 1 and 2 for the Phase II RI at Load Line 1 (USACE 1999a and 2000b). The field and analytical programs were conducted in accordance with the RVAAP Facility-Wide SAP (USACE 2000a) and the SAP Addenda Nos. 1 and 2 for the Phase II RI at Load Line 1 (USACE 1999a and 2000b). Investigation objectives, rationale, sampling methods, and sampling locations are discussed in this section.

Field activities were conducted in September 1999 and September and October 2000. The 1999 field investigation activities included the installation, sampling, and testing of eight monitoring wells and the resampling of the six Phase I wells. Surface soil sampling at the four former change houses (CB-8, CB-12, CB-22, and CB-23) was also carried out, and a report on these activities and the results were submitted under separate covers in 1999. Demolition of LL 1 took place following the 1999 field effort. The 2000 field program included surface and subsurface soil sampling, sampling of all 14 monitoring wells, and surface water and sediment sampling to address data gaps from the Phase I RI and to further characterize the AOC following the completion of building demolition activities. The Phase II RI sample locations were reviewed by representatives of RVAAP, Ohio EPA, and USACE based on the results of the Phase I RI and on new information collected after the Phase I RI on potential source areas. The rationales for each component of the field program are described in the following sections.

#### 3.1 SURFACE SOIL AND SEDIMENT CHARACTERIZATION

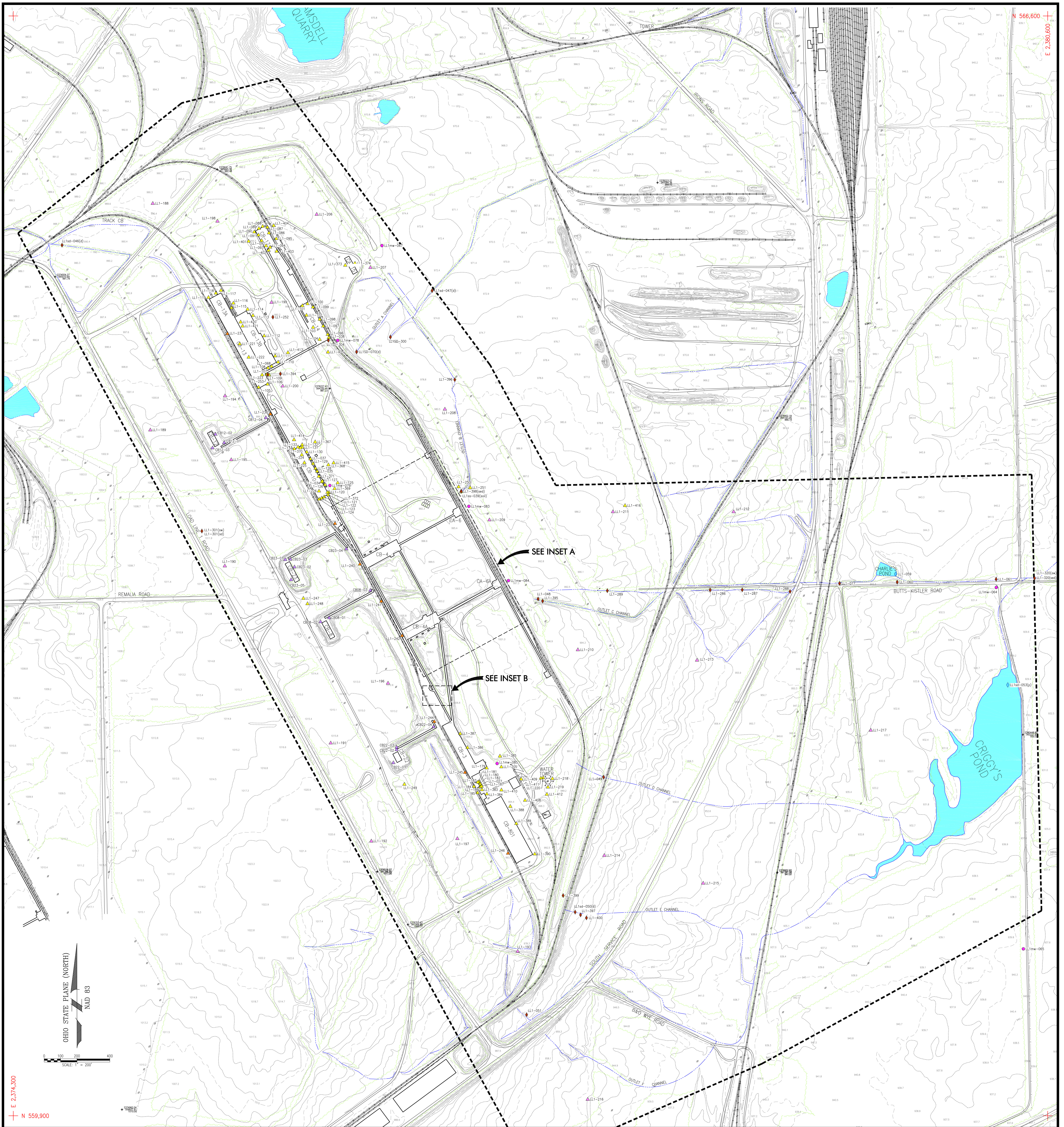
Surface soil samples and dry sediments in ditches [from 0 to 0.3 m (0 to 1 ft)] were collected to evaluate nature and extent of contaminants in soils at LL 1. Surface soil sample locations at LL 1 are illustrated on Plate 3-1. Off-AOC sediment sample locations are shown in Figure 3-1. Sediment samples within the AOC are depicted on Plate 3-1, along with surface water and groundwater sample locations. All soil samples collected are documented in soil boring logs presented in Appendix A. Sediment sampling logs are presented in Appendix B.

The results of the Phase I RI at LL 1 indicated that the release of explosive residues, metals, and other chemicals onto surface soils occurred at several of the buildings. The assemblage of possible contaminants was found to vary with the historical functions or uses of the buildings. Surface water runoff from these areas may have conveyed contaminants overland to drainage ditches that traverse the load line and ultimately to streams that exit RVAAP to the east and northwest.

The Phase II RI objectives for the surface soil and dry sediment sampling program were as follows:

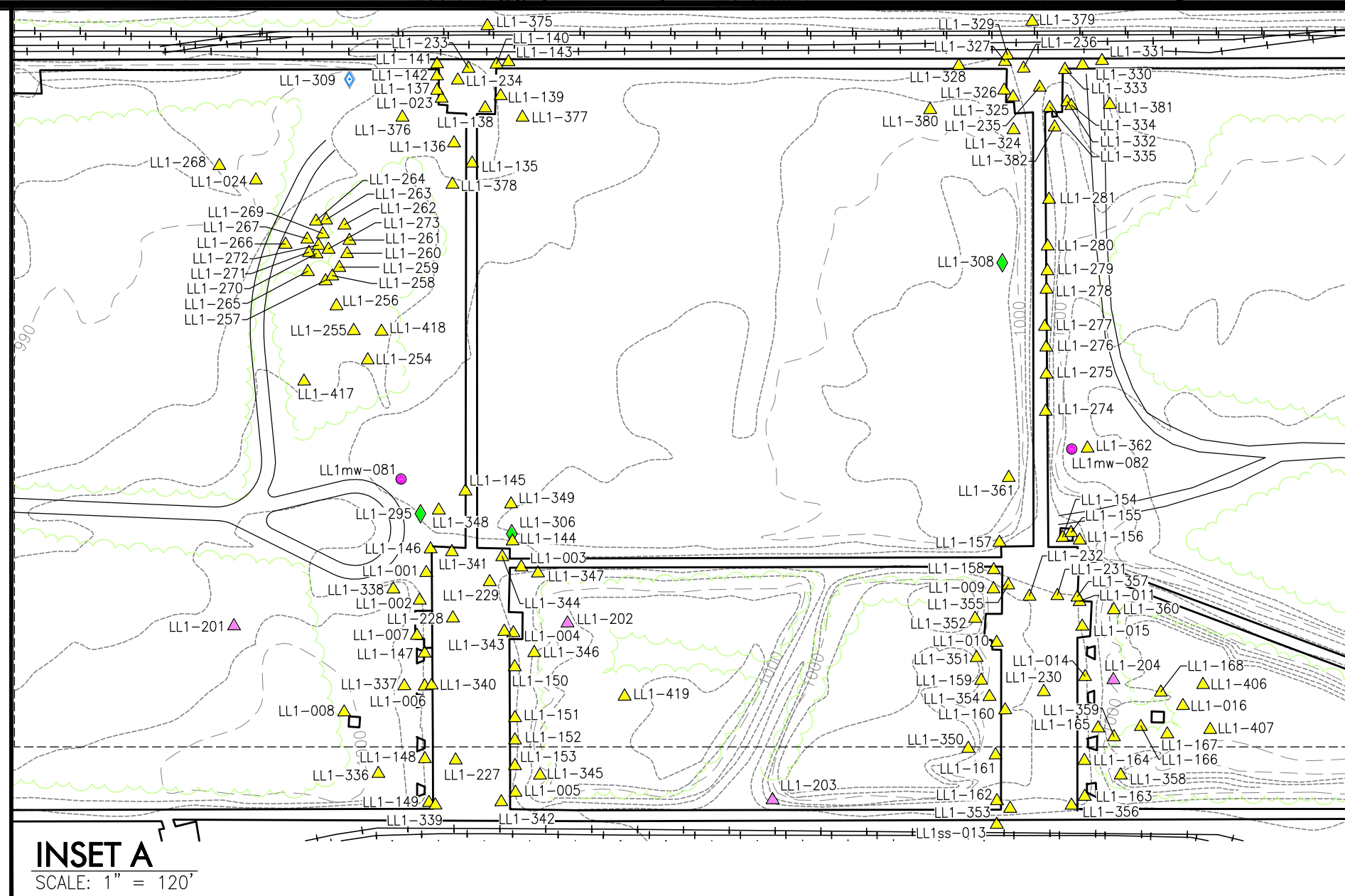
- To determine the nature and horizontal extent of contamination using biased sampling at each area within LL 1 having either explosives greater than or equal to 1 ppm or lead in excess of 100 ppm in surface soils during the Phase I RI. The primary buildings of interest are Buildings CA-17, CB-13, CB-13B, CB-14, CB-10, CB-4 and CB-4A, CA-6, and CA-6A, the former concrete settling tanks east of Building CB-4 and south of Buildings CB-4A, CB-2, and the former Water Tower.
- To compare the surface soil data to the RVAAP facility-wide background data set, which characterizes natural site-wide variability for 23 TAL metals.

