4. INVESTIGATION RESULTS

4.1 DATA EVALUATION METHODS

The process of deriving COPCs involves several steps. First, site-related chemicals are identified. These include all organic chemicals detected and inorganic chemicals present in concentrations above site background concentrations. In the next chapter, the site-related chemicals will be screened against relevant risk-based criteria to develop COPCs. The methods for identifying site-related chemicals are described in the following sections. The general process for identifying site-related chemicals involves four steps: initial data reduction, background characterization, background comparison, and weight of evidence screening. Analytical results were reported by the laboratory in electronic form and loaded into a database. Site data were extracted from the database so that only one result was used for each station and depth sampled. Quality control data such as sample splits and duplicates and laboratory reanalyses and dilutions were excluded. Samples rejected in the validation process were also excluded. Results for soil samples predesignated as background were summarized to obtain the site-specific background criteria for metal concentrations. The remaining data were summarized by medium and AOC. Analytes detected in each AOC were compared to the background criteria to determine if the analyte was a site-related contaminant (SRC).

4.1.1 Determination of Site Chemical Background

To provide a quantitative means of comparison for soil and sediment samples, three soil samples were taken outside the process areas in each of five AOCs to make a total of fifteen background samples [designated by xxxss-xxx(b) on the AOC location maps]. The rationale for the location of background samples is presented in Section 2.1.1.3. These samples were analyzed for process-related metals only. Process-related metals were those identified as of concern based on process or operational history at the site. These include aluminum, arsenic, barium, cadmium, chromium, lead, manganese, mercury, selenium, silver, and zinc. The site-specific background criteria for each metal were determined using the following procedure:

(1) Group analytes into one of three frequencies of detection categories:

- Frequency of detection $\geq$50 percent
- Frequency of detection between >0 and 50 percent
- Frequency of detection = 0 percent (all non-detects)

(2) When frequency of detection $\geq$50 percent, determine the best fit distribution for each analyte using the Shapiro-Wilk test. Use normal data and log-transformed data to test the hypothesis that data are normally distributed; if one fit is statistically significant ($p > 0.05$), assign the distribution. If both fits have associated confidence of $p > 0.05$, select the fit based on the largest p-value. Calculate the 95 percent upper tolerance limit (UTL) using either the data or log-transformed data:

$$UTL = \bar{x} + k(STD_x) ,$$

where:

$\bar{x}$ = arithmetic mean of the background data,
k = appropriate tolerance factor for one-sided tolerance interval,
STD_x = standard deviation of the background concentrations.

If the UTL is greater than the maximum detected background concentration, use the maximum detected background concentration for the background criteria.

If the distribution is neither normal or log-normal (i.e., if $p < 0.05$), calculate the nonparametric UTL as described by Walpole and Myers (1978).

(3) If the frequency of detection is between 0 and 50 percent, there is very little confidence that the background distribution can be adequately characterized. In this situation, use the 99th percentile of the background data as the background criteria.

(4) If the frequency of detection is 0 percent (no detects), use the largest reported quantitation limit for the background screen.

(5) If fewer than three results are available for a given chemical, use the maximum detected background concentration for the screen.

Based on this procedure, the background criteria were set to the maximum detected result for all analytes except for silver, for which the quantitation limit was used because silver was not detected in any of the background samples. Background samples were not collected for other media.

4.1.2 Definition of Aggregates

Data were aggregated by AOC and within AOC by medium [(soil, sediment, (drainage ditch and pond sediments were aggregated together), and groundwater] for calculating summary statistics. Soil samples from Demolition Area #2 were further divided by the sampling depth into 0 to 2 feet and >2 feet aggregates. Screening was performed for each aggregate as described below.

4.1.3 Data Screening

For each soil aggregate the concentration of each metal for each sample was compared to the background criteria. This screening was performed to determine the nature of contamination and is not a risk-based screening. A metal was considered site related in an aggregate if it was detected above the background criteria in more than 5 percent of the samples analyzed. Because the UTL represents the 95th percentile of the data, one would expect hits above the UTL that are still within the expected range of background. If there were no detects greater than the background criteria, the metal was not considered site related.

Analytes without background criteria were considered site related if they were detected, unless other evidence indicated that they were not site related. Because many inorganic

elements occur naturally at concentrations above the detection limit, additional evidence included qualitative comparison with U.S. Geological Survey (USGS) data for metal concentrations in surface soils in Ohio (Shacklette and Boerngen 1984; Boerngen and Shacklette 1981) and consideration of metals that are essential elements. Naturally occurring essential elements include calcium, iron, magnesium, potassium, and sodium. These chemicals are an integral part of the country's food supply, and are often added to foods as supplements, and thus are not generally addressed as contaminants. All organic and explosive compounds detected were considered site related.

The background soil criteria were used for screening the drainage ditch and pond sediments in the same manner as for soils. This is consistent with the Hazard Ranking System (HRS) rules regarding sediments present in drainage swales that have flow on an intermittent basis. For groundwater all analytes detected were reported, as no background data exist for comparison. Tables showing the screening results are included in the following sections by AOC.

4.1.4 Data Presentation

In the remainder of this chapter, the analytical results are discussed for each AOC and each environmental medium within the AOC. A tabular summary of analytical results is given, and selected data are presented graphically. The tables present a summary of the data and the rationale for determining if a particular analyte is a site-related chemical. Any detected organic compound is a site-related chemical if it was detected in 5 percent of samples analyzed. Inorganic elements with no background are considered site-related chemicals if detected in >5 percent of samples analyzed. The 11 process-related metals for which background criteria are available are considered site-related chemicals if detected above the background value in >5 percent of the samples. The elements calcium, iron, magnesium, potassium, and sodium are screened out on the basis of being essential nutrients.

The strategy for determining which analytes were shown on the figures involved several considerations, including those analytes that would be shown to exceed risk criteria (so that discussion in Chapter 5 could refer to the figures presented in this section); and those analytes which were detected most frequently and at the highest concentrations above background. To avoid making the figures too confusing, the number of analytes shown on a given figure were generally limited to four or less; but all detected analytes are discussed in the text, and those identified as process-related site-related chemicals are discussed in greater detail.

4.2 DEMOLITION AREA #2 (RVAAP-04)

The Phase I RI sampling at Demolition Area #2 (RVAAP-04) included surface soil, subsurface soil, and sediment sampling of areas within the AOC excluding the former RCRA open detonation (OD) area. The former RCRA OD area is the subject of a separate investigation; however, data collected from this area were used to identify potential site-related chemicals within this AOC. Analytical results for samples collected at Demolition Area #2 (RVAAP-04) during the Phase I RI are summarized in **Table 4.1** and presented in detail in Table 4.16 and in Appendix G.

Table 4.1. Demolition Area #2 Analytical Results (Surface Soil, Subsurface Soil, and Sediment)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
SURFACE SOIL									
2,4,6-Trinitrotoluene	µg/kg	4/ 30	.		540	4400		Yes	Detected > 5% of Samples
Tetryl	µg/kg	1/ 30	.		3500	3500		Yes	Detected > 5% of Samples
Aluminum	mg/kg	30/ 30	15600	3/ 30	7730	19900	20000 - 100000	Yes	> 5% Detect Above Background
Arsenic	mg/kg	30/ 30	19.6	6/ 30	11.1	25.7	5.2 - 27.0	Yes	> 5% Detect Above Background
Barium	mg/kg	30/ 30	75	12/ 30	27.1	266	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	1/ 1	.		0.51	0.51	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	27/ 30	0.29	22/ 30	0.13	3.1	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	1/ 1	.		4350	4350	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	30/ 30	18.7	4/ 30	9.7	25.8	15.0 - 100.0	Yes	> 5% Detect Above Background
Cobalt	mg/kg	1/ 1	.		9.8	9.8	7 - 20	Yes	No Background Data Available
Copper	mg/kg	1/ 1	.		67.4	67.4	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	1/ 1	.		23500	23500	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	30/ 30	17.9	16/ 30	12.2	1900	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	1/ 1	.		3770	3770	3000 - 15000	No	Essential Nutrient

Table 4.1 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Manganese	mg/kg	30/ 30	728	6/ 30	188	1120	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	19/ 30	0.08	10/ 30	0.04	0.28	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	1/ 1	.		22	22	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	1/ 1	.		1300	1300	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	26/ 30	2.6	0/ 30	0.35	2	<0.1 - 1.2	No	Below Background
Sodium	mg/kg	1/ 1	.		218	218	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	1/ 1	.		1.1	1.1		Yes	No Background Data Available
Vanadium	mg/kg	1/ 1	.		14	14	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	30/ 30	72.1	15/ 30	57.9	375	25 - 110	Yes	> 5% Detect Above Background
SUBSURFACE SOIL									
2,4,6-Trinitrotoluene	µg/kg	5/ 29	.		420	2300		Yes	Detected > 5% of Samples
2,4-Dinitrotoluene	µg/kg	1/ 29	.		2600	2600		Yes	Detected > 5% of Samples
Tetryl	µg/kg	2/ 29	.		420	4300		Yes	Detected > 5% of Samples
Aluminum	mg/kg	29/ 29	15600	1/ 29	6700	16600	20000 - 100000	No	<5% Detect Above Background
Arsenic	mg/kg	29/ 29	19.6	8/ 29	10.7	30.8	5.2 - 27.0	Yes	> 5% Detect Above Background

Table 4.1 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Barium	mg/kg	29/ 29	75	11/ 29	29.9	593	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	2/ 2	.		0.71	0.83	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	25/ 29	0.29	12/ 29	0.11	2.9	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	2/ 2	.		1280	18400	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	29/ 29	18.7	6/ 29	10	21.9	15.0 - 100.0	Yes	> 5% Detect Above Background
Cobalt	mg/kg	2/ 2	.		10.7	12.4	7 - 20	Yes	No Background Data Available
Copper	mg/kg	2/ 2	.		20.6	23.3	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	2/ 2	.		24600	25900	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	29/ 29	17.9	8/ 29	9.6	87.2	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	2/ 2	.		2940	5780	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	29/ 29	728	2/ 29	132	1080	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	9/ 29	0.08	6/ 29	0.04	1	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	2/ 2	.		21.8	29.7	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	2/ 2	.		832	1820	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	21/ 29	2.6	0/ 29	0.35	1.3	<0.1 - 1.2	No	Below Background
Sodium	mg/kg	2/ 2	.		175	236	5000 - 7000	No	Essential Nutrient

Table 4.1 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Thallium	mg/kg	2/ 2	.		0.82	1.2		Yes	No Background Data Available
Vanadium	mg/kg	2/ 2	.		17.5	20.5	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	29/ 29	72.1	11/ 29	45.8	235	25 - 110	Yes	> 5% Detect Above Background
Bis(2-ethylhexyl)phthalate	µg/kg	1/ 2	.		50	50		Yes	Detected > 5% of Samples
Methylene chloride	µg/kg	1/ 2	.		6	6		Yes	Detected > 5% of Samples
Toluene	µg/kg	1/ 2	.		170	170		Yes	Detected > 5% of Samples
SEDIMENT									
Cyanide	mg/kg	1/ 1	.		0.15	0.15		Yes	No Background Data Available
Aluminum	mg/kg	3/ 3	15600	0/ 3	1320	2040	20000 - 100000	No	Below Background
Arsenic	mg/kg	3/ 3	19.6	0/ 3	3.1	10.4	5.2 - 27.0	No	Below Background
Barium	mg/kg	3/ 3	75	0/ 3	8	19.7	300 - 700	No	Below Background
Cadmium	mg/kg	2/ 3	0.29	0/ 3	0.1	0.16	1 - 2	No	Below Background
Calcium	mg/kg	1/ 1	.		387	387	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	3/ 3	18.7	0/ 3	2.2	3	15.0 - 100.0	No	Below Background
Cobalt	mg/kg	1/ 1	.		2	2	7 - 20	Yes	No Background Data Available
Copper	mg/kg	1/ 1	.		3.6	3.6	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	1/ 1	.		4730	4730	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	3/ 3	17.9	0/ 3	2.9	7.1	15 - 30	No	Below Background

Table 4.1 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Magnesium	mg/kg	1/ 1	.		469	469	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	3/ 3	728	0/ 3	87.6	401	150 - 1000	No	Below Background
Nickel	mg/kg	1/ 1	.		4	4	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	1/ 1	.		250	250	11800 - 25100	No	Essential Nutrient
Sodium	mg/kg	1/ 1	.		153	153	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	1/ 1	.		0.4	0.4		Yes	No Background Data Available
Vanadium	mg/kg	1/ 1	.		2.6	2.6	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	3/ 3	72.1	0/ 3	16.4	30.5	25 - 110	No	Below Background
Chloroform	µg/kg	1/ 1	.		2	2		Yes	Detected > 5% of Samples

4.2.1 Surface Soil

Thirty surface soil samples (0 to 2 feet BGS) were collected from this AOC during the Phase I RI. Sampling locations were distributed fairly evenly across the cleared portions of the AOC, excluding the RCRA OD area. Sampling was focused adjacent to existing unimproved roadways as employee interviews indicated that potential waste disposal activities in this AOC (i.e., former detonation pits) would likely have taken place along these roads, and in the area of the potential Past Disposal Area overlooking Sand Creek. **Figure 4.1** illustrates the location and analytical parameters for samples collected within this AOC. Analytical parameters for surface soil included explosives (30 samples) and process-related metals (30 samples). Additionally, a single sample was analyzed for the expanded metals suite, cyanide, VOCs, SVOCs, and PCBs/pesticides to verify the presence or absence of these chemicals at that location within the AOC.

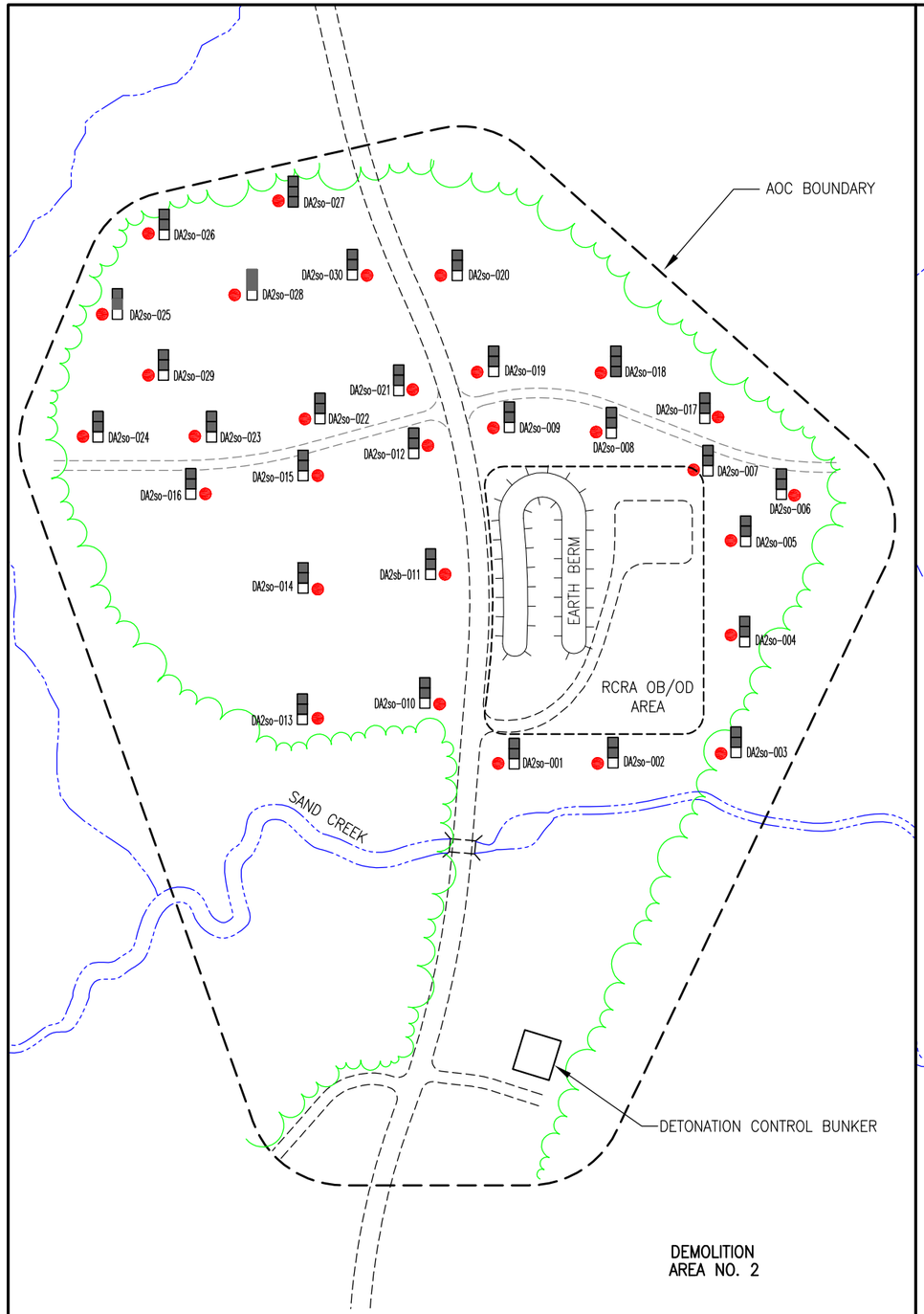
Explosives

Explosive compounds were detected in surface soil at five locations within the AOC as summarized in Table 4.1. Four samples (DA2so-002, DA2so-006, DA2so-010, and DA2so-013) contained moderately elevated concentrations (0.540 to 4.4 mg/kg) of TNT, and one sample (DA2so-014) contained a moderately elevated concentration (3.5 mg/kg) of tetryl. These samples were located primarily south and west of the OD area near the Past Disposal Area overlooking Sand Creek. **Figure 4.2** illustrates the distribution of explosive compounds in surface soil. In 25 of the 30 surface samples covering the remaining portion of the AOC, no explosive compounds were detected.

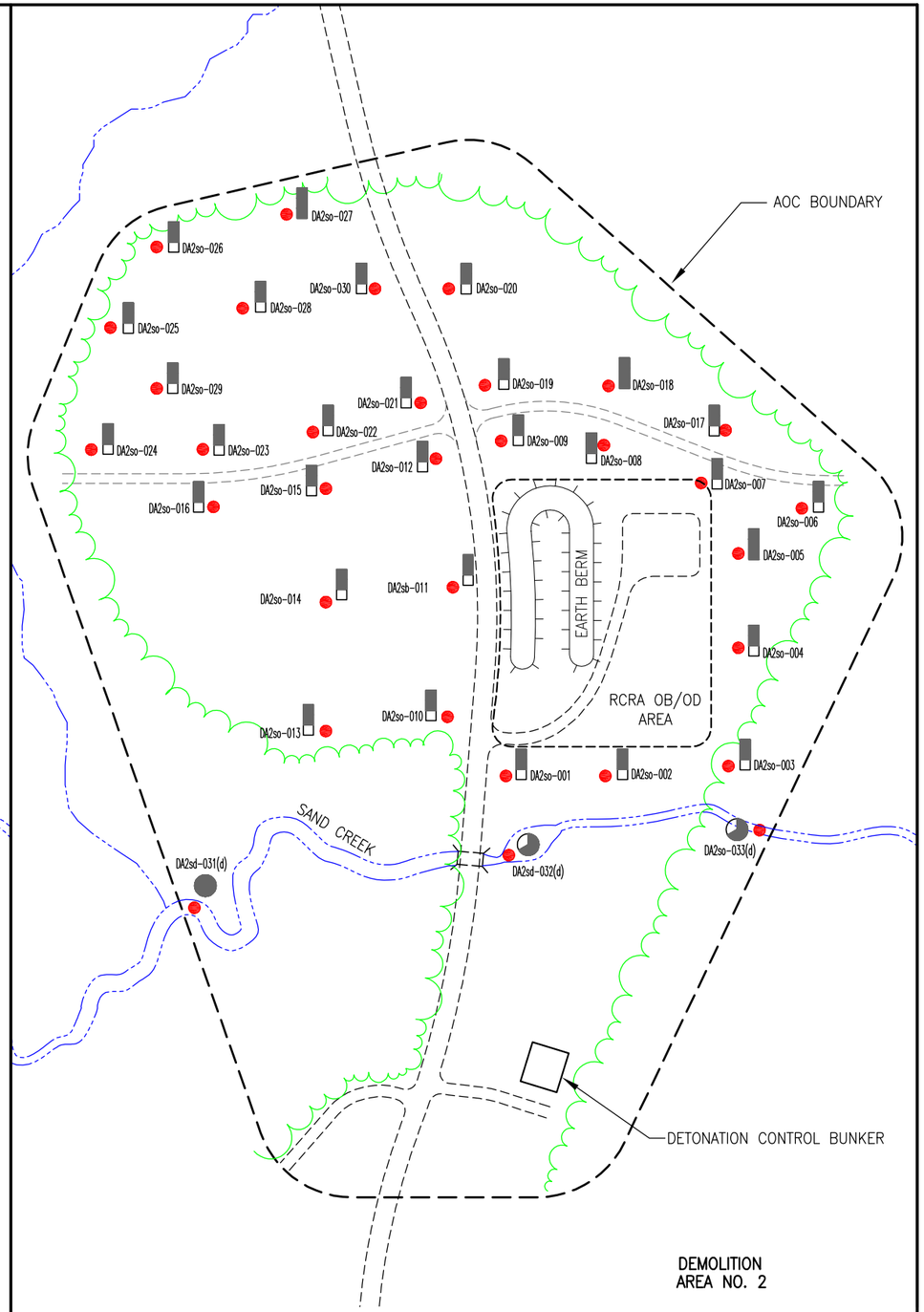
Inorganic Analytes

Inorganic analytes, including the 11 process-related metals and expanded suite metals, were detected above site background at 27 of 30 locations sampled, as summarized in Table 4.1. Antimony, silver, and cyanide were not detected in any surface soil sample within the AOC. Selenium was not considered further as the maximum detected concentration is below the site background value. Of the remaining 15 non-nutrient analytes, six did not have site background values (beryllium, cobalt, copper, nickel, thallium, and vanadium) for comparison and were retained as SRCs for this reason. A comparison of concentrations of the remaining 15 analytes to USGS reference values for Ohio indicates that four analytes (cadmium, lead, manganese, and mercury) at six locations exceed the maximum value of the published concentration ranges.

