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Shaw Environmental & Infrastructure, Inc.

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Site-Specific Sampling and Analysis Plan Addendum
Remedial Investigation
TNT Area B to Waste Water Treatment Plant No. 1 Sewer Line

Former Plum Brook Ordnance Works, Sandusky, Ohio

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Revision 1

Table of Contents

Page

Table of Contents (Continued)

Page

List of Tables

List of Figures

List of Acronyms

ASTM	American Society for Testing and Materials
bgs	below ground surface
°C	degrees Celsius
DNT	dinitrotoluene
DOD	U.S. Department of Defense
DQO	data quality objective
Eh	oxygen-reduction potential
EPA	U.S. Environmental Protection Agency
IDW	investigation-derived waste
NASA	National Aeronautics and Space Administration
NTU	nephelometric turbidity unit
OD	outside diameter
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
PARCCS	precision, accuracy, representativeness, completeness, comparability, and sensitivity
PBOW	Plum Brook Ordnance Works
PCB	polychlorinated biphenyl
PPE	personal protective equipment
PRG	preliminary remediation goal
PVC	polyvinyl chloride
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RBSC	risk-based screening concentration
RI	remedial investigation
Shaw	Shaw Environmental, Inc.
SSAP	site-specific sampling and analysis plan
SWSAP	sitewide sampling and analysis plan
SVOC	semivolatile organic compound
TCL	target compound list
TNT	trinitrotoluene
TNTB	TNT Area B
USACE	U.S. Army Corps of Engineers
VOC	volatile organic compound
WWTP1	Waste Water Treatment Plant No. 1

1.0 Project Description

The U.S. Army is conducting studies of the environmental impact of suspected hazardous waste sites at previously owned U.S. Department of Defense (DOD) properties. One such site is the former Plum Brook Ordnance Works (PBOW), 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 and Huntington Districts of the U.S. Army Corps of Engineers (USACE). The 9,000-acre PBOW facility was used for the manufacture of explosives during World War II and is currently owned by the National Aeronautics and Space Administration (NASA) and 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 the remedial investigation (RI) for the waste water sewer lines which extended from the former TNT Area B (TNTB) to the former Waste Water Treatment Plant No. 1 (WWTP1). This SSAP is an addendum to the sitewide sampling and analysis plan (SWSAP) (Shaw, 2008a) and was developed in accordance with the PBOW SWSAP (Shaw, 2008a) 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 PBOW 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 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 of 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 PBOW since 1963, and it is currently the NASA Glenn Research Center, Plum Brook Station.

Figure 1-2 shows various PBOW areas of concern, including WWTP1 and TNTB. TNTB has been investigated extensively, a TNTB feasibility study has been conducted, and a removal action was completed in December 2006. WWTP1 has been investigated separately; an additional investigation of WWTP1 began in December 2008 and is currently ongoing. This SSAP focuses exclusively on the sewer line from TNTB to WWTP1.

1.2 WWTP1 Sewer Line Description and History

During production in the 1940s, three waste water treatment plants were used to process production waste water from the three TNT manufacturing areas at PBOW. The wastes were accumulated in the settling basins of the TNT manufacturing areas. These wastes were transported to the waste water treatments plants via aboveground and belowground wood-stave sewer lines (USACE, 1995). Chemicals in the waste streams included sodium salts of sulfite, sulfate, nitrite, and nitrate; sulfonates of unwanted TNT isomers; trinitrobenzoic acid; trinitrobenzaldehyde; trinitrobenzyl alcohol; nitrotoulenes; and dinitrotoluenes (Dames and Moore, Inc., 1996).

The manufacturing areas were denoted TNT Area A, TNTB, and TNT Area C; the waste water treatment plants were denoted WWTP1, Waste Water Treatment Plant No. 2, and Waste Water Treatment Plant No. 3. WWTP1 received waste water from TNTA to the east and from TNTB to the south. This SSAP includes the sewer line that reportedly extended between TNTB and WWTP1.