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**LEGEND:**

	BUILDING
	ASPHALT ROAD
	GRAVEL ROAD
	RAILROAD TRACKS
	FENCE LINE
	PROPERTY BOUNDARY
	POND
	STREAM
	GRID TIC
	CONTOUR (2 FT. INTERVAL)
	CONTOUR (10 FT. INTERVAL)
	SOIL SAMPLE
	PHASE II RI GRID SAMPLING LOCATIONS
	PHASE II SOIL SAMPLE - RR TRACK
	PHASE II SOIL SAMPLE - CHANGE HOUSE
	GROUNDWATER MONITORING WELL
	SURFACE WATER
	SEDIMENT SAMPLE
	PHASE II MANHOLE SEDIMENT SAMPLE



**U.S. ARMY ENGINEER DISTRICT**  
 US Army Corps of Engineers  
 Louisville District

**CORPS OF ENGINEERS**  
 LOUISVILLE, KENTUCKY

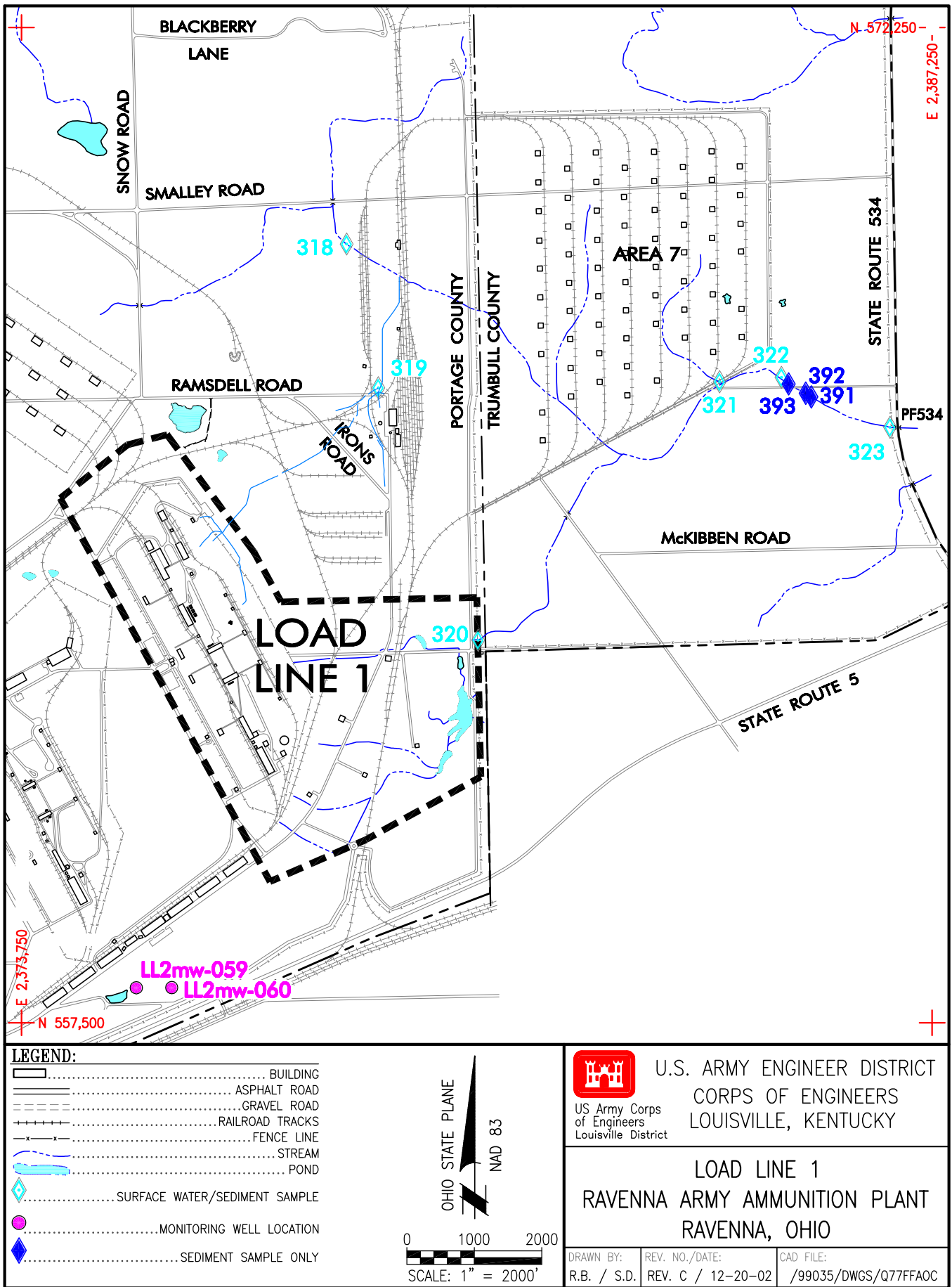
**SAIC**  
 Science Applications  
 International Corporation

**LOAD LINE 1 PHASE I AND II RI LOCATIONS SAMPLING**  
**RAVENNA ARMY AMMUNITION PLANT**  
**RAVENNA, OHIO**

REV.	DRAWN BY:	CHKD. BY:	DATE:
0	R.B. / S.D.	K. JAGO	10-28-02
A	S. DUNLAP	K. JAGO	11-07-02

DRAWING # \_\_\_\_\_ CAD FILE # \_\_\_\_\_  
 PLATE 3-1 /99035/DWGS/Q77SB03.DWG

**Plate 3-1. Surface Soil, Sediment, Groundwater, and Surface Water Samples  
within the Load Line 1 AOC (continued)**



**Figure 3-1. Off-AOC Sediment, Surface Water, and Groundwater Monitoring Well Sample Locations for Load Line 1**

- To assess the suitability of field-portable XRF spectrometry for performing in-situ and ex-situ analyses of metals in soil samples. Results of these tests will determine the suitability of metals field data for future environmental investigations and remedial activities.
- To characterize non-production areas of the load line using statistical sampling methods (random-grid samples) to confirm the absence of contamination at levels presenting a risk to human or ecological receptors.

The following section also includes a brief description of field colorimetric methods used to determine whether explosives were present at a given sample location.