Aluminum was detected slightly above site background (15,600 mg/kg), at concentrations ranging from 16,100 to 19,900 mg/kg, in three samples in the northwest portion of the AOC. These values are significantly below the maximum range (100,000 mg/kg) of the USGS reference values. Arsenic was detected above site background (19.6 mg/kg) in six samples ranging from 20.1 to 25.7 mg/kg near the northwest and southwest corners of the OD area. These results are below the 27.0 mg/kg maximum of the USGS reference values. Arsenic concentrations in excess of site background are illustrated on **Figure 4.3**. Barium was identified above site background (75.0 mg/kg) in 12 samples ranging from 78.0 to 266.0 mg/kg, distributed randomly across the site. While these results are well below the



DEMOLITION AREA NO. 2
SUBSURFACE SOIL SAMPLES



DEMOLITION AREA NO. 2
SURFACE SOIL/SEDIMENT SAMPLES

LEGEND:

- BUILDING
- ASPHALT ROAD
- RAILROAD TRACKS
- FENCE LINE
- POND
- STREAM
- GRID TIC
- SAMPLE LOCATION
- ANALYZED
- NOT ANALYZED
- EXPLOSIVES IN SURFACE SOIL
- INORGANICS IN SURFACE SOIL
- ORGANICS IN SURFACE SOIL
- ORGANICS IN SEDIMENT
- EXPLOSIVES IN SEDIMENT
- INORGANICS IN SEDIMENT
- ORGANICS IN GROUNDWATER
- EXPLOSIVES IN GROUNDWATER
- INORGANICS IN GROUNDWATER

0 75 150 300

SCALE: 1" = 150'

US Army Corps of Engineers Nashville District

U.S. ARMY ENGINEER DISTRICT
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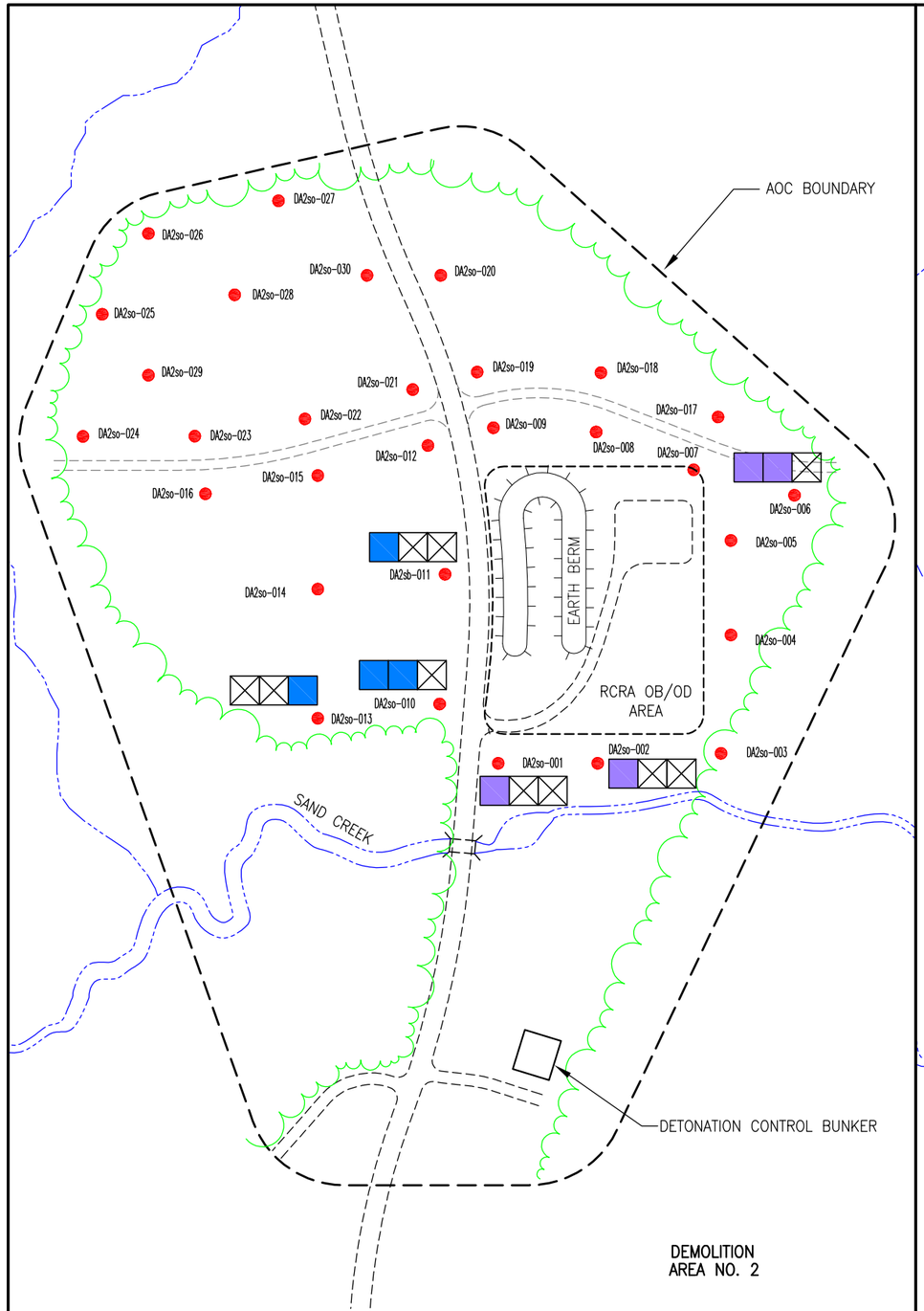
NASHVILLE, TENNESSEE

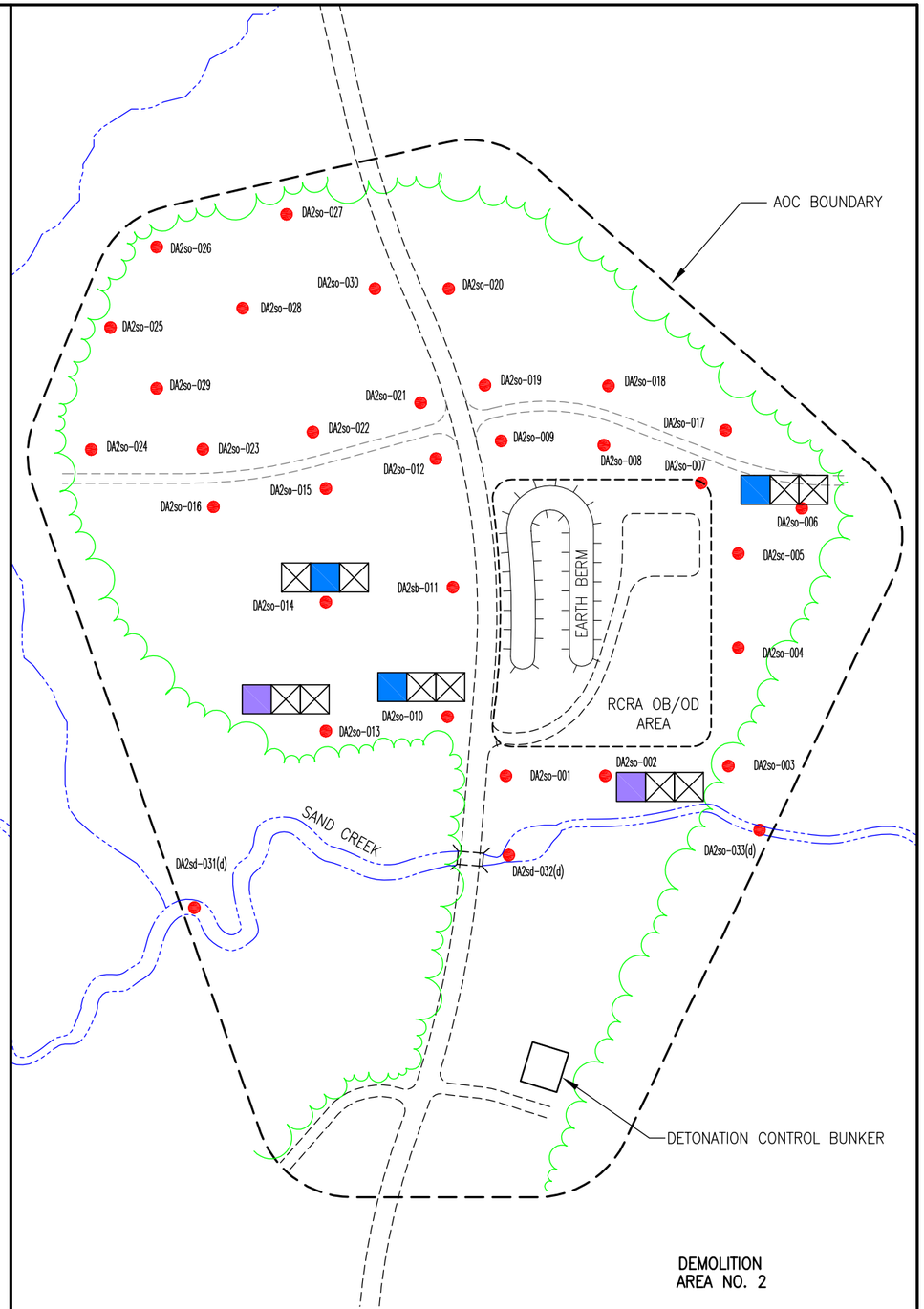
RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
DEMOLITION AREA NO. 2
(RVAAP-04)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
S. DUNLAP	REV. A/04-07-97	95021/DWGS/583RVP04

Fig. 4-1. Demolition Area #2 Sampling Locations and Analytical Parameters.



DEMOLITION AREA NO. 2
TNT, Tetryl & DNT IN SUBSURFACE SOIL



DEMOLITION AREA NO. 2
TNT, Tetryl & DNT IN SURFACE SOIL/SEDIMENT

LEGEND:

- BUILDING
- ASPHALT ROAD
- RAILROAD TRACKS
- FENCE LINE
- POND
- STREAM
- GRID TIC
- SAMPLE LOCATION

- DNT
- Tetryl
- 2,4,6 TNT

- NOT DETECTED OR BELOW BACKGROUND
- 0.01 – 0.1 mg/kg
- 0.1 – 1.0 mg/kg
- 1 – 10 mg/kg
- 10 – 100 mg/kg
- 100 – 1,000 mg/kg
- 1,000 – 10,000 mg/kg
- > 10,000 mg/kg

N

0 75 150 300

SCALE: 1" = 150'

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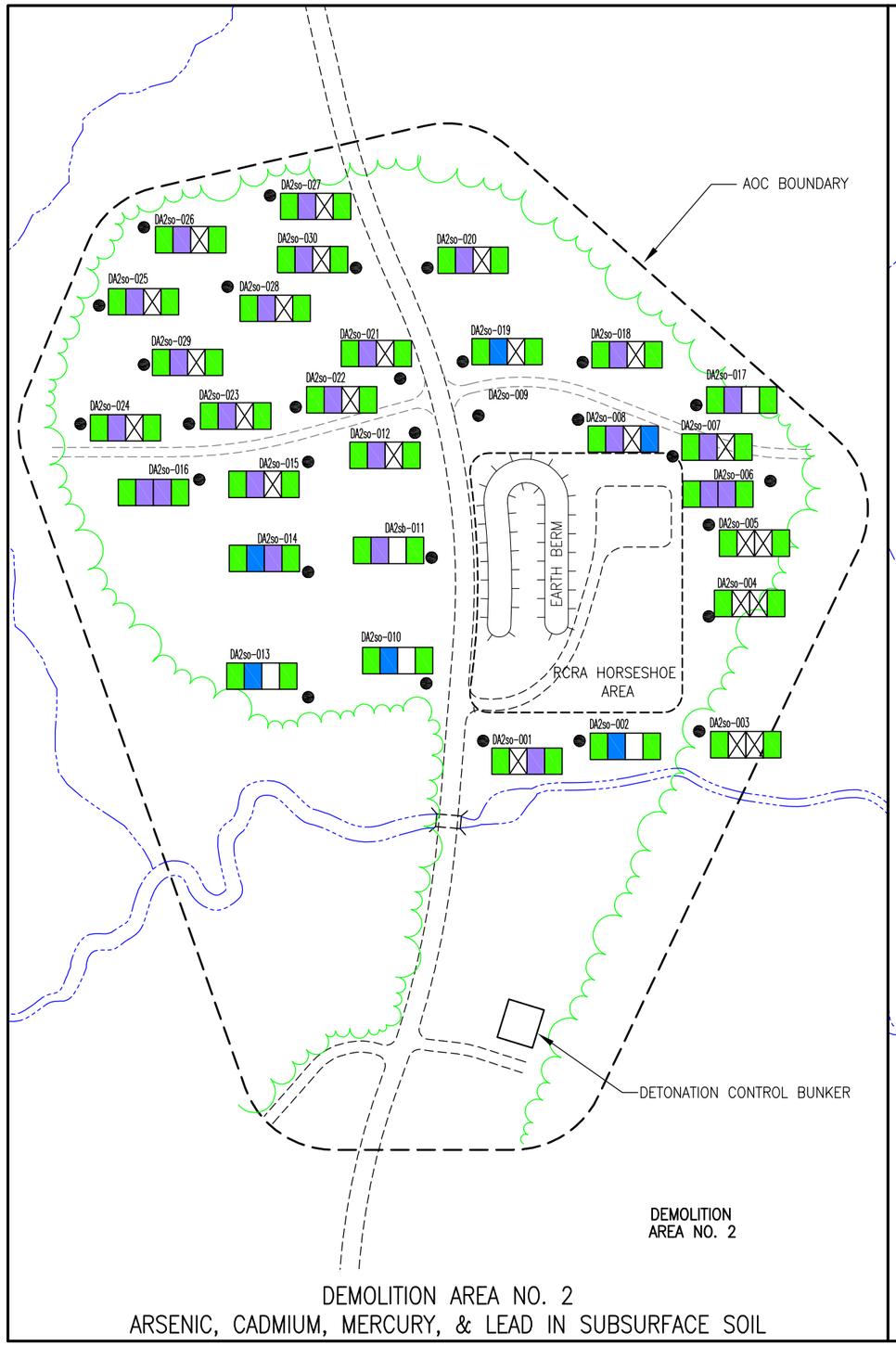
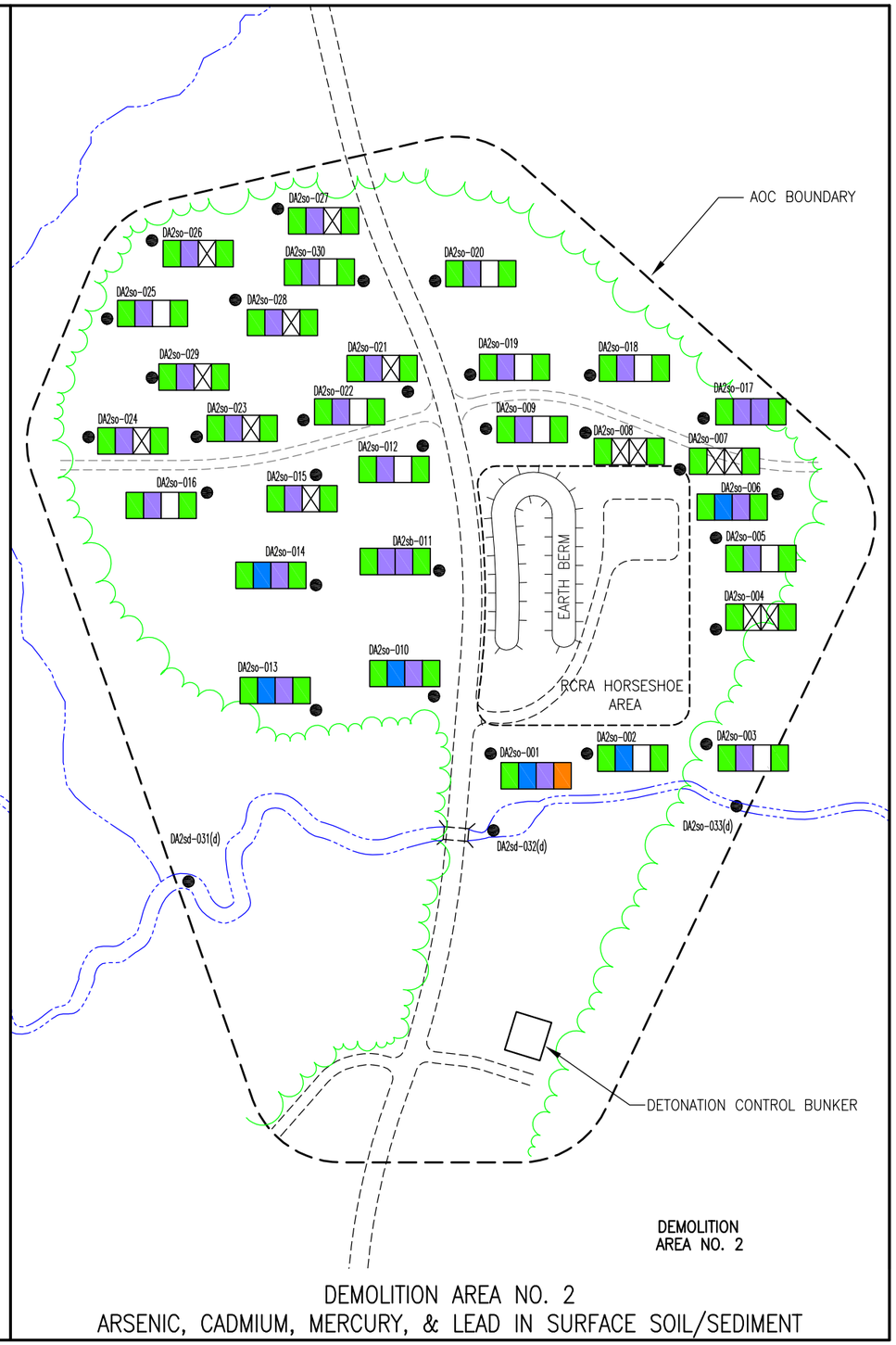
S. DUNLAP	REV. B/01-27-98	95021/DWGS/588RVP04

Fig. 4-2. Relative Concentrations of Explosive Compounds in Surface and Surbsurface Soils at Demolition Area #2



DEMOLITION AREA NO. 2
ARSENIC, CADMIUM, MERCURY, & LEAD IN SUBSURFACE SOIL



DEMOLITION AREA NO. 2
ARSENIC, CADMIUM, MERCURY, & LEAD IN SURFACE SOIL/SEDIMENT

LEGEND:

- BUILDING
- ASPHALT ROAD
- RAILROAD TRACKS
- FENCE LINE
- POND
- STREAM
- GRID TIC
- SAMPLE LOCATION

- LEAD
- MERCURY
- CADMIUM
- ARSENIC

- NOT DETECTED OR BELOW BACKGROUND
- 0.01 – 0.1 mg/kg
- 0.1 – 1.0 mg/kg
- 1 – 10 mg/kg
- 10 – 100 mg/kg
- 100 – 1,000 mg/kg
- 1,000 – 10,000 mg/kg
- > 10,000 mg/kg

0 75 150 300

SCALE: 1" = 150'

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RAVENNA, OHIO
DEMOLITION AREA NO. 2
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Fig. 4-3. Relative Concentration of Selected Inorganic Elements in soil and Sediment at Demolition Area #2

maximum USGS reference value range of 300.0 to 700.0 mg/kg, the maximum concentration detected is greater than three times site background.

Cadmium was detected above site background (0.29 mg/kg) in 22 samples ranging from 0.34 to 3.10 mg/kg as shown in Figure 4.3. The highest concentrations of cadmium (greater than 1.0 mg/kg) were clustered in the five southernmost samples (DA2so-001, DA2so-002, DA2so-010, DA2so-013, and DA2so-014). One sample (DA2so-002) exceeded the USGS maximum reference value of 2.0 mg/kg. Chromium was detected slightly above site background (18.70 mg/kg), ranging from 18.90 to 25.80 mg/kg, in four samples located primarily in the northwestern portion of the AOC. These concentrations are well within the USGS reference value range of 15.0 to 100.0 mg/kg for chromium.

Lead was detected above site background (17.90 mg/kg) in 16 samples ranging from 18.5 to 1,900 mg/kg. Three samples (DA2so-001, DA2so-002, and DA2so-006) in the southeastern portion of the site adjacent to the OD area exceed the maximum USGS reference value of 30.0 mg/kg. Figure 4.3 illustrates the distribution and relative concentrations of lead at Demolition Area #2. Manganese was present above the site background value (728.0 mg/kg) in six samples with concentrations ranging from 827.0 to 1,120.0 mg/kg, occurring primarily in the northeastern portion of the AOC. Two samples (DA2so-017 and DA2so-020) demonstrate concentrations greater than the maximum USGS reference value of 1,000 mg/kg.

Mercury was detected above site background (0.08 mg/kg), ranging from 0.09 to 0.28 mg/kg, in 10 samples in the southern and eastern portions of the AOC as shown in Figure 4.3. Two samples (DA2so-001 and DA2so-014) in the southern portion of the AOC demonstrated concentrations slightly above the USGS reference value maximum concentration of 0.22 mg/kg. Zinc was present above the site background value of 72.10 mg/kg in 15 samples with concentrations ranging from 81.2 to 375.0 mg/kg, occurring primarily in the central and eastern portions of the AOC. The maximum concentration exceeds the range of the USGS reference values of 25 to 110 mg/kg.

Six metals from the expanded metals suite were detected in sample DA2so-005, the single sample analyzed for expanded metals. These include beryllium, cobalt, copper, nickel, thallium, and vanadium. No site background values were developed for extended metals, but the detected concentrations of each of these analytes is below or within the USGS reference value ranges, except for thallium, which has no published USGS reference values (Table 4.1).

Organic Analytes

Organic analytes, including pesticides/PCBs, SVOCs, and VOCs were analyzed in a single sample (DA2so-005) to evaluate the presence or absence of these compounds in surface soil at the AOC. This sample is in the eastern portion of the AOC near the OD area at a location considered visually representative of potential impacts from past site activities. No organic compounds were detected at this location (Table 4.1).

4.2.2 Subsurface Soil

Twenty-nine subsurface soil samples were collected from the Demolition Area #2 during the Phase I RI. Sampling locations were co-located with surface soil sample locations, and were distributed fairly evenly across the cleared portions of the AOC, excluding the RCRA OD area. Subsurface soil samples were generally collected from 2 to 4 feet BGS unless obstructions (i.e., large rocks) required a shallower interval. Subsurface samples were collected to evaluate the possible presence of undocumented buried waste within the AOC. Figure 4.1 illustrates the location, distribution, and analytical parameters for sampling within this AOC. Analytical parameters for subsurface soil included explosives (29 samples) and process-related metals (29 samples). Additionally, two samples were analyzed for expanded metals, cyanide, VOCs, SVOCs, and PCBs/pesticide to verify the presence or absence of these chemicals within the AOC.

Explosives

Explosive compounds were detected in subsurface soil at six locations within the AOC as summarized in Table 4.1. Five samples (DA2so-001, DA2so-002, DA2so-006, DA2so-010, and DA2so-011) contained moderately elevated concentrations (0.42 to 2.3 mg/kg) of TNT, and one sample (DA2so-013) contained a moderately elevated concentration (2.6 mg/kg) of 2,4-DNT. These samples were primarily located south and west of the OD area near the Past Disposal Area overlooking Sand Creek. These locations correspond closely with the locations of elevated explosives concentrations in surface soil. Figure 4.2 illustrates the distribution of explosive compounds in subsurface soil. In 23 of the 30 subsurface samples covering the remaining portion of the AOC, no explosive compounds were detected.

Inorganic Analytes

Inorganic analytes, including the 11 process-related metals and expanded metals, were detected above site background at 24 of 29 locations sampled, as summarized in Table 4.1. Antimony, silver, and cyanide were not detected in any subsurface soil sample within the AOC. Selenium and aluminum were not considered further as the maximum detected concentrations are below the site background values. Of the remaining 14 non-nutrient analytes, 6 did not have site background values (beryllium, cobalt, copper, nickel, thallium, and vanadium) for comparison and were retained as SRCs for this reason. A comparison of concentrations of the remaining 14 analytes to USGS reference values indicates that five analytes (arsenic, cadmium, lead, manganese, and mercury) at eight locations exceed the maximum of the published concentration ranges. Two of these locations correspond to surface soil locations with concentrations exceeding the reference values.

Arsenic was detected above site background (19.6 mg/kg) in eight samples with concentrations ranging from 20.3 to 30.8 mg/kg, occurring primarily in the west-central portion of the AOC and east of the OD area. One sample (DA2so-004) exceeded the 27.0 mg/kg maximum of the USGS reference values. Arsenic concentrations in excess of site background are illustrated on Figure 4.3. Barium was identified above site background (75.0 mg/kg) in 11 samples ranging from 77.0 to 593.0 mg/kg, distributed randomly across

the site. These results are below the maximum USGS reference value range of 300.0 to 700.0 mg/kg, but the maximum concentration is greater than six times site background.

Cadmium was detected above site background (0.29 mg/kg) in 12 samples ranging from 0.31 to 2.90 mg/kg, distributed across the AOC. The highest concentrations of cadmium (greater than 1.0 mg/kg) were primarily in the southern and southwestern portions of the AOC with a single sample (DA2so-019) north of the OD area demonstrating the highest cadmium concentration. Five samples (DA2so-002, DA2so-010, DA2so-013, DA2so-014, and DA2so-019) exceeded the USGS maximum reference value of 2.0 mg/kg. Figure 4.3 illustrates the distribution of cadmium in subsurface soil. Chromium was detected slightly above site background (18.70 mg/kg), ranging from 19.0 to 21.9 mg/kg, in six samples located primarily in the southwestern and northwestern portions of the AOC. These concentrations are within the USGS reference value range of 15.0 to 100.0 mg/kg for chromium.

Lead was detected above site background (17.90 mg/kg) in eight samples ranging from 18.7 to 87.2 mg/kg in samples surrounding the OD area extending to the southwest. Four samples (DA2so-002, DA2so-010, DA2so-013, and DA2so-019), located primarily in the southern portion of the site, exceed the maximum USGS reference value of 30.0 mg/kg. Figure 4.3 illustrates lead concentrations in excess of site background. Manganese was present above the site background value (728.0 mg/kg) in two samples (DA2so-006 and DA2so-023) ranging from 957.0 to 1,080.0 mg/kg. One sample (DA2so-023) also exceeded the maximum USGS reference value of 1,000 mg/kg.

Mercury was detected above site background (0.08 mg/kg), ranging from 0.09 to 1.00 mg/kg, in six samples in the southern and southwestern portions of the AOC as shown in Figure 4.3. Two samples (DA2so-014 and DA2so-016) in the southwestern portion of the AOC demonstrated concentrations above the USGS reference value maximum concentration of 0.22 mg/kg. Zinc was present above the site background value of 72.10 mg/kg in 11 samples with concentrations ranging from 72.7 to 235.0 mg/kg, located primarily in the central and southern portions of the AOC. The maximum concentrations exceeds the range of the USGS reference values of 25 to 110 mg/kg.

Six additional metals were detected in samples DA2so-018 and DA2so-027, the two samples analyzed for expanded metals. Beryllium, cobalt, copper, nickel, thallium, and vanadium were detected in both samples, with concentrations shown on Table 4.9. Site background values were not developed for the expanded metals suite, but the detected concentration for five of the six metals were below or within the USGS reference values (Table 4.9). There is no published USGS reference value for thallium.

Organic Analytes

Organic analytes, including VOCs, SVOCs, and pesticides/PCBs were analyzed in two samples (DA2so-018 and DA2so-027) to evaluate the presence or absence of these compounds in subsurface soil at the AOC. These samples are in the northern portion of the AOC at representative locations to characterize waste disposal activities at the AOC. Two VOCs were detected in these samples. Methylene chloride was detected at 0.006 mg/kg in DA2so-018, and toluene was detected at 0.170 mg/kg in sample DA2so-027. One SVOC, bis(2-ethylhexyl)

phthalate, was detected in sample DA2so-018 at 0.050 mg/kg. No pesticides/PCBs were detected in subsurface soils at this location.

4.2.3 Sediment

Three sediment samples were collected from Demolition Area #2 during the Phase I RI. Samples were located in Sand Creek at the upstream point where the creek enters the AOC, at the mid-point of the AOC near the Past Disposal Area, and at the downstream point where the creek exits the AOC. Sediment samples were generally collected from 0 to 0.5 feet below the sediment/water interface near the center of the creek. Sediment samples were collected to determine if residual explosive compounds or related chemicals have accumulated in the creek from past disposal activities or from current runoff. Figure 4.1 illustrates the location, distribution, and analytical parameters for sampling within this AOC. Analytical parameters for sediment included explosives (three samples) and process-related metals (three samples). Additionally, one sample was analyzed for the expanded metals suite, cyanide, VOCs, SVOCs, and pesticides/PCBs to verify the presence or absence of these chemicals within the AOC. Geotechnical grain size distribution curves are presented in Appendix G.4. TOC ranged from 1,240 mg/kg in DAsd-032 to 1,890 mg/kg in DAsd-033.

Explosives

No explosive compounds were detected in sediment samples collected from this AOC.

