Site-Specific Sampling and Analysis Plan

Remedial Investigation
Data Gap Investigation for the Garage Maintenance Area-
Former Sellite Area and Unloading Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

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List of Acronyms

AOC	area of concern
ASTM	American Society for Testing and Materials
bgs	below ground surface
^{o}C	degrees Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DNT	dinitrotoluene
DoD	U.S. Department of Defense
DPT	direct push technology
Eh	oxygen-reduction potential
EPA	U.S. Environmental Protection Agency
FADL	field activity daily log
GMA	Garage Maintenance Area
IDW	investigation-derived waste
LEL	lower explosive limit
MK	Morrison Knudsen Corporation
µg/kg	micrograms per kilogram
mL/min	milliliters per minute
NASA	National Aeronautics and Space Administration
OD	outside diameter
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon
PBOW	Plum Brook Ordnance Works
PCB	polychlorinated biphenyl
PID	photoionization detector
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RBSC	risk-based screening concentration
RI	remedial investigation
RSL	regional screening level

List of Acronyms *(Continued)*

Shaw	Shaw Environmental, Inc.
SSAP	site-specific sampling and analysis plan
SVOC	semivolatile organic compound
SWSAP	site-wide sampling and analysis plan
TAL	target analyte list
1,1,1-TCA	1,1,1-trichloroethane
TCE	trichloroethene
TCL	target compound list
TOC	total organic carbon
TNT	2,4,6- trinitrotoluene
USACE	U.S. Army Corps of Engineers
UST	underground storage tank
VOC	volatile organic compound

1.0 Project Description

The U.S. Army is conducting studies of the environmental impact of suspected hazardous waste sites at former U.S. Department of Defense (DoD) properties. The former Plum Brook Ordnance Works (PBOW) is located in Sandusky, Erie County, Ohio (Figure 1-1). PBOW is being investigated under the Defense Environmental Restoration Program for Formerly Used Defense Sites. The investigation is being managed and technically overseen by the Nashville District of the U.S. Army Corps of Engineers (USACE). This 9,000-acre facility was used for the manufacture of explosives during World War II. The site is currently controlled and maintained by the National Aeronautics and Space Administration (NASA) and is operated as the Plum Brook Station of the John Glenn Research Center at Lewis Field.

This site-specific sampling and analysis plan (SSAP) has been prepared by Shaw Environmental, Inc. (Shaw) for the fieldwork to be carried out in support of soil and groundwater remedial investigations (RI) at the former Sellite Area and Unloading Area. This SSAP is an addendum to the sitewide sampling and analysis plan (SWSAP) (Shaw, 2008a) and was developed in accordance with the PBOW SWSAP and the quality assurance project plan (QAPP) (Shaw, 2008b) to ensure that work performed at the subject site will be of the quality required to satisfy the overall and site-specific project objectives. A sitewide accident prevention/sitewide safety and health plan (Shaw, 2008c) was also prepared for this investigation to help provide a safe work environment.

1.1 Plum Brook Ordnance Works Facility History

The PBOW site was built in early 1941 and manufactured 2,4,6-trinitrotoluene (TNT), dinitrotoluene (DNT), and pentolite. Production of explosives began in December 1941 and continued until 1945. After the plant was shut down, decontamination of TNT, acid, pentolite, and DNT processing lines began; decontamination was completed by the Army during the last quarter of 1945. The property was under the supervision of the Army Ordnance Department. The War Assets Administration accepted custody of the property (3,230 acres) except for the retained area, which is known as the magazine area (2,800 acres), in 1946. The Department of the Army reacquired the 3,230 acres in 1954 and performed cleanup efforts during the 1950s through 1963. Two property use agreements were entered into by the National Advisory Committee on Aeronautics, the predecessor of NASA, and the Army in 1956 and 1958, respectively. In 1963, accountability and custody of the entire PBOW property (6,030 acres) was transferred to NASA by the Department of the Army. NASA has operated and maintained the PBOW site since 1963, and it is currently the NASA Glenn Research Center, Plum Brook Station. Figure 1-2 shows the various PBOW areas of concern, including the Garage Maintenance Area (GMA). The GMA includes the Sellite Area, Unloading Area, and the Locomotive Building. The Locomotive Building contains the maintenance pit and associated pit sump being investigated.

1.2 Site History and Summary of Existing Site Data

1.2.1 Unloading Area

1.2.1.1 Site Description

The Unloading Area, on the north side of Maintenance Road between Ransom Road and Taylor Road, was used principally for unloading of toluene and possibly other chemicals from railcars. It is estimated that more than 400 million pounds of toluene may have been unloaded at this site during the PBOW operational period (International Consultants, Inc., 1995). Figures 1-3, 1-4, and 1-5 show historical aerial photographs of the two sites; in addition, a current aerial photograph is also included on Figure 1-3. In 1942, five underground storage tanks (UST) (#28, #32, #33, #34, and #35) were installed in the GMA to support maintenance work (Tetra Tech, Inc., 2001). The USTs contained gasoline, solvents, and waste oil. Tanks #33, #34, and #35 can be seen on Figure 1-6. Tank #32 was located north of NASA Building No. 7131 (Ebasco Environmental, 1991). Tank #28 was located east of NASA Building No. 7121 and on the east side of Garage Road. In 1964, NASA installed three USTs (#29, #30, and #31) at the GMA for the storage of solvents (acetone, trichloroethene [TCE], and 1,1,1-trichloroethane [1,1,1-TCA]) (Tetra Tech, Inc., 2001). Tanks #29, #30, and #31 were located east of Building 7121 (Ebasco Environmental, 1991). Tanks #28, #29, #30, #31, #33, #34, and #35 were removed in 1989. Tank #32 was removed in 1990 (Tetra Tech, Inc., 2001). Relative to the overburden groundwater flow direction, all of these USTs are either downgradient or crossgradient of the Unloading Area. The decommissioning of the Unloading Area was begun in 1945, when ordnance manufacturing ceased. No other post-operational activities are known to have occurred in this area. However, its proximity to the GMA may have led to its informal use for staging of equipment and supplies (International Consultants, Inc., 1995).

1.2.1.2 Summary of Existing Site Data

In 1993, an investigation was conducted by the Morrison Knudsen Corporation (MK) covering a number of areas of concern (AOC), including the Unloading Area (referred to as the Rail Car Unloading Area by MK [MK, 1994]). During this investigation, two surface soil samples (MK-SS-15 and MK-SS-16), and one subsurface soil sample (SB11) were collected from the vicinity of the Unloading Area.

The two surface soil samples (MK-SS-15 and MK-SS-16) and one subsurface soil sample from boring SB11 were collected along the rail spur near Maintenance Road (Figure 1-6). All of the samples were analyzed for volatile organic compounds (VOC), semivolatile organic compounds (SVOC), pesticides/polychlorinated biphenyls (PCB), explosives, and metals. Four compounds, all polycyclic aromatic hydrocarbons (PAH), exceeded their regional screening levels (RSL) (U.S. Environmental Protection Agency [EPA], 2010) in the subsurface soil sample from SB11: benzo(a)anthracene (260 micrograms per kilogram [µg/kg]), benzo(a)pyrene (230 µg/kg), benzo(b)fluoranthene (340 µg/kg), and dibenzo(a,h)anthracene (27 µg/kg). Only low levels of PAHs were reported in the two surface soil samples (MK-SS-15 and MK-SS-16).

One monitoring well, installed in 1993, is within the Unloading Area (MK-MW19) and is located on the northeast edge of the Unloading Area, just south of the rail line. Depth to groundwater ranges from 3.5 to 8.5 feet. All of the samples were analyzed for VOCs, SVOCs, explosives, and metals. The following compounds were found above the RSLs (EPA, 2010) and maximum contaminant levels (EPA, 2011) in groundwater sample MK-MW19: 1,1-dichloroethane (18 micrograms per liter) and 1,1,1-TCA (360 micrograms per liter). In addition, aluminum, cobalt, iron, lead, nickel, and vanadium exceeded both RSLs and background in one or more unfiltered groundwater samples. Metals were not detected above RSLs and background in any of the filtered samples. This suggests that the exceedances in the unfiltered samples may have been the result of elevated turbidity. Depth to groundwater ranges from 3.5 to 8.5 feet.

The presence of 1,1,1-TCA in groundwater is problematic because records indicate that its use post-dates PBOW activities. 1,1,1-TCA became a widely used replacement for TCE, carbon tetrachloride, and tetrachloroethylene in metal degreasing and cleaning applications only in the late 1950s and 1960s (Doherty, 2000). A 1941 review of new solvents did not mention 1,1,1-TCA, suggesting that it was not widely used at the time. 1,1,1-TCA was not included on 1940s market price lists, which typically listed chemicals used in large commercial quantities. Before approximately 1957, 1,1,1-TCA was not widely used because adequate stabilizer formulations could not be found. In 1965, Dow Chemical introduced Dowclene WR, developed for cleaning microcircuitry and machined parts in the aerospace industry.

Groundwater flow in this area is to the north. Although USTs were present east of this site, no NASA activities were reported to have occurred within the Unloading Area. It is likely this groundwater contamination is related either to the USTs or some other upgradient location.

1.2.2 Sellite Area

1.2.2.1 Site History

The Sellite Area, located west of the Unloading Area, was used for the production and storage of sellite (sodium sulfite) used for the TNT washing process (Dames and Moore, Inc. [D&M], 1995). Review of historical site photographs show that the Sellite Area consisted of one building approximately 60 feet by 70 feet, a sulfur storage bin (20 feet by 60 feet) along the east side of the building, and six aboveground storage tanks along the south side of the building. Figures 1-3 through 1-5 show historical photographs, and Figure 1-3 includes a current photograph of the Sellite Area and Unloading Area. Information regarding the exact sellite production process could not be located; however, it is believed that sulfur was incinerated to produce sulfur dioxide and sulfur trioxide.

Extensive areas of bare soil and pieces of sulfur and slag were observed at the former Sellite Area during field reconnaissance by D&M (D&M, 1995) and again by Shaw in October 2010. A shallow surface ditch which received runoff from the Sellite Area is located east, north, and west of the Sellite Area (D&M, 1995).

1.2.2.2 Summary of Existing Site Data

In 1993, an investigation was conducted by MK covering a number of AOCs, including the Sellite Area (MK, 1994). During this investigation, three surface soil samples (MK-SS-34, MK-SS-35, and MK-SS-36) were collected (Figure 1-6). These samples were obtained just west of the rail line within the Sellite Area, near the intersection of Maintenance Road and the abandoned rail spur, although the exact locations for all three samples was not clear in the MK report. The report states that “SS34, SS35, and SS36 were obtained from an area void of vegetation and covered with lumps of sulfur and coke just west of the intersection of Maintenance Road and the rail spur. Broken timbers were found that indicate that a wooden structure of some sort used to exist in this area” (MK, 1994). The samples were analyzed for nitroaromatics, VOCs, SVOCs, and metals. Two of these surface samples (MK-SS-34 and MK-SS-35) contained compounds (all PAHs) exceeding their RSLs.

- MK-SS-34: benzo(a)anthracene (220 µg/kg), benzo(b)pyrene (130 µg/kg), and benzo(b)fluoranthene (310 µg/kg)
- MK-SS-35: benzo(a)anthracene (920 µg/kg), benzo(b)pyrene (680 µg/kg), benzo(b)fluoranthene (2,400 µg/kg), chrysene (1,500 µg/kg), dibenzo(a,h)anthracene (91 µg/kg), and indeno(1,2,3-cd)pyrene (430 µg/kg).

No other analytes exceeded risk-based screening concentrations (RBSC) and background concentrations (metals only).

1.2.3 Locomotive Building Maintenance Pit and Pit Sump

1.2.3.1 Site History

The locomotive building is the easternmost building in the GMA (Shaw, 2010). It was used for the maintenance of equipment, vehicles, and railcars. The maintenance pit is inside this building and was built to allow maintenance personnel to work below locomotives and railcars during the operation of PBOW. The pit measures 60 feet long; 3 feet, 8 inches wide; and 5 feet deep. The pit is located beneath the northern set of railroad tracks that run through the building. The sump being investigated is within the pit. NASA has backfilled the pit with loose stone and currently uses this building as a storage garage. When the pit was operational, the waste effluent from the pit drained into the pit sump and from there to a sump basin on the south side of the building. A sump pump in the sump basin sent the waste to the sanitary sewer system. A pump is still present in the 2.5-foot-diameter and 9-foot, 2-inch-deep sump basin. The Locomotive Building, also known as the Locomotive Shop, was Building 718 on the facility buildings list. It was located south of a track known as “Z” track. “Z” track was labeled as being the track “to (the) caustic dock.”

1.2.3.2 Summary of Existing Site Data

In 1999, a limited site investigation (SI) was conducted of the surface and subsurface soil within the Locomotive Building Area (Shaw, 2010). Two surface and 10 subsurface soil samples were collected from six borings and analyzed for SVOCs, PCBs, and target analyte list (TAL) metals. One of the samples (DP-01) came from the maintenance pit in the Locomotive Building. Figure 1-7 shows this sample location. Sample DP-01 was collected at an interval of 6 to 7.5 feet below ground surface (bgs) from a sump at the bottom of the maintenance pit. This sample was collected from the lining of the maintenance pit sump and was not truly soil, but rather was composed of crushed limestone and associated fines that were evidently stained with petroleum-related materials. No organic compounds other than a low level of Aroclor 1260 (0.45 milligrams per kilogram) were detected in sample DP-01. However, this borehole was reported to have a strong petroleum odor. The sample from DP-01 exhibited strong matrix interference during analysis and had to be diluted 50-fold. The sample also had high organic carbon content (13,000 milligrams per kilogram). This sample’s concentrations for antimony, arsenic, chromium, iron, lead, and PCBs exceeded preliminary remediation goals (EPA, 2004).

In 2009, RI activities were conducted by Shaw at the Locomotive Building Area (Shaw, 2010). Included in this RI were three direct-push borings in the maintenance pit which sampled pit fill material. Figure 1-7 shows these three borings (SB-07, SB-08, and SB-09). Each boring was drilled to refusal at 4.9 feet below the surface level of fill material in the pit. The refusal material could not be confirmed, but the pit is evidently lined with concrete or some other impervious material. Each pit sample was collected from approximately 3 to 4.5 feet below the surface level of fill material in the pit. VOCs were not analyzed for in these samples due to the composition of sample matrix (mostly gravel); however, target compound list (TCL) SVOCs, nitroaromatics, PCBs, and TAL metals were analyzed. A weathered petroleum odor was encountered in boring SB-09, which was drilled within 5 feet of 1999 SI boring DP-01. Elevated petroleum-contaminated material found in DP-01 was not observed in borings SB-07, SB-08, or SB-09 or reflected in the analytical results. Therefore, the petroleum contamination encountered during the 1999 SI appears to be limited to the vicinity of the maintenance pit sump and is not present throughout the pit. No nitroaromatics were detected in the pit samples. SVOCs were detected, with benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene exceeding their RBSCs. No PCBs were detected in the pit samples. No metals were detected at concentrations exceeding both screening levels and background concentrations.

1.3 Sitewide Hydrogeology

Two hydrolithologic units are known to exist at PBOW: the overburden/shale and underlying limestone bedrock. Data from investigations conducted over the past decade (Shaw, 2005; International Technologies Corporation, 1997, 1999) have found that groundwater in the overburden/shale is in discontinuous pockets during dry time periods exemplified by monitoring wells that are typically dry or areas in which wells could not be installed due to a lack of water in the overburden/shale at the time of drilling. Because of the general lack of water in the overburden/shale, only limited lateral migration of contaminants would typically occur during the dry period. During a wet period, the general flow direction in the overburden/shale water-bearing zone (where present) is to the north-northeast, largely mirroring surface topography. The flow also corresponds somewhat to the topography of the top of the bedrock. In contrast, the limestone bedrock water-bearing zone is saturated year-round. The conceptual model of the site shows that groundwater flow in the limestone water-bearing zone migrates and is influenced by the frequency, orientation, density, and connectivity of fractures in the bedrock. Similar to the overburden/shale flow direction, groundwater in the limestone generally flows to the north-northeast towards Lake Erie.

Based on groundwater elevation data collected in May and August of 2010, overburden groundwater flow in the Unloading Area is to the north. Due to lack of well coverage, groundwater elevation data are not available for the Sellite Area, but groundwater flow is also interpreted to be to the north; however, the presence of the drainage ditch around the perimeter of the Sellite Area may influence groundwater flow, particularly during periods of high precipitation. Overburden/shale thickness in the Unloading Area/Sellite Area is approximately 40 feet and consists of glacial outwash (20 feet), weathered shale (10 feet), and shale (10 feet).

2.0 Scope of Work and Objectives

2.1 Scope of Work

As specified in the scope of work (USACE, 2010), the RI field activities are covered by this SSAP:

- Soil sampling (using direct-push technology [DPT])
- Sediment sampling
- Locomotive Building pit sump sampling
- Installation of temporary piezometers and monitoring wells
- Groundwater sampling of piezometers and wells
- Laboratory analysis of soil and groundwater
- Management and disposal of investigation-derived waste (IDW)
- Preparation and submittal of a geographic information system deliverable
- Preparation of an electronic data deliverable.

