Groundwater

- Overall, explosives contamination from Load Line 2 and Kelly's Pond do not appear to have migrated to groundwater at the perimeter of the AOC, although TNT was detected at 0.34 μg/L at LL2mw-059.

- Site-related inorganic analytes detected in groundwater are limited to aluminum, arsenic, barium, cobalt, iron, manganese, nickel, and zinc, in addition to cyanide. This assemblage of analytes differs from the most concentrated analytes detected in pond sediments upgradient from the monitoring wells. Kelly's Pond would be the most immediate upgradient source of contaminants to these wells, therefore, the source of inorganic contamination noted in groundwater may not be Kelly's Pond.

- Site-related organic compounds found in solid media do not appear to be present in groundwater in the perimeter locations sampled.

4.6 LOAD LINE 3

The Phase I sampling at Load Line 3 included surface soil and sediment sampling of areas within the AOC. The analytical data are summarized in **Table 4.7**, and presented in detail in Table 4.20 and in Appendix G.

4.6.1 Surface Soil

Thirty-nine surface soil samples were collected at Load Line 3, and 37 of these were analyzed for explosives. Thirty-two samples were analyzed for the 11 process-related metals, and nine samples received analysis for the expanded metals suite, cyanide, SVOCs, and pesticides/PCBs. Eight samples were analyzed for VOCs. **Figure 4.18** shows the location of the samples and analytical parameters for each sample.

Explosives

Explosive compounds were detected in 27 of the 37 samples collected. TNT was detected in each of these samples, and occurred in the highest concentrations of any load line. In seven of the samples (LL3ss-002, -009, -011, -012, -013, -026, and -034), TNT concentrations were 10 mg/kg or greater. Many of these samples are located around the melt/pour buildings EB-4 and EB-4A. The maximum concentration detected was 390,000 mg/kg at LL3ss-034, located near a vacuum pump housing east of Building EB-10 (**Figure 4.19**).

Seven surface soil samples (LL3ss-004, -009, -011, -012, -013, -026, and-034) also had detectable quantities of 1,3,5-DNT. Concentrations ranged from 0.253 mg/kg at LL3ss-026 to 110 mg/kg at LL3ss-034. With the exception of LL3ss-004, located immediately north of melt/pour building EB-4, all of these samples also had high concentrations of TNT.

Table 4.7. Load Line 3 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	6/ 9	.		0.12	0.38		Yes	No Background Data Available
1,3,5-Trinitrobenzene	µg/kg	7/ 37	.		253	110000		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	26/ 37	.		142	390000000		Yes	Detects > 5% of Samples
HMX	µg/kg	1/ 37	.		14000	14000		Yes	No Background Data Available
RDX	µg/kg	1/ 37	.		10000	10000		Yes	No Background Data Available
Aluminum	mg/kg	37/ 37	15600	1/ 37	3720	23900	20000 - 100000	No	<= 5% Detect Above Background
Antimony	mg/kg	4/ 9	.		3.4	30		Yes	No Background Data Available
Arsenic	mg/kg	37/ 37	19.6	2/ 37	7	23.2	5.2 - 27.0	Yes	> 5% Detect Above Background
Barium	mg/kg	37/ 37	75	10/ 37	16.1	447	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	9/ 9	.		0.31	1.2	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	36/ 37	0.29	24/ 37	0.06	4.1	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	9/ 9	.		772	13500	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	37/ 37	18.7	4/ 37	4.9	150	15.0 - 100.0	Yes	> 5% Detect Above Background
Cobalt	mg/kg	9/ 9	.		3.7	8.7	7 - 20	Yes	No Background Data Available

Table 4.7 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Copper	mg/kg	9/ 9	.		8.9	99.4	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	9/ 9	.		14900	26100	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	37/ 37	17.9	27/ 37	11.1	2620	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	9/ 9	.		1140	3330	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	37/ 37	728	8/ 37	75.3	4800	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	8/ 37	0.08	3/ 37	0.04	0.2	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	9/ 9	.		7	21.9	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	9/ 9	.		468	967	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	35/ 37	2.6	1/ 37	0.35	4.1	<0.1 - 1.2	No	< = 5% Detect Above Background
Silver	mg/kg	5/ 37	0.24	5/ 37	0.28	2.4	0.7	Yes	> 5% Detect Above Background
Sodium	mg/kg	9/ 9	.		137	232	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	9/ 9	.		0.78	3.5		Yes	No Background Data Available
Vanadium	mg/kg	9/ 9	.		9.9	22.5	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	37/ 37	72.1	19/ 37	30.9	626	25 - 110	Yes	> 5% Detect Above Background
4,4'-DDE	µg/kg	2/ 9	.		3.8	12		Yes	No Background Data Available
4,4'-DDT	µg/kg	2/ 9	.		11	77		Yes	No Background Data Available

Table 4.7 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Alpha chlordane	µg/kg	1/ 9	.		590	590		Yes	No Background Data Available
Aroclor-1254	µg/kg	3/ 9	.		170	21000		Yes	No Background Data Available
Beta-BHC	µg/kg	1/ 9	.		30	30		Yes	No Background Data Available
Endosulfan II	µg/kg	1/ 9	.		4.5	4.5		Yes	No Background Data Available
Endrin	µg/kg	2/ 9	.		10	3200		Yes	No Background Data Available
Endrin aldehyde	µg/kg	1/ 9	.		4.8	4.8		Yes	No Background Data Available
Gamma chlordane	µg/kg	1/ 9	.		110	110		Yes	No Background Data Available
Heptachlor	µg/kg	1/ 9	.		1.6	1.6		Yes	No Background Data Available
Heptachlor epoxide	µg/kg	1/ 9	.		94	94		Yes	No Background Data Available
2-Methylnaphthalene	µg/kg	1/ 9	.		48	48		Yes	No Background Data Available
Acenaphthene	µg/kg	2/ 9	.		66	95		Yes	No Background Data Available
Acenaphthylene	µg/kg	2/ 9	.		54	58		Yes	No Background Data Available
Anthracene	µg/kg	2/ 9	.		160	320		Yes	No Background Data Available
Benzo(a)anthracene	µg/kg	4/ 9	.		39	1200		Yes	No Background Data Available

Table 4.7 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Benzo(a)pyrene	µg/kg	4/ 9	.		36	1000		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	5/ 9	.		35	1100		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	2/ 9	.		440	610		Yes	No Background Data Available
Benzo(k)fluoranthene	µg/kg	6/ 9	.		38	1000		Yes	No Background Data Available
Bis(2-ethylhexyl)phthalate	µg/kg	3/ 9	.		98	440		Yes	Detected > 5% of Samples
Butyl benzyl phthalate	µg/kg	1/ 9	.		88	88		Yes	No Background Data Available
Carbazole	µg/kg	2/ 9	.		110	250		Yes	No Background Data Available
Chrysene	µg/kg	5/ 9	.		45	1500		Yes	No Background Data Available
Di-n-butyl phthalate	µg/kg	2/ 9	.		110	190		Yes	No Background Data Available
Dibenzo(a,h)anthracene	µg/kg	2/ 9	.		150	250		Yes	No Background Data Available
Dibenzofuran	µg/kg	1/ 9	.		57	57		Yes	No Background Data Available
Fluoranthene	µg/kg	6/ 9	.		51	2200		Yes	No Background Data Available
Fluorene	µg/kg	2/ 9	.		58	94		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	2/ 9	.		460	590		Yes	No Background Data Available

Table 4.7 (continued)

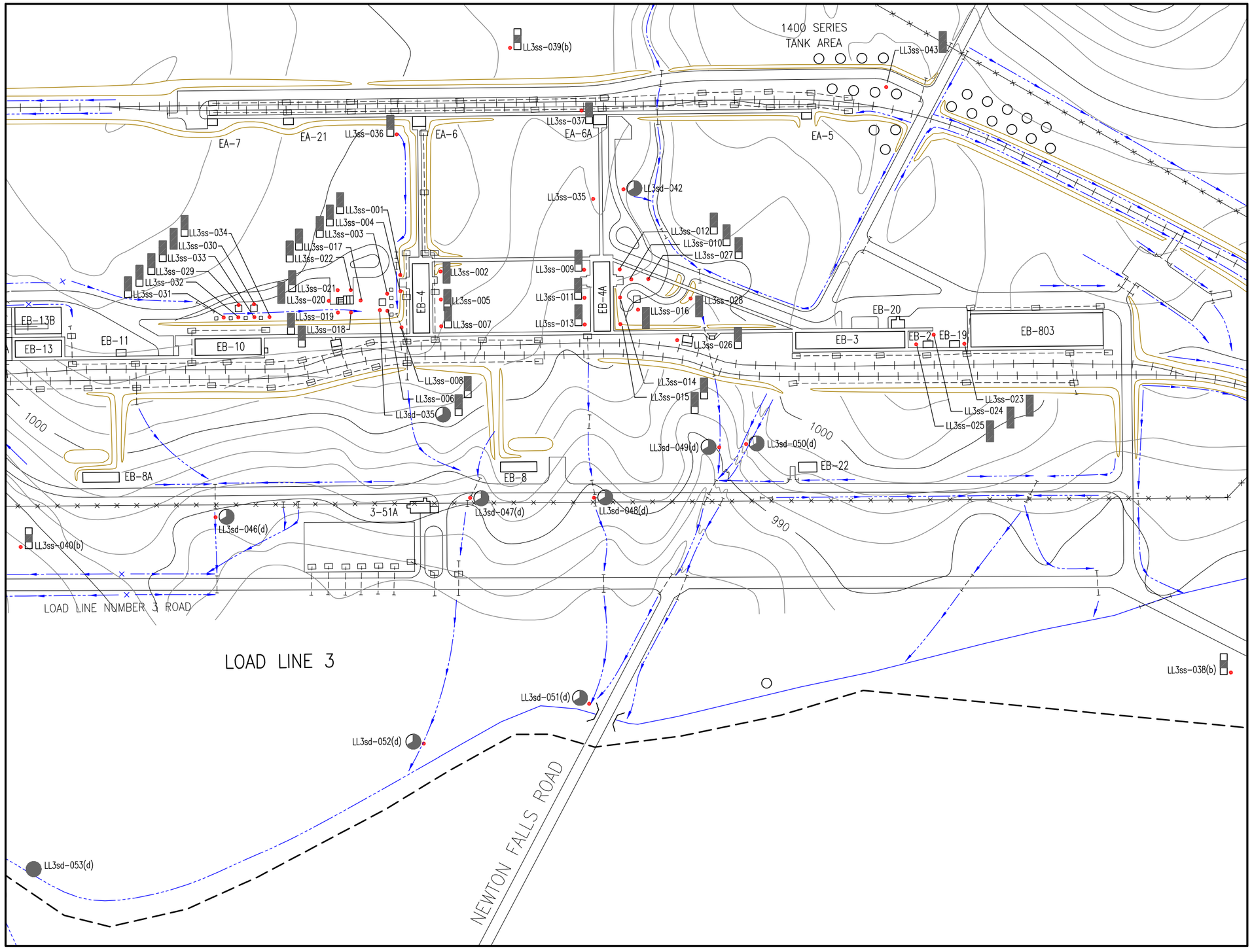
Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Naphthalene	µg/kg	2/ 9	.		43	52		Yes	No Background Data Available
Phenanthrene	µg/kg	4/ 9	.		72	1200		Yes	No Background Data Available
Pyrene	µg/kg	5/ 9	.		44	1800		Yes	No Background Data Available
Methylene chloride	µg/kg	2/ 8	.		2	4		Yes	Detected > 5% of Samples
Toluene	µg/kg	2/ 8	.		14	38		Yes	Detected > 5% of Samples
SEDIMENT									
2,4,6-Trinitrotoluene	µg/kg	6/ 10	.		450	4600		Yes	Detected > 5% of Samples
Aluminum	mg/kg	10/ 10	15600	0/ 10	5400	14100	20000 - 100000	No	Below Background
Antimony	mg/kg	1/ 1	.		0.97	0.97		Yes	No Background Data Available
Arsenic	mg/kg	10/ 10	19.6	0/ 10	4.5	18.8	5.2 - 27.0	No	Below Background
Barium	mg/kg	10/ 10	75	4/ 10	39.8	115	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	1/ 1	.		0.68	0.68	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	7/ 10	0.29	3/ 10	0.06	1.6	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	1/ 1	.		1460	1460	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	10/ 10	18.7	0/ 10	7.4	18.1	15.0 - 100.0	No	Below Background
Cobalt	mg/kg	1/ 1	.		6.5	6.5	7 - 20	Yes	No Background Data Available

Table 4.7 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Copper	mg/kg	1/ 1	.		18.3	18.3	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	1/ 1	.		18500	18500	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	10/ 10	17.9	7/ 10	8.8	63	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	1/ 1	.		1680	1680	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	10/ 10	728	2/ 10	134	2310	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	5/ 10	0.08	0/ 10	0.05	0.06	0.03 - 0.22	No	Below Background
Nickel	mg/kg	1/ 1	.		16	16	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	1/ 1	.		543	543	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	10/ 10	2.6	0/ 10	0.65	2.3	<0.1 - 1.2	No	Below Background
Silver	mg/kg	2/ 10	0.24	1/ 10	0.23	2.4	0.7	Yes	> 5% Detect Above Background
Sodium	mg/kg	1/ 1	.		176	176	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	1/ 1	.		0.89	0.89		Yes	No Background Data Available
Vanadium	mg/kg	1/ 1	.		19.4	19.4	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	10/ 10	72.1	7/ 10	45.2	560	25 - 110	Yes	> 5% Detect Above Background
4,4'-DDE	µg/kg	1/ 1	.		3.2	3.2		Yes	No Background Data Available
4,4'-DDT	µg/kg	1/ 1	.		8.1	8.1		Yes	No Background Data Available
Endrin	µg/kg	1/ 1	.		10	10		Yes	No Background Data Available

Table 4.7 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Gamma chlordane	µg/kg	1/ 1	.		2.9	2.9		Yes	No Background Data Available
Benzo(a)anthracene	µg/kg	1/ 1	.		100	100		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	1/ 1	.		140	140		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	1/ 1	.		130	130		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	1/ 1	.		88	88		Yes	No Background Data Available
Benzo(k)fluoranthene	µg/kg	1/ 1	.		140	140		Yes	No Background Data Available
Bis(2-ethylhexyl)phthalate	µg/kg	1/ 1	.		54	54		Yes	Detected > 5% of Samples
Chrysene	µg/kg	1/ 1	.		130	130		Yes	No Background Data Available
Dibenzo(a,h)anthracene	µg/kg	1/ 1	.		55	55		Yes	No Background Data Available
Fluoranthene	µg/kg	1/ 1	.		240	240		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	1/ 1	.		110	110		Yes	No Background Data Available
Phenanthrene	µg/kg	1/ 1	.		91	91		Yes	No Background Data Available
Pyrene	µg/kg	1/ 1	.		180	180		Yes	No Background Data Available
Toluene	µg/kg	1/ 1	.		4	4		Yes	Detected > 5% of Samples



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
- SOIL/SEDIMENT SAMPLE STATION
- WELL POINT/MONITORING WELL 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

0 100 200 300 600

SCALE: 1" = 300'

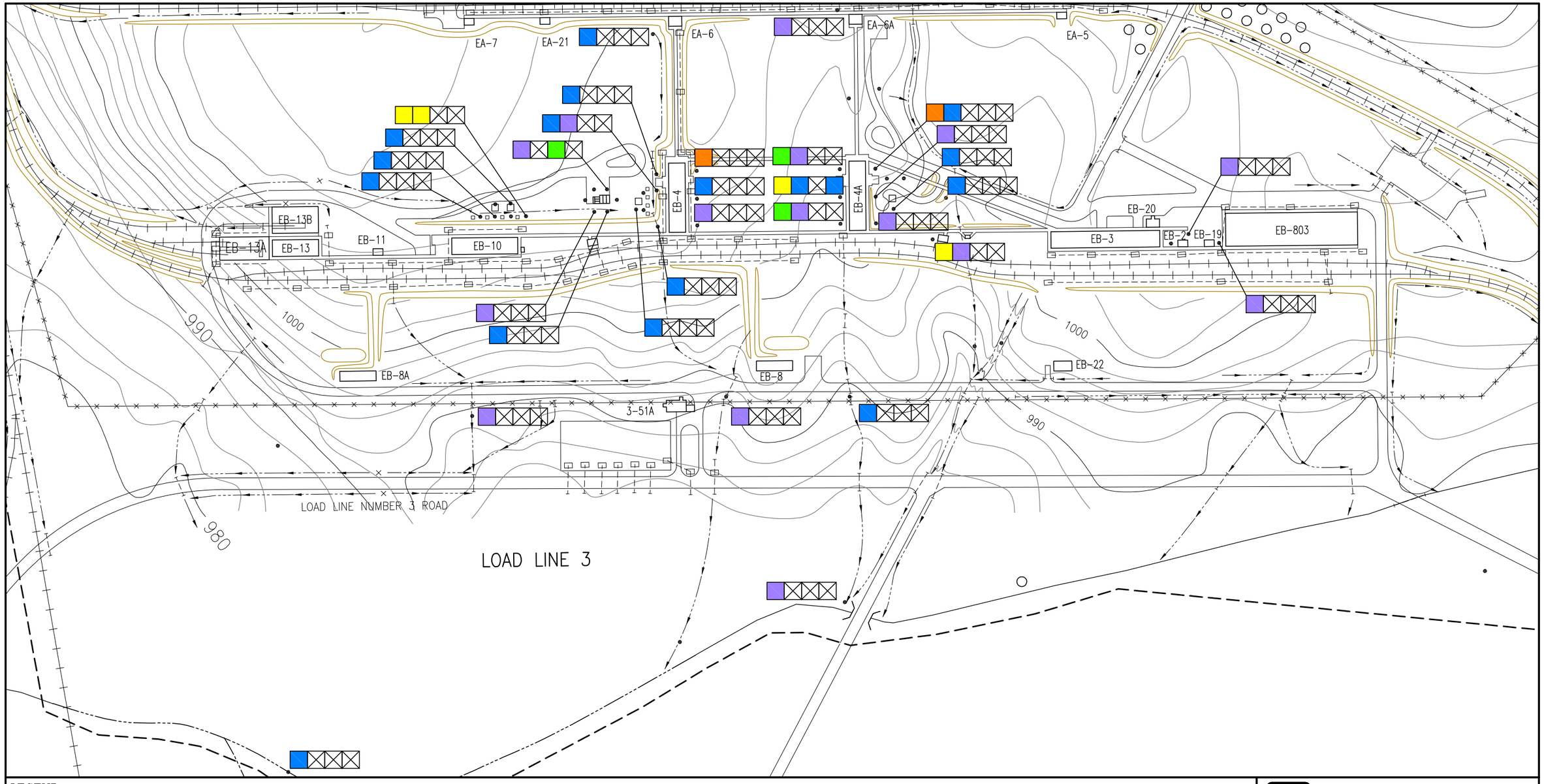
US Army Corps of Engineers Nashville District

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

RAVENNA ARMY AMMUNITION PLANT
RAVENNA, OHIO
LOAD LINE 3, DILUTION
SETTLING POND (RVAAP-10)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	REV. A/04-08-97	95021/DWGS/583RVP10

Fig. 4-18. LL3 Sample Locations and Analytical Parameters



LEGEND:

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

- RDX
- HMX
- 135TNB
- 246TNT

- 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

0 100 200 300 600

SCALE: 1" = 300'

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 3, DILUTION
SETTLING POND (RVAAP-10)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	REV. 0/12-03-96	95021/DWGS/583RV10A

Fig. 4-19. Relative Concentrations of Explosive Compounds in Surface Soil and Sediment at LL3

HMX and RDX were each detected once. HMX was found at LL3ss-022 at 14 mg/kg, in a group of sampling points in which no other explosives were detected. RDX was detected at 10 mg/kg at LL3ss-011, north of melt/pour building EB-4A.

Inorganic Analytes

All 23 inorganic elements and cyanide were detected in surface soils at Load Line 3. Aluminum and selenium were detected at concentrations exceeding the background criteria in fewer than 5 percent of the samples analyzed. The remaining 16 non-nutrient analytes (nine process-related and seven metals from the expanded analyte list) and cyanide were either present above background or no background criteria were available (Table 4.7). Cadmium, chromium, copper, lead, manganese, and silver are present in concentrations that exceed the range of USGS Ohio reference values. No such values are available for antimony or thallium, and they are presumed to be site-related. **Figure 4.20** shows the relative concentrations of chromium, lead, and manganese in surface soils at Load Line 3.

The process-related metals were all detected in almost all of the 37 samples (Table 4.7). Lead and cadmium were detected above their background criteria most frequently. Lead concentrations ranged from 11.1 to 2,620 mg/kg, with 27 of 37 samples occurring at concentrations exceeding the site background (17.9 mg/kg). Lead concentrations were also in excess of the maximum USGS reference value (30 mg/kg) at this site. Cadmium was detected at concentrations from 0.06 to 4.1 mg/g, and exceeded the site background criteria (0.29 mg/kg) in 24 out of 37 samples. Cadmium concentrations exceeded the USGS reference value maximum of 2 mg/kg.

Barium was detected at concentrations ranging from 16.1 to 447 mg/kg, and exceeded the background criteria of 75 mg/kg in 10 samples. The maximum concentration of barium was within the range of USGS reference values (300 to 700 mg/kg). Manganese was detected at concentrations from 75.3 to 7,800 mg/kg, and occurred above the background criteria (728 mg/kg) in eight samples. Manganese also occurred above the maximum USGS reference value (1,000 mg/kg). Chromium was detected from 4.9 to 150 mg/kg, exceeding the background criteria (18.7 mg/kg) in four samples. Chromium occurred above the maximum USGS reference value of 100 mg/kg.

Mercury exceeded the background criteria (0.08 mg/kg) in three samples, with concentrations detected ranging from 0.04 to 0.2 mg/kg. The maximum detected concentration for mercury was below the maximum USGS reference value (2.2 mg/kg). Arsenic was detected at concentrations ranging from 7 to 23.2 mg/kg, exceeding the background criteria of 19.6 mg/kg in two samples. The detected concentrations were within the range of USGS reference values (5.2 to 27 mg/kg).

The expanded metals suite analytes beryllium, cobalt, copper, nickel, thallium, and vanadium were each detected in every one of the nine samples in which they were analyzed, suggesting these analytes may occur in many other locations at Load Line 3. Antimony was found in four of the nine samples, at LL3ss-002, -023, -025, and -043.

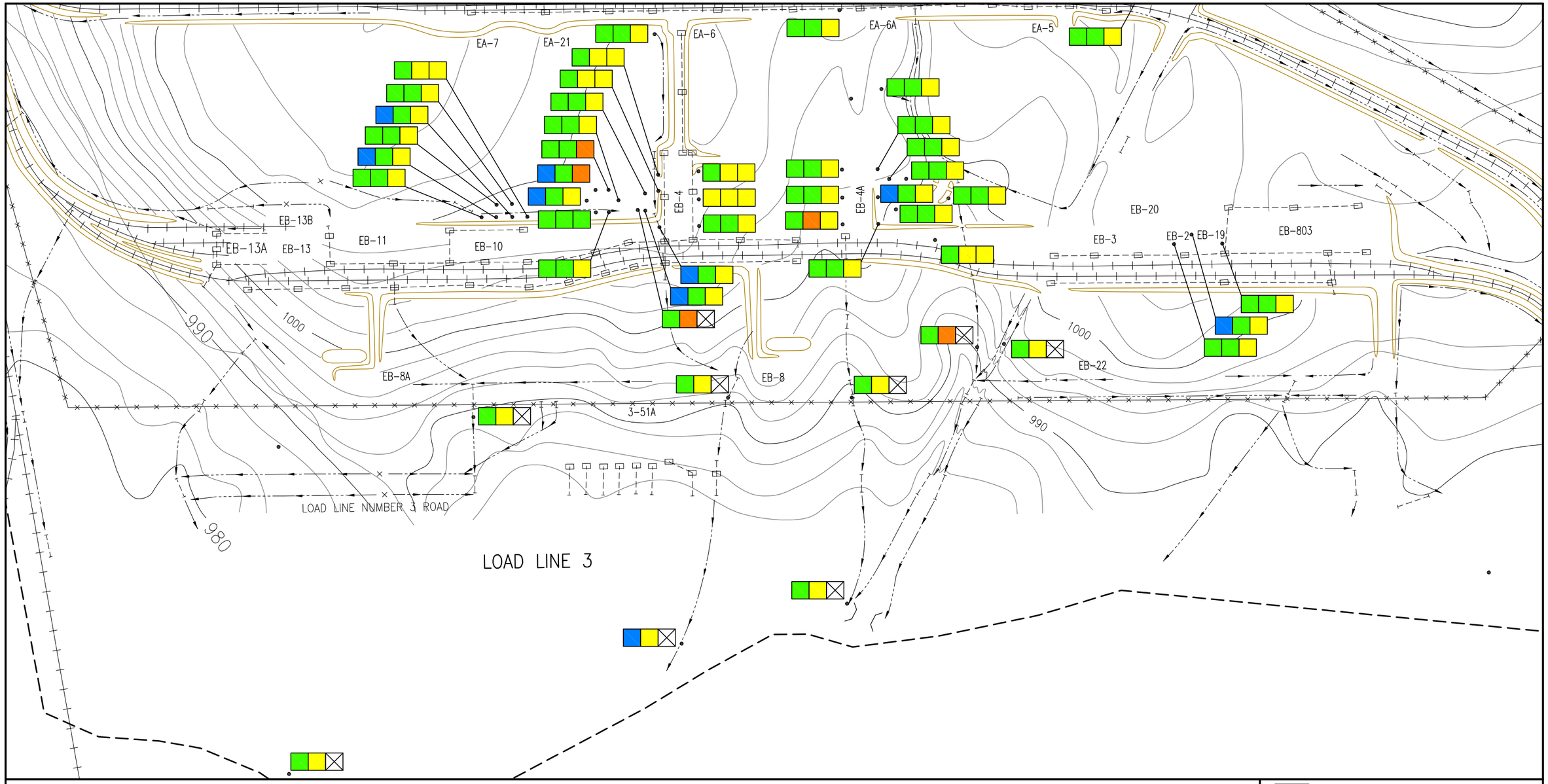


Fig. 4-20. Relative Concentrations of Inorganic Elements in Surface Soil and Sediment at LL3

Cyanide was detected in low concentrations ranging from 0.12 to 0.38 mg/kg in six samples: LL3ss-002, -016, -020, -025, -028, and -030. The maximum concentration of 0.38 mg/kg occurred at LL3ss-030, east of a vacuum pump housing beside Building EB-10.