Inorganic Analytes

Inorganic analytes, including process-related metals, expanded metals, and cyanide, were detected above site background at one of three locations sampled, as summarized in Table 4.1. Antimony, beryllium, mercury, selenium, and silver were not detected in any sediment sample within the AOC. Aluminum, arsenic, barium, cadmium, chromium, lead, manganese, and zinc were not considered further as the maximum detected concentrations are below the site background values. All six of the remaining non-nutrient analytes (cobalt, copper, cyanide, nickel, thallium, and vanadium) were from the expanded metals suite, and do not have site background values for comparison and were retained for this reason. A comparison of concentrations of the remaining six analytes to USGS reference values indicates that four analytes (cobalt, copper, nickel, and vanadium) are below the range of the USGS reference values. There are no published USGS reference values for cyanide and thallium.

Organic Analytes

Organic analytes, including pesticides/PCBs, SVOCs, and VOCs were analyzed for in one sample (DA2sd-031) to evaluate the presence or absence of these compounds in sediment at the AOC. This sample represents the downstream location, and should integrate any chemicals originating from the AOC which are being transported via surface water and deposited in sediment. No pesticides/PCBs or SVOCs were detected at this location. Chloroform, a VOC and common laboratory contaminant, was detected at 0.002 mg/kg.

4.2.4 Discussion/Summary of Results

Contamination of surface and subsurface soil by explosive compounds and inorganic analytes was identified during the Phase I RI at Demolition Area #2. No significant contamination (i.e., not attributable to possible laboratory contamination or negligible environmental concentrations) from organic analytes was detected in the samples analyzed during the investigation.

Explosive compounds, particularly 2,4,6-TNT, were identified in five surface soil and six subsurface soil samples at moderately elevated concentrations, ranging from 0.420 to 4.4 mg/kg for 2,4,6-TNT. The distribution of the explosive compounds is clustered in an area along the southern boundary of the cleared portion of the AOC and in a single highly localized occurrence east of the OD area. The southernmost sample locations (DA2so-001, DA2so-002, DA2so-010, and DA2so-013) may reflect contamination associated with the Past Disposal Area overlooking Sand Creek. Alternatively, the locations and concentrations of explosive compounds within the AOC may reflect a direct relationship to the OD disposal activities. Transportation losses or wind deposition of unburned explosive residues could produce the observed pattern. Additionally, the distribution of explosive compounds in conjunction with the distribution of inorganic analytes may indicate the presence of former detonation pits in the vicinity of DA2so-006, DA2so-010/DA2so-013, and DA2so-001/002.

Inorganic analytes detected above site background were distributed throughout the AOC in both surface and subsurface soil. Fifteen inorganic analytes exceeded site background values in at least one location for surface soils, and 14 inorganic analytes exceeded site background values in at least one location for subsurface soils. Of these constituents, four inorganic analytes at six locations in surface soil and five inorganic analytes at eight locations in subsurface soil exceed the maximum USGS reference values for Ohio. The distribution of inorganic constituents above site background and/or USGS reference values indicates that slightly to moderately elevated inorganic concentrations are present along the southern boundary of the cleared portion of the AOC and in several localized occurrences primarily in the east-central portion of the AOC.

Elevated levels of lead, cadmium, and mercury were detected along the southern boundary of the AOC in surface and subsurface soil at locations DA2so-001, DA2so-002, DA2so-010, DA2so-013, and DA2so-014. Since these locations correspond to the locations of elevated explosive compounds, the source(s) of contamination may be related to the Past Disposal Area overlooking Sand Creek, residues from OD disposal activities, and/or former detonation pits.

Elevated levels of lead and cadmium were associated with surface and subsurface soil in localized occurrences at DA2so-006, DA2so-018, and DA2so-019, and in surface soil only at DA2so-017 and DA2so-026. Since the inorganic analyte concentrations at these locations are relatively low and since, other than DA2so-006, no explosive compounds are associated with these locations, these levels may reflect wind deposition of OD residues or locally elevated background concentrations.

4.3 WINKLEPECK BURNING GROUNDS

Winklepeck Burning Grounds sampling activities included surface soil sampling and ditch sediment sampling. The analytical data are summarized on **Table 4.2** and presented in detail in Table 4.17 and in Appendix G.

4.3.1 Surface Soil

Seventy-nine surface soil samples were collected from Winklepeck Burning Grounds and analyzed for explosives, and 72 were analyzed for the 11 process-related metals. In addition, seven of these samples were analyzed for the expanded metals suite, SVOCs, and PCBs/pesticides, and six samples were analyzed for cyanide. Ten samples were analyzed for VOCs. The location of these samples and the analytical parameters for each is illustrated on **Figure 4.4.**

Explosives

Analytical data were verified and validated data for 78 samples. A total of five explosives were detected, including TNB, TNT, DNT, HMX, and RDX. The distribution and relative concentrations of TNT, TNB, DNT, and RDX are shown on **Figure 4.5**. Explosives are present in several concentrated areas within the AOC: on the south side of Pallet Road E East and E West, on the south side of Pallet Road C East (near the Burning Trays), and on the south of Pallet Road A West. TNT was by far the most commonly detected explosive compound, occurring in 19 samples with concentrations ranging from 0.230 to 3,800 mg/kg. The highest concentrations (>3000 mg/kg) occur along Pallet Road E East. Detected concentrations in other areas are in the 0.20 to 300 mg/kg range, with 9 of the 19 samples at concentrations <1.0 mg/kg. TNB, HMX, and RDX were each detected in three samples (Table 4.2 and Figure 4.5). DNT was detected in one sample with a concentration of 0.3 mg/kg.

Inorganic Elements and Compounds

All 23 inorganic elements plus cyanide were detected in at least one surface soil sample from the Winklepeck Burning Grounds AOC. Selenium was detected at concentrations exceeding the background criteria in only 2 of 79 samples, and was screened out as a site-related chemical because less than 5 percent of the detections exceeded background. The remaining 17 non-nutrient elements and cyanide are considered to be site-related chemicals in surface soil at Winklepeck Burning Grounds. **Figure 4.6** shows the distribution and relative concentrations of selected inorganic elements (barium, beryllium, cadmium, and lead) in surface soil.

Inorganics were detected at concentrations exceeding the background criteria in 61 of the 79 samples analyzed. Inorganic chemicals are concentrated in several portions of the AOC similar to the distribution of explosives: on the south side of Pallet Road E West and E East; on the south side of Pallet Road C East (near the Burning Trays); and, to a lesser extent, on the south sides of Pallet Road C West and Pallet Road A West (Figure 4.6).

Table 4.2. Winklepeck Burning Ground Analytical Results (Surface Soil and Sediment)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
SURFACE SOIL									
Cyanide	mg/kg	2/ 7	.		0.23	0.59		Yes	No Background Data Available
1,3,5-Trinitrobenzene	µg/kg	3/ 78	.		490	490000		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	19/ 78	.		230	3800000		Yes	Detected > 5% of Samples
2,4-Dinitrotoluene	µg/kg	1/ 78	.		310	310		Yes	No Background Data Available
HMX	µg/kg	3/ 78	.		1900	1700000		Yes	No Background Data Available
RDX	µg/kg	3/ 78	.		6500	9500000		Yes	No Background Data Available
Aluminum	mg/kg	79/ 79	15600	6/ 79	1410	30400	20000 - 100000	Yes	> 5% Detect Above Background
Antimony	mg/kg	1/ 7	.		2.6	2.6		Yes	No Background Data Available
Arsenic	mg/kg	79/ 79	19.6	4/ 79	2.5	21.6	5.2 - 27.0	Yes	> 5% Detect Above Background
Barium	mg/kg	79/ 79	75	29/ 79	11.7	7780	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	6/ 7	.		0.47	2.6	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	60/ 79	0.29	39/ 79	0.06	877	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	7/ 7	.		805	88900	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	79/ 79	18.7	10/ 79	5.4	118	15.0 - 100.0	Yes	> 5% Detect Above Background

Table 4.2 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Cobalt	mg/kg	7/ 7	.		4.6	8.9	7 - 20	Yes	No Background Data Available
Copper	mg/kg	7/ 7	.		9.3	29.3	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	7/ 7	.		12800	27300	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	79/ 79	17.9	38/ 79	10.2	916	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	7/ 7	.		1480	13100	3000 - 15000	No	Essential Element
Manganese	mg/kg	79/ 79	728	12/ 79	65.4	3910	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	25/ 79	0.08	7/ 79	0.03	0.28	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	7/ 7	.		7.4	18.5	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	7/ 7	.		400	1600	11800 - 25100	No	Essential Element
Selenium	mg/kg	68/ 79	2.6	2/ 79	0.34	5	<0.1 - 1.2	No	<= 5% Detect Above Background
Silver	mg/kg	10/ 79	0.24	8/ 79	0.22	6.4	0.7	Yes	> 5% Detect Above Background
Sodium	mg/kg	7/ 7	.		77.8	962	5000 - 7000	No	Essential Element
Thallium	mg/kg	7/ 7	.		1.4	3.1		Yes	No Background Data Available
Vanadium	mg/kg	7/ 7	.		12.7	19.6	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	79/ 79	72.1	28/ 79	28.6	1050	25 - 110	Yes	> 5% Detect Above Background

Table 4.2 (continued)

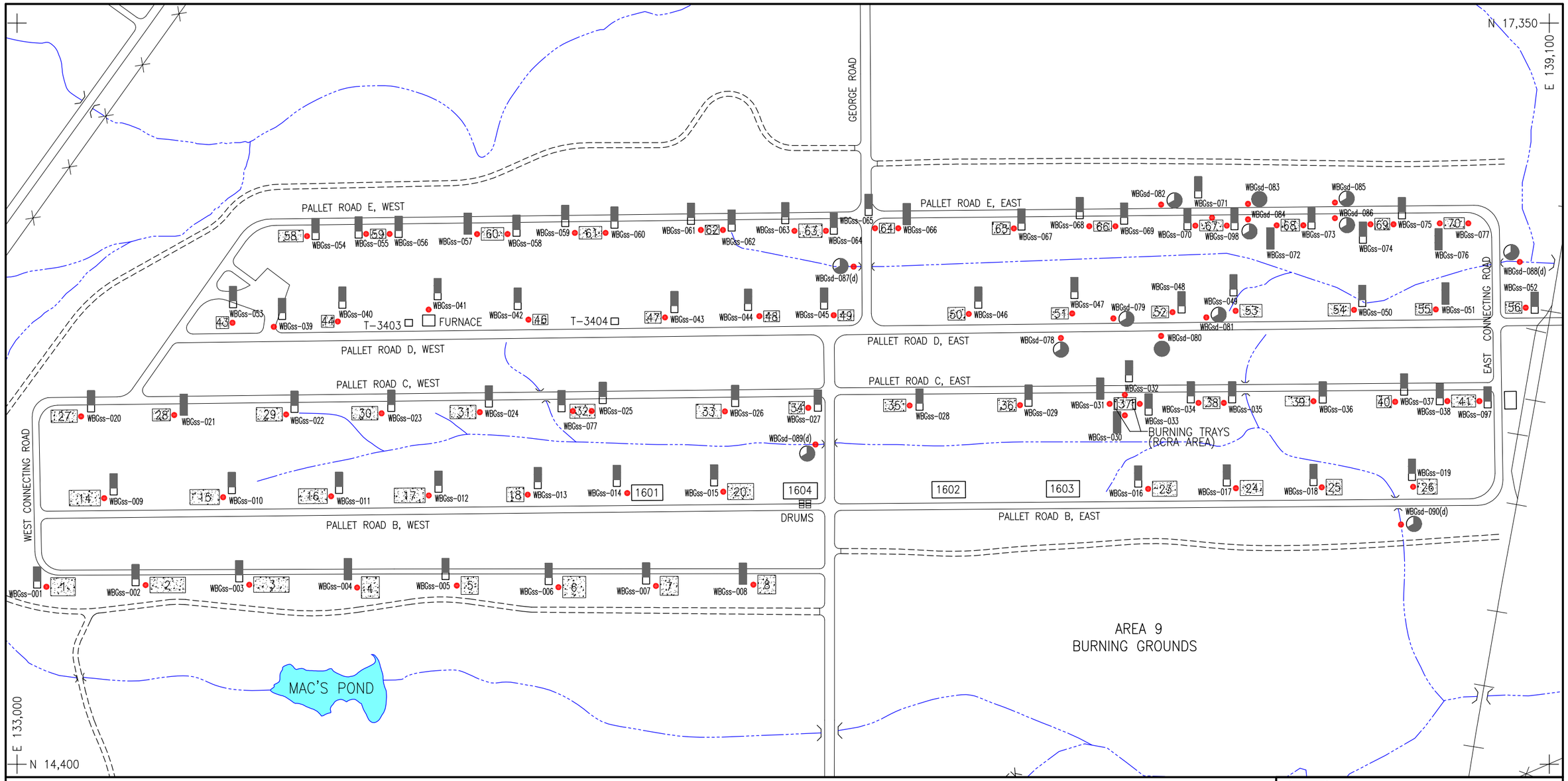
Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
2-Methylnaphthalene	µg/kg	1/ 7	.		80	80		Yes	No Background Data Available
Bis(2-ethylhexyl)phthalate	µg/kg	1/ 7	.		34	34		Yes	No Background Data Available
Di-n-butyl phthalate	µg/kg	1/ 7	.		53	53		Yes	No Background Data Available
Fluoranthene	µg/kg	1/ 7	.		40	40		Yes	No Background Data Available
Naphthalene	µg/kg	1/ 7	.		76	76		Yes	No Background Data Available
Phenanthrene	µg/kg	1/ 7	.		70	70		Yes	No Background Data Available
Pyrene	µg/kg	1/ 7	.		36	36		Yes	No Background Data Available
Chloroform	µg/kg	1/ 7	.		2	2		Yes	No Background Data Available
Methylene chloride	µg/kg	1/ 7	.		12	12		Yes	No Background Data Available
Toluene	µg/kg	5/ 7	.		17	170		Yes	No Background Data Available
SEDIMENT									
Cyanide	mg/kg	1/ 2	.		0.11	0.11		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	3/ 13	.		360	970		Yes	No Background Data Available
Aluminum	mg/kg	13/ 13	15600	1/ 13	4740	16100	20000 - 100000	Yes	> 5% Detect Above Background

Table 4.2 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Antimony	mg/kg	1/ 2	.		0.32	0.32		Yes	No Background Data Available
Arsenic	mg/kg	13/ 13	19.6	0/ 13	8.1	18.1	5.2 - 27.0	No	Below Background
Barium	mg/kg	13/ 13	75	9/ 13	36.8	528	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	2/ 2	.		0.45	0.6	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	6/ 13	0.29	1/ 13	0.06	0.56	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	2/ 2	.		1080	1720	1100 - 31000	No	Essential Element
Chromium	mg/kg	13/ 13	18.7	0/ 13	7.2	16.9	15.0 - 100.0	No	Below Background
Cobalt	mg/kg	2/ 2	.		8.6	10.4	7 - 20	Yes	No Background Data Available
Copper	mg/kg	2/ 2	.		18.6	18.8	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	2/ 2	.		18200	24000	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	13/ 13	17.9	4/ 13	10.2	27.3	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	2/ 2	.		2050	3280	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	13/ 13	728	2/ 13	183	1050	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	2/ 13	0.08	0/ 13	0.04	0.05	0.03 - 0.22	No	Below Background
Nickel	mg/kg	2/ 2	.		15.9	28.3	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	2/ 2	.		665	1030	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	6/ 13	2.6	0/ 13	0.37	1.7	<0.1 - 1.2	No	Below Background

Table 4.2 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Sodium	mg/kg	2/ 2	.		52.3	74	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	2/ 2	.		1.5	1.8		Yes	No Background Data Available
Vanadium	mg/kg	2/ 2	.		13	15.9	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	13/ 13	72.1	4/ 13	38.3	155	25 - 110	Yes	> 5% Detect Above Background
Chloroform	µg/kg	1/ 2	.		2	2		Yes	Detected > 5% of Samples
Toluene	µg/kg	1/ 2	.		25	25		Yes	No Background Data Available



LEGEND:

- BUILDING
- ASPHALT ROAD
- RAILROAD TRACKS
- FENCE LINE
- POND
- STREAM
- GRID TIC
- SAMPLE STATION
- ANALYZED
- NOT ANALYZED
- EXPLOSIVES IN SURFACE SOIL
- INORGANICS IN SURFACE SOIL
- ORGANICS IN SURFACE SOIL
- ORGANICS IN SEDIMENT
- EXPLOSIVES IN SEDIMENT
- INORGANICS IN SEDIMENT
- ORGANICS IN GROUNDWATER
- EXPLOSIVES IN GROUNDWATER
- INORGANICS IN GROUNDWATER

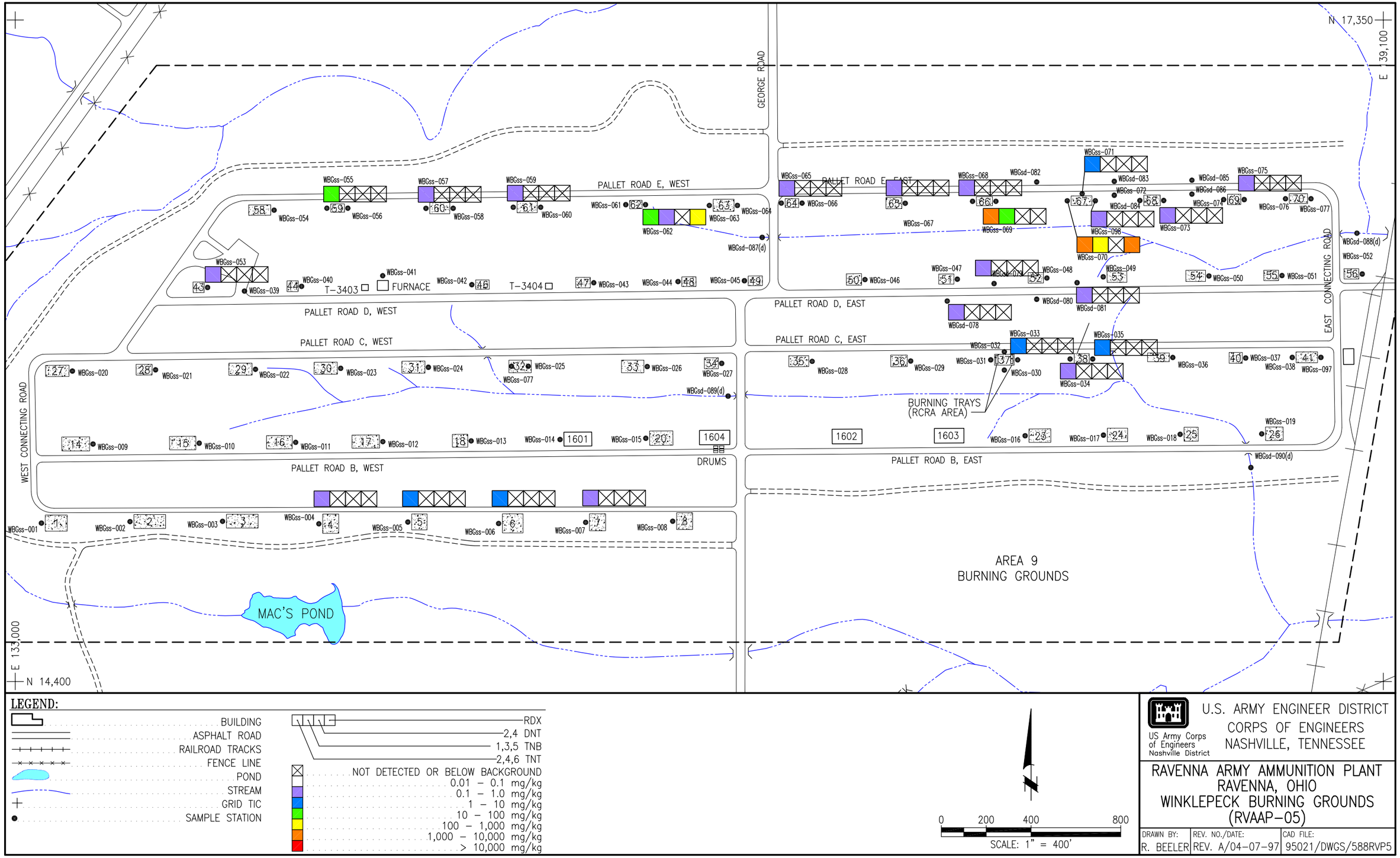
US Army Corps of Engineers Nashville District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NASHVILLE, TENNESSEE

RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
WINKLEPECK BURNING GROUNDS
(RVAAP-05)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	REV. A/04-07-97	95021/DWGS/583RVP5

Fig. 4-4. WBG Sample Locations and Analytical Parameters



LEGEND:

- BUILDING
- ASPHALT ROAD
- RAILROAD TRACKS
- FENCE LINE
- POND
- STREAM
- GRID TIC
- SAMPLE STATION

- RDX
- 2,4 DNT
- 1,3,5 TNB
- 2,4,6 TNT
- NOT DETECTED OR BELOW BACKGROUND
- 0.01 – 0.1 mg/kg
- 0.1 – 1.0 mg/kg
- 1 – 10 mg/kg
- 10 – 100 mg/kg
- 100 – 1,000 mg/kg
- 1,000 – 10,000 mg/kg
- > 10,000 mg/kg

US Army Corps of Engineers Nashville District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NASHVILLE, TENNESSEE

RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
WINKLEPECK BURNING GROUNDS
(RVAAP-05)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	REV. A/04-07-97	95021/DWGS/588RVP5

Fig. 4-5. Relative Concentrations of Explosives in Surface Soil and Sediment at WBG

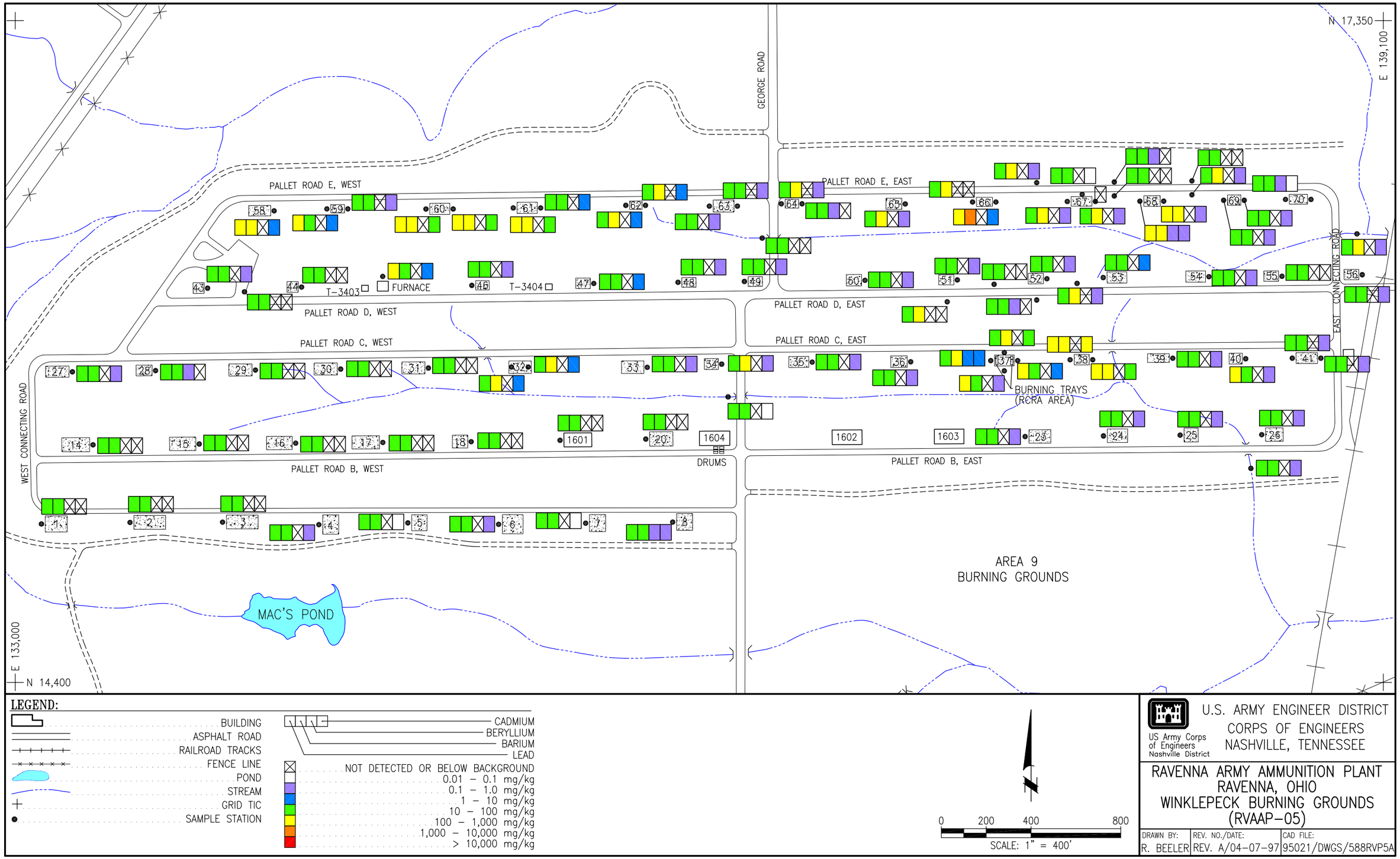


Fig. 4-6. Relative Concentrations of Selected Inorganic Elements in Surface Soil at WBG

Cadmium and lead were the most frequently detected analytes with concentrations exceeding the background criteria. Cadmium was detected above background (0.29 mg/kg) in 39 of 79 samples, with concentrations above background ranging from 0.34 mg/kg in both WBGss-016 and WBGss-018, to a site maximum of 877 mg/kg in WBGss-034. Fourteen of the detections above background also exceeded the USGS Ohio reference level range (1 to 2 mg/kg). Lead was detected above the background criteria (17.9 mg/kg) in 38 samples, with concentrations above background ranging from 17.9 mg/kg in WBGss-024 and WBGss-097 to 916 mg/kg in WBGss-055. The detected concentrations above background exceeded the USGS Ohio reference level for lead (15 to 30 mg/kg) in 23 samples.