Based on historical as-built maps (Trojan Powder Company, 1944), the sewer line originally extended from TNTB to WWTP1 (Figure 1-3). The figure shows a single sewer line that extends north-northeast from the TNTB settling basins (Building 187) for approximately 5,500 feet to the Raw Waste Storage Tank at WWTP1. A portion of the sewer line along Shortcut Road apparently was removed in November 1945. Wood-stave pipes were constructed of small wood slats (i.e., staves) joined together in a tongue-and-groove fashion and reinforced with steel banding. Use of wood-stave pipes was not uncommon for water and sewage conveyance during the late 1800s until the 1950s. Based on the investigation of the TNTA to WWTP1 sewer line, it is unlikely that any of the TNTB wooden sewer line remains other than pieces of rusted metal banding.

No specific investigation has been conducted at PBOW concerning the TNTB to WWTP1 sewer line.

During PBOW operations, the TNTA sewer lines reportedly often became clogged with TNT residue, and in some instances were completely plugged. The plugged lines were abandoned, and larger diameter bypass sewer lines were constructed around the blocked areas to provide continual drainage of the waste water (USACE, 1995). There is no record as to whether similar activities were required for the TNTB sewer line to WWTP1.

Review of aerial photographs indicates limited portions of the sewer line are still visible based on ground scarring. Site walks conducted in the spring of 2009 confirmed linear depressions in the ground surface, possibly the result of the degradation of the wooden sewer line and collapse of the overlying soil. The observation of surface scarring is consistent with the findings from the TNTA to WWTP1 investigation where ground scarring was observed on aerial photographs and confirmed during site walks and excavations. The scarring presumably resulted from settling of the overlying soil after the sewer lines have decomposed. The approximate location of the sewer line based on ground scarring is shown on Figure 1-3.

1.3 Sitewide Hydrogeology

Two hydrolithologic units have been identified at PBOW. The overburden unit, composed of glacial outwash materials, has a thickness ranging from a few feet in the south to more than 40 feet in some locations in the north. Based on data from monitoring wells installed closest to the area of concern, the overburden thickness ranges from 5 feet near TNTB to 30 feet at WWTP1. Depth to water is variable, depending on overburden thickness and precipitation. Overall, the water-producing capacity of the overburden materials is strongly controlled by seasonal changes, and varies spatially across the PBOW facility (IT Corporation, 1999). The overburden in the vicinity of the WWTP1 sewer lines is initially underlain by the Plum Brook Shale followed by the Delaware Limestone. The shale bedrock is expected to be encountered at depths ranging from 5 to 30 feet along the TNTB to WWTP1 sewer line. Both the Plum Brook Shale and Devonian Limestone dip to the southeast at approximately 35 feet per mile.

In general, groundwater flows in a northerly direction, towards Lake Erie, in both the unconsolidated overburden/shale material and the underlying limestone bedrock. However, on the western side of the installation, groundwater in the overburden/shale water-bearing zone flows to the northwest, while groundwater in the bedrock aquifer flows to the northeast. Both the overburden/shale and deeper limestone groundwater are expected to flow toward the northeast in the area of the TNTB to WWTP1 sewer line.

2.0 Scope of Work and Objectives

2.1 Scope of Work

As specified in the scope of work (USACE, 2009), RI field activities covered by this SSAP consist of the following tasks:

- Conduct soil trenching
- Sample soil (from trench and using direct-push)
- Install temporary piezometers and monitoring wells
- Develop monitoring wells
- Sample groundwater in piezometers and wells
- Laboratory analysis of soil and groundwater samples
- Manage and dispose of investigation-derived waste (IDW)
- Prepare and submit a geographic information system deliverable
- Prepare an electronic data deliverable.

The above activities, analytical data, and evaluation will be presented in a site characterization report.

2.2 Objectives

The primary objective of the TNTB to WWTP1 Sewer Line investigation is to determine the soil and overburden groundwater quality and the extent of contamination in soil and groundwater along the TNTB to WWTP1 sewer line. Specific objectives of the continued RI are summarized as follows:

- Define site physical features and characteristics.
- Determine nature and extent of DOD-related contamination in soil and groundwater along the TNTB to WWTP1 sewer line.
- Determine chemical characteristics of contamination.
- Evaluate fate and transport of contamination.
- Determine whether overburden groundwater underlying the sewer line is in 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.

2.3 Site-Specific Data Quality Objectives

2.3.1 Overview

The data quality objectives (DQO) 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 DQO process, described in U.S. Environment Protection Agency (EPA) publication 9355.9-01, *Data Quality Objectives for Superfund* (EPA, 1993), 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 in Figure 3-2 of the SWSAP (Shaw, 2008a).