The above activities, analytical data, and evaluation will be presented in a site characterization report, which will comprise Volume 1 of the RI report. This information will also be used in the baseline human health risk assessment and screening-level ecological risk assessment, which will comprise Volumes 2 and 3 of the RI report, respectively. A separate work plan will be submitted for Volumes 2 and 3.

2.2 Site-Specific Data Quality Objectives

2.2.1 Overview

The data quality objectives process followed during the planning stages of the RI evaluated data requirements needed to support the decision-making process and select the best action to satisfy these requirements. Incorporated components of the data quality objectives process, described in EPA guidance (EPA, 2006), are discussed in detail in Section 3.3 of the SWSAP. Determining factors for procedures necessary to satisfy investigative objectives and to establish the basis of future actions at PBOW are presented on Figure 3-1 of the SWSAP (Shaw, 2008a). The data uses and needs for this investigation are summarized in Table 2-1.

2.2.2 Problem Statements

The Sellite Area consisted of buildings and infrastructure needed for the production of sodium sulfite (sellite). In addition to the raw materials needed for sellite production (soda ash and sulfur), potential waste products such as ash from the combustion of sulfur and PAHs from building demolition may also be present. Although present on the ground surface in numerous areas around the Sellite Area, elemental sulfur itself does not pose a threat to human or ecological receptors. However, associated with the sulfur is what appears to be a silty-type material that may be weathered ash. This material may contain PAHs and/or metals that result in the barren areas present at the site. The Unloading Area consists of a rail track spur with visible scarring present on historical aerial photographs between the rail line and Maintenance Road. No accurate records exist regarding the “unloading” practices. However, the lack of any visible infrastructure on historical photographs and maps does not suggest that raw products such as toluene were actually removed from the railcars. It is more likely that the area was used to disconnect the railcars and move them to the toluene tanks, where unloading occurred. However, some transfer of material likely occurred within this area, as is evident by an earthen loading dock seen on historical photographs (Figure 1-5). Possible sources or release points included leaks and spills from railcars as well as leaks and spills from materials unloaded and stored in this area. Based on information obtained during interviews with former employees at Volunteer Army Ammunition Plant, formerly located in Chattanooga, Tennessee, waste oils were typically used around building foundations and tank cradles to suppress vegetation. Such waste oil may have contained PCBs, as these were previously included in many lubricants such as coolants, hydraulic fluids, and cutting oils. It appears that this same practice of applying waste oils around buildings, tank cradles, and other structures may have been practiced at PBOW. In addition, PCBs were an established part of many paints by the 1950s, and its inclusion in paint was not banned until 1978 (Environmental Protection, 2000). Chlorinated rubber paint was the most common paint to contain PCBs and had excellent water and chemical resistance, elasticity, and durability. Since chlorinated rubber alone made paint too brittle for long-term performance, a plasticizer was added. Until the ban on the manufacture of PCBs, Aroclor 1254 was the plasticizer of choice when chemical resistance was desired. PCBs significantly enhance the chemical resistance of the chlorinated rubber. Alternatively, the PCBs found in soils may have originated from leaky transformers, spills, or equipment that leaked lubricants (especially hydraulic fluid).

Site-related contaminants include VOCs, SVOCs, PCBs, and metals. Limited groundwater data are available for these areas, and the impacts from these areas are unknown. One overburden well in the area does contain elevated concentrations of 1,1,1-TCA; however, as previously noted, it is unlikely that this is related to Army activities.

This RI is being conducted at the site to determine if there has been a release to surface or subsurface soil, sediments, surface water, or groundwater. The RI also is being conducted to evaluate the nature of the associated threats and to eliminate from further consideration those releases that pose no significant threat to public health or the environment. Review of available information regarding historical operations has been used to develop a preliminary conceptual site model for the sites, summarized in Section 2.2.3.

At this stage of the investigation, the following problem statements relate primarily to initial uncertainties regarding environmental conditions and potential risks to human and ecological receptors. Data are needed to answer the following questions:

- Have historical activities resulted in the release of contaminants to the environment?
- If contaminants have been released from site historical activities, do they serve as current or future sources of groundwater contamination?
- If contamination is identified in soil, sediment, surface water, and/or groundwater, is it present at sufficient levels to warrant further investigation?

The planned investigation for this site addresses these questions through the selection of sample locations designed to evaluate specific potential contaminant sources and release points (biased sampling).

2.2.3 Conceptual Site Model

Four factors considered in defining the conceptual site model (USACE, 2008) for the RI are as follows:

- Potential contaminant sources
- Migration pathways
- Potential human health and ecological receptors
- Types of contaminant of an affected medium.

A source of contamination at PBOW is past TNT manufacturing activities, including the production and storage of raw materials. Sources at the proposed areas of investigation result from sellite production, unloading of materials, and locomotive maintenance activities. The migration pathways for potential contaminants include those associated with overburden/shale groundwater, bedrock groundwater, soil, sediment, and surface water. Unless the RI shows otherwise, it is assumed that the overburden/shale groundwater is also of sufficient volume to be used as a potable source.

Exposure of site workers to potential contaminants under current land use at PBOW is negligible, because the Sellite Area and Unloading Area are remote from regular site worker activity and because any potentially contaminated material within the locomotive building pit sump is covered with clean material. PBOW is opened to deer hunting by permit; therefore, hunters may be exposed to potential contaminants in soil and potentially exposed via ingestion of venison from deer that have grazed in these areas. Exposure to hunters is expected to be limited for the following reasons: 1) hunters would be present on PBOW for a limited number of days per year because of restricted access and the duration of the season; 2) contact with soil would be limited because hunting season is during the cooler months, when the full clothing would protect the hunter from dermal contact with soil; and 3) the area of the sites addressed by this SSAP are relatively small compared with the overall area available for hunting. The assumption for future land use is unrestricted. Future off-site residents are assumed to be exposed to current groundwater concentrations via migration of contaminants in groundwater. Potential ecological receptors at the Sellite Area and Unloading Area are wildlife communities, plant communities, and aquatic communities associated with creeks. Note that groundwater in the vicinity of the site is not used as a potable source. Chemicals of potential concern, based on past use of PBOW, should primarily be nitroaromatic explosives, but may also include VOCs, SVOCs, metals, and PCBs.

The sources of contamination at the Sellite Area are leaks from sellite storage tanks and possible surficial material within the barren areas. The sources of contamination at the Unloading Area are toluene spills during unloading of the material and any other possible raw materials and chemicals unloaded and/or within the Unloading Area. The source of contamination at the Locomotive Building maintenance pit is spills, specifically solvents and petroleum-based chemicals, associated with locomotive maintenance. The migration pathways for potential contaminants include leaching to overburden/shale groundwater and bedrock groundwater and runoff to creeks associated with precipitation events.

2.2.4 Goals of the Remedial Investigation

Historical data and data collected during the planned investigation will be evaluated to meet the following goals and address the problem statements presented in Section 2.2.2.

- Evaluate and use existing data appropriate to the AOCs.
- Define the physical features and characteristics of the AOCs.
- Determine whether there has been a release of DoD-related contamination in soil and groundwater at the AOCs.
- Determine chemical characteristics of contamination.

- Determine the nature and extent of the associated contamination.
- Evaluate fate and transport of contamination.
- Determine if overburden groundwater underlying the AOCs is of sufficient volume and quality to be defined as a potential drinking water source in the state of Ohio.
- Obtain site data of quality, quantity, and distribution appropriate for site characterization, risk assessment, and feasibility study.
- Determine the need for additional investigation.

2.2.5 Information Inputs

The locations and analytical suites for planned samples of environmental media were selected based on available historical information and existing data. Data obtained during the planned RI will be used to determine if suspected releases have occurred at the site and to evaluate the need for further investigation. Samples will be collected at locations selected in a biased manner to evaluate all discrete potential contaminant sources which have been identified.

In addition to this SSAP, the SWSAP and QAPP have been prepared to ensure that data collected during this investigation are of the appropriate type and quality to support their intended uses (Shaw, 2008a, b). Samples collected during implementation of the sampling effort will meet the recommended method guidance found in *Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods* (EPA, 1996), and its subsequent updates. The subcontracted analytical laboratories will be accredited under the DoD Environmental Laboratory Accreditation Program (ELAP) for all analyses performed and compliant with *Quality Systems Manual for Environmental Laboratories, Version 4.2* (DoD, 2010). All other requested analyses will conform to their specified method(s). In general, this sampling plan has been developed to ensure that the data obtained satisfy the following requirements:

- Data will be of sufficient quality to be legally defensible under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).
- Data will have reporting limits based on the limit of detection (as defined in the DoD Quality Systems Manual, Version 4.2, that can support the preparation of future CERCLA reports for the site. Current reporting limits are presented in Appendix A.
- Data will be usable for the intended evaluations.
- Sampling locations, depths, and quantities will be sufficient to confirm/deny contaminants in soil and groundwater.

Data will be sufficient to ascertain whether surface and subsurface soil serve as ongoing or future sources of contaminants to groundwater. The following inputs will be required to make informed decisions regarding the questions listed above:

- Soil samples will be collected from the three areas for laboratory analysis which, depending on their locations, may include the following: nitroaromatics, SVOCs, PCBs, TAL metals, and VOCs.
- Groundwater samples will be collected from temporary piezometers installed in DPT soil borings for laboratory analysis which, depending on their locations, may include the following: nitroaromatics, SVOCs, VOCs, TAL metals, and water quality parameters. These screening results will be used to determine placement of the new permanent monitoring wells.
- Groundwater samples will be collected from newly installed monitoring wells for laboratory analysis which, depending on their locations, may include the following: nitroaromatics, VOCs, SVOCs, TAL metals, and water quality parameters.
- The laboratory will provide data packages consisting of laboratory receipt documentation, sample prep and run log documentation, calibration forms, quality control (QC) forms, Form I documents, and all raw data generated in support of sample analysis.

Data collection methods and analytical procedures are intended to provide results of sufficient quality to satisfactorily determine the spatial distribution of contaminants at the site.

2.2.6 Boundaries of the Sites

The site boundaries for the Former Sellite Area and Unloading Area are shown on Figure 1-3. The site boundary for the Locomotive Building maintenance pit is defined as the area within the maintenance pit. Should this RI determine that any soil or groundwater contamination associated with a specific AOC extends beyond these boundaries, the investigation boundaries will be modified as needed.

2.2.7 Decision Rules

Analytical results from the planned sampling efforts will be evaluated to determine if there had been a release and to determine where contaminant sources are located. Confirmation of contamination during the RI will be based upon a comparison of detected contaminants in samples from this investigation to the most current RBSCs. Groundwater RBSCs are currently derived from EPA Region 9, May, 2010 RSL tap water criteria and soil RBSCs are derived from residential soil RSLs. Inorganics in soil and bedrock groundwater will also be screened against

PBOW background screening concentrations. Note that no background data sets exist for other media or for naturally occurring organic compounds. Background contributions associated with these organic compounds and other media (i.e., overburden groundwater and sediment) will be qualitatively evaluated in the risk assessments as appropriate. Definitive data will be used to determine whether the established guidance criteria are exceeded in the media. These definitive data will be adequate for confirming the presence of the contamination and for supporting a risk assessment and a feasibility study.

The following decision rules apply to the complete RI effort:

- If after completion of the sampling activities, results indicate that contamination is not encountered at concentrations that pose a significant threat to public health or the environment, then additional evaluation will not be recommended. Results will be reported in an RI report.

- If after completion of the sampling activities, results indicate that contamination is encountered at concentrations that pose a significant threat to public health or the environment, then additional evaluation will be recommended.

2.2.8 Performance or Acceptance Criteria (Decision Errors)

The primary sources of decision errors, errors that might lead to a wrong decision, include sample density and sampling and analytical methods.

Sample Density. Sample locations, the spacing between the individual samples, and sample depths are important in obtaining data which represent the true distribution of contaminants with sufficient accuracy to achieve project objectives. Potential errors have been minimized by 1) identifying historical and environmental data and 2) selecting additional sample locations which are biased toward suspected contaminant sources.

Sampling and Analytical Methods. Sampling and analytical methods may be sources of error if proper sample collection procedures are not followed, if the analytical reporting limits exceed target goals, or if the analytical methods have an unacceptably high margin of error. To limit errors in sample collection, procedures for sample collection have been provided in the SWSAP (Shaw, 2008a).

Groundwater and soil samples will be collected and analyzed to meet the objectives of the RI. Quality assurance (QA)/QC samples will be collected for all sample types, as described in Chapter 3.0 of this SSAP. All samples will be analyzed by EPA-approved methods and will comply with EPA definitive data requirements. In addition to meeting the quality needs of the RI, data analyzed at this level of quality are appropriate for all phases of the RI and risk assessments.

3.0 Field Activities

Field activities associated with the RI include site clearing/grubbing and restoration, direct-push soil sampling, temporary piezometer installation, monitoring well installation, groundwater sampling, sediment sampling, sump sampling, land surveying, and investigation-derived waste (IDW) management. The purpose of soil sampling at the AOCs is to determine the nature and extent of contamination at each of the AOCs and complete other objectives, as defined in Section 2.2. The purpose of piezometer groundwater sampling is to aid in determining the appropriate locations of monitoring wells to be installed. Monitoring wells will be used to evaluate potential impact to groundwater at the site.

3.1 Soil Remedial Investigation

The following sections summarize the proposed soil investigations. Table 3-1 summarizes the samples and analytical parameters.

Direct-Push Soil Sampling and Methodology. The purpose of the direct-push sampling is to determine the presence/absence of contamination at the Sellite Area and Unloading Area. A qualified geologist or geotechnical engineer will be on site for all drilling and sampling operations. The geologist/geotechnical engineer will visually classify and log all borehole material according to the Unified Soil Classification System, EM 1110-1-4000 (USACE, 1998) on the hazardous, toxic, and radioactive waste drilling log (USACE Eng. Forms 5056-R and 5056A-R).

Borings will be advanced and soil samples will be collected using direct-push drilling technology. The direct-push unit uses a hydraulically powered percussion hammer to drive a decontaminated soil sampling device with retractable tip (point) to a required depth. Soil samples for chemical analysis will be handled and packaged as described in Chapter 5.0. All direct-push sampling equipment that will come in contact with the samples will be decontaminated prior to use and between each sample collected, in accordance with Section 4.3.

At many PBOW sites, following closure and removal of the manufacturing structures, tanks, and equipment, a local fill sand was brought to the areas to cover the remaining concrete building foundations and demolition scars and to provide a natural landscape appearance.

Soil samples collected for chemical analysis will be documented by sample collection logs and analysis request/chain-of-custody record forms (Figures 4-7 and 6-2 of the SWSAP [Shaw, 2008a]), following field custody procedures specified in Section 5.1 of the QAPP (Shaw, 2008b). Any changes from this SSAP or the SWSAP will be recorded in chronological order on a variance log for this project similar to that shown as Figure 9-1 of the SWSAP (Shaw, 2008a). All direct-push soil samples collected by Shaw field personnel will be documented through the use of drilling borelogs (USACE Eng. Forms 5056-R and 5056A-R).

Continuous logging performed by the geologist/geotechnical engineer will include detailed subsurface information from examining drill cuttings, recording samples/cores, and noting first-encountered and static groundwater levels for each borehole. Daily field notes will be recorded on a field activity daily log (FADL) and will include sufficient information to reconstruct the progress of excavation, drilling operations, problems encountered, temporary piezometer installation procedures (Section 3.2.2), etc. Figure 4-5 of the SWSAP shows a typical piezometer construction form that will be completed for all piezometers. After completion of database entry, all field forms and documents will be archived in the project files at the Shaw office in Knoxville, Tennessee. A copy of borelogs and well construction logs will be included in an appendix to the final RI report.

The equipment required for soil sampling includes the following:

- Hazardous, toxic, and radioactive waste borelog, sample collection log, and chain of custody
- Appropriate sample jars and Terra Cores®, if collection of VOCs are required
- Clean, stain-less steel bowl and mixing device or new resealable plastic bag
- Plastic sheeting
- Photoionization detector (PID)/lower explosive limit (LEL) meter
- Cooler packed with ice for sample storage.

For soil intervals that are collected for analytical sample analysis, the samples will be collected in the appropriate jars prior to lithologic logging. Prior to any homogenization, samples for VOC analysis will be collected using a Terra Core® sampling device and preserved with sodium bisulfate, if possible. If the soil or sediment contains an abundant amount of gravel to prevent use of a Terra Core® sampler, soil for VOC analysis will be placed in a laboratory grade sample jar and filled to eliminate any sample jar headspace. If additional sample volume is required for the analysis, QA/QC requirements, or other purposes, the soil will be placed into a decontaminated stainless-steel bowl. In the case of direct-push samples, a second boring will be completed immediately adjacent to the original location. The surface soil sample (0- to 1-foot bgs interval) from the adjacent boring will be combined with the original surface soil sample, homogenized, and transferred to appropriate sample jars. Samples collected for VOC analysis will not be homogenized. Upon filling a sample container, the jar will be placed on ice and the proper paperwork completed.

