1.0 INTRODUCTION

This report documents the results of the Phase II Remedial Investigation (RI) of Load Line 3 at the U. S. Army Operations Support Command's (OSC's) Ravenna Army Ammunition Plant (RVAAP), Ravenna, Ohio (Figures 1-1 and 1-2). The Phase II RI was conducted under the U.S. Department of Defense Installation Restoration Program (IRP) by Science Applications International Corporation (SAIC) and its subcontractors, under contract with the U.S. Army Corps of Engineers (USACE), Louisville District contract number F44650-99-D-0007, Delivery Order No. CY01. The Phase II RI was conducted in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), following work plans reviewed and commented on by the Ohio Environmental Protection Agency (Ohio EPA).

This document summarizes the results of the Phase II RI field activities conducted in July and August 2001 and January and February 2002 at Load Line 3. The field program, environmental setting, and nature and extent of contamination are discussed. Contaminant fate and transport modeling, a screening human health risk assessment (SHHRA), and a screening level ecological risk assessment (ERA) were used to develop a revised conceptual site model (CSM) for Load Line 3 in support of the investigation summary and conclusions, which are the framework for decisions regarding future IRP actions at Load Line 3.

1.1 PURPOSE AND SCOPE

Figure 1-3 presents the approach to implementing the CERCLA process under the guidance of the IRP. Priorities for environmental restoration at Areas of Concern (AOCs) at RVAAP are based on their relative potential threat to human health and the environment, derived from Relative Risk Site Evaluations (RRSEs). Thirty-eight AOCs were identified in the *Preliminary Assessment for the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 1996a). Thirteen new AOCs were identified in 1998 as a result of additional records searches and site walkovers. These were ranked by the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) and entered into the Defense Sites Environmental Restoration Tracking System. Those AOCs ranked as high-priority sites [i.e., those with high relative risk site evaluation (RRSE) scores] are targeted first for characterization (e.g., Phase I RIs) and remedial actions. Medium- and low-priority sites will be characterized to the extent required to develop a remedial decision following completion of characterization for high-priority AOCs. Investigation and remedial actions under the CERCLA process are implemented at the AOCs in order of priority as funding becomes available, unless other priorities emerge, such as land use needs.

The purpose of the Phase II RI is to determine the nature and extent of contamination so that quantitative human health and ecological risk assessments can be performed. Depending upon the outcome of the risk assessments, an AOC will either require no further action (NFA) or will be the subject of a Feasibility Study (FS) to evaluate potential remedies and future actions.

The scope of this investigation is to determine the extent of contamination in affected media (i.e., soils, sediments, surface water, and groundwater), as initially identified during the Phase I RI at Load Line 3 (USACE 1998). The primary objectives of the Phase II RI are as follows.

- Characterize the physical environment of Load Line 3, as well as its surroundings, and, to the extent necessary, define potential contaminant transport pathways and risk receptor populations.