The highest concentrations of antimony (30 mg/kg at LL3ss-043) and manganese (4,800 mg/kg at LL3ss-022) in surface soils sampled at RVAAP during Phase I were detected in Load Line 3. These occurrences do not coincide with the presence of explosives or organic compounds in high concentrations. The highest concentrations of other metals, such as barium, cadmium, chromium, copper, lead, and mercury, are found among six sampling locations that are associated with specific areas or buildings in Load Line 3, where contamination caused by explosives and/or organic compounds has been noted. Barium (447 mg/kg), copper (99.4 mg/kg), and iron and nickel (21.9 mg/kg) occur at their highest concentrations within Load Line 3 at LL3ss-002, on the southeast corner of melt/pour building EB-4. Arsenic, cadmium, and chromium are found at their maximum concentrations at LL3ss-005, at 23.2, 4.1, and 150 mg/kg, respectively, immediately west of LL3ss-002. LL3ss-001, -013, and -016 also exhibit high concentrations of metals and are located beside melt/pour buildings. LL3ss-023, on the northwest corner of Building EB-803, is also the locus of high concentrations of beryllium, copper, manganese, and nickel. Vanadium, cobalt, and antimony concentrations are high at LL3ss-043, near the asbestos storage area in the southeast corner of Load Line 3.

Organic Compounds

Organic vapors were monitored during sampling for both the breathing zone and in headspace gases. No organic vapors were measured using hand-held instruments during sample collection activities at Load Line 3.

VOCs were detected in four samples at low concentrations. Methylene chloride was detected at LL3ss-023 and -025 at 0.002 and 0.004 mg/kg; toluene was detected in LL3ss-002 and -030 at 0.014 and 0.038 mg/kg. No definitive statement can be made about the sources of these VOCs. No other VOCs were detected.

Seventeen PAH compounds were found in the nine surface soil samples analyzed (Table 4.7). The maximum concentration of any PAH in Load Line 3 soils was 2.2 mg/kg of fluoranthene at LL3ss-016. LL3ss-016 was the locus of maximum concentrations for 12 other PAHs as well. The sample was collected adjacent to a vacuum pump house near an exhaust vent immediately south of Building EB-4A. LL3ss-028 had the maximum concentrations for four of the PAHs, and was collected downgradient of a tank outfall approximately 76 m (250 feet) south of EB-4A. PAHs were also present in low concentrations in LL2ss-002, -023, -025, -030, and -043. The relative concentrations of total PAHs and total carcinogenic PAHs are shown on **Figure 4.21.** 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).

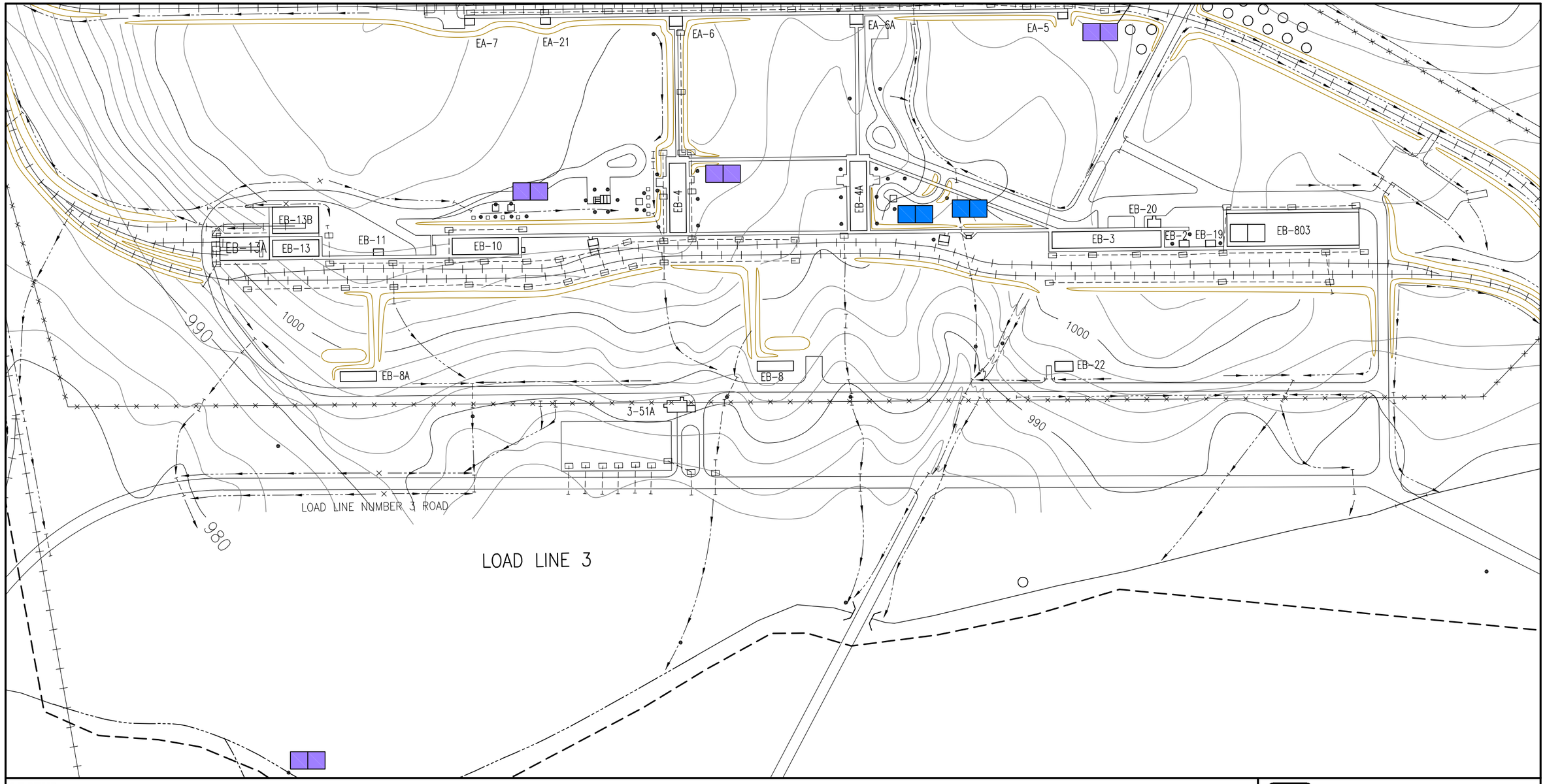


Fig. 4-21. Relative Concentrations of Total PAHs and Total Carcinogenic PAHs in Surface Soil and Sediment at LL3

Eleven pesticides and/or PCBs were detected in the nine surface soil samples evaluated for organic constituents. Four of these compounds (alpha chlordane, beta-BHC, gamma chlordane, and heptachlor) are found in only one sample—LL3ss-002—at concentrations ranging from 0.03 mg/kg beta-BHC to 3.2 mg/kg endrin. Aroclor-1254 is present in LL3ss-002 (21 mg/kg), -023 (0.59 mg/kg), and -028 (0.17 mg/kg). Heptachlor and endrin aldehyde were each detected once, at LL3ss-023 at 0.002 and 0.005 mg/kg, respectively. Endosulfan II was detected once, at LL3ss-016 at 0.005 mg/kg. 4,4'-DDE was found at LL3ss-023 and -028 at 0.012 and 0.004 mg/kg, and 4.4'-DDT was found at LL3ss-016 and -023 at 0.011 and 0.077 mg/kg. Occurrences of these compounds are associated with the south sides of the melt/pour buildings, with activities at Building EB-803, and with the gallery that joins Buildings EB-4A and EB-3. Two samples north of the melt/pour buildings that were subjected to the full suite of analyses exhibited no indication of contamination with pesticides or PCBs (**Figure 4.22**).

4.6.2 Sediment

Ditch sediment was collected from nine locations throughout Load Line 3. Eight of these locations were sampled to characterize the impact of plant effluent on drainage ditches that exit the property to the west. The ninth location is within the plant on the north side of melt/pour building EB-4. All ditch sediment samples were subjected to analyses for explosives and the 11 process-related inorganics; one sample was also analyzed for the expanded metals suite, cyanide, VOCs, SVOCs, and pesticides/PCBs (Figure 4.18). Geotechnical grain size distribution curves are presented in Appendix G.4. TOC ranged from 2,580 mg/kg in LL3sd-052 to 28,900 mg/kg in LL3sd-048.

Explosives

TNT was detected in six of the nine sediment samples collected. Concentrations ranged from 0.45 mg/kg at LL3sd-046 to 4.6 mg/kg at LL3sd-035. This maximum value was observed in a ditch on the north side of melt/pour building EB-4; the concentration of 0.65 mg/kg observed at LL3sd-047, downstream from LL3sd-035, may result from drainage of the area around the melt/pour building. Further downstream in this ditch, at LL3sd-052, no explosives were detected. TNT is present at 1.1 mg/kg at LL3sd-048, downstream from the second melt-pour building, where high concentrations of TNT were noted in surface soil samples LL3ss-009, -011, and -013. Further downstream from LL3sd-048, the concentration of TNT at LL3sd-051 is 0.82 mg/kg in the ditch before it joins the stream that discharges to Upper Cobbs Pond. In the main drainage channel downstream of the ditch discharge points, TNT was present at 1.4 mg/kg. This suggests Load Line 3 ditches contribute explosives contamination to the main channel, which may eventually be transported to Upper Cobbs Pond. Figure 4.19 shows the distribution and concentrations of TNT in Load Line 3 sediments.

No other explosives were detected in Load Line 3 sediments.

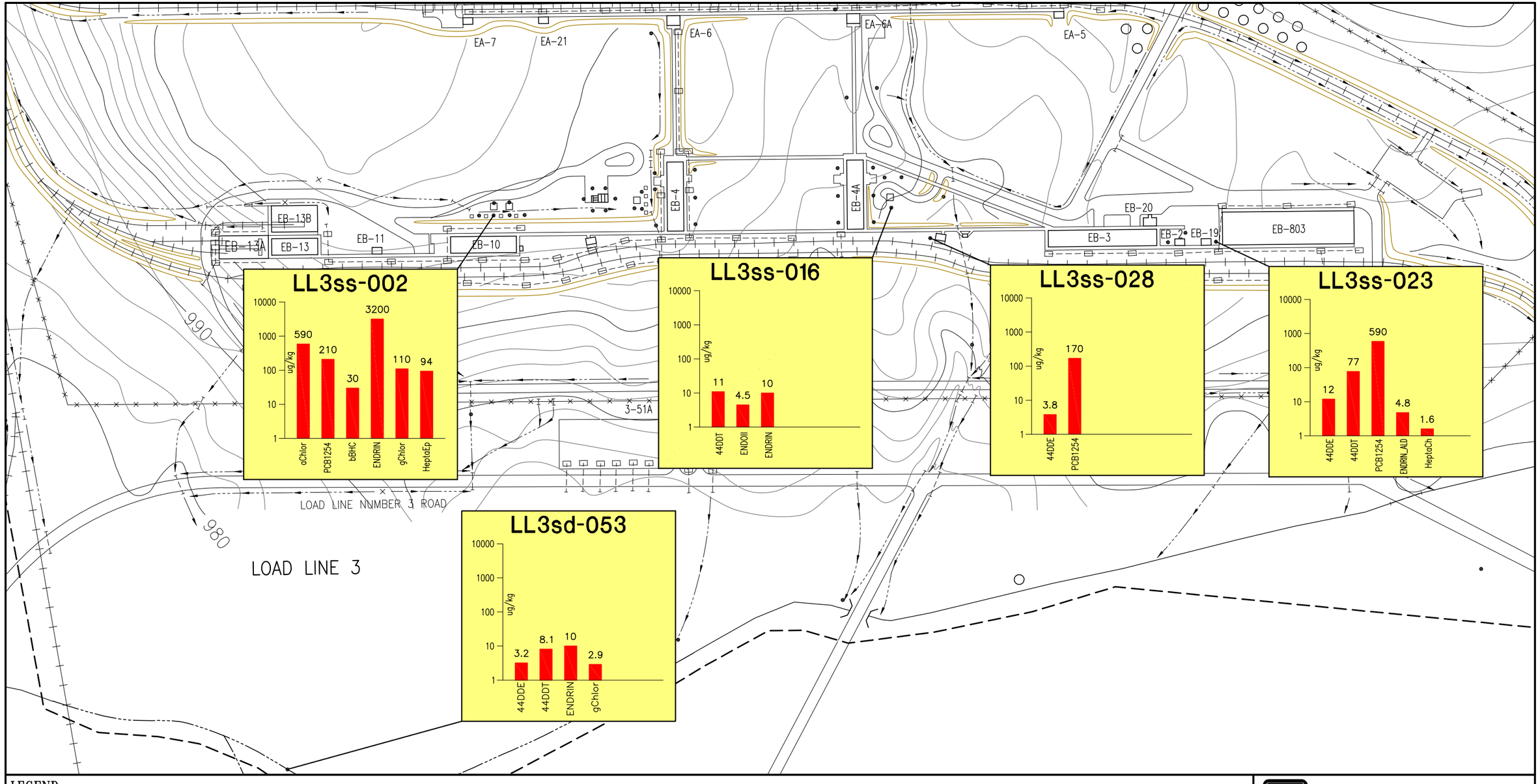


Fig. 4-22. Relative Concentrations of PCBs and Pesticides in Surface Soil and Sediment at LL3

Inorganic Analytes

Twenty-three inorganic elements were detected in sediment samples from Load Line 3. Cyanide was not detected in any sediment sample in Load Line 3. Aluminum, arsenic, chromium, manganese, and selenium were not detected at concentrations in excess of site background criteria. Of the remaining 13 non-nutrient analytes, five are process-related metals exceeding background criteria (barium, cadmium, lead, silver, and zinc), and eight are expanded metals suite analytes and cyanide, for which background data are not available (Table 4.7). Maximum concentrations of cadmium, cobalt, copper, nickel, vanadium, and zinc fell within or below the range of USGS reference values; the maximum values for lead, manganese, and silver, however, exceeded the USGS maximum reference value. Figure 4.20 shows the relative concentration of lead and manganese in sediments at Load Line 2.

Lead and zinc were detected above background most frequently. Lead was detected at concentrations ranging from 8.8 to 63 mg/kg, and exceeded the background criteria (17.9 mg/kg) in 7 of 10 samples, and the maximum USGS reference value (30 mg/kg) was also exceeded. Zinc was detected from 45.2 to 560 mg/kg, occurring above the background criteria of 72.1 in 7 samples. Zinc also occurred above the maximum USGS reference value of 110 mg/kg. Barium was detected above background (75 mg/kg) in 4 of 10 samples, with detected concentrations ranging from 39.8 to 115 mg/kg. All detected concentrations were below the range of USGS values (300 to 700 mg/kg).

Cadmium was detected at concentrations ranging from 0.06 to 1.6 mg/kg, exceeding the background criteria of 0.29 in three samples. Detected concentrations of cadmium were below or within the range of USGS reference values (1 to 2 mg/kg). Manganese exceeded the background criteria (728 mg/kg) in two samples, with detections ranging from 134 to 2,310 mg/kg. Manganese occurred above the maximum USGS reference value (1,000 mg/kg). Silver was detected at a concentration of 0.23 and 2.4 mg/kg, the maximum value exceeded the background criteria (0.24 mg/kg) and the USGS reference value (0.7 mg/kg).

One sample (LL3sd-053) was subjected to analyses for the expanded metal suite; antimony, beryllium, cobalt, copper, nickel, thallium, and vanadium were detected and are considered to be site-related. Table 4.7 lists the detected concentrations for these analytes.

The highest concentrations of metals in Load Line 3 sediments were found at six of the nine sampling locations. LL3sd-035, northwest of Building EB-4, was the locus of the maximum values for cadmium (1.60 mg/kg), lead (63 mg/kg), and silver (2.4 mg/kg). The maximum barium concentration was found at LL3sd-051, at 115 mg/kg, in the drainage ditch north of Newton Falls Road. High values of manganese, lead, and cadmium are found at LL3sd-047, -048, and -049, in three southwesterly-flowing ditches that drain the center of Load Line 3. The metal analytes are present in other ditch sediments at lower concentrations.

Organic Compounds

One sediment sample, LL3sd-053, in the main stream that drains Load Line 3 to the northwest, was analyzed for VOCs, SVOCs, and pesticides/PCBs. Toluene was the only VOC detected, at a concentration of 0.004 mg/kg. Eleven PAHs were detected, all in low

concentrations (< 1 mg/kg); the maximum concentration of any PAH was 0.240 mg/kg of fluoranthene. Figure 4.21 shows the relative concentrations of total PAHs and total carcinogenic PAHs. Bis(2-ethylhexyl)phthalate was also present, at 0.054 mg/kg. Four pesticides were also detected at low concentrations: 4,4'-DDE at 0.003 mg/kg, 4,4'-DDT at 0.008 mg/kg, endrin at 0.010 mg/kg, and gamma chlordane at 0.003 mg/kg (Table 4.7). Figure 4.22 shows the concentrations of pesticides in sediments at Load Line 3. No other organic constituents were found in the sample. Because only one ditch sediment sample was evaluated for organic compounds, it is not possible to pinpoint which of the ditches that conveyed effluent from the load line may be contributing these compounds to the main stream.

4.6.3 Discussion/Summary of Results

Surface Soil

- High concentrations of TNT and other explosives are present in soils outside the melt/pour buildings and near vacuum pump housings at Building EB-10.

- Isolated high concentrations of HMX and RDX were noted at one location each. The occurrence of RDX is associated with melt/pour building EB-4A; HMX is associated with an unnamed structure between Buildings EB-4 and EB-10.

- The highest concentrations of several metals are associated with the melt/pour buildings and Building EB-803. A large number of metals are present in surface soils in concentrations above background. Chromium, copper, lead, and manganese were detected in concentrations that exceed the range of USGS reference values.

- PCBs or pesticides were present in four samples. The greatest amount of contamination is associated with the south side of melt/pour building EB-4, where Aroclor-1254 was found at 21 mg/kg. PCBs are also found at Building EB-803 and along the connecting gallery between Buildings EB-4A and EB-3.

- PAHs appear to be most abundant in two samples south of melt/pour building EB-4A.

Sediment

- TNT is the only explosive found in ditch sediments, and is present in concentrations an order of magnitude or greater below those observed in surface soils. The greatest amounts of explosives in ditches are associated with the melt/pour buildings. TNT was also present in the main creek that drains Load Line 3 and discharges into Upper Cobbs Pond.

- Chromium and arsenic are not present above background criteria in ditch sediments at Load Line 3. However, 14 metal analytes were detected that are possibly site related. These metals occur in greatest abundance and concentration in sediment samples collected north of Building EB-4 and in the main drainage ditch that discharges to Upper Cobbs Pond.

- Low concentrations of PAHs were found in the one sediment sample analyzed for organic constituents. Four pesticides were present in this sample, collected from the main creek that drains Load Line 3, at concentrations from 0.003 to 0.010 mg/kg.

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

4.7 LOAD LINE 4 AND DILUTION/SETTLING POND

Load Line 4 sampling activity included surface soil, ditch sediment, and groundwater sampling at three temporary well points. The analytical data are summarized in **Table 4.8** and presented in detail in Table 4.21 and in Appendix G.

4.7.1 Surface Soil

Load Line 4 surface soils were sampled in 47 locations; all 47 samples were analyzed for explosives and the 11 process-related metals, and 11 samples were also analyzed for the expanded metals suite, cyanide, VOCs, SVOCs, and pesticides/PCBs. The location of all samples and the analytical parameters for each are shown on **Figure 4.23**.

Explosives

Explosives were detected in nine sampling locations. TNT was encountered in each of the nine locations, with a maximum concentration of 2.2 mg/kg at LL4ss-032, located beside Building G-12A. TNT was present in soils from all samples around Building G-12A, and in two samples north and east of Building G-8, respectively. TNT was present at 0.69 mg/kg at LL4ss-023 beside the unnamed structure east of Building G-8, and east of Building G-13 at LL4ss-028. LL4ss-007, collected adjacent to a washout facility, also exhibited TNT at 0.27 mg/kg. **Figure 4.24** shows the distribution and concentrations of TNT and other explosive compounds in surface soils.

HMX and RDX were each detected in one location in concentrations of 1.0 mg/kg HMX at LL4ss-067 and 0.27 mg/kg RDX at LL4ss-007.

In 38 surface soil sampling locations, no explosives were detected. Six of these samples are located in close proximity [i.e., less than about 30 m (100 feet)] to five of the soil samples referred to above that contain detectable quantities of explosives. For example, LL4ss-003 had 0.41 mg/kg TNT, but LL4ss-005, located about 24 m (80 feet) from LL4ss-003, had no detectable quantity of TNT. This suggests TNT is not mobile in surface soils.

Inorganic Analytes

Twenty-one of the 23 TAL metals were detected in surface soils at Load Line 4. Antimony and silver were never detected; arsenic was detected below background, and aluminum, chromium, mercury, and selenium were detected above the site-related background criteria in fewer than 5 percent of the samples. Of the 11 non-nutrient elements remaining,

Table 4.8. Load Line 4 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	6/ 11	.		0.11	0.51		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	9/ 47	.		240	2200		Yes	Detected > 5% of Samples
HMX	µg/kg	1/ 47	.		1000	1000		Yes	No Background Data Available
RDX	µg/kg	1/ 47	.		270	270		Yes	No Background Data Available
Aluminum	mg/kg	47/ 47	15600	1/ 47	4210	22700	20000 - 100000	No	< = 5% Detect Above Background
Arsenic	mg/kg	47/ 47	19.6	0/ 47	2	17.8	5.2 - 27.0	No	Below Background
Barium	mg/kg	47/ 47	75	10/ 47	17.3	238	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	11/ 11	.		0.25	3.6	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	44/ 47	0.29	16/ 47	0.04	5.2	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	11/ 11	.		731	8100	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	47/ 47	18.7	1/ 47	5.2	30.1	15.0 - 100.0	No	< = 5% Detect Above Background
Cobalt	mg/kg	11/ 11	.		3	10.4	7 - 20	Yes	No Background Data Available
Copper	mg/kg	11/ 11	.		7.7	106	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	11/ 11	.		7850	28700	15000 - 50000	No	Essential Nutrient

Table 4.8 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Lead	mg/kg	47/ 47	17.9	22/ 47	8.1	384	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	11/ 11	.		864	14300	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	47/ 47	728	5/ 47	43.5	2830	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	10/ 47	0.08	1/ 47	0.03	0.16	0.03 - 0.22	No	< = 5% Detect Above Background
Nickel	mg/kg	11/ 11	.		7.8	32.1	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	11/ 11	.		379	1810	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	38/ 47	2.6	1/ 47	0.32	3.2	<0.1 - 1.2	No	< = 5% Detect Above Background
Sodium	mg/kg	11/ 11	.		128	649	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	11/ 11	.		0.46	13.3		Yes	No Background Data Available
Vanadium	mg/kg	11/ 11	.		8.9	19.7	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	47/ 47	72.1	19/ 47	25.4	1850	25 - 110	Yes	> 5% Detect Above Background
4,4'-DDD	µg/kg	1/ 11	.		9.8	9.8		Yes	No Background Data Available
4,4'-DDE	µg/kg	2/ 11	.		18	19		Yes	No Background Data Available
4,4'-DDT	µg/kg	3/ 11	.		8.7	230		Yes	No Background Data Available
Aldrin	µg/kg	2/ 11	.		17	43		Yes	No Background Data Available

Table 4.8 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Alpha chlordane	µg/kg	3/ 11	.		5.6	34		Yes	No Background Data Available
Aroclor-1254	µg/kg	3/ 11	.		110	3200		Yes	No Background Data Available
Aroclor-1260	µg/kg	1/ 11	.		4500	4500		Yes	No Background Data Available
Dieldrin	µg/kg	1/ 11	.		4.8	4.8		Yes	No Background Data Available
Endosulfan II	µg/kg	1/ 11	.		37	37		Yes	No Background Data Available
Endrin	µg/kg	3/ 11	.		7.5	18		Yes	No Background Data Available
Endrin aldehyde	µg/kg	1/ 11	.		4.5	4.5		Yes	No Background Data Available
Gamma chlordane	µg/kg	3/ 11	.		1.6	19		Yes	No Background Data Available
Acenaphthylene	µg/kg	2/ 11	.		270	560		Yes	No Background Data Available
Anthracene	µg/kg	3/ 11	.		190	1200		Yes	No Background Data Available
Benzo(a)anthracene	µg/kg	3/ 11	.		450	2100		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	4/ 11	.		40	2700		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	4/ 11	.		40	7200		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	3/ 11	.		240	3800		Yes	No Background Data Available

Table 4.8 (continued)