3.1.1 Sellite Area

A total of 14 borings will be advanced at the Sellite Area. Figure 3-1 shows the proposed soil boring locations. Three soil samples will be collected from each boring: one from 0 to 1 foot bgs (soil below fill material, if encountered), one from 3 to 5 feet bgs, and one from 8 to 10 feet bgs, for a total of 42 samples. If fill material is encountered in any of the borings, the 8- to 10-foot sample will still be collected at the respective depth below the current ground surface; however, the 0- to 1-foot bgs and 3- to 5-foot bgs samples may be adjusted based on the thickness of the fill material. For example, if 1 foot of fill material is present, samples will be collected at 1 to 2 feet bgs and 4 to 6 feet bgs. Fill material will also be sampled (0 to 1 foot bgs). This will provide information for the current ground surface fill, the historical ground surface which is likely to have the highest contamination, and subsurface zones to evaluate potential future exposure for construction workers.

The 42 samples will be analyzed for nitroaromatics, VOCs, SVOCs, and TAL metals. The 0- to 1-foot and 3- to 5-foot bgs soils samples will also be analyzed for PCBs. One surface soil (0- to 1-foot) sample will be analyzed for total organic carbon (TOC). Table 3-1 summarizes the samples and analytical parameters.

3.1.2 Unloading Area

A total of 12 borings will be advanced at the Unloading Area. Figure 3-2 shows the proposed soil boring locations. Ten soil borings will be located along the north and south sides of the rail line. Two soil borings will be completed in a potential barren area along Maintenance Road in the extreme southeastern corner of the site. Three soil samples will be collected from each boring; one from 0 to 1 foot bgs (soil below fill material, if encountered), one from 3 to 5 feet bgs, and one from 8 to 10 feet bgs, for a total of 36 samples. If fill material is encountered in any of the borings, the 8- to 10-foot sample will still be collected at the respective depth below the current ground surface. If apparent contamination layers are encountered, soil samples will be obtained from the contaminated zones instead of the “rule of thumb” zones.

The 36 samples will be analyzed for nitroaromatics, VOCs, SVOCs, and TAL metals. PCBs will be analyzed in the 0-1 foot soil samples and the 3-5 feet bgs soil samples. One surface soil (0-1 foot) sample will be analyzed for TOC. Table 3-1 summarizes the samples and analytical parameters.

3.2 Groundwater Remedial Investigation

Groundwater will be investigated in a phased approach. First, temporary piezometers will be installed in a total of eight piezometer borings drilled at the Former Sellite Building and eight piezometer borings at the Unloading Area. Each of these borings will be advanced to bedrock and a continuous lithologic log recorded. Based on the analytical results and groundwater flow patterns of the piezometer samples, three monitoring wells at the Sellite Area and three monitoring wells at the Unloading Area will be installed in the overburden/shale. A source area well will be installed at or near the location of the temporary piezometer exhibiting the highest groundwater analytical result (nitroaromatic, SVOC, or VOC) at each site. Based upon groundwater flow direction determined from temporary piezometers, an upgradient and downgradient monitoring well will also be installed at each site. In addition, up to three monitoring wells will be installed at each area in the underlying bedrock; however, the decision to install bedrock wells will be contingent on results of the piezometer sampling.

Each piezometer and monitoring well will be sampled using the low-flow technique described in Section 3.2.7, unless the Ohio Environmental Protection Agency (OEPA) and USACE approve a variation. Table 3-1 summarizes the samples and analytical parameters.

It is not anticipated that limestone bedrock will be encountered at less than 5 feet due to the overburden/shale thickness being approximately 40 feet (Section 1.3). It is possible that a buried boulder or similar object could be encountered at less than 5 feet. In this case, a suitable alternate location will be sought. In addition, previous investigations at PBOW have shown a strong seasonal and topographic variation in water levels in the overburden, which can result in dry boreholes. The water levels in the piezometers will be measured a minimum of 24 hours after installation of the last piezometer and periodically over the course of the field effort for this site. Water level measurements in the piezometers will be taken to the nearest 0.01 foot.

3.2.1 Piezometer Samples

3.2.1.1 Sellite Area

A total of eight piezometers will be installed for the Sellite Area. Figure 3-1 shows the proposed locations. Once soil sampling is complete and the associated soil samples are collected (Section 3.1), the borings will be advanced to bedrock (or refusal). As described in Section 3.1, the boring will be continuously logged, with lithologic and hydrologic observations appropriately recorded. Piezometer installation is described in Section 3.2.2. Each piezometer water sample will be collected using a low-flow technique and analyzed for nitroaromatics, VOCs, SVOCs, TAL metals (total/dissolved), and water quality parameters (Table 3-2). All sampling and purging equipment (pumps, tapes, discharge piping) will be decontaminated prior to use and after each successive use. The sample results should aid in determining whether the overburden groundwater is of quantity and quality to be considered a potable water supply in the state of Ohio or of quality requiring a risk assessment. The sample results should also indicate if groundwater in the overburden/shale may be impacted and if there is a need for installation of monitoring wells and further investigation of the two groundwater zones (i.e., overburden/shale and underlying limestone).

3.2.1.2 Unloading Area

A total of eight piezometers will be installed for the Unloading Area. Figure 3-2 shows the proposed locations. The investigation at this AOC will focus on the eastern portion of the site near MK-MW19. The well previously showed elevated concentrations of chlorinated solvents. The piezometers will be installed along and downgradient of the rail line. In addition, one piezometer will be placed in the approximate location of the barren area in the Unloading Area seen on the historical photograph on Figure 1-3. Once soil sampling is complete and the associated soil sample is collected (Section 3.1), the boring will be advanced to bedrock (or refusal). As described in Section 3.1, the boring will be continuously logged, with lithologic and hydrologic observations appropriately recorded. Piezometer installation is described in Section 3.2.2. Each piezometer water sample will be collected using a low-flow technique and analyzed for nitroaromatics, VOCs, SVOCs, TAL metals (total/dissolved), and water quality parameters (Table 3-2). All sampling and purging equipment (pumps, tapes, discharge piping) will be decontaminated prior to use and after each successive use. The piezometers will be used to determine the extent of any overburden groundwater contamination and to help determine overburden groundwater flow direction(s). The sample results should aid in determining whether the overburden groundwater is of quantity and quality to be considered a potable water supply in the state of Ohio or of quality requiring a risk assessment. The sample results should also indicate if groundwater in the overburden/shale may be impacted and if there is a need for installation of monitoring wells and further investigation of the two groundwater zones (i.e., overburden/shale and underlying limestone).

3.2.2 Piezometer Installation

Temporary piezometers are typically used t measure static water levels and collect groundwater quality samples in commonly slow recharging environments. The piezometers will be made of new 1-inch-outside diameter polyvinyl chloride (PVC) material and placed into the borehole through the direct-push tooling prior to removal or inserted into the borehole after the tooling is removed. These will be advanced to bedrock (or refusal), and continuous lithologic logging will be performed. The piezometer will be constructed with 5 to 10 feet of PVC screen (0.010 slot) and PVC casing. No filter pack material will be placed around the well screen. Because the sampling will occur reasonably quickly after the piezometers have been installed, semi-permanent seals are not necessary. A plastic seal will be used in the upper foot of the borehole annular space to prevent any solid material from entering the subsurface. The plastic seal will be covered with an additional sheet of plastic on the ground surface with bentonite placed over the top of this sheet. The bentonite on the ground surface will slope away from the piezometer to promote runoff and prevent any surface water from entering the borehole. The bentonite surface seal typically extends out approximately 1 foot around the piezometer and up to a foot in thickness. The size and thickness of the bentonite seal may vary depending on site conditions. Figure 4-5 of the SWSAP shows a typical piezometer construction form that will be completed for all piezometers. Upon an adequate water column in the piezometer to permit sample collection (i.e., greater than 24 inches), groundwater sampling will be conducted as described in Section 3.2.7.

Following the groundwater level measurement associated with the first round of monitoring well sampling (Section 3.2.3) and permission from USACE, the PVC material (PVC screen and casing) will be removed from all temporary piezometer boreholes. The boreholes will be abandoned by a licensed driller in accordance with OEPA and Ohio Department of Natural Resources (ODNR) codes, regulations, and guidance, including the following: Ohio Administrative Code 3745-9-10, *Abandoned Well Sealing*; OEPA (2005) *Sealing Abandoned Monitoring Wells and Boreholes* technical guidance; and Ohio Revised Code Section 1521.05, *Well Construction and Sealing Log*. Fine granular bentonite will be added to the boreholes in 5-foot intervals. The bentonite in the borehole will be tamped at each 5-foot interval to assure the material is compacted for better settling. A PVC pipe or similar material will be used to tamp the borehole. After 24 hours, the boreholes will be checked for settlement and additional bentonite added, if necessary. Well sealing reports will be submitted to the ODNR Division of Water. Piezometer material will be cut into 5-foot manageable lengths, decontaminated using the procedure described in Section 4.3, and discarded into the Shaw-contracted dumpster.

3.2.3 Monitoring Well Samples

3.2.3.1 Sellite Area

A total of six wells will be installed at the Sellite Area, based on the analytical results of the soil and piezometer groundwater samples. Three of these six monitoring wells will be installed in the overburden/shale and the other three wells will be installed in the limestone bedrock. The specific location of each well will be determined by the geologist/geotechnical engineer, based on the analytical results of the soil and piezometer groundwater samples. All proposed monitoring well locations will be determined in conjunction with USACE and OEPA.

Each monitoring well sample will be collected using a low-flow technique (Section 3.2.7) and analyzed for nitroaromatics, VOCs, SVOCs, TAL metals (total/dissolved), and water quality parameters (Table 3-2). Two rounds of samples will be collected from each well at different times of the year (e.g., spring and fall) to allow for seasonal differences. All sampling and purging equipment (pumps, tapes, discharge piping) will be decontaminated prior to use and after each successive use. All monitoring wells for this investigation will be installed prior to the first sampling event; no monitoring wells currently exist for this site. During the second sampling event, the condition of all surface components of the monitoring wells sampled will be documented with the recommendation for repair, if necessary. The surface components will include the concrete pad, protective posts, protective casing, and well casing. In addition, the condition of the well locks and lock hasps will be documented.

3.2.3.2 Unloading Area

A total of six wells will be installed at the Unloading Area, based on the analytical results of the soil and piezometer groundwater samples. Three of these six monitoring wells will be installed in the overburden/shale and the other three wells will be installed in the limestone bedrock. Two existing overburden/shale wells (MK-MW19 and EB-GM04) may be suitable for sampling; however, final determination will be made following the piezometer investigation. The specific location of each well will be determined by the geologist/geotechnical engineer, based on the analytical results of the soil and piezometer groundwater samples. All proposed monitoring well locations will be determined in conjunction with USACE and OEPA.

Each monitoring well sample will be collected using a low-flow technique (Section 3.2.7) and analyzed for nitroaromatics, VOCs, SVOCs, TAL metals (total/dissolved), and water quality parameters (Table 3-2). Two rounds of samples will be collected from each well at different times of the year (e.g., spring and fall) to allow for seasonal differences. All sampling and purging equipment (pumps, tapes, discharge piping) will be decontaminated prior to use and after each successive use. All monitoring wells for this investigation will be installed prior to the first sampling event. During the second sampling event, the condition of all surface components of the monitoring wells sampled will be documented with the recommendation for repair, if necessary. The surface components will include the concrete pad, protective posts, protective casing, and well casing. In addition, the condition of the well locks and lock hasps will be documented.

3.2.4 Monitoring Well Installation and Development

3.2.4.1 Monitoring Well Installation

The geologist/geotechnical engineer will schedule and coordinate the locating of all underground utilities in the vicinity of the borehole site prior to drilling activities. The geologist/geotechnical engineer will assume one mobilization for activities related to installation of the new monitoring wells.

The specific location of each overburden/shale well will be determined based on the analytical results of the soil and piezometer groundwater samples and groundwater flow direction determined from piezometer measurements. Limestone bedrock well locations will be determined based on historical bedrock groundwater flow direction.

The estimated depth for each of the six new overburden/shale wells is 20 feet for both AOCs. The estimated depth for each of the six new limestone bedrock monitoring wells for both AOCs is 89 feet. The target depth of each new overburden/shale well is estimated based on well construction information from existing wells in the area. Actual installation depths will be adjusted in the field as necessary for collection of groundwater samples. Borings for overburden/shale monitoring wells will be advanced 7 to 8 feet past the depth at which groundwater is encountered or until bedrock using hollow-stem auger drilling methods or other appropriate drilling methods. Two-inch-inside diameter PVC well material consisting of a 10-foot-long screen and riser will be installed into the borehole. A filter pack will be placed into the borehole (tremied if depths are greater than 20 feet) to surround the screen and brought to a height of approximately 2 feet above the screen top. An approximate 2- to 5-foot bentonite seal will be placed to a depth above filter pack and allowed to hydrate for at least 1 hour. A neat cement/bentonite mixture (95 percent Type II or V portland cement and 5 percent bentonite powder mixed with 5 to 7 gallons of clean water) will be placed from the bentonite seal to approximately 3 feet below grade. In addition to the new wells, two existing overburden/shale wells (MK-MW19 and EB-GW04) will be redeveloped.

The limestone bedrock monitoring wells (if needed) will be 2-inch diameter and installed with double casing as described in Section 3-10 of EM 1110-1-4000. A pilot borehole for each well will be drilled until auger refusal using 4 l/4-inch hollow-stem augers, followed by overdrilling the borehole using 8 l/4-inch hollow-stem augers. Five feet of competent bedrock will be drilled within the augers using an 8-inch-outside diameter roller cone bit to allow for the installation of low-carbon steel isolation casing. The steel isolation casing will be pressure grouted in place, and the grout will be allowed to cure for at least 48 hours. Limestone bedrock borings will be completed using a rock core bit, cutting a maximum 6-inch-outside diameter (OD) borehole and a rock core tube measuring 5 to 10-feet in length. If a 6-inch-OD rock bit is not used during bedrock drilling, the borehole will be reamed with a rotary bit to attain a 6-inch-OD borehole after reaching the desired depth for monitoring well installation. This will allow for a 2-inch annular filter pack surrounding the 2-inch-diameter screen. Upon removal of the rock core tube, measurement of the rock recovered compared to the run length (length of the bedrock drilled) will be performed. If the rock core length does not match the run length, total depth of the borehole will be measured to determine if the rock core was lost or washed way. Mention of the lost core will be made on the borelog. Fractures (mechanical, natural, or healed) will also be included on the borelog.

A qualified geologist/geotechnical engineer will be on site for all drilling, installation, development, and testing operations. Well installation will be performed by an Ohio licensed/certified driller, and drilling methods will be in accordance with the procedures and requirements described in EM 1110-1-4000, *Monitor Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites*, and applicable state regulations and requirements, including Ohio Administrative Code 3745-9-03, *Monitoring Well*. A well log will be completed and filed on line with ODNR (http://www.dnr.state.oh.us/water/maptechs/submitlogs/). All monitoring well drill cuttings will be drummed, labeled, and handled as described in Chapter 6.0.

3.2.4.2 Monitoring Well Development

Each monitoring well will be developed using a submersible pump or bailer as soon as practical, but no sooner than 48 hours nor longer than 7 calendar days after the placement of the internal mortar collar around the well. Prior to development, the static water level will be measured from the top of the casing and recorded. Static water levels will also be measured 24 hours after development. The well will be developed until discharging water is clear to the unaided eye and the sediment thickness remaining in the well is less than 5 percent of the screen length. If yields permit, the standing water volume in the well (calculated as the volume of water in the well screen and casing and saturated annulus) will be removed at least five times. In addition, if water is used during bedrock drilling, any volume lost will be recorded, and five times the amount will be removed during development. For each well, a sample of the last water removed during development will be captured and retained for visual inspection and photographing. During development, field measurements of pH, specific conductance, and temperature will be made, and descriptions of the development technique and the physical characteristics of the water (clarity, color, turbidity, and odor) will be recorded by the geologist/geotechnical engineer. Field water quality measurements will be taken every 15 minutes. Wells will be developed by pumping, bailing, and surging without using acids, flocculants, disinfectants, or dispersing agents. All purged water will be drummed at the well site. During development, the pump inlet will be moved through the entire screened interval or the bailer will be lifted from different depths in the well. The development procedure will continue until the following conditions are met:

- Thickness of the accumulated sediment in the well is less than 5 percent of the length of the well screen.
- Temperature, pH, turbidity, dissolved oxygen, oxidation-reduction potential (Eh) and specific conductance values ***stabilize*** (i.e. no upward/downward trends) in three consecutive readings collected at approximate 15-minute interval and are within the following criteria::
  - Temperature +/- 3 percent degrees Celsius (^{o}C)
  - pH +/- 0.1 standard units
  - Conductivity +/-3 percent of reading
  - Turbidity +/-10 percent
  - Eh +/- 10 millivolts
- A volume of water has been removed equal to five times standing water in the well, including the well casing and screen, and the saturated annular space assuming 30 percent porosity.

If heavy or caked sediments must be removed by washing, the water will be from a potable water source and a sample will be submitted for analysis. Analytical data will be reviewed prior to using any potable water to ensure it does not have any contaminants that may impact groundwater sampling results.