2.3.2 Data Users and Available Data

Soil and groundwater samples have not been collected along the TNTB-WWTP1 sewer line; therefore, a site-specific conceptual model was developed using existing information. This information includes historical as-built drawings and information obtained during the investigation of other PBOW areas, most notably the investigation of the TNTA-WWTP1 sewer line (Shaw, 2008d). During the project planning process, effective methodologies for filling the data gaps were designed and reviewed by the data users, USACE, NASA, and OEPA, with the most efficient data collection design implemented. The SSAP records the rationale for the design, including the location, number, and type of samples necessary to fill the data gaps and to satisfy the DQOs. The SSAP, along with companion documents, provides the regulatory agencies with sufficient detail that they can conclude whether the investigative effort is adequate to satisfy the study objectives.

2.3.3 Conceptual Site Model

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

- Potential contaminant sources
- Migration pathways
- Potential receptors
- Types of contaminants in effected media.

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 TNT and DNT disposal activities. The migration pathways for potential contaminants include groundwater and/or bedrock groundwater, soil, sediment, and surface water runoff to creeks. Potential ecological receptors along the WWTP1 sewer lines are wildlife communities, plant communities, and aquatic communities associated with creeks. Exposure of humans to potential contaminants under current land use at PBOW is unlikely, because the site is a secure NASA research station and any contamination would be expected to be below the surface, away from potential contact. 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 receptors near the facility include off-site water users. 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 volatile organic compounds (VOC), semivolatile organic compounds (SVOC), metals, and pesticides/polychlorinated biphenyls (PCB).

2.3.4 Decision-Making Process, Data Uses, and Needs

The decision-making process that will be followed during the RI, presented in detail in Section 3.3.4 of the SWSAP (Shaw, 2008a), consists of a seven-step process. Data uses and needs are summarized in Table 2-1.

2.3.5 Risk-Based Evaluation

Confirmation of contamination during the RI will be based upon a comparison of detected contaminants in samples from this investigation to the most current risk-based screening concentrations (RBSC). Groundwater RBSCs are currently derived from EPA (2004) preliminary remediation goal (PRG) tap water criteria, and soil RBSCs are derived from residential soil PRGs. Depending on further PBOW team discussion and potential future agreements, the Regional Screening Levels (Oak Ridge National Laboratory-EPA, 2008) may be used to derive RBSCs in the future rather than PRGs. 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, if necessary, a feasibility study.

2.3.6 Data Quality, Types, and Quantities

Groundwater and soil samples will be collected and analyzed to meet the objectives of the RI. Quality assurance (QA)/quality control (QC) samples will be collected for all sample types described in Chapter 3.0 of this SSAP (Table 2-2). 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.

2.3.7 *Precision, Accuracy, Representativeness, Completeness, Comparability, and Sensitivity*

Laboratory requirements of precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) for all samples generated during the RI are provided in Chapter 3.0 of the QAPP (Shaw, 2008b). Tables 7-1 through 7-5 of the QAPP list the laboratory reporting limits (sensitivity) and method detection limits. Table 9-1 of the QAPP addresses the laboratory requirements and laboratory QC parameters that affect PARCCS.

The lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions is defined as the laboratory reporting limit. Typically, the laboratory reporting limit is 3 to 5 times the MDL.

The method detection limit is defined as the lowest concentration that can be detected by an instrument with correction for the effects of sample matrix and method-specific parameters such as sample preparation. "Detected" in this context means that a sample that contains the analyte detected at the MDL can be distinguished from a blank with 99 percent certainty.

3.0 Field Activities

The continued RI approach will be consistent with work conducted previously at the PBOW facility. A series of trenches will be excavated to confirm the sewer line location, inspect its condition, and provide access for sampling associated soil. Direct-push soil samples will be collected from along the sewer lines; their locations dependent upon the analytical results from the trench samples. A temporary piezometer will be installed in each boring. Three overburden/shale and three limestone monitoring wells will be installed after the review of the analytical results of the piezometers. Thus, field activities under this SSAP will include the following:

- Install 34 test pits to confirm the presence of the TNTB to WWTP1 sewer line, inspect their condition, and provide access for sampling of associated soil.
- Sample soil immediately underlying the sewer line from the test pits, 1 sample for each of 34 test pits.
- Advance 16 soil borings along the TNTB to WWTP1 sewer line using direct-push technology.
- Collect one soil sample from each of six direct-push soil boring locations for nitroaromatics analysis.
- Collect 2 soil samples from each of 10 direct-push soil boring locations for analysis of nitroaromatics, SVOCs, target analyte list metals, and PCBs (1 surface soil sample will also be analyzed for total organic carbon).
- Install piezometers in 10 borings along the TNTB to WWTP1 sewer line.
- Sample groundwater from the 10 piezometers for analysis of nitroaromatics.
- Install three overburden/shale and three limestone monitoring wells along the TNTB to WWTP1 sewer line.
- Develop the six monitoring wells.
- Sample the six monitoring wells for analysis of nitroaromatics, SVOCs, VOCs, metals, and PCBs.
- Manage and dispose of IDW.

All boring and well locations will be sketched and surveyed; land elevations will be surveyed to within $\pm$ 0.01 foot referenced to the National Geodetic Vertical Datum of 1929, and horizontal coordinates referenced to the North American Datum 1983. Values will be scaled to the nearest 0.1 foot and referenced to the Ohio State Plane Coordinate System (Section 3.3). A notch will be filed into the top of the well or piezometer riser or the top of the riser will be otherwise marked to serve as a vertical and horizontal measuring point. One edge of each test pit location above the approximate center of the pipe will likewise be surveyed. Any site clearing that may be necessary for equipment access, as well as utility clearances prior to intrusive activities (Section 3.4), will be coordinated with NASA. Also, a dig permit will be coordinated with NASA prior to commencing any intrusive activities.

3.1 Soil Investigations

Two types of soil samples will be collected as part of this investigation. First, soil samples will be collected from up to 34 test pit excavations (Section 3.1.1). After the test pit soil sample analytical results are received and reviewed, soil samples will be collected from each of 16 soil borings (Section 3.1.2). Table 2-2 summarizes the samples and analytical parameters, and Table 3-1 identifies the specific analytical methods.

A qualified geologist or geotechnical engineer will be on site for all excavation, drilling, and sampling operations. The geologist/geotechnical engineer will perform logging and collect other information, as described in Section 3.1.3. All soil samples will be field screened using a field test kit for nitroaromatics (e.g., D-Tech® or equivalent) to ensure that the concentration of nitroaromatics are safe to ship to the laboratory (i.e., nitroaromatics concentrations less than 10 percent). Also, any materials associated with the sewer line that appear to be contaminated will be field screened. Although not expected, if raw explosive material is encountered during soil sampling, all activities will stop, and Shaw will contact USACE to discuss procedures for disposal of the raw explosive material.

3.1.1 Test Pit Excavations and Soil Samples

A total of 34 test pits will be completed with an excavator, perpendicular to the TNTB to WWTP1 sewer line throughout its length. These test pits will serve to confirm the location of the sewer line as determined from as-built drawings for the site (Section 3.1). The location of the sewer line traces will be inferred from as-built drawings, field observations, and aerial photographs. Current aerial photographs show linear scarring along the ground surface in the vicinity of the former sewer line near Short Cut Road and Fox Road. The test pits will also be used to provide access for sampling soils underlying the sewer line. Condition, composition, and size of the sewer lines will also be recorded. Potential locations of the 34 test pits will be determined in the field and will be influenced by field conditions and observations. The main obstacle to the investigation is the presence of underground utilities at the site which restrict access to the entire sewer line. Preliminary test pit locations in excess of the 34 originally scoped will be marked in the field based on site knowledge; however, some of these locations likely will not be accessible due to utilities.

One soil sample will be collected immediately below the sewer line in each test pit. Depending on the depth of the test pit, the samples will be collected either with the excavator bucket or by stainless steel trowel. Each of these 34 samples (and 3 duplicates) will be analyzed for nitroaromatics, using EPA Method SW-846 8330. The analytical results of these samples will be used to determine whether waste materials previously transported by the TNTB to WWTP1 sewer line have leaked and impacted adjacent soil.

3.1.2 Direct-Push Soil Samples

A total of 16 direct-push borings will be advanced immediately along the TNTB to WWTP1 sewer line. The locations of these borings will be based on the analytical results from the test pit soil samples and field observations.