Barium exceeded the background criteria (75 mg/kg) in 29 samples, ranging in concentration from 83.1 mg/kg in WBGss-066 to 7,780 mg/kg in WBGss-069. The concentrations above background exceeded the maximum USGS reference value (300 to 700 mg/kg) in two samples. Zinc exceeded background criteria (72.1 mg/kg) in 28 samples, with concentrations ranging from 79.0 in WBGss-063 to 1,050 mg/kg in WBGss-057 and WBGss-069. Detected zinc concentrations above background exceeded the USGS reference level (25 to 110 mg/kg) in 20 samples.

Manganese exceeded the background criteria (728 mg/kg) in 12 samples, 7 of which also exceeded the maximum USGS reference level (150 to 1000 mg/kg). The concentrations ranged from 782 mg/kg in WBGss-027 to 2580 mg/kg in WBGss-032. Chromium was detected above background (18.7 mg/kg) in 10 samples, with concentrations ranging from 23.0 mg/kg in both WBGss-067 and WBGss-073 to 118.0 mg/kg in WBGss-055. Only the maximum concentration exceeded the USGS reference levels for Ohio (15 to 100 mg/kg). Silver exceeded the background criteria (0.24 mg/kg) in eight samples, with concentrations ranging from 0.27 mg/kg (WBGss-067) to 6.4 mg/kg (WBGss-054). Four samples have concentrations exceeding the USGS reference level (0.7 mg/kg).

Mercury was detected at concentrations exceeding the site background (0.08 mg/kg) in seven samples, ranging in concentration from 0.09 mg/kg, detected at both WBGss-058 and WBGss-062 to 0.28 mg/kg, detected at WBGss-069. Two samples had concentrations exceeding the maximum USGS reference level (0.03 to 0.22 mg/kg). Aluminum was detected above the background criteria in six samples, with concentrations ranging from 16,900 to 30,400 mg/kg in WBGss-032. None of the detected concentrations exceed the USGS Ohio reference values (20,000 to 100,000 mg/kg). Arsenic exceeded the background criteria in four samples ranging from 19.8 to 21.6 mg/kg, which did not exceed the USGS reference levels (5.2 to 27 mg/kg).

The other detected inorganics do not have background criteria against which to compare. These include antimony, beryllium, cobalt, copper, nickel, thallium, vanadium, and cyanide. Table 4.2 lists the number of detections out of the seven samples analyzed, and the range of concentrations for each of these chemicals. The maximum concentration for beryllium (2.6 mg/kg) also exceeded the range of USGS reference values (1.5 to 2 mg/kg). Antimony and thallium do not have published USGS reference values; all other metals in this group had maximum concentrations that fell below or within the range of USGS reference values (Table 4.2).

Organic Compounds

A total of 10 organic compounds were detected in soil samples from Winklepeck Burning Grounds, including three VOCs and seven SVOCs (Table 4.2). Toluene was detected in five samples, with concentrations ranging from 0.017 to 0.17 mg/kg. Chloroform and methylene chloride were each detected in one sample (Table 4.2). All of the VOCs were detected at relatively low concentrations, and are potential laboratory contaminants although not enough data exist to determine the source of the VOCs detected. The SVOCs included four polycyclic aromatic hydrocarbon (PAH) compounds, and two phthalates, each of which was detected in one sample (Table 4.2). The distribution of samples with organic chemicals detected is similar to that for explosives and inorganics in this AOC, with detections concentrated along the south side of Pallet Road E, East; the south side of Pallet Road C East, near the burning trays; and the south side of Pallet Road A, West.

Samples WBGss-004, -030, and -057 had no detections of any organic compound. WBGss-008 contained 2-methylnaphthalene (0.08 mg/kg), naphthalene (0.076 mg/kg), and phenanthrene (0.07 mg/kg). WBGss-031 contained bis(2-ethylhexyl)phthalate (0.034 mg/kg), di-n-butyl phthalate (0.053 mg/kg), and toluene (0.017 mg/kg). WBGss-066 contained fluoranthene (0.04 mg/kg), pyrene (0.036 mg/kg), and toluene (0.019 mg/kg). Toluene (0.170 mg/kg and chloroform (0.002 mg/kg) were detected in WBGss-076, and toluene was detected also in WBGss-072 (0.085 mg/kg) and WBGss-021 (0.04 mg/kg). Methylene chloride was detected in WBGss-051 (0.012 mg/kg).

4.3.2 Sediment

A total of 13 drainage ditch sediment samples were collected and analyzed for explosives. Eleven of these were also analyzed for the 11 process-related metals, and two samples (WBGsd-080 and -083) were analyzed for the expanded metals suite, cyanide, VOCs, SVOCs, and PCBs/pesticides. The location and the analytical parameters of each sample is presented on Figure 4.4. Analytical data are summarized on Table 4.2 and presented in detail in Appendix G. Geotechnical grain size distribution curves are presented in Appendix G.4. TOC values ranged from 2,270 mg/kg at WBGsd-083 to 25,800 mg/kg at WBGsd-088.

Explosives

TNT was detected in three sediment samples, with concentrations of 0.36 mg/kg in WBGsd-078, 0.97 mg/kg in WBGsd-079, and 0.42 mg/kg in WBGsd-081 (Figure 4.5). No other explosive compounds were detected in sediment in the Winklepeck Burning Grounds AOC. Explosives were not detected in soil samples in this general area (Figure 4.5).

Inorganic Elements and Compounds

Silver was not detected in any sediment samples from Winklepeck Burning Grounds, and arsenic, beryllium, mercury, and selenium were detected at concentrations below the background criteria for those elements. The remaining 13 non-nutrient elements and cyanide, were detected at concentrations exceeding the site background criteria, or no background value was available, and are considered to be site-related chemicals at the Winklepeck Burning

Grounds (Table 4.2). Aluminum, barium, chromium, lead, manganese, and zinc were all detected at concentrations exceeding the background criteria. Two sediment samples, WBGsd-085 and WBGsd-087, did not have any inorganic elements detected at concentrations exceeding the background criteria.

Barium was the most frequently detected element exceeding background criteria (75.0 mg/kg), with 9 of 13 samples in excess of the criteria. Concentrations ranged from 78.3 mg/kg at WBGsd-079 to a maximum of 528 mg/kg at WBGsd-082. All concentrations were within the range of USGS Ohio reference values (Table 4.2). Lead and zinc each exceeded the background criteria (17.9 mg/kg and 72.1 mg/kg, respectively) four times. Concentrations of lead ranged from 21.8 mg/kg at WBGsd-086 to 25.4 mg/kg at WBGsd-079, all within the USGS reference value range (15 to 30 mg/kg). Zinc concentrations ranged from 79.7 mg/kg at WBGsd-079 to 155 mg/kg at WBGsd-088. Two samples had values exceeding the USGS reference values for zinc in Ohio (25 to 110 mg/kg) (Table 4.2).

Manganese was detected at concentrations exceeding the background criteria (728 mg/kg) in three samples, with values of 728 mg/kg at WBGsd-082, 897.0 mg/kg at WBGsd-081, and 1,050 mg/kg at WBGsd-078. The maximum detected concentration exceeds the USGS Ohio reference value for manganese (Table 4.2). Aluminum was detected once above background, with a concentration of 16,100 mg/kg in WBGsd-078. Cadmium exceeded the background criteria at WBGsd-088 with a concentration of 0.56 mg/kg (Table 4.2).

Two sediment samples were analyzed for the expanded metals suite and cyanide, there is no background criteria for these chemicals. Beryllium, cobalt, copper, nickel, thallium, and vanadium were each detected in both samples, and antimony and cyanide were detected in one (Table 4.2). All detected concentrations were below or within the range of USGS Ohio reference values, with the exception of antimony and thallium, which have no published USGS reference criteria.

Organic Compounds

Two organic chemicals, chloroform and toluene, were detected in the two sediment samples analyzed for organic constituents. Chloroform was detected at a concentration of 0.002 mg/kg in WBGsd-083, and toluene had a concentration of 0.025 mg/kg in WBGsd-080 (Table 4.2). Both of these chemicals are potential laboratory contaminants, and were detected at relatively low concentrations, but no definitive statement can be made about the source of these VOCs.

4.3.3 Discussion/Summary of Results

Explosives, inorganic chemicals, and organic compounds were detected in both soil and sediment in the Winklepeck Burning Grounds AOC. Contamination was much more pronounced in soil than in sediment, and occurred in four general areas within the AOC. TNT was the most pervasive explosive encountered, with detections in 19 soil samples. Concentrations were as high as 3,800 mg/kg, but most concentrations detected were in the range of 0.2 to 2.0 mg/kg. TNT was also detected in three sediment samples, but all

concentrations were less than 1.0 mg/kg. There does not appear to be a pattern of association between grain size, TOC, and analytical results in sediments at this AOC.

Inorganic contamination was widespread in soil, with concentrations of cadmium, lead, manganese, and silver frequently exceeding the background criteria, and concentrations of most metals exceeding the USGS Ohio reference values in one or two samples. The distribution of inorganic contamination in soil was similar to that of explosives. Inorganics were also detected above the background criteria in sediment, although concentrations tended to be lower and few were high enough to exceed the range of USGS Ohio reference values.

Organic compounds were detected somewhat sporadically even given the low number of samples analyzed for these chemicals, and detected concentrations were in general low. The source of VOCs detected in sediment is unknown, while in soil, the presence of PAH and phthalate compounds is expected in such a burn area.

4.4 LOAD LINE 1 AND DILUTION/SETTLING POND

Load Line 1 sampling activity included surface soil sampling, ditch sediment sampling, and groundwater sampling of well points and monitoring wells. Analytical data are summarized in **Tables 4.3** (soil and sediment) **and 4.4** (groundwater), and presented in detail in Table 4.18 and in Appendix G.

4.4.1 Surface Soil

Forty-eight surface soil samples were collected in Load Line 1 and analyzed for explosives. Thirty-eight were also analyzed for the 11 process-related metals, and 12 samples were analyzed for the expanded metals suite, cyanide, VOCs, SVOCs, and pesticides/PCBs. The validated, verified data set includes analyses for 46 explosive and process-related metals samples, and 11 expanded metals suite, cyanide, VOC, SVOC, and PCB/pesticide samples. **Figure 4.7** shows the sample locations and analysis types for each sample.

Explosives

Explosive compounds were detected in 29 of the 46 soil samples analyzed. The compounds 2,4,6-TNT and 1,3,5-TNB were the most widespread in occurrence and occurred in the highest concentrations; TNT was detected in 28 samples, and 1,3,5-TNB was present in 10 samples. 2,4-DNT was detected in five of the samples. HMX and RDX occurred in LL1ss-011 and LL1ss-014. The highest concentrations of TNT (e.g., 700 to 5,800 mg/kg) are noted in areas surrounding melt/pour buildings CB-4 and adjacent washout buildings, the vacuum pump houses at CB-101, and east of CA-6 at LL1ss-039. Building CB-3A, in the southern portion of the load line, also exhibits explosives contamination in the surrounding surface soils (see **Figure 4.8** for the distribution of these contaminants).

Table 4.3. Load Line 1 Analytical Results (Surface Soil and Sediment)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
SURFACE SOIL									
Cyanide	mg/kg	8/ 12	.		0.11	112		Yes	No Background Data Available
1,3,5-Trinitrobenzene	µg/kg	10/ 47	.		550	110000		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	28/ 47	.		260	5800000		Yes	Detected > 5% of Samples
2,4-Dinitrotoluene	µg/kg	5/ 47	.		100	1500		Yes	Detected > 5% of Samples
HMX	µg/kg	2/ 47	.		2600	9100		Yes	No Background Data Available
RDX	µg/kg	2/ 47	.		1800	49000		Yes	No Background Data Available
Aluminum	mg/kg	47/ 47	15600	4/ 47	1860	47600	20000 - 100000	Yes	> 5% Detect Above Background
Antimony	mg/kg	8/ 12	.		0.45	8.8		Yes	No Background Data Available
Arsenic	mg/kg	47/ 47	19.6	3/ 47	4.5	77	5.2 - 27.0	Yes	> 5% Detect Above Background
Barium	mg/kg	47/ 47	75	21/ 47	22.2	1380	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	12/ 12	.		0.2	2.5	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	42/ 47	0.29	35/ 47	0.15	23.5	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	12/ 12	.		452	56700	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	47/ 47	18.7	17/ 47	4.8	394	15.0 - 100.0	Yes	> 5% Detect Above Background

Table 4.3 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Cobalt	mg/kg	12/ 12	.		3.9	33.7	7 - 20	Yes	No Background Data Available
Copper	mg/kg	12/ 12	.		11.3	110	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	12/ 12	.		13500	75600	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	47/ 47	17.9	41/ 47	10.8	3610	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	12/ 12	.		750	9100	3000 - 15000	No	Essential Element
Manganese	mg/kg	47/ 47	728	10/ 47	113	2140	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	41/ 47	0.08	14/ 47	0.03	1.4	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	12/ 12	.		9.4	45.8	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	12/ 12	.		358	2690	11800 - 25100	No	Essential Element
Selenium	mg/kg	44/ 47	2.6	4/ 47	0.32	4.3	<0.1 - 1.2	Yes	> 5% Detect Above Background
Silver	mg/kg	1/ 47	0.24	0/ 47	0.24	0.24	0.7	No	Below Background
Sodium	mg/kg	12/ 12	.		148	535	5000 - 7000	No	Essential Element
Thallium	mg/kg	12/ 12	.		0.84	7.9		Yes	No Background Data Available
Vanadium	mg/kg	12/ 12	.		5.5	92.9	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	47/ 47	72.1	34/ 47	34.1	1560	25 - 110	Yes	> 5% Detect Above Background
4,4'-DDD	µg/kg	2/ 12	.		42	250		Yes	No Background Data Available

Table 4.3 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
4,4'-DDE	µg/kg	4/ 12	.		3.3	840		Yes	No Background Data Available
4,4'-DDT	µg/kg	3/ 12	.		63	450		Yes	No Background Data Available
Aldrin	µg/kg	1/ 12	.		2.5	2.5		Yes	No Background Data Available
Alpha chlordane	µg/kg	3/ 12	.		19	140		Yes	No Background Data Available
Aroclor-1254	µg/kg	5/ 12	.		95	36000		Yes	No Background Data Available
Aroclor-1260	µg/kg	1/ 12	.		680	680		Yes	No Background Data Available
Dieldrin	µg/kg	1/ 12	.		170	170		Yes	No Background Data Available
Endosulfan I	µg/kg	1/ 12	.		40	40		Yes	No Background Data Available
Endosulfan II	µg/kg	1/ 12	.		8.7	8.7		Yes	No Background Data Available
Endrin	µg/kg	1/ 12	.		37	37		Yes	No Background Data Available
Endrin aldehyde	µg/kg	2/ 12	.		9.6	53		Yes	No Background Data Available
Gamma chlordane	µg/kg	4/ 12	.		1.9	250		Yes	No Background Data Available
Heptachlor epoxide	µg/kg	1/ 12	.		2.3	2.3		Yes	No Background Data Available
Anthracene	µg/kg	1/ 12	.		60	60		Yes	No Background Data Available

Table 4.3 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Benzo(a)anthracene	µg/kg	5/ 12	.		77	330		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	5/ 12	.		86	420		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	4/ 12	.		100	400		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	4/ 12	.		74	530		Yes	No Background Data Available
Benzo(k)fluoranthene	µg/kg	5/ 12	.	.	94	500		Yes	No Background Data Available
Bis(2-ethylhexyl)phthalate	µg/kg	5/ 12	.		42	1400		Yes	Detected > 5% of Samples
Carbazole	µg/kg	1/ 12	.		36	36		Yes	No Background Data Available
Chrysene	µg/kg	6/ 12	.		90	600		Yes	No Background Data Available
Di-n-butyl phthalate	µg/kg	4/ 12	.		410	14000		Yes	No Background Data Available
Dibenzo(a,h)anthracene	µg/kg	3/ 12	.		40	160		Yes	No Background Data Available
Dimethyl phthalate	µg/kg	1/ 12	.		1900	1900		Yes	No Background Data Available
Fluoranthene	µg/kg	6/ 12	.		120	1000		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	4/ 12	.		74	310		Yes	No Background Data Available
N-nitrosodiphenylamine	µg/kg	2/ 12	.		110	270		Yes	No Background Data Available

Table 4.3 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Pentachlorophenol	µg/kg	1/ 12	.		3900	3900		Yes	No Background Data Available
Phenanthrene	µg/kg	4/ 12	.		67	500		Yes	No Background Data Available
Pyrene	µg/kg	5/ 12	.		110	890		Yes	No Background Data Available
Acetone	µg/kg	1/ 9	.		270	270		Yes	No Background Data Available
Chloroform	µg/kg	3/ 12	.		2	2		Yes	Detected > 5% of Samples
Toluene	µg/kg	5/ 12	.		6	31		Yes	Detected > 5% of Samples
SEDIMENT									
Cyanide	mg/kg	2/ 3	.		0.35	1.1		Yes	No Background Data Available
1,3,5-Trinitrobenzene	µg/kg	2/ 22	.		380	6800		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	3/ 22	.		430	770000		Yes	Detected > 5% of Samples
HMX	µg/kg	2/ 22	.		2800	12000		Yes	No Background Data Available
RDX	µg/kg	2/ 22	.		430	16000		Yes	No Background Data Available
Aluminum	mg/kg	22/ 22	15600	2/ 22	3400	19900	20000 - 100000	Yes	> 5% Detect Above Background
Antimony	mg/kg	2/ 3	.		15.3	2460		Yes	No Background Data Available

Table 4.3 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Arsenic	mg/kg	22/ 22	19.6	7/ 22	6.9	67.1	5.2 - 27.0	Yes	> 5% Detect Above Background
Barium	mg/kg	22/ 22	75	16/ 22	38.5	269	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	3/ 3	.		0.38	1.7	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	20/ 22	0.29	18/ 22	0.21	26.9	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	3/ 3	.		3040	36200	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	22/ 22	18.7	7/ 22	9.5	345	15.0 - 100.0	Yes	> 5% Detect Above Background
Cobalt	mg/kg	3/ 3	.		4.7	43.2	7 - 20	Yes	No Background Data Available
Copper	mg/kg	3/ 3	.		9	558	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	3/ 3	.		9340	199000	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	22/ 22	17.9	14/ 22	12.9	2220	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	3/ 3	.		2110	9370	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	22/ 22	728	9/ 22	80.1	2340	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	15/ 22	0.08	7/ 22	0.05	1.4	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	3/ 3	.		9.8	108	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	3/ 3	.		185	673	11800 - 25100	No	Essential Nutrient

Table 4.3 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Selenium	mg/kg	20/ 22	2.6	4/ 22	0.43	10.3	<0.1 - 1.2	Yes	> 5% Detect Above Background
Silver	mg/kg	2/ 22	0.24	2/ 22	1.5	3.9	0.7	Yes	> 5% Detect Above Background
Sodium	mg/kg	3/ 3	.		195	484	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	3/ 3	.		0.8	8.1		Yes	No Background Data Available
Vanadium	mg/kg	3/ 3	.		11.9	14.5	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	22/ 22	72.1	17/ 22	48.2	2530	25 - 110	Yes	> 5% Detect Above Background
4,4'-DDD	µg/kg	1/ 3	.		12	12		Yes	No Background Data Available
4,4'-DDE	µg/kg	1/ 3	.		740	740		Yes	No Background Data Available
4,4'-DDT	µg/kg	1/ 3	.		440	440		Yes	No Background Data Available
Alpha chlordane	µg/kg	1/ 3	.		9.9	9.9		Yes	No Background Data Available
Aroclor-1254	µg/kg	2/ 3	.		290	44000		Yes	No Background Data Available
Endrin	µg/kg	1/ 3	.		160	160		Yes	No Background Data Available
Endrin aldehyde	µg/kg	1/ 3	.		320	320		Yes	No Background Data Available
Gamma chlordane	µg/kg	2/ 3	.		11	130		Yes	No Background Data Available

Table 4.3 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Heptachlor	µg/kg	1/ 3	.		3.4	3.4		Yes	No Background Data Available
Anthracene	µg/kg	1/ 3	.		260	260		Yes	No Background Data Available
Benzo(a)anthracene	µg/kg	2/ 3	.		260	860		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	3/ 3	.		350	1300		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	2/ 3	.		600	3000		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	2/ 3	.		460	1400		Yes	No Background Data Available
Benzo(k)fluoranthene	µg/kg	2/ 3	.		500	1500		Yes	No Background Data Available
Bis(2-ethylhexyl)phthalate	µg/kg	2/ 3	.		120	490		Yes	Detected > 5% of Samples
Carbazole	µg/kg	1/ 3	.		240	240		Yes	No Background Data Available
Chrysene	µg/kg	3/ 3	.		130	1800		Yes	No Background Data Available
Di-n-butyl phthalate	µg/kg	1/ 3	.		870	870		Yes	No Background Data Available
Dibenzo(a,h)anthracene	µg/kg	2/ 3	.		180	560		Yes	No Background Data Available
Fluoranthene	µg/kg	2/ 3	.		510	2100		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	2/ 3	.		440	1100		Yes	No Background Data Available

Table 4.3 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Phenanthrene	µg/kg	2/ 3	.		190	380		Yes	No Background Data Available
Pyrene	µg/kg	3/ 3	.		140	1400		Yes	No Background Data Available
Acetone	µg/kg	1/ 2	.		110	110		Yes	No Background Data Available
Chloroform	µg/kg	1/ 3	.		4	4		Yes	Detected > 5% of Samples

Table 4.4. Load Line 1 Analytical Results (Groundwater)

Analyte	Frequency of Detects	Minimum Detect (µg/L)	Maximum Detect (µg/L)
GROUNDWATER			
Cyanide	1/ 7	2.9	2.9
Aluminum	7/ 7	27.8	235
Arsenic	3/ 7	8.4	64.1
Barium	7/ 7	20.3	105
Beryllium	2/ 6	0.33	0.43
Calcium	6/ 6	4050	196000
Cobalt	5/ 6	1.4	27.5
Copper	4/ 6	0.93	7.4
Iron	4/ 6	37.3	822
Magnesium	6/ 6	2590	80700
Manganese	7/ 7	130	3120
Mercury	3/ 7	0.1	0.13
Nickel	6/ 6	1.6	73.2
Potassium	6/ 6	1010	5090
Sodium	6/ 6	4360	18100
Zinc	4/ 7	9.1	82.5
Heptachlor	1/ 6	0.05	0.05
2,4-Dimethylphenol	1/ 5	1	1
Diethyl phthalate	1/ 6	1	1
Acetone	1/ 4	18	18
Methylene chloride	1/ 7	11	11