If the groundwater is not clear and free of sand after four hours of well development, Shaw field personnel and the Shaw project geologist will develop a plan for proceeding and will discuss this plan with USACE. In addition, the goal of well development is to remove excess sediment from the well and filter pack to allow collection of a representative groundwater sample. As noted in USACE guidance (USACE, 1998), some groundwater may be naturally turbid and achieving low turbidity (e.g., 10 nephelometric turbidity units) may not be achievable. This is typically the case in temporary piezometers which are installed without a filter pack and low-recharging overburden wells. In addition, turbidity is also an issue in bedrock wells due to the presence of natural petroleum and hydrogen sulfide. The key to well development and purging/sampling is that turbidity measurements are no longer continuing to decrease given that this is typically the last parameter to stabilize.

After final development of each well, approximately 1 liter of water from the well will be collected in a clear glass jar, labeled, and photographed in color with a quality digital or 35-millimeter camera. The photograph will be submitted as part of the well development log. The photograph will be a suitably back-lit close-up to show the clarity of the water. The development water sample will be archived until receipt of photographs. The well will not be sampled for a minimum of 14 days after development.

The following records will be kept in a well development log:

- Project name and location
- Well designation and location
- Date and time of well installation
- Date and time of well development
- Static water level from top of well casing before well development and 24 hours after well development

- Quantity of fluid in well prior to development:
  - Standing in well
  - Contained in saturated annulus, based on an assumed 30 percent porosity

- Field measurements of pH, conductivity, turbidity and temperature collected at 15-minute intervals until these values stabilize.

- Depth from top of well casing to bottom of well

- Screen length

- Depth from top of well casing to top of sediment inside well, before and after development

- Physical character of removed water, including changes in clarity, color, particulate, and odor

- Type and size/capacity of pump and/or bailer used

- Description of surge technique

- Measured height of well casing above ground surface at time of development

- Typical pumping rate and estimated well yield

- Quantity of water/fluid removed during development, both incremental and total

- Disposal of development water.

3.2.5 Water Level Monitoring

After the AOC's piezometers have been installed for a minimum of 24 hours (and prior to groundwater sampling), groundwater levels will be measured and recorded for all piezometers. Water elevation measurements will also be recorded for each piezometer immediately prior to sampling. The depth to water will be measured to the nearest 0.01 foot from the top of the PVC riser at the point which was marked during surveying (Section 3.2.4).

The water elevations of all monitoring wells at the AOC will be measured simultaneously, prior to purging the first well (Section 3.2.7). The water levels of the piezometers will also be taken at this time during the first monitoring well sampling event. This is done to provide more complete information concerning groundwater flow in the vicinity of the AOC. The depth to water will be measured to the nearest 0.01 foot at the point on the riser (inner casing) which was marked during surveying. Note that the piezometers will be abandoned after this measurement, as described in Section 3.5. Therefore, the water levels of only the monitoring wells will be measured as part of the second monitoring well sampling event.

3.2.6 Groundwater Sampling Equipment

The equipment required for groundwater sampling includes the following:

- Water level indicator
- Low-flow submersible pump with Teflon®-lined tubing
- Eh, dissolved oxygen, pH, temperature, turbidity, and specific conductance meters
- Flow-through cell
- Appropriate sample bottles and temperature-controlled container
- Plastic sheeting
- Five-gallon buckets with lids
- Photoionization detector (PID)/lower explosive limit (LEL) meter
- Mason jar for calculating purge rate
- Well construction diagrams.

If because of low water yield the well cannot be sampled using a low-flow technique, the following equipment will be required:

- Clean, unused nylon rope

- Clean, unused Teflon or PVC bailer or clean, decontaminated stainless-steel bailer of appropriate size for the monitoring well fitted with a bottom-emptying device.

3.2.7 Groundwater Sampling Methodology and Procedures

Piezometers will be sampled approximately 24 hours after installation in conjunction with the water level measurements. A water level will be recorded for all piezometers just prior to the piezometer sampling event (Section 3.2.5). The monitoring wells will be purged and sampled a minimum of 14 days after development (Section 3.2.4.2), unless a variance is agreed to by USACE. Immediately prior to the first round of monitoring well groundwater sampling, the water levels of all piezometers and monitoring wells involved in this investigation will be measured. This will allow for more accurate groundwater flow mapping and flow direction determination. Before a sample is collected from each well, the water level will be measured again. This same protocol will be followed immediately prior to the second round of monitoring well sampling, except that the piezometers will have been removed (Section 3.2.2).

Two procedures are available for purging and sampling wells and piezometers: low-flow (minimal drawdown) and bailing. Low-flow is the preferred purging method where adequate recharge exists. If wells or piezometers do not recharge adequately to use low-flow sampling, bailing will be used depending on the static water level relative to the screened interval. Both of these methods are described in the following procedures:

- The well or piezometer will be checked for proper identification and structural integrity.

- After unlocking the well or piezometer and removing the cap, a PID/LEL meter will be used to measure the concentration of organic vapors and hydrogen sulfide at the top of casing and in the breathing zone. If readings are above background, safety precautions outlined in the sitewide safety and health plan will be followed.

- The depth to water will be measured using a decontaminated water level indicator. Then the volume of water in the casing and screen and annular volume will be calculated.

- Where recharge rates permit, the well or piezometer will be purged and sampled using a modified low-flow (minimal drawdown) sampling methodology. Either an electric submersible pump or a bladder pump will be used to complete the sampling. The pump will be inserted into the midportion of the screened interval or suspected water-producing interval and operated at a rate that minimizes drawdown. Typically, purging rates are on the order of 200 to 500 milliliters per minute (mL/min). The purge rate will be set such that drawdown is never greater than 0.5 foot (6 inches), if possible. If drawdown is greater than 0.5 foot, it is critical that stability of the water level is reached and maintained, above the screened interval. Water chemistry parameters (pH, Eh, conductivity, temperature, dissolved oxygen, and turbidity) will be monitored to confirm stability.

- If the pre-pumping (static) water level is above the top of the screened interval and drawdown exceeds 0.5 foot even at the lowest setting of the pump, low-flow sampling cannot be conducted. In this situation, iterative pumping and recovery cycles will be required to remove at least one volume of the standing water in the casing and annular space. In this instance, the water level must not be allowed to drop below the top of the screened interval. It is, however, acceptable to pump out the stagnant water in the casing at a higher purge rate, but pumping must be stopped when the water level reaches the top of the screened interval. Once at least one volume is removed, the well or piezometer may be sampled. It should be noted, however, that attempts will be made to remove more than one volume of water.

- If the pre-pumping (static) water level is below the top of the screened interval and drawdown exceeds 0.5 foot even at the lowest setting of the pump, low-flow sampling cannot be conducted. In this situation, iterative pumping and recovery cycles will be required to remove at least one volume of the standing water in the casing and annular space. However, in some wells, recharge may be so low that adequate purging may not be achieved even over a period of days. In this case, the well or piezometer may be sampled without purging, after consultation with USACE.

- During purging, field measurement of pH, Eh, temperature, turbidity, dissolved oxygen, and conductivity will be performed. When using low-flow sampling, once these parameters are stable, samples can be collected. If stability is not achieved after 4 hours of purging, Shaw will notify USACE and discuss a plan for sampling the well or piezometer. Stability is defined as three consecutive readings collected at 15-minute intervals having no consistent upward or downward trends. The criteria for these parameters is as follows:

  - pH +/- 0.1 standard units
  - Eh +/- 10 millivolts
  - Temperature +/- 3% degrees Celsius (^{o}C)
  - Turbidity - +/-10%
  - Dissolved oxygen +/-1%
  - Conductivity +/-3% of reading.

- For slow recharging wells or piezometers, field parameters will be recorded after sampling to ensure adequate volume is available for the chemical analysis.

- Where possible, groundwater samples will be collected using a submersible sampling pump and in-line sampling. Where the use of in-line sampling is not possible, a bottom-emptying Teflon bailer will be used.

- For slow recharging wells or piezometers, a second sample will be collected for field measurement of temperature, pH, Eh, dissolved oxygen, and conductivity immediately after collection of the sample for chemical analysis.

- Sample containers will be labeled with appropriate identifying information (location, date, time, condition, added preservatives, sample crew, and requested analysis). Preprinted labels will be provided by the field sampling crew leader. Each sample will be logged in a field notebook or FADL at the time of collection. Sample containers of appropriate volume and composition will be prepared in advance to ensure the collection of sufficient volumes for all specified analyses.

- The samples will be collected so as to minimize aeration as water enters the bottle. Pumping rates will not exceed 500 mL/min. Samples collected for nitroaromatic analysis will be collected first.

- Samples for metals analysis will be collected in two separate containers; one will be filtered and the other unfiltered. Filtered samples will be collected during groundwater sample collection using a disposable, inline 0.45-micron filter attached to the discharge tubing. The filter will be disposed after groundwater sample collection from each sample point.

- All filled sample containers will be transferred to a cooler chest (kept at 4 degrees ^{o}C) and delivered to the laboratory in sufficient time so that specified holding times are not exceeded. Details of the sample preservation, packing, and shipping are provided in Chapter 5.0.

In addition to the primary water samples, certain field QC samples will be prepared. The geologist/geotechnical engineer will coordinate with the primary and QA laboratories as to the volumes of sample necessary to satisfy all internal laboratory QC requirements. All samples will be collected and analyzed in conformance with applicable EPA and USACE requirements, using techniques and equipment described herein and in the SWSAP (Shaw, 2008a).

3.3 Sediment Sampling

A sediment sampling effort will be conducted at the Former Sellite Building and Unloading Area. A total of six sediment samples will be collected from the ditch that surrounds the Former Sellite Building and separates the two AOCs. This ditch is a wet weather conveyance and only contains water during significant precipitation events; it does not represent an aquatic habitat, even seasonally. Thus, no surface water is present for sampling. Figure 3-1 shows the proposed sampling locations. Sediment samples will be collected from 0 to 6 inches if sediment is present to this depth. Each sediment sample will be analyzed for SVOCs, nitroaromatics, PCBs, and TAL metals. In addition, one sediment sample will be analyzed for TOC.

3.4 Locomotive Building Maintenance Pit and Pit Sump Sampling

A sampling effort will be conducted at the Locomotive Building within the former maintenance pit and associated sump. First, the material from ground surface to 4 feet bgs will be removed, segregated, and stockpiled as clean material based on previous sampling results. Three samples will be collected from the bottom one foot of the pit, including one sample from within the pit sump. Figure 3-3 shows the proposed sampling locations. The sample locations of the two samples not from the pit sump will be based on visual and/or PID observations of contamination if present. The samples will be analyzed for TAL metals, VOCs, SVOCs, PCBs, and nitroaromatic explosives. Each of the three samples will be a composite sample taken from the backhoe bucket and composed of aliquots homogenized prior to placement in the sample jar, except those aliquots for VOC analysis. Aliquots for VOC analysis will be collected either with Terra Cores or in 4-ounce jars. The aliquots for VOC analysis will not be homogenized.

After sampling activities are completed, any remaining material preventing determination of the integrity of the pit floor and walls will be removed and stockpiled, with its own plastic liner and cover, separately from the previously stockpiled clean material.

Any potentially contaminated material removed from the pit sump will be properly disposed of as IDW.

Once the integrity of the pit has been determined and documented, the pit will be backfilled with the clean material that was removed and stockpiled. The material will be placed back into the pit, compacted, and topped with clean gravel to the ground surface.

3.5 Borehole and Well Abandonment

Soil and Temporary Piezometer Boreholes. Upon completion of soil borings at the Sellite Area and Unloading Area, soil boreholes will be abandoned in accordance with ODNR requirements, following OEPA (2005) guidance. For boreholes in which a temporary piezometer was installed, after permission from the USACE has been received informing Shaw that no further action will be conducted with the groundwater, the temporary screen and casing will be removed. Abandonment for soil borings and temporary piezometers will be performed as follows:

- For boreholes with piezometers, the PVC screen and casing will be removed and cut into approximately 5-foot lengths and decontaminated using the approach described in Section 5.1 of the SWSAP.
- All boreholes will be abandoned by pouring bentonite chips into the borehole. Boreholes that are abandoned immediately after sampling are "open" due to the cohesive nature of the site soils and do not require any tamping. Boreholes that are used for piezometers typically collapse to varying degrees due to the time between drilling and abandonment (days to weeks). For piezometer boreholes, the bentonite chips will be added in 6-inch lifts and tamped into place using a metal rod to ensure that bridging of the bentonite chips does not occur.
- After 24 hours, the borehole will be checked for settlement and additional bentonite added, if necessary.

Monitoring Wells. After the initial sampling of any monitoring well, if characteristics are similar to former monitor well BED-MW27 (off-gassing of hydrogen sulfide), abandonment may be conducted if requested by the USACE. Well abandonment may be needed if off-gassing of hydrogen sulfide presents a health hazard due to elevated concentrations in ambient air. Abandonment may also be required if off-gassing creates nuisance odors for site workers or off-site residents. The decision to abandon any monitoring well will be made by USACE in conjunction with OEPA. Well BED-MW27 was abandoned due to impacts to nearby residences of PBOW. Well abandonment procedures will follow the USACE guidelines and will be in accordance with OEPA and ODNR codes, regulations, and guidance, including the following: Ohio Administrative Code 3745-9-10, *Abandoned Well Sealing*; OEPA (2005) *Sealing Abandoned Monitoring Wells and Boreholes* technical guidance; and Ohio Revised Code Section 1521.05, *Well Construction and Sealing Log*. Well sealing reports will be submitted to the ODNR Division of Water. Abandonment will be performed by a licensed driller as follows:

- Removal of well material will be attempted. If the well isolation casing and PVC well casing and screen can be removed, it will be cut into approximately 5-foot lengths and decontaminated using the approach described in Section 5.1 of the SWSAP. Surface completion material (guard posts, pad, protective steel casing) will be removed.

- If removal of the isolation casing and the well screen/casing is not possible, abandonment in place will be conducted. Steel isolation casing and PVC well material will be cut approximately 3 feet bgs.

- A concrete/grout mixture will be tremied from the bottom of the boring until undiluted grout flows from the borehole/well at the ground surface. During this type of abandonment, the grout will replace the water within the well and ultimately run out on the ground surface. To the extent practical, all displaced groundwater that flows to the surface will be removed and containerized for disposal.

- After 24 hours, the borehole/well will be checked for settlement and additional grout added, if necessary. A tremie pipe will be used again if the depth of the unfilled portion of the borehole is more than 15 feet.

- Ground surface will be restored as originally found, which may include reseeding with grass seed and straw, repairing asphalt, or repairing concrete.

3.6 Surveying

Prior to site clearing, Shaw will secure the services of an Ohio-registered professional land surveyor to determine the coordinates and elevations of both existing and new locations. All sampling locations will be surveyed by an Ohio-registered surveyor prior to sampling.

In addition, upon completion of the field soil sampling and piezometer installation, each soil boring location and piezometer location will be surveyed. Following monitoring well installation, each of the permanent wells will be surveyed.

For each soil boring, piezometer, and monitoring well location, the coordinates and elevations will be established according to EM 1110-1-4000. The horizontal coordinates will be to the closest 0.1 foot and referenced to the North American Datum of 1983, Ohio State Plane North. Vertical coordinates (ground elevation and well riser, if applicable) will be to the nearest 0.01 foot and referenced to the 1929 National Geodetic Vertical Datum. U.S. feet will be used for all measurements. All survey data will be tabulated. Loop closure for survey accuracy will be within the horizontal and vertical limits given above.

3.7 Utility Clearances

Prior to beginning any intrusive investigation (i.e., soil boring, temporary piezometer installation), to fulfill Shaw standard operating procedures and USACE requirements, all sites will be marked for underground utilities by personnel from NASA, Plum Brook Station Health and Safety Division, or other appropriate department. Even after NASA has located underground utilities that may be present in the AOC, all direct-push locations will be hand dug, probed with an air knife, or screened with geophysical instrumentation to a depth of 5 feet before drilling begins.

3.8 Site Clearing and Restoration

Brush clearing may be required for equipment access to the sampling locations. The necessary clearing will be proposed to and coordinated with NASA. Clearing activities will be kept to a minimum. The area is currently covered with grass, brush, and gray dogwoods. It is anticipated that only invasive species of brush and gray dogwoods will be removed during the site clearing.

Shaw and its subcontractors will restore the area to pre-investigation conditions. Shaw and its subcontractors will regrade any ruts, depressions, and earthen piles that may cause a walking and driving safety hazard. The site will be restored to the satisfaction of on-site USACE personnel.

3.9 Site Access

All Shaw personnel and subcontractors will meet each morning at the NASA/Plum Brook Station, Shaw office trailer, or other “headquarters” type area for the morning tailgate safety/job safety analysis meeting, equipment calibration, gathering of needed material, and replenishing of water. At the end of each day, IDW generated during fieldwork will also be moved by the subcontractor back onto the Shaw IDW storage area located in the secured NASA staging area. Names of Shaw personnel and Shaw subcontractors will be provided by Shaw to Mr. Robert Lallier, NASA Environmental Coordinator, at least 72 hours in advance so that site access can be arranged. All personnel entering the NASA (former PBOW) facility will be appropriately trained and instructed by Plum Brook Station concerning site safety issues. All Shaw personnel and any subcontracted personnel involved must be a U.S. citizen.