### 3.1.1 Rationale

The rationale for the biased surface soil and sediment sampling strategy was to fully characterize the buildings and areas known or suspected to have contamination. The exact locations of the samples were finalized in the field based on observations (e.g., staining, vegetative stress, drainage, etc.). The rationale for random-grid samples was to characterize large non-production areas using a statistical approach to ensure adequate coverage.

Surface soils were collected from 295 locations throughout LL 1. Sediments were collected in 44 locations. Thirty additional contingency samples were assigned to various locations after the first 295 samples were collected. Approximately 40 additional samples remaining from planned, but unexpended subsurface samples (see Section 3.2) were also collected. These samples were used to delineate horizontal extent of contamination or to characterize visibly contaminated spots on the ground surface.

Included in the sampling strategy for soils at LL 1 was the use of color spectrophotometry, or colorimetry, to analyze explosive compounds TNT and RDX in the field. All subsurface and surface soil samples in LL 1, as well as all dry sediment samples, were subject to analysis with the colorimetric method to determine whether explosives were present in the soils at concentrations greater than or equal to 1 ppm. Section 3.6.1 outlines the specific methodology for field colorimetry analysis for TNT and RDX. The rationale for employing the field method was to delineate extent of explosives-contaminated “hot spots” on a “real-time” basis and to select samples for fixed-base laboratory analysis to characterize the nature and extent of contamination (see Section 3.6.1). Jenkins (1990) has shown that field colorimetric results for TNT can be, under proper conditions, as accurate and precise as the EPA SW-846 Method 8330 results (EPA 1990a).

It should be noted that sample preparation methods for TNT and RDX result in color development for explosives other than TNT or RDX that are typically found at RVAAP [e.g., DNT, tetryl, TNB, or dinitrobenzene (DNB) in the TNT method; HMX, propellants, or pentaerythritol tetranitrate (PETN) in the RDX method]. Because of these interferences, field colorimetric measurements are considered bulk values for TNT, RDX, and related compounds. As such, colorimetric data cannot be used in human health or ecological risk assessments because each concentration used to calculate risk must be for a single analyte. However, the data can be used to help define the extent of contamination. For example, a non-detect of explosives in surface soil at a given location indicates that

- TNT, RDX, or related explosives are present at concentrations less than 1 ppm in the surface soil at this location. Therefore, any “hot spot” in a particular location does not extend to the sample point.
- It is unlikely that explosives are present in the subsurface given the surficial nature of the releases (unless the soil has been reworked); therefore, no subsurface sampling is proposed to define the vertical extent of contamination.

On the basis of the field colorimetric results for TNT and RDX, all samples that had detectable levels of these compounds in the field method were sent to the fixed-base laboratory for explosives and propellant analysis. In addition, 15% of the samples having field colorimetric non-detects were also sent to the fixed-base laboratory for explosives analysis. The field and fixed-base analytical results for all soil samples are presented in Chapter 4.0 and Appendices H and I of this report.

All soil and dry sediment samples were also screened in the field for metals using a portable XRF spectrometer. In-situ measurements of the concentrations of 24 metals were collected at each surface soil/sediment sampling location. In addition, an aliquot of each homogenized soil/sediment sample was subjected to ex-situ analyses at an on-site laboratory. Unlike the explosives field screening, the XRF method was not used to select samples for fixed-base laboratory analysis. Rather, all soil and sediment samples were sent to the laboratory for analysis with the standard SW-846 technique regardless of the field results. A discussion of the XRF methodology is presented in Section 3.6.2.

All surface soil samples collected at LL 1 during the Phase II RI were analyzed for TAL metals and cyanide. VOC, SVOC, and PCB analyses were performed for 39 randomly selected surface soil or sediment samples.

### **3.1.2 Field Sampling Methods**

For all surface soil and dry sediment sampling stations in the Phase II RI at LL 1, composite samples from the mixture of three subsamples were collected for explosives and propellants analyses, as described below. Chemical data have shown that the explosives commonly used at RVAAP are generally immobile in soils and are distributed as unexploded, bulk material. Concentrations may range from non-detectable to the percent range in samples collected a few feet apart. Solid pieces of TNT or other bulk explosives have been observed in surface soils. Because of this erratic distribution of explosives compounds in soils, sampling errors may result from collection of single, discrete surface soil samples. Composite sampling has been shown to reduce statistical sampling errors in surface soil data at sites with a history of explosives contamination in surface soils (Jenkins et al. 1996). That is, the likelihood of capturing detectable levels of explosives in soils over a small area is greater with composite sampling than with discrete sampling. Composite sampling data are considered acceptable to EPA (RAGS, Part A) to assess the presence or absence of contamination in soil, sediment, groundwater, or surface water; however, they may be used in risk assessment only to represent average concentrations over the area or timeframe sampled (EPA 1989a).

Surface soil and dry sediment explosives and propellants samples were collected from the 0 to 0.3 m (0 to 1 ft) interval. Each surface soil sample was composited from three subsamples collected from a 0.9 × 0.9-m (3 × 3 ft) area in a roughly equilateral triangle pattern. Sampling was accomplished using hand augers with a 7.62-cm (3-in.) bucket or a stainless steel spoon or scoop. Material collected in the auger bucket during augering of each interval was removed using a stainless-steel spoon. Equal portions of soil from the subsamples were composited and homogenized in a stainless steel bowl. After the samples were homogenized and split, a portion was analyzed with the field colorimetry methods described in Section 3.1.1. If the sample tested positive for either TNT or RDX in the field colorimetric analyses, a portion of the sample was sent for fixed-base laboratory analysis. This sampling strategy was employed for all surface soil and dry sediment samples. In sample locations where access was extremely limited, such as beneath the floor slabs of the major buildings, no three-point composite sampling was attempted. Instead, soil was collected from single boreholes.

Surface soil and sediment samples for metals, VOC, SVOC, and PCB analyses were collected from a point in the middle of the triangle formed by the three subsamples, with the volatile fraction collected first from unhomogenized material.

Wet sediment samples were also collected from areas of the stream channels where surface water was pooled or ponded. All wet sediment samples were collected from 0 to 0.015 m (0 to 0.5 ft) below the sediment-water interface. Samples were collected using a stainless-steel scoop or trowel, as described in Section 4.3.1.3 of the SAP Addendum No. 2 (USACE 2000b).

During sample collection, all samples were field screened for VOCs using a hand-held photoionization detector (PID) organic vapor analyzer (OVA). No headspace samples were collected for organic vapor monitoring.

Following collection of the sample, the surface soil descriptions and/or general soil characteristics were recorded in the project logbooks. After completion, each borehole was staked with a 60.96-cm (2-ft) rebar stake and labeled. Excess soil from the borehole was placed in lined, labeled 242-L (55-gal) drums that were sealed after each use and staged at Building 1036. Investigation-derived waste practices for all media are discussed in Appendix O.

The sampling results are discussed in detail in Section 4.2; analytical data are provided at the end of Chapter 4.0 and in Appendixes H, I, J, and K.

## **3.2 SUBSURFACE SOIL CHARACTERIZATION**

The collection of subsurface soils at LL 1 was intended to define the vertical extent of contamination and to study transport pathways of any such contamination. Opportunities for the collection of soils below a depth of 0.3 m (1 ft) were extremely limited in LL 1 because of the occurrence of shallow bedrock.

### **3.2.1 Rationale**

The subsurface soil samples were collected at the locations of surface soil samples with concentrations of explosives greater than or equal to 1 ppm as determined from Phase I RI analytical results or Phase II field colorimetric data. If the 0- to 0.3-m (0- to 1-ft) sample tested positive ( $\geq 1$  ppm) for explosives via the field method, the 0.3 to 0.9-m (1- to 3-ft) sample was collected. If that sample also tested positive ( $\geq 1$  ppm) for explosives, the sampling crews attempted to collect soil from the 0.9 to 1.5-m (3- to 5-ft) interval in the same location. Unlike the surface soil and sediment samples, and regardless of field colorimetric results, all subsurface soil samples were analyzed by the fixed-base laboratory for explosives, metals, and cyanide for confirmation purposes, per the SAP. Subsurface soil sampling locations are illustrated in Figure 3-2. Boring logs for subsurface soil samples are presented in Appendix A.