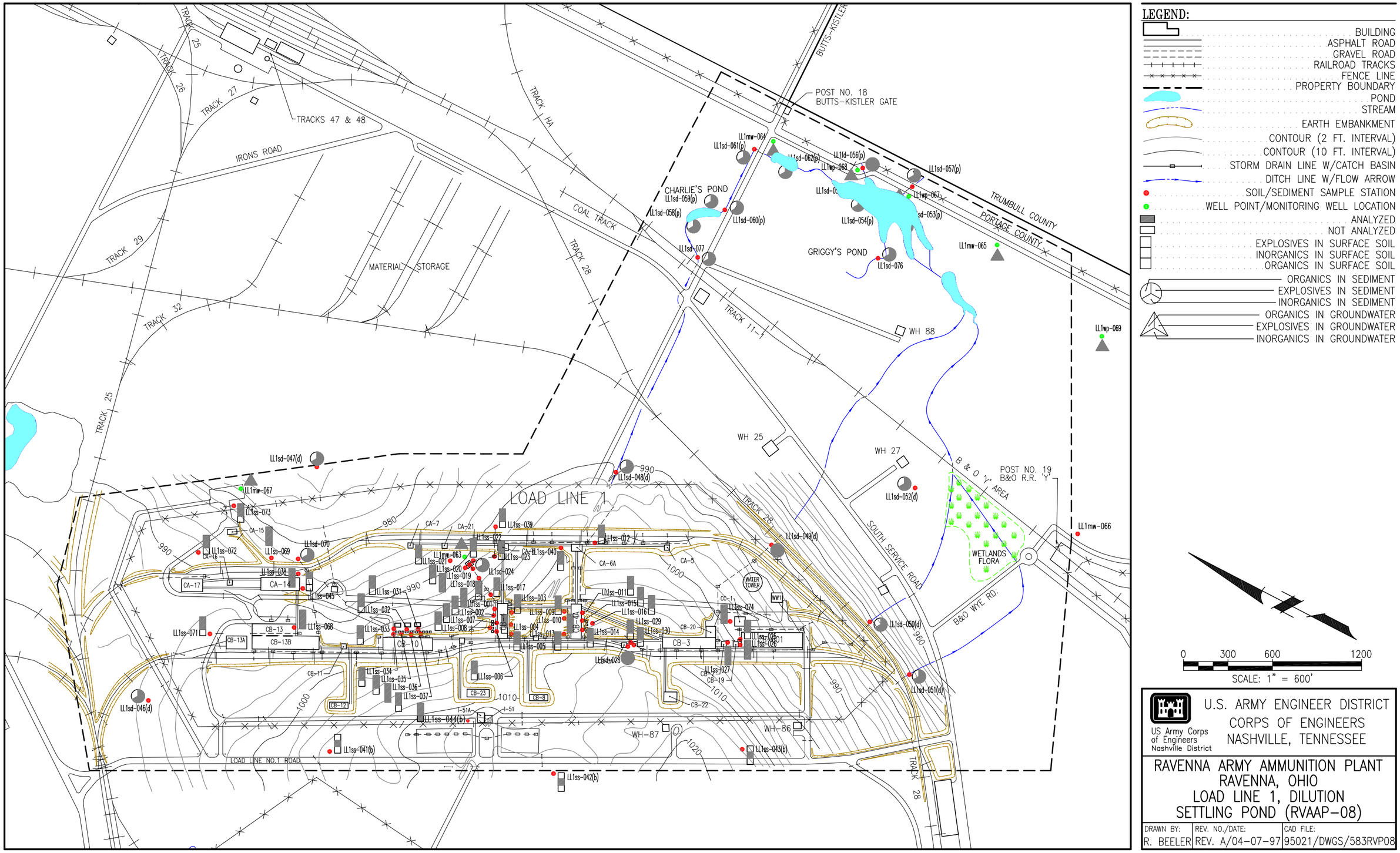
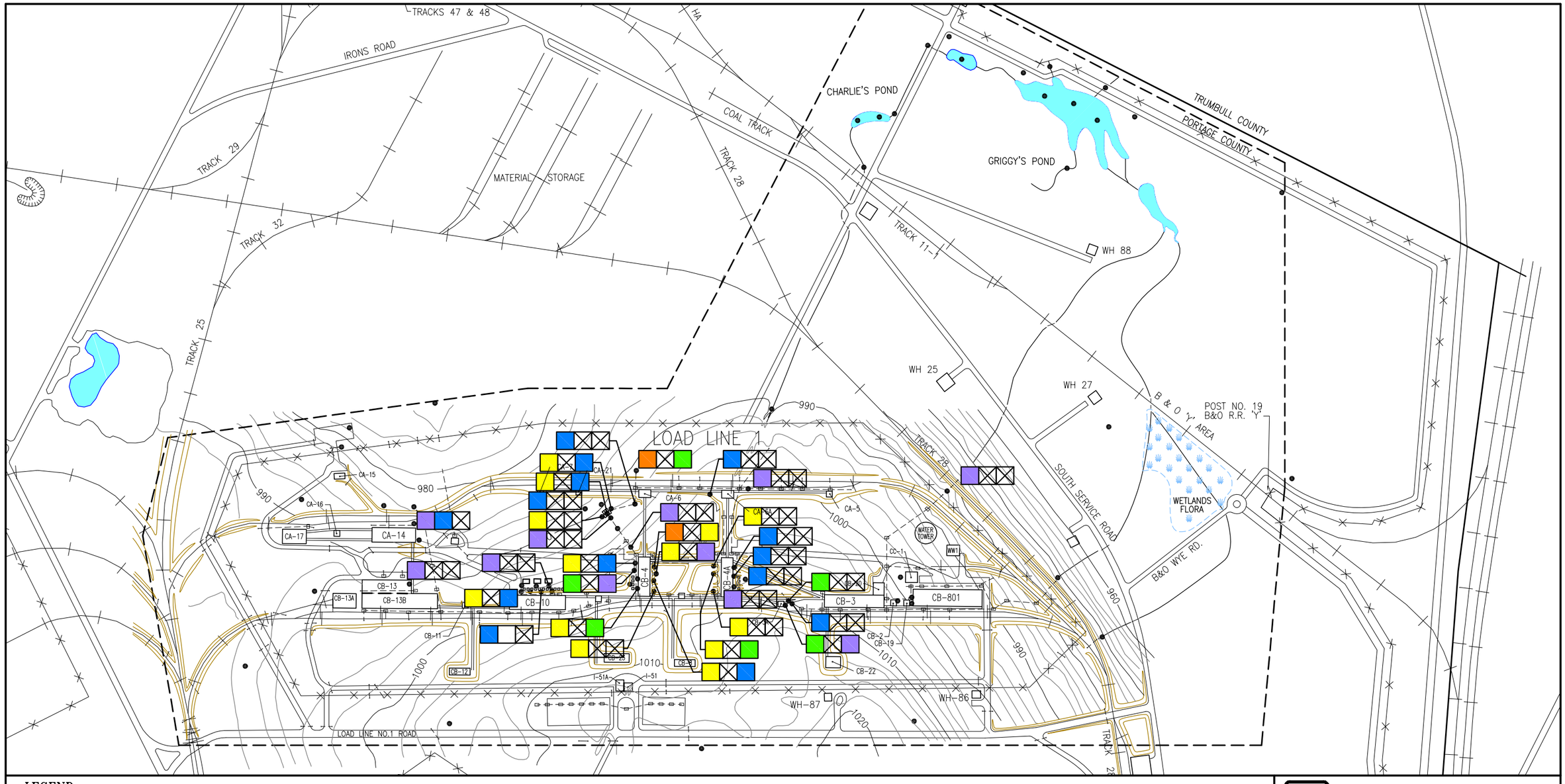


Fig. 4-7. LL1 Sample Locations and Analytical Parameters



LEGEND:

- BUILDING
- ASPHALT ROAD
- GRAVEL ROAD
- RAILROAD TRACKS
- FENCE LINE
- PROPERTY BOUNDARY
- POND
- STREAM
- EARTH EMBANKMENT
- CONTOUR (2 FT. INTERVAL)
- CONTOUR (10 FT. INTERVAL)
- STORM DRAIN LINE W/CATCH BASIN
- DITCH LINE W/FLOW ARROW
- SAMPLE STATION
- 246TNT
- 24DNT
- 135TNB
- NOT DETECTED OR BELOW BACKGROUND
- 0.01 – 0.1 mg/kg
- 0.1 – 1.0 mg/kg
- 1 – 10 mg/kg
- 10 – 100 mg/kg
- 100 – 1,000 mg/kg
- 1,000 – 10,000 mg/kg
- > 10,000 mg/kg

US Army Corps of Engineers Nashville District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NASHVILLE, TENNESSEE

RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
LOAD LINE 1, DILUTION
SETTLING POND (RVAAP-08)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	REV. 0/12-11-96	95021/DWGS/588RVP8A

Fig. 4-8. Relative Concentrations of Explosives in Surface Soil and Sediment at LL1

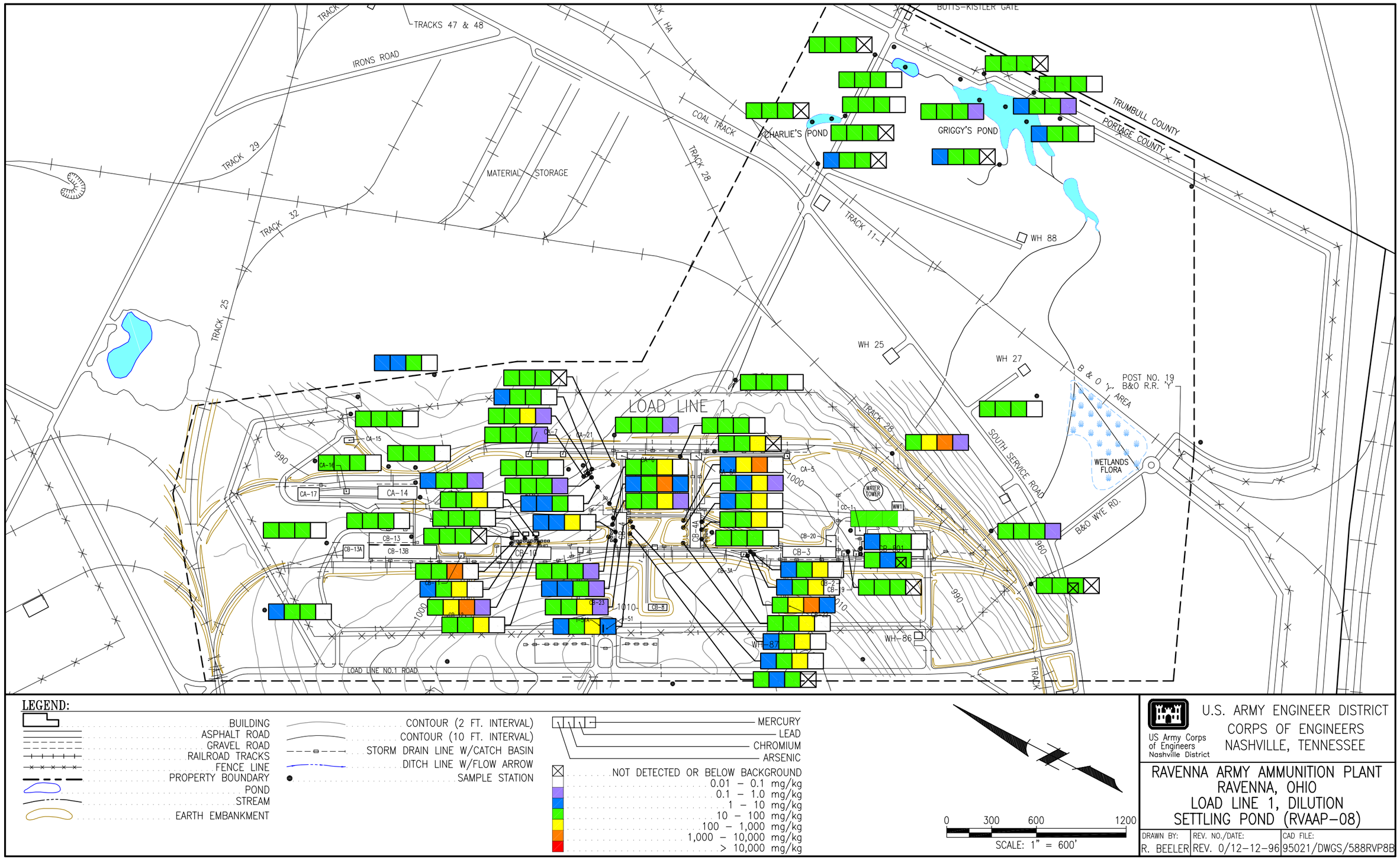
In 17 of the 46 samples, no explosive compounds were detected. Sampling locations at the north end of Load Line 1 (LL1ss-069, -070, -071, and -072) had no detectable quantities of explosives. However, at Building CB-13, where explosive materials were visually located, soil sample analyses of LL1ss-068 indicate contamination. Similarly, at the south end of Load Line 1, soil samples collected next to Building CB-801 (LL1ss-025 and -026) contain no detectable amounts of explosives. Sampling locations LL1ss-007, -008, -018, -033, -035, and -037 had no detectable quantities of explosives, but were located within 50 to 100 feet of a sample that did contain explosives (e.g., LL1ss-034 with 281 mg/kg of TNT, next to LL1ss-035, with no detectable TNT). Thus, although concentrations of TNT and other explosive compounds in some surface soils are very high, the compounds appear to be immobile in the soils.

Inorganic Analytes

Metals were detected above background in every surface soil sample collected at Load Line 1 and are scattered irregularly throughout the plant. The 18 non-nutrient metals and cyanide were each detected in at least one surface soil sample. Silver was screened out because the maximum detected concentration was below the background criteria. The remaining 17 metals and cyanide are considered to be site-related chemicals in surface soil at Load Line 1 (Table 4.7). **Figure 4.9** shows the distribution and relative concentrations of selected site-related metals in surface soils at Load Line 1.

All 11 process-related metals except silver were detected at concentrations exceeding the background criteria, and all, except for aluminum, also exceeded the upper range of USGS reference values. Lead, cadmium, and zinc were the most frequently detected metals exceeding the background criteria. Lead was detected at concentrations ranging from 10.8 to 3,610 mg/kg, and occurred above background (17.9 mg/kg) in 41 of 47 samples (Figure 4.9). Concentrations of lead also exceeded the upper range of USGS reference values for this analyte (30 mg/kg). Cadmium was detected at concentrations from 0.15 to 23.5, and concentrations exceeded the background criteria (0.29 mg/kg) in 35 of 47 samples, and exceeded the USGS upper reference value (2 mg/kg) in 15 samples. Zinc was detected at concentrations ranging from 34.1 to 1,560 mg/kg, occurring above background (72.1 mg/kg) in 34 samples, and was detected at concentrations above the upper range of USGS reference values (110 mg/kg).

Barium was detected at concentrations from 22.2 to 1380 mg/kg, and was present above the background concentration of 75 mg/kg in 21 of 47 samples. Barium was detected at concentrations in excess of the maximum USGS reference value (700 mg/kg). Chromium was detected with values from 4.8 to 394 mg/kg, occurring in 17 of 47 samples at concentrations exceeding background (18.7 mg/kg). Chromium was present at concentrations in excess of the upper range of USGS values (100 mg/kg). Mercury was present from 0.03 to 1.4 mg/kg, and exceeded the background criteria (0.08 mg/kg) in 14 samples. Mercury also exceeded the maximum USGS reference value (0.22 mg/kg). The distribution and relative concentrations of chromium and mercury are illustrated on Figure 4.9.



LEGEND:

- BUILDING
- ASPHALT ROAD
- GRAVEL ROAD
- RAILROAD TRACKS
- FENCE LINE
- PROPERTY BOUNDARY
- POND
- STREAM
- EARTH EMBANKMENT
- CONTOUR (2 FT. INTERVAL)
- CONTOUR (10 FT. INTERVAL)
- STORM DRAIN LINE W/CATCH BASIN
- DITCH LINE W/FLOW ARROW
- SAMPLE STATION
- MERCURY
- LEAD
- CHROMIUM
- ARSENIC
- NOT DETECTED OR BELOW BACKGROUND
- 0.01 – 0.1 mg/kg
- 0.1 – 1.0 mg/kg
- 1 – 10 mg/kg
- 10 – 100 mg/kg
- 100 – 1,000 mg/kg
- 1,000 – 10,000 mg/kg
- > 10,000 mg/kg

0 300 600 1200

SCALE: 1" = 600'

US Army Corps of Engineers Nashville District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NASHVILLE, TENNESSEE

RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
LOAD LINE 1, DILUTION
SETTLING POND (RVAAP-08)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	REV. 0/12-12-96	95021/DWGS/588RVP8B

Fig. 4-9. Relative Concentrations of Selected Inorganic Elements in Surface Soil and Sediment at LL1

Manganese was detected at concentrations from 113 to 2,140 mg/kg, occurring above the background criteria (728 mg/kg) in 10 samples, and exceeding the maximum USGS reference value (1,000 mg/kg). Aluminum and selenium were each detected above background (15,600 mg/kg and 2.6 mg/kg, respectively) in four samples. The maximum detected concentration of aluminum was 47,600 mg/kg, which is within the range of USGS reference values (20,000 to 100,000 mg/kg). Selenium had a maximum concentration of 4.3 mg/kg, which exceeds the upper range of USGS values (1.2 mg/kg). It should be noted that selenium was not detected at concentrations exceeding the background criteria at any other RVAAP Phase I AOC. Arsenic was detected at concentrations from 4.5 to 77 mg/kg, occurring above background (19.6 mg/kg) in three samples (Figure 4.9). Concentrations of arsenic were also above the maximum USGS reference value (27 mg/kg).

The metals from the expanded analyte list, beryllium, cobalt, copper, nickel, thallium, and vanadium, were each detected in all 12 samples in which they were analyzed, and antimony was detected in 8 of the 12 samples. The range of concentrations for these analytes is given on Table 4.3. Cyanide was also detected in 8 of 12 samples (Table 4.3).

The three highest concentrations of any metal occur in 13 sampling locations that appear to be associated with a few specific features or buildings at Load Line 1. Sampling locations LL1ss-019 and -036 are the sites of the highest and/or second-highest concentrations of seven process-related metals, including aluminum, arsenic, barium, chromium, manganese, selenium, and zinc, as well as the seven non-nutrient metals from the expanded analyte list (antimony, beryllium, cobalt, copper, nickel, thallium, and vanadium). The maximum values detected for arsenic, cobalt, chromium, lead, vanadium, and selenium in Load Line 1 soils were the highest concentrations measured at RVAAP during Phase I. Maximum values occur with equal frequency in samples that also contain high concentrations of explosives and/or organic compounds as those that do not. Six other samples—LL1ss-002, -003, -005, -009, -015, and -025—were the sites of the maximum concentrations for process-related metals arsenic, cadmium, barium, mercury, and lead, as well as cobalt and antimony. These samples are located near melt/pour buildings CB-4 and CB-4A, Building CB-101, or Building CB-801.

The maximum values for aluminum and selenium, as well as expanded analyte list metals beryllium, nickel, thallium, and vanadium occurred at LL1ss-019. Sampling location LL1ss-019 is located next to the concrete settling tank northeast of melt/pour building CB-4, and also contains detectable quantities of explosives and PAHs. Concentrations of these metals in LL1ss-019, -020, -021, and -022 are as much as six times higher than in the next downslope soil sample, LL1ss-018. Elevated metals concentrations are also noted for LL1ss-023, east of the LL1ss-019 to -022 sample cluster near Building CA-6. At LL1ss-036, near a vacuum pump house east of Building CB-101, metals such as chromium, manganese, and zinc occur at their maximum concentrations, which are more than two times higher than is encountered in LL1ss-034, -035, or -037 nearby.

Organic Compounds

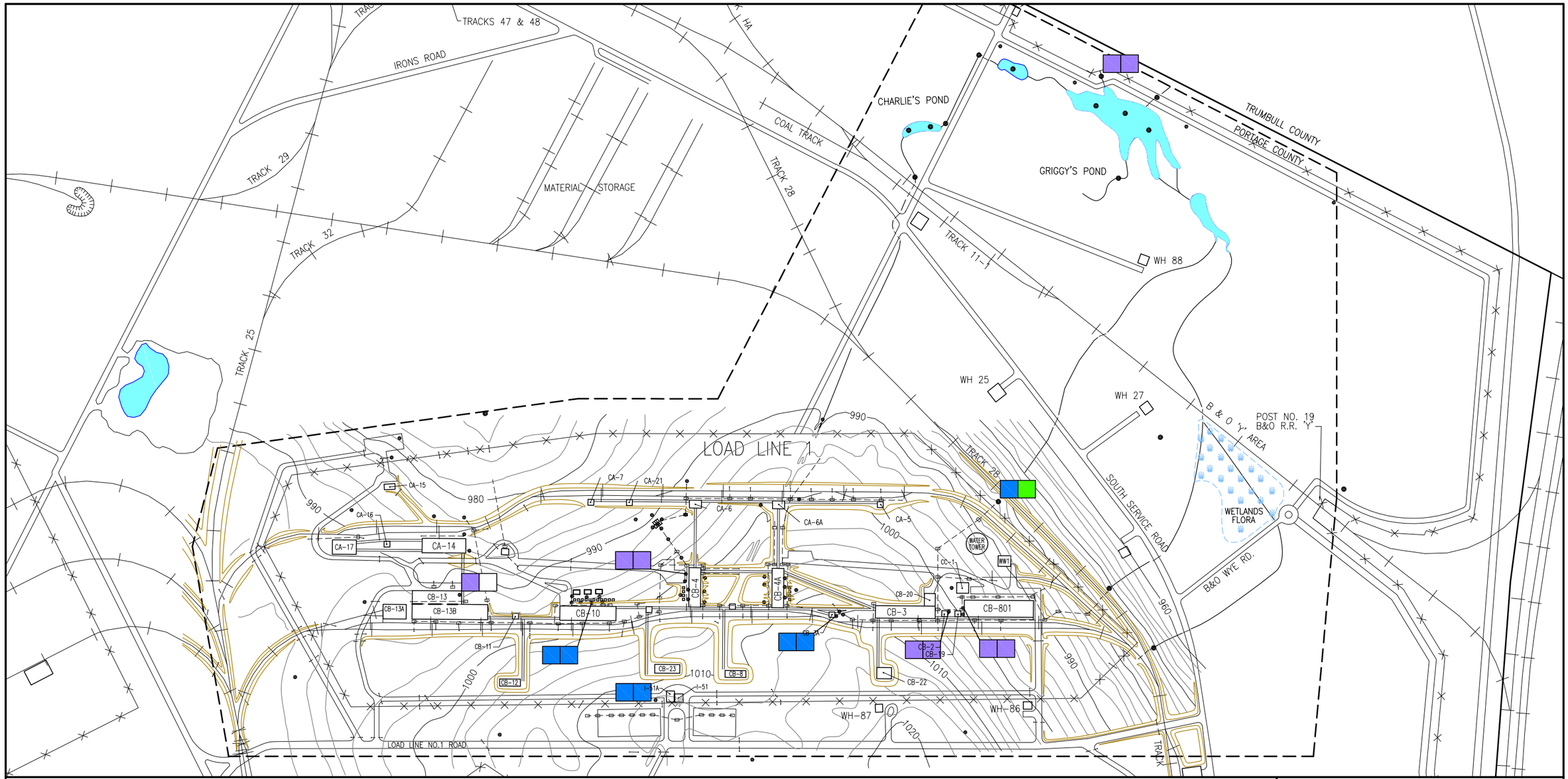
Organic vapors were detected using field instruments in ten soil borings, either in headspace gases or in the breathing zone. The remaining soil borings showed no detectable quantities of organic vapors. Concentrations ranged from 8 to 1200 ppm in headspace gases,

and from 0.8 to 17.5 ppm in the breathing zone. Analyses of organic compounds were performed for twelve soil borings; of these, eight soil samples had detectable quantities of organic analytes although no detectable quantities of organic vapors were found in the field. The remaining four samples (LL1ss-027, -044, -068, and -069) had detectable or large quantities of volatile, semi-volatile, and PCB compounds, with readings of 8 ppm or lower in headspace and breathing zone gases. Seven soil samples had headspace gases in excess of 5 ppm, but were not analyzed for organic compounds by the laboratory (LL1ss-013, -014, -029, -030, -071, -072, and -073).

Samples from twelve soil borings were analyzed for the full suite of organic chemicals. These are LL1ss-001, -010, -019, -025, -026, -027, -036, -038, -044, -068, -069, and -075. VOCs are present in eight samples (acetone, chloroform, and toluene), in low concentrations of 0.017 mg/kg or less.

SVOCs are present in the form of PAHs and phthalate esters in seven sample locations: LL1ss-001, -025, -027, -036, -038, -044, and -068. The majority of detections of SVOCs were PAHs, which are a common chemical signature of industrial facilities. The highest concentrations of each of the 13 PAHs detected were found in LL1ss-036, located adjacent to a vacuum pump house next to Building CB-101. **Figure 4.10** shows the relative concentration of total PAHs and total carcinogenic PAHs in surface soil and sediment. Carcinogenic PAHs include benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene (see Section 5). Phthalate esters were present in LL1ss-001, -036, -038, and -068. Di-n-butyl phthalate was present at 14 mg/kg at LL1ss-068, and 5.3 mg/kg at LL1ss-038; dimethyl phthalate occurred at a concentration of 1.9 mg/kg at LL1ss-036. Pentachlorophenol was also detected at LL1ss-036, at a concentration of 3.9 mg/kg.

Seven of the samples contained pesticides and/or PCB compounds: LL1ss-001, -010, -026, -027, -036, -038, and -068. The highest concentration of any PCB was 36 mg/kg of Aroclor-1254 at LL1ss-036; concentrations of 34 mg/kg and 11 mg/kg of Aroclor-1254 were measured at LL1ss-001 and -038, respectively. 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha chlordane, gamma chlordane, heptachlor epoxide, and endrin aldehyde were also present in these six samples. Aldrin, Aroclor-1260, dieldrin, endosulfan II, and endrin were each detected in one sample. The lowest concentration observed was 0.002 mg/kg of gamma chlordane at LL1ss-010. High concentrations of these compounds remain isolated and do not appear to be influencing soil chemistry at nearby sampling locations [for example, the maximum of 36 mg/kg of Aroclor-1254 at LL1ss-036 does not impact LL1ss-034, which also was subjected to the full suite of analyses, some 46 m (150 ft) away]. It is possible that PCB-laden oils were used in a vacuum pump beside LL1ss-036, resulting in soil contamination. However, it is less clear why soils at the railroad siding of Building CA-14 or south of Building CB-2 should be contaminated with these chemicals. **Figure 4.11** illustrates the spatial distribution of pesticides and PCBs in surface soils at Load Line 1.