4.0 Sample Analysis and Decontamination Procedures

4.1 Sample Numbering System

The sample numbering system to be used during this investigation will conform to the USACE Nashville District's numbering convention. Specifically, each sample will be assigned a unique sample identification number that describes where the sample was collected. Each number consists of a group of letters and numbers, separated by hyphens. The sample media and numbering system are described as follows.

Project Code	Year	Sample Type[a]	Site Identification[b]	Location (Well ID)	Sample Number	Depth[c]
PBOW	11	XXX	FSB	XXXX	XXXX	(XXXX)

[a]Sample type:
- SS – surface soil sample
- SB – subsurface soil sample
- SE – sediment sample
- GW – groundwater sample
- MS – matrix spike
- MSD – matrix spike duplicate.

[b]Site Identification:
- FSB – Former Sellite Building
- ULA – Unloading Area
- MP – Maintenance Pit

[c]Depth: Only required for soil samples.

In addition, field QC is identified by the sample purpose; field duplicates and field splits use the same sample numbering convention shown above. The sample purpose is recorded on the sample collection log and in the ShawView PBOW database. The sample purpose is suppressed when creating chain-of-custody and bottle labels. Thus, field QC remains blind to the subcontract laboratories. See the sitewide QAPP (Shaw, 2008b) for a detailed discussion of field QC.

The complete sample number will be recorded by the Shaw field geologist/geotechnical engineer in the FADL and/or in the boring log, and in the sample collection log as appropriate.

4.2 Analytical Program

The analytical program has been designed to acquire sufficient and defensible data to determine the extent of contamination in the investigated areas. Table 4-1 summarizes the analytical parameters required and associated laboratory methods to be used during this investigation.

A contract laboratory will analyze samples for nitroaromatics by EPA Method SW-846 8330A. Multi-incremental sampling by Method 8330B will not be used for the analysis of soil sample for explosives. Method 8330B is designed to meet the data quality objectives of characterization of the mean concentrations of explosive compounds within specific decision units at military firing ranges and is only applicable to surface soils. Method 8330B is of limited utility where information is limited about potential contaminant releases and the distribution characteristics are unknown.

All applicable analyses will meet all project specific requirements, DoD Quality Systems Manual, Version 4.2 requirements, and the recommended method guidance found in *Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition Update (EPA, 1996) and its subsequent updates. The analytical laboratory will be accredited under the DOD Environmental Laboratory Accreditation Program for all analyses performed and compliant with *DoD Quality Systems Manual for Environmental Laboratories, Version* 4.2 (DoD, 2010). All other requested analyses will conform to their specified method(s).

In addition to laboratory QC/QA samples, the following types of field QA/QC samples will be collected: field duplicates, field splits, equipment rinsates, trip blanks, and source water samples. Definitions of both field and laboratory QA/QC can be found in the QAPP (Shaw, 2008b). Appendix A provides updated laboratory reporting and QC limits.

4.3 Decontamination Procedures

Decontamination requirements and procedures are specified in detail in Chapter 5.0 of the SWSAP (Shaw, 2008a) and will be followed during the current RI. The Shaw field coordinator will contact Plum Brook Station for access to a potable water source for decontamination use. The following text summarizes decontamination procedures for equipment before site entry, between borings, and before site departure.

Nonsampling equipment (direct-push rods, augers, drill rods, etc., that do not contact analytical samples) and abandoned well materials:

- Steam rinse with potable water, or wash and scrub using a brush with nonphosphate detergent and then rinse with potable water.

Equipment that may come in contact with samples for chemical analysis (stainless-steel homogenization bowls, mixing spoons, drill bit shoes, drill sleeves, etc.):

- Pre-wash and scrub using a brush in potable water.
- Wash and scrub using a brush with nonphosphate detergent.
- Rinse with potable water.
- Rinse with American Society for Testing and Materials (ASTM) Type II water.
- Rinse with a rinse agent containing 10 percent nitric or hydrochloric acid (when sampling for metals).
- Rinse with methanol when sampling for organics.
- Rinse with ASTM Type II water.
- Rinse with hexane (when sampling for PCBs).
- Final rinse with ASTM Type II water; the volume of water used will be at least five times greater than the volume of hexane used.
- Air dry.
- Wrap in aluminum foil.

Pre-wash, wash, and rinse waters will be changed at least daily and as they become excessively dirty.

Decontamination wash water and rinse water will be managed for disposal as described in Section 6.2.

5.0 Sample Preservation, Packing, and Shipping

Sample containers and caps will be new, certified as precleaned, and made of materials recommended by the EPA in Title 40, Code of Federal Regulations, Part 136 and SW-846 (EPA, 1996). Sample containers and preservatives/preservation methods are summarized in Table 5-1. Sample containers will be supplied and shipped to the job site by the designated primary laboratory.

Each sample container will be bagged before placement in the cooler. Sample holding times will be calculated from the date the sample is collected.

Samples for chemical analysis will be placed in coolers filled with ice immediately after collection and will be packed to minimize container breakage by using styrofoam peanuts or bubble wrap to fill void spaces in the cooler. Coolers will be taped, marked, and sealed, and custody will be maintained, as described in Chapter 6.0 of the SWSAP. Samples will be cooled to a temperature of approximately $4^{o} \pm 2^{\circ}$C and maintained at that temperature by means of double-bagged ice until the cooler is received at the laboratory. Coolers will be shipped to the laboratory by a next-day delivery service. The temperature of each cooler will be taken with an infrared thermometer upon receipt. Notification of shipment, including airbill number, will be telephoned or faxed to the laboratory on the day of sample collection. If this is not possible, the laboratory will be notified the following morning.

Soil samples for VOC analysis will be collected using Terra Core samplers preserved with sodium bisulfate for low and medium level VOC analysis and methanol for high level VOC analysis. If the soil or sediment contains an abundant amount of gravel to prevent use of a Terra Core sampler, soil for VOC analysis will be placed in a laboratory-grade sample jar and filled to eliminate any sample jar headspace. All water samples collected for VOC analysis will be shipped in one cooler with a trip blank.

Completed analytical request/chain-of-custody records for regular field samples and field duplicates will be secured and included with each shipment of coolers to:

ATTN: Sue Bell
Accutest Laboratories
4405 Vineland Road, Suite C-15
Orlando, FL 32811
Lab Phone: (407) 425-6700
Phone: (813) 741-3338

Fax: (813) 741-9137
Email: SueB@Accutest.com

Completed analytical request/chain-of-custody records for field split samples will be secured and included with each shipment of coolers to:

ATTN: Denise Pohl
Test America
4101 Shuffel Street NW
North Canton, OH 44720
Phone: (330) 966-9789
Fax: (330) 497-0772
Email: Denise.Pohl@testamericainc.com

6.0 Investigation-Derived Waste Management Plan

Anticipated IDW during field activities includes soil (drill cuttings), development/purge water, well drilling fluids, rock cores, decontamination fluid, and disposable personal protective equipment (PPE). Detailed procedures for IDW management are provided in Chapter 8.0 of the SWSAP (Shaw, 2008a). The following is a brief summary of the procedures for handling IDW.

6.1 Soil

Surface soil and sediment are considered to be at sampling depths less than 1 foot. Excess soil from each specific surface soil or sediment sample location will be disposed of at the point of origin, specifically in the borehole.

DPT soil and drill cuttings will be placed in 55-gallon drums upon completion of field sampling. IDW drums will be labeled to indicate project name and date collected.

6.2 Development and Purged Groundwater

Water generated from well development and purging activities will be collected and containerized. The development and purged groundwater IDW will be separated by AOC. The volume of development water and purge water will be measured and documented. The containers will be clearly labeled as to the contents, the location at which the aqueous liquids were generated, and date.

6.3 Well Drilling Fluids

Well drilling fluids from bedrock well installation activities will be placed in 55-gallon drums. IDW drums will be labeled to indicate project name and date collected.

6.4 Rock Cores

Rock cores from monitoring well installation will be stored on-site until the investigation is complete. Upon the completion of the investigation, a method of disposal will be determined in conjunction with USACE.

6.5 Decontamination Fluid

Limited quantities of decontamination fluid, including wash water, nonphosphate soapy water, and final rinse water, will be kept in plastic tubs during the decontamination process and will be placed in 55-gallon drums upon completion of field sampling. Decontamination fluid containing small quantities of solvents such as isopropanol, methanol, and hexane will be collected in metal pans for evaporation.

6.6 Sampling Equipment and Personal Protective Equipment

Limited quantities of PPE and sampling equipment, including Tyvek® suits, latex/nitrile gloves, plastic, and disposable tubing used for groundwater sampling, will be generated during sampling. All sampling equipment and PPE will be double-bagged and disposed of in an on-site, Shaw-contracted dumpster. If any of the sampling equipment and PPE appears to be grossly contaminated, it will be decontaminated prior to disposal.

6.7 Investigation-Derived Waste Sampling

All soil and water IDW will be sampled at the completion of fieldwork. Table 4-1 summarizes the analytical parameters and methods for the IDW samples. Soil and water composite samples will be collected from IDW for each AOC. The composite samples will then be submitted to the identified laboratory for a full toxicity characteristic leaching procedure analysis and nitroaromatics. Seven-day turnaround time will be used, unless otherwise directed by the Project Manager.

When the analytical results are received, Shaw personnel will evaluate the results and make a determination of off-site disposal methods. Possible disposal facilities will be identified by Shaw; however, selection of the facility or facilities to receive the IDW will be the responsibility of USACE.

For each AOC, the following will be collected:

- One composite sample from the soil IDW from the soil and piezometer DPT borings
- One composite sample from the soil IDW from the overburden/shale and bedrock monitoring well activities
- One sample (composite if appropriate) of the decontamination water generated by the soil and piezometer DPT boring activities
- One composite sample from the decontamination water generated by the overburden/shale and bedrock monitoring well installation activities
- Two composite samples from purge water generated during the two rounds of groundwater sampling.

The samples shall be composites of the IDW generated except for those IDW aliquots to be sampled for VOCs. The IDW sample aliquots collected for VOCs shall be grab samples.

7.0 References

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TABLES

Table 2-1

Summary of Data Quality Objectives
Data Gap Investigation for the Garage Maintenance Area, Former Sellite Area, and Unloading Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

Potential Data Users	Available Data	Conceptual Model	Media of Concern	Data Uses and Objectives	Data Types	Analytical Level
EPA OEPA DOD USACE NASA Shaw Other Contractors Possible Future Land Users	**Sellite Area:** Previous environmental investigations show varying degrees of PAH contamination in soil. In addition, areas of apparent stressed vegetation (barren areas) are present along with pieces of sulfur on the ground surface. No groundwater data is available for the site. **Unloading Area:** Only limited soil data is available which indicated impact by PAHs. Groundwater has been impacted by VOCs but the source of these are not likely related to activities associated with the Unloading Area. **Locomotive Building:** Petroleum- and solvent-related compounds in the maintenance pit sump.	Contaminant Source Production of Sellite and associated raw materials transfer and storage at both the Sellite Area and Unloading Area. Petroleum- and solvent-related compounds in the maintenance pit sump. Migration Pathways Soil, sediment, surface water, and groundwater Potential receptors Wildlife, human Potential Contaminants of Concern VOCs, SVOCs, metals, PCBs, and and explosives	Groundwater Soil Sediments	Determine if there are hazardous substances present that constitute an unacceptable risk to human health and the environment. Define site physical features and characteristics. Evaluate fate and transport pathways Determine the nature and extent of source areas. Define current and future routes of exposure. Determine whether contaminant distribution is consistent with DOD activities	Groundwater Metals Explosives SVOCs VOCs Water quality parameters Soil Metals Explosives PCBs SVOCs VOCs TOC Sediments Metals Explosives PCBs SVOCs TOC	Definitive Laboratory Definitive[a]

DNT - Dinitrotoluene.
DOD - U.S. Department of Defense.
EPA - U.S. Environmental Protection Agency.
OEPA - Ohio Environmental Protection Agency.
USACE - U.S. Army Corps of Engineers
NASA - National Aeronautics and Space Administration.
SVOC - Semivolatile organic compound.
TNT - Trinitrotoluene.
Shaw - Shaw Environmental, Inc.
TOC - Total Organic Carbon.
PCB - Polychlorinated Biphenyls.
VOC - Volatile organic compound.
PAH - Polycyclic Aromatic Hydrocarbon.

[a] The laboratory will provide data packages consisting of all laboratory receipt documentation, sample prep and run log documentation, calibrations forms, QC forms, Form I's, and all raw data generated in support of the analysis of PBOW samples.

Table 3-1

Summary of Soil, Sediment, and Groundwater Analytical Samples
Data Gap Investigation for the Garage Maintenance Area, Former Sellite Area, and Unloading Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

Former Sellite Area Soil Borings						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	42	4	1	1	NA	2/2
TCL VOCs	42	4	1	1	NA	2/2
TCL SVOCs	42	4	1	1	NA	2/2
TAL Metals	42	4	1	1	NA	2/2
PCBs	28	3	1	1	NA	2/2
TOC	1	0	0	0	NA	0/0
Unloading Area Soil Borings						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	36	4	1	1	NA	2/2
TCL VOCs	36	4	1	1	NA	2/2
TCL SVOCs	36	4	1	1	NA	2/2
TAL Metals	36	4	1	1	NA	2/2
PCBs	24	2	1	1	NA	1/1
TOC	1	0	0	0	NA	0/0
Garage Maintenance Area Pit Material						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	3	1	1	1	NA	1/1
TCL VOCs	3	1	1	1	NA	1/1
TCL SVOCs	3	1	1	1	NA	1/1
TAL Metals	3	1	1	1	NA	1/1
PCBs	3	1	1	1	NA	1/1
Sellite Area/Unloading Area Sediment Samples						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	6	1	1	1	NA	1/1
TCL SVOCs	6	1	1	1	NA	1/1
TAL Metals	6	1	1	1	NA	1/1
PCBs	6	1	1	1	NA	1/1
TOC	1	0	0	0	NA	0/0

Table 3-1

Summary of Soil, Sediment, and Groundwater Analytical Samples
Data Gap Investigation for the Garage Maintenance Area, Former Sellite Area, and Unloading Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

Former Sellite Area Piezometers						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	8	1	1	1	NA	1/1
TCL VOCs	8	1	1	1	2	1/1
TCL SVOCs	8	1	1	1	NA	1/1
TAL Dissolved Metals (Filtered)	8	1	1	1	NA	1/1
TAL Total Metals (Unfiltered)	8	1	1	1	NA	1/1
Water Quality Parameters	8	1	1	1	NA	1/1
Unloading Area Piezometers						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	8	1	1	1	NA	1/1
TCL VOCs	8	1	1	1	2	1/1
TCL SVOCs	8	1	1	1	NA	1/1
TAL Dissolved Metals (Filtered)	8	1	1	1	NA	1/1
TAL Total Metals (Unfiltered)	8	1	1	1	NA	1/1
Water Quality Parameters	8	1	1	1	NA	1/1
Former Sellite Area Monitoring Wells						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	12	1	1	1	NA	2\2
TCL VOCs	12	1	1	1	2	2\2
TCL SVOCs	12	1	1	1	NA	2\2
TAL Dissolved Metals (Filtered)	12	1	1	1	NA	2\2
TAL Total Metals (Unfiltered)	12	1	1	1	NA	2\2
Water Quality Parameters	12	1	1	1	NA	2\2
Former Unloading Area Monitoring Wells						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	12	1	1	1	NA	2\2
TCL VOCs	12	1	1	1	2	2\2
TCL SVOCs	12	1	1	1	NA	2\2
TAL Dissolved Metals (Filtered)	12	1	1	1	NA	2\2
TAL Total Metals (Unfiltered)	12	1	1	1	NA	2\2
Water Quality Parameters	12	1	1	1	NA	2\2

Table 3-1

Summary of Soil, Sediment, and Groundwater Analytical Samples
Data Gap Investigation for the Garage Maintenance Area, Former Sellite Area, and Unloading Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

Soil IDW Samples						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water[b]**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	3	NA	NA	NA	NA	NA
TCLP VOCs	3	NA	NA	NA	NA	NA
TCLP SVOCs	3	NA	NA	NA	NA	NA
TCLP Metals	3	NA	NA	NA	NA	NA
RCI	3	NA	NA	NA	NA	NA
Water IDW Samples						
Parameters	**Field Samples**	**QA/QC Samples**	**Rinsates**	**Source Water[b]**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	5	NA	NA	NA	NA	NA
TCL VOCs	5	NA	NA	NA	NA	NA
TCL SVOCs	5	NA	NA	NA	NA	NA
TAL Metals	5	NA	NA	NA	NA	NA
RCI	5	NA	NA	NA	NA	NA
pH	5	NA	NA	NA	NA	NA

TCL - Target compound list.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
PCB - Polychlorinated biphenyl.
VOC - Volatile organic compound.
TOC - Total organic compound.
QC samples are field duplicates submitted blind to primary contract laboratory.
QA samples are field splits sent blind to secondary Department of Defense Environmental Laboratory Accreditation Program approved laboratory.
[a] Refer to Table 3-2 for identification of water quality parameters.