A total of 39 subsurface soil samples were collected at LL 1 to characterize nature and extent of contamination. Of the 39 subsurface samples, 29 were pre-planned or were collected from locations where field colorimetric results indicated explosives contamination in the overlying surface soil sample. All of the subsurface samples were collected from the 0.3 to 0.9-m (1- to 3-ft) interval. In approximately half of those borings where field explosives results indicated that deeper sampling [below 0.9 m (3 ft)] was warranted, deeper penetration was not possible because of the shallow occurrence of bedrock. In the remaining borings, the deepest sample collected showed no detections of explosives with the field method. Three of the subsurface samples were collected even though the field explosives results from the overlying surface soil sample indicated that explosives contamination was not present. In four borings, field laboratory results indicated a subsurface sample should be collected, but logbook documentation does not indicate why the subsurface sample was not collected; likely the reason was refusal on bedrock, which commonly occurred as noted above.



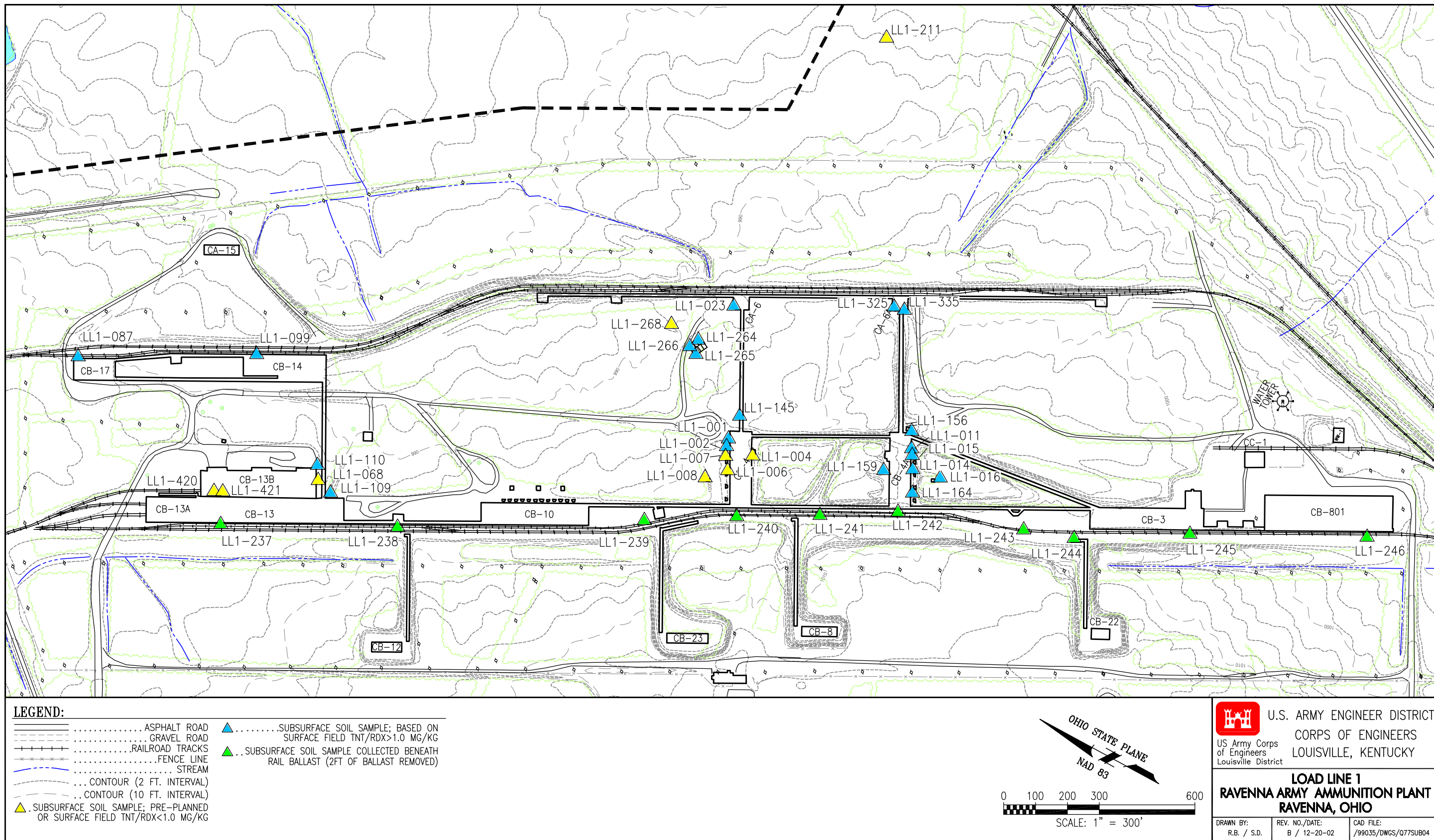


Figure 3-2. Subsurface Soil Sample Locations for Load Line 1 Phase II RI

In addition, 10 soil samples were collected from beneath the railroad ballast along Track CB. These sampling results are not part of the nature and extent evaluation, but were subject to the same field screening procedures as the other samples. All samples along this track were collected from a depth of from 0.6 to 0.67 m (2 to 2.2 ft) bgs to account for the thickness of the overlying ballast. Therefore, these samples are considered subsurface soils for the purposes of this report.

### **3.2.2 Field Sampling Methods**

One discrete subsurface soil sample was collected from each location where surface soil samples exhibited evidence of explosives contamination (i.e., TNT and/or RDX greater than or equal to 1 ppm by field colorimetric analysis). Subsurface soil samples were collected from a boring in the center of the triangular area formed by surface soil composite samples. Subsurface soil sampling was accomplished by using the hand auger to advance the boring. If the sample tested positive for either TNT or RDX, sample collection from the 0.9- to 1.5-m (3- to 5-ft) interval was attempted. This was accomplished using either the hand auger or hand-operated power auger to advance the boring. The power auger flights, 15.2 cm (6 in.) in diameter, were attached to and rotated by a gasoline-powered hydraulic drive. By increasing the diameter of the borehole in the overlying interval(s), the bucket hand auger was more easily advanced to the target depth. Where subsurface conditions permitted, the hand auger was used to complete the boring without the use of the power auger. In about 50% of the sampling locations, refusal of either the hand or power auger on bedrock prevented reaching the target sampling depth. In such cases, samples were collected from the deepest subsurface interval achieved.

The soil samples were collected from each depth interval by mixing in a stainless-steel bowl before filling sampling containers. Samples collected for VOC analysis were not homogenized. Material collected in the auger bucket was removed using a stainless-steel spoon.

Organic vapors were monitored in the subsurface soil boring using hand-held OVAs. No headspace samples were collected. Breathing zone gas concentrations were recorded in the project logbooks.

Following collection of the sample, the subsurface soil lithologies and/or general soil characteristics were recorded in the project logbooks. The borehole was plugged with bentonite hole plug and water. Excess soil from the borehole was placed in lined, labeled 242-L (55-gal) drums that were sealed after each use and staged at Building 1036. Investigation-derived waste practices for all media are discussed in Appendix O.

The sampling results are discussed in Section 4.3; analytical data are provided at the end of Chapter 4.0 and in Appendixes H, I, J, and K.

## **3.3 SURFACE WATER CHARACTERIZATION**

### **3.3.1 Rationale**

Runoff from contaminated soils may contribute contaminants in dissolved and suspended form to the surface water system at LL 1. Surface water samples were collected at 10 locations in Criggy's Pond, Charlie's Pond, and in the surface water conveyances where water was present (see Plate 3-1 and Figure 3-1). These locations were selected to evaluate whether the drainages at LL 1 contribute contaminants to the surface water system that exits the RVAAP facility to the east. One sample each was collected from Criggy's Pond, Charlie's Pond, and two sewer line locations. Surface water samples were collected from six locations outside the AOC boundary. The six locations outside the AOC boundary were sampled in two rounds, approximately two months apart, to evaluate seasonal fluctuations in chemical water quality. These off-AOC stations were selected for multiple sampling due to potential concerns resulting from a Phase I RI at Erie Burning Grounds, which detected low levels of explosive compounds at station PF534. Subaqueous sediment samples (discrete grab samples) were collected from

each of the off-AOC surface water stations and three additional contingency stations (LL1-391, -392, and -393), as shown on Figure 3-1. The sediment and surface water sampling logs are presented in Appendices B and C, respectively, of this report.

### **3.3.2 Field Sampling Methods**

Surface water samples were collected first at each location, beginning with the furthest downstream point and moving upstream, to minimize the effects of sediment turbidity on water quality. All surface water was collected as described in Section 4.6.2.1.1 of the Facility-Wide SAP (USACE 2000a). The hand-held bottle method was used to sample water in the streams. Each container was submerged into the water, with the cap in place. The cap was removed under water, and the container was allowed to slowly and continuously fill. Water quality measurements (pH, conductivity, dissolved oxygen content, and temperature) were recorded during sample collection using hand-held field instruments. Surface water samples were not filtered and were analyzed for explosives, propellants, TAL metals, and cyanide. VOCs, SVOCs, pesticides, and PCBs were also analyzed in nine samples. Corresponding subaqueous sediment samples were collected using a stainless steel spoon or clamshell sampler, as necessary, after collection of the surface water samples. These samples represent the uppermost 15 cm (6 in.) of subaqueous sediment in most cases.