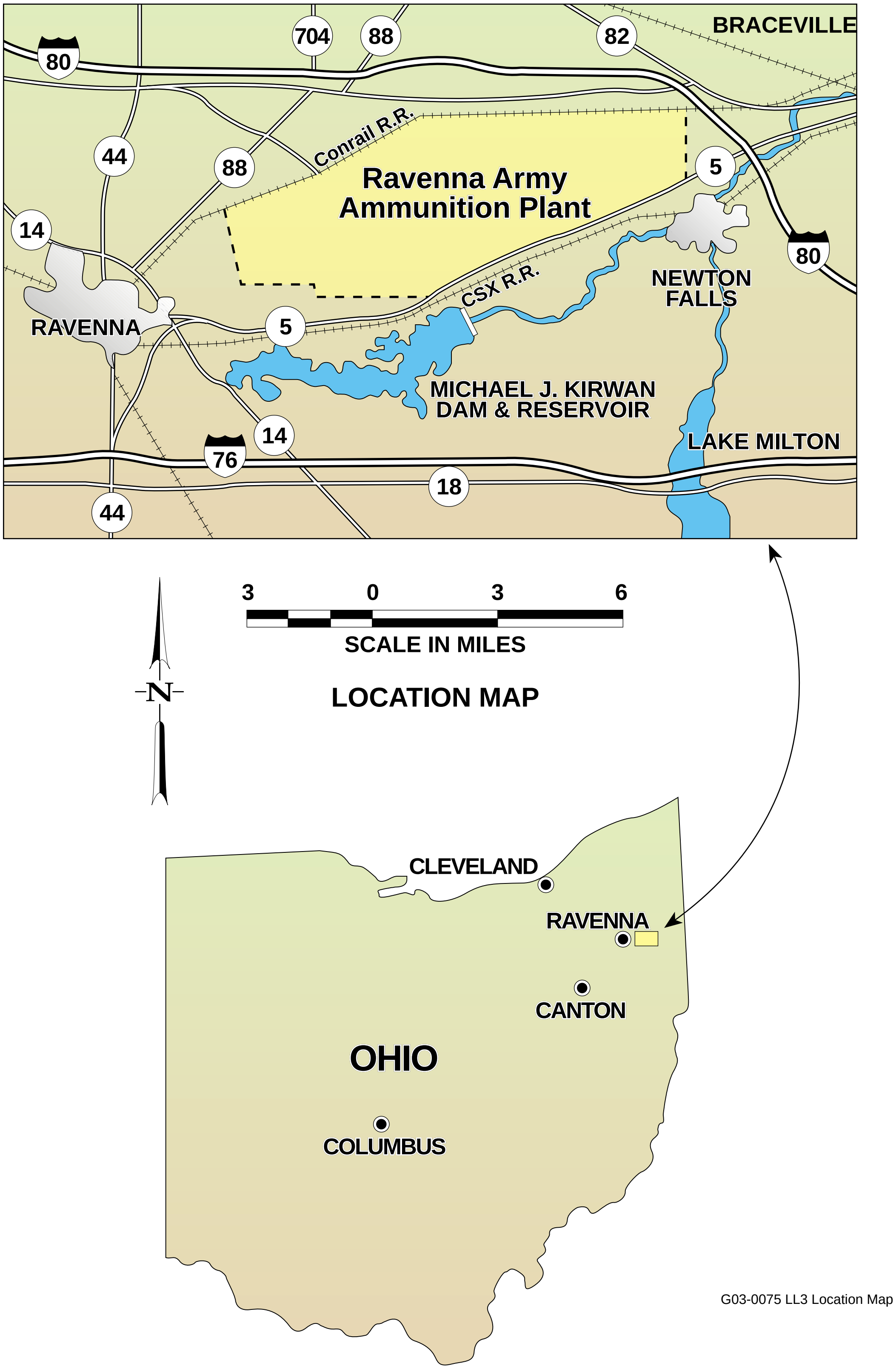

Figure 1-1. General Location and Orientation of RVAAP

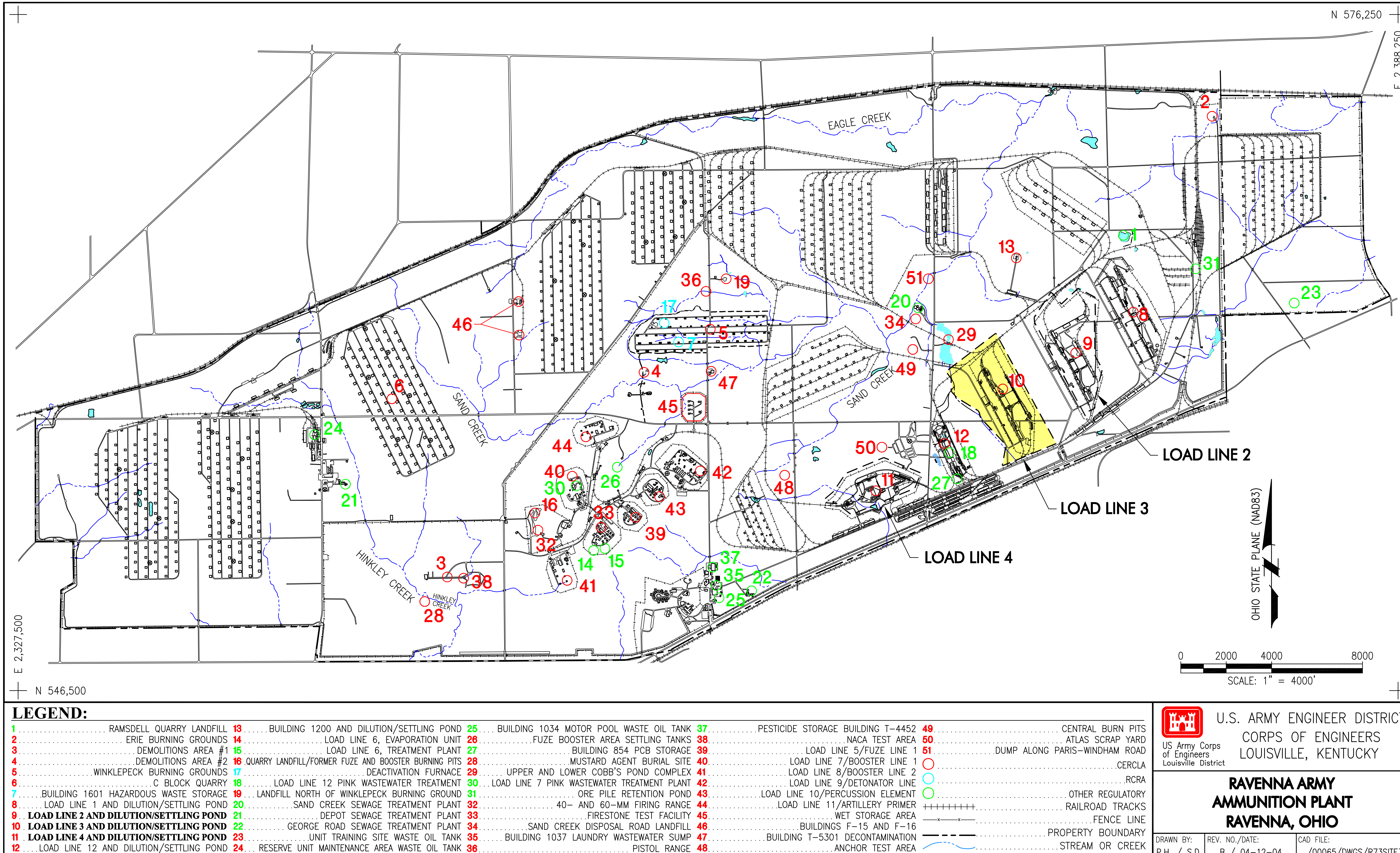

Figure 1-2. RVAAP Facility Map

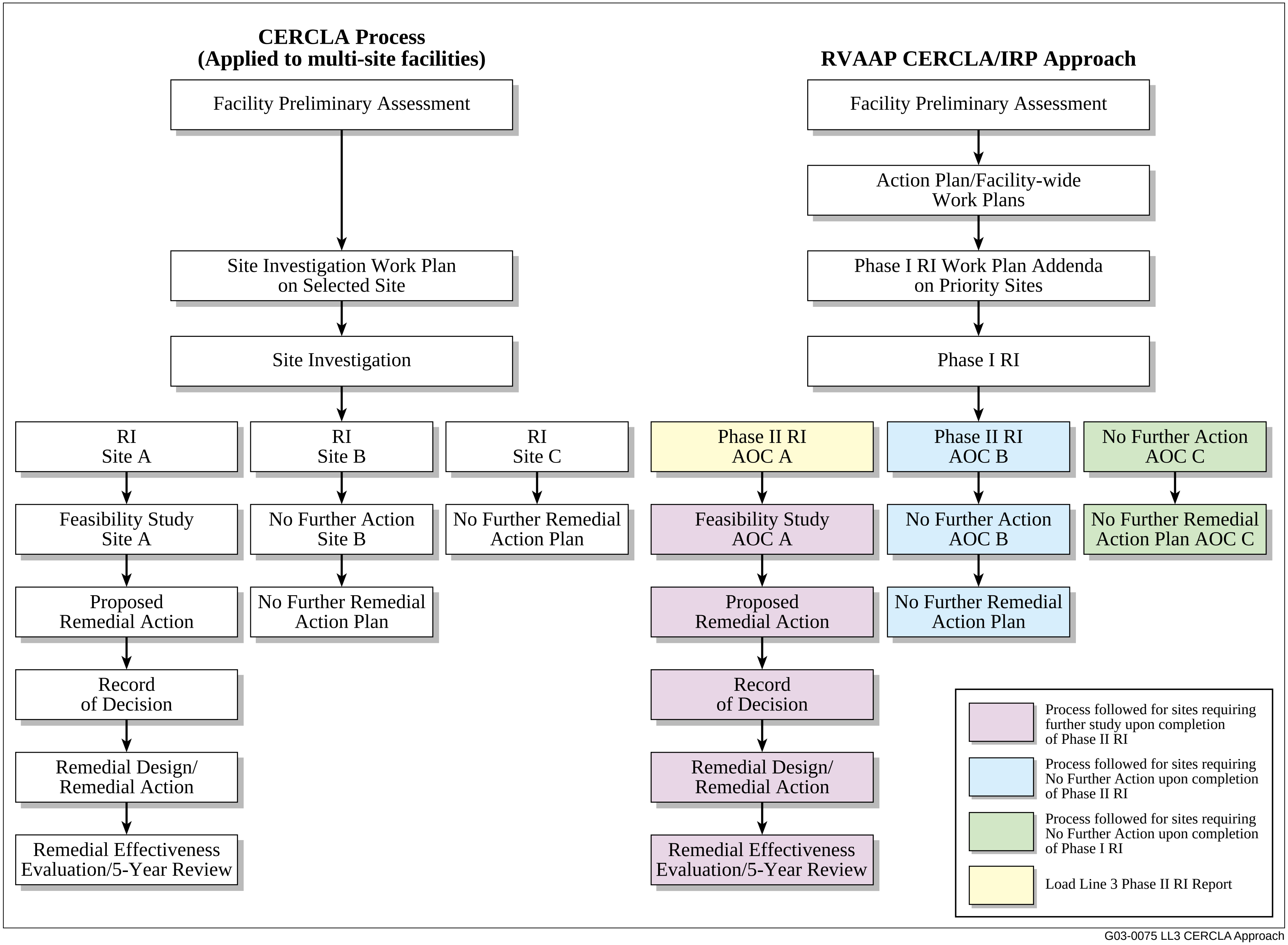

Figure 1-3. CERCLA Approach at RVAAP

- Characterize the sources of contamination at Load Line 3 sufficient to screen and evaluate remedial alternatives in a subsequent FS. This will be accomplished by collecting data pertaining to source locations, types and concentrations of contaminants, potential release mechanisms, physical and chemical properties of identified contaminants, and geotechnical characteristics of environmental media.

- Identify whether releases of contamination beyond the AOC boundary are occurring, by reviewing applicable historical information and collecting environmental samples (surface water, sediment, and groundwater) downstream of the AOC boundary within the exit conveyances.