LEGEND:

- BUILDING
- ASPHALT ROAD
- GRAVEL ROAD
- RAILROAD TRACKS
- FENCE LINE
- PROPERTY BOUNDARY
- POND
- STREAM
- EARTH EMBANKMENT
- CONTOUR (2 FT. INTERVAL)
- CONTOUR (10 FT. INTERVAL)
- STORM DRAIN LINE W/CATCH BASIN
- DITCH LINE W/FLOW ARROW
- SAMPLE STATION
- PAHs
- CARC. PAHs
- NOT DETECTED OR BELOW BACKGROUND
- 0.01 – 0.1 mg/kg
- 0.1 – 1.0 mg/kg
- 1 – 10 mg/kg
- 10 – 100 mg/kg
- 100 – 1,000 mg/kg
- 1,000 – 10,000 mg/kg
- > 10,000 mg/kg

0 300 600 1200

SCALE: 1" = 600'

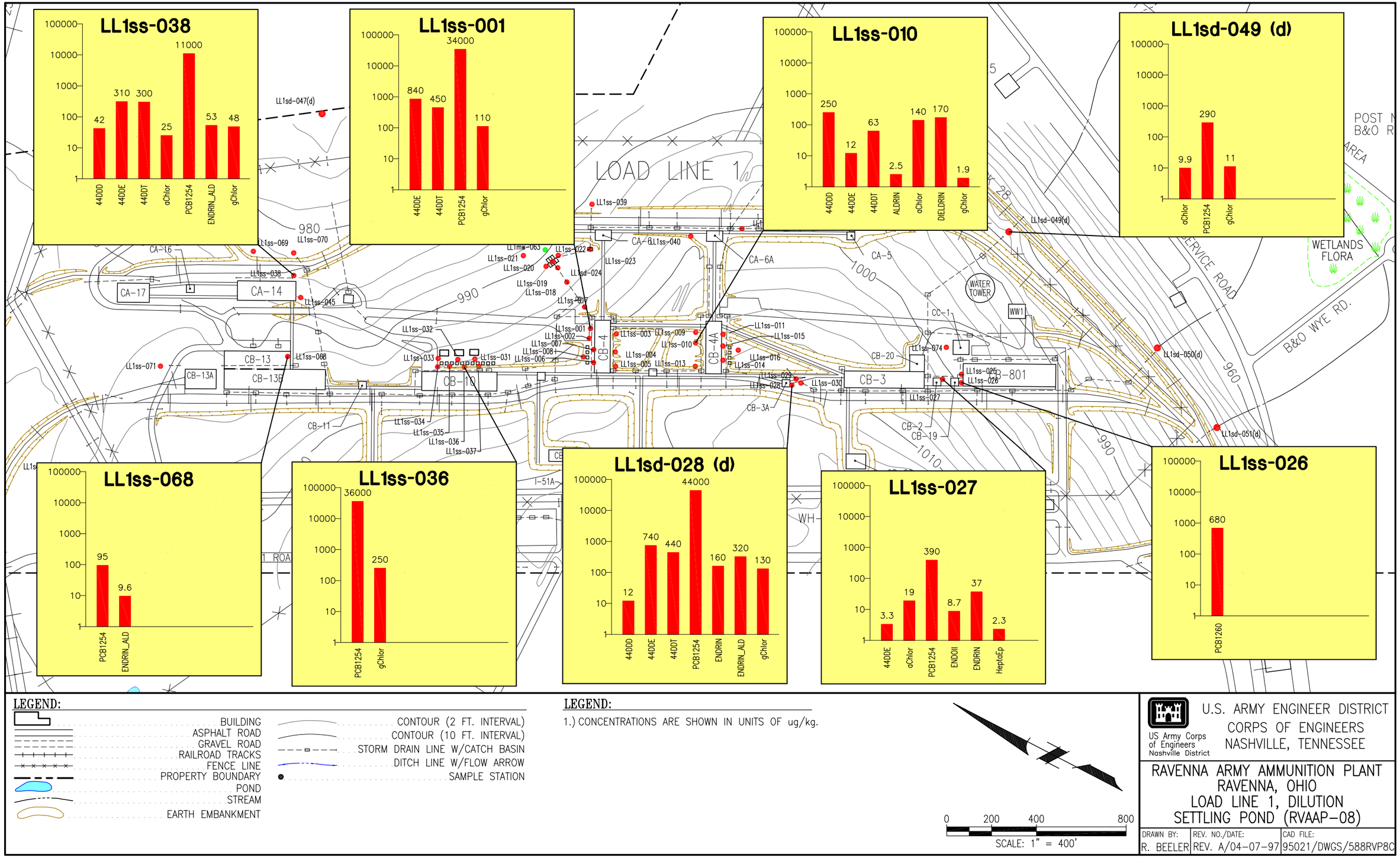
US Army Corps of Engineers Nashville District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NASHVILLE, TENNESSEE

RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
LOAD LINE 1, DILUTION
SETTLING POND (RVAAP-08)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
S. DUNLAP	REV. 0/12-11-96	95021/DWGS/588RVP8

Fig. 4-10. Relative Concentrations of Total PAHs and Total Carcinogenic PAHs in Surface Soil and Sediment at LL1



LEGEND:

- BUILDING
- ASPHALT ROAD
- GRAVEL ROAD
- RAILROAD TRACKS
- FENCE LINE
- PROPERTY BOUNDARY
- POND
- STREAM
- EARTH EMBANKMENT
- CONTOUR (2 FT. INTERVAL)
- CONTOUR (10 FT. INTERVAL)
- STORM DRAIN LINE W/CATCH BASIN
- DITCH LINE W/FLOW ARROW
- SAMPLE STATION

LEGEND:

1.) CONCENTRATIONS ARE SHOWN IN UNITS OF ug/kg.

0 200 400 800

SCALE: 1" = 400'

US Army Corps of Engineers Nashville District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
NASHVILLE, TENNESSEE

RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
LOAD LINE 1, DILUTION
SETTLING POND (RVAAP-08)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	REV. A/04-07-97	95021/DWGS/588RVP8C

Fig. 4-11. Distribution and Concentrations Of PCBs/Pesticides in Soil and Sediment at LL1

4.4.2 Sediment

Twenty-two sediment samples were collected in Load Line 1 for analysis of the 11 process-related inorganic compounds and explosives. Three of these samples were also analyzed for the expanded metals suite, cyanide, VOCs, SVOCs, and pesticides/PCBs. The analytical data is summarized in Table 4.3, and presented in detail in Appendix G. The sample locations and analysis type for each are shown in Figure 4.7. Geotechnical grain size distribution curves are presented in Appendix G.4. TOC ranged from 7,020 mg/kg in LL1sd-058 to 146,000 mg/kg in LL1sd-061.

Explosives

Explosive compounds were detected in six sediment samples in Load Line 1. 1,3,5-TNB was detected once, at LL2sd-028 (at Building CB-3A), at 0.38 mg/kg. TNT was detected in three samples: LL1sd-024 (770 mg/kg), LL1sd-028 (16 mg/kg), and LL1sd-049 (0.43 mg/kg). High concentrations of TNT in LL1sd-024 and -028 result from accumulation of pinkwater residue in concrete settling tanks. LL1sd-049 was collected from a ditch exiting the south end of Load Line 1. There is no apparent process or drainage relationship among these three sampling locations. HMX was detected twice, at LL1sd-024 (12 mg/kg) and LL1sd-049 (2.8 mg/kg). Drainage ditches may have conveyed effluent from this concrete settling tank to the surface stream that exits Load Line 1. RDX was detected in LL1sd-049 (16 mg/kg) and LL1sd-056 (0.43 mg/kg), but was not present in Griggy's Pond, as would be expected if the drainage ditch were causing contaminant loading sufficient to reach LL1sd-056 (see Figure 4.8).

Explosives were not detected in sediment samples from three of the four main drainage ditches that exit Load Line 1 from the south (LL1sd-050, -051, -052, and -048), or from LL1sd-046, which is located in a ditch that exits the load line at the north end (see Figure 4.8). Pond sediments from Griggy's and Charlie's Ponds exhibit no detectable contamination with explosives, except for LL1sd-056 as described above.

Inorganic Analytes

A total of 23 inorganic elements and cyanide were detected, and all 18 of the non-nutrient elements and cyanide are considered to be site-related because concentrations exceeded the background criteria in at least one sample, or no background criteria were available. Figure 4.9 shows the distribution of representative metals contaminants in ditch and pond sediments at Load Line 1.

All eleven of the process-related metals were detected at concentrations exceeding the background criteria. Cadmium, zinc, and barium were most frequently detected at concentrations exceeding the background criteria (Table 4.3). Cadmium was detected at concentrations from 0.21 to 26.9 mg/kg, and exceeded background (0.29 mg/kg) in 18 of 22 samples. Concentrations were also above the maximum USGS reference value (2 mg/kg). Zinc was detected at concentrations from 48.2 to 2,530 mg/kg, occurring above background (72.1 mg/kg) in 17 samples. Zinc detections also exceeded the maximum USGS reference value (110 mg/kg.) Barium was detected at concentrations ranging from 38.5 to 269 mg/kg,

and exceeded the background criteria (75 mg/kg) in 16 samples. The maximum barium concentration was below the range of USGS reference criteria (300 to 700 mg/kg).

Lead was detected at concentrations from 12.9 to 2,220 mg/kg, and was present above background (17.9 mg/kg) in 14 samples, with concentrations also exceeding the maximum USGS reference value (30 mg/kg). The distribution and relative concentrations of lead in sediment are shown on Figure 4.9. Manganese was detected at concentrations from 80.1 to 2,340 mg/kg, and exceeded background (728 mg/kg) in 9 samples. The USGS maximum value (1,000 mg/kg) for manganese was also exceeded. Mercury, chromium, and arsenic were each detected in seven samples at concentrations exceeding the background criteria (Table 4.3). The distribution and relative concentration of these three metals in sediment at Load Line 2 is illustrated in Figure 4.9. The USGS maximum concentrations for cadmium chromium, and arsenic were also exceeded (Table 4.3).

Selenium was detected above the background criteria (2.6 mg/kg) in four samples, with a maximum concentration of 3.9 mg/kg. The maximum USGS reference level (1.2 mg/kg) for selenium is less than the site-specific background criteria. Aluminum and silver were each detected in two samples at concentrations exceeding the background criteria (15,600 mg/kg and 0.24 mg/kg, respectively). The maximum detection of aluminum was within the range of USGS reference values (Table 4.3), while that for silver exceeded the USGS value of 0.7 mg/kg.

The seven non-nutrient expanded metals were also all detected in at least one sample. Beryllium, cobalt, copper, nickel, vanadium, and thallium were detected in all three samples analyzed; antimony was detected in two of the three samples. Table 4.3 gives the range of detected concentrations for each of these metals. The maximum concentration for cobalt, copper, and nickel exceeds the upper range of USGS reference values; there is no published USGS reference value for antimony or thallium.

Cyanide was detected in two sediment samples (LL1sd-028 and LL1sd-049), at concentrations of 1.1 and 0.35 mg/kg, respectively. LL1sd-028 is located in the ditch beside Building CB-3A and may contribute to the observance of cyanide downstream past its discharge point in the southward-draining creek where LL1sd-049 is located.

Of the 22 samples analyzed, the highest concentrations of the 18 site-related metals occur in LL1sd-024, -028, -048, -049 -050, -054, -055, -056, -057, -058, -059, and -060. Most of these sampling locations were found to have no detectable quantities of explosives. LL1sd-028, 049, and -056 were the locations of the three highest detections for the process-related metal chromium. The expanded metals suite analytes—antimony, beryllium, cobalt, copper, iron, nickel, thallium, and vanadium—were only analyzed for in these three locations. LL1sd-028, located south of Building CB-3A, was the locus of the maximum values for 12 analytes. LL1sd-024 was the site of the maximum concentrations of barium and silver.

Many of the maximum concentrations occurred in either Griggy's Pond or Charlie's Pond. For example, concentrations of aluminum ranged from 3,400 to 19,900 mg/kg, with the maximum detections measured at LL1sd-054 and -055 in Griggy's Pond. Arsenic was detected at its highest concentration (67.10 mg/kg) in Charlie's Pond at LL1sd-058. The

maximum concentration of barium in Load Line 1 sediments was found at LL1sd-024, at 210 mg/kg, with the next highest value at Griggy's Pond. The maximum concentration of chromium in any RVAAP sediment sample was observed in LL1sd-028, at 345 mg/kg. The next highest concentration was measured at 218 mg/kg in LL1sd-049. These two values exceed the reference range 15 to 100 mg/kg.

Maximum concentrations of lead, mercury, and manganese in sediments were substantially higher than the next highest concentrations detected. Lead concentrations ranged from 12.9 (LL1sd-062) to 2,220 mg/kg (LL1sd-028), which was the maximum concentration of lead found in RVAAP sediments. Occurrences of lead at LL1sd-049, -056, -024, -048, -070, -050, and -077 were also found to exceed the maximum USGS reference value of 30 mg/kg, but were five or more times lower than the concentration at LL1sd-028. This suggests the presence of lead at LL1sd-028 is site-related. Mercury's maximum value of 1.4 mg/kg at LL1sd-028, and possibly the other sediment locations, was twice as large as the next highest concentration observed at LL1sd-024. The maximum concentration of manganese occurred at LL1sd-057, with a value of 2,340 mg/kg. However, the next highest concentration of manganese was at least two times smaller than that at LL1sd-057.

Organic Compounds

Organic vapors were monitored using hand-held instruments in the field. Six sediment samples had organic vapors in the headspace gases sampled. Concentrations ranged from 3.0 to 160 ppm. Of these, one sample was analyzed for organic compounds by the laboratory (LL1sd-049) and was found to have significant quantities of VOCs, SVOCs, and PCBs. LL1sd-056 also possessed detectable quantities of organic compounds, but did not produce readings on hand-held instruments in either headspace or breathing zone gases.

Three samples were analyzed for VOCs, SVOCs, and pesticides/PCBs: LL1sd-028, -049, and -056. LL1sd-056 had 0.11 mg/kg of acetone and LL1sd-049 had 0.004 mg/kg of chloroform. No other VOCs were present in sediments.

PAHs are present in concentrations from 0.13 to 3 mg/kg at LL1sd-049, -028 and -056. LL1sd-049 is the locus of the maximum concentration for each of the thirteen PAHs found in Load Line 1 sediments; generally concentrations of PAHs in this sample are twice those in either LL1sd-028 or -056.

Pesticides and PCBs occurred most commonly in LL1sd-028 and -048, with only one pesticide, gamma chlordane, detected in LL1sd-056 at Griggy's Pond. Concentrations ranged from 0.011 mg/kg gamma chlordane at LL1sd-049 to 44 mg/kg Aroclor-1254 at LL1sd-028. A second occurrence of Aroclor-1254 was discovered at LL1sd-049, at 0.29 mg/kg. Unlike PCB occurrences in surface soils, which appear to be present throughout the load line complex, PCBs in sediment are apparently restricted to the southern third of the plant and to one ditch that exits the plant and discharges to Griggy's Pond.

Figure 4.11 depicts the distribution and concentrations of organic compounds at Load Line 1.

4.4.3 Groundwater

Groundwater collected from four monitoring wells (LL1mw-063, LL1mw-064, LL1mw-065, and LL1mw-067) and three temporary well points (LL1wp-067, LL1wp-068, and LL1wp-069) was analyzed for inorganics and explosives. All monitoring well samples and samples from well points were also analyzed for VOCs, SVOCs, and pesticides/PCBs. The analytical results are summarized in Table 4.4 and presented in their entirety in Appendix G.

Explosives

No explosive compounds were detected in either the monitoring wells or temporary well points sampled in Load Line 1.

Inorganic Analytes

A total of 15 inorganic elements and cyanide were detected in Load Line 1 groundwater. The non-nutrient analytes, including aluminum, arsenic, barium, beryllium, cobalt, copper, manganese, mercury, nickel, and zinc, were all detected in at least one groundwater sample. Table 4.4 gives the range of detected concentrations, and the distribution of selected metals (arsenic, cobalt, manganese, and zinc) is shown on **Figure 4.12**. As there are no background criteria for inorganics in groundwater, all of these chemicals are considered to be site-related.

Organic Compounds

All groundwater collected was analyzed for VOCs, SVOCs, and pesticides/PCBs. Two VOCs, methylene chloride and acetone, were detected in LL1wp-68. The four monitoring wells and all of the other well points at Load Line 1 were free of detectable quantities of organic compounds.

Heptachlor was detected at a concentration of 0.05 μg/L in LL1wp-068. Two SVOCs, 2,4-dimethylphenol and diethyl phthalate, were each detected at 1.0 μg/L in this sample. No other organic compounds were detected in LL1wp-068.

4.4.4 Discussion/Summary of Results

The interpretation of chemical data obtained from Load Line 1 surface soils, sediment, and groundwater is summarized as follows.

Surface Soils

- TNT and DNT are present in high concentrations around melt/pour buildings CB-3A and CB-101, and near the settling tank near LL1mw-063. High concentrations of these explosives are localized around doorways, drains, and vacuum pumps.

- Although explosives are present in over half of the samples, the extreme north and south ends of the load line appear to be free of explosives contamination at the locations sampled.

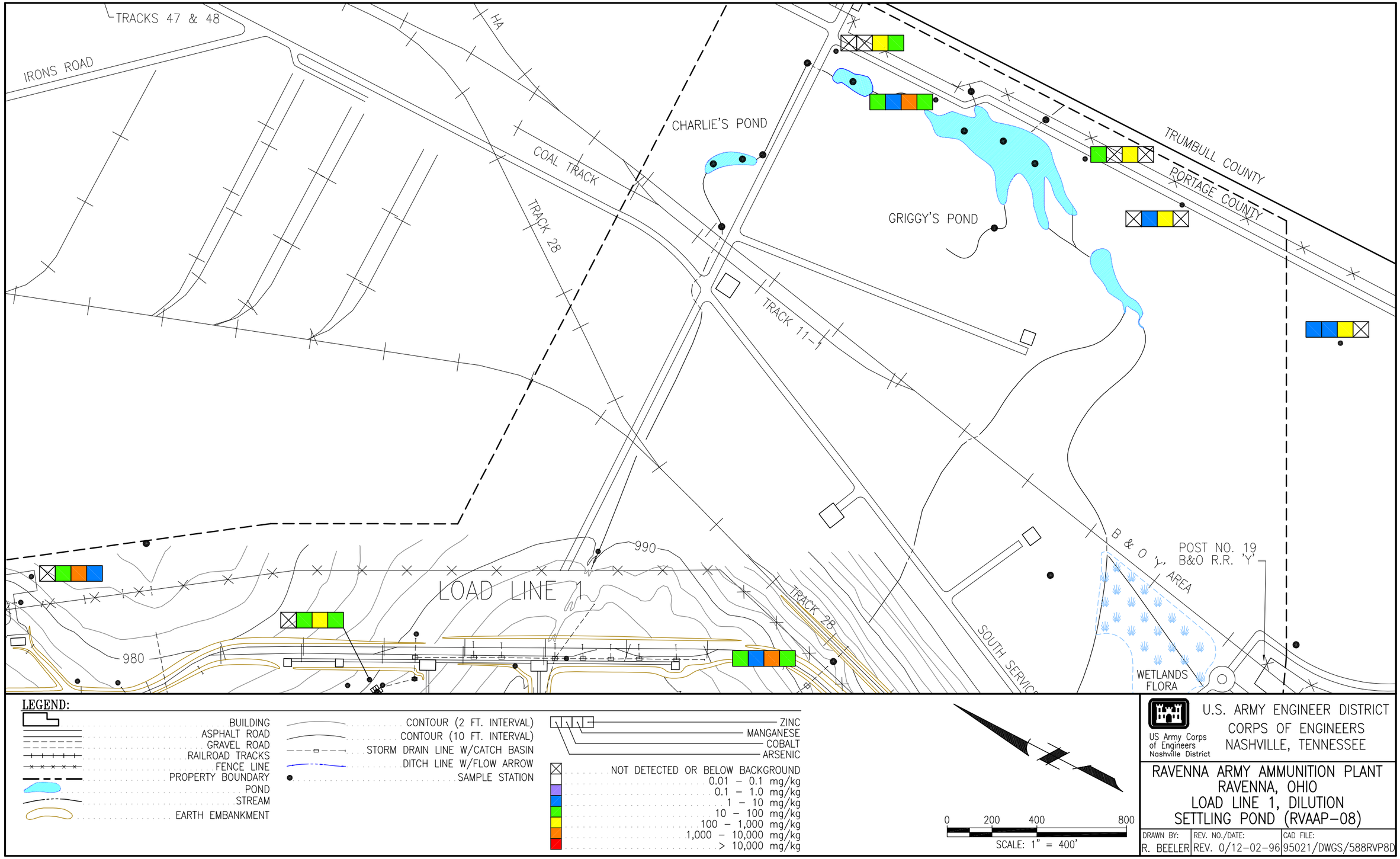


Fig. 4-12. Relative Concentrations of Selected Inorganic Elements in Groundwater at LL1

- Explosives in surface soils do not appear to be mobile even in very high concentrations, as evidenced by the occurrence of highly concentrated explosive immediately next to a sample where no explosives were detected.

- The maximum concentrations in soil of several metals (e.g., arsenic, chromium, and lead) studied during the Phase I RI were encountered at Load Line 1, and are clustered around 13 sampling locations associated with the melt/pour buildings and other features. The presence of some of these analytes in high concentrations does not appear to influence nearby soil samples or drainage ditches significantly. The locations with the highest concentrations of metals are generally the same as those with high concentrations of explosives and/or organic compounds.

- Selenium is widespread in occurrence in Load Line 1 soils, but is generally not found in soils in other AOCs.

- PCBs appear to be most concentrated around the vacuum pump houses at CB-101 and the melt/pour buildings, although isolated high concentrations are found near Buildings CA-14 and CB-2. PAHs appear to follow this pattern of distribution.

Sediments

- Ditch sediments in the concrete settling tanks contain the greatest quantity of explosives. However, the drainage ditches do not appear to contribute much of these explosives to the three streams that drain Load Line 1 to the east, towards Griggy's Pond. Only one sediment sample (LL1sd-049) contained detectable levels of explosives (TNB), and it is located proximal to the load line.

- Load Line 1 does not appear to have caused explosive contamination in sediment that is conveyed along the ditch that drains the facility to the north, toward Charlie's Pond. The source of all explosives in ditch and pond sediments is thought to be from pink wastewater discharged directly from the load line, rather than migration of surface soil contamination.

- Metals are found in all sediment samples but are most abundant and concentrated in LL1sd-028, near Building CB-3A, LL1sd-049, in a drainage ditch that discharges to Griggy's Pond, and LL1sd-056, in Griggy's Pond. LL1sd-024 also contains site-related metals contaminants.

- PCBs in sediment are found in the southern third of the plant, including the drainage ditch where LL1sd-049 is located. Isolated high concentrations are associated with Building CB-3 and the drainage ditch. This suggests the transport of PCBs through erosion of surface soils has not dispersed PCBs across the drainage network.

- There does not appear to be a pattern of association among grain size, TOC, and contaminant concentrations in sediments sampled at this AOC.

Groundwater

- Explosives are not present in groundwater at the perimeter locations sampled.
- All metals present in groundwater, with the exception of essential nutrients, are considered to be site-related.
- Organic compounds are generally not found in groundwater at the perimeter locations sampled, except for LL1wp-068, which exhibits minor contamination with heptachlor. Other compounds detected may not be site-related.

4.5 LOAD LINE 2 AND DILUTION/SETTLING POND

Sampling activity at Load Line 2 included surface soil, ditch and pond sediment, and groundwater sampling. Summaries of the analytical data are provided in **Tables 4.5** (soil and sediment) **and 4.6** (groundwater), and presented in detail in Table 4.19 and in Appendix G.

4.5.1 Surface Soil

Forty-five surface soil locations were sampled and analyzed for explosives. Thirty-seven of these were also analyzed for the 11 process-related inorganic analytes, and 11 were analyzed for the expanded metals suite, cyanide, VOCs, SVOCs, and pesticides/PCBs. The validated, verified data set includes analyses for 44 explosive and site-related metals samples, and 11 expanded metals, cyanide, VOCs, SVOCs, and pesticides/PCBs samples. **Figure 4.13** shows the sample locations and analytical parameters for each sample.

Explosives

Explosive compounds were detected in 26 of the 44 sample locations at Load Line 2. TNT is the most widespread and highly concentrated of the explosives detected. Concentrations of TNT vary from 0.24 mg/kg at LL2ss-061 to 1,200 mg/kg at LL2ss-044; the second-highest concentration of TNT was 470 mg/kg at LL2ss-014. 1,3,5-TNB was present in five samples (LL2ss-001, -010, -044, -062, and -063), at concentrations ranging from 0.32 mg/kg at LL2ss-062 to 160 mg/kg at LL2ss-044. HMX and RDX were both detected in LL2ss-010, -014, -018, and -039; the highest concentrations of these compounds (1,500 mg/kg and 9,800 mg/kg, respectively) were found in LL2ss-014. RDX was also present in LL2ss-012, -028, and -044. **Figures 4.14a and b** shows the distribution and relative concentrations of explosives in surface soils.