The results of surface water sampling are discussed in detail in Section 4.5. Subaqueous sediment results are presented in Section 4.4. Analytical data are provided at the end of Section 4 and in Appendix H.

## **3.4 GROUNDWATER CHARACTERIZATION**

### **3.4.1 Rationale**

The rationale for the placement of the eight new monitoring wells in Phase II at LL 1 is presented in Table 3-1. Generally, the purpose of placing wells in the selected locations was to target areas of known soil contamination identified in the Phase I RI. These areas are directly downgradient of former operational facilities. The placement of the wells maximizes the potential to identify contaminated groundwater resulting from the leaching and infiltration at known and suspected source areas (i.e., the melt-pour buildings, settling basins, and high-explosives prep areas). The wells installed in Phase II and the six wells installed during the Phase I RI provide data on the LL 1 flow system and chemical groundwater quality. The locations of all LL 1 monitoring wells are shown on Plate 3-1. Two additional wells included in the investigation, which are also downgradient of LL 2, are shown on Figure 3-1.

### **3.4.2 Field Sampling Methods**

All monitoring well installation, development, and sampling were conducted according to the Facility-Wide SAP and the SAP Addenda Nos. 1 and 2 (USACE 2000a, 1999a, 2000b).

The eight Phase II RI monitoring wells were installed in August 1999, using hollow-stem auger (HSA) and air-rotary drilling methods under the direct supervision of a qualified geologist. Ten and 1/8-cm (4.2-in.) and/or 15.9-cm (6.25-in.) inside diameter, HSAs were 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 during well drilling for description of soil stratigraphy and geotechnical evaluation only. The bedrock was cored with NQ-sized (approximate 3-in.) and/or HQ-sized (approximate 3.8-in.) wireline tool string bits. Cores were used to determine lithologies and degree of weathering and fracturing in bedrock. The cored interval was then overdrilled, using an air-rotary system with a 15.24-cm (6-in.) tricone roller bit, to

**Table 3-1. Rationale for Placement of Phase II Monitoring Wells at Load Line 1**

<b>Well ID</b>	<b>Location</b>	<b>Rationale</b>
LL1mw-078	East of tracks near Building CB-14, north end of load line	Downgradient of building (demilitarization facility) with elevated explosives, metals, pesticides/PCBs in soils
LL1mw-079	Southeast corner of CB-10	Downgradient of building (drill and booster facility) with high levels of lead, pesticide/PCBs, and explosives in soil
LL1mw-080	North of CB-3, near former concrete settling tank	High levels of lead, pesticide/PCBs, and PAHs in soil associated with settling tank
LL1mw-081	East of CB-4	Downgradient of significant source area (melt-pour building) for explosives and metals
LL1mw-082	East of CB-4A	Downgradient of significant source area (melt-pour building) for explosives and metals
LL1mw-083	East of CA-6	Downgradient of significant source area (bulk-explosives prep building) for explosives
LL1mw-084	East of CA-6A	Downgradient of significant source area (bulk-explosives prep building) for explosives
LL1mw-085	East of CB-20, south end of load line	Downgradient of former paint mixing and solvent storage building, potential source of SVOCs and PCBs

PAH = polyaromatic hydrocarbons.

PCB = polychlorinated biphenyl.

SVOC = semivolatile organic compound.

achieve a sufficient borehole diameter for the installation of a monitoring well. A borehole log, including lithologic information, was entered in the project logbooks for each monitoring well boring. The monitoring well boring logs, including soil classifications, bedrock lithologic descriptions, and monitoring well constriction data, are provided in Appendix D.

Organic vapors were monitored from soil and rock cuttings at each borehole using a hand-held OVA. In addition, the breathing zone was continuously monitored for evidence of organic chemicals. All readings are recorded in the project logbooks.

Following drilling of monitoring well boreholes to the appropriate depths, monitoring wells were constructed from pre-cleaned 5.0-cm (2.0-in.) schedule 40 polyvinyl chloride (PVC) pipe. Well screens were commercially fabricated with slot widths of 0.025 cm (0.01 in.). The monitoring wells were constructed using 3-m (10-ft) screens. The well casing and screen were assembled and lowered into the open borehole. Following placement of the well casing and screen, a pre-washed filter pack, consisting of Global Supply No. 7 sand, was tremied in place from the bottom of the borehole to approximately 0.6 m (2 ft) above the top of the well screen in each well. A 0.6-m (2-ft) or 0.9-m (3-ft) bentonite pellet annular seal was then poured into the borehole on top of the filter pack. A grout mixture consisting of Type I Portland cement and 5% bentonite was then tremied from the top of the annular seal to the ground surface, followed by the placement of a protective steel surface casing and construction of a mortar collar and cement pad. Three steel posts were installed around each well and were painted and labeled. Monitoring well installation procedures are provided in Section 4.3.2 of the Facility-Wide SAP (USACE 2000a). Construction diagrams are provided in Appendix D.

At least 48 h after completion, 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 a bailer, until the development water was visually clear and sediment thickness in the well was less than 3.0 cm (1.2 in.). Well development records were included in the project logbooks and are provided in Appendix E. Well diagrams, provided in Appendix D,

summarize the construction details for the monitoring wells installed during the Phase II RI at LL 1, including depths, screened intervals, and groundwater elevations. This information is summarized in Table 3-2.

**Table 3-2. Summary of Load Line 1 Phase I and Phase II RI Well Construction Data**

Well ID	TD (ft below TOC)	Elevation (GL)	Elevation (TOC)	Screened Interval (ft below TOC)	Screened Interval	Year Installed
LL2mw-059	21.84	964.33	966.67	11.82 to 21.62	Sharon Sandstone	1996
LL2mw-060	20.94	958.93	961.57	10.58 to 20.44	Sharon Sandstone	1996
LL1mw-063	30.04	992.20	994.84	19.8 to 29.8	Sharon Sandstone	1996
LL1mw-064	21.13	932.32	935.10	10.77 to 20.77	Unconsolidated sand	1996
LL1mw-065	23.38	941.53	944.41	12.9 to 22.9	Unconsolidated sand	1996
LL1mw-067	25.61	977.55	980.36	15.73 to 25.49	Sharon Sandstone	1996
LL1mw-078	41.14	993.40	995.84	31.73 to 41.20	Sharon Sandstone	1999
LL1mw-079	42.03	995.30	997.87	32.53 to 41.93	Sharon Sandstone	1999
LL1mw-080	22.04	993.7	996.27	12.50 to 21.97	Sharon Sandstone	1999
LL1mw-081	41.87	996.4	998.92	32.38 to 41.85	Sharon Sandstone	1999
LL1mw-082	41.77	1,003.7	1,006.45	31.90 to 41.45	Sharon Sandstone	1999
LL1mw-083	41.70	992.80	995.2	32.07 to 41.62	Sharon Sandstone	1999
LL1mw-084	39.29	996.40	998.73	29.73 to 39.28	Sharon Sandstone	1999
LL1mw-085	44.68	994.3	996.84	35.13 to 44.64	Sharon Sandstone	1999

GL = ground level elevation.  
 RI = remedial investigation.  
 TD = total depth.  
 TOC = top of casing.

Coring of bedrock borings was initially planned for the eight Phase II RI monitoring wells using air to cool the bit and circulate cuttings. Upon initiation of drilling in the field, the use of air alone was not sufficient to allow coring. As such, potable water was added to assist circulation. Due to low water table conditions (extremely dry weather) and fracture zones, large quantities of water were required. Because of the water losses, the decision was made to only core four of the eight borings as practicable (LL1mw-079, -080, -081, and -085). The remaining borings were drilled with conventional air rotary equipment and boring logs were obtained from cuttings. Because of slow recharge and the large volumes of potable water added, attempts to recover the volume of water added to wells LL1mw-078 and -085 were unsuccessful. Appendix F contains field change and contact report documentation regarding drilling/development difficulties and resolutions.