- Characterize nature and extent of contamination at Load Line 3 such that risk assessments can be conducted to evaluate the potential threats to human health and the environment and to develop risk-based remedial goal options (RGOs) for use in determining areas that may require remediation.

- Provide preliminary recommendations for any additional investigations and/or actions.

To meet the primary project objectives, investigation-specific data quality objectives (DQOs) were developed using the approach presented in the Facility-wide Sampling and Analysis Plan (SAP) (USACE 2001a). The DQOs specific to the Load Line 3 Phase II RI are discussed in Section 1.4.

The investigation approach for the Phase II RI at Load Line 3 involved a combination of field and laboratory activities to characterize the AOC. Field investigation techniques included soil boring advancement and sampling, as well as sampling of surface water, sediment, and groundwater. The field program was conducted in accordance with the Facility-wide SAP (USACE 2001a) and the *SAP Addendum No. 1 for the Phase II Remedial Investigation of Load Lines 2,3, and 4* (USACE 2001b).

1.2 GENERAL FACILITY DESCRIPTION

1.2.1 Historical Mission and Current Status

RVAAP is a government-owned, contractor-operated (GOCO) facility, located in northeastern Ohio within east-central Portage County and southwestern Trumbull County. The facility is located approximately 37 km (23 miles) east of the city of Akron, 4.8 km (3 miles) east-northeast of the city of Ravenna, and approximately 1.6 km (1 mile) northwest of the town of Newton Falls. The installation consists of 8,668.3 ha (21,419 acres) contained in a 17.7-km (11-miles)-long, 5.6-km (3.5-miles)-wide tract, bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad on the south; Garretsville and Berry Roads on the west; and the CONRAIL Railroad on the north (see Figures 1-1 and 1-2). The installation is surrounded by several less populous communities: Windham directly to the north; Garretsville 9.6 km (6 miles) to the northwest; Charlestown directly to the southwest; and Wayland 4.8 km (3 miles) to the southeast.

RVAAP was constructed in 1940 and 1941 with the primary missions of depot storage and ammunition loading during World War II. Industrial operations at RVAAP consisted of 12 munitions-assembly facilities referred to as “load lines.” Load Lines 1 through 4 were used to melt and load trinitrotoluene (TNT) and Composition B into large-caliber shells and bombs. The operations on the load lines produced explosive dust, spills, and vapors that collected on the floors and walls of each building. Periodically, the floors and walls would be cleaned with water and steam. The liquid containing TNT and Composition B was known as “pink water” for its characteristic pink color. Pink water was collected in concrete holding tanks, filtered, and pumped into unlined ditches for transport to earthen settling ponds. Load Lines 5 through 11 were used to manufacture fuzes, primers, and boosters. Potential contaminants in these load lines include lead compounds, mercury compounds, and explosives. From 1946 to 1949, Load Line 12 was used to produce ammonium nitrate for explosives and fertilizers.

In 1950, the facility was placed on standby status and operations were limited to renovation, demilitarization, and normal maintenance of equipment, along with storage of munitions. Production activities were resumed during the Korean Conflict (July 1954 to October 1957) and again during the Vietnam Conflict (May 1968 to August 1972). In addition to production missions, various demilitarization activities were conducted at facilities constructed at Load Lines 1, 2, 3, and 12. Demilitarization activities included disassembly of munitions and explosives melt-out and recovery operations using hot water and steam processes. Periodic demilitarization of various munitions continued through 1992.

In addition to production and demilitarization activities at the load lines, other facilities at RVAAP include sites that were used for the burning, demolition, and testing of munitions. These burning and demolition grounds consist of large parcels of open space or abandoned quarries. Potential contaminants at these AOCs include explosives, propellants, metals, waste oils, and sanitary waste. Other types of AOCs present at RVAAP include landfills, an aircraft fuel tank testing facility, and various general industrial support and maintenance facilities.

In 1992, the status of RVAAP changed from inactive-maintained to modified-caretaker. The only activities still being carried out from the wartime era are the storage of bulk explosives and propellants and the infrequent demolition of unexploded ordnance (UXO) found at the installation. The Army is also overseeing the reclamation of railroad tracks, telephone lines, and steel for re-use or recycling. The Army has completed the demolition of excess buildings at Load Lines1 and 12, and is currently conducting demolition activities at Load Line 2, which includes the removal of friable asbestos. RVAAP's operations and mission-related activities are directed by OSC. Environmental restoration activities at RVAAP are conducted under the auspices of the IRP. As of January 2003, oversight and funding responsibilities for the IRP were transferred from OSC to the U.S. Army Environmental Center.

1.2.2 Demography and Land Use

Population statistics from the 2000 Census state that the total populations of Portage and Trumbull Counties are 152,061 and 225,116, respectively. Population centers closest to RVAAP are Ravenna, with a population of 11,771, and Newton Falls, with a population of 5,002. The RVAAP facility is located in a rural area and is not close to any major industrial or developed areas. Approximately 55% of Portage County, in which the majority of RVAAP is located, consists of either woodland or farmland acreage. The Michael J. Kirwan Reservoir (also known as West Branch Reservoir) is the closest major recreational area and is located adjacent to the western half of RVAAP, south of State Route 5.

Until May 1999, about 1,024 ha (2,533 acres) of land and some existing facilities at RVAAP were used by the National Guard Bureau (NGB) for training purposes administered by the Ohio Army National Guard (OHARNG). Training and related activities include field operations, bivouac training, convoy training, equipment maintenance, and storage of heavy equipment. In a Memorandum of Agreement (MOA) dated December 1998, 6,544 ha (16,164 acres) of land was transferred from the Army OSC to NGB, effective May 1999, for expanded training missions. On May 13, 2002, an additional 3,774 acres of land was transferred from OSC to NGB via an amendment to the MOA. Approximately 1,481 acres of property remain under the control of RVAAP; this acreage includes AOCs and active mission areas (Figure 1-4). As AOCs are remediated, transfer of the remaining acreage to NGB will occur. OHARNG has prepared a comprehensive Environmental Assessment and an Integrated Natural Resources Management Plan, which addresses future use of the property. These uses include two live-fire rifle