Ten soil borings will be completed at the areas of highest soil contamination along the TNTB to WWTP1 sewer line based on test pit analytical results. Two soil samples will be collected from each of these 10 soil borings, including one soil sample from 0 to 1 foot below ground surface (bgs) and one from 9 to 10 feet bgs. The 20 soil samples (and 2 duplicates) collected in the areas of highest soil contamination will be analyzed for nitroaromatics, SVOCs, PCBs, and target analyte list metals. One surface soil sample will also be analyzed for total organic carbon to provide information for modeling, if needed.

Six borings at three locations will be used to delineate the lateral extent of subsurface soil contamination. At each of the three locations, one boring will be placed on each side of the line at a distance of approximately 10 feet from the trace of the sewer line. This will allow a "cross-sectional" view of line and determine if there was a preferential flow for the waste away from the line. One soil sample will be collected from each of these six soil borings from a depth of 8 to 10 feet bgs and analyzed for nitroaromatics.

The analytical results of the deeper direct-push soil samples will be used in conjunction with the results of the test pit samples to determine whether materials previously transported via the TNTB to WWTP1 sewer line have impacted adjacent soils. The analytical results of the surface soil samples will be used to determine if any leakage from the TNTB to WWTP1 sewer line have impacted the associated surface soil such that exposure may result in potential human health and/or ecological effects. These direct-push soil samples will be collected using the procedures described in Section 3.1.3.

3.1.3 Soil Sampling Procedures

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 and EM 1110-1-4000 (USACE, 1998) on the hazardous, toxic, and radiological waste drilling log (Figure 4-2 of the SWSAP).

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 in the variance log shown on Figure 9-1 of the SWSAP (Shaw, 2008a). All direct-push soil samples collected by Shaw field personnel will be documented on 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. Soil overburden material will be sampled continuously for the purpose of visual classification of the borehole material, but samples will not be saved for geotechnical analysis. Daily field notes will be kept in chronological order on a field activity daily log and will include sufficient information to reconstruct the progress of excavation, drilling operations, problems encountered, temporary piezometer installation procedures (Section 3.2.3), etc. After database entry is completed, 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.

For soil intervals that are collected for analytical sample analysis, the samples will be collected in the appropriate jars prior to lithologic logging. 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 or new, gallon-size resealable plastic bag. 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 interval) and/or subsurface soil sample (9- to 10-foot interval) from the adjacent boring will be combined with the original soil sample, homogenized, and transferred to appropriate sample jars. After the sample container has been filled, the jar will be placed on ice in a sample cooler and the proper paperwork will be completed.

As mentioned in Section 3.1.2, 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 a retractable tip (point) to the 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. Once the subsurface soil sample is collected, selected borings will be advanced to bedrock (or refusal) and a piezometer will be installed, as described in Section 3.2.3. Continuous logging will be performed to the bottom of the borehole.

Soil borings in which a piezometer is not installed will be abandoned when the soil sampling and piezometer installation activities are completed. The abandonment will be performed in accordance with Ohio Department of Natural Resources (ODNR) requirements, following Ohio Environmental Protection Agency (OEPA) (2005) guidance. A well sealing report will be submitted to ODNR. The boreholes will be abandoned by pressure grouting with neat cement from the bottom to the top of the borehole using a tremie pipe or by backfilling and tamping with bentonite chips. The neat cement mixture used to seal the borehole will be composed of a ratio of one 94-pound bag of portland cement to no more than 8.5 gallons of water and 2 to 8 percent bentonite powder.

After direct-push soil sampling and piezometer installation is completed (Section 3.2.3), the remaining soil from the boring will be drummed. A composite soil sample of this drummed material will be analyzed for chemical parameters for disposal characterization, as described in Chapter 6.0.

3.2 Groundwater Investigations

Groundwater will be investigated in a phased approach. First, groundwater will be collected from each of 10 piezometers installed along the TNTB to WWTP1 sewer line within the overburden unit. Based on the analytical results and groundwater flow patterns of the piezometer samples, three monitoring wells will be installed in the overburden/shale and three monitoring wells will be installed in the underlying limestone formation. Each piezometer and monitoring well will be sampled using a low-flow technique described in Section 3.2.7, unless OEPA and USACE approve a variation. Table 2-2 summarizes the samples and analytical parameters, and Table 3-1 identifies the specific analytical methods.