Following development of the new wells, groundwater samples were collected at the monitoring wells installed during the Phase II RI and at the six Phase I monitoring wells. Two rounds of groundwater sampling were performed—one in September 1999 and one in October 2000. The procedure for sampling groundwater is described in Sections 4.3.4 and 4.3.5 of the Facility-Wide SAP (USACE 2000a). Before sampling, the monitoring wells were purged until readings of pH, conductivity, dissolved oxygen, and water temperature reached equilibrium. Groundwater samples were collected using low-flow sampling systems in 1999 and 2000. Wells that could not be sampled with the low-flow systems (LL1mw-085 and LL1mw-067 in October 2000), due to insufficient water column height for pump and water indicator placement, were sampled using disposable Teflon® bailers.

All September 1999 groundwater samples were analyzed for explosives, propellants, TAL metals (filtered and unfiltered), and cyanide. Two samples received VOCs, SVOCs, and pesticides/PCBs analyses as well. Per the SAP, all October 2000 groundwater samples from LL 1 were analyzed for dissolved TAL

metals (filtered) and for explosives, propellants, cyanide, VOCs, SVOCs, and pesticides/PCBs. Groundwater samples analyzed for dissolved metals were filtered during sample collection using a disposable, in-line barrel filter with 0.45-um pores. Where low-flow sampling could not be performed, filtering was accomplished using a negative-pressure system with a hand-operated pump and disposable barrel filter.

The results of groundwater sampling at LL 1 are discussed in detail in Section 4.6. The analytical data are presented at the end of Chapter 4.0 and in Appendix H.

### **3.4.3 In-Situ Permeability Testing**

Slug tests were performed at the eight 1999 wells to determine the hydraulic conductivity of the geologic materials surrounding each well screen. Slug tests followed the provisions of the SAP Addendum No. 1 (USACE 1999a). These analyses calculate horizontal hydraulic conductivities in the screened interval of each well. Rising-head tests were completed by removing a cylinder (slug) from the well and monitoring the return to pretest static water level over time. The tests were performed after each well had fully recovered from groundwater sampling, using pressure transducers for water level measure and automated data collection. The slug was designed to displace 0.3 m (1 ft) of water.

Prior to slug testing, a pressure transducer was placed in the lower portion of the screened interval (approximately 1 ft from the bottom of the screen) and calibrated. The slug was placed into the well and the water level was allowed to equilibrate to static conditions or until a minimum of 6 h had elapsed. To begin the test, the slug was withdrawn quickly from the well, and water level measurement recording began at that moment. Water level measurements were recorded using a pre-programmed logarithmic time interval. Water levels were monitored for a period of 6 h or until the well re-equilibrated to 90% of the pretest water level. The data were evaluated using the updated Bouwer and Rice method (Bouwer 1989; Butler 1998). Compensation for water levels within the screened interval is included in this evaluation method. The results of the slug tests performed in September 1999 are presented in Appendix E and in Table 2-2. The slug test data for the six wells installed in Phase I are presented in the *Phase I Remedial Investigation Report for 11 High-Priority AOCs at Ravenna Army Ammunition Plant* (USACE 1997a).

## **3.5 SEWER LINE CAMERA SURVEY AND SAMPLING**

### **3.5.1 Rationale**

Migration of contaminants to surface water (by flushing during storm events) or groundwater (through leaking or breached sewer pipe) from the storm water and sanitary sewer systems at LL 1 may represent a major source release mechanism. Investigations of storm and sanitary lines at other Army Ammunition Plants (AAPs) in load lines similar to LL 1 have shown that sewer lines are commonly contaminated with bulk explosives, particularly at load lines that were heavily used. In the past, camera surveys of such lines revealed cracks or other breaches in the pipe, as well as bulk explosives partially filling the pipe.

Archived plan drawings indicate that a substantial length of pipe was laid in trenches cut in bedrock at LL 1 and that the trenches were backfilled with coarse material. Given these conditions, intrusive sampling of the pipe and trench material was not feasible. As an alternative characterization method, a color video survey of the main sanitary and storm sewer lines at LL 1 was conducted to characterize the extent of explosives contamination in sewer pipe, to assess the integrity of that pipe and its potential for releasing contaminants to the environment, and to provide data for the evaluation of remedial alternatives.

The camera survey was biased to the portions of those systems located near the most contaminated areas of the load line, namely, the melt-pour and drilling-boostering areas.

In addition to the camera surveys, sampling of water and sediment within the sewer systems was also planned. The purpose of the planned sampling was to determine concentrations of potential contaminants, including explosives and propellants, identified in the pipes during the camera survey. However, in the course of the preliminary examination of the catch basins and manholes in the sewer systems, it became clear that there were few places where sediment had accumulated. Therefore, the collection of samples from the sewers proceeded independently of the camera survey.

The analytical data from the sanitary and storm sewer system samples were part of the Phase II RI, but were collected to meet data quality objectives outside those stated in Section 1.4. As such, these data are reported in Chapter 4.0, but are not considered in the human health and ecological risk assessments.

Storm sewer segments selected for the video survey included (Figure 3-3)

- Segment of storm sewer A, north of the drill and booster building (CB-10) and south of building CB-14, which discharges to a drainage ditch along the western portion of the load line and exits the AOC at the northwest corner of the boundary. Sediment samples were collected from this ditch at station LL1-046 (Plate 3-1) to characterize potential contamination from releases to this surface water exit pathway.
- Segment of storm sewer B traversing LL 1, north of melt-pour building CB-4, to bulk explosive preparation building CA-6, and discharging at Outlet B. Sediment sampling of the Outlet B channel surface water exit pathway was conducted at station LL1-398 (Plate 3-1) for contaminant nature and extent characterization purposes.
- Segment of storm sewer D, east of building CB-3, and a segment of storm sewer E south of building CB-801, which discharge to Outlets D and E, respectively. Sediment samples were collected from the Outlet D channel at station LL1-049 for nature and extent characterization. Outlet E channel sediments were sampled at stations LL1-050, -397, and -400 (Plate 3-1).

The sanitary sewer system at LL 1 was a contained system with discharge directed through Ejector Station No. 1 at the north end of the load line. Three segments of the sanitary sewer system were surveyed (Figure 3-3). No open discharge points exist for the sanitary sewer system. Characterization of this utility system was achieved through sampling sediment accumulations within manhole access points.

Sediment samples were collected from the following storm and sanitary sewer locations: LL1-295, LL1-300, LL1-301, LL1-304, LL1-306, LL1-308, and LL1-310. The locations of these samples are shown on Figure 3-3. Water samples were collected from the storm sewer system at LL1sw-301 and LL1sw-309, as shown on Figure 3-3. Analytical results from these samples are discussed in Section 4.7, and the analytical data are provided at the end of Chapter 4.0 and in Appendix H.

### **3.5.2 Camera Survey**

The extent of the video survey of sanitary and storm sewer lines at LL 1 is shown in Figure 3-3. Sewer pipes in the main production area and at key collection points were inspected. Because of significant obstructions (e.g., root growth, gravel/sediment accumulations) at some of the planned access points, the coverage provided by the survey differs somewhat from that proposed in the SAP Addendum No. 2 (USACE 2000b). However, the actual linear footage of pipe inspected afforded more extensive coverage of the sewer lines. Results of the camera survey are discussed in Section 4.7.