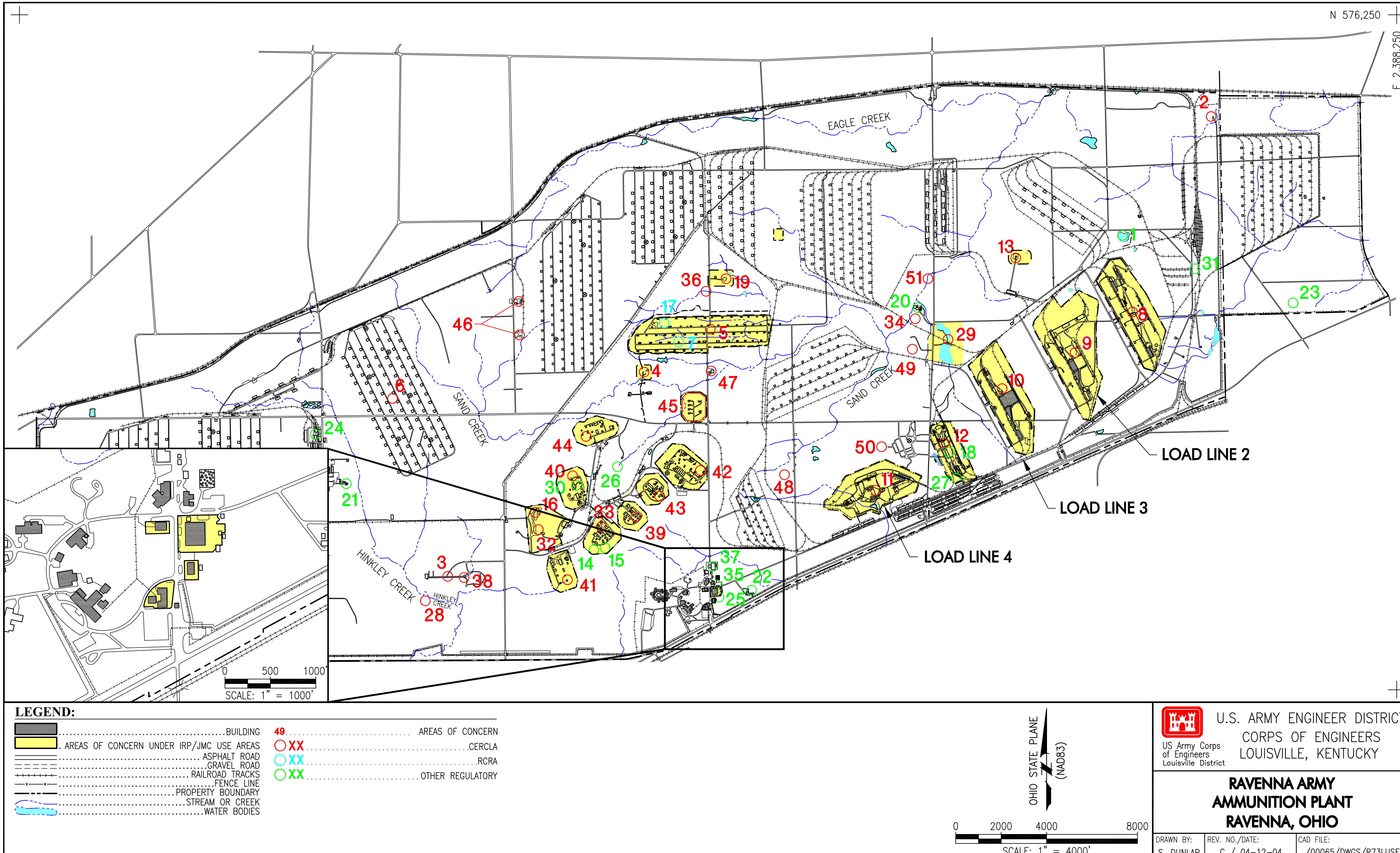

Figure 1-4. Current Land Use at RVAAP

ranges, hand grenade practice and qualification ranges, a light demolition range, and two armored vehicle maneuver areas. Additional field support and cantonment facilities will be constructed to support future training.

1.3 LOAD LINE 3 SITE DESCRIPTION

A detailed history of process operation and waste processes for the original 38 identified AOCs at RVAAP, including Load Line 3, is presented in the Preliminary Assessment (PA) for RVAAP (USACE 1996a). The following is a summary of history and related contaminants for Load Line 3.

1.3.1 Operational History

Production Operations

Load Line 3 (Figure 1-5) was used to melt and load Composition B into large-caliber shells and bombs. The line operated during World War II, from 1951 to 1957, and again from 1969 to 1971. Figure 1-6 presents historical photographs of typical load line production operations. During its operation history, Load Line 3 produced about 6.5 million munitions. Table 1-1 provides a summary of the operations conducted at Load Line 3.

During operations, bulk TNT in granular form was offloaded at Buildings EA-6 and EA-6A for screening and preparation. Bulk hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX) were received in chunk or nugget form and were manually examined to remove any foreign material. Following preparation, bulk explosive was manually transported in wheeled carriers via a covered walkway to the melt-pour buildings (EA-4 and EA-4A) for processing and loading into shells. Bulk explosive was manually introduced to steam-jacketed melting kettles located on the third floor of the buildings and piped to loading bays on the first floor. The primary charge was loaded into the shells and they were staged in finishing/cooling bays, also located on the first floors of the melt-pour buildings. Funnel removal, manual topping of the primary charge, and face off operations were conducted in these areas. Upon completion of primary charge loading, shells were transported to Building EB-10 for drilling operations for booster charges or other preparation steps depending on the type of munition. Drilling operations utilized vacuum equipment to contain explosive dust, which was piped to exterior dust collection units located along the north side of Building EB-10. Radiography equipment used to provide quality assurance (QA) of the primary charge was located in Building EB-10A. Buildings EB-13A, -13B, and -13C housed packaging and shipping operations. Shell receiving and preparation operations, including cleaning and painting, were contained in Building EB-3. Bulk explosive carrier washout activities were conducted in Building EB-25; effluent was directed to an above-grade concrete settling tank immediately south the building, which discharged to an unlined drainage ditch.

Other ancillary facilities include the following:

- Buildings EB-8, EB-8A, and EB-22 – change houses, offices, and cafeteria facilities;
- Building EB-803 – receiving and inert storage;
- Buildings EA-28 and EA-28A – elevator machine houses; and
- Physical plant service buildings (EA-5, EA-7, EA-21, EB-2, EB-9/9A, EB-11, EB-19, and EB-20).