If bedrock (or refusal) is encountered at less than 5 feet and the borehole is dry, then no piezometer or well will be installed at this location, as it is unlikely to produce measurable water. In this case, a suitable alternate location will be sought. In addition, previous investigations have shown a strong seasonal and topographic variation in water levels in the overburden at PBOW which can result in dry boreholes. The water levels in the piezometers will be measured a minimum of 24 hours after the last piezometer was installed 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

A piezometer will be installed at each of the 10 soil boring locations described in Section 3.1.2. Once soil sampling is complete to the bottom of the sewer line and the associated soil sample is collected (Section 3.1.3), the boring will be advanced to bedrock (or refusal). As described in Section 3.1.3, the boring will be continuously logged, with lithologic and hydrologic observations appropriately recorded. Piezometer installation is described in Section 3.2.3. Each piezometer water sample will be collected using a low-flow technique and analyzed only for nitroaromatics. All sampling and purging equipment (pumps, tapes, discharge piping) will be decontaminated prior to use and after each successive use. The piezometer sample results will be used to determine the appropriate locations for installing monitoring wells in the two groundwater zones (overburden/shale and limestone). To expedite the schedule, these samples will be analyzed on a 7-day turnaround.

3.2.2 Monitoring Well Samples

A total of six wells will be installed along or adjacent to the TNTB to WWTP1 sewer line based upon the highest nitroaromatic groundwater piezometer results, unless the project delivery team makes the determination that one or more of these wells are unnecessary based on the results of the piezometer samples and other site observations. Three of these six monitoring wells will be installed in the residual materials, and the other three wells will be installed in the shale bedrock water-bearing zone (limestone water-bearing zone if installed in the northern section of the TNTB line). 2004 Groundwater Investigation and Data Summary report data show that overburden/shale sitewide groundwater flow is mostly north to northwesterly. Residual and overburden/shale bedrock wells will be paired together to provide groundwater information in upgradient and downgradient directions from the TNTB sewer line. If residual groundwater flow directions are found contrary to the expected bedrock groundwater flow, the wells will not be paired but spaced to provide upgradient and downgradient results. The specific location of each well will be determined by the geologist or geotechnical engineer based on the analytical results from the piezometer samples. Monitoring well installation and development are described in Section 3.2.4.

Each monitoring well will be sampled using a low-flow technique (Section 3.2.7) and analyzed for VOCs, SVOCs, nitroaromatics, PCBs, metals (filtered and unfiltered), and water quality parameters. 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. In addition, the condition of all surface components of the monitoring wells will be documented with recommendations for repair. The surface components include the concrete pad, protective posts, protective casing, and well casing. In addition, the condition of well locks and lock hasps will be documented.

3.2.3 Piezometer Installation

Temporary piezometers are typically used to measure static water levels and collect groundwater quality samples in slow recharging environments. The TNTB to WWTP1 sewer line piezometers will be made of new 1-inch-outside diameter (OD) 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, semipermanent seals are not necessary. The top 1 to 2 feet of the borehole will be sealed with bentonite to prevent precipitation water or surface runoff from infiltrating the borehole. If sealing with bentonite proves difficult, a plastic surface seal may be used around the borehole and covered with additional soil or bentonite sloping away from the piezometer to promote runoff and prevent any surface water from entering the borehole. Figure 4-5 of the SWSAP shows a typical piezometer construction form that will be completed for all piezometers. Groundwater sampling will be conducted as described in Section 3.2.7 once the piezometer has an adequate water column to permit sample collection (i.e., greater than 24 inches).

Following the groundwater level measurement associated with the first round of monitoring well sampling (Section 3.2.5) and permission from USACE, the PVC materials will be removed from all temporary piezometer boreholes. The boreholes will be abandoned in accordance with OEPA and ODNR codes, regulations, and guidance, including the following: Ohio Administrative Code 3745-9-10, *Abandoned Well Sealing*; OEPA (2005) technical guidance on sealing abandoned monitoring wells and boreholes; and Ohio Revised Code Section 1521.05, *Well Construction and Sealing Log*. Boreholes will be abandoned using either bentonite or cement. If bentonite is used it will be emptied into the borehole and tamped into place in 3-foot depth intervals up to ground surface. If cement is used, pressure grouting from the bottom to the top of the borehole with a tremie pipe will be used to seal the wells. After 24 hours, the borehole will be checked for settlement and additional grout will be added, if necessary. Neat cement grout, which uses a ratio of one 94-pound bag of portland cement to no more than 8.5 gallons of water and 2 to 8 percent bentonite powder, will be used as the sealant. Bentonite is the preferred abandonment method because it does not increase localized pH levels. Piezometer material (PVC screen and casing) will be cleaned, cut into manageable lengths of 5 feet, and discarded into the local sanitary trash.