Table 3-2

Summary of Water Quality Parameters
Data Gap Investigation for the Garage Maintenance Area, Former Sellite Area, and Unloading Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

Water Quality Parameter	Analytical Method
Turbidity	MCAWW 180.1
Alkalinity	MCAWW 310.1
Hardness	MCAWW 130.2
Total Dissolved Solids	MCAWW 160.1
Total Suspended Solids	MCAWW 160.2
Chloride	MCAWW 325.3
Cyanide, total	SW-846 9010A/9012B
Nitrate	MCAWW 352.1
Oxidative-reduction potential (ORP)	ASTM D1498-08
Ferrous iron	Field test kit
Dissolved Oxygen	ASTM-D888-09
Temperatrue	Field test
pH	ASTM D5128/SW-846 9040C
Conductivity	ASTM D1125
Sulfate	MCAWW 375.3

Table 4-1

Summary of Soil, Sediment, and Groundwater Analytical Parameters and Methods
Data Gap Investigation for the Garage Maintenance Area, Former Sellite Area, and Unloading Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Analytical Parameters[a]	Analytical Method[b]
Groundwater	TCL Volatile Organic Compounds	SW-846 8260B
	TCL Semivolatile Organic Compounds	SW-846 3510C/8270D
	Nitroaromatic Compounds	SW-846 3535A/8330A
	Total TAL Metals	SW-846 3010A/6010C/7470A
	Dissolved TAL Metals	SW-846 3005A/6010C/7470A
	Turbidity[c]	MCAWW 180.1
	Alkalinity[c]	MCAWW 310.1
	Hardness[c]	MCAWW 130.2
	Total Dissolved Solids[c]	MCAWW 160.1
	Total Suspended Solids[c]	MCAWW 160.2
	Chloride[c]	MCAWW 325.3
	Cyanide, total[c]	SW-846 9012B
	Nitrate[c]	MCAWW 352.1
	Oxidation-reduction potential (ORP)[c]	ASTM D-1498-08
	Ferrous iron[c]	Field test kit[c]
	Sulfate[c]	MCAWW 375.3
Soil/Sediment	TCL Volatile Organic Compounds	SW-846 5035A/8260B
	TCL Semivolatile Organic Compounds	SW-846 3550C/8270D
	Nitroaromatic Compounds	SW-846 8330A
	Polychlorinated Biphenyls	SW-846 3550C/8082A
	TAL Metals	SW-846 3050B/6010C/7471B
	Total Organic Carbon	Walkley-Black
Groundwater IDW	Target Compound List Volatile Organic Compound	SW-846 8260B
	Target Compound List Semivolatile Organic Compound	SW-846 3510C/8270D
	Nitroaromatics	SW-846 8330A
	TAL Metals	SW-846 3010A/6010C/7470A
	Ignitability	SW-846 1010A
	pH	SW-846 9045D
	Corrosivity	SW-846 1110A
	Reactive Cyanide	7.3.3/7.3.4
	Reactive Sulfide	7.3.3/7.3.4
Soil IDW	TCLP Volatile Organic Compounds	SW-846 1311/8260B
	TCLP Semivolatile Organic Compounds	SW-846 1311/3510C/8270C
	TCLP Metals	SW-846 1311/3010A/6010C/7470A
	Ignitability	SW-846 1010A
	Corrosivity	SW-846 1110A
	Reactivity	7.3.3.2/7.3.4.2

Table 4-1

Summary of Soil, Sediment, and Groundwater Analytical Parameters and Methods
Data Gap Investigation for the Garage Maintenance Area, Former Sellite Area, and Unloading Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

[a]Target analyte list (TAL) and target compound list (TCL) are used to designate parameter lists with no requirements for Contract Laboratory Program method quality control or data reporting packages

[b]Analyses found in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* USEPA Publication, Third Edition, and *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, March 1983 and subsequent revisions, except as noted.

[c]Water quality parameter.

[d]Field testing will use an appropriate field test kit or method according to EPA 600/4-79-020: Method for Chemical Analysis of Water and Wastes in Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, USEPA Publication, Third Edition.

IDW - Investigation-derived waste.
TCLP - Toxicity characteristic leaching procedure.
TOC - Total organic compound.

Table 5-1

Analytical Methods, Containers, Preservatives, and Holding Times
Data Gap Investigation for the Garage Maintenance Area, Former Sellite Area, and Unloading Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Parameter	Analytical Method	Sample Container*	Preservation Requirements	Holding Time
Groundwater	TCL VOCs	SW-846 8260B	(3) 40 ml VOA vial	Cool to 4°C, HCL to pH <2	14 days
	TCL SVOCs	SW-846 3510C/8270D	(2) 1 L amber glass	Cool to 4° ± 2°C	7 days extraction/40 days
	Nitroaromatics	SW-846 3535A/8330A	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	PCBs	SW-846 3510C/8082A	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	TAL Metals (Total)	SW-846 3010A/6010C/7470A	(2) 500 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months (28 days for Hg)
	TAL Metals (Dissolved)	SW-846 3005A/6010C/7470A	(2) 500 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months (28 days for Hg)
	Turbidity	MCAWW 180.1	(1) 1 L amber glass	Cool to 4°C	48 Hours
	Alkalinity	MCAWW 310.1		Cool to 4°C	14 days
	Total Disolved Solids	MCAWW 160.1		Cool to 4°C	7 days
	Total Suspended Solids	MCAWW 160.2		Cool to 4°C	7 days
	Sulfate	MCAWW 375.3		Cool to 4°C	28 days
	Chloride	MCAWW 325.3		Cool to 4°C	28 days
	Hardness	MCAWW 130.2	(1) 125 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months
	Cyanide, Total	SW-846 9012B	(1) 125 mL HDPE	Cool to 4°C, NaOH to pH >12	14 days
	Nitrate	MCAWW 352.1	(1) 125 mL HDPE	Cool to 4°C	48 Hours
Soil/Sediment	TCL VOCs	SW-846 5035A8260B	Terracores	Cool to 4°C,NaSO2,MeOH	14 days
	TCL SVOCs	SW-846 3550C/8270D	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	14 days extraction/40 days
	Nitroaromatics	SW-846 8330A			14 days extraction/40 days
	PCBs	SW-846 3550C/8082A			14 days extraction/40 days
	TAL Metals	SW-846 3050B/6010C/7471B			6 months (28 days for Hg)
	TOC	Walkley-Black			28 days

Table 5-1

Analytical Methods, Containers, Preservatives, and Holding Times
Data Gap Investigation for the Garage Maintenance Area, Former Sellite Area, and Unloading Area
Former Plum Brook Ordnance Works, Sandusky, Ohio

Matrix	Parameter	Analytical Method	Sample Container*	Preservation Requirements	Holding Time
Groundwater IDW	TCL VOCs	SW-846 8260B	(3) 40 ml VOA vial	Cool to 4^oC, HCL to pH <2	14 days
	TCL SVOCs	SW-846 3510C/8270D	(2) 1 L amber glass	Cool to 4^oC	7 days extraction/40 days
	Nitroaromatics	SW-846 8330A	(1) 1 L amber glass	Cool to 4^oC	7 days extraction/40 days
	TAL Metals	SW-846 3050C/6010C/7470A	(1) 250 mL HDPE	Cool to 4^oC, HNO_3 to pH <2	6 months (28 days for Hg)
	Ignitability pH Corrosivity Reactive Cyanide Reactive Sulfide	SW-846 1010A SW-846 9045D SW-846 1110A 7.3.3/7.3.4 7.3.3/7.3.4	(1) 1 L Amber	Cool to 4^oC	ASAP
Soil IDW	TCLP VOCs TCLP SVOCs TCLP Metals Ignitability Corrosivity Reactivity	SW-846 1311/8260B SW-846 1311/3510C/8270D SW-846 1311/3010A/6010C/7470A SW-846 1010A SW-846 1110A 7.3.3.2/7.3.4.2	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4^oC	14 days extraction 14 days extraction/40 days 14 days /ext./6 months (28 days for Hg) ASAP ASAP ASAP

^oC - Degrees Celsius.
CWM - Clear wide mouth.
H_2S0_4 - Sulfuric acid.
HCI - Hydrochloric acid.
HDPE - High-density polyethylene.
Hg - Mercury.
HNO_3 - Nitric acid.
L - Liter.
mL - Milliliter.

NaOH - Sodium hydroxide.
PAH - Polynuclear aromatic hydrocarbon.
SVOC - Semivolatile organic compound.
TAL - Target analyte list.
TCL - Target compound list.
TOC - Total organic compound.
VOC - Volatile organic compound.
IDW - Investigation-derived waste.
EPA - U.S. Environmental Protection Agency.
VOA - Volatile organic analysis.
OZ - Ounces.
Ext. - Extraction
ASAP - As soon as possible.

*Number of containers required in ( ).

FIGURES

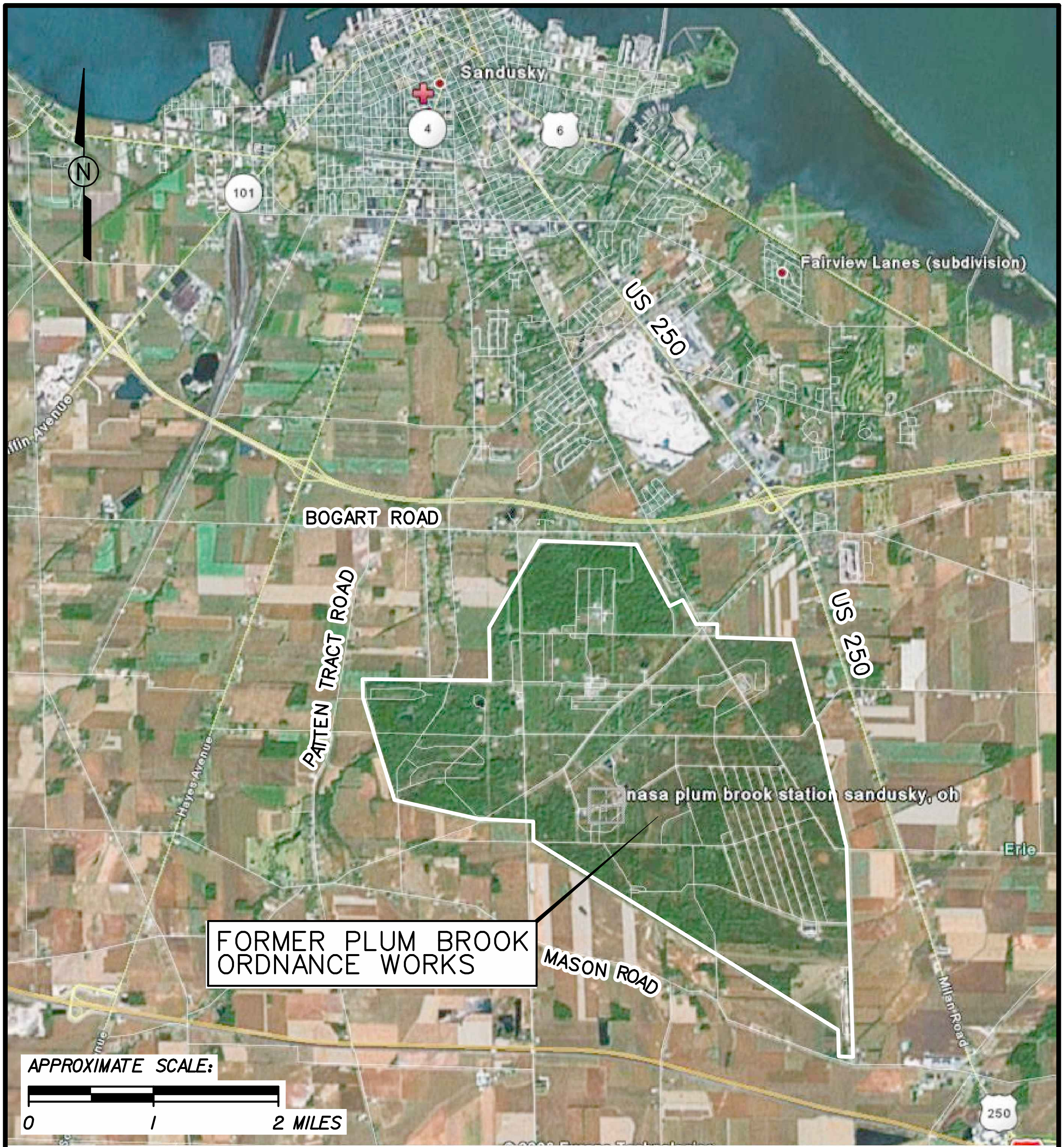

FIGURE 1-1
PBOW VICINITY MAP

DATA GAP INVESTIGATION FOR THE GMA - FORMER SELLITE AREA AND UNLOADING AREA SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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LEGEND:

- AREA OF CONCERN
- APPROXIMATE LOCATION OF SEWER LINES
- POND
- CREEK, DITCH, CONVEYANCE
- RAILROAD
- ROAD
- FENCE
- FACILITY BOUNDARY

NOTES:

1. SNAKE ROAD BURNING GROUND AREA WAS ALSO REFERRED TO AS "SNAKE ROAD BURN PIT", "SCHEID ROAD BURNING GROUNDS", AND "DISPOSAL AREA THREE".
2. REACTOR FACILITY CONSTRUCTED BY NASA POST WWII AND IS IDENTIFIED FOR LOCATION PURPOSES ONLY.
3. GARAGE MAINTENANCE AREA INCLUDES THE THREE SITES COVERED IN THIS INVESTIGATION: SELLITE AREA, UNLOADING AREA, AND LOCOMOTIVE BUILDING MAINTENANCE PIT.

FIGURE 1-2
LOCATIONS OF AREAS OF CONCERN

DATA GAP INVESTIGATION FOR THE GMA - FORMER SELLITE AREA AND UNLOADING AREA SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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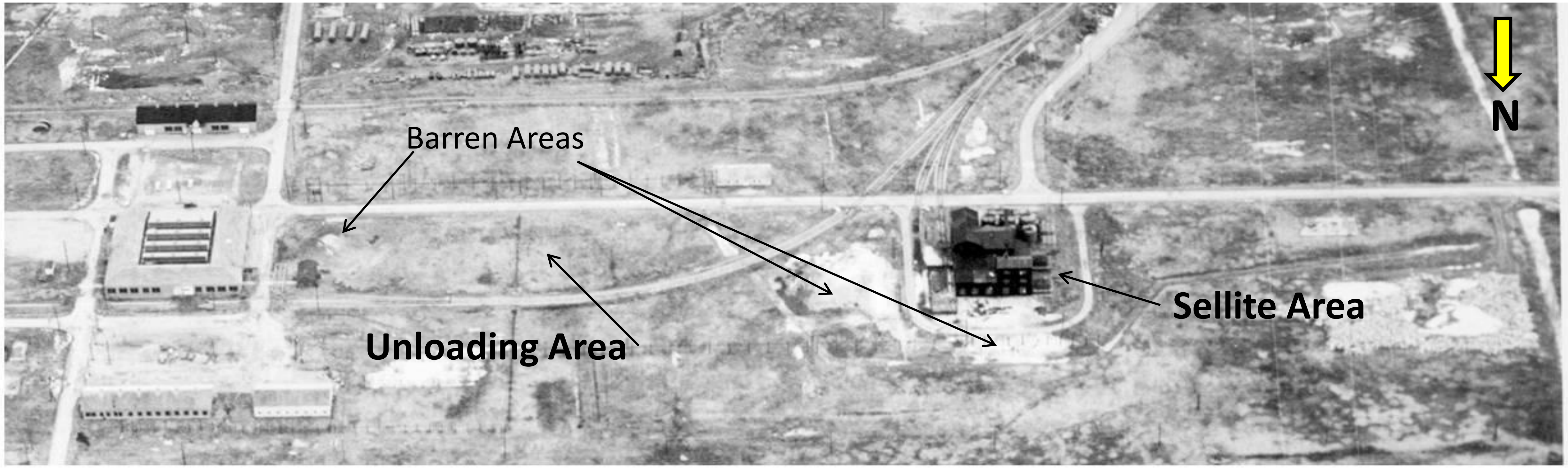
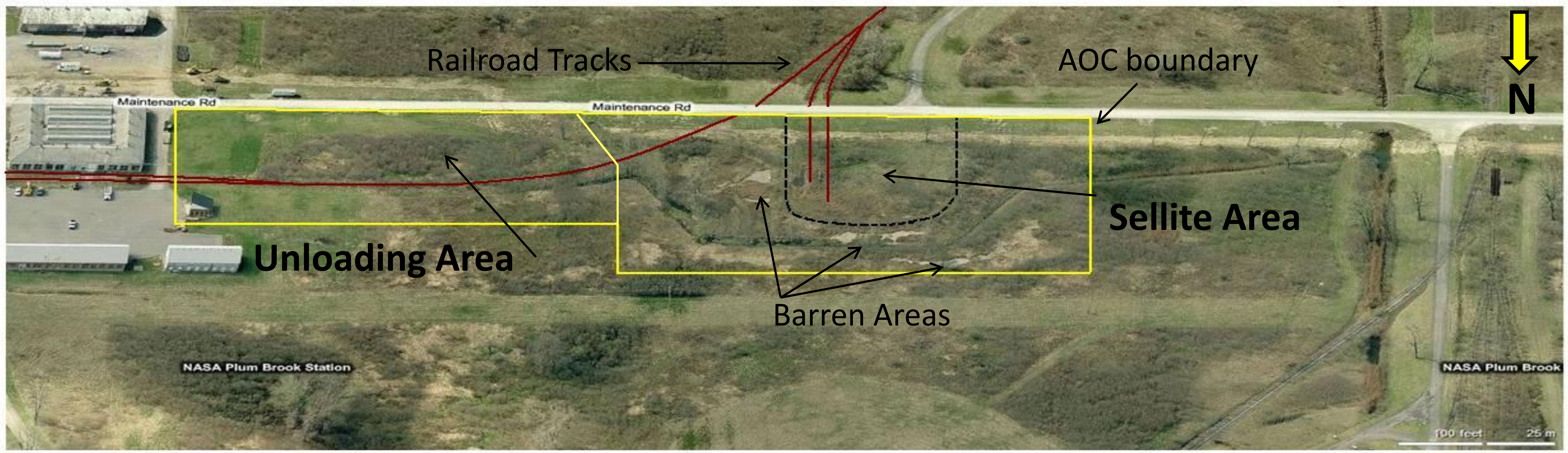