Most of the occurrences of explosive compounds in surface soils are associated with melt-pour buildings DB-4 and DB-4A in the center of Load Line 2, or with Building DB-10. The maximum concentrations of all explosives detected come from either LL2ss-014 (at the northwest corner of Building DB-4A) or -044 (near the northeast corner of Building DB-4A). LL2ss-023 (along the road between Building DB-10 and the eastern rail line), LL2ss-038, and LL2ss-039 (both at the explosives offloading areas at Buildings DA-6 and DA-6A) also had detections of TNT, RDX, and HMX. Again, even where concentrations of these compounds

Table 4.5. Load Line 2 Analytical Results (Surface Soil and Sediment)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
SURFACE SOIL									
Cyanide	mg/kg	7/ 11	.		0.1	5		Yes	No Background Data Available
1,3,5-Trinitrobenzene	µg/kg	6/ 44	.		320	160000		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	27/ 44	.		240	12000000		Yes	Detected > 5% of Samples
HMX	µg/kg	4/ 44	.		2800	1500000		Yes	No Background Data Available
RDX	µg/kg	8/ 44	.		400	9800000		Yes	No Background Data Available
Aluminum	mg/kg	44/ 44	15600	2/ 44	3100	24500	20000 - 100000	No	< = 5% Detect Above Background
Antimony	mg/kg	3/ 11	.		0.33	1.2		Yes	No Background Data Available
Arsenic	mg/kg	44/ 44	19.6	2/ 44	4.4	28.4	5.2 - 27.0	No	< = 5% Detect Above Background
Barium	mg/kg	44/ 44	75	14/ 44	19.4	297	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	8/ 11	.		0.28	2.9	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	38/ 44	0.29	30/ 44	0.05	22.7	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	11/ 11	.		921	73500	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	44/ 44	18.7	9/ 44	5.5	116	15.0 - 100.0	Yes	> 5% Detect Above Background
Cobalt	mg/kg	11/ 11	.		3.3	17	7 - 20	Yes	No Background Data Available

Table 4.5 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Copper	mg/kg	11/ 11	.		11.7	53.4	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	11/ 11	.		12200	55500	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	44/ 44	17.9	32/ 44	7	881	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	11/ 11	.		923	8500	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	44/ 44	728	5/ 44	146	4240	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	15/ 44	0.08	2/ 44	0.04	0.94	0.03 - 0.22	No	< = 5% Detect Above Background
Nickel	mg/kg	11/ 11	.		7	41.9	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	11/ 11	.		546	2410	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	22/ 44	2.6	1/ 44	0.37	3.1	<0.1 - 1.2	No	< = 5% Detect Above Background
Silver	mg/kg	2/ 44	0.24	2/ 44	0.47	1.5	0.7	No	< = 5% Detect Above Background
Sodium	mg/kg	11/ 11	.		148	649	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	11/ 11	.		0.81	7.6		Yes	No Background Data Available
Vanadium	mg/kg	11/ 11	.		7.2	24.8	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	44/ 44	72.1	24/ 44	29.8	892	25 - 110	Yes	> 5% Detect Above Background
4,4'-DDD	µg/kg	1/ 11	.		12	12		Yes	No Background Data Available

Table 4.5 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
4,4'-DDE	µg/kg	8/ 11	.		3.9	81		Yes	No Background Data Available
4,4'-DDT	µg/kg	6/ 11	.		6.2	170		Yes	No Background Data Available
Aldrin	µg/kg	2/ 11	.		2.2	24		Yes	No Background Data Available
Alpha chlordane	µg/kg	1/ 11	.		570	570		Yes	No Background Data Available
Aroclor-1254	µg/kg	6/ 11	.		150	2500		Yes	No Background Data Available
Aroclor-1260	µg/kg	2/ 11	.		240	6000		Yes	No Background Data Available
Delta-BHC	µg/kg	1/ 11	.		2.2	2.2		Yes	No Background Data Available
Dieldrin	µg/kg	2/ 11	.		3.1	27		Yes	No Background Data Available
Endrin	µg/kg	1/ 11	.		5.6	5.6		Yes	No Background Data Available
Endrin aldehyde	µg/kg	2/ 11	.		15	120		Yes	No Background Data Available
Gamma chlordane	µg/kg	2/ 11	.		5.6	7.5		Yes	No Background Data Available
Gamma-BHC (lindane)	µg/kg	1/ 11	.		4.8	4.8		Yes	No Background Data Available
Heptachlor epoxide	µg/kg	1/ 11	.		4.2	4.2		Yes	No Background Data Available
2-Methylnaphthalene	µg/kg	1/ 11	.		120	120		Yes	No Background Data Available

Table 4.5 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Acenaphthene	µg/kg	1/ 11	.		740	740		Yes	No Background Data Available
Anthracene	µg/kg	1/ 11	.		1900	1900		Yes	No Background Data Available
Benzo(a)anthracene	µg/kg	7/ 11	.		52	2900		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	7/ 11	.		59	2300		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	6/ 11	.		43	170		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	6/ 11	.		38	1100		Yes	No Background Data Available
Benzo(k)fluoranthene	µg/kg	7/ 11	.		54	3200		Yes	No Background Data Available
Bis(2-ethylhexyl)phthalate	µg/kg	2/ 11	.		86	190		Yes	Detected > 5% of Samples
Butyl benzyl phthalate	µg/kg	2/ 11	.		84	810		Yes	No Background Data Available
Carbazole	µg/kg	1/ 11	.		1200	1200		Yes	No Background Data Available
Chrysene	µg/kg	8/ 11	.		60	2700		Yes	No Background Data Available
Di-n-butyl phthalate	µg/kg	3/ 11	.		68	110		Yes	No Background Data Available
Dibenzo(a,h)anthracene	µg/kg	2/ 11	.		48	720		Yes	No Background Data Available
Dibenzofuran	µg/kg	1/ 11	.		540	540		Yes	No Background Data Available

Table 4.5 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Fluoranthene	µg/kg	9/ 11	.		39	7700		Yes	No Background Data Available
Fluorene	µg/kg	1/ 11	.		910	910		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	5/ 11	.		49	1300		Yes	No Background Data Available
Naphthalene	µg/kg	1/ 11	.		270	270		Yes	No Background Data Available
Phenanthrene	µg/kg	7/ 11	.		56	6400		Yes	No Background Data Available
Pyrene	µg/kg	8/ 11	.		70	5000		Yes	No Background Data Available
Chloroform	µg/kg	4/ 10	.		2	3		Yes	No Background Data Available
Methylene chloride	µg/kg	1/ 10	.		6	6		Yes	No Background Data Available
Toluene	µg/kg	1/ 10	.		5	5		Yes	No Background Data Available
SEDIMENT									
2,4,6-Trinitrotoluene	µg/kg	3/ 11	.		350	860		Yes	Detected > 5% of Samples
Aluminum	mg/kg	11/ 11	15600	2/ 11	3160	18000	20000 - 100000	Yes	> 5% Detect Above Background
Antimony	mg/kg	1/ 3	.		10.2	10.2		Yes	No Background Data Available
Arsenic	mg/kg	11/ 11	19.6	1/ 11	3.5	19.8	5.2 - 27.0	Yes	> 5% Detect Above Background

Table 4.5 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Barium	mg/kg	11/ 11	75	5/ 11	32.4	178	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	3/ 3	.		0.32	1.2	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	5/ 11	0.29	4/ 11	0.26	0.99	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	3/ 3	.		1450	17800	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	11/ 11	18.7	5/ 11	6.2	129	15.0 - 100.0	Yes	> 5% Detect Above Background
Cobalt	mg/kg	3/ 3	.		3.7	12.2	7 - 20	Yes	No Background Data Available
Copper	mg/kg	3/ 3	.		21.6	167	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	3/ 3	.		19800	38800	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	11/ 11	17.9	5/ 11	8.8	85.1	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	3/ 3	.		1890	2740	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	11/ 11	728	1/ 11	74	877	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	6/ 11	0.08	1/ 11	0.05	0.09	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	3/ 3	.		12.1	36	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	3/ 3	.		363	1540	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	7/ 11	2.6	0/ 11	0.38	2.3	<0.1 - 1.2	No	Below Background
Silver	mg/kg	1/ 11	0.24	1/ 11	23.1	23.1	0.7	Yes	> 5% Detect Above Background

Table 4.5 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Sodium	mg/kg	3/ 3	.		173	277	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	3/ 3	.		1	4.2		Yes	No Background Data Available
Vanadium	mg/kg	3/ 3	.		9.3	20.1	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	11/ 11	72.1	5/ 11	35.1	299	25 - 110	Yes	> 5% Detect Above Background
Endrin	µg/kg	1/ 3	.		22	22		Yes	No Background Data Available
2-Methylnaphthalene	µg/kg	1/ 3	.		170	170		Yes	No Background Data Available
Acenaphthene	µg/kg	1/ 3	.		1400	1400		Yes	No Background Data Available
Acenaphthylene	µg/kg	1/ 3	.		310	310		Yes	No Background Data Available
Anthracene	µg/kg	1/ 3	.		2600	2600		Yes	No Background Data Available
Benzo(a)anthracene	µg/kg	2/ 3	.		76	9500		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	1/ 3	.		15000	15000		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	2/ 3	.		130	14000		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	1/ 3	.		11000	11000		Yes	No Background Data Available
Benzo(k)fluoranthene	µg/kg	2/ 3	.		88	19000		Yes	No Background Data Available

Table 4.5 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Carbazole	µg/kg	1/ 3	.		3000	3000		Yes	No Background Data Available
Chrysene	µg/kg	2/ 3	.		110	15000		Yes	No Background Data Available
Di-n-butyl phthalate	µg/kg	1/ 3	.		110	110		Yes	No Background Data Available
Dibenzo(a,h)anthracene	µg/kg	1/ 3	.		5400	5400		Yes	No Background Data Available
Dibenzofuran	µg/kg	1/ 3	.		500	500		Yes	No Background Data Available
Fluoranthene	µg/kg	2/ 3	.		130	30000		Yes	No Background Data Available
Fluorene	µg/kg	1/ 3	.		1100	1100		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	1/ 3	.		9900	9900		Yes	No Background Data Available
Phenanthrene	µg/kg	1/ 3	.		13000	13000		Yes	No Background Data Available
Pyrene	µg/kg	2/ 3	.		82	25000		Yes	No Background Data Available
Acetone	µg/kg	1/ 3	.		99	99		Yes	No Background Data Available
Chloroform	µg/kg	1/ 3	.		3	3		Yes	Detected > 5% of Samples
Toluene	µg/kg	1/ 3	.		6	6		Yes	Detected > 5% of Samples

Table 4.6. Load Line 2 Analytical Results (Groundwater)

Analyte	Frequency of Detects	Minimum Detect (µg/L)	Maximum Detect (µg/L)
GROUNDWATER			
Cyanide	1/ 2	8.7	8.7
2,4-Dinitrotoluene	1/ 2	0.34	0.34
Aluminum	1/ 2	27.4	27.4
Arsenic	1/ 2	2.6	2.6
Barium	2/ 2	13.3	18.7
Calcium	2/ 2	28800	34600
Cobalt	2/ 2	0.87	14.7
Iron	1/ 2	26.4	26.4
Magnesium	2/ 2	7510	9900
Manganese	2/ 2	106	642
Nickel	2/ 2	3.8	17.9
Potassium	2/ 2	831	1470
Sodium	2/ 2	3050	6200
Zinc	2/ 2	7.8	8.4
Bis(2-ethylhexyl)phthalate	1/ 2	2	2

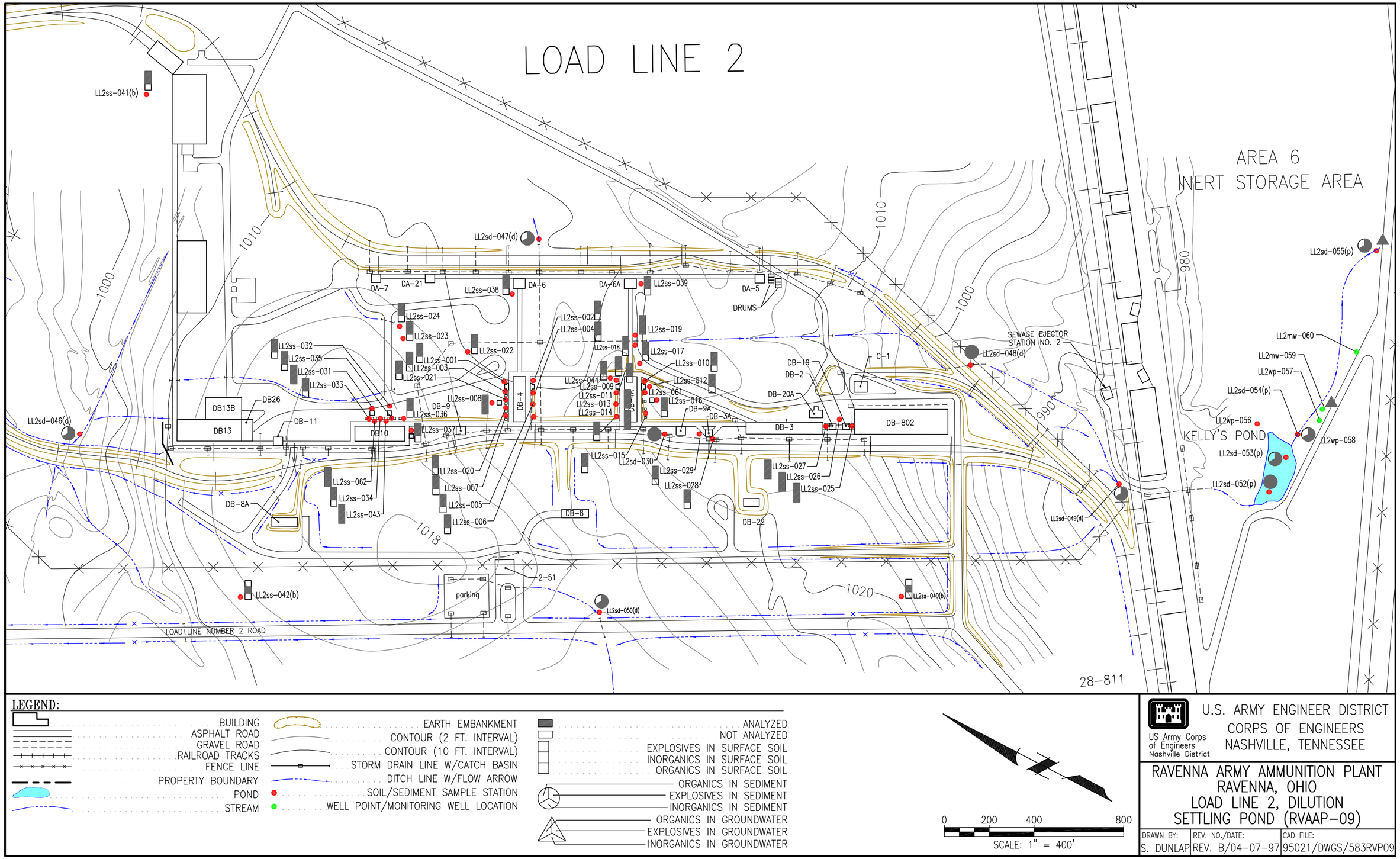


Fig. 4-13. LL2 Sample Locations and Analytical Parameters

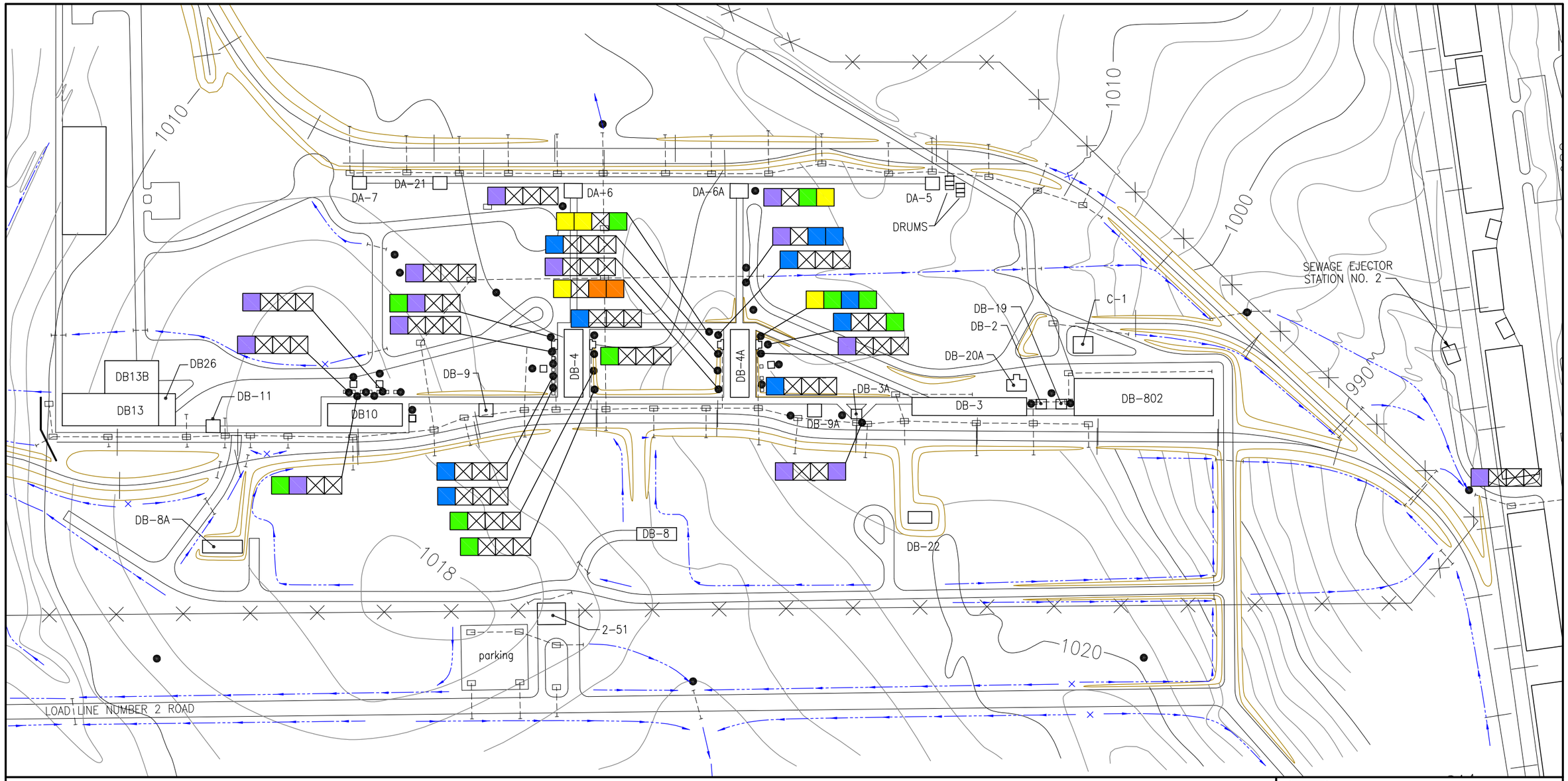


Fig. 4-14a. Relative Concentrations of Explosive Compounds in Surface Soil and Sediment at LL2

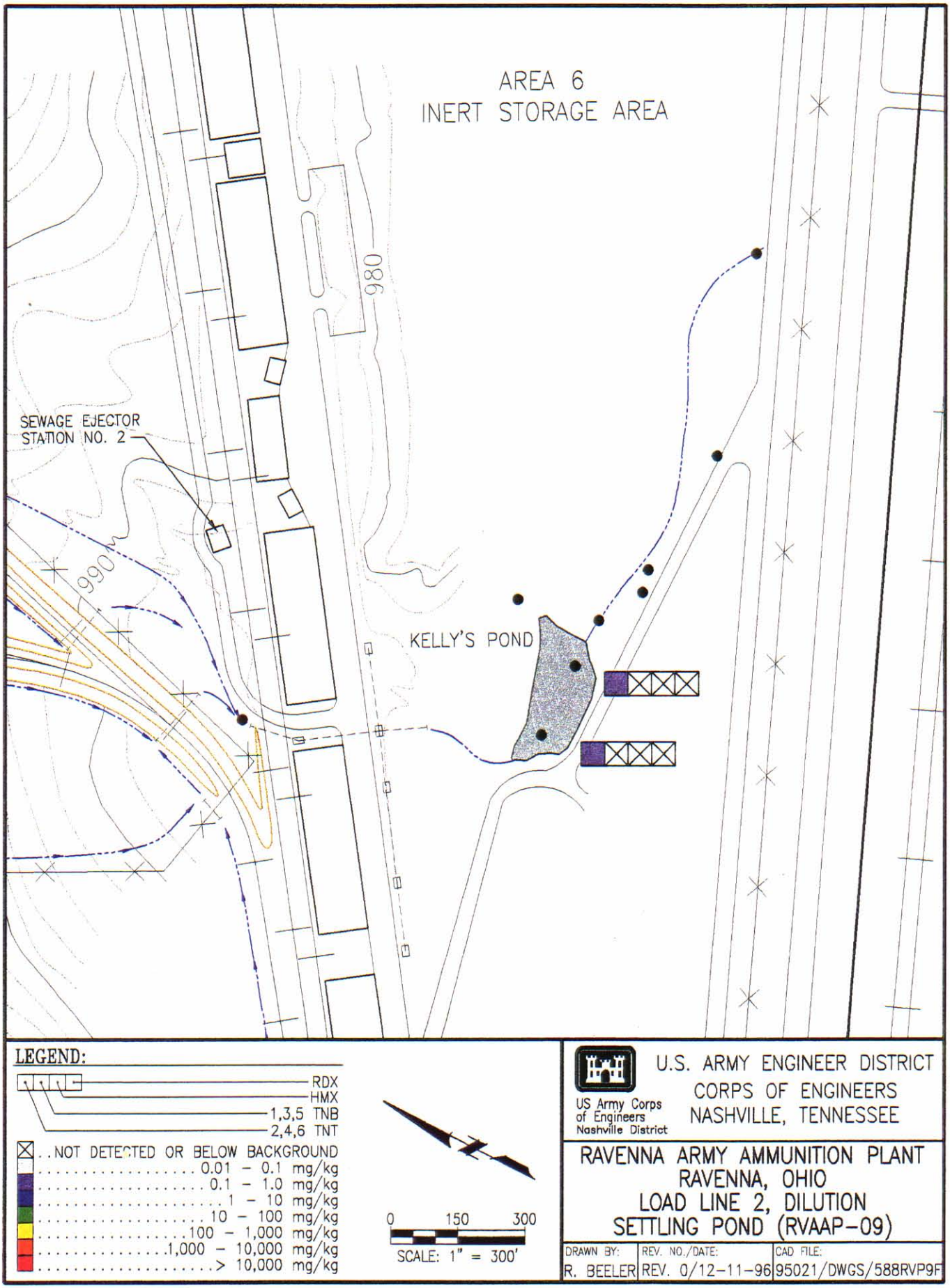


Figure 4.14b. Relative Concentrations of Explosive Compounds in Surface Soil and Sediment at Load Line 2

are high, they do not appear to be mobile in the surface soils or to influence sediment chemistry in drainage ditches.

Seventeen surface soils were found to have no detectable quantities of explosives. Some of these samples are located adjacent to those where high concentrations of an explosive were found. For example, LL2ss-004 with 54 mg/kg TNT is located next to LL2ss-022, with no detectable quantities. Similarly, LL2ss-031 and -032, located approximately 30 m (100 feet) northeast of Building DB-10 along the approach road, bear no indications of explosives contamination that is apparent outside Building DB-10. All surface soils south of the melt/pour buildings had no detectable quantities of explosives.

Inorganic Analytes

All 23 inorganic elements and cyanide were detected in surface soils at Load Line 2. Aluminum, arsenic, mercury, selenium, and silver are not considered site-related because of their occurrence above background in fewer than 5 percent of the samples analyzed. The 14 non-nutrient analytes remaining (six process-related metals, seven non-nutrient metals from the expanded analyte suite, and cyanide) were either present above background in more than 5 percent of the samples, or no background criteria were available. The maximum values for lead and manganese fall above the maximum concentrations of USGS Ohio reference values; all others fall within or below the range of reference values, or no reference value is available (Table 4.5).

The process-related metals barium, cadmium, chromium, lead, manganese, and zinc were detected above the background criteria in at least 5 percent of the samples. The distribution and relative concentrations of cadmium, chromium, lead, and manganese at Load Line 2 are shown on **Figures 4.15a and b**. Lead, cadmium, and zinc were the most frequently detected above background criteria (Table 4.5). Lead was detected at concentrations ranging from 7 to 881 mg/kg, exceeding background (17.9 mg/kg) in 32 of 44 samples, and also exceeded the maximum USGS reference value (30 mg/kg). Cadmium was detected at concentrations from .05 to 22.7 mg/kg, occurring above the background criteria of 0.29 mg/kg in 30 samples (Figures 4.15a and b). Concentrations of cadmium also exceeded the USGS reference value maximum of 2 mg/kg. Zinc was detected from 29.8 to 892 mg/kg, and exceeded background (72.1 mg/kg) in 24 samples. Zinc also exceeded the USGS maximum reference value (110 mg/kg).

Barium was detected at concentrations from 19.4 mg/kg to 297 mg/kg, and occurred above the background criteria of 75 mg/kg in 14 samples. All detections above background were below the USGS range of reference values (300 to 700 mg/kg). Chromium was detected at concentrations ranging from 5.5 to 116 mg/kg, exceeding background (18.7 mg/kg) in nine samples (Figures 4.15a and b). The USGS maximum reference value for chromium was exceeded. Manganese was detected at concentrations from 146 to 4240 mg/kg, and was present above its background criteria (728 mg/kg) in five samples (Figure 4.15a and b). Manganese concentrations also exceeded the maximum USGS reference value (1000 mg/kg).