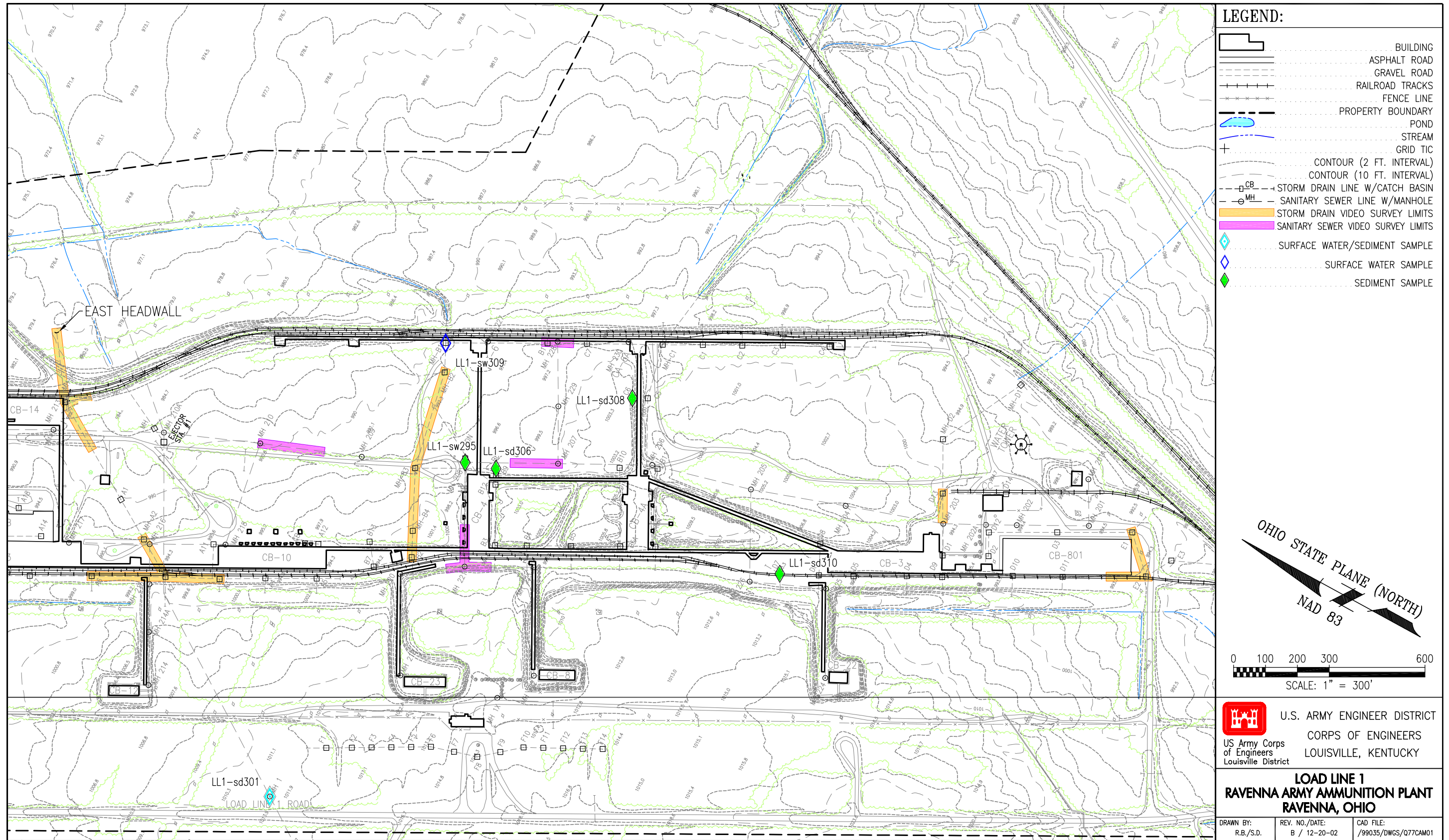


Figure 3-3. Phase II RI Sanitary and Storm Sewer Line Camera Survey and Sample Locations



The camera survey was performed using a motorized camera assembly with a fiber-optic cable. The camera assembly was capable of maneuvering in pipes as small as 10 cm (4 in.) in diameter. The camera system allowed for imaging of the entire periphery of pipe interiors from 20 cm (8 in.) to 76 cm (30 in.) in diameter. The surveys were recorded on videotape. The camera was moved through each pipe at a uniformly slow rate. The technician controlling the camera added voice narrative to the videotape to point out important features. The inspection log included locations of reference points, points of entry, and observed obstructions, cracks, offsets, and other potential problems. The details of the survey are provided in their entirety in Appendix M. Video records of the survey were provided by the vendor; copies are maintained in the project file at the USACE, Louisville District.

### **3.5.3 Field Sampling Methods**

The collection of grab samples from the bottom of manholes and junction boxes required the use of an Eckmann sampler. The Eckmann sampler is a clamshell-style device that was deployed on a cable from the ground surface. The spring-activated doors of the device were armed by the user and deployed on contact with the sediment surface. Then the assembly was returned to the ground surface, and the sample material was removed. This sampler was deployed repeatedly into the sediment until sufficient material was collected to satisfy sample volume requirements. The sediment was homogenized in a stainless-steel bowl using a stainless-steel spoon or scoop. Volatile fractions were collected directly from the sampler before homogenization. Upon completion of the sampling at an individual location, the Eckmann sampler was decontaminated according to the SAP Addendum No. 2 (USACE 2000b).

During sample collection, all samples were field screened for VOCs using a hand-held PID OVA. No headspace samples were collected for organic vapor monitoring.

Sampling of liquid media in sewers always preceded sampling of sediment in order to minimize turbidity in the water sample caused by suspended solids. Where storm or sanitary sewer water was present in sufficient volume, a water sample was retrieved using a disposable Teflon<sup>®</sup> bailer. The bailer was lowered into the sewer from the ground surface on a nylon rope and retrieved as many times as necessary to provide the required sample volume. Every effort was made to avoid agitating any accumulated sediment during water sampling. The field team emptied the bailer's contents into the appropriate sample containers, with the VOC fraction decanted first. Samples for metals analysis were not filtered.

### **3.5.4 Topographic Survey**

In order to record accurate locations of sample stations, portable geopositioning system (GPS) and formal surveys were employed prior to, and following, Phase II RI sampling activities. As part of Phase II RI planning, field teams conducted a site walkover of LL 1 and, using logbook records, located as many Phase I RI sampling locations as possible (marked with steel pins). A field-portable GPS was used to record horizontal coordinates (northing and easting) for the Phase I locations because these stations had not been previously surveyed. Phase I RI locations were then plotted on the current base maps for RVAAP. These data were then used to plan additional Phase II locations.

During Phase II RI sampling activities, horizontal coordinates of soil, sediment, and surface water sampling stations were surveyed as work progressed by field sampling crews using a field-portable GPS unit. For stream surface water and sediment sampling stations, the coordinates at the water's edge, closest to the collection point, were determined. Coordinates established through field-portable GPS were measured in longitude and latitude and converted to Ohio State Plane Coordinates using conversion software.

The horizontal coordinates for groundwater monitoring wells were determined by a licensed surveying subcontractor to within 1.0 ft and referenced to a brass identification plate embedded in the pad.

Elevations of the concrete pad, referenced to the brass identification plate, were also measured. A water level measuring point elevation was established at the top of the inner (riser) casing, as referenced to a permanent groove or indentation cut into the top of the inner casing. All elevations were determined to 0.01 ft vertical accuracy. Horizontal coordinates for all Phase II RI monitoring wells were conveyed in Ohio State Plane Coordinates (NAD83). The vertical datum for all elevations was the 1929 National Geodetic Vertical Datum.

Appendix L contains results of field-portable GPS surveys and a copy of the subcontractor report containing the monitoring well survey results.

### **3.6 ANALYTICAL PROGRAM OVERVIEW**

#### **3.6.1 Field Analysis for Explosives Determinations**

All surface soil and sediment samples were field analyzed with colorimetric methods for TNT and RDX. The purpose of the analysis was to define the extent of surface soil contamination with respect to these explosive compounds. Field colorimetry was also used as a screening method to reduce the number of samples that required fixed-base laboratory analysis for explosives. The strategy can be summarized as follows:

- If the field method indicated TNT was present at  $\geq 1$  ppm, the sample was sent to the off-site laboratory for analysis of explosives and propellants.
- If the concentration of TNT was  $< 1$  ppm, the analysis for RDX was performed.
- If RDX was present at a concentration  $\geq 1$  ppm, the sample was sent to the off-site laboratory for analysis of explosives and propellants.
- In addition, 15% of the samples showing non-detects of TNT and RDX were sent to the off-site laboratory for analysis of explosives.
- All samples collected, regardless of field colorimetry results, were submitted for TAL metals analysis.

The procedure for measuring TNT concentrations in soils involves a liquid extraction of the explosives from the soil matrix with acetone and the formation of a color complex with sodium sulfite and potassium hydroxide. Absorbance is measured at a wavelength of 540 nm. For RDX, all nitrate must be removed from the extract, and then glacial acetic acid and zinc powder are added. A color-producing agent is added to the sample, and absorbance is measured at 507 nm. In both methods, percent absorbance is correlated to concentration.

A full discussion of the field screening and laboratory results for TNT and RDX is presented in Section 4.9.1 of this report. A comparative analysis of the field and laboratory data sets indicates that field screening values for TNT provided 1% false negative information and 35% false positive information. Consideration of samples having explosives values less than 2 ppm reduces the false positive rate to 19%. Comparison of positive TNT data where both laboratory and field screening values were greater than 2 ppm provided a correlation coefficient of 0.252. The disparity between quantified field screening and laboratory values is believed to be a result of sample heterogeneity and incomplete mixing of individual subsamples prior to analysis in the field. In summary, field screening for TNT has provided a valid representation of the presence or absence of TNT above 1-2 ppm; however, quantified field results indicate a low bias relative to laboratory analyses and should not be interpreted as viable values for this study.