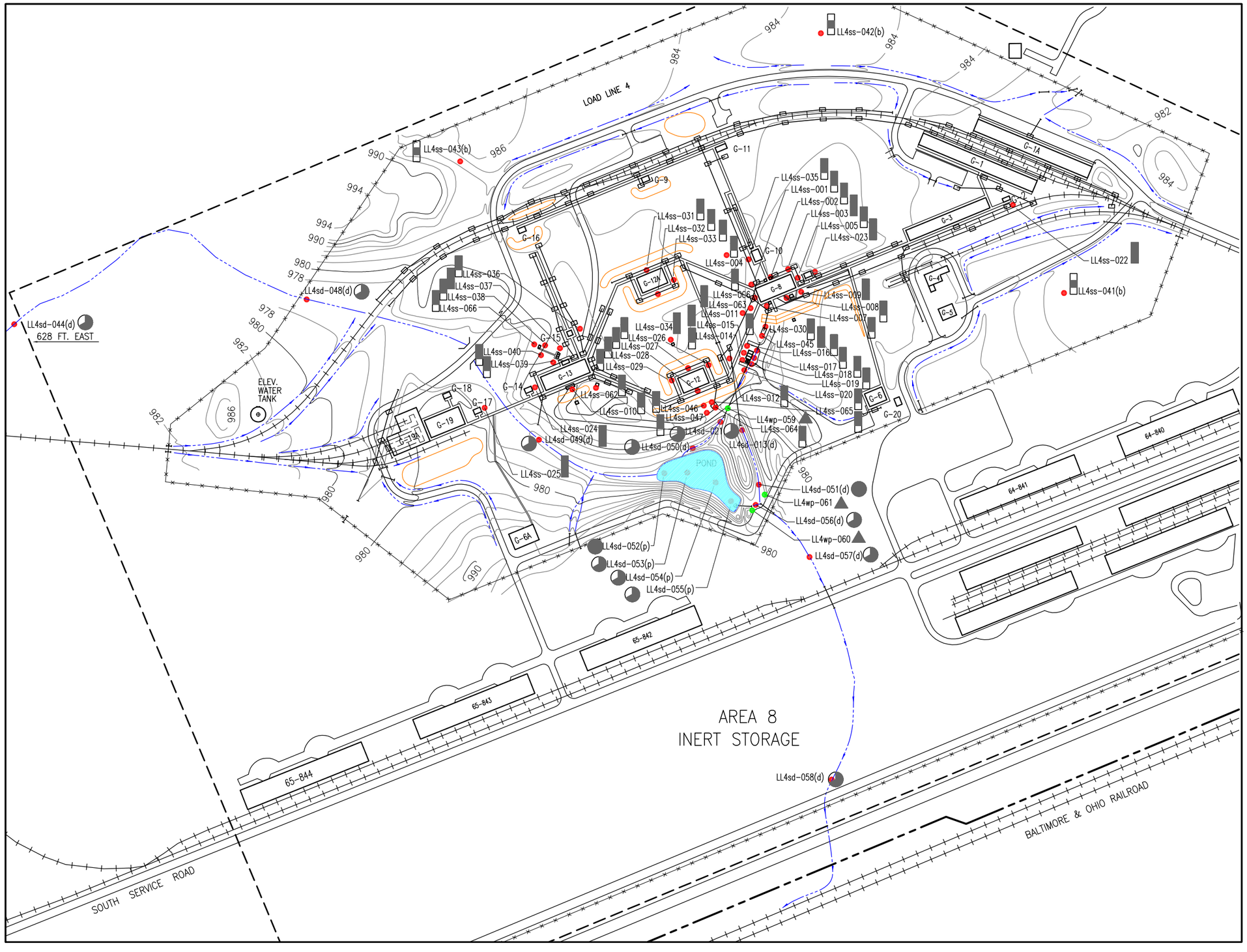
Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Benzo(k)fluoranthene	µg/kg	3/ 11	.		330	5000		Yes	No Background Data Available
Bis(2-ethylhexyl)phthalate	µg/kg	5/ 11	.		43	170		Yes	Detected > 5% of Samples
Carbazole	µg/kg	3/ 11	.		120	1400		Yes	No Background Data Available
Chrysene	µg/kg	5/ 11	.		38	6400		Yes	No Background Data Available
Di-n-butyl phthalate	µg/kg	1/ 11	.		920	920		Yes	No Background Data Available
Dibenzo(a,h)anthracene	µg/kg	3/ 11	.		140	1200		Yes	No Background Data Available
Fluoranthene	µg/kg	7/ 11	.		38	8100		Yes	No Background Data Available
Fluorene	µg/kg	2/ 11	.		64	120		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	3/ 11	.		230	3700		Yes	No Background Data Available
Phenanthrene	µg/kg	3/ 11	.		140	2300		Yes	No Background Data Available
Pyrene	µg/kg	5/ 11	.		35	5400		Yes	No Background Data Available
Acetone	µg/kg	1/ 7	.		50	50		Yes	No Background Data Available
Chloroform	µg/kg	1/ 11	.		2	2		Yes	Detected > 5% of Samples
Toluene	µg/kg	2/ 11	.		5	12		Yes	Detected > 5% of Samples

Table 4.8 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
SEDIMENT									
Cyanide	mg/kg	1/ 2	.		0.16	0.16		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	4/ 14	.		190	8700		Yes	Detected > 5% of Samples
Aluminum	mg/kg	14/ 14	15600	0/ 14	2360	12600	20000 - 100000	No	Below Background
Arsenic	mg/kg	14/ 14	19.6	0/ 14	4	18.5	5.2 - 27.0	No	Below Background
Barium	mg/kg	14/ 14	75	5/ 14	15.8	107	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	2/ 2	.		0.27	0.62	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	12/ 14	0.29	5/ 14	0.07	0.72	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	2/ 2	.		3170	7470	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	14/ 14	18.7	0/ 14	4.2	16.7	15.0 - 100.0	No	Below Background
Cobalt	mg/kg	2/ 2	.		5.1	9.1	7 - 20	Yes	No Background Data Available
Copper	mg/kg	2/ 2	.		10.4	16.2	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	2/ 2	.		10400	21600	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	14/ 14	17.9	3/ 14	7.8	21.4	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	2/ 2	.		1960	2690	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	14/ 14	728	3/ 14	91.9	895	150 - 1000	Yes	> 5% Detect Above Background

Table 4.8 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Mercury	mg/kg	4/ 14	0.08	2/ 14	0.05	0.11	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	2/ 2	.		10.8	18	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	2/ 2	.		378	1250	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	7/ 14	2.6	0/ 14	0.41	1.3	<0.1 - 1.2	No	Below Background
Sodium	mg/kg	2/ 2	.		199	322	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	1/ 2	.		1.3	1.3		Yes	No Background Data Available
Vanadium	mg/kg	2/ 2	.		6.2	15.9	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	14/ 14	72.1	8/ 14	39.1	208	25 - 110	Yes	> 5% Detect Above Background
2-Butanone	µg/kg	1/ 2	.		53	53		Yes	No Background Data Available
Acetone	µg/kg	1/ 1	.		250	250		Yes	No Background Data Available
Carbon disulfide	µg/kg	1/ 2	.		13	13		Yes	No Background Data Available



LEGEND:

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

N

0 200 400 800

SCALE: 1" = 300'

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 NO. 4, DILUTION
SETTLING POND (RVAAP-11)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
S. DUNLAP	REV. B/04-08-97	95021/DWGS/583RVP11

Fig. 4-23. LL4 Sample Locations and Analytical Parameters

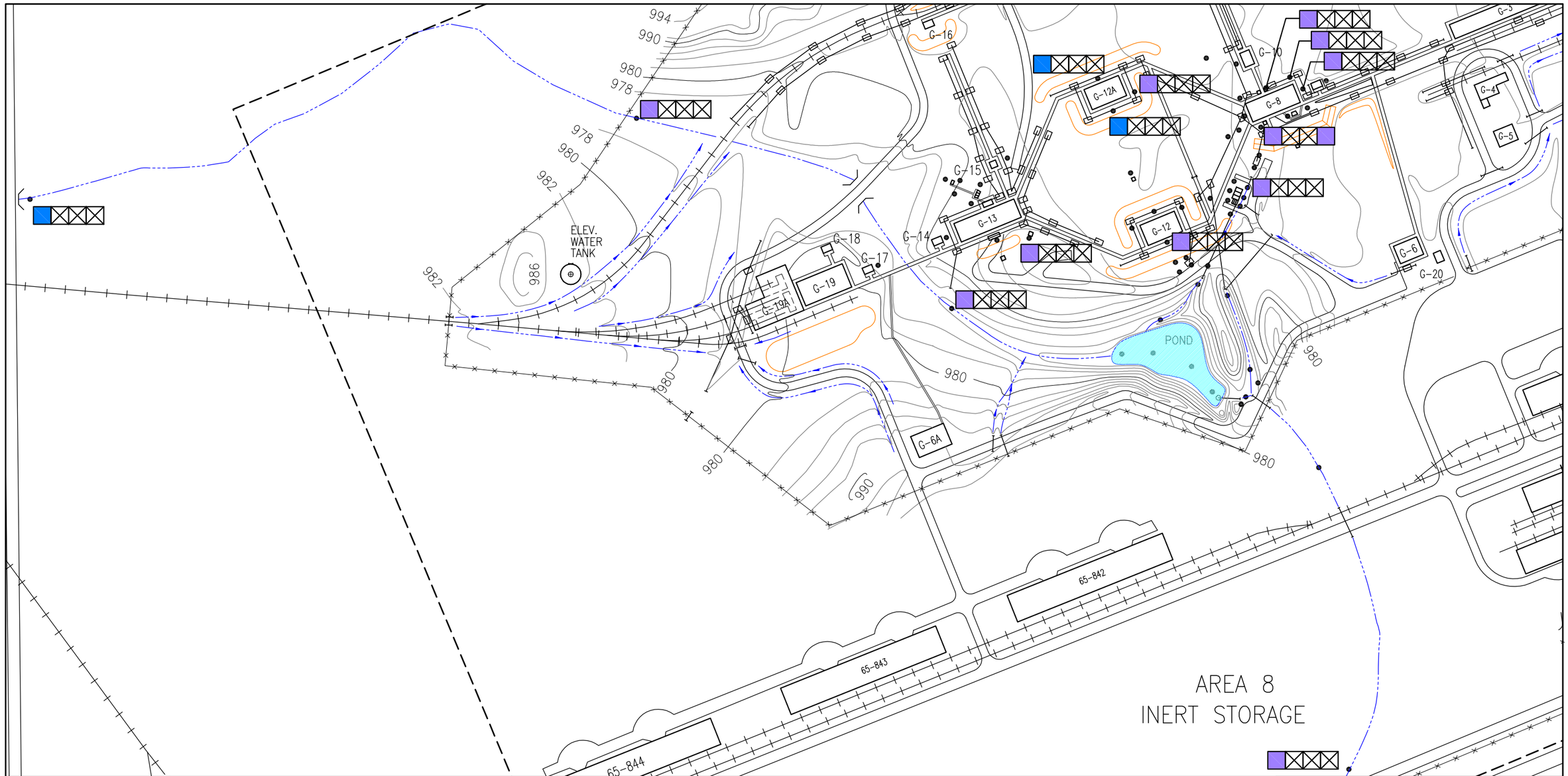


Fig. 4-24. Relative Concentrations of Explosive Compounds in Surface Soil and Sediment at LL4

five are process-related metals occurring at concentrations above background, and six are metals from the expanded suite (beryllium, cobalt, copper, nickel, thallium, and vanadium) for which no background value is available. These analytes are considered to be SRCs at Load Line 4.

Beryllium, cadmium, copper, lead, and manganese are present in soils at concentrations that exceed the USGS maximum reference values. Barium, cobalt, iron, nickel, vanadium, and zinc are present at concentrations that fall within or below the range of USGS reference values. No published USGS reference values are available for thallium (Table 4.8).

All of the 11 process-related inorganic SRCs were detected in all 47 samples. Lead, zinc, and cadmium were the most frequently detected metals occurring above the background criteria. Lead was detected at concentrations ranging from 8.1 to 384 mg/kg, and occurred above the background criteria (17.9 mg/kg) in 22 samples. Lead concentrations also exceeded the maximum USGS reference value (30 mg/kg). Zinc was detected above background (72.1 mg/kg) in 19 samples, with detected concentrations ranging from 25.4 to 1850 mg/kg. The maximum USGS reference value (110 mg/kg) was also exceeded. Cadmium was detected at concentrations ranging from 0.04 to 5.2 mg/kg, exceeding the background criteria (0.29 mg/kg) in 16 samples. Cadmium concentrations also exceeded the maximum USGS reference value (2 mg/kg).

Barium was detected at concentrations ranging from 17.3 to 238 mg/kg, and occurred above the background criteria (75 mg/kg) in 10 samples. The maximum detected concentration was below the range of USGS reference values (300 to 700 mg/kg). Manganese was detected above the background criteria (728 mg/kg) in five samples. Detected concentrations ranged from 43.5 to 2830 mg/kg. Concentrations exceeded the maximum USGS reference value (1000 mg/kg). The relative concentrations of barium, cadmium, lead, and manganese are shown in **Figure 4.25**.

Eleven samples were analyzed for the expanded metal suite. Beryllium, cobalt, copper, nickel, thallium, and vanadium were detected in each of the 11 samples evaluated. These results suggest these analytes may be present in many sampling locations distributed throughout the load line.

Cyanide was detected at low concentrations in six of the 11 samples: LL4ss-003, -009, -022, -023, -034, and -045. The maximum concentration of cyanide was measured at 0.34 mg/kg at LL4ss-034. These samples were also found to have pesticides and/or PCBs in high concentrations, but with the exception of LL4ss-003 and -023, none contained explosives.

A number of metals were detected in each of the 47 surface soil samples collected. The highest concentrations of metals in Load Line 4 surface soils are found in 12 of the 47 samples. These occurrences are associated with a few specific buildings within the load line. For example, barium, beryllium, and thallium are all found at their maximum concentrations in LL4ss-003, on the northeast side of Building G-8. Manganese occurs at its maximum (2830 mg/kg) at LL4ss 014, next to a concrete settling basin. At LL4ss-023, beryllium, cadmium, cobalt, copper, iron, lead, nickel, and zinc were found at either their maximum or second-highest concentrations. Maximum values for beryllium, copper, and zinc may be two to eight

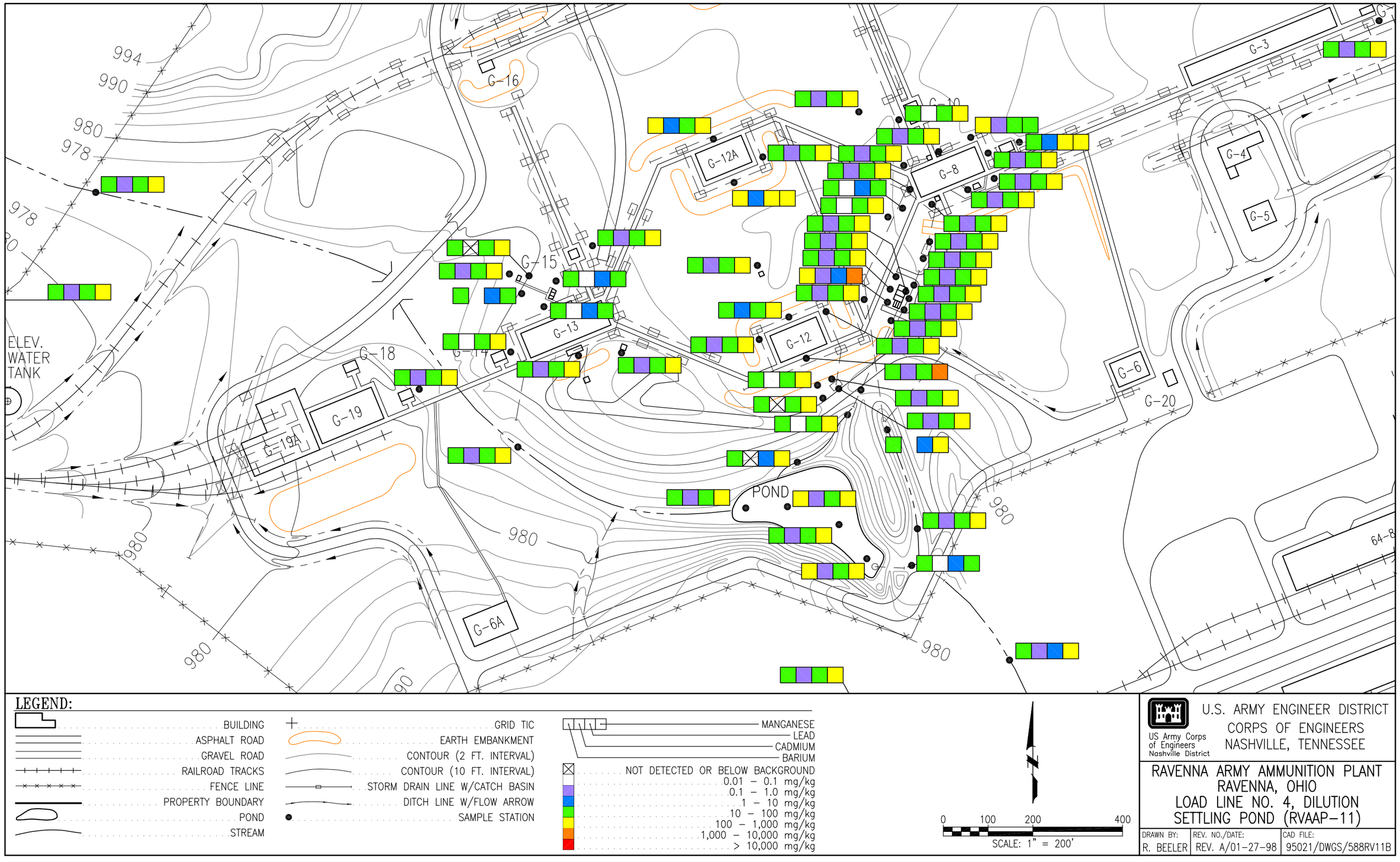


Fig. 4-25. Relative Concentrations of Selected Inorganic Elements In Surface Soil and Sediment at LL4

times higher than the next highest values. Vanadium reached its maximum concentration in LL4ss-025. Cadmium, lead, and zinc were found at their maximum concentrations in Load Line 4 at LL4ss-032. LL4ss-032 is located on the southeast side of Building G-12A, where explosives were also present. Note that LL4ss-003 and -023, adjacent to Building G-8, are known to be contaminated with explosives, and metals may be associated with explosives found in the surface soils.

High concentrations of beryllium, cobalt, copper, iron, nickel, and vanadium are also found at LL4ss-024, located between Building G-13 and G-14, and at LL4ss-025, east of Building G-17. Figure 4.25 shows the spatial distribution of representative metals in surface soils across Load Line 4.

Organic Compounds

Six samples that were analyzed for organic compounds were monitored in the field for organic vapors in the borehole and in headspace gases. Of these, two samples produced no or minuscule readings on hand-held instruments (LL4ss-026 and LL4ss-037). Two samples had high headspace concentrations (700 ppm at LL4ss-045 and 600 ppm at LL4ss-063) when SVOCs or pesticides were detected in modest to high concentrations in LL4ss-045, and VOCs were present in low concentrations in LL4ss-063. Low concentrations of organic vapors in headspace and borehole gases were noted at LL4ss-015, where endrin, fluoranthene, and pyrene were detected.

VOCs including acetone, chloroform, and toluene are found in three of the 11 samples analyzed for organic compounds. These constituents are generally present in low concentrations (Table 4.8) and are possible laboratory contaminants. SVOCs were detected in nine samples (LL4ss-003, -009, -015, -022, -023, -034, -037, -045, and -063). Most of these detections were PAHs; the maximum concentration of any PAH was 8.1 mg/kg of fluoranthene at LL4ss-009. Fourteen PAHs detected occurred at their maximum concentration in LL4ss-009. LL4ss-009, -034, and -045 have the greatest abundance and the highest concentrations of PAHs. **Figure 4.26** shows the relative concentrations of total PAHs and total carcinogenic PAHs. 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). Di-n-butylphthalate was detected once, at a concentration of 0.92 mg/kg, at LL4ss-023. Bis(2-ethylhexyl) phthalate was detected in five samples, with the maximum concentration of 0.17 mg/kg at LL4ss-045.

Pesticides and/or PCBs were detected in seven of the 11 samples: LL4ss-003, -009, -015, -023, -025, -034, and -045. Aroclor-1254 was present in three of the samples: LL4ss-009 (1.3 mg/kg), LL4ss-023 (3.2 mg/kg), and LL4ss-025 (0.11 mg/kg). Aroclor-1260 was detected at LL4ss-023 at 4.5 mg/kg. Samples containing PCBs or pesticides are found at the southeast corners of Buildings G-8 and G-12, and immediately east of Building G-17. **Figure 4.27** shows the distribution of pesticides/PCBs in surface soils at Load Line 4. High concentrations of these analytes in surface soil do not appear to have an impact on nearby ditch sediments or groundwater.

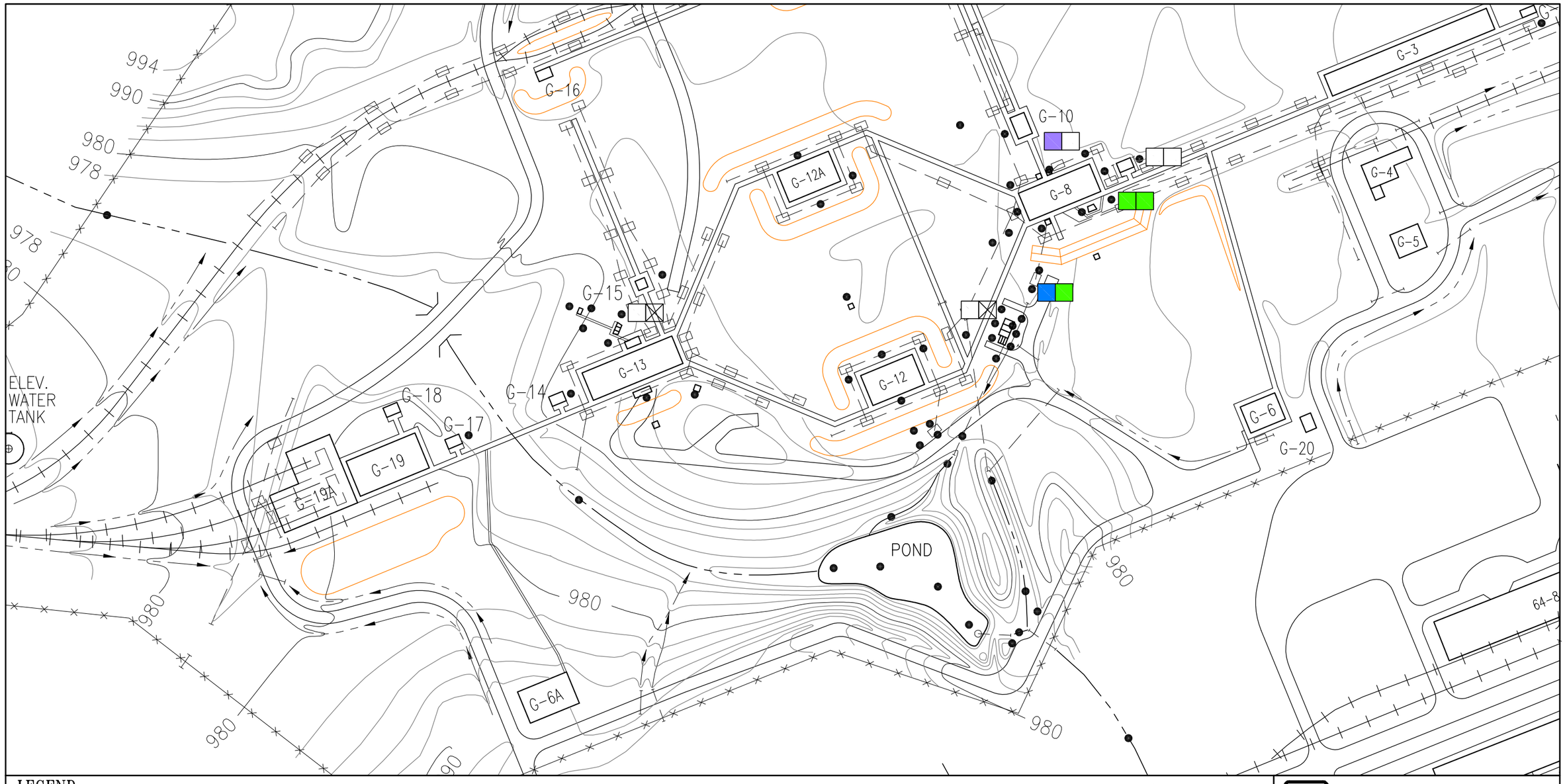


Fig. 4-26. Relative Concentrations of Total PAHs and Total Carcinogenic PAHs in Surface Soil at LL4

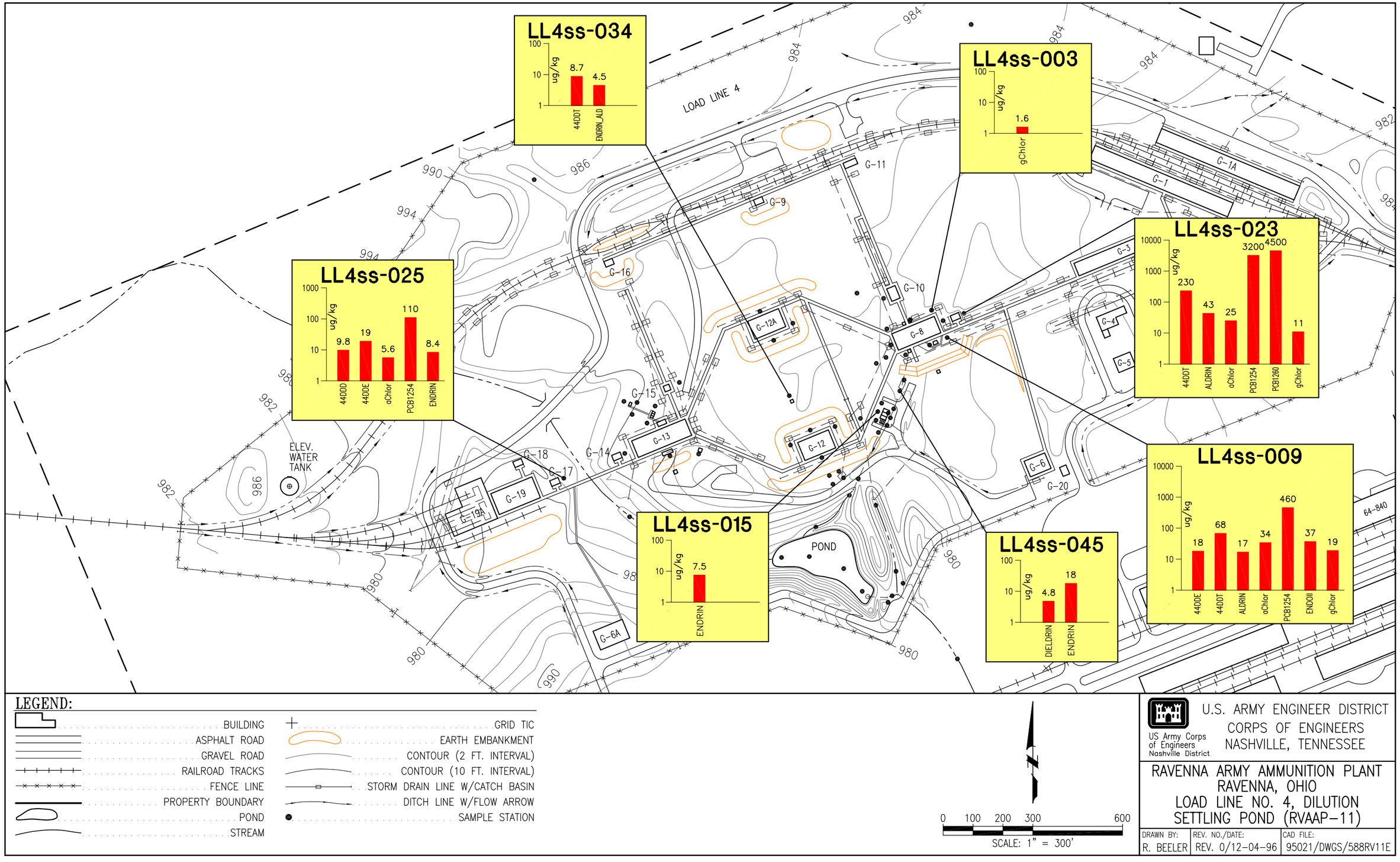


Fig. 4-27. Relative Concentrations of PCBs and Pesticides in Surface Soil at LL4

4.7.2 Sediment

Ditch and settling pond sediments from one major and one minor drainage pathway were sampled in 14 locations at Load Line 4. Two sediment samples were subjected to the full suite of analyses, including the expanded metals suite, cyanide, VOCs, SVOCs, and pesticides/PCBs. Geotechnical grain size distribution curves are presented in Appendix G.4. TOC ranged from 3,610 mg/kg in LL4sd-058 to 17,700 mg/kg in LL4sd-052.