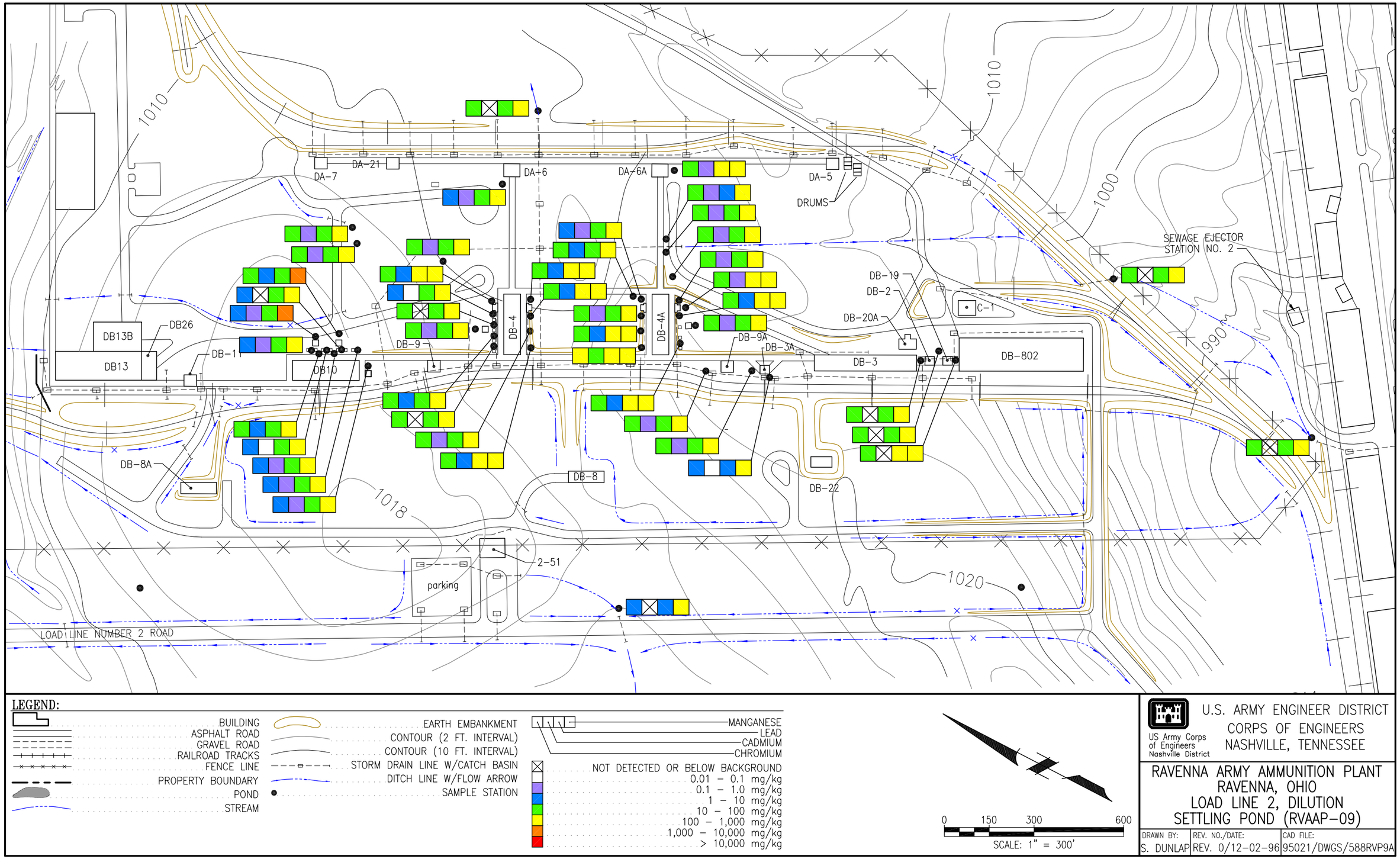


Fig. 4-15a. Relative Concentrations of Selected Metals in Surface Soil and Sediment at LL2

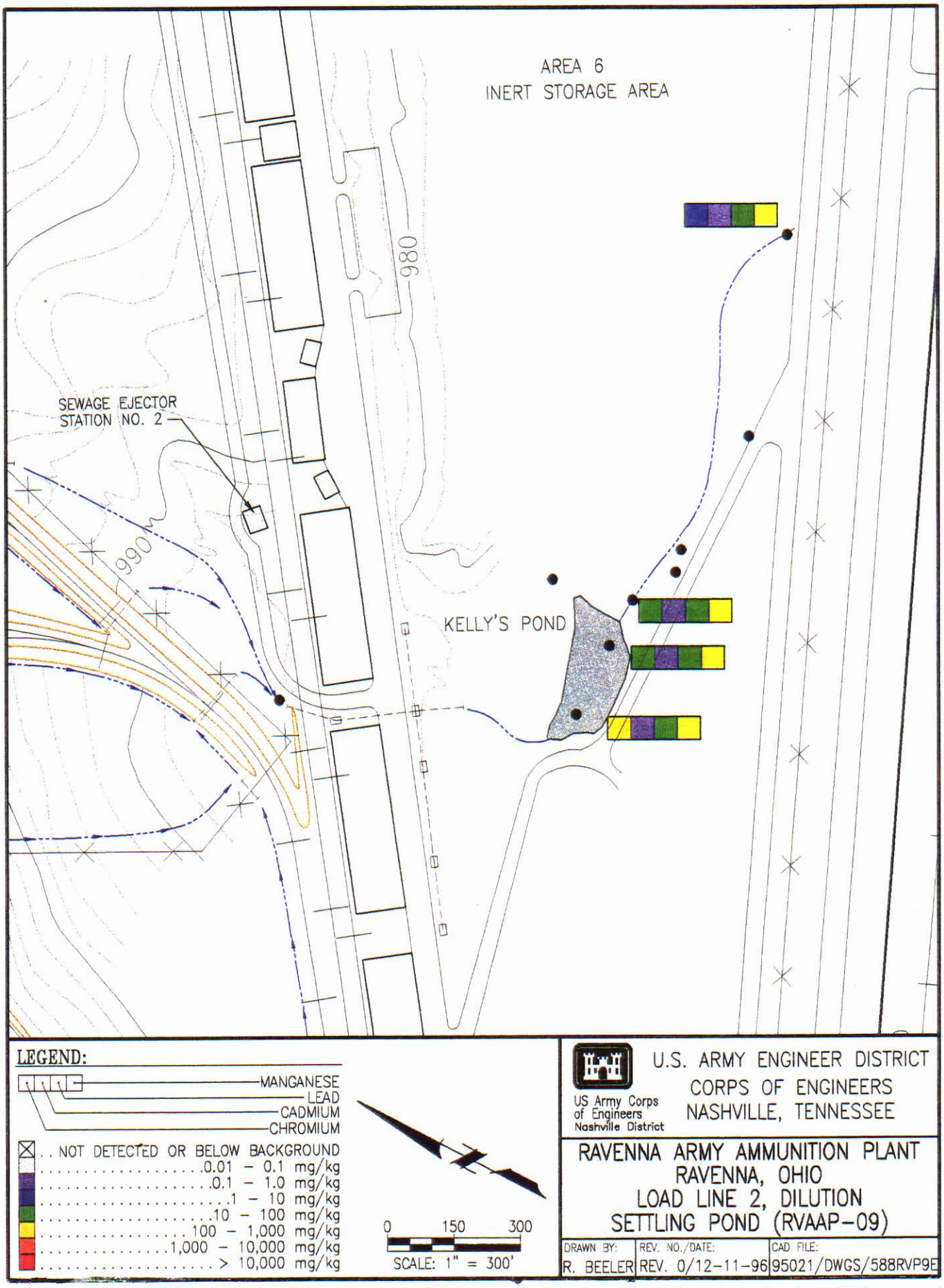


Figure 4.15b. Relative Concentrations of Selected Metals (Chromium, Cadmium, Lead, and Manganese) in Surface Soil and Sediment at Load Line 2

The seven metals from the expanded analyte list that were detected in at least one sample include cobalt, copper, nickel, thallium, and vanadium, each detected in 11 of 11 samples, and beryllium, detected in 8 samples, and antimony, detected three times. Cyanide was detected in 7 of 11 samples. Table 4.5 gives the range of concentrations detected for these analytes.

The highest concentrations of the 13 site-related metals are found in samples surrounding the melt/pour buildings DB-4 and DB-4A, east of DB-10, and the connector between Building DB-4A and DA-6A. The maximum concentrations of cadmium, chromium, lead, and zinc were detected in Load Line 2 at LL2ss-014, located at the northwest corner of Building DB-4A. The maximum concentration detected for chromium and leads were two to three times greater than the next highest values detected. The second- and third-highest detections of manganese and antimony, respectively, as well as the maximum values for the expanded suite metals, beryllium and thallium, were detected at LL2ss-03, located between the road and vacuum pump house east of Building DB-10. LL2ss-061 is also the locus of maximum or high concentrations for several analytes, including process-related metals, barium and cadmium, as well as cobalt, nickel, and vanadium.

Organic Compounds

Organic vapors were not detected with field instruments during sampling in either headspace or breathing zone gases.

Three VOCs were detected at least once in the ten samples analyzed for VOCs, each at low concentrations of 0.003 to 0.006 mg/kg. Chloroform was detected in four samples; methylene chloride and toluene were each detected once. SVOCs, including 16 PAHs and two phthalate esters, were detected in 8 of 11 samples. The highest concentration of any PAH was 7.7 mg/kg of fluoranthene at LL2ss-008. This sampling point, located adjacent to a vacuum pump house near an exhaust vent north of Building DB-4, was the locus of the maximum concentrations for the other 16 PAHs detected in Load Line 2 soils. PAHs range in concentration from 0.038 mg/kg benzo(g,h,i)perylene at LL2ss-031 to 6.4 mg/kg phenanthrene at LL2ss-008. **Figure 4.16** shows the relative concentrations of total PAHs and total carcinogenic PAHs in Load Line 2 surface soils. Carcinogenic PAHs include benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene (see Section 5).

Nine of the eleven samples (all except LL2ss-019 and 031) contained pesticides and/or PCBs. Fourteen such compounds were detected. 4,4'-DDE was the most commonly occurring compound; it was found in eight samples, in concentrations of 0.039 to 0.081 mg/kg, which occurred at LL2ss-062. Six samples contained Aroclor-1254, with the maximum value of 2.5 mg/kg at LL2ss-061. Aroclor-1260 was detected in LL2ss-062 and -063 at 6.0 and 0.24 mg/kg, respectively. All other pesticide/PCB compounds were detected either once or twice; LL2ss-061 and -062 appear to possess the largest variety of these organic contaminants, generally in low concentrations. These samples were collected adjacent to vacuum pump houses where PCB-laden oils may have been used. PCBs, including Aroclor-1254, are also present in LL2ss-025, -026, and -027, between Buildings DB-3 and DB-802 on the south end of Load Line 2. **Figure 4.17** shows the distribution and concentrations of pesticides/PCBs in Load Line 2 surface soils.

No detectable quantities of organic compounds were found in LL2ss-019 or -031.

4.5.2 Sediment

Eleven ditch and pond sediment samples were collected at Load Line 2 for analysis of the 11 process-related inorganic compounds and explosives. Three of these samples received analyses for the expanded metals suite, VOCs, SVOCs, and pesticides/PCBs. Geotechnical grain size distribution curves are presented in Appendix G.4. TOC ranged from 2,960 mg/kg in LL2sd-049 to 30,800 mg/kg in LL2sd-052.

Explosives

Explosive compounds were detected in three of the 11 samples collected. TNT was detected at 0.86, 0.7, and 0.35 mg/kg, respectively, in samples LL2sd-049, -052, and-053. LL2sd-049 is located in the main drainage ditch that exits the load line to the south, upgradient from Kelly's Pond; the other two samples were collected in Kelly's Pond. LL2sd-048, upstream from LL2sd-049, had no detectable quantities of explosives. No explosives were detected in the ditches west or north of the plant area, or in the pond effluent at LL2sd-054. Explosive contamination in ditch and pond sediments is likely from pink wastewater effluent directly from the load line and not due to migration of contamination from surface soil.

Figures 4.14a and b depict the distribution and relative concentrations of these compounds in sediment.

Inorganic Analytes

All 23 inorganic elements were detected in at least one sediment sample from Load Line 2. Cyanide was not detected in any of the 11 sediment samples collected. Selenium was detected at concentrations below the background criteria. The remaining 17 elements were either detected at concentrations exceeding the background criteria, or no background is available (Table 4.6), and they are considered to be site-related chemicals. Most of the 17 site-related elements occurred at concentrations within or below the range of USGS Ohio reference values; chromium, copper, lead, silver, and zinc were found in concentrations higher than the maximum USGS reference value, and no published USGS values are available for antimony or thallium.

All of the process-related metals except selenium were detected at concentrations exceeding background in at least 5 percent of the samples (Table 4.5). Figures 4.15a and b illustrates the distribution and relative concentrations of selected metals (cadmium, chromium, lead, and manganese). Barium, chromium, lead, and zinc were the most frequently detected at concentrations exceeding the site background values. Barium was detected at concentrations ranging from 32.4 to 178 mg/kg, exceeding the site background (75 mg/kg) in 5 samples. The maximum detected concentration is below the range of USGS reference values for barium (300 to 700 mg/kg). Chromium was detected at concentrations ranging from 6.2 to 129 mg/kg, exceeding the site background (18.7 mg/kg) in five samples. The maximum detected concentration is slightly above the maximum USGS reference value (100 mg/kg). Lead was detected at concentrations from 8.8 to 85.1 mg/kg, occurring above the background

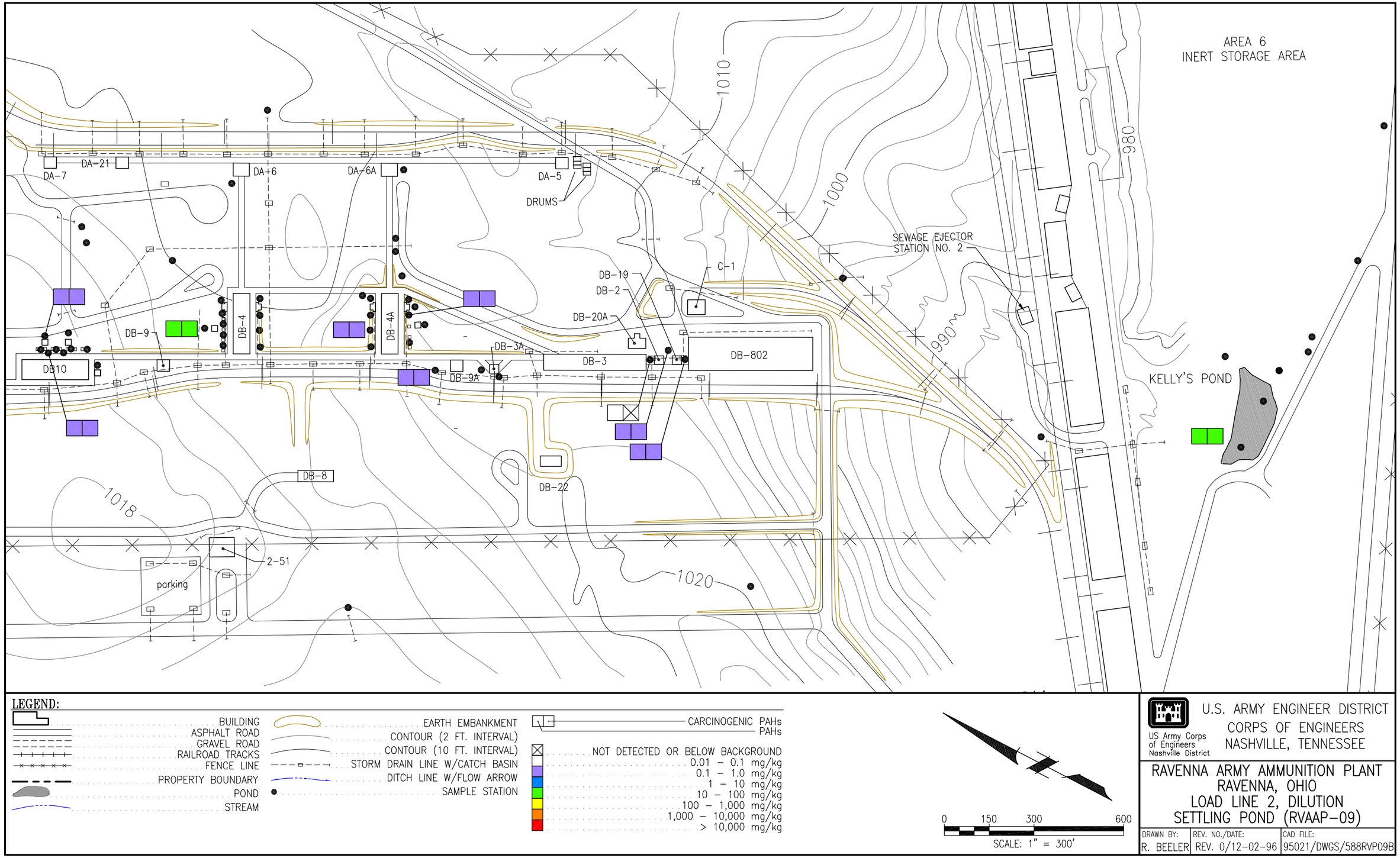


Fig. 4-16. Relative Concentrations of Total PAHs and Total Carcinogenic PAHs in surface soil at LL2

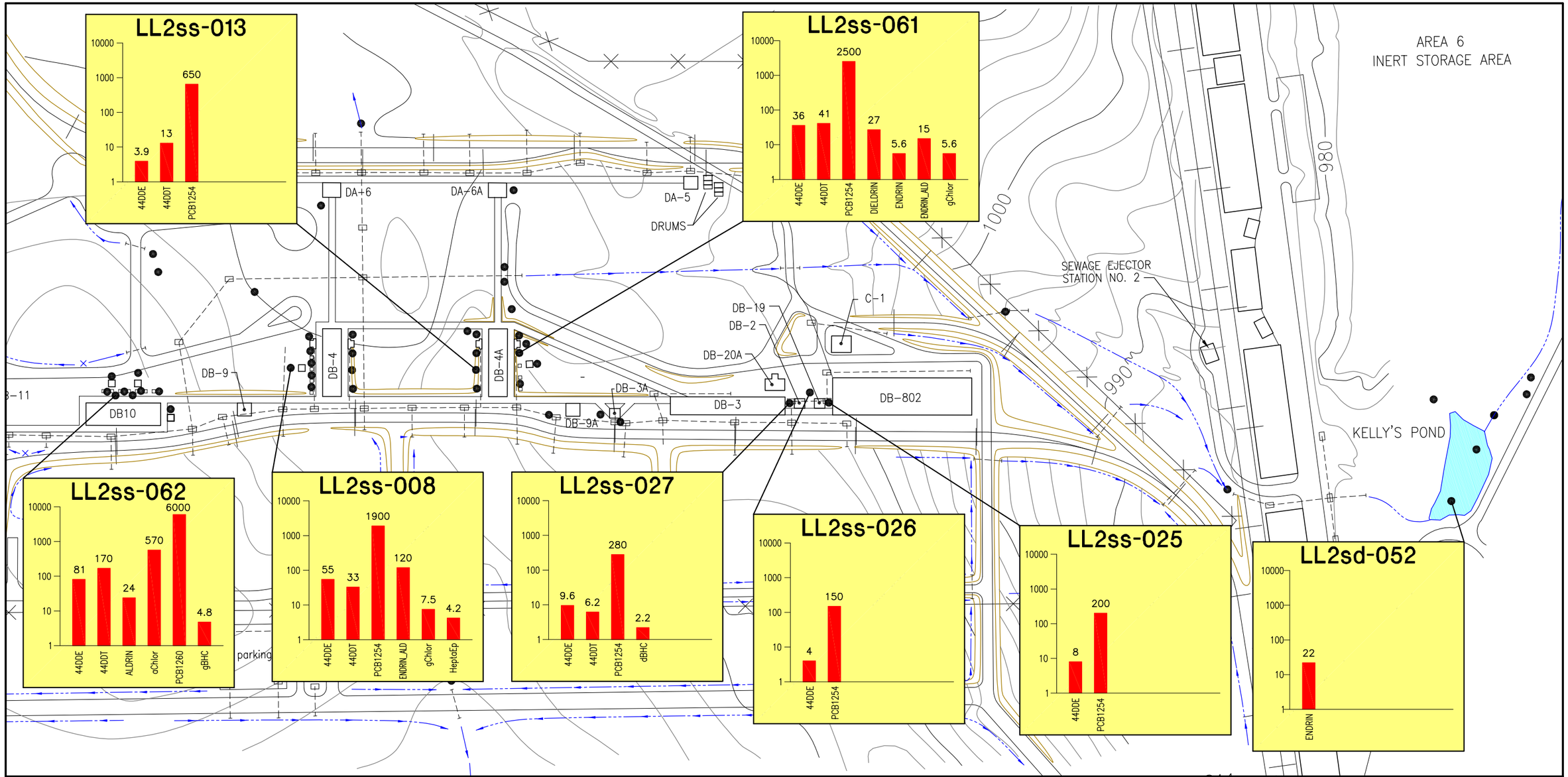


Fig. 4-17. Relative Concentrations of PCBs and Pesticides in Surface Soil and Sediment at LL2

criteria (17.9 mg/kg) in five samples. Lead also exceeded the maximum range of USGS reference values (30 mg/kg). Zinc was detected from 35.1 to 299 mg/kg, with five samples exceeding the site background (72.1 mg/kg). Zinc was also present above the USGS maximum reference level (110 mg/kg).

Cadmium was detected in five samples with concentrations ranging from 0.26 to 0.99 mg/kg, exceeding the site background (0.29) in four samples. The maximum cadmium concentration was within the range of USGS reference values (1 to 2 mg/kg). Aluminum was detected at concentrations ranging from 3,160 to 18000 mg/kg, occurring above the background criteria (15,600 mg/kg) in two samples. The maximum concentrations were below the USGS reference value range (20,000 to 100,000 mg/kg). The remaining process-related metals (arsenic, manganese, mercury, and silver) were each detected above the background criteria in one sample, with concentrations shown on Table 4.5. Silver was the only one of the four to exceed the maximum USGS reference value.

Seven non-nutrient elements from the expanded analyte list were also detected in sediment samples. Beryllium, cobalt, copper, nickel, thallium, and vanadium were each detected in all three samples analyzed for expanded metals; and antimony was detected in two samples. Cyanide was detected in two of three samples. Table 4.5 gives the range of detected values for these analytes.

The maximum concentrations of many of the inorganic analytes were found in LL2sd-048 and -052. LL2sd-048 is located in a southwestward-draining ditch immediately inside the fence line at the south end of Load Line 2. Arsenic as well as beryllium, cobalt, nickel, and vanadium were found at their highest concentrations in this sample. LL2sd-052 is located in Kelly's Pond. The pond sediments appear to have the greatest variety of inorganic chemicals and the highest concentrations of the process-related metals lead, zinc, and mercury, in Load Line 2. Settling of inorganics and their accumulation in pond sediments is apparently responsible for the observed lower concentrations of these metals in LL2sd-55, located in the pond effluent ditch. This sample had the lowest values for aluminum, barium, chromium, and mercury, and the second-lowest concentration of lead, measured in Load Line 2 sediments. Manganese, however, was present at the third-highest concentration in LL2sd-055.

LL2sd-030, located on the north side of Building DB-9A, also exhibits some of the higher concentrations of process-related metal cadmium, plus cobalt, nickel, thallium, and vanadium measured in Load Line 2 sediments. The drainage relationship of this sample to the main ditches that feed Kelly's Pond is unknown.

Comparison of analytical results from ditch sediment samples from the east and west sides of Load Line 2 (LL2sd-047 and LL2sd-051) shows that concentrations of process-related metals aluminum, arsenic, chromium, lead, manganese, and mercury are higher at LL2sd-047 than at LL2sd-051. Both ditches drain off of Load Line 2. The northwestward-draining ditch at the northwest corner of the load line (where LL2ss-046 is located) does not appear to differ substantially from the ditch at the south end (LL2sd-048) in the abundance or concentrations of inorganic analytes found in sediments.

Organic Compounds

Three samples received the full suite of analyses for organic compounds: LL2sd-030, -052, and -053. Organic contaminant chemistry in sediments is different from that in surface soils, with far fewer detections of pesticides and the majority of analytes detected consisting of PAHs in LL2sd-052. High concentrations of several PAHs were observed in this sample (e.g., 25 mg/kg pyrene; 30 mg/kg fluoranthene; 19 mg/kg benzo(k)fluoranthene). LL2sd-030 had many of the same PAHs, but in much lower concentrations. Acetone, chloroform, and toluene were each detected once, in concentrations ranging from 0.003 to 0.99 mg/kg (Table 4.5). Endrin was the only PCB or pesticide detected, at 0.022 mg/kg at LL2sd-052 in Kelly's Pond. LL2sd-053, located in Kelly's Pond, had no detectable quantities of either SVOCs or pesticides/PCBs (see Figures 4.16 and 4.17). Thus it appears that these compounds have remained relatively immobile in pond sediments at LL2sd-052.

4.5.3 Groundwater

Groundwater was collected from two monitoring wells downgradient from Kelly's Pond (LL2mw-059 and LL2mw-060) and subjected to the full suite of analyses. Well points installed during Phase I did not produce sufficient water to be sampled. The analytical results for monitoring well samples are summarized in Table 4.6, and presented in their entirety in Appendix G.

Explosives

The only explosive detected in Load Line 2 groundwater was TNT at 0.34 μg/L in LL2mw-059, immediately south of Kelly's Pond. No explosives were found at LL2mw-060.

Inorganic Analytes

Eleven metals and cyanide were detected in Load Line 2 groundwater. No background criteria were available for groundwater. The non-nutrient analytes aluminum, arsenic, barium, cobalt, manganese, nickel, zinc, and cyanide are considered to be SRCs based on their occurrence above detection limits.

Aluminum was detected in one of the two samples (27.40 μg/L at LL2mw-060); all others were present in both. The maximum concentration of zinc was detected in LL2mw-060 (8.4 μg/L), which is less than 1 μg/L above the concentration at LL2mw-059. The highest values of cobalt and manganese were found in LL2mw-059. There is 15 times more cobalt and six times more manganese in this groundwater sample than in LL2mw-060.

Organic Compounds

One organic compound, bis(2-ethylhexyl)phthalate, was detected in LL2mw-060, at 2 μg/kg. No other organic compounds were present above detection limits in Load Line 2 groundwater samples.

4.5.4 Discussion/Summary of Results

The chemical analyses discussed above, and the interpretations thereof, are summarized as follows.

Surface Soil

- High concentrations of explosives were found in soils around the melt/pour buildings, Building DB-10, and Buildings DA-6 and DA-6A. Explosives contamination may be highly localized around vacuum pumps, doorways, or drains. Explosives contamination does not appear to be present in soils south of Building DB-9A.

- Site-related metals reach their highest concentrations around the melt/pour buildings and Building DB-10. Chromium, lead, and manganese are commonly present in very high concentrations.

- PAHs occur in high concentrations in surface soils, apparently following the pattern of distribution of explosives around the melt/pour buildings and Building DB-10.

- PCBs are present in soils east of Building DB-10, south of DB-4A, and immediately south of Building DB-3. PCB contamination also appears to be highly localized around vacuum pumps and Buildings DB-2 and DB-19.

Sediments

- Two ditch samples appear to be impacted by explosives contamination: LL2sd-028, near Building DB-9A, and LL2sd-049, in the ditch that exits the load line and discharges to Kelly's Pond. Samples from the pond also contain TNT. The source of this contamination is thought to be from pink wastewater effluent directly from the load line rather than migration of surface soil contamination. However, storm drains, drainage ditches on the north and west sides of the load line, and the outfall from Kelly's Pond do not possess explosives contamination at the locations sampled.

- Inorganic analytes are most abundant and most concentrated in sediments from Kelly's Pond and in the easternmost ditch that discharges to the pond. Cadmium, chromium, copper, and lead are SRCs found in these sediments. A drainage ditch near Building DB-9A also contains a number of metals at high concentrations.

- High concentrations of PAHs and one PCB were found in one sample from Kelly's Pond. Other SVOCs and VOCs are minor constituents in LL2sd-030, located south of Building DB-3A.

- There does not appear to be a pattern of association among grain size, TOC, and contaminant concentrations in sediments sampled at this AOC.