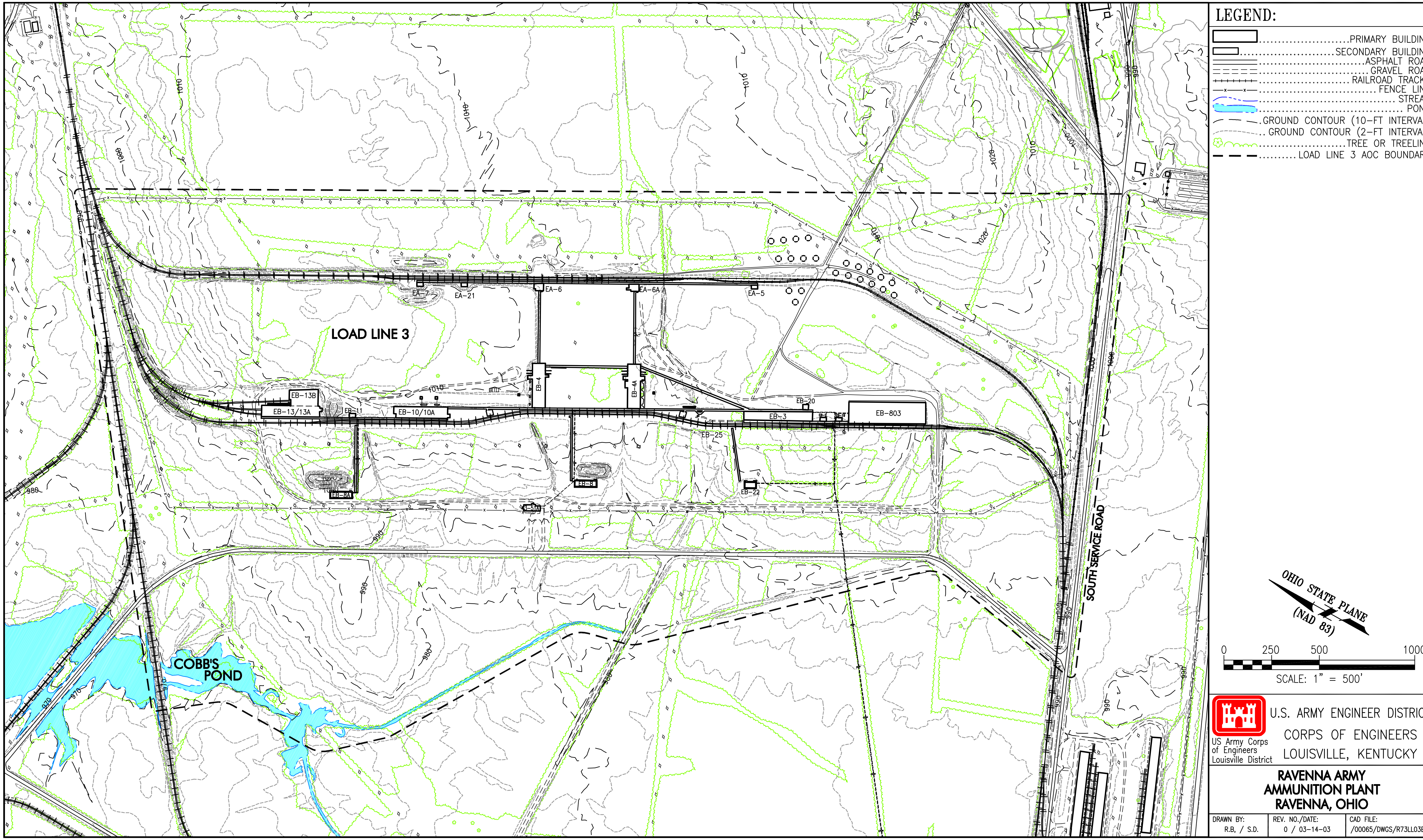

Figure 1-5. Load Line 3 Site Map

Booster cavities are being drilled in each shell. All TNT particles and dust are removed by the vaccum system.

Splash pans are cleaned with hot water or steam, resulting in the production of "pink water."

General operations in the melt-pour buildings. Cooled liquid TNT is being poured into each shell.

G03-0075 LL3 Old Photos

Figure 1-6. Typical Historical Operations at RVAAP

Table 1-1. Load Line 3 Operations Chronology

Area of Concern	Munitions	Quantities
World War II-Era Production		
Load Line 3	8-in. projectile Bomb, 100 lb Bomb, 500 lb Bomb, 2,000 lb 155-mm projectile 240-mm projectile Bomb, 1,000 lb	582,586 293,670 131,862 91,536 73,701 73,100 13,309 Total = 1,259,764
Late 1940s and 1951 to 1957 Demilitarization Activities		
Load Line 3	M74, 3-mm shot M1, 105-mm projectile M80, 3-mm shot	219,773 8,015 360 Total = 228,148
1951 to 1957 Production		
Load Lines 2 and 3	M107, high explosive, 155-mm projectile M101, high explosive, 155-mm projectile	5,619,243 256,585 Total = 5,875,828
1969 to 1971 Production		
Load Line 3	155-mm projectile (Composition B charge)	Total = 2,275,695

Demilitarization Operations

Demilitarization activities were conducted between 1951 and 1957. Beginning in the early 1950's the Defense Logistics Agency (DLA) conducted a strategic materials storage mission at Load Line 3. One hundred above-grade storage tanks (Tank Nos. 1401 through 1500), having a capacity of 500 barrels (21,000 gal), were constructed to store strategic materials. Tank Nos. 1401 through 1476 were used to store silica carbide. The remainder were used to store various other strategic solid materials.

Demolition Activities

By the late 1970's all but 20 tanks had been removed; those remaining were used to store antimony, asbestos, and magnesium silicate (talc). All DLA storage tanks are now empty; the remaining materials were removed approximately 3.5 years ago. Approximately 228,000 munitions were processed during demilitarization work.

1.3.2 Regulatory Status

Load Line 3 is a high-priority AOC in the current revision of the RVAAP Installation Action Plan (U.S. Army 2003). The priority ranking for Load Line 3 was determined through the RRSE process and the PA, as described in Section 1.3.3. Completion of a Phase I RI (USACE 1988a) at the AOC confirmed the presence of contaminants above risk-based screening criteria, indicating the need for additional characterization and human health and ecological risk evaluation as part of a Phase II RI. No other regulations [e.g., Resource Conservation and Recovery Act, National Pollutant Discharge Elimination System, etc.] pertain to past waste disposal and potential contamination at this AOC.

1.3.3 Previous Investigations at Load Line 3

Table 1-2 presents a summary of the analytical results from previous investigations performed at Load Line 3. Two previous investigations have been conducted: (1) the PA (USACE 1996a), and (2) the Phase I RI (USACE 1998).

Preliminary Assessment

The PA of Load Line 3 performed in 1996 included the load lines in the list of high-priority sites based on a relative risk ranking methodology. Reevaluation of the Load Line 3 risk ranking was performed at the completion of the Phase I RI and resulted in the site retaining its "High Risk" ranking.

Phase I Remedial Investigation

The Phase I RI sampling activities at Load Line 3 included surface soil and sediment sampling of areas within the AOC (Figure 1-7); groundwater was not investigated. An effort was made in the spring of 2001 to locate the Phase I sampling stations, for Phase II RI planning purposes, and to established coordinates with a global positioning system (GPS). This effort was required, as coordinate surveys of the soil and sediment sampling stations were not conducted during the Phase I RI. The locations of 30 soil and 2 sediment stations were confirmed (sample station stakes were still present) with GPS during the spring 2001 field effort. Coordinate data from the remaining Phase I RI stations were established to the best degree of accuracy possible from field sketches and maps. Figure 1-7 illustrates Load Line 3 and the Phase I RI surface soil and sediment sampling locations. The analytical data are presented in detail in Table 4.20 of Appendix G in the Phase I RI Report (USACE 1998). A summary of the Phase I RI analytical results is presented in Table 1-2. Use of Phase I RI data in nature and extent evaluations and risk assessments is detailed in Section 4.1.5.

During the Phase I RI field investigation, samples were collected from 40 surface soil locations and 10 ditch sediment locations. Of the 40 surface soil samples collected, the following analyses were performed:

- 36 samples were analyzed for explosives;
- 31 samples were analyzed for 11 site-related metals;
- 9 samples were analyzed for target analyte list (TAL) metals, cyanide, semivolatile organic compounds (SVOCs), and pesticides/polychlorinated biphenyls (PCBs); and
- 8 samples were analyzed for volatile organic compounds (VOCs).

TNT and other explosives were detected in the soil samples collected outside the melt-pour building and near the vacuum pump housings at Building EB-10. Isolated detectable concentrations of HMX and RDX were noted at one surface sample location each. The occurrence of RDX was associated with the melt-pour Building EB-4A; HMX was associated with the settling basin 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 soil in concentrations that exceed the range of U.S. Geological Survey (USGS) reference values.