Explosives

The explosive TNT was encountered in four ditch sampling locations: LL4sd-044, -048, -049, and -058, in concentrations ranging from 0.19 mg/kg at LL4sd-058 to 8.7 mg/kg at LL4sd-044. The latter sample is located in the drainage ditch that enters the load line from the east. It is thus clear that some site-related contamination, possibly caused by explosives handling in the bunker complex immediately to the east of Load Line 4, enters the Load Line via the drainage ditch. The lowest concentration is found at LL4sd-058, in the drainage ditch that exits the load line to the south (see Figure 4.24). Pond sediments contained no detectable quantities of TNT or other explosives, which is unexpected if it is assumed that the eastward-flowing ditch is contributing TNT to the pond.

Inorganic Analytes

Twenty-one of the 23 TAL metals were detected in sediment samples in Load Line 4. Antimony and silver were not detected. Aluminum, arsenic, chromium, and selenium were present at concentrations below the background criteria and are not considered site-related. Of the 12 remaining non-nutrient analytes, six are process-related metals occurring at concentrations exceeding the background criteria, and six are metals from the expanded suite for which no background criteria are available. All but one process-related SRC, in addition to beryllium, cobalt, copper, nickel, thallium, or vanadium, are present at concentrations either within or below the range of USGS reference values. Zinc occurs above the maximum USGS reference value (110 mg/kg), and there is no published USGS reference value for thallium in Ohio (Table 4.8).

All of the process-related metals were detected in all 14 samples, with the exception of cadmium, which was detected in 12 samples. Zinc was the most frequently detected at concentrations exceeding the background criteria, occurring in 8 of 14 samples at concentrations above 72.1 mg/kg. The range of concentrations detected for zinc was from 39.1 to 208 mg/kg. Cadmium and barium were each detected above the background criteria (0.29 mg/kg and 75 mg/kg, respectively) in five samples. Cadmium detections ranged from 0.07 to 0.72 mg/kg, and barium was detected from 15.8 to 107 mg/kg.

Lead and manganese were each detected above the background criteria (17.9 and 728 mg/kg, respectively) in three samples. Lead concentrations ranged from 7.8 to 21.4 mg/kg, while manganese concentrations ranged from 91.9 to 895 mg/kg. Mercury exceeded the background criteria (0.08 mg/kg) in two samples, with a maximum concentration of 0.11 mg/kg.

The maximum concentration of manganese (895 mg/kg) was found at LL4sd-044, which is the location where the highest concentrations of explosives were detected. Barium, cadmium, lead, mercury, and zinc were detected at their maximum concentrations at LL4sd-053, in the settling pond (Table 4.8).

Two samples were analyzed for the expanded suite of 23 TAL metals: LL4sd-051 in the ditch outfall from the settling pond, and LL4sd-052 within the pond. LL4sd-052 is the locus of maximum concentrations for the following analytes: beryllium (0.62 mg/kg), cobalt (9.1 mg/kg), copper (16.2 mg/kg), nickel (18.0 mg/kg), thallium (1.3 mg/kg, not detected elsewhere), and vanadium (15.9 mg/kg). Because these metals were detected in both samples, it is likely that the occurrence of these metals extends to other parts of Load Line 4.

Cyanide was detected in one sediment sample, LL4sd-051, at a concentration of 0.16 mg/kg. This sample contained no explosives.

Organic Compounds

The organic compounds detected in Load Line 4 sediment samples bear little resemblance to the assemblage found in Load Line 4 surface soils, which presumably make their way to the settling pond through storm runoff. VOCs consist of 2-butanone (0.053 mg/kg), acetone (0.25 mg/kg), and carbon disulfide (0.013 mg/kg). No SVOCs, pesticides, or PCB compounds were detected.

4.7.3 Groundwater

Groundwater was collected from three well points installed downgradient from the settling pond at Load Line 4. All samples received the full suite of analyses, including explosives, the expanded metals suite, and cyanide, VOCs, SVOCs, pesticides, and PCBs.

Explosives

Explosives were not detected in any of the well points sampled at Load Line 4.

Inorganic Analytes

Fifteen metals and cyanide were detected in groundwater from Load Line 4 well points. Calcium, magnesium, potassium, and sodium are essential nutrients and were screened out from further consideration. Aluminum, arsenic, barium, beryllium, iron, manganese, and nickel were each detected in all three samples. Cobalt and zinc were detected in two of three samples, and lead and vanadium were detected in one sample. **Table 4.9** lists the range of concentrations detected for each inorganic element. Cyanide was also detected in all three samples. **Figure 4.28** shows the distribution of cobalt, manganese, and zinc in Load Line 4 groundwater.

Table 4.9. Load Line 4 Analytical Results (Groundwater)

Analyte	Frequency of Detects	Minimum Detect (µg/L)	Maximum Detect (µg/L)
GROUNDWATER			
Cyanide	3/ 3	2.7	7.7
Aluminum	3/ 3	23.7	271
Arsenic	3/ 3	5.1	12
Barium	3/ 3	36.1	80
Beryllium	3/ 3	0.33	0.34
Calcium	3/ 3	44600	176000
Cobalt	2/ 3	1	1.6
Iron	3/ 3	1910	29600
Lead	1/ 3	1.9	1.9
Magnesium	3/ 3	18500	50400
Manganese	3/ 3	183	2670
Nickel	3/ 3	0.85	3.9
Potassium	3/ 3	1280	1390
Sodium	3/ 3	7310	7780
Vanadium	1/ 3	0.67	0.67
Zinc	2/ 3	10.1	14.2

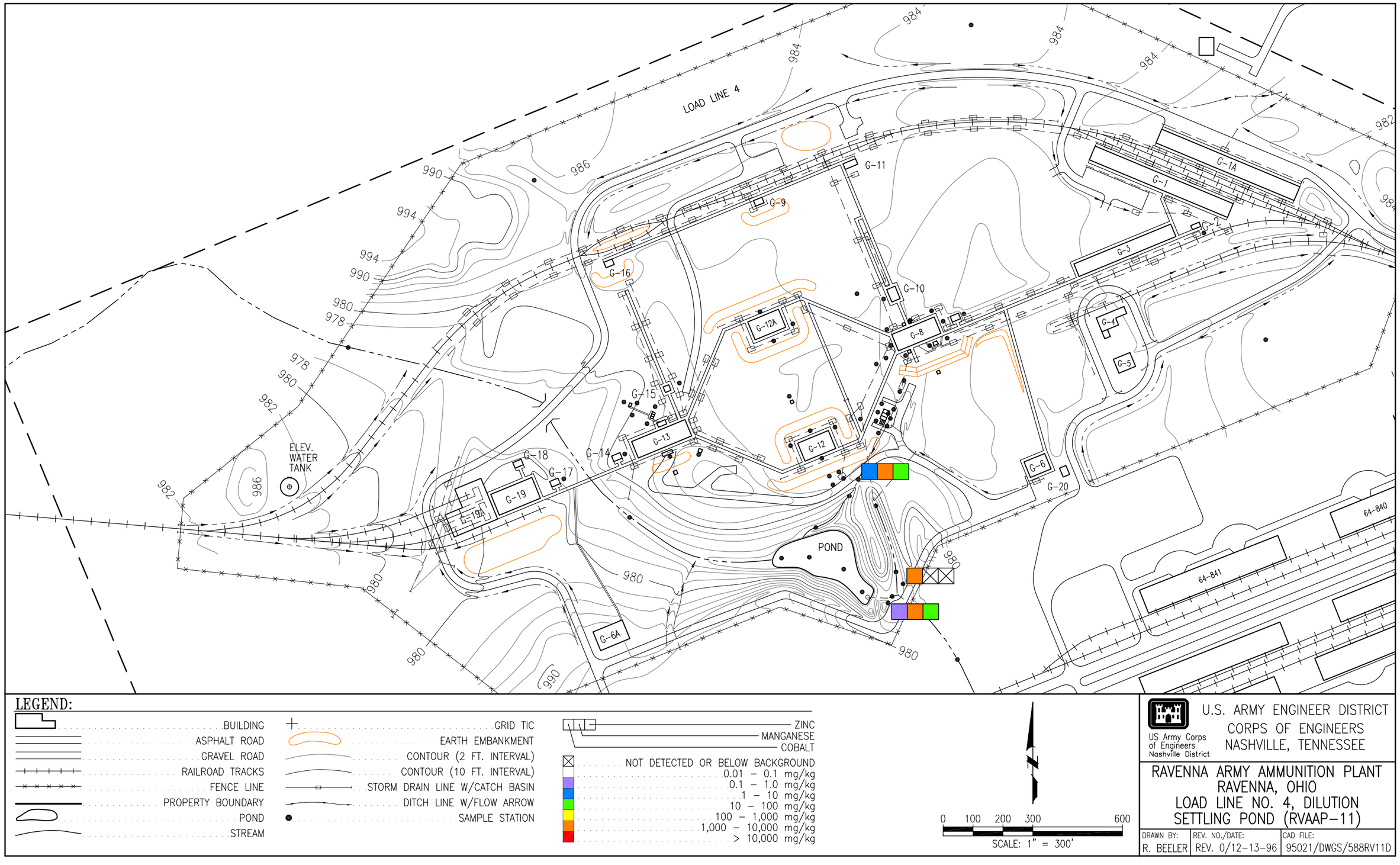


Fig. 4-28. Relative Concentrations of Selected Inorganic Elements in Groundwater at LL4

Organic Compounds

Organic vapor monitoring of groundwater extracted from the well points produced no readings on hand-held instruments.

No organic constituents were detected in groundwater from Load Line 4 well points.

4.7.4 Discussion/Summary of Results

The interpretation of the chemical data acquired in Load Line 4 during the Phase I RI is summarized as follows:

Surface Soils

- TNT was present in nine of the 46 sample locations. These samples are associated with Buildings G-8, the washout facility south of Building G-8, and Buildings G-12, G-12A, and G-13.

- Inorganic analytes are present in all samples, but are found at the highest concentrations above background outside of Buildings G-12 and G-12A, G-8 and its unnamed outbuilding, G-13, and G-17.

- Beryllium, cadmium, cobalt, lead, nickel, and zinc are the most abundant and concentrated of the metals detected in surface soils.

- PAHs and pesticide/PCB compounds are the dominant organic constituents in Load Line 4 soil samples. The greatest concentrations of these analytes are found southeast and east of Building G-8, the southeast corner of Building G-12, and immediately east of Building G-17, and at vacuum pump exhaust outlets at the ammunition cooling building northeast of Building G-12.

Sediments

- TNT is present in sediment upgradient from Load Line 4, where a ditch enters from the east.

- Pond sediments contain no detectable quantities of TNT or other explosives.

- Inorganic analytes suspected to be related to RVAAP processes—e.g.,chromium and arsenic—are present below background concentrations in ditch and pond sediments.

- Pond sediments contain the highest concentrations of several metals such as cadmium, lead, and zinc. Ditch sediments possess these contaminants, but not at high concentrations compared to the ponds.

- Low concentrations of three VOCs were measured in one sediment sample from the settling pond. No other organic constituents were detected.

- 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 were not detected in the perimeter well points installed at Load Line 4.
- Eleven inorganic metals and cyanide were detected in groundwater in at least one well point sampled in Load Line 4.
- No VOCs or SVOCs were detected in groundwater from the perimeter Load Line 4 well points sampled..

4.8 LOAD LINE 12

The Phase I RI sampling at Load Line 12 and Dilution/Settling Pond and Load Line 12 Pink Wastewater Treatment Plant (RVAAP-12 and RVAAP-18) included surface soil and sediment sampling of areas within the AOC. The analytical data are summarized in **Table 4.10** and presented in detail in Table 4.22 and in Appendix G.

4.8.1 Surface Soil

Thirty-one surface soil samples (0 to 1 feet or 0 to 2 feet BGS) were collected from this AOC during the Phase I RI. Sampling locations were generally biased toward known or suspected source areas. Sampling was particularly focused on buildings used for demilitarization operations (Buildings 900 and 904), the Nitrate Settling Basin and Filter Bed, and the Pink Wastewater Treatment Plant. **Figure 4.29** illustrates the location, distribution, and analytical parameters for sampling within this AOC. Analytical parameters for surface soil included explosives (31 samples) and the 11 process-related metals (31 samples). Additionally, eight samples were analyzed for the expanded suite metals, cyanide, pesticides/PCBs, SVOCs, and VOCs to verify the presence or absence of these chemicals within the AOC.

Explosive Compounds

Explosive compounds were detected in surface soil at 18 locations within the AOC as summarized in Table 4.10. TNB, TNT, DNT, HMX, and RDX were detected within the AOC. **Figure 4.30** illustrates the distribution of TNB, TNT, HMX, and RDX in surface soil. In 13 of the 31 surface soil samples covering the remaining portion of the AOC, no explosive compounds were detected.

TNB was detected in three locations, ranging from 0.25 to 4.60 mg/kg, in the vicinity of Building 904 and the Pink Wastewater Treatment Plant. TNT was present at 18 locations with concentrations ranging from 0.45 to 19,000 mg/kg. All but one location with highly elevated (> 10 mg/kg) concentrations and all moderately elevated concentrations (1 to 10 mg/kg) were located in the vicinity of the Building 904 and the Pink Wastewater Treatment Plant. Slightly

Table 4.10. Load Line 12 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	6/ 8	.		0.15	1.6		Yes	No Background Data Available
1,3,5-Trinitrobenzene	µg/kg	3/ 30	.		250	4600		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	18/ 30	.		450	19000000		Yes	Detected > 5% of Samples
2,4-Dinitrotoluene	µg/kg	1/ 30	.		13000	13000		Yes	Detected > 5% of Samples
HMX	µg/kg	6/ 30	.		1300	180000		Yes	No Background Data Available
RDX	µg/kg	8/ 30	.		2800	6800000		Yes	No Background Data Available
Aluminum	mg/kg	30/ 30	15600	3/ 30	2190	105000	20000 - 100000	Yes	> 5% Detect Above Background
Antimony	mg/kg	2/ 8	.		0.86	5.9		Yes	No Background Data Available
Arsenic	mg/kg	30/ 30	19.6	0/ 30	4	17.4	5.2 - 27.0	No	Below Background
Barium	mg/kg	30/ 30	75	16/ 30	20.2	274	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	8/ 8	.		0.27	1.5	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	27/ 30	0.29	16/ 30	0.09	6.6	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	8/ 8	.		2390	171000	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	30/ 30	18.7	7/ 30	7	163	15.0 - 100.0	Yes	> 5% Detect Above Background

Table 4.10 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Cobalt	mg/kg	8/ 8	.		3.6	13.8	7 - 20	Yes	No Background Data Available
Copper	mg/kg	8/ 8	.		14.8	3610	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	8/ 8	.		13700	26700	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	30/ 30	17.9	25/ 30	13.2	589	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	8/ 8	.		937	22500	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	30/ 30	728	3/ 30	42.7	1760	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	13/ 30	0.08	2/ 30	0.04	0.32	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	8/ 8	.		10.2	199	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	8/ 8	.		404	1130	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	28/ 30	2.6	0/ 30	0.34	2.2	<0.1 - 1.2	No	Below Background
Silver	mg/kg	3/ 30	0.24	3/ 30	0.5	4.7	0.7	Yes	> 5% Detect Above Background
Sodium	mg/kg	8/ 8	.		167	370	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	7/ 8	.		0.91	4.3		Yes	No Background Data Available
Vanadium	mg/kg	8/ 8	.		5.7	26.9	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	30/ 30	72.1	18/ 30	33.9	1030	25 - 110	Yes	> 5% Detect Above Background
4,4'-DDE	µg/kg	2/ 8	.		4.9	39		Yes	No Background Data Available

Table 4.10 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
4,4'-DDT	µg/kg	3/ 8	.		3.5	25		Yes	No Background Data Available
Alpha chlordane	µg/kg	2/ 8	.		20	38		Yes	No Background Data Available
Aroclor-1254	µg/kg	2/ 8	.		760	1700		Yes	No Background Data Available
Aroclor-1260	µg/kg	1/ 8	.		2600	2600		Yes	No Background Data Available
Endosulfan II	µg/kg	1/ 8	.		3.3	3.3		Yes	No Background Data Available
Endrin	µg/kg	6/ 8	.		4.7	110		Yes	No Background Data Available
Endrin aldehyde	µg/kg	1/ 8	.		31	31		Yes	No Background Data Available
Endrin ketone	µg/kg	1/ 8	.		38	38		Yes	No Background Data Available
Gamma chlordane	µg/kg	2/ 8	.		7.2	38		Yes	No Background Data Available
Gamma-BHC (lindane)	µg/kg	1/ 8	.		15	15		Yes	No Background Data Available
Heptachlor	µg/kg	2/ 8	.		1.9	8.1		Yes	No Background Data Available
Heptachlor epoxide	µg/kg	1/ 8	.		2.8	2.8		Yes	No Background Data Available
Methoxychlor	µg/kg	1/ 8	.		47	47		Yes	No Background Data Available
1,2,4-Trichlorobenzene	µg/kg	1/ 8	.		85	85		Yes	No Background Data Available

Table 4.10 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
2-Methylnaphthalene	µg/kg	4/ 8	.		81	260		Yes	No Background Data Available
Acenaphthene	µg/kg	5/ 8	.		44	2700		Yes	No Background Data Available
Acenaphthylene	µg/kg	2/ 8	.		81	280		Yes	No Background Data Available
Anthracene	µg/kg	5/ 8	.		120	8700		Yes	No Background Data Available
Benzo(a)anthracene	µg/kg	6/ 8	.		240	14000		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	6/ 8	.		240	12000		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	5/ 8	.		290	11000		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	6/ 8	.		160	8500		Yes	No Background Data Available
Benzo(k)fluoranthene	µg/kg	6/ 8	.		170	14000		Yes	No Background Data Available
Bis(2-ethylhexyl)phthalate	µg/kg	4/ 8	.		40	220		Yes	Detected > 5% of Samples
Carbazole	µg/kg	5/ 8	.		110	3800		Yes	No Background Data Available
Chrysene	µg/kg	6/ 8	.		240	13000		Yes	No Background Data Available
Dibenzo(a,h)anthracene	µg/kg	6/ 8	.		66	4400		Yes	No Background Data Available
Dibenzofuran	µg/kg	4/ 8	.		280	1900		Yes	No Background Data Available

Table 4.10 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Fluoranthene	µg/kg	7/ 8	.		73	30000		Yes	No Background Data Available
Fluorene	µg/kg	5/ 8	.		42	3200		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	6/ 8	.		130	9200		Yes	No Background Data Available
Naphthalene	µg/kg	3/ 8	.		130	270		Yes	No Background Data Available
Phenanthrene	µg/kg	6/ 8	.		140	23000		Yes	No Background Data Available
Pyrene	µg/kg	6/ 8	.		380	25000		Yes	No Background Data Available
Acetone	µg/kg	2/ 6	.		55	99		Yes	No Background Data Available
Toluene	µg/kg	2/ 7	.		7	16		Yes	Detected > 5% of Samples
SEDIMENT									
Cyanide	mg/kg	1/ 3	.		1.4	1.4		Yes	No Background Data Available
1,3,5-Trinitrobenzene	µg/kg	1/ 19	.		660	660		Yes	No Background Data Available
2,4,6-Trinitrotoluene	µg/kg	5/ 19	.		160	170000		Yes	Detected > 5% of Samples
Aluminum	mg/kg	19/ 19	15600	1/ 19	6870	18500	20000 - 100000	Yes	> 5% Detect Above Background
Antimony	mg/kg	1/ 3	.		2.6	2.6		Yes	No Background Data Available

Table 4.10 (continued)

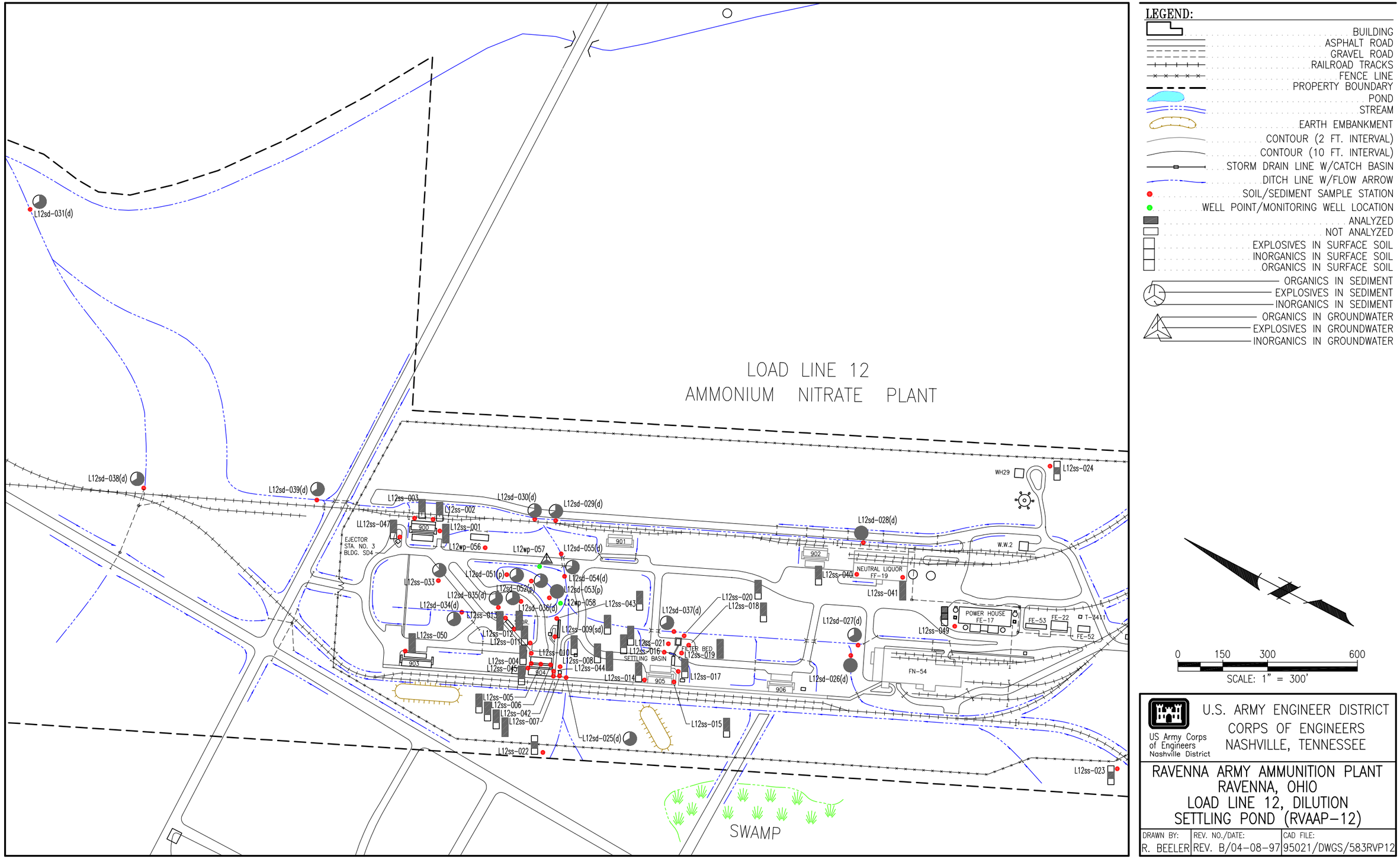
Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Arsenic	mg/kg	19/ 19	19.6	3/ 19	4	217	5.2 - 27.0	Yes	> 5% Detect Above Background
Barium	mg/kg	19/ 19	75	5/ 19	26.7	170	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	3/ 3	.		0.66	2.5	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	18/ 19	0.29	11/ 19	0.09	2	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	3/ 3	.		2710	4510	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	19/ 19	18.7	5/ 19	8.2	27.7	15.0 - 100.0	Yes	> 5% Detect Above Background
Cobalt	mg/kg	3/ 3	.		8	27.7	7 - 20	Yes	No Background Data Available
Copper	mg/kg	3/ 3	.		28.9	399	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	3/ 3	.		19400	48800	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	19/ 19	17.9	12/ 19	10.3	88.7	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	3/ 3	.		2160	2420	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	19/ 19	728	1/ 19	53.7	1170	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	8/ 19	0.08	6/ 19	0.06	1.2	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	3/ 3	.		19	59.7	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	3/ 3	.		800	1050	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	16/ 19	2.6	0/ 19	0.41	2.4	<0.1 - 1.2	No	Below Background