Circa late 1950s (View is southward)



Present (View is southward)

Figure 1-3
Sellite Area and Unloading Area
Air Photos

Figure 1-4
Sellite Area and Unloading Area, January 19, 1942 Construction Photo
(View is to the East)

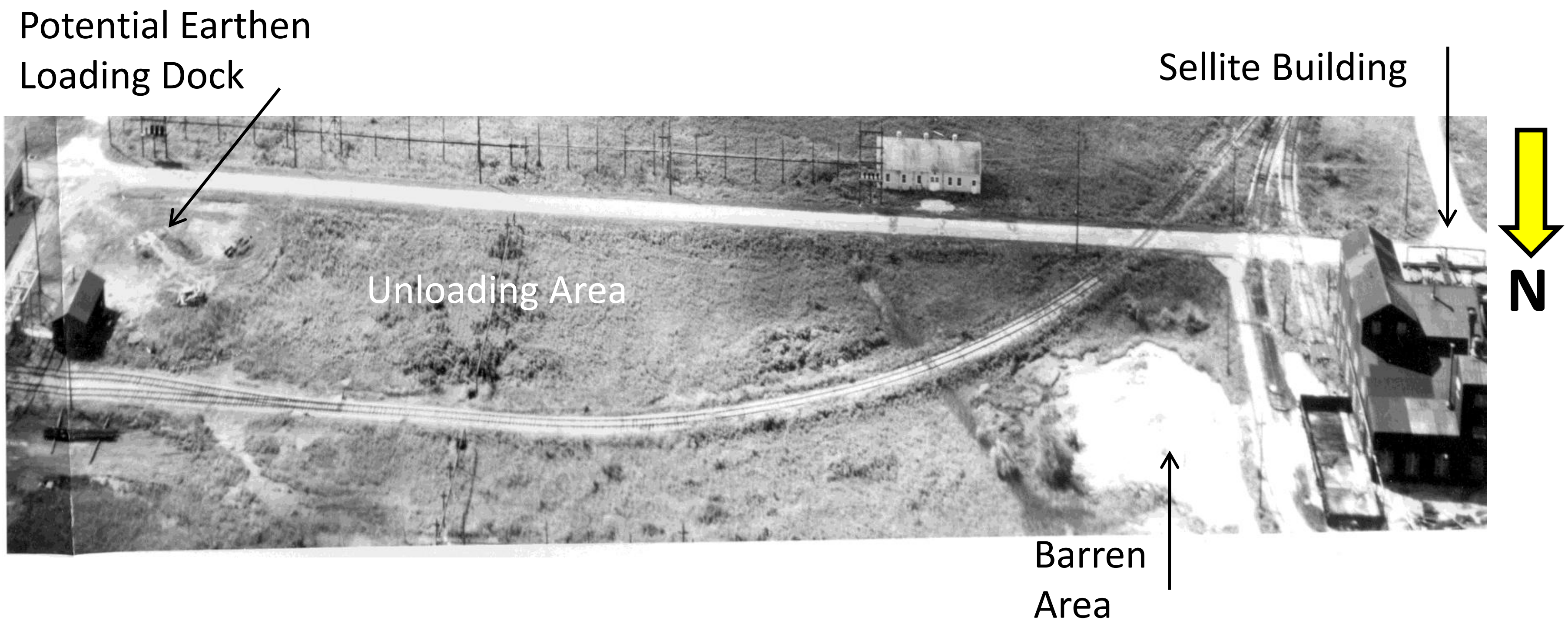
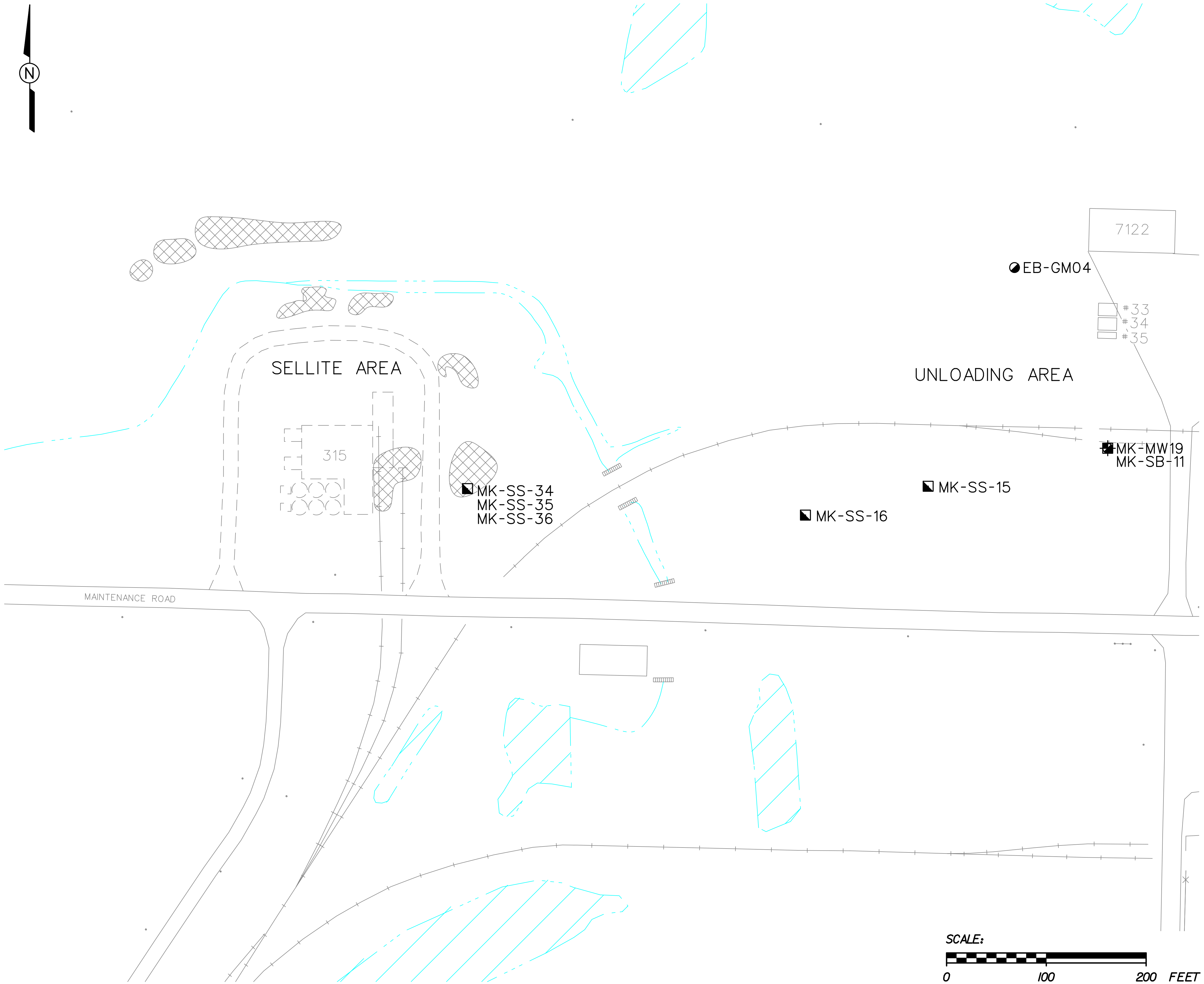


Figure 1-5
Sellite Building and Unloading Area, Circa 1940s Photo
(View is to the South)



LEGEND:

- POND
- CREEK, DITCH, CONVEYANCE
- ABANDONED RAILROAD
- ROAD
- APPROXIMATE LOCATION OF FORMER STRUCTURES
- OVERBURDEN MONITORING WELL
- SURFACE SOIL SAMPLE
- SOIL BORING
- BARREN AREA
- #33 FORMER UNDERGROUND STORAGE TANK

NOTES:

1. LOCATIONS OF HISTORIC SURFACE SOIL SAMPLES ARE APPROXIMATE DUE TO LACK OF SURVEY DATA.
2. UNDERGROUND STORAGE TANKS #33, #34, AND #35 WERE REMOVED IN 1989.

FIGURE 1-6
HISTORIC SAMPLING LOCATIONS FORMER SELLITE AND UNLOADING AREAS

DATA GAP INVESTIGATION FOR THE GMA - FORMER SELLITE AREA AND UNLOADING AREA SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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LEGEND:

- HISTORIC SOIL BORING
- RAILROAD
- ROAD

NOTES:

1. MATERIAL IN PIT IS NOT TRULY SOIL, BUT IS MOSTLY GRAVEL AND ASSOCIATED FINES.
2. SB-07 THROUGH SB-09 SAMPLES WERE COLLECTED IN 2009 AS PART OF THE REMEDIAL INVESTIGATION. THE DP-01 SAMPLE WAS COLLECTED IN 1999 AS PART OF THE SITE INVESTIGATION.

SCALE: 0 20 40 FEET

FIGURE 1-7
HISTORIC SOIL BORING LOCATIONS
LOCOMOTIVE BUILDING
MAINTENANCE PIT

DATA GAP INVESTIGATION FOR THE GMA - FORMER SELLITE AREA AND UNLOADING AREA SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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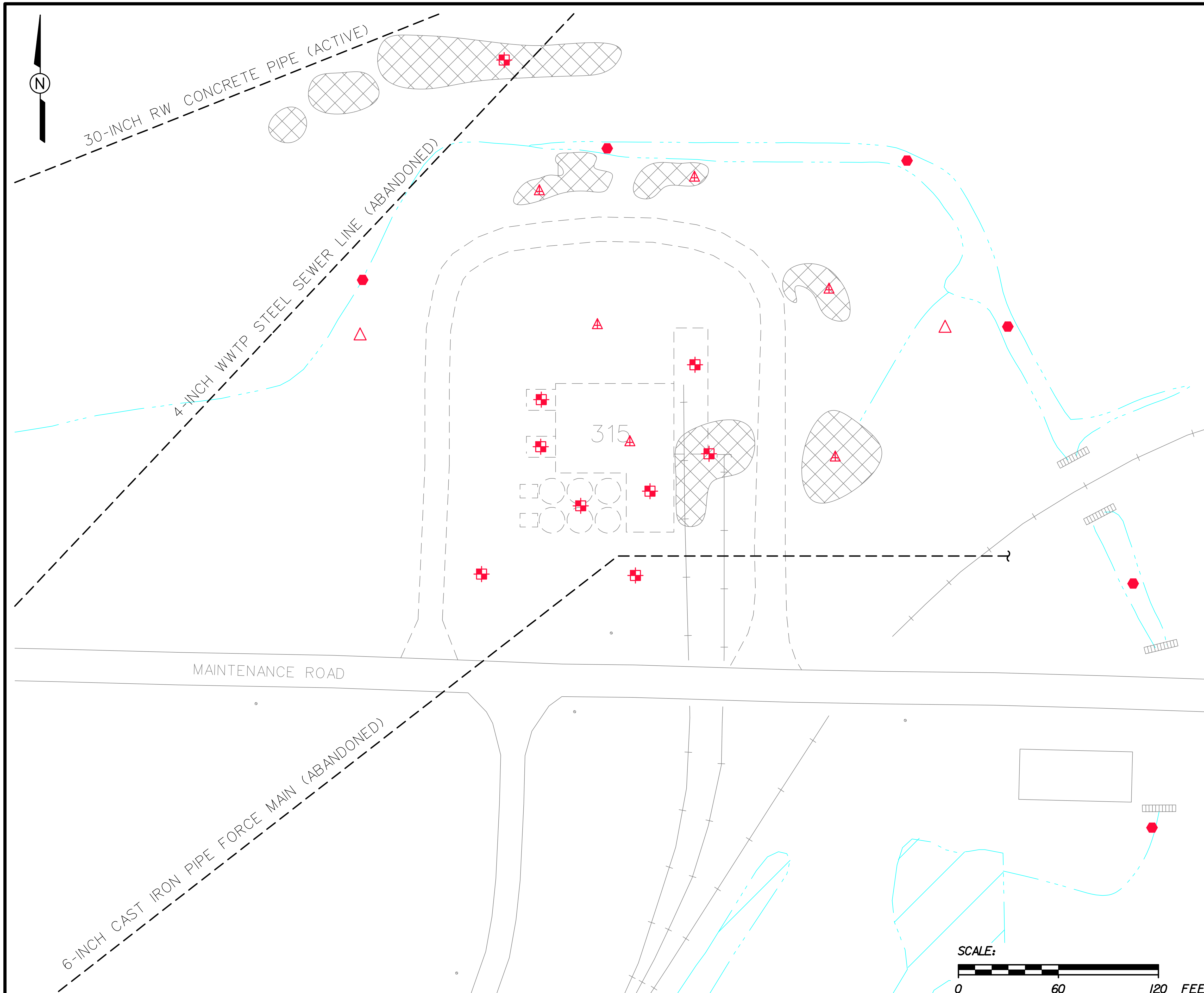

LEGEND:

- POND
- CREEK, DITCH, CONVEYANCE
- ABANDONED RAILROAD
- ROAD
- APPROXIMATE LOCATION OF FORMER STRUCTURES
- PROPOSED SOIL BORING
- PROPOSED SOIL BORING/PIEZOMETER
- PROPOSED PIEZOMETER
- PROPOSED SEDIMENT SAMPLE
- BARREN AREA

NOTES:

1. SAMPLING LOCATIONS MAY BE ADJUSTED BASED ON FIELD CONDITIONS. (E.G. SITE ACCESS, UTILITIES, ETC.)

FIGURE 3-1
PROPOSED SAMPLING LOCATIONS FORMER SELLITE AREA

DATA GAP INVESTIGATION FOR THE GMA - FORMER SELLITE AREA AND UNLOADING AREA SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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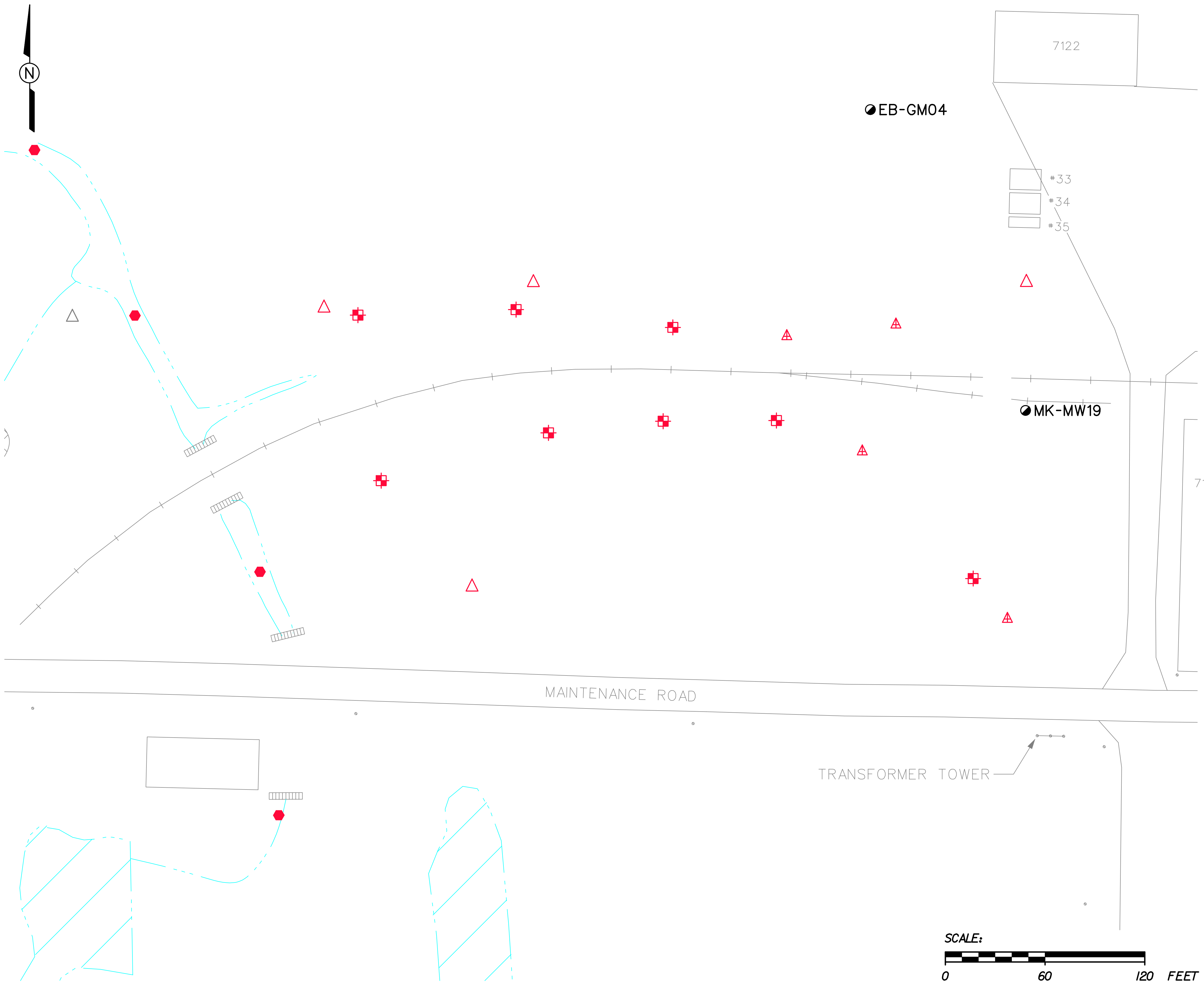

LEGEND:

- OVERBURDEN MONITORING WELL
- POND
- CREEK, DITCH, CONVEYANCE
- ABANDONED RAILROAD
- ROAD
- PROPOSED SOIL BORING
- PROPOSED SOIL BORING/PIEZOMETER
- PROPOSED PIEZOMETER
- PROPOSED PIEZOMETER (SELLITE AREA)
- PROPOSED SEDIMENT SAMPLE
- #33 FORMER UNDERGROUND STORAGE TANK

NOTES:

1. PROPOSED SOIL BORING/PIEZOMETER LOCATIONS MAY BE ADJUSTED PENDING FIELD CONDITIONS.
2. PROPOSED SEDIMENT SAMPLE LOCATIONS ADDRESSED IN SELLITE AREA (FIGURE 3-1).
3. UNDERGROUND STORAGE TANKS #33, #34, AND #35 REMOVED IN 1989.