A comparative evaluation of field RDX results indicates 0% false negative information and 8% false positive information relative to associated laboratory analyses. Eighty-six percent of the RDX values were confirmed to be below 1 ppm, and 6% were confirmed to be greater than 1 ppm. Due to the limited positive RDX data available, correlation coefficient information was not feasible. It is believed the field screening has provided a valid representation of the presence or absence of RDX above 1 ppm; however, these few comparisons do not provide confidence in the field screening quantified results.

It has been shown that some explosive compounds (i.e., trinitrobenzene, dinitrotoluenes, nitrotoluenes, nitrocellulose, etc.), when present, may also contribute to the TNT field screening color development. Review of laboratory results indicates there were no impacts on the field determinations from these compounds. A similar review of laboratory results for compounds that, when present, may contribute to the RDX field screening color development (i.e., HMX, nitrocellulose, nitroguanidine, etc.) also does not indicate any obvious impacts on the field screening determinations from these compounds.

### **3.6.2 Field Analyses for Metals Determinations**

Field measurements of metals concentrations were made using XRF spectrometry. Both in-situ and ex-situ analyses of soils were performed using a Niton™ 700 series spectrometer. This instrumentation can be employed as either a hand-held instrument or a bench-top piece of equipment. These analytical methods can rapidly provide on-site information relative to metal concentrations and can be useful in facilitating real-time decisions for field sample collection.

In-situ analysis of soils involved taking measurements at the soil surface prior to collection of samples for chemical analyses. Measurement locations were based on the triangulation sampling scheme followed for the collection of samples for explosives and metals as described in Section 3.1.2. Each sample station was located and cleared of vegetation and debris by the SAIC sampling team. Subcontract personnel (MKM Engineers, Inc.) used the Niton XRF instrument to collect data from the points forming three vertices of the triangle established for explosives and propellants samples. A fourth in-situ measurement was collected from the center of the triangle, consistent with the location of the metals soil sample collection point. This approach allowed an assessment of the variability of the in-situ XRF method over a small area. The instrument was calibrated three times per day using the internal calibration procedure designated by the manufacturer for in-situ measurements. For in-situ measurements, soils are not processed prior to data collection and are therefore subject to higher variability and less precision.

Ex-situ analyses involved processing (drying and grinding) splits of soil samples provided by the SAIC sampling team in the MKM field laboratory in accordance with EPA Method 6200. Method QA/QC procedures were implemented during analysis. Calibration verification checks were conducted using NIST standards provided by the instrument manufacturer. Ten percent of the sample analyses were duplicated, and a NIST blank sample was analyzed periodically to ensure the instrument probe window had not become contaminated.

The Niton 700 series XRF instrument is a dual-detector system containing both cadmium and americium excitation sources. The cadmium source allows detection of arsenic, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, rubidium, selenium, strontium, titanium, zinc, and zirconium. The americium source allows detection of antimony, barium, cadmium, indium, iodine, palladium, silver, and tin. Results from the in-situ and ex-situ analyses have been provided in Appendix J. In-situ, ex-situ, and laboratory result comparisons are discussed in Section 4.9.2.

### 3.6.3 Geotechnical Analyses

Soil and sediment samples collected using the bucket hand auger method are classified as disturbed samples. Geotechnical analysis of samples collected using these methods was limited to grain size, Atterberg limits, moisture content, and USCS characterization. Each soil sample collected was visually classified in the field according to the USCS. Seven surface soil samples and one subsurface soil were sent to a geotechnical laboratory for analysis of moisture content, Atterberg limits, and USCS classification. Thirty-three sediment samples were examined for grain size distribution and Total Organic Carbon (TOC) content. The results of the geotechnical evaluation for soils and sediment samples are discussed in Chapter 4.0 and included in entirety in Appendix K.

### 3.6.4 Laboratory Analyses

All analytical procedures were completed in accordance with applicable professional standards, EPA requirements, government regulations and guidelines, Louisville District analytical QA guidelines, and specific project goals and requirements. The sampling and analysis program conducted during the Phase II RI for LL 1 involved the collection and analysis of surface soil, subsurface soil, sediment, surface water, and groundwater. Field screening for organic vapors was conducted at each sampling location using an OVM. All samples were analyzed by an independent analytical laboratory under contract for the investigation.

Samples collected during the investigation were analyzed by Severn Trent Laboratories (STL), North Canton, Ohio, a USACE Center of Excellence (CX)-certified laboratory. QA samples were collected of soil, sediment, surface water, and groundwater and were analyzed by USACE's contracted QA laboratory, GP Environmental, Inc., located in Gaithersburg, Maryland. Laboratories supporting this work have statements of qualifications including organizational structures, QA manuals, and standard operating procedures, which can be made available upon request.

Samples were collected and analyzed according to the Facility-Wide SAP (USACE 2000a) and SAP Addenda Nos. 1 and 2 for the Phase II RI at Load Line 1 (USACE 1999a and 2000b). Prepared in accordance with USACE and EPA guidance, the Facility-Wide SAP and associated addenda outline 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. Project DQOs were established in accordance with EPA Region V guidance, and requirements for sample collection, handling, analysis criteria, target analytes, laboratory criteria, and data validation criteria for LL 1 are consistent with EPA requirements for National Priorities List (NPL) sites. DQOs for this project included analytical precision, accuracy, representativeness, completeness, comparability, and sensitivity for the measurement data. Appendix G presents an assessment of those objectives as they apply to the analytical program.

Strict adherence to the requirements set forth in the Facility-Wide SAP and project addenda 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 1990a), *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. The analysis for propellants was by proprietary methods. Laboratories were required to comply with all methods as written; recommendations were considered requirements.

The requisite number of QA/QC samples was obtained during the Phase II RI (refer to Appendix G). QC samples for this project included field blanks, trip blanks, field duplicates, laboratory method blanks, laboratory control samples, laboratory duplicates, and 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 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 rinseate blanks were used to assess the adequacy of the 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. Matrix spikes 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 precision of the analysis for the samples of interest. Evaluation of these QC measures and of their contribution to documenting the project data quality is provided in Appendix G as the project Quality Control Summary Report (QCSR).

SAIC is the custodian of the project file and will maintain the contents of the file 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 PM until they are transferred to the USACE, Louisville District and RVAAP. Analytical data reports from STL have been forwarded to the USACE, Louisville District laboratory data validation contractor (Lee A. Knuppel and Associates) for validation review and QA comparison. STL will retain all original raw data information (both hard copy and electronic) in a secure area under the custody of the laboratory Project Manager (PM).

### **3.6.5 Data Review, Validation, and Quality Assessment**

Samples were properly packaged for shipment and dispatched to STL for analysis. A separate signed custody record with sample numbers and locations listed was enclosed with each shipment. When transferring the possession of samples, the individuals who relinquished and received the samples signed, dated, and noted the time on the record. All shipments were in compliance with applicable Department of Transportation regulations for environmental samples.

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.

STL performed in-house analytical data reduction under the direction of the laboratory PM and QA officer. These individuals were responsible for assessing data quality and informing SAIC and USACE of any data that 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 PM.
- The laboratory PM completed a thorough review of all reports.

- The laboratory PM generated the final reports.
- Data were then delivered to SAIC for data verification. Lee A. Knuppel and Associates performed independent full data validation on 10% of the total analytical reserves for the USACE. Copies of all data packages were forwarded to them for evaluation and preparation of QA documents.

STL prepared and retained full analytical and QC documentation for the project in both hard (paper) copy and electronic storage media (e.g., magnetic tape) as directed by the analytical methodologies employed. STL 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.

A systematic process for data verification was performed by SAIC to ensure that the precision and accuracy of the analytical data were adequate for their intended use. This verification also attempted 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 was appropriate for determining contaminants of concern and calculating risk. Samples were identified through implementation of “definitive” analytical methods. “Definitive Data” were reported consistent with the deliverables identified in the project SAP. These Definitive Data were then verified through the review process outlined in the SAP and are presented in Appendix G.

Independent data validation was performed by Lee A. Knuppel and Associates under a separate task with the Louisville USACE. This review constituted comprehensive validation of 10% of the primary data set, comprehensive validation of the QA split sample data set, and a comparison of primary sample, field duplicate sample, and field QA split sample information.