Table 4.10 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Silver	mg/kg	2/ 19	0.24	2/ 19	0.47	58	0.7	Yes	> 5% Detect Above Background
Sodium	mg/kg	3/ 3	.		287	654	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	3/ 3	.		0.74	2.4		Yes	No Background Data Available
Vanadium	mg/kg	3/ 3	.		16.1	22.7	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	19/ 19	72.1	16/ 19	57.3	794	25 - 110	Yes	> 5% Detect Above Background
Aroclor-1254	µg/kg	1/ 3	.		310	310		Yes	No Background Data Available
Heptachlor	µg/kg	1/ 3	.		1.9	1.9		Yes	No Background Data Available
Anthracene	µg/kg	1/ 3	.		350	350		Yes	No Background Data Available
Benzo(a)anthracene	µg/kg	1/ 3	.		460	460		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	1/ 3	.		340	340		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	1/ 3	.		320	320		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	1/ 3	.		240	240		Yes	No Background Data Available
Benzo(k)fluoranthene	µg/kg	1/ 3	.		350	350		Yes	No Background Data Available
Chrysene	µg/kg	1/ 3	.		620	620		Yes	No Background Data Available

Table 4.10 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Fluoranthene	µg/kg	1/ 3	.		1600	1600		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	1/ 3	.		280	280		Yes	No Background Data Available
N-nitrosodiphenylamine	µg/kg	1/ 3	.		2000	2000		Yes	No Background Data Available
Phenanthrene	µg/kg	1/ 3	.		540	540		Yes	No Background Data Available
Pyrene	µg/kg	1/ 3	.		980	980		Yes	No Background Data Available
2-Butanone	µg/kg	1/ 3	.		440	440		Yes	No Background Data Available
Acetone	µg/kg	2/ 3	.		150	870		Yes	No Background Data Available
Carbon disulfide	µg/kg	1/ 3	.		180	180		Yes	No Background Data Available



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
- SOIL/SEDIMENT SAMPLE STATION
- WELL POINT/MONITORING WELL 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

0 150 300 600

SCALE: 1" = 300'

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 12, DILUTION
SETTLING POND (RVAAP-12)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	REV. B/04-08-97	95021/DWGS/583RVP12

Fig. 4-29. LL12 Sample Locations and Analytical Parameters

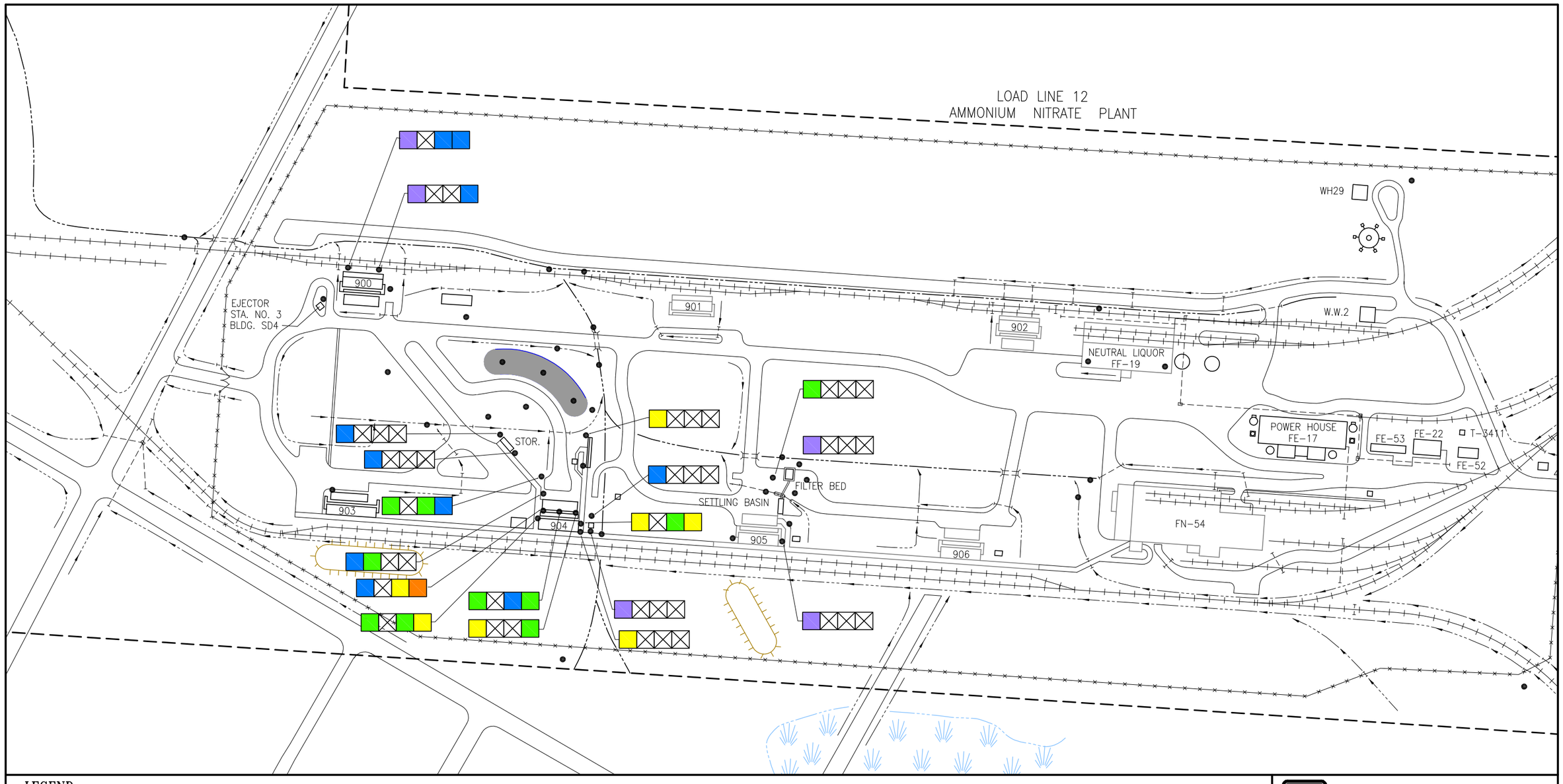


Fig. 4-30. Relative Concentrations of Explosive Compounds in Surface Soil and Sediment at LL12

elevated (< 1 mg/kg) concentrations of TNT were present in the vicinity of the Building 900 fertilizer/demilitarization operations facility, and at the Nitrate Settling Basin and Filter Bed with the exception of L12ss-021 at 14 mg/kg. DNT was detected at L12ss-010 at 13 mg/kg immediately north of the Pink Wastewater Treatment Plant.

HMX was present in five locations in the immediate vicinity of the Pink Wastewater Treatment Plant ranging from 4 to 180 mg/kg, and at L12ss-003 north of the Building 900 fertilizer/demilitarization operations facility at a concentration of 1.3 mg/kg. RMX was detected at eight locations, ranging from 2.8 to 6,800 mg/kg. Four highly and two moderately elevated concentrations were present in the vicinity of the Building 904 demilitarization facility and the Pink Wastewater Treatment Plant. Two moderately elevated samples, L12ss-002 and L12ss-003, were present near the Building 900 fertilizer/demilitarization operations facility.

Inorganic Elements and Compounds

Inorganic analytes, including process-related metals, expanded suite metals, and cyanide, were detected above site background at 25 of 31 locations sampled, as summarized in Table 4.10. Arsenic and selenium were not considered further as the maximum detected concentrations were below the site background value. Of the remaining 16 analytes, nine were process-related metals and seven were from the expanded metals suite, (antimony, beryllium, cobalt, copper, nickel, thallium, and vanadium) and were retained as SRCs because there are no site-background concentrations for comparison. Nine of the SRCs (aluminum, antimony, cadmium, chromium, copper, lead, manganese, mercury, and nickel) exceed the maximum range of the USGS reference values. There are no published USGS reference values for antimony and thallium. The maximum concentrations of seven of these analytes were found at two locations, L12ss-002 and L12ss-041.

Aluminum was detected at concentrations ranging from 2,190 to 10,5000 mg/kg, occurring above site background (15,600 mg/kg) in three samples near Building FF-19 and at the Nitrate Settling Basin and Filter Bed. The maximum concentration is slightly above the maximum range (100,000 mg/kg) of the USGS reference value in L12ss-040 near Building FF-19. Barium was detected as concentrations ranging from 20.2 to 274 mg/kg, and was identified above site background (75 mg/kg) in 16 samples. These results are below the USGS reference value range of 300 to 700 mg/kg with no apparent outliers.

Cadmium was detected at concentrations ranging from 0.09 to 6.6 mg/kg, occurring above site background (0.29 mg/kg) in 15 samples distributed across the AOC as shown in **Figure 4.31**. The highest concentrations of cadmium (greater than 2 mg/kg) were located in the vicinity of Buildings 900 and FF-19, and the Pink Wastewater Treatment Plant. Five samples (L12ss-001, L12ss-002, L12ss-003, L12ss-004, and L12ss-041) exceeded the maximum USGS reference value of 2 mg/kg. Chromium was detected at concentrations ranging from 7 to 163 mg/kg, and was present above site background (18.7 mg/kg) in seven samples in the vicinity of Buildings 900 and FF-19, and the Pink Wastewater Treatment Plant. Two of these samples (L12ss-040 and L12ss-041) exceed the maximum USGS reference value of 100 mg/kg. The distribution of chromium above site background is shown in Figure 4.31.

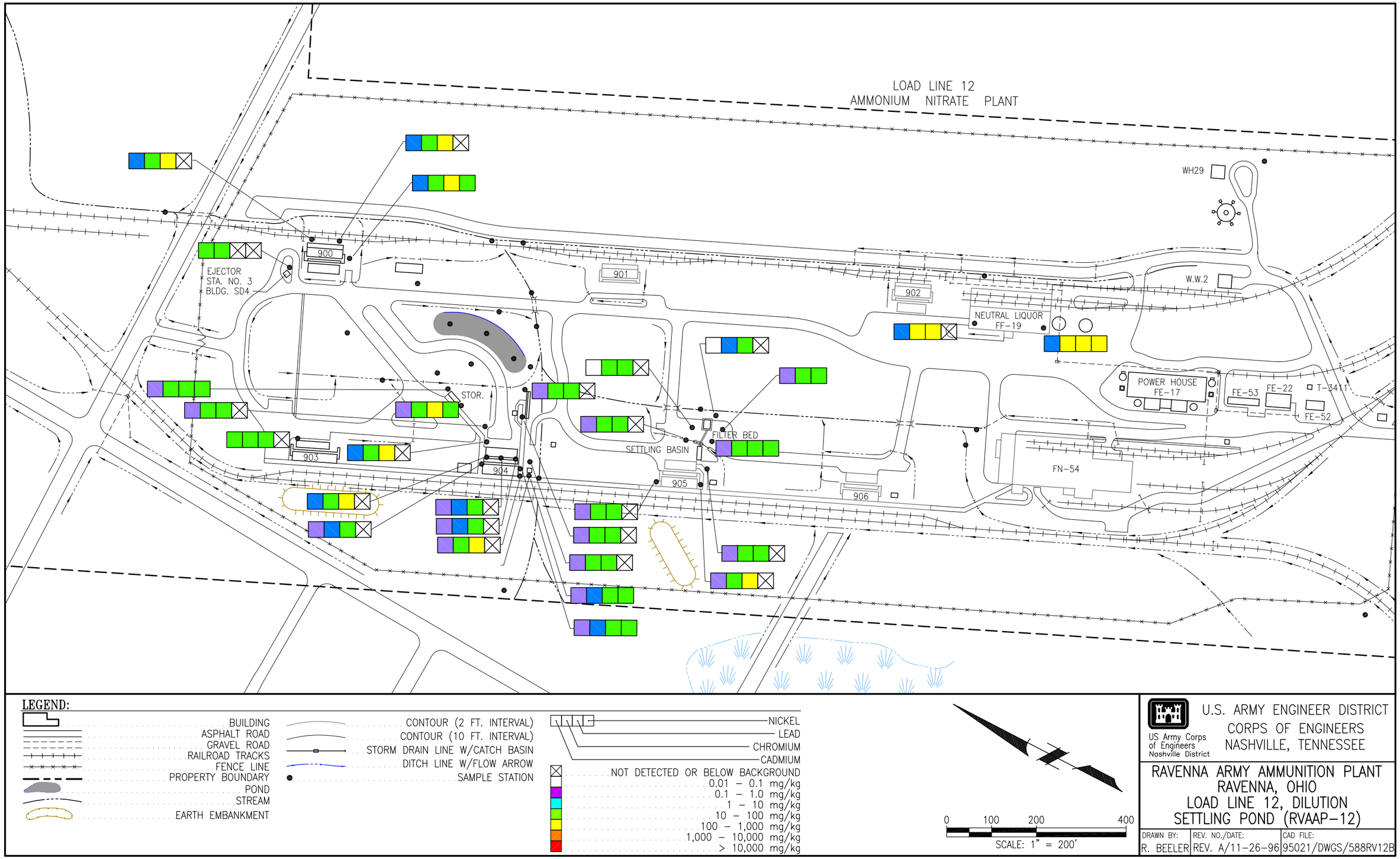


Fig. 4-31. Relative concentrations of Selected Inorganic Elements in Surface Soil at LL12

Lead was detected ranging in concentration from 13.2 to 589 mg/kg, occurring above site background (17.9 mg/kg) in 25 samples. Five samples (L12ss-040, L12ss-041, L12ss-042, L12ss-044, and L12ss-049) near Buildings FF-19 and 904 exceed the maximum USGS reference value of 30 mg/kg. Figure 4.31 illustrates lead concentrations in excess of site background. Manganese was present at detected concentrations from 42.7 to 1,760 mg/kg, and was above the site background value (728 mg/kg) in three samples, primarily near Building 900. One sample (L12ss-041) demonstrates a concentration greater than the maximum USGS reference value of 1,000 mg/kg. Mercury was detected at concentrations from 0.04 to 0.32 mg/kg, and was identified above site background (0.08 mg/kg) in two samples near Buildings 900 and 904; both of which slightly exceed the USGS reference value maximum concentration of 0.22 mg/kg.

Silver was detected above site background (0.24 mg/kg) in three of eight samples, ranging from 0.5 to 4.7 mg/kg. These samples were located primarily in the vicinity of Building FF-19, and also exceed the USGS reference values of 0.7 mg/kg. Zinc was detected at concentrations from 33.9 to 1,030 mg/kg, and was present above the site background value of 72.1 mg/kg in 18 samples across the AOC These results exceed the maximum USGS reference values of 110 mg/kg.

All seven non-nutrient expanded metals suite analytes were detected in surface soils in Load Line 12. Beryllium, cobalt, copper, nickel, and vanadium were detected in all eight samples in which they were analyzed. Beryllium, cobalt, and vanadium concentrations were below or within the range of USGS reference values. Copper and nickel exceeded the maximum range of USGS reference values in one sample (L12ss-041). Thallium was detected in seven of eight samples, ranging from 0.91 to 4.3 mg/kg. There is no published USGS reference value for this analyte. Antimony was detected in two samples, ranging from 0.86 to 5.9 mg/kg, near Buildings FF-19 and 900. Cyanide was detected in six of eight samples. There are no USGS reference values for either of these analytes.

Organic Compounds

Organic analytes, including pesticides/PCBs, SVOCs, and VOCs, were detected in surface soils at Load Line 12 (Table 4.10). Of the pesticide/PCB compounds, 12 individual pesticides were identified at eight locations, and two PCBs were identified at 2 locations. SVOCs detected included 16 PAHs, one phthalate compound, one furan compound, 2-methylnaphthalene, and carbazole distributed across the eight sample locations. Two VOCs, acetone and toluene, were detected at low concentrations at four locations.

PAH compounds detected within the AOC include acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene (Table 4.10). For all 16 PAHs, the highest or second highest concentrations for each individual analyte was located at either L12ss-012 or L12ss-041 with one exception (the highest concentration of naphthalene was detected at L12ss-044). Concentrations of PAHs at other locations were typically 5 to 10 times less than the two highest concentrations. **Figure 4.32** illustrates the distribution of summed PAHs for all detected above the CDRL and summed carcinogenic PAHs. The highest

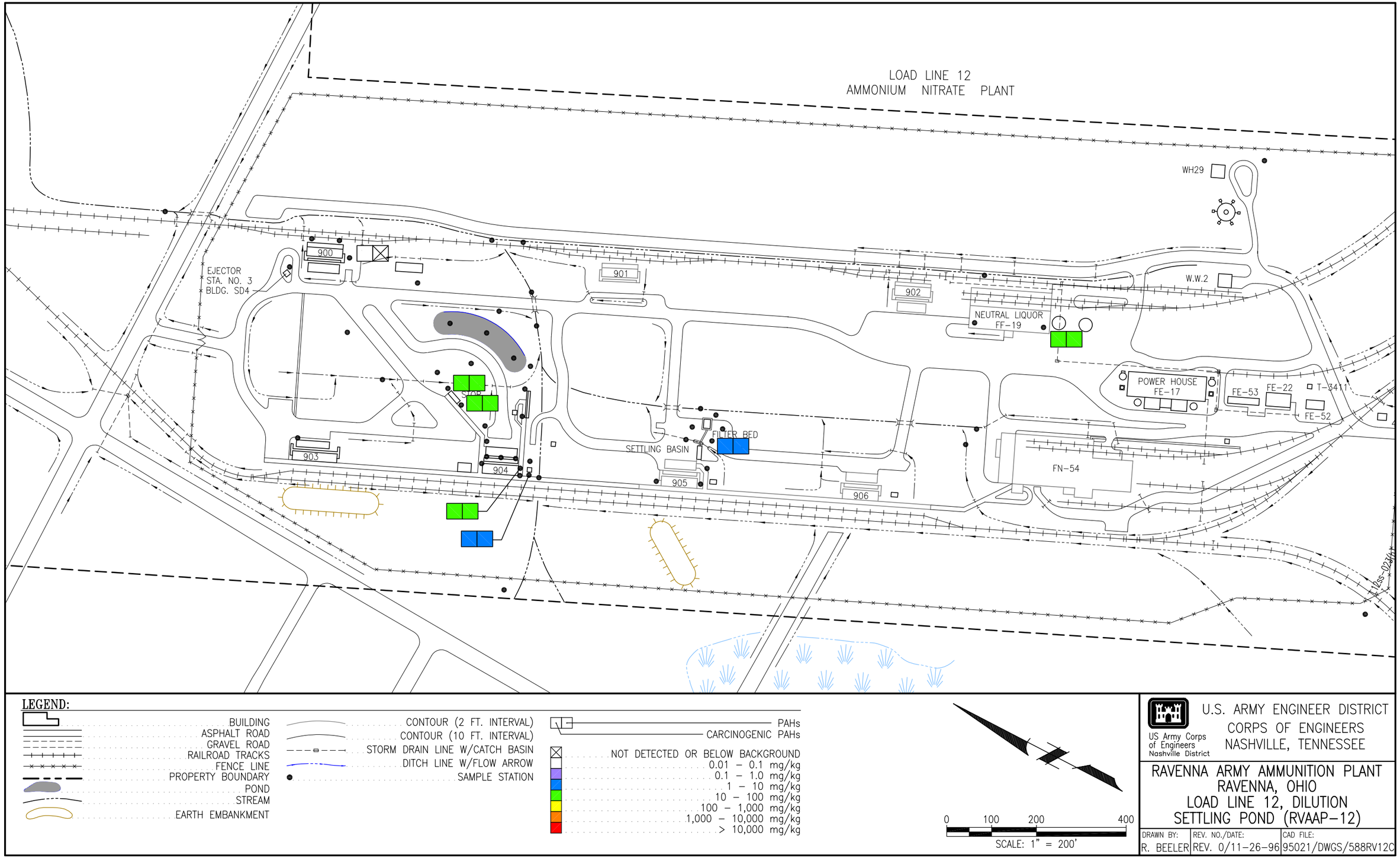


Fig. 4-32. Relative Concentrations of Total PAHs and Total Carcinogenic PAHs in Surface Soil at LL12

concentrations of PAHs were associated with Building FF-19 and near a reinforced storage building at the northern end of the Building 904 demilitarization facility.

Pesticides/PCBs detected within the AOC include 4,4'-DDE, 4,4'-DDT, alpha chlordane, Aroclor-1254, Aroclor-1260, endosulfan I, endrin, endrin aldehyde, endrin ketone, gamma chlordane, gamma-BHC, heptachlor, heptachlor epoxide, and methoxychlor (Table 4.10). The maximum detected concentrations for nine of these compounds were detected at location L12ss-041, and the maximum concentrations of three of the four remaining compounds were detected at L12ss-001. Compounds with concentrations in excess of 0.1 mg/kg include Aroclor-1254 (0.76 mg/kg at L12ss-001 and 1.7 mg/kg at L12ss-041), Aroclor-1260 (2.6 mg/kg at L12ss-041), and endrin (0.11 mg/kg at L12ss-041).

Figure 4.33 illustrates the distribution of pesticides/PCBs within the AOC. The greatest number of pesticides appear to have been used/stored in the vicinity of Building FF-19. Endrin was the most commonly detected pesticide, which may reflect its preference as a pesticide at this facility or the persistence of this compound in the environment.

Other SVOCs detected include 1,2,4-trichlorobenzene, 2-methylnaphthalene, bis(2-ethylhexyl)phthalate, carbazole, and dibenzofuran (Table 4.10). With one exception for the five remaining SVOCs, the highest and second highest concentrations were all found in three samples (L12ss-012, L12ss-041, and L12ss-044), which corresponds closely to the spatial distribution of PAHs. The concentrations of these SVOCs in the remaining samples typically were more evenly distributed than the PAHs. These compounds were primarily located in the vicinity of Building 904 (L12ss-007 and L12ss-044), the reinforced storage building (L12ss-012 and L12ss-013), and Building FF-19 (L12ss-041).

Two VOCs were identified at relatively low concentrations in four samples in four different locations. Acetone was detected in L12ss-012 and L12ss-013, ranging from 0.055 to 0.099 mg/kg. Toluene was detected in L12ss-007 and L12ss-041 at 0.007 and 0.016 mg/kg. Both of these compounds are possible laboratory contaminants, however, the presence of SVOCs at elevated concentrations in these same samples may indicate slight VOC contamination as well.

4.8.2 Sediment

Nineteen ditch and pond sediment samples were collected at Load Line 12 and analyzed for explosives and the 11 process-related inorganic elements. Three of these samples were also analyzed for the expanded metals suite, cyanide, VOCs, SVOCs, and PCBs/pesticides to verify whether these chemicals were present in sediments at this load line. The sample locations and analytical parameters for each sample are shown on Figure 4.29. The analytical data are summarized in Table 4.10 and presented in detail in Appendix G. Geotechnical grain size distribution curves are presented in Appendix G.4. TOC ranged from 5,780 mg/kg in L12sd-035 to 91,900 mg/kg in L12sd-028.