Table 1-2. Summary of Historical Analytical Data for Load Line 3

Analyte	Units	Minimum Detect	Maximum Detect	No. of Detects per No. of Results
Sampling Program: Phase I RI (Surface Soil)				
Cyanide	mg/kg	0.12	0.38	6/9
1,3,5-Trinitrobenzene	mg/kg	0.253	110	7/37
2,4,6-Trinitrotoluene	mg/kg	0.142	390,000	26/37
HMX	mg/kg	14	14	1/37
RDX	mg/kg	10	10	1/37
Aluminum	mg/kg	3,720	23,900	37/37
Antimony	mg/kg	3.4	30	4/9
Arsenic	mg/kg	7	23.2	37/37
Barium	mg/kg	16.1	447	37/37
Beryllium	mg/kg	0.31	1.2	9/9
Cadmium	mg/kg	0.06	4.1	36/37
Calcium	mg/kg	772	13,500	9/9
Chromium	mg/kg	4.9	150	37/37
Cobalt	mg/kg	3.7	8.7	9/9
Copper	mg/kg	8.9	99.4	9/9
Iron	mg/kg	14,900	26,100	9/9
Lead	mg/kg	11.1	2,620	37/37
Magnesium	mg/kg	1,140	3,330	9/9
Manganese	mg/kg	75.3	4,800	37/37
Mercury	mg/kg	0.04	0.2	8/37
Nickel	mg/kg	7	21.9	9/9
Potassium	mg/kg	468	967	9/9
Selenium	mg/kg	0.35	4.1	35/37
Silver	mg/kg	0.28	2.4	5/37
Sodium	mg/kg	137	232	9/9
Thallium	mg/kg	0.78	3.5	9/9
Vanadium	mg/kg	9.9	22.5	9/9
Zinc	mg/kg	30.9	626	37/37
4,4'-DDE	mg/kg	0.0038	0.012	2/9
4,4'-DDT	mg/kg	0.011	0.077	2/9
Alpha Chlordane	mg/kg	0.590	0.590	1/9
PCB-1254	mg/kg	0.170	21	3/9
Beta-BHC	mg/kg	0.030	0.030	1/9
Endosulfan II	mg/kg	0.0045	0.0045	1/9
Endrin	mg/kg	0.010	3.2	2/9
Endrin Aldehyde	mg/kg	0.0048	0.0048	1/9
Gamma Chlordane	mg/kg	0.110	0.110	1/9
Heptachlor	mg/kg	0.0016	0.0016	1/9
Heptachlor Epoxide	mg/kg	0.094	0.094	1/9
2-Methylnaphthalene	mg/kg	0.048	0.048	1/9
Acenaphthene	mg/kg	0.066	0.095	2/9

Table 1-2. Summary of Historical Analytical Data for Load Line 3 (continued)

Analyte	Units	Minimum Detect	Maximum Detect	No. of Detects per No. of Results
Acenaphthylene	mg/kg	0.054	0.058	2/9
Anthracene	mg/kg	0.160	0.320	2/9
Benzo(*a*)anthracene	mg/kg	0.039	1.2	4/9
Benzo(*a*)pyrene	mg/kg	0.036	1	4/9
Benzo(*b*)fluoranthene	mg/kg	0.035	1.1	5/9
Benzo(*g,h,i*)perylene	mg/kg	0.440	0.610	2/9
Benzo(*k*)fluoranthene	mg/kg	0.038	1	6/9
Bis(2-ethylhexyl)phthalate	mg/kg	0.098	0.440	3/9
Butyl benzyl phthalate	mg/kg	0.088	0.088	1/9
Carbazole	mg/kg	0.110	0.250	2/9
Chrysene	mg/kg	0.045	1.5	5/9
Di-n-butyl phthalate	mg/kg	0.110	0.190	2/9
Dibenzo(*a,h*)anthracene	mg/kg	0.150	0.250	2/9
Dibenzofuran	mg/kg	0.057	0.057	1/9
Fluoranthene	mg/kg	0.051	2.2	6/9
Fluorene	mg/kg	0.058	0.094	2/9
Indeno(1,2,3-*cd*)pyrene	mg/kg	0.460	0.590	2/9
Naphthalene	mg/kg	0.043	0.052	2/9
Phenanthrene	mg/kg	0.072	1.2	4/9
Pyrene	mg/kg	0.044	1.8	5/9
Methylene Chloride	mg/kg	0.002	0.004	2/8
Toluene	mg/kg	0.014	0.038	2/8
Sampling Program: Phase I RI (Sediment)				
2,4,6-Trinitrotoluene	mg/kg	0.450	4.6	6/10
Aluminum	mg/kg	5,400	14,100	10/10
Antimony	mg/kg	0.97	0.97	1/1
Arsenic	mg/kg	4.5	18.8	10/10
Barium	mg/kg	39.8	115	10/10
Beryllium	mg/kg	0.68	0.68	1/1
Cadmium	mg/kg	0.06	1.6	7/10
Calcium	mg/kg	1,460	1,460	1/1
Chromium	mg/kg	7.4	18.1	10/10
Cobalt	mg/kg	6.5	6.5	1/1
Copper	mg/kg	18.3	18.3	1/1
Iron	mg/kg	18,500	18,500	1/1
Lead	mg/kg	8.8	63	10/10
Magnesium	mg/kg	1,680	1,680	1/1
Manganese	mg/kg	134	2,310	10/10
Mercury	mg/kg	0.05	0.06	5/10
Nickel	mg/kg	16	16	1/1
Potassium	mg/kg	543	543	1/1

Table 1-2. Summary of Historical Analytical Data for Load Line 3 (continued)

Analyte	Units	Minimum Detect	Maximum Detect	No. of Detects per No. of Results
Selenium	mg/kg	0.65	2.3	10/10
Silver	mg/kg	0.23	2.4	2/10
Sodium	mg/kg	176	176	1/1
Thallium	mg/kg	0.89	0.89	1/1
Vanadium	mg/kg	19.4	19.4	1/1
Zinc	mg/kg	45.2	560	10/10
4,4'-DDE	mg/kg	0.0032	0.0032	1/1
4,4'-DDT	mg/kg	0.0081	0.0081	1/1
Endrin	mg/kg	0.010	0.010	1/1
Gamma Chlordane	mg/kg	0.0029	0.0029	1/1
Benzo(*a*)anthracene	mg/kg	0.100	0.100	1/1
Benzo(*a*)pyrene	mg/kg	0.140	0.140	1/1
Benzo(*b*)fluoranthene	mg/kg	0.130	0.130	1/1
Benzo(*g,h,i*)perylene	mg/kg	0.088	0.088	1/1
Benzo(*k*)fluoranthene	mg/kg	0.140	0.140	1/1
Bis(2-ethylhexyl)phthalate	mg/kg	0.054	0.054	1/1
Chrysene	mg/kg	0.130	0.130	1/1
Dibenzo(*a,h*)anthracene	mg/kg	0.055	0.055	1/1
Fluoranthene	mg/kg	0.240	0.240	1/1
Indeno(1,2,3-*cd*)pyrene	mg/kg	0.110	0.110	1/1
Phenanthrene	mg/kg	0.091	0.091	1/1
Pyrene	mg/kg	0.180	0.180	1/1
Toluene	mg/kg	0.004	0.004	1/1

BHC = Benzene hexachloride.
DDE = Dichlorodiphenyldichloroethylene.
DDT = Dichlorodiphenyltrichloroethane.
HMX = Otahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine.
RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine.
RI = Remedial Investigation.