FIGURE 3-2
PROPOSED SAMPLING LOCATIONS FORMER UNLOADING AREA

DATA GAP INVESTIGATION FOR THE GMA - FORMER SELLITE AREA AND UNLOADING AREA SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

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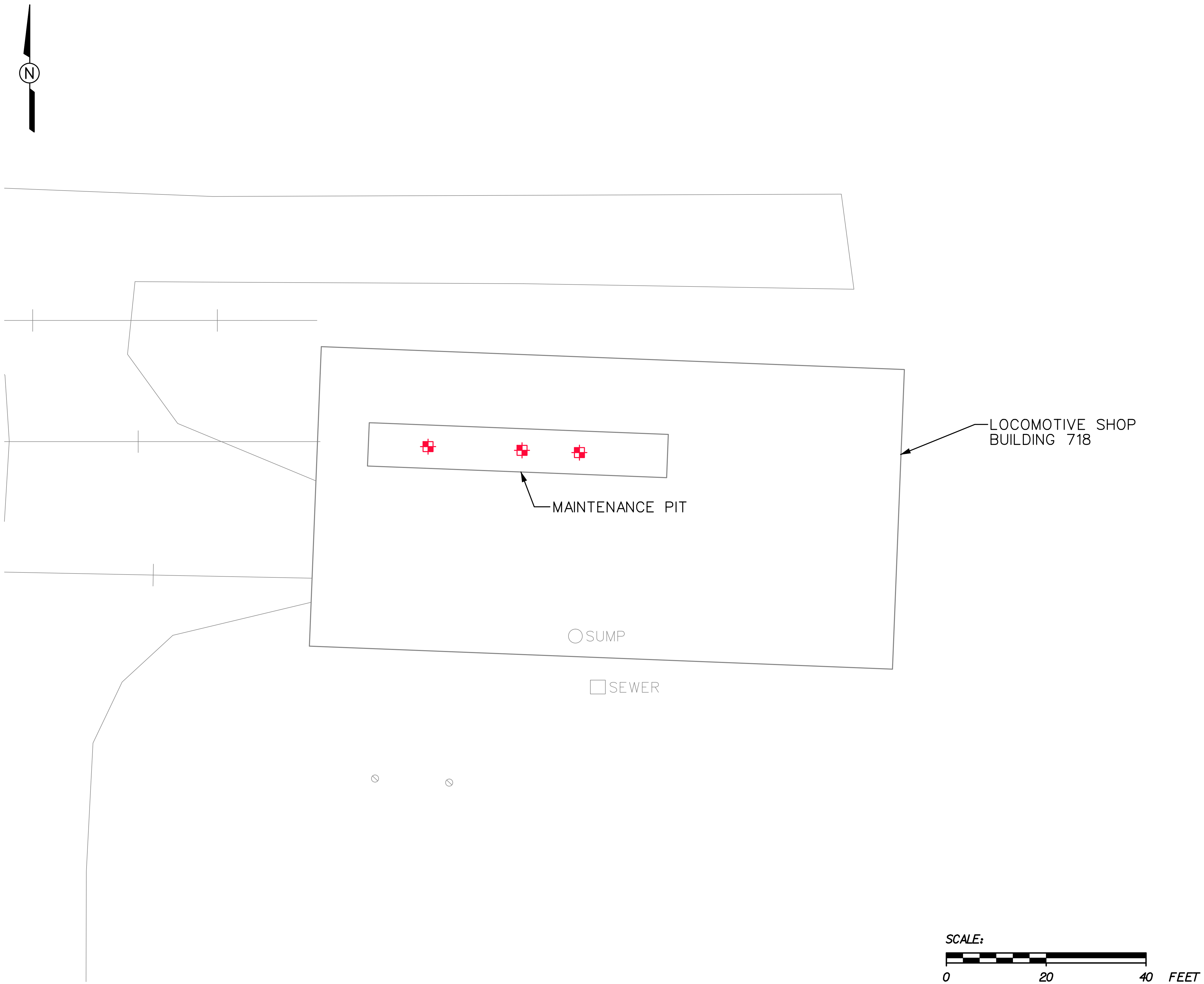

LEGEND:

- PROPOSED PIT MATERIAL SAMPLE LOCATION
- RAILROAD
- ROAD

NOTES:

1. ONE SAMPLE MUST BE FROM WITHIN THE MAINTENANCE PIT SUMP.
2. OTHER TWO SAMPLES MAY BE ADJUSTED BASED ON VISUAL AND/OR PID OBSERVATIONS OF CONTAMINATION IF PRESENT.

FIGURE 3-3

PROPOSED SAMPLING LOCATIONS LOCOMOTIVE BUILDING MAINTENANCE PIT

DATA GAP INVESTIGATION FOR THE GMA - FORMER SELLITE AREA AND UNLOADING AREA SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
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APPENDIX A

LABORATORY REPORTING AND QUALITY CONTROL LIMITS

Target Compound List
Volatile Organic Compounds and Laboratory Reporting Limits
for Soil and Groundwater Sample SW-8260B
Site Investigations and Groundwater Investigation
Former Plum Brook Ordnance Works
Sandusky, Ohio

Compound	Soils Reporting Limit[a] (µg/kg)	Groundwater Reporting Limit (µg/L)
Acetone	50	25
Benzene	5	1
Bromodichloromethane	5	1
Bromoform	5	1
Bromomethane	5	2
2-Butanone	25	10
Carbon disulfide	5	2
Carbon tetrachloride	5	1
Chlorobenzene	5	1
Chlorodibromomethane	5	1
Chloroethane	5	2
Chloroform	5	1
Chloromethane	5	2
cis-1,3-Dichloropropene	5	1
1,1-Dichloroethane	5	1
1,1-Dichloroethene	5	1
1,2-Dichloroethane	5	1
1,2-Dichloroethene (total)	5	1
1,2-Dichloropropane	5	1
trans-1,3-Dichloropropene	5	1
Ethyl benzene	5	1
2-Hexanone	25	10
Methylene chloride	10	5

Target Compound List
Volatile Organic Compounds and Laboratory Reporting Limits
for Soil and Groundwater Sample SW-8260B
Site Investigations and Groundwater Investigation
Former Plum Brook Ordnance Works
Sandusky, Ohio

Compound	Soils Reporting Limit[a] (µg/kg)	Groundwater Reporting Limit (µg/L)
4-Methyl-2-pentanone	25	10
Styrene	5	1
Tetrachloroethene	5	1
1,1,2,2-Tetrachloroethane	5	1
Toluene	5	1
Trichloroethene	5	1
1,1,1-Trichloroethane	5	1
1,1,2-Trichloroethane	5	1
Vinyl chloride	5	1
Xylenes (total)	15	3

a. Specific reporting limits are highly matrix dependent. Reporting limits are adjusted based on dryness calculations, dilution factors, etc. Reporting limits are based on the LOQ (DOD QSM 4.1).

Target Compound List
Semivolatile Organic Compounds and Laboratory Reporting Limits
for Soil and Groundwater Sample SW-8270D
Site Investigations and Groundwater Investigation
Former Plum Brook Ordnance Works
Sandusky, Ohio

Compound	Soils Reporting Limits[a] (μg/kg)	Groundwater Reporting Limits (μg/L)
Acenaphthene	170	5
Acenaphthylene	170	5
Anthracene	170	5
Benzo(a)anthracene	170	5
Benzo(a)pyrene	170	5
Benzo(b)fluoranthene	170	5
Benzo(g,h,i)perylene	170	5
Benzo(k)fluoranthene	170	5
4-Bromophenyl-phenyl ether	170	5
Butyl benzyl phthalate	170	5
Carbazole	170	5
Chrysene	170	5
bis(2-Chloroethoxy)methane	170	5
bis(2-Chloroethyl)ether	170	5
4-Chloro-3-methylphenol	170	5
4-Chloroaniline	170	5
2-Chloronaphthalene	170	5
2-Chlorophenol	170	5
4-Chlorophenyl-phenyl ether	170	5
Di-n-butyl phthalate	170	5
Di-n-octyl phthalate	170	5
Dibenzo(a,h)anthracene	170	5

Target Compound List
Semivolatile Organic Compounds and Laboratory Reporting Limits for Soil and Groundwater Sample SW-8270D
Site Investigations and Groundwater Investigation
Former Plum Brook Ordnance Works
Sandusky, Ohio

Compound	Soils Reporting Limits[a] (µg/kg)	Groundwater Reporting Limits (µg/L)
Dibenzofuran	170	5
1,2-Dichlorobenzene	170	5
1,3-Dichlorobenzene	170	5
1,4-Dichlorobenzene	170	5
3,3'-Dichlorobenzidine	330	10
2,4-Dichlorophenol	170	5
Diethyl phthalate	170	5
Dimethyl phthalate	170	5
2,4-Dimethylphenol	170	5
4,6-Dinitro-2-methylphenol	330	10
2,4-Dintrophenol	830	25
2,4-Dinitrotoluene	170	5
2,6-Dinitrotoluene	170	5
bis(2-Ethylhexyl)phthalate	170	5
Fluoranthene	170	5
Fluorene	170	5
Hexachlorobenzene	170	5
Hexachlorobutadiene	170	5
Hexachlorocyclopentadiene	330	10
Hexachloroethane	170	5
Indeno(1,2,3-cd)pyrene	170	5
Isophorone	170	5
	170	5

Target Compound List
Semivolatile Organic Compounds and Laboratory Reporting Limits
for Soil and Groundwater Sample SW-8270D
Site Investigations and Groundwater Investigation
Former Plum Brook Ordnance Works
Sandusky, Ohio

Compound	Soils Reporting Limits[a] (μg/kg)	Groundwater Reporting Limits (μg/L)
2-Methylnaphthalene		
2-Methylphenol	170	5
4-Methylphenol	170	5
Naphthalene	170	5
2-Nitroaniline	170	5
3-Nitroaniline	170	5
4-Nitroaniline	170	5
Nitrobenzene	170	5
2-Nitrophenol	170	5
4-Nitrophenol	830	25
N-Nitroso-di-n-propylamine	170	5
N-nitrosodiphenylamine	170	5
2,2'-oxybis (1-Chloropropane)	170	5
Pentachlorophenol	830	25
Phenanthrene	170	5
Phenol	170	5
Pyrene	170	5
1,2,4-Trichlorobenzene	170	5
2,4,5-Trichlorophenol	170	5
2,4,6-Trichlorophenol	170	5

a Specific reporting limits are highly matrix dependent. Reporting limits are adjusted based on dryness calculations, dilution factor, etc. Reporting limits are based on the LOQ (DOD QSM 4.1).

Target Compound List
Pesticides/PCB Compounds and Laboratory Reporting Limits
for Soil and Groundwater Samples
Former Plum Brook Ordnance Works
Sandusky, Ohio
(Methods SW-846 8081B/8082A)

Compound	Soil/Sediment Reporting Limit[a] (μg/kg)	Water Reporting Limit (μg/L)
Aldrin	1.7	0.05
Aroclor 1016	17	0.5
Aroclor 1221	17	0.5
Aroclor 1232	17	0.5
Aroclor 1242	17	0.5
Aroclor 1248	17	0.5
Aroclor 1254	17	0.5
Aroclor 1260	17	0.5
alpha-BHC	1.7	0.05
beta-BHC	1.7	0.05
delta-BHC	1.7	0.05
gamma-BHC (Lindane)	1.7	0.05
Chlordane (Technical)	17	0.5
4,4'-DDD	3.3	0.1
4,4'-DDE	3.3	0.1
4,4'-DDT	3.3	0.1
Dieldrin	1.7	0.05
Endrin	3.3	0.1
Endrin aldehyde	3.3	0.1
Endosulfan I	1.7	0.05
Endosulfan II	1.7	0.05
Heptachlor	1.7	0.05
Heptachlor epoxide	1.7	0.05

Target Compound List
Pesticides/PCB Compounds and Laboratory Reporting Limits
for Soil and Groundwater Samples
Former Plum Brook Ordnance Works
Sandusky, Ohio
(Methods SW-846 8081B/8082A)

Compound	Soil/Sediment Reporting Limit[a] (µg/kg)	Water Reporting Limit (µg/L)
Methoxychlor	3.3	0.1
Toxaphene	83	2.5

a Specific reporting limits are highly matrix dependent. Reporting limits are adjusted based on dryness calculations, dilution factors, etc. Reporting limits are based on the LOQ (DOD QSM 4.1).

Nitroaromatic Compounds and Laboratory Reporting Limits for Soil and Groundwater Sample SW-846 8330A Site Investigations and Groundwater Investigation Former Plum Brook Ordnance Works Sandusky, Ohio

Compound	Soils Reporting Limit[a] (mg/kg)	Groundwater Reporting Limit (μg/L)
4-Amino-2,6-dinitrotoluene	0.2	0.2
1,3-Dinitrobenzene	0.2	0.2
2,4-Dinitrotoluene	0.2	0.2
2,6-Dinitrotoluene	0.2	0.2
HMX	0.2	0.2
Nitrobenzene	0.2	0.2
2-Nitrotoluene	0.2	0.2
3-Nitrotoluene	0.2	0.2
RDX	0.2	0.2
Tetryl	0.2	0.2
1,3,5-Trinitrobenzene	0.2	0.2
2,4,6-Trinitrotoluene	0.2	0.2

a Specific reporting limits are highly matrix dependent. Reporting limits are adjusted based on dryness calculations, dilution factor, etc. Reporting limits are based on the LOQ (DOD QSM 4.1).

Target Analyte List
Inorganic Compounds and Laboratory Reporting Limits
for Soil and Groundwater Sample SW-846, 6010C/7470A/7471B
Site Investigations and Groundwater Investigation
Former Plum Brook Ordnance Works
Sandusky, Ohio

Analyte	Soils Reporting Limit[a] (mg/kg)	Groundwater Reporting Limit (mg/L)
Aluminum	10	0.2
Antimony	1.0	0.006
Arsenic	0.5	0.01
Barium	10	0.2
Beryllium	0.25	0.004
Cadmium	0.2	0.005
Calcium	250	1
Chromium	0.5	0.01
Cobalt	2.5	0.05
Copper	1.25	0.025
Iron	15	0.3
Lead	1.0	0.005
Magnesium	250	5
Manganese	0.75	0.015
Mercury	0.083	0.001
Nickel	2	0.04
Potassium	500	10
Selenium	1	0.01
Silver	0.5	0.01
Sodium	500	10
Thallium	0.5	0.01
Vanadium	2.5	0.05
Zinc	1.0	0.02
Total Cyanide	0.5	0.01

a Specific reporting limits are highly matrix dependent. Reporting limits are adjusted based on dryness calculations, dilution factor, etc. Reporting limits are based on the LOQ (DOD QSM 4.1).