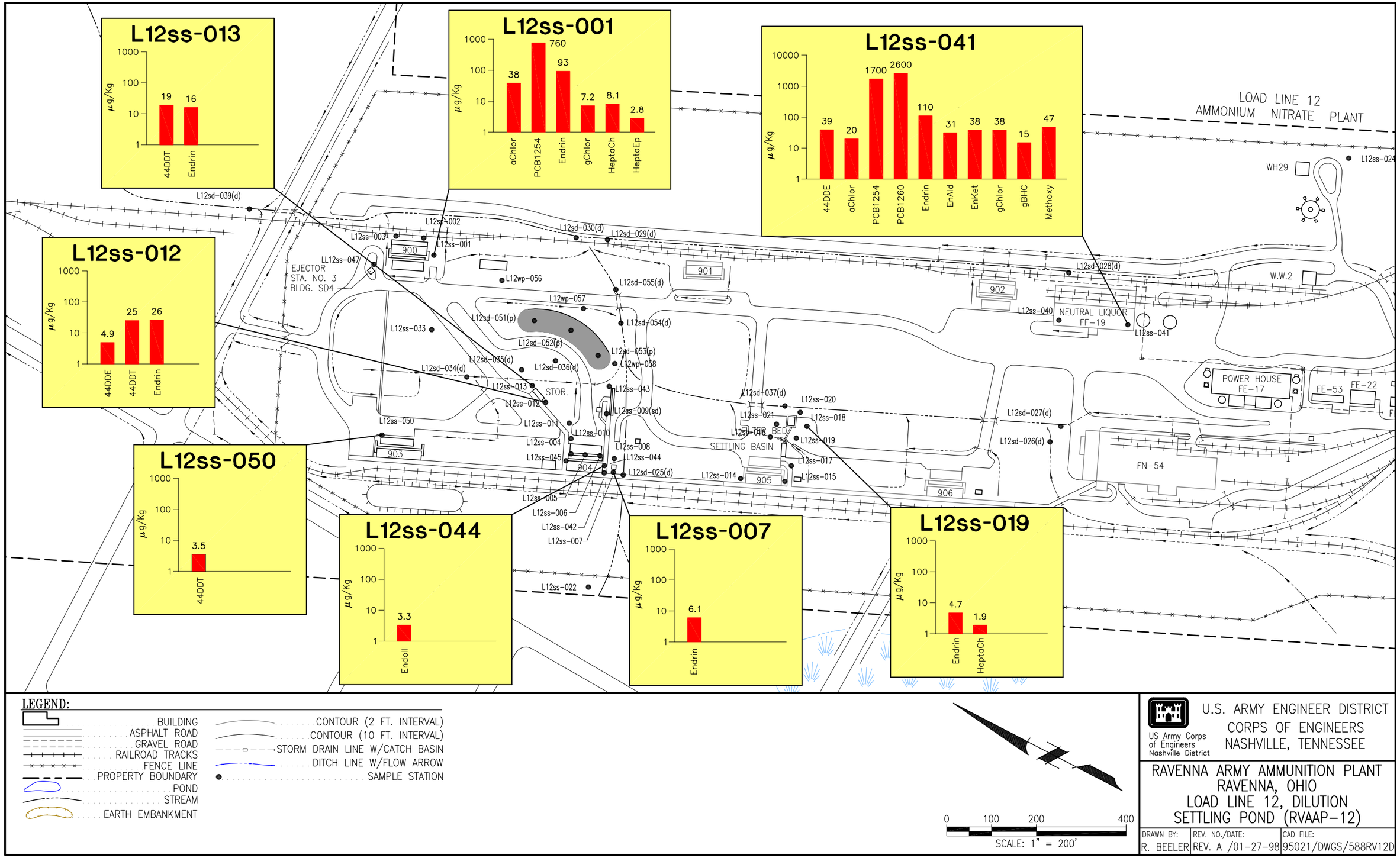


Fig. 4-33. Relative Concentrations of PCBs and Pesticides in Surface Soil at LL12

Explosive Compounds

Two explosives, TNT and TNB, were detected in a total of five sediment samples at Load Line 12. TNT was detected in five sediment samples (Figure 4.30) with concentrations ranging from 0.016 mg/kg at L12sd-038 to 170 mg/kg at L12sd-037. TNB was also detected in L12sd-037 with a concentration of 0.66 mg/kg. This sediment sample is located just north of the Nitrate Settling Basin and Filter Bed. Fourteen sediment samples had no detectable concentrations of explosives.

Inorganic Elements and Compounds

Twenty-three inorganic elements, and cyanide, were detected in sediments in Load Line 12. Selenium was screened out because the maximum detected concentration was less than the background criteria. The remaining 17 non-nutrient elements and cyanide were retained as SRCs because they either had concentrations exceeding the site-specific background criteria, or no background criteria existed (Table 4.10).

Ten of the 11 process-related metals were detected at concentrations exceeding background (Table 4.10). Zinc was the most frequently detected metal in this group, with concentrations ranging from 57.3 to 794 mg/kg, and 16 detections exceeding the background criteria (72.1 mg/kg). Concentrations above background ranged from 76 mg/kg in L12sd-037 to 794 mg/kg in L12sd-028. Nine detections also exceeded the USGS Ohio reference values of 25 to 110 mg/kg. Lead was detected at concentrations from 10.3 to 88.7 mg/kg, and exceeded the background criteria (17.9 mg/kg) in 12 samples, with detections above background ranging from 18 mg/kg in L12sd-037 to 88.7 mg/kg in L12sd-028. Four detections exceeded the USGS reference values of 15 to 30 mg/kg. Cadmium was detected from 0.09 to 2 mg/g, and exceeded the background criteria in 11 samples. The maximum concentration was detected in L12sd-028. All detections were within the range of USGS reference values (1 to 2 mg/kg).

Mercury was detected at concentrations from 0.06 to 1.2 mg/kg, occurring above background criteria in six samples, with concentrations ranging from 0.09 mg/kg at L12sd-031 to 1.2 mg/kg, which was detected in L12sd-028 (**Figure 4.34**). The maximum concentration exceeded the maximum USGS reference value (0.22 mg/kg). Barium and chromium were each detected above the background criteria in five samples. Both analytes were detected in L12sd-026, -027, and -028, as well as -039, and the maximum concentration for each occurred in L12sd-026. All detections of both elements were within the range of USGS Ohio reference values (Table 4.10). Arsenic was detected in three samples at concentrations exceeding background, from 22.7 mg/kg in L12sd-039 to 217 mg/kg in L12sd-028. Two of the three detections also exceed the maximum range of USGS reference values (Figure 4.34).

Silver was detected above background criteria in two samples, with concentrations of 0.47 mg/kg at L12sd-031 and 58 mg/kg in L12sd-039. The maximum detection exceeds the USGS reference value (0.7 mg/kg). Aluminum and manganese were each detected above background in one sample, aluminum with a concentration of 18,500 mg/kg in L12sd-028, and manganese at 1,170 mg/kg in L12sd-039.

LOAD LINE 12
AMMONIUM NITRATE PLANT

WH29

EJECTOR
STA. NO. 3
BLDG. SD4

900

901

902

W.W.2

NEUTRAL LIQUOR
FF-19

POWER HOUSE
FE-17

FE-53

FE-22

T-3411

FE-52

STOR.

FILTER BED

SETTLING BASIN

903

904

905

906

FN-54

Uss-023/1

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
- ARSENIC
- MERCURY
- NICKEL
- 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

0 100 200 400
SCALE: 1" = 200'

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 12, DILUTION
SETTLING POND (RVAAP-12)

DRAWN BY:	REV. NO./DATE:	CAD FILE:
R. BEELER	REV. 0/11-27-96	95021/DWGS/588RV12E

Fig. 4-34. Relative Concentrations of Selected Inorganic Elements in Sediment at LL12

The maximum concentration of six process-related metals occurred in sample L12sd-028 (aluminum, arsenic, cadmium, lead, mercury, and zinc), and the maximum concentration of three additional process-related metals (barium, manganese, and silver) occurred at L12sd-039. L12sd-028 is located northeast of Building FF-19, and L12sd-039 is located in the main drainage channel exiting Load Line 12 to the north. Process-related metals were also detected in L12sd-029 and -030, located between the two sediment samples with the highest concentrations, but detected concentrations were less frequently in excess of site background, suggesting the contamination present in L12sd-028 and -039 is derived from the nearby source areas (Building FF-19 and Building 900 areas) and not migrating along the drainage channel. Figure 4.31 shows the distribution and relative concentrations of arsenic, mercury, and nickel.

Detected expanded suite metals include beryllium, cobalt, copper, nickel, thallium, and vanadium, each detected in three of three samples, and antimony, which was detected once. Table 4.10 gives the range of detected concentrations, and the relative concentration of nickel is illustrated on Figure 4.34. There were no site-specific background criteria available for comparison for these analytes, but beryllium, cobalt, copper, and nickel occurred at concentrations exceeding the maximum USGS reference value (Table 4.10). There is no published USGS value for antimony or thallium.

Organic Compounds

VOCs, SVOCs, and PCBs/pesticides were detected in the three sediment samples analyzed for organic constituents in Load Line 12. VOCs 2-butanone, acetone, and carbon disulfide were all detected in sediment sample L12sd-028; acetone was also detected in L12sd-053. The concentrations for these chemicals are given in Table 4.10. SVOCs are primarily composed of PAHs, all of which were detected in L12sd-028 in concentrations ranging from 0.24 mg/kg to 1.6 mg/kg (Table 4.10). Figure 4.32 shows the relative concentrations of total PAHs and total carcinogenic PAHs in sediment. The SVOC n-nitrosodiphenylamine was also detected in L12sd-028 at a concentration of 2 mg/kg. Aroclor-1254 was detected in L12sd-028 at 0.31 mg/kg, and heptachlor was detected in L12sd-053 at a concentration of 0.002 mg/kg.

4.8.3 Groundwater

Two temporary well points were installed immediately downgradient of the settling pond in Load Line 12. Recharge was insufficient in L12wp-058 to collect a sample for analysis, and L12wp-057 yielded only enough water for VOC analysis. There were no VOCs detected in this sample.

4.8.4 Discussion/Summary of Results

Surface Soil

- Explosives were detected at concentrations up to 19,000 mg/kg in three main areas within the AOC: the Building 904 demilitarization facility, the Building 900 fertilizer/demilitarization operations facility, and the Nitrate Settling Basin and Filter Bed

facility. TNT was the most pervasive explosive contaminant detected, but scattered detections of HMX, RDX, and DNT occurred.

- Inorganics were detected in soil throughout the AOC, with concentrations of cadmium, chromium, lead, and mercury occurring often at concentrations above the USGS Ohio reference values. Inorganic contamination was concentrated in the vicinity of Buildings 900, 904, FF-19, and the Nitrate Settling Basin and Filter Bed.

- Organic contamination consists of scattered detections of PAHs at relatively low concentrations (< 1 mg/kg) and a wide variety of pesticides/PCBs. PAHs occur mainly in the vicinity of Building 904 and the demilitarization facility, while pesticides/PCBs are most numerous in the Building 900 and Building FF-19 areas.

Sediment

- Explosives TNT and TNB were detected in sediment samples, but the maximum detected concentration was 170 mg/kg, several orders of magnitude lower than concentrations in soil. Maximum concentrations occurred in the sediment sample located northeast of the Settling Basin/Filter Bed facility.

- Inorganic analytes were detected in sediment samples throughout the AOC with concentrations in excess of the USGS Ohio reference values, but the maximum concentration for almost all metals occurred in either L12sd-028, located in the vicinity of Building FF-19, or L12sd-039, located in the main drainage leading from the AOC to the north.

- Organics were detected in two of the three samples analyzed for these constituents, with the majority of detections occurring in L12sd-028, near Building FF-19. Several organic compounds were also detected in L12sd-053, which is located along the drainage running east from the Building 904 facility.

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

Groundwater

- Two VOCs were detected in the one groundwater sample analyzed from this AOC. Inorganics and other organic compounds were not analyzed in this sample.

4.9 BUILDING 1200 AND DILUTION/SETTLING POND

Building 1200 and the Dilution/Settling Pond sampling activity included surface soil and sediment sampling. The analytical data are summarized on **Table 4.11** and presented in detail in Table 4.23 and in Appendix G.

Table 4.11. Building 1200 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	1/ 1	.		0.21	0.21		Yes	No Background Data Available
Aluminum	mg/kg	2/ 2	15600	0/ 2	11500	12200	20000 - 100000	No	Below Background
Antimony	mg/kg	1/ 1	.		1.1	1.1		Yes	No Background Data Available
Arsenic	mg/kg	2/ 2	19.6	0/ 2	13.8	13.9	5.2 - 27.0	No	Below Background
Barium	mg/kg	2/ 2	75	1/ 2	69.9	75.8	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	1/ 1	.		0.6	0.6	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	2/ 2	0.29	0/ 2	0.14	0.28	1 - 2	No	Below Background
Calcium	mg/kg	1/ 1	.		1880	1880	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	2/ 2	18.7	0/ 2	14.3	15.6	15.0 - 100.0	No	Below Background
Cobalt	mg/kg	1/ 1	.		8.8	8.8	7 - 20	Yes	No Background Data Available
Copper	mg/kg	1/ 1	.		15	15	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	1/ 1	.		22800	22800	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	2/ 2	17.9	1/ 2	17.4	24.7	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	1/ 1	.		2410	2410	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	2/ 2	728	0/ 2	265	426	150 - 1000	No	Below Background
Nickel	mg/kg	1/ 1	.		18.6	18.6	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	1/ 1	.		932	932	11800 - 25100	No	Essential Nutrient

Table 4.11 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Selenium	mg/kg	2/ 2	2.6	0/ 2	0.63	0.76	<0.1 - 1.2	No	Below Background
Sodium	mg/kg	1/ 1	.		143	143	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	1/ 1	.		1.5	1.5		Yes	No Background Data Available
Vanadium	mg/kg	1/ 1	.		22.1	22.1	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	2/ 2	72.1	0/ 2	51.5	59.9	25 - 110	No	Below Background
Alpha chlordane	µg/kg	1/ 1	.		240	240		Yes	No Background Data Available
Gamma chlordane	µg/kg	1/ 1	.		230	230		Yes	No Background Data Available
Benzo(a)anthracene	µg/kg	1/ 1	.		140	140		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	1/ 1	.		160	160		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	1/ 1	.		140	140		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	1/ 1	.		95	95		Yes	No Background Data Available
Benzo(k)fluoranthene	µg/kg	1/ 1	.		130	130		Yes	No Background Data Available
Bis(2-ethylhexyl)phthalate	µg/kg	1/ 1	.		40	40		Yes	Detected > 5% of Samples
Chrysene	µg/kg	1/ 1	.		160	160		Yes	No Background Data Available
Dibenzo(a,h)anthracene	µg/kg	1/ 1	.		48	48		Yes	No Background Data Available

Table 4.11 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Fluoranthene	µg/kg	1/ 1	.		130	130		Yes	No Background Data Available
Indeno(1,2,3-cd)pyrene	µg/kg	1/ 1	.		96	96		Yes	No Background Data Available
Pyrene	µg/kg	1/ 1	.		130	130		Yes	No Background Data Available
Methylene chloride	µg/kg	1/ 1	.		3	3		Yes	Detected > 5% of Samples
SEDIMENT									
2,4,6-Trinitrotoluene	µg/kg	5/ 7	.		280	2200		Yes	Detected > 5% of Samples
Aluminum	mg/kg	7/ 7	15600	0/ 7	8020	13700	20000 - 100000	No	Below Background
Arsenic	mg/kg	7/ 7	19.6	0/ 7	4.5	17.6	5.2 - 27.0	No	Below Background
Barium	mg/kg	7/ 7	75	4/ 7	64.5	101	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	2/ 2	.		0.45	0.84	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	7/ 7	0.29	1/ 7	0.09	0.51	1 -2	Yes	> 5% Detect Above Background
Calcium	mg/kg	2/ 2	.		562	828	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	7/ 7	18.7	0/ 7	11	17.9	15.0 - 100.0	No	Below Background
Cobalt	mg/kg	2/ 2	. .		4	12.7	7 - 20	Yes	No Background Data Available
Copper	mg/kg	2/ 2	.		13.2	22.5	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	2/ 2	.		21800	28700	15000 - 50000	No	Essential Nutrient

Table 4.11 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Lead	mg/kg	7/ 7	17.9	2/ 7	11.9	19	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	2/ 2	.		1470	3760	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	7/ 7	728	0/ 7	112	679	150 - 1000	No	Below Background
Nickel	mg/kg	2/ 2	.		10.4	29.8	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	2/ 2	.		757	1210	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	7/ 7	2.6	0/ 7	0.57	1.6	<0.1 - 1.2	No	Below Background
Sodium	mg/kg	2/ 2	.		186	210	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	2/ 2	.		0.93	1.4		Yes	No Background Data Available
Vanadium	mg/kg	2/ 2	.		18.7	20.4	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	7/ 7	72.1	2/ 7	39.2	92.5	25 - 110	Yes	> 5% Detect Above Background
Acetone	µg/kg	1/ 2	.		73	73		Yes	No Background Data Available

4.9.1 Surface Soil

Two surface soil samples were collected in the Building 1200 AOC, and analyzed for the 11 process-related metals and explosives. One of the samples was analyzed for the expanded metals suite, VOCs, SVOCs, and pesticides/PCBs, plus cyanide. The location of these samples and the analytical parameters for each are presented on **Figure 4.35**.

Explosives

No explosive compounds were detected in surface soils at Building 1200.

Inorganic Elements and Compounds

Mercury and silver were not detected in any sample. Seven elements were screened out because the maximum detected value was less than the background criteria (Table 4.11). The remaining 10 non-nutrient analytes are considered to be site-related because they were detected at concentrations exceeding the background criteria, or there are no background criteria against which to compare. Barium and lead were detected at concentrations exceeding the background criteria (75.8 mg/kg and 24.7 mg/kg, respectively, both occurring in B12ss-002), and there are no background criteria for antimony, beryllium, cobalt, copper, nickel, thallium, vanadium, and cyanide, which were detected in B12ss-001. All detected concentrations of inorganic chemicals in soils at Building 1200 were within the range of USGS background reference values (Table 4.11), except for thallium, for which there is no published USGS reference value.

Organic Compounds

The sample from B12ss-001 was analyzed for VOCs, SVOCs, and PCBs/pesticides. Methylene chloride, a VOC and common laboratory contaminant, was detected at a concentration of 0.003 mg/kg. The pesticides alpha chlordane and gamma chlordane were each detected, at concentrations of 0.240 and 0.230 mg/kg, respectively. SVOCs include a total of 10 PAH compounds detected in this sample (Table 4.11), with concentrations ranging from 0.048 to 0.160 mg/kg. Of these, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, chrysene, and indeno(1,2,3-cd)pyrene are known to have carcinogenic risks (Section 5). The phthalate bis(2-ethylhexyl)phthalate was also detected at a concentration of 0.040 mg/kg.

4.9.2 Sediment

Seven sediment samples were collected in the drainage leading from Building 1200 and the receiving dilution pond, and analyzed for explosives and the 11 process-related metals. Two of these samples were analyzed for the expanded metals suite, VOCs, SVOCs, PCBs/pesticides, plus cyanide. The location of these samples and the analytical parameters for each are presented on Figure 4.35. Analytical data are summarized on Table 4.11 and presented in detail in Appendix G. Geotechnical grain size distribution curves are presented in Appendix G.4. TOC ranged from 2,910 mg/kg in B12sd-009 to 48,500 mg/kg in B12sd-008.

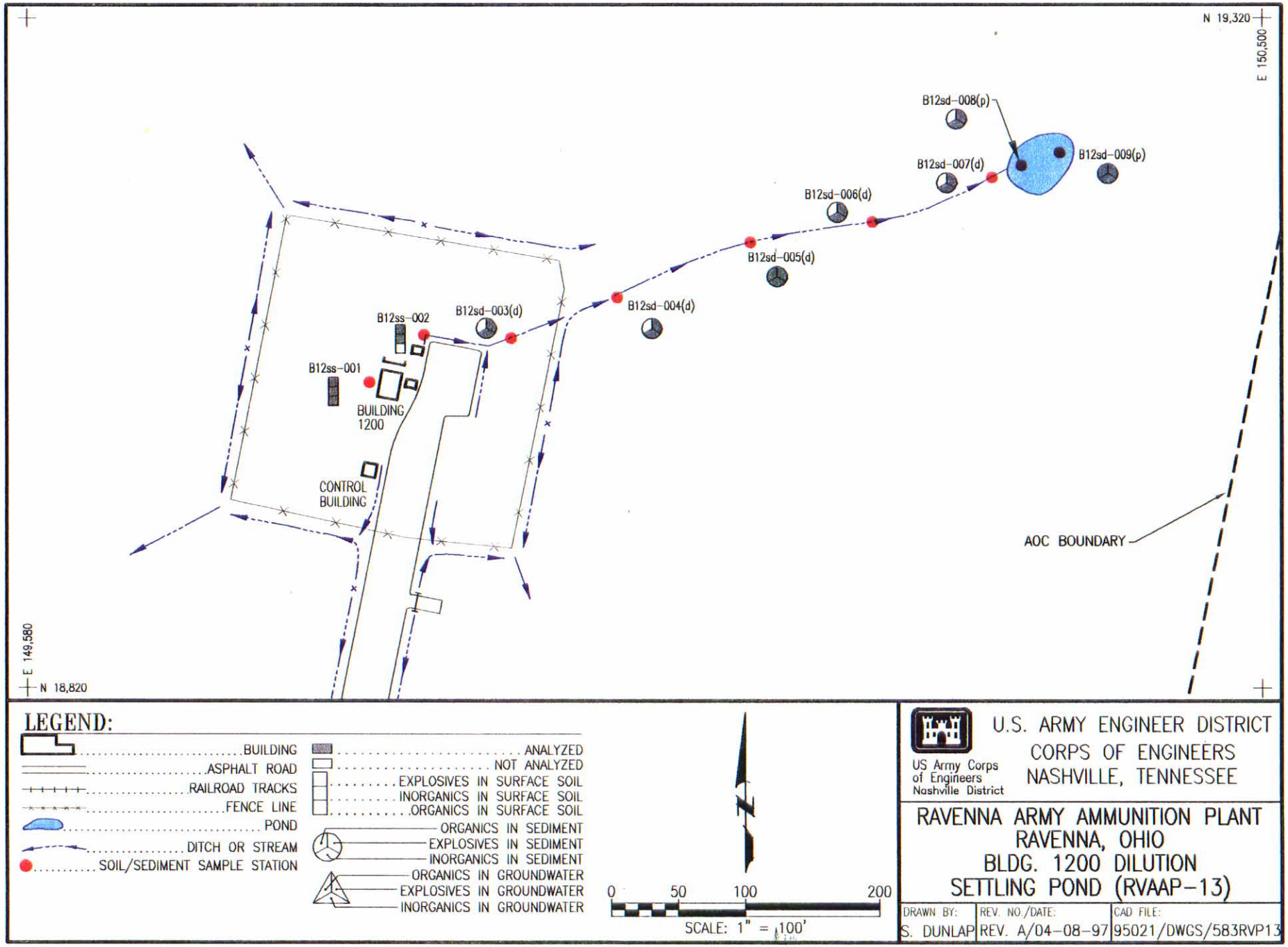


Figure 4.35. Building 1200 Sample Locations and Analytical Parameters

Explosives

The explosive 2,4,6 TNT was detected in five of the seven sediment samples, with concentrations ranging from 0.290 to 2.20 mg/kg (Table 4.11). The highest concentrations were detected in the dilution pond (**Figure 4.36**). No other explosive compounds were detected in sediment in this AOC.

Inorganic Elements and Compounds

Two of the sediment samples (B12sd-005 and -009) were analyzed for the expanded suite of metals and cyanide, the remaining five samples were analyzed only for process-related metals. Antimony, mercury, silver, and cyanide were not detected in any sample. Five elements were detected at concentrations below the background criteria. The remaining 10 non-nutrient elements are considered to be site-related because they were detected at concentrations exceeding the background criteria, or no background value was available (Table 4.11).

Barium was the most frequently detected metal in sediments, occurring above the background criteria (75 mg/kg) in four of seven samples (B12sd-004, -007, -008, and -009) with concentrations above background ranging from 80.7 to 101 mg/kg. Zinc was detected above the background criteria (72.1 mg/kg) in two samples (B12sd-003 and -004) at concentrations of 83 mg/kg and 92.5 mg/kg, respectively. Lead was also detected at concentrations exceeding background (17.9 mg/kg) in two samples, with values of 18 mg/kg in B12sd-004 and 19 mg/kg in B12sd-007. Cadmium exceeded the background criteria (0.29 mg/kg) in B12sd-006 with a concentration of 0.51 mg/kg. These concentrations are not significantly above the background values, and are well within the range of USGS Ohio reference values (Table 4.11). The metals detected from the expanded metals suite also occurred below or within the range of USGS reference values, with the exception of thallium, for which there is no published USGS reference value.

Organic Compounds

Two samples (B12sd-005 and -009) were analyzed for organic compounds. A single hit of acetone, a common laboratory contaminant, was reported at a concentration of 0.073 mg/kg in B12sd-009. No other organic compounds were detected in sediment samples in the Building 1200 AOC.