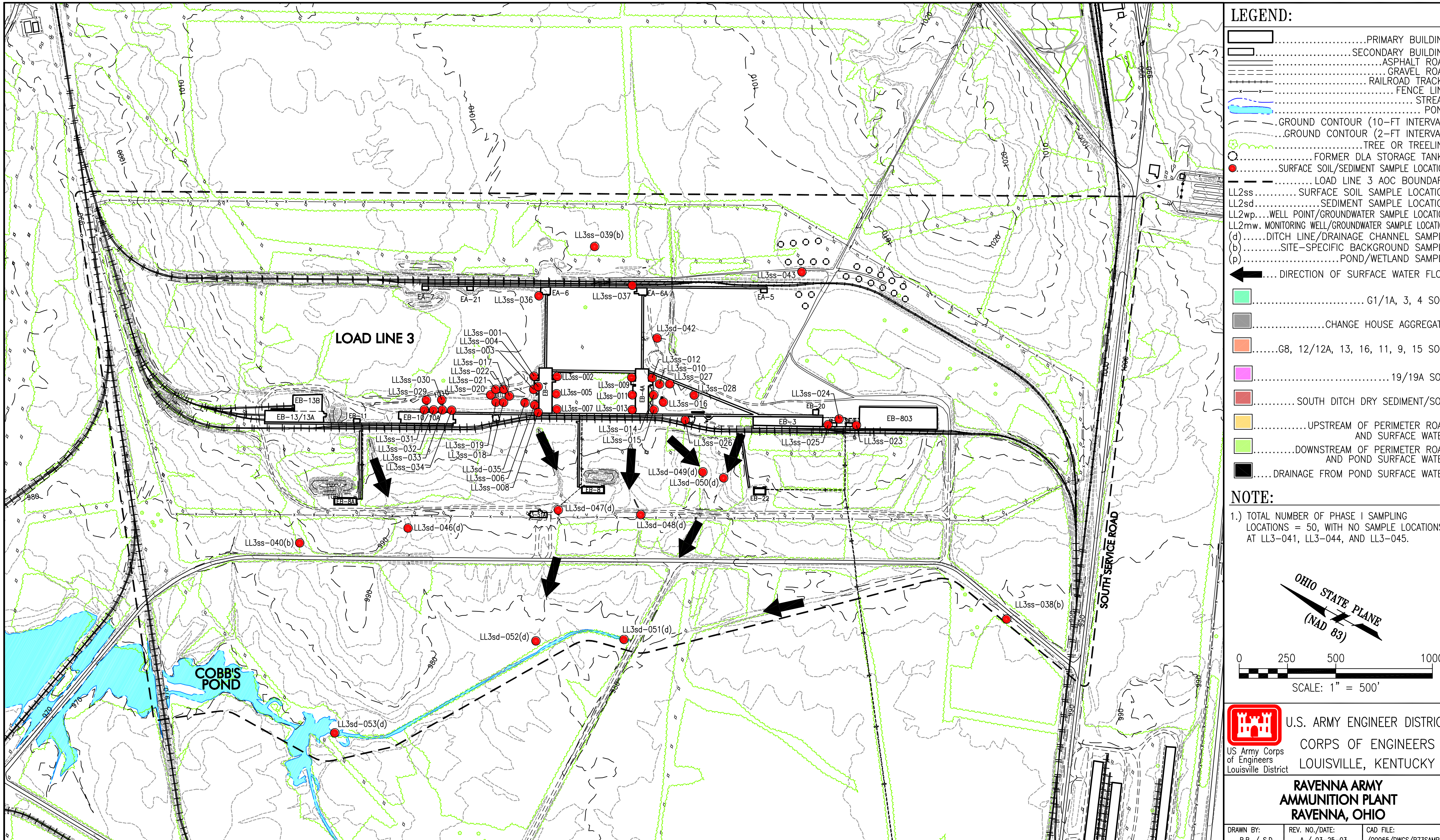

Figure 1-7. Load Line 3 Phase I RI Sampling Location Map

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

Polycyclic aromatic hydrocarbons (PAHs) were detected in two samples south of melt-pour building EB-4A.

Ditch sediment samples were analyzed for the following parameters:

- 10 samples were analyzed for explosives and 11 site-related metals; and
- 1 sample was analyzed for TAL metals, cyanide, VOCs, SVOCs, and pesticides/PCBs.

TNT was the only explosive found in ditch sediment and was detected at concentrations an order of magnitude or greater below those observed in the surface soil. The greatest amounts of explosives in ditches are associated with the melt-pour buildings. TNT was also present in the main stream that drains Load Line 3 and discharges into Upper Cobb's Pond.

Metal analytes were detected that are possible site-related constituents. These metals were observed primarily in sediment samples collected north of Building EB-4 and in the main drainage ditch, which discharges to Upper Cobb's Pond.

PAHs and pesticides were detected in the one sediment sample analyzed for organic constituents. The samples were collected from the main stream that drains Load Line 3.

1.3.4 Chemicals of Concern

Previous sampling data at Load Line 3 indicate that explosives contamination is present in surface soil surrounding former operations areas including Buildings EB-4, EB-4A, and EB-10; the settling basin north of EB-4; and EB-3A (carrier washout building) (Figure 1-5). Phase I RI surface soil samples show that detected explosives are almost exclusively TNT and 1,3,5-trinitrobenzene (TNB). Only one detection each of RDX and HMX was observed. Metals above Phase I RI background values (primarily chromium, copper, lead, and manganese) were concentrated around Buildings EB-4, EB-4A, and EB-803. Low levels of PAHs and pesticides were also detected near some of the former process buildings. PCBs were detected in several locations, with the highest concentrations occurring at Buildings EB-10 and EB-803. Phase I RI samples from Load Line 3 were analyzed for only a limited suite of metals (site-related); therefore, all metal contaminants above background may not have been identified at the AOC.

Based on available process knowledge and previous investigation results, the primary sources of contamination at Load Line 3 are explosives residues and metals (e.g., TNT, chromium, copper, lead, and manganese) generated from production of munitions and demilitarization operations. The presence of PAHs and PCBs are likely related to general operations of the Load Line 3 physical plant rather than directly to munitions production (e.g., steam plant operations, PCB-bearing paint residues), but are also of potential concern. Surface contamination exists adjacent to process buildings due to explosive and metal residues and the potential for subsurface soil contamination exists in these areas. There is potential for surface soil, sediment, and surface water contamination from the release of large volumes of process effluent (pink water) and runoff containing explosive and metal constituents into unlined earthen drainage ditches. Sediment and surface water contamination by explosive compounds and metals within Cobb's Pond is also possible due to large volumes of process effluents and runoff that were discharged to this surface water body.

1.4 DATA QUALITY OBJECTIVES

The facility-wide CSM, operational information, historical data and records, and data collected during previous investigations were used to design the Phase II RI sampling effort. The DQO approach, as outlined in the Facility-wide SAP (USACE 2001a), was employed during the scoping and planning process, including problem definition, identifying key decisions, and establishing study area boundaries and chemical data quality requirements. The key decisions for all investigations at RVAAP have been identified in Section 3.2.4 and in Table 3-1 of the Facility-wide SAP. The DQOs for the Phase II RI at Load Line 3 were presented in detail in the *Final Phase II Remedial Investigation Sampling and Analysis Plan for Load Lines 2, 3, and 4 at the Ravenna Army Ammunition Plant, Ravenna, Ohio* (USACE 2001b). A summary of the DQOs is presented below for reference purposes in this report.

The purpose of the Phase II RI was to determine the extent of contamination in affected media (i.e., soil, sediment, surface water, and groundwater) identified during the Phase I RI. The specific objectives of the Phase II RI included the following.

- Characterization of the physical environment of Load Line 3 and surroundings, to the extent necessary, to define potential contaminant transport pathways and receptor populations.

- Characterization of nature and extent of contamination such that risk evaluations could be conducted and results compared to those from baseline risk assessments at a risk extrapolation reference site [Load Line 1, Winklepeck Burning Grounds (WBG), or Load Line 12]. The risk extrapolation process was developed among the Army, USACE, and Ohio EPA and implemented under RVAAP's Facility-Wide Human Health Risk Assessor's Manual (FWHHRAM; USACE 2004).

- Identifying whether releases of contamination beyond the AOC boundary are occurring by collecting environmental samples (surface water and sediment) downstream of the AOC boundary within exit conveyances and using applicable historical information, including results of the Phase I RI. Data collected prior to the Phase I RI are of limited use due to lack of corresponding QA/quality control (QC) data and information on detection limits and any verification/validation processes.