4.9.3 Discussion/Summary of Results

Inorganic and organic compounds were detected in both soils and sediment, and explosives were detected in sediment in the Building 1200 AOC. Inorganic elements were detected frequently in both media, but at concentrations below or only slightly above the background criteria and well within the range of USGS Ohio reference values. Organic compounds including methylene chloride, bis(2-ethylhexyl)phthalate, PAHs, and pesticides were detected in the one soil sample analyzed for organics, and acetone was detected in the sediment sample analyzed for organic compounds. TNT was detected in five of seven sediment samples, at low concentrations ranging from 0.29 to 2.2 mg/kg. No explosives were

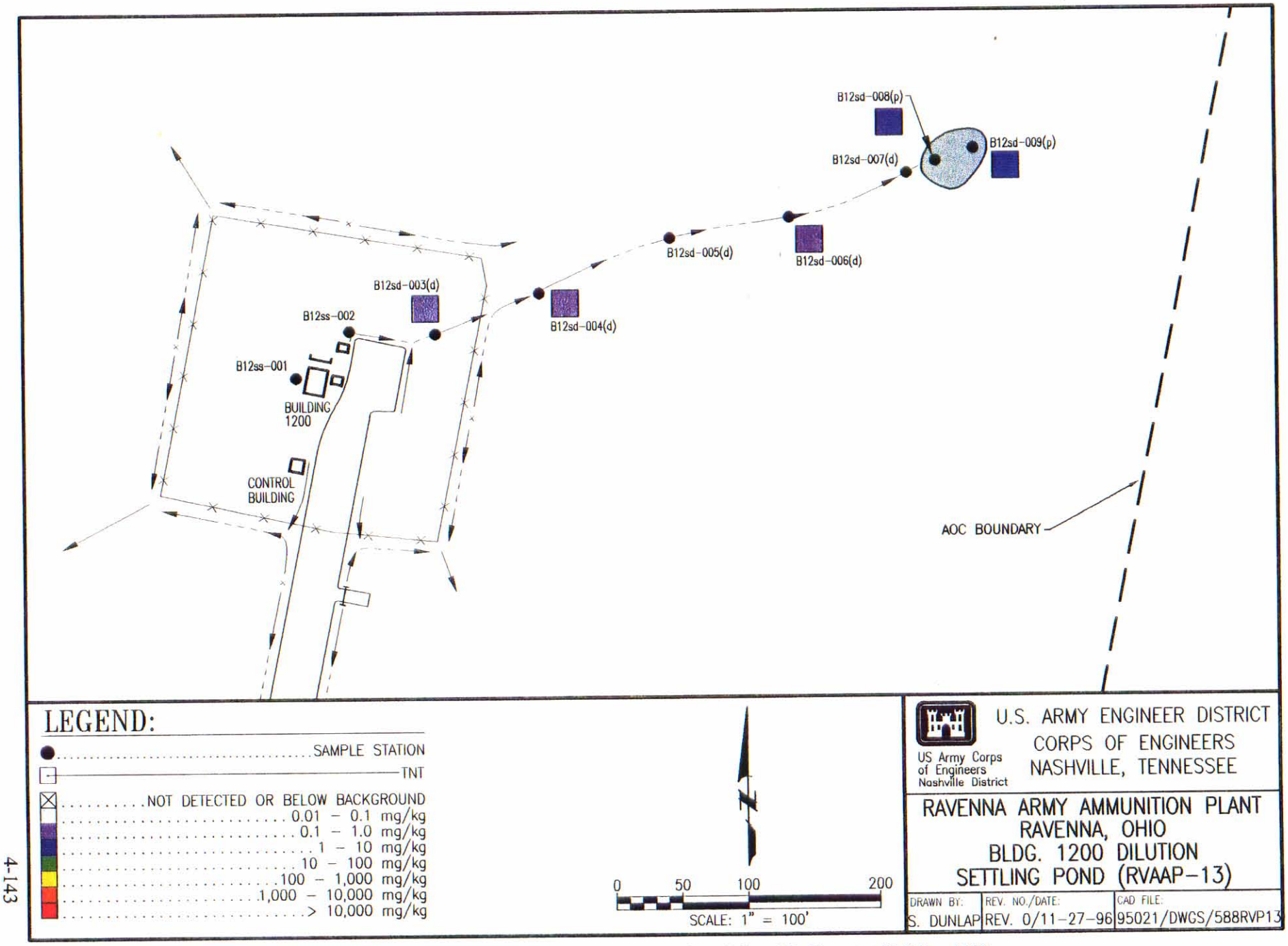


Figure 4.36. Concentration of TNT in Surface Soil and Sediment at Building 1200

detected in soil samples near Building 1200, so it is unlikely that the soil is a source of explosives at this site. The higher concentrations of TNT observed in the dilution/settling pond are expected as trace amounts of this explosive in building effluent are washed in and accumulate. There does not appear to be a pattern of association among grain size, TOC, and contaminant concentrations in sediments sampled at this AOC.

4.10 LANDFILL NORTH OF WINKLEPECK BURNING GROUNDS

The Landfill north of Winklepeck Burning Grounds sampling activity included trench soil sampling, ditch sediment sampling, pond sediment sampling, and groundwater sampling of well points. The analytical data are summarized in **Tables 4.12** (sediment), **and 4.13** (groundwater), and presented in detail in Table 4.24 and in Appendix G.

4.10.1 Geophysical Surveys

A geophysical survey covering approximately 1.6 ha (4 acres) in the vicinity of the former landfill site was conducted during the Phase I RI. The geophysical survey identified 12 to 14 anomalies located in four general areas that indicate the presence of buried metallic debris and waste. The locations of the trench samples were selected based on the geophysical anomalies, and buried material was encountered during sampling activity. The survey report is included in Appendix D of this report.

4.10.2 Soil

A total of nine soil samples were collected from depths ranging from 0 to 0.9 m (0 to 3 feet) BGS at five trench locations in the Landfill AOC. All samples were analyzed for the expanded metals suite, (including the 11 process-related metals), cyanide, explosives, VOC, SVOCs, and PCBs/pesticides. The location of the trench samples and analytical parameters are shown on **Figure 4.37**.

Explosives

No explosive compounds were detected in soil at the Landfill North of Winklepeck Burning Grounds.

Inorganic Elements and Compounds

Mercury was not detected in any soil sample. Seven elements were detected at concentrations below the background criteria (Table 4.12). The remaining 10 non-nutrient elements and cyanide are considered to be site-related chemicals because they were detected in at least one sample at concentrations above the background criteria, or there are no background criteria against which to compare. Cadmium, lead, and zinc were detected at concentrations exceeding their background criteria.

Table 4.12. Landfill North of Winklepeck Burning Grounds Analytical Results (Soil and Sediment)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
SOIL									
Cyanide	mg/kg	3/ 9	.		0.14	0.25		Yes	No Background Data Available
Aluminum	mg/kg	9/ 9	15600	0/ 9	7320	11200	20000 - 100000	No	Below Background
Antimony	mg/kg	1/ 9	.		1.3	1.3		Yes	No Background Data Available
Arsenic	mg/kg	9/ 9	19.6	0/ 9	10	18.5	5.2 - 27.0	No	Below Background
Barium	mg/kg	9/ 9	75	0/ 9	30	53.1	300 - 700	No	Below Background
Beryllium	mg/kg	9/ 9	.		0.35	0.53	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	4/ 9	0.29	2/ 9	0.15	0.52	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	9/ 9	.		549	1740	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	9/ 9	18.7	0/ 9	9	13.1	15.0 - 100.0	No	Below Background
Cobalt	mg/kg	9/ 9	.		6.1	9.4	7 -20	Yes	No Background Data Available
Copper	mg/kg	9/ 9	.		13.1	32.2	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	9/ 9	.		17300	28400	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	9/ 9	17.9	3/ 9	9.9	28.4	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	9/ 9	.		1580	2610	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	9/ 9	728	0/ 9	222	338	150 - 1000	No	Below Background
Nickel	mg/kg	9/ 9	.		11.8	19.3	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	9/ 9	.		467	942	11800 - 25100	No	Essential Nutrient

Table 4.12 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Selenium	mg/kg	9/ 9	2.6	0/ 9	0.45	1.9	<0.1 - 1.2	No	Below Background
Silver	mg/kg	1/ 9	0.24	0/ 9	0.22	0.22	0.7	No	Below Background
Sodium	mg/kg	9/ 9	.		148	197	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	9/ 9	.		0.98	2.4		Yes	No Background Data Available
Vanadium	mg/kg	9/ 9	.		11.1	17.5	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	9/ 9	72.1	4/ 9	40	212	25 - 110	Yes	> 5% Detect Above Background
4,4'-DDD	µg/kg	1/ 8	.		62	62		Yes	No Background Data Available
4,4'-DDE	µg/kg	3/ 9	.		3.4	110		Yes	No Background Data Available
4,4'-DDT	µg/kg	5/ 9	.		2.6	37		Yes	No Background Data Available
Aroclor-1254	µg/kg	1/ 9	.		87	87		Yes	No Background Data Available
Delta-BHC	µg/kg	1/ 9	.		4.9	4.9		Yes	No Background Data Available
Endrin aldehyde	µg/kg	1/ 9	.		2.7	2.7		Yes	No Background Data Available
Heptachlor	µg/kg	2/ 8	.		1.6	1.9		Yes	No Background Data Available
1,4-Dichlorobenzene	µg/kg	1/ 9	.		130	130		Yes	No Background Data Available
Bis(2-ethylhexyl)phthalate	µg/kg	6/ 9	.		37	100		Yes	Detected > 5% of Samples

Table 4.12 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Di-n-butyl phthalate	µg/kg	1/ 9	.		36	36		Yes	No Background Data Available
Chlorobenzene	µg/kg	1/ 9	.		150	150		Yes	No Background Data Available
Methylene chloride	µg/kg	5/ 9	.		4	19		Yes	Detected > 5% of Samples
SEDIMENT									
Cyanide	mg/kg	1/ 1	.		0.34	0.34		Yes	No Background Data Available
Aluminum	mg/kg	7/ 7	15600	1/ 7	3660	16500	20000 - 100000	Yes	> 5% Detect Above Background
Arsenic	mg/kg	7/ 7	19.6	0/ 7	2.5	17.3	5.2 - 27.0	No	Below Background
Barium	mg/kg	7/ 7	75	5/ 7	30.3	186	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	1/ 1	.		0.7	0.7	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	7/ 7	0.29	5/ 7	0.11	1.3	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	1/ 1	.		1990	1990	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	7/ 7	18.7	1/ 7	6.2	20.6	15.0 - 100.0	Yes	> 5% Detect Above Background
Cobalt	mg/kg	1/ 1	.		8.1	8.1	7 - 20	Yes	No Background Data Available
Copper	mg/kg	1/ 1	.		13.4	13.4	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	1/ 1	.		20800	20800	15000 - 50000	No	Essential Nutrient

Table 4.12 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Lead	mg/kg	7/ 7	17.9	4/ 7	10.3	54.5	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	1/ 1	.		2240	2240	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	7/ 7	728	4/ 7	209	1130	150 - 1000	Yes	> 5% Detect Above Background
Mercury	mg/kg	5/ 7	0.08	1/ 7	0.05	0.11	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	1/ 1	.		16.7	16.7	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	1/ 1	.		785	785	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	5/ 7	2.6	1/ 7	0.43	2.7	<0.1 - 1.2	Yes	> 5% Detect Above Background
Silver	mg/kg	1/ 7	0.24	1/ 7	0.61	0.61	0.7	Yes	> 5% Detect Above Background
Thallium	mg/kg	1/ 1	.		3.2	3.2		Yes	No Background Data Available
Vanadium	mg/kg	1/ 1	.		20.1	20.1	20 - 150	Yes	No Background Data Available
Toluene	µg/kg	1/ 1	.		5	5		Yes	Detected > 5% of Samples

Table 4.13. Landfill North of Winklepeck Burning Grounds Analytical Results (Groundwater)

Analyte	Frequency of Detects	Minimum Detect (µg/L)	Maximum Detect (µg/L)
GROUNDWATER			
Aluminum	2/ 2	19.3	140
Antimony	1/ 2	3.9	3.9
Arsenic	1/ 2	9.2	9.2
Barium	2/ 2	14.6	72.1
Beryllium	1/ 2	0.35	0.35
Calcium	2/ 2	28900	73900
Iron	1/ 2	477	477
Lead	1/ 2	1.5	1.5
Magnesium	2/ 2	8880	17800
Manganese	2/ 2	37.1	187
Nickel	2/ 2	3.5	110
Potassium	2/ 2	1410	2500
Sodium	2/ 2	3250	7330
Zinc	1/ 2	23.1	23.1
Heptachlor epoxide	1/ 1	0.06	0.06
Acetone	2/ 2	11	27

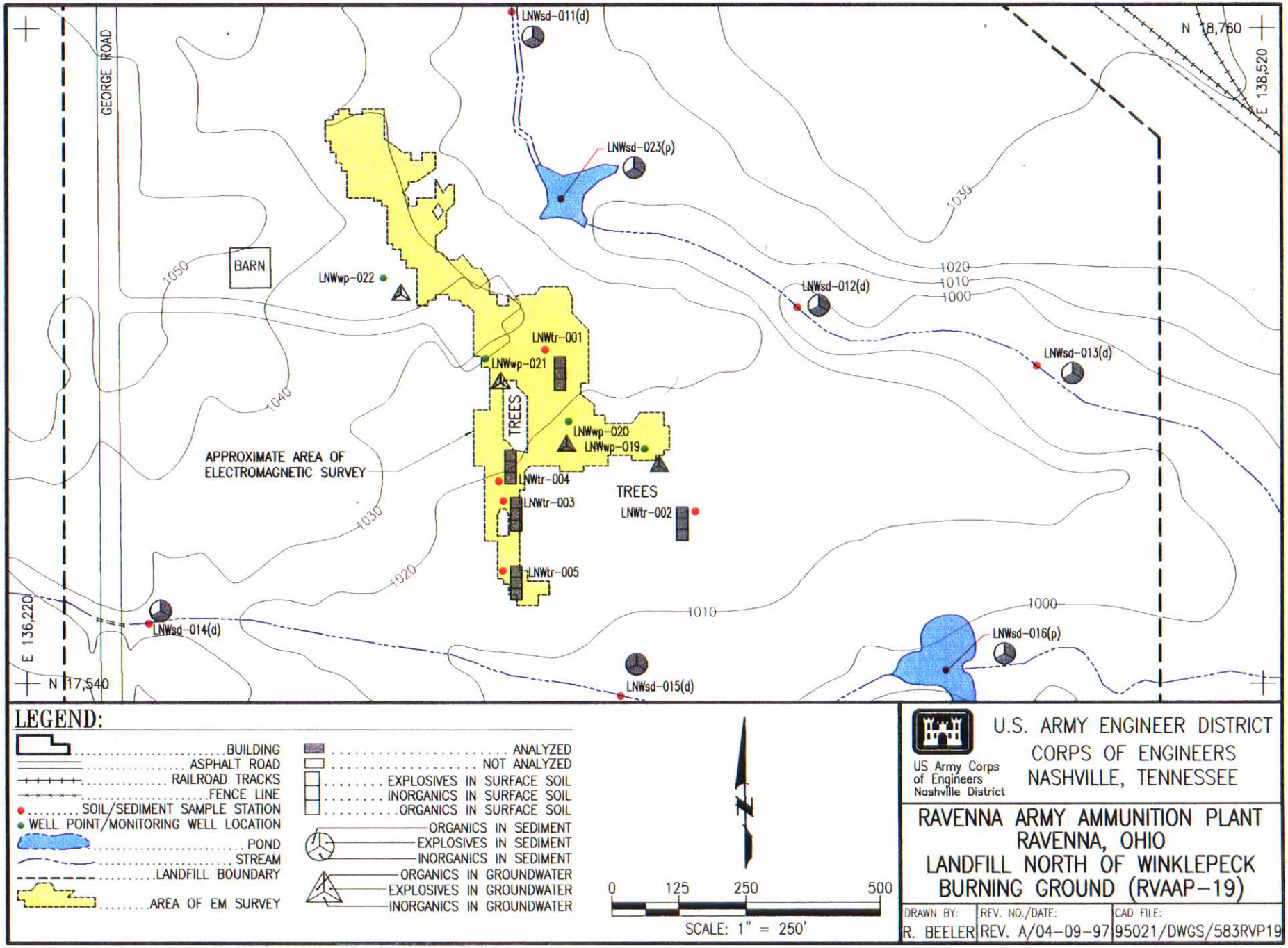


Figure 4.37. Landfill North of Winklepeck Burning Grounds Sample Locations and Analytical Parameters

Zinc was detected above its background criteria (72.1 mg/kg) in four samples (LNWtr-001, -002, -003, and -004) with concentrations above background ranging from 91.1 to 212 mg/kg. Two of these concentrations also exceeded the USGS Ohio reference levels for zinc (25 to 110 mg/kg). Lead was detected above the background criteria of 17.4 mg/kg in three samples (LNWtr-001, -002, and -003) with concentrations from 22.9 to 28.4 mg/kg. Cadmium was detected at concentrations exceeding background (0.29 mg/kg) in LNWtr-001 (0.35 mg/kg) and LNWtr-002 (0.52 mg/kg). The remaining detected inorganic chemicals (cyanide, antimony, beryllium, cobalt, copper, nickel, thallium, and vanadium) do not have site-related background values for comparison, but all detected concentrations were within the range of USGS Ohio reference values (Table 4.12) with the exception of thallium, which has no published USGS reference value. The distribution of concentrations exceeding background for selected inorganic elements (beryllium, lead, and manganese) is shown on **Figure 4.38**.

Organic Compounds

A number of organic compounds were detected in soils at the Landfill AOC, including VOCs, phthalates, PCB-1254, and a variety of pesticides (Table 4.12). Methylene chloride, a common laboratory contaminant, was detected in five of nine soil samples, being detected at least once at each trench location with concentrations ranging from 0.004 to 0.019 mg/kg. Chlorobenzene and 1,4 dichlorobenzene were each detected once in LNWtr-003, with concentrations of 0.15 and 0.13 mg/kg, respectively. Bis(2-ethylhexyl) phthalate was detected in six of nine soil samples, with concentrations ranging from 0.037 to 0.1 mg/kg. Di-n-butyl phthalate was detected in LNWtr-004 at 0.036 mg/kg. Pesticides were detected at all trench locations, and are illustrated on **Figure 4.39**. The highest concentrations and greatest diversity of pesticides occurred at LNWtr-002, with 4,4′-DDE, 4,4′-DDD, 4,4′-DDT, and delta-BHC detected. LNWtr-003 also contained 4,4′-DDE, 4,4′-DDT, heptachlor, and the PCB Aroclor-1254. Heptachlor and 4,4′-DDT were detected at LNWtr-005, and 4,4′-DDT was detected at LNWtr-001 and -004.

4.10.3 Sediment

A total of seven sediment samples (five ditch samples and two pond samples) were collected and analyzed for process-related metals and explosives. In addition, sediment sample LNWsd-015(d) was analyzed for the expanded metals suite including cyanide, VOCs, SVOCs, and PCBs/pesticides. The locations of these samples and the analytical parameters for each are shown on Figure 4.37. The analytical data are summarized in Table 4.12, and presented in detail in Appendix G. Geotechnical grain size distribution curves are presented in Appendix G.4. TOC ranged from 2,680 mg/kg in LNWsd-014 to 117,000 mg/kg in LNWsd-011.

Explosives

Explosives were not detected in any sediment samples in the Landfill North of Winklepeck Burning Grounds AOC.

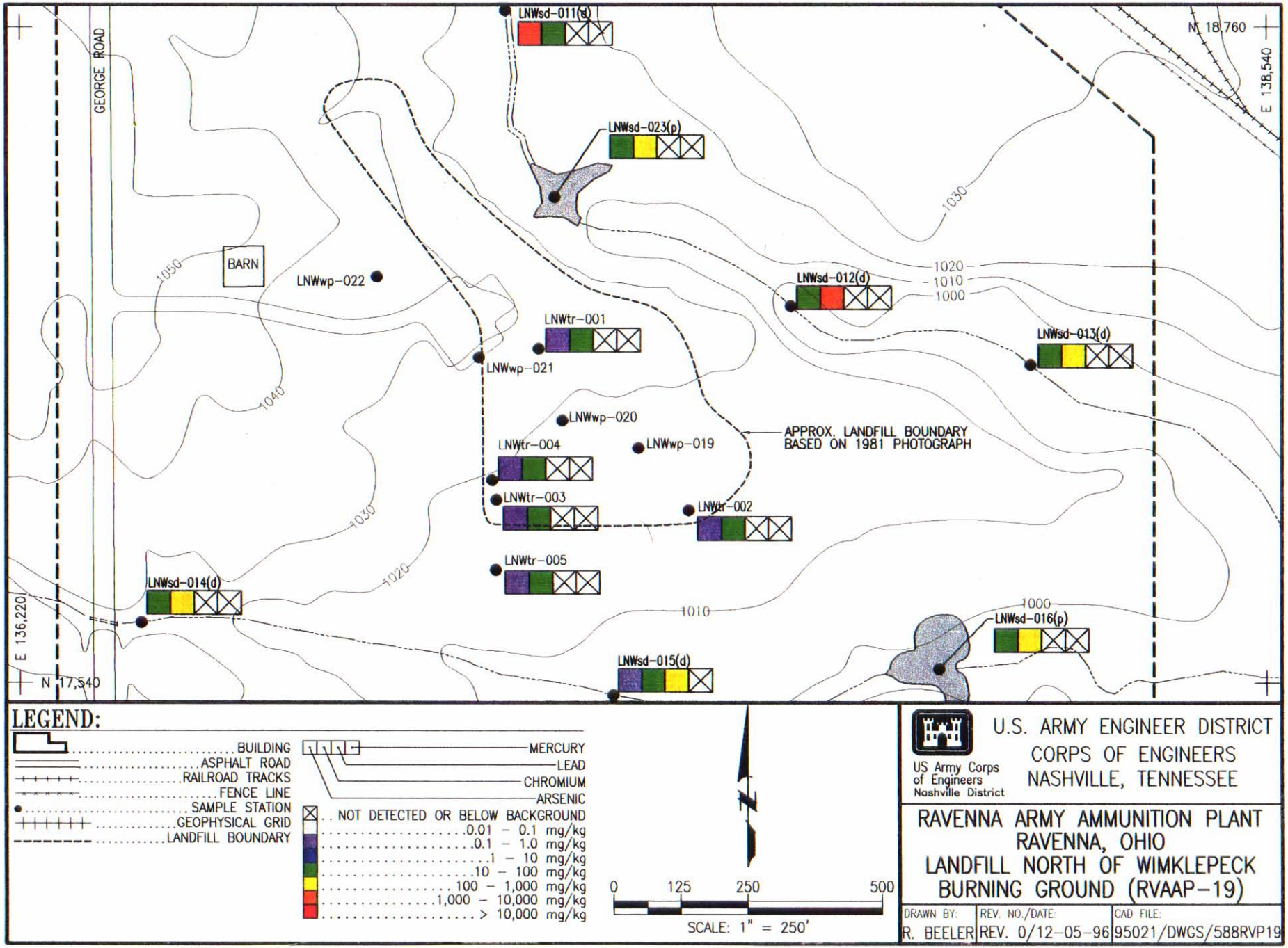


Figure 4.38. Relative Concentrations of Selected Inorganic Elements (Arsenic, Chromium, Lead, and Mercury) in Surface Soil and Sediment at the L ill North of Winklepeck Burning Grounds

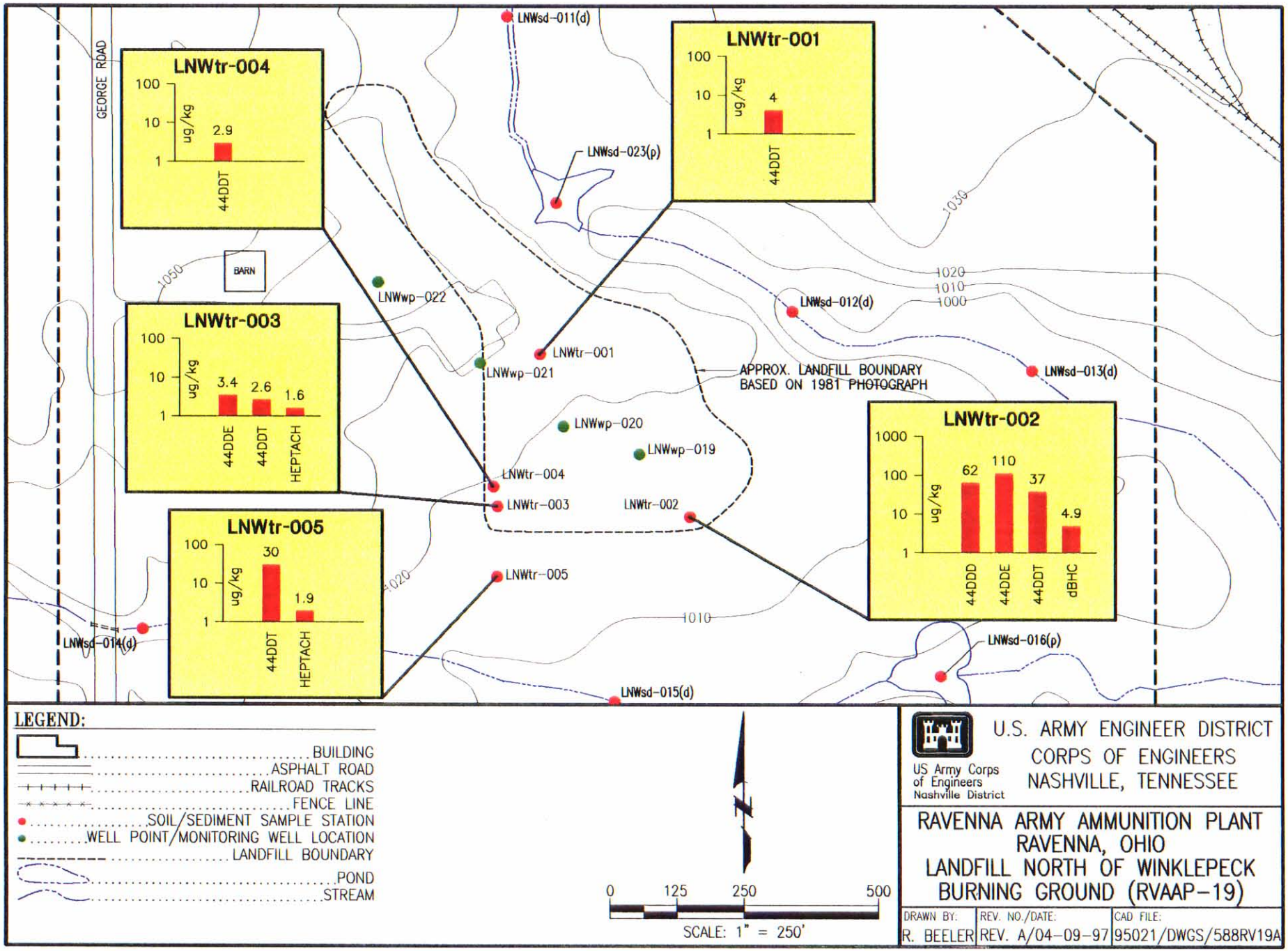


Figure 4.39. Concentrations of Pesticides in Soil at the Landfill North of Winklepeck Burning Grounds

Inorganic Elements and Compounds

Antimony was not detected in any sediment samples. Arsenic was detected at concentrations below the background criteria. The remaining 16 non-nutrient inorganic elements and cyanide are considered to be site-related chemicals because they were either detected at concentrations exceeding their background criteria, or there is no site-related background value against which to screen (Table 4.12). Aluminum, barium, cadmium, chromium, lead, manganese, mercury, selenium, silver, and zinc were all detected in at least one sample above their background criteria.

Cadmium was detected most frequently above its background criteria (0.29 mg/kg), occurring in five samples with concentrations ranging from 0.34 mg/kg at LNWsd-013(d) to 1.3 mg/kg at LNWsd-011(d). Barium was also detected above the background criteria (75 mg/kg) in five samples, with concentrations ranging from 118 mg/kg at LNWsd-023(p) to 186 mg/kg at LNWsd-011(d). Manganese and lead were each detected above their background criteria (728 mg/kg and 17.9 mg/kg, respectively) in four samples. The distribution of both manganese and lead is shown on Figure 4.38. Zinc was detected above background (72.1 mg/kg) in two samples, with concentrations of 73 mg/kg at LNWsd-015(d) and 133 mg/kg at LNWsd-011(d), which also exceeds the USGS Ohio reference level range of 25 - 110 mg/kg. Aluminum was detected at a concentration of 16,500 mg/kg in LNWsd-016(p), which was the only detection exceeding the background criteria of 15,600 mg/kg. Chromium was detected above background (18.7 mg/kg) in LNWsd-013 with a concentration of 20.6 mg/kg. Mercury, selenium, and silver were each detected above background in LNWsd-011(d).

The detected concentration for lead exceeds the USGS Ohio reference values at LNWsd-011(d). The detected concentrations of manganese exceed the USGS reference values at LNWsd-011(d) and -012(d), and selenium concentrations at LNWsd-011(d), -012(d), and -013(d) also exceed the range of USGS Ohio reference values (Table 4.12).

The inorganic elements without background criteria are metals, including beryllium, cobalt, copper, nickel, thallium, and vanadium, and were all detected in LNWsd-015(d). Table 4.12 gives the detected concentration for each of these. The detected concentrations for beryllium, cobalt, copper, nickel, and vanadium were within the range of USGS Ohio reference values. There is no USGS reference value for thallium. The concentration of beryllium in both soil and sediment in the Landfill AOC is shown on Figure 4.38.

Organic Compounds

A single organic compound, toluene, was detected in LNWsd-015(d) at a concentration of 0.005 mg/kg. No definitive statement can be made about the sources of this VOC.

4.10.4 Groundwater

Four well points were installed and sampled for chemical analyses in the Landfill AOC. VOC analysis was run for all four well points. Explosives and inorganic analyses were run for LNWwp-019 and -020. Cyanide, SVOC, and PCB/pesticide analysis was also run on

LNWwp-019. The locations of these points and the analysis type are shown on Figure 4.37. The analytical data are summarized in Table 4.13, and presented in detail in Appendix G.

Explosives

No explosive compounds were detected in the sampled groundwater in the Landfill North of Winklepeck Burning Grounds.

Inorganic Elements and Compounds

A total of 14 of the 23 expanded metals suite were detected in groundwater from two well points in the Landfill AOC. There are no background data for groundwater, so the remaining nine non-nutrient elements are considered to be site-related chemicals (Table 4.13). Aluminum, barium, manganese, and nickel were detected in both well points, with the maximum concentration for aluminum (140 μg/L), manganese (187 μg/L), and barium (72.1 μg/L) detected in LNWwp-020, and the maximum value for nickel (110 μg/L) detected in LNWwp-019. Antimony, arsenic, beryllium, and zinc were also detected in LNWwp-020, and lead was detected in LNWwp-019. The detected concentrations for these chemicals are given in Table 4.13.

Organic Compounds

Acetone was detected in LNWwp-019 (11 μg/L) and LNWwp-020 (27 μg/L). No definitive statement can be made about the source of this compound. VOCs were also analyzed for in LNWwp-021 and -022, but none were detected. The pesticide heptachlor epoxide was detected in LNWwp-019 at a concentration of 0.06 μg/L.

4.10.5 Discussion/Summary of Results

No explosives were detected in soil, sediment, or groundwater in the Landfill North of Winklepeck Burning Grounds at the locations sampled. Inorganic chemicals were detected in all media, but, in general, at values below or just above the site-related background criteria and within the range of USGS Ohio reference values in soil and sediment. The exceptions to this are lead, manganese, and selenium, which occurred in sediment at concentrations above the maximum USGS Ohio reference values. The highest concentration of eight of the site-related metals occurred in LNWsd-011(d), and no metals were detected above background concentrations in LNWsd-014(d). Scattered detections of organic compounds in sediment and groundwater occurred, although acetone and toluene are both common lab contaminants. A variety of pesticides occurred in trench soils, and one pesticide was detected in groundwater. Other organic compounds including bis(2-ethylhexyl) phthalate and methylene chloride occurred in one or more samples at each trench location. There does not appear to be a pattern of association among grain size, TOC, and contaminant concentrations in sediments sampled at this AOC.

4.11 UPPER AND LOWER COBBS PONDS

Upper and Lower Cobbs Pond sampling activity included sediment and groundwater sampling. Analytical data are summarized on **Tables 4.14** (soil and sediment) **and 4.15** (groundwater) and presented in detail in Table 4.25 and in Appendix G.

4.11.1 Sediment

A total of 10 sediment samples (8 pond sediments and 2 drainage sediments) were analyzed for the 11 process-related metals and explosives. In addition, one sample [CPCsd-007(p)] was analyzed for the expanded metals suite, cyanide, VOCs, SVOCs, and PCB/pesticides. The location of each of these samples and the analytical parameters for each are presented on **Figure 4.40**. Geotechnical grain size distribution curves are presented in Appendix G.4. TOC ranged from 8,980 mg/kg in CPCsd-010 to 41,200 mg/kg in CPCsd-005.

Explosives

A single detection of nitrobenzene occurred in CPCsd-005(p), with a reported concentration of 0.380 mg/kg. No other explosive compounds were detected in sediments in the Cobbs Ponds AOC.

Inorganic Elements and Compounds

Cyanide was not detected in any sediment sample. Aluminum was detected at concentrations below the background criteria. The remaining 17 non-nutrient elements are considered to be site-related chemicals because they were detected in at least one sample at concentrations exceeding the background criteria, or no background criteria were available against which to screen (Table 4.14). Arsenic, barium, cadmium, chromium, lead, manganese, selenium, silver, and zinc were each detected above the background criteria.

Cadmium, chromium, and zinc were each detected at concentrations exceeding background criteria in seven of 10 samples. Cadmium, with a background value of 0.29, was detected at concentrations ranging from 0.54 mg/kg in CPCsd-001(p), -003(p), and -005(p) to 1.4 mg/kg in CPCsd-008(p). Chromium (background criteria 18.7 mg/kg) was detected at concentrations above background ranging from 30.8 mg/kg in CPCsd-004(p) to a maximum of 329 mg/kg in CPCsd-007(p). This concentration exceeds the range of USGS Ohio reference values (Table 4.14). The distribution of chromium is shown on **Figure 4.41**. Zinc was detected in concentrations exceeding the background criteria (72.1 mg/kg) ranging from 90.8 mg/kg at CPCsd-004(p) to 254 mg/kg at CPCsd-007(p). Six concentrations exceeding background also were above the range of USGS reference values for Ohio (25 to 110 mg/kg).

Silver exceeded the background criteria (0.24 mg/kg) in all six samples in which it was detected, and exceeded the USGS reference level (0.7 mg/kg) in all but the sample at CPCsd-004(p). Concentrations ranged from 0.38 mg/kg in CPCsd-004(p) to 1.7 mg/kg in CPCsd-007(p). Occurring almost as frequently, mercury was detected above the background criteria of 0.08 mg/kg in five samples, with concentrations above background ranging from 0.08 mg/kg in CPCsd-003(p) to 0.23 mg/kg in CPCsd-004(p). This concentration is above the

Table 4.14. Upper and Lower Cobbs Pond Analytical Results (Sediment)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
SEDIMENT									
Nitrobenzene	µg/kg	1/ 10	.		380	380		Yes	No Background Data Available
Aluminum	mg/kg	10/ 10	15600	0/ 10	4310	12500	20000 - 100000	No	Below Background
Antimony	mg/kg	1/ 1	.		1.9	1.9		Yes	No Background Data Available
Arsenic	mg/kg	10/ 10	19.6	1/ 10	4.9	23.4	5.2 - 27.0	Yes	> 5% Detect Above Background
Barium	mg/kg	10/ 10	75	3/ 10	40.8	100	300 - 700	Yes	> 5% Detect Above Background
Beryllium	mg/kg	1/ 1	.		0.73	0.73	1.5 - 2.0	Yes	No Background Data Available
Cadmium	mg/kg	7/ 10	0.29	7/ 10	0.54	1.4	1 - 2	Yes	> 5% Detect Above Background
Calcium	mg/kg	1/ 1	.		2320	2320	1100 - 31000	No	Essential Nutrient
Chromium	mg/kg	10/ 10	18.7	7/ 10	7.9	329	15.0 - 100.0	Yes	> 5% Detect Above Background
Cobalt	mg/kg	1/ 1	.		11.1	11.1	7 - 20	Yes	No Background Data Available
Copper	mg/kg	1/ 1	.		316	316	7.0 - 70.0	Yes	No Background Data Available
Iron	mg/kg	1/ 1	.		19600	19600	15000 - 50000	No	Essential Nutrient
Lead	mg/kg	10/ 10	17.9	5/ 10	8.8	37.8	15 - 30	Yes	> 5% Detect Above Background
Magnesium	mg/kg	1/ 1	.		1640	1640	3000 - 15000	No	Essential Nutrient
Manganese	mg/kg	10/ 10	728	1/ 10	171	816	150 - 1000	Yes	> 5% Detect Above Background

Table 4.14 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Mercury	mg/kg	6/ 10	0.08	5/ 10	0.08	0.23	0.03 - 0.22	Yes	> 5% Detect Above Background
Nickel	mg/kg	1/ 1	.		20.9	20.9	15 - 50	Yes	No Background Data Available
Potassium	mg/kg	1/ 1	.		683	683	11800 - 25100	No	Essential Nutrient
Selenium	mg/kg	10/ 10	2.6	1/ 10	1.1	2.9	<0.1 - 1.2	Yes	> 5% Detect Above Background
Silver	mg/kg	6/ 10	0.24	6/ 10	0.38	1.7	0.7	Yes	> 5% Detect Above Background
Sodium	mg/kg	1/ 1	.		458	458	5000 - 7000	No	Essential Nutrient
Thallium	mg/kg	1/ 1	.		2.3	2.3		Yes	No Background Data Available
Vanadium	mg/kg	1/ 1	.		15.1	15.1	20 - 150	Yes	No Background Data Available
Zinc	mg/kg	10/ 10	72.1	7/ 10	46.2	254	25 - 110	Yes	> 5% Detect Above Background
Benzo(a)anthracene	µg/kg	1/ 1	.		210	210		Yes	No Background Data Available
Benzo(a)pyrene	µg/kg	1/ 1	.		260	260		Yes	No Background Data Available
Benzo(b)fluoranthene	µg/kg	1/ 1	.		560	560		Yes	No Background Data Available
Benzo(g,h,i)perylene	µg/kg	1/ 1	.		200	200		Yes	No Background Data Available
Chrysene	µg/kg	1/ 1	.		270	270		Yes	No Background Data Available
Fluoranthene	µg/kg	1/ 1	.		380	380		Yes	No Background Data Available

Table 4.14 (continued)

Analyte	Units	Frequency of Detects	Background Criteria	Detects > Background	Minimum Detect	Maximum Detect	USGS Value	Site Related?	Justification
Indeno(1,2,3-cd)pyrene	µg/kg	1/ 1	.		190	190		Yes	No Background Data Available
Pyrene	µg/kg	1/ 1	.		270	270		Yes	No Background Data Available
Acetone	µg/kg	1/ 1	.		330	330		Yes	No Background Data Available

Table 4.15. Upper and Lower Cobbs Pond Analytical Results (Groundwater)

Analyte	Frequency of Detects	Minimum Detect (µg/L)	Maximum Detect (µg/L)
GROUNDWATER			
Cyanide	1/ 3	3.8	3.8
Aluminum	2/ 3	17.6	21
Arsenic	3/ 3	2.8	15
Barium	3/ 3	36	115
Beryllium	2/ 3	0.35	0.36
Calcium	3/ 3	67400	118000
Iron	3/ 3	1200	8760
Magnesium	3/ 3	6690	40200
Manganese	3/ 3	332	3020
Nickel	3/ 3	1.4	13.8
Potassium	3/ 3	1800	3860
Sodium	3/ 3	15700	48000
Thallium	1/ 3	1.1	1.1
Zinc	2/ 3	7.6	67.1
4-Chloro-3-methylphenol	1/ 3	2	2

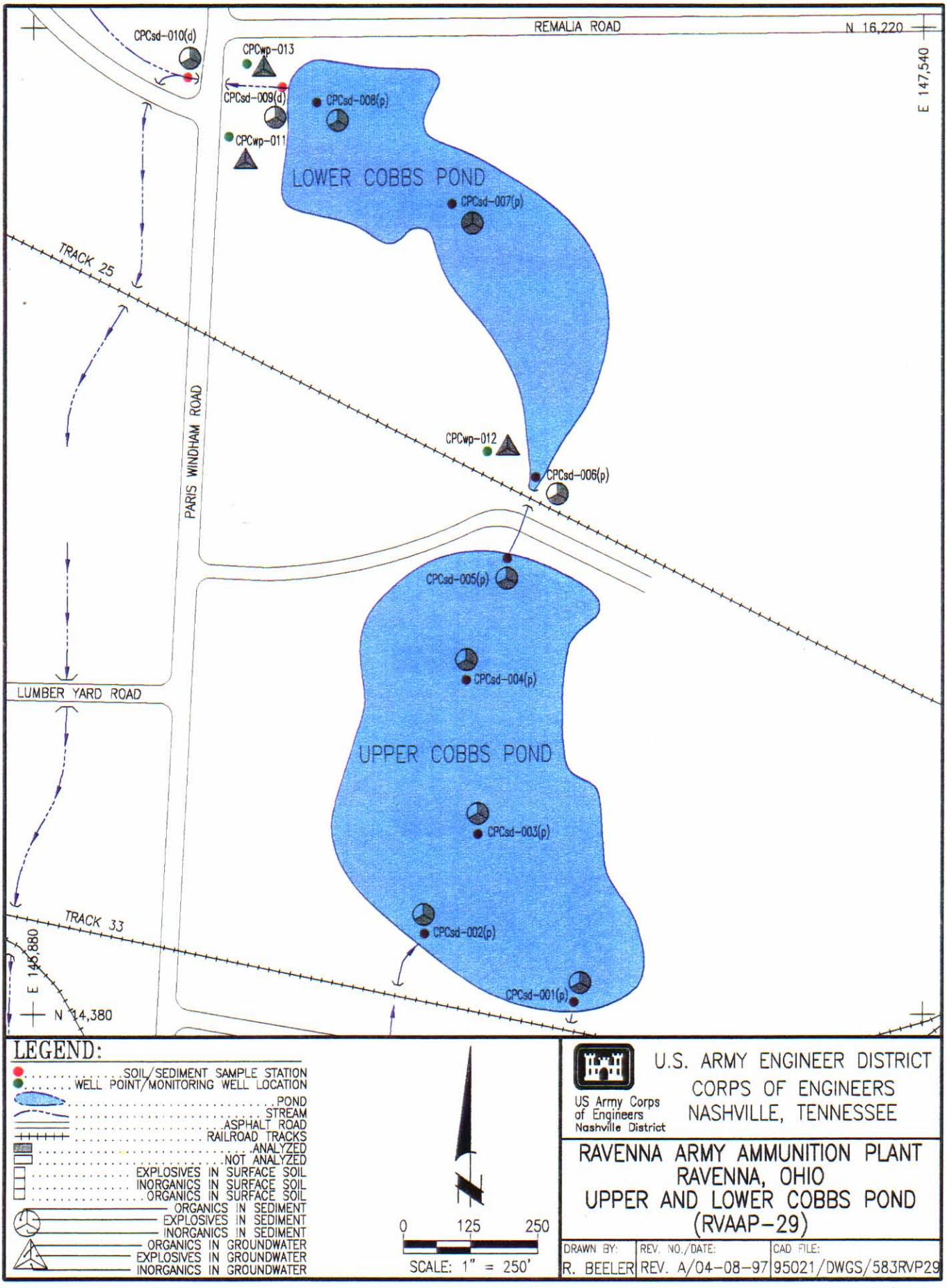


Figure 4.40. Upper and Lower Cobbs Ponds Sampling Locations and Analytical Parameters

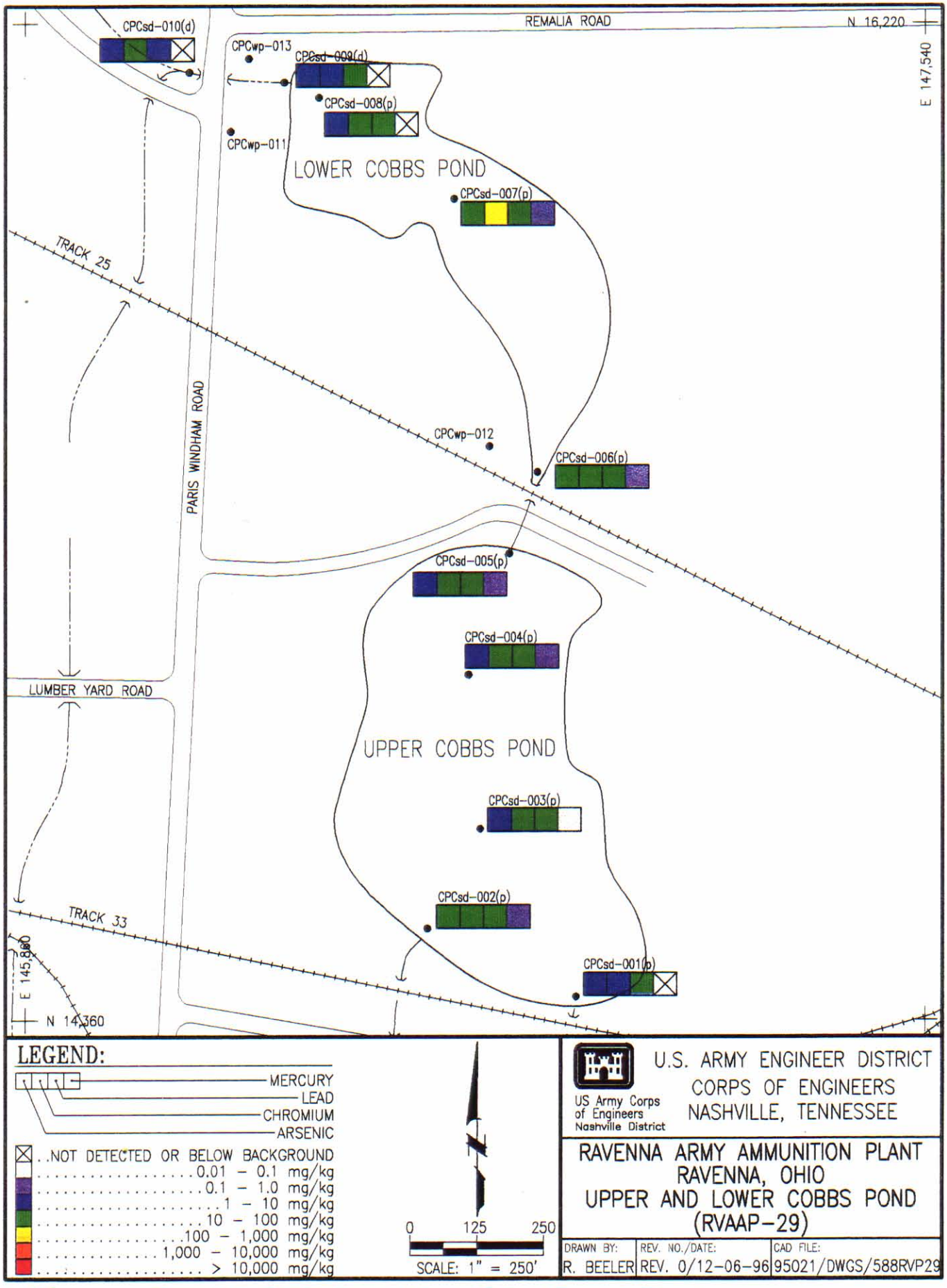


Figure 4.41. Relative Concentrations of Selected Inorganic Elements (Arsenic, Chromium, Lead, and Mercury) in Sediment at Upper and Lower Cobb Ponds

range of USGS Ohio reference values (Table 4.14). Lead was also detected above background (17.9 mg/kg) in five samples, with concentrations ranging from 17.9 mg/kg in CPCsd-003(p) to a maximum of 37.8 in CPCsd-006(p). Lead concentrations in four sediment samples (CPCsd-002(p) -006(p), -007(p), and -008(p) exceeded the range of USGS Ohio reference values. The distribution of lead is shown on Figure 4.41.

Barium exceeded its background criteria (75 mg/kg) in three samples, with concentrations above background ranging from 77.3 in CPCsd-008(p) to 100 mg/kg in CPCsd-006(p). All detections above background occurred in Lower Cobbs Pond. Arsenic, manganese, and selenium were each detected above their background criteria in one sediment sample, with arsenic occurring at a concentration of 23.4 mg/kg, selenium occurring at a concentration of 2.9 mg/kg in CPCsd-002(p), and manganese occurring at a concentration of 816 mg/kg in CPCsd-010(d). The range of USGS Ohio reference values for selenium (<0.1 to 1.2 mg/kg) is less than the site-related background criteria. Eight of the 10 selenium values exceeded the USGS reference values. Manganese was the only inorganic element detected at concentrations above the background criteria in either of the two drainage sediment samples.

Site-related background data are not available for antimony, beryllium, cobalt, copper, nickel, thallium, or vanadium. These metals were detected in sediment sample CPCsd-007(p), at the concentrations listed on Table 4.14. All detected concentrations were within the range of USGS Ohio reference values, with the exception of thallium, for which there is no USGS value.

Organic Compounds

A single sediment sample (CPCsd-007(p) was analyzed for organic constituents. Acetone was detected at a concentration of 0.33 mg/kg. Eight PAH compounds, including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, and pyrene, were detected at concentrations ranging from 0.19 mg/kg to 0.56 mg/kg (Table 4.14). No other organic compounds were detected.

4.11.2 Groundwater

Three well points were installed and samples submitted for chemical analysis. All three samples were analyzed for the extended suite of metals, cyanide, explosives, VOCs, SVOCs, and PCBs/pesticides. The location of these well points is shown on Figure 4.40. Analytical data are summarized on Table 4.15, and presented in detail in Appendix G.

Explosives

No explosive compounds were detected in groundwater sampled from well points at the Cobbs Ponds AOC.

Inorganic Elements and Compounds

A total of 13 inorganic elements from the expanded metals suite, and cyanide, were detected in at least one groundwater sample from the Cobbs Ponds AOC. There are site-

related background criteria for inorganic analytes in groundwater, so the remaining eight non-nutrient inorganic elements detected, including aluminum, arsenic, barium, beryllium, manganese, nickel, thallium, and zinc, are considered to be site-related. Cyanide is also considered to be site-related.

Arsenic, barium, manganese, and nickel were detected in all three well points. The range of concentrations is indicated on Table 4.15. Aluminum was detected in CPCwp-013 (17.6 μg/L) and CPCwp-012 (21 μg/l). Beryllium was detected in CPCwp-011 and -012, with concentrations of 0.35 and 0.36 μg/L, respectively. Zinc was detected in CPCwp-012 and -013, with concentrations of 7.6 and 67.1 μg/L. Thallium was detected once with a concentration of 1.10 μg/L in CPCwp-013. Cyanide was detected at a concentration of 3.4 μg/L in CPCwp-011.

Organic Compounds

The compound 4-chloro-3-methylphenol was detected at a concentration of 0.002 mg/L in CPCwp-013. No other organic compounds were detected in groundwater in the Cobbs Ponds AOC.

4.11.3 Discussion/Summary of Results

A single detection of the explosive nitrobenzene occurred in sediment at the outfall of Upper Cobbs Pond. Inorganic constituents were detected in both sediment and groundwater. Of the 18 metals detected at concentrations exceeding background or where no background was available, concentrations were only slightly above the background criteria and within the range of USGS Ohio reference levels, with the exception of chromium, copper, lead, mercury, and selenium, which were detected at concentrations sometimes exceeding the USGS range. Samples from the central portions of the ponds tended to have higher concentrations and greater diversity of metal detected, probably related to mechanisms of sediment accumulation in the ponds. Concentrations of inorganic chemicals in drainage sediments were below the background criteria with the exception of a single detection of manganese above background, so it appears that contaminants may not be leaving the ponds. There does not appear to be a pattern of association among grain size, TOC, and contaminant concentrations in sediments sampled at this AOC. Inorganic chemicals detected in groundwater were all considered to be site-related as there were no screening criteria. A single organic compound was detected in one groundwater sample.