- Characterization of sources of contamination at Load Line 3 sufficient to screen and evaluate remedial alternatives in a subsequent FS. Data on source locations, types and concentrations of contaminants, potential release mechanisms, physical and chemical properties of contaminants present, and geotechnical characteristics of environmental media identified as key data needs.

- Provide recommendations for any additional investigations and/or actions.

Surface Soil. The majority of Phase I RI surface soil samples were analyzed for only a limited suite of site-related metals; additionally, a limited number of samples for SVOCs, VOCs, and PCBs were collected. Therefore, all site-related contaminants (SRCs) were not fully identified nor characterized by the Phase I RI. The Phase I RI and other historical sampling did not characterize all of the former process areas. To address these data needs, an expanded analytical suite was employed for the Phase II RI. Those areas not previously characterized were specifically targeted for biased sampling in the Phase II RI. In addition, to investigate whether soil contamination is present in those portions of the AOC outside of the former process areas, random grid sampling methods were selected. The methodology for defining exposure units (EUs) outside the former process areas is discussed in Section 4.3. Contaminated surface soil within and adjacent to former process areas were identified as potential secondary sources of contamination to sediment, surface water, and groundwater. Contaminants may be released from surface soil and migration storm runoff either in dissolved phase or adsorbed to particulates and/or colloids. To address these data needs and migration pathways, further characterization of known areas of surficial soil contamination was planned to define contaminant nature and extent and to provide sufficient data for remedial alternatives analysis in a subsequent FS.

Subsurface Soil. Subsurface soil characterization was not performed in the Phase I RI. Characterization of this medium was identified as a data need to determine if leaching processes may be a potential mechanism for contaminant migration to groundwater. Subsurface soil in all process areas was targeted for characterization using biased sampling in conjunction with that for surface soil.

Sediment. Sediment within ditches and tributaries represents a receptor media for contaminants eroded or leached from soil and transported by storm runoff. The surface water system also represents the primary mechanism for contaminant transport off of the AOC. In addition, sediment may function as a transport mechanism considering that contaminants adsorbed to particulates may be mobilized by surface water flow. Operational data suggested that the ditches in the vicinity of former process areas represented the most likely locations where contaminants may have accumulated through erosional transport. Overall drainage patterns for surface water and sediment from Load Line 3 are to the west via ditches and unnamed tributaries (Figure 1-7). The drainageways ultimately feed into a tributary flowing along the western boundary of the AOC, which flows into Upper Cobb's Pond. This tributary is the only potential surface water contaminant exit pathway for the AOC. Sediment sampling in ditches within the AOC and in the tributary flowing to Upper Cobb's Pond was conducted during the Phase I RI. These data showed detectable TNT within the AOC boundary at several locations along ditches and at two locations in the exit pathway tributary. Metals contaminants (primarily lead) were concentrated at levels above Phase I RI background screening criteria in numerous locations within AOC ditches and in the tributary to Upper Cobb's Pond. Considering the available data and the CSM, both confirmed and additional suspected source areas, as well as the exit pathway, were specifically targeted for biased sampling.

Surface Water. Surface water represents the likely primary mechanism for mobilization and transport of contamination within and off of the AOCs. Most chemical transport via surface water is presumed to occur along the ditches within the AOC and is primarily episodic and related to storm events that produce flushing of the surface water system and mobilization of contaminated soil and sediment through erosion. Surface water sampling was not conducted during the Phase I RI at these load lines. Because of these factors, potential transport of contaminants via surface water off of the AOC and the RVAAP facility installation was identified as an unknown element to the CSM to be addressed by the Phase II RI. Drainage ditches near several former process buildings and the tributaries exiting Load Line 3 were specifically targeted for biased sampling to be co-located with sediment samples.

Groundwater. Very limited hydrogeologic and analytical data exist for groundwater at Load Line 3. For the purpose of DQO development and investigation planning, it was presumed that groundwater flow patterns at the AOC followed site topography and surface water drainage patterns. Concentrations of some of the principal soil SRCs are substantially elevated above background, indicating that the potential exists for groundwater contamination. Because of the limited available groundwater data, establishing groundwater flow directions and contaminant migration from source areas to groundwater (via leaching or surface water infiltration) was identified as a key data need for the Phase II RI. Installation of monitoring wells and piezometers was planned to target known and suspected areas with the highest levels of soil contamination. Monitoring wells were also specifically planned along the southern boundary of Load Line 3 to determine whether groundwater flow and potential contaminant transport off of the AOC is occurring. In addition to monitoring wells, characterization of unconsolidated zone stratigraphy to depths of approximately 15 ft was planned using six test pits excavated by backhoe. Additionally, a facility-wide water level measurement effort, including all new monitoring wells at Load Lines 2, 3, and 4, was identified as a data need to obtain contemporaneous data and to establish general groundwater flow patterns throughout the installation.

Utilities. Storm sewer and sanitary sewer system infrastructures remain in place at Load Line 3. These sewer systems may represent accumulation points for contaminants introduced through building floor drains and sink drains during AOC operations. Reconnaissance of the AOCs and investigations to date indicated that most of the storm and sanitary sewer systems at Load Line 3 were above the water table and were dry. Considering the age of the systems, cracks or gaps in the piping could potentially allow groundwater influx or seepage of storm water from the pipes. Thus, if the piping contains accumulated contaminants in sludges or sediment, it may represent a source to groundwater. Also, the system may function as a preferential migration pathway for shallow groundwater transport. Accordingly, a visual and video camera survey was planned to investigate the condition of the system. Sludge or sediment samples were planned at identified accumulation points to investigate if contaminants migrated into the sewer systems from process areas. Also, samples of accumulated water were planned to determine if any identified contaminants are partitioning from sediment or sludge to accumulated water within the pipes and are, subsequently, being discharged at outlet locations.

1.5 REPORT ORGANIZATION

This Phase II RI Report is organized to meet Ohio EPA requirements in accordance with the U.S. Environmental Protection Agency (EPA), the CERCLA Superfund process, and USACE guidance. The report consists of an Executive Summary, Chapters 1.0 through 10.0, and supporting appendices. Chapter 1.0 describes the purpose, objectives, and organization of this report, and provides a description and operational history of Load Line 3. Chapter 2.0 describes the environmental setting at RVAAP and Load Line 3, including the geology, hydrogeology, climate, population, and ecological resources. Chapter 3.0 describes the specific Phase II RI methods used for field data collection and describes the approach to analytical data management and laboratory programs. Chapter 4.0 presents the data generated during the Phase II RI and discusses the occurrence and distribution of contamination at Load Line 3. Chapter 5.0 includes the methodology and results for contaminant fate and transport modeling. Chapters 6.0 and 7.0 present the methodology and results of the human health and ecological risk evaluations, respectively. Chapter 8.0 summarizes the results and conclusions of this study and presents lessons learned. Chapter 9.0 presents the recommendations, and Chapter 10.0 provides a list of referenced documents used to support this Phase II RI.

Appendices (A through S) to this report for Load Line 3 contain supporting data collected during the Phase II RI. These appendices consist of soil sampling logs (Appendix A); sediment and surface water sampling logs (Appendix B); piezometer and monitoring well installation and development and sampling logs (Appendixes C and D, respectively); slug test logs and solutions (Appendix F); QA documentation (Appendixes G and H); laboratory and field analytical data (Appendixes I through K); fate and transport modeling results (Appendix L); survey data (Appendix M); sewer line video survey results (Appendix N); ordnance and explosives (OE) avoidance report (Appendix O); investigation-derived waste (IDW) management characterization reports (Appendix P); and supporting data for the SHHRA and screening ERA (SERA) (Appendixes Q and R, respectively); and USACE radiological survey (Appendix S).