3.2.4 Monitoring Well Installation and Development

3.2.4.1 Monitoring Well Installation

The geologist or 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 or geotechnical engineer will mobilize one time for activities related to installation of the six new monitoring wells.

The estimated depth for each of the three new overburden/shale wells is 20 feet, and the estimated depth for each of the three new limestone monitoring wells is 80 feet. These depths are estimated based on well construction information from existing wells in the area. Actual installation depths will be adjusted in the field as necessary to collect representative groundwater samples.

A qualified geologist or geotechnical engineer will be on site for all drilling, installation, development, and testing operations. Well installation and drilling methods will be performed 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 3575-9-03, *Monitoring Well*. Limestone wells are anticipated to be installed using "double casing" as described in Section 3-10 of EM 1110-1-4000 to install a well through a contaminated upper zone (USACE, 1998). A hot work permit will be coordinated with NASA prior to installing double-cased wells if welding is anticipated. A well log will be completed and filed on line with ODNR (http://www.dnr.state.oh.us/water/maptechs/submitlogs/).

Soil and rock core logging will be continuous for the entire drilling procedure during the monitoring well installation. The geologist or geotechnical engineer will visually classify and log all borehole material according to the Unified Soil Classification System and EM 1110-1-4000 (USACE, 1998). Soil overburden material will be sampled continuously to visually classify the borehole material, but samples will not be saved for geotechnical analysis. Soil boring samples collected during well installation processes will not be analyzed for chemical parameters, except for disposal characterization, as described in Chapter 6.0.

Three overburden/shale and three limestone bedrock monitoring wells will be installed along the TNTB to WWTP1 sewer line. Borings for overburden/shale monitoring wells will be advanced 7 to 8 feet past the depth at which groundwater is encountered or until bedrock is encountered 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 tremied into the borehole 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 tremied to depth above the filter pack followed with a neat cement/bentonite mixture (95 percent Type II or V portland cement and 5 percent bentonite powder mixed with 8.5 gallons clean water) to approximately 3 feet below grade.

Bedrock borings will be drilled into limestone bedrock using a rock core bit cutting a maximum 6-inch-OD borehole and a rock core tube 5 to 10 feet in length. If a 6-inch-OD rock bit is not used during bedrock drilling, after reaching the desired depth for monitoring well installation, the borehole will be reamed with a rotary bit to attain a 6-inch-OD borehole. This will allow a total of 4 inches of filter pack material to surround the 2-inch-diameter screen placed in the borehole for the monitoring well. After the rock core tube is removed, the length of rock recovered will be measured and compared to the run length (length of the bedrock drilled). 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. Any suspected lost core will be documented on the borelog. Fractures (mechanical, natural, or healed) will also be noted on the borelog.

After a lithologic interpretation of the rock core is completed, the bedrock core will be placed into a wooden or cardboard core box and photographed with a digital camera. The rock core will be sprayed with water prior to photographing to help distinguish the features of the rock core (i.e. color, fracturing). The top of the core run should be in the upper left of the photograph and the bottom of the core in the lower right corner of the photograph. A scale (i.e. rock hammer, note book, tape measure) will be included in the photograph to approximate distance.

Construction of the limestone bedrock wells will follow the same requirements as the overburden/shale wells. Requirements are listed in USACE (1998). Typical monitoring well installation and construction diagrams are included in the SWSAP (Shaw, 2008a). 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, Waterra pump, or bailer as soon as practical, but no sooner than 48 hours and no longer than 7 calendar days after the internal mortar collar was placed around the well. Prior to development, the static water level from the top of the casing will be measured 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 1 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 or geotechnical engineer. 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:

- Water is clear to the unaided eye, free of sand, and free of drilling fluids.
- Thickness of the accumulated sediment in the well is less than 1 percent of the length of the well screen.
- Temperature (±3 degrees Celsius [°C]), pH (±0.1 standard units), specific conductance (±3 percent of reading) values stabilize.
- Three consecutive turbidity readings are less than 100 nephelometric turbidity units (NTU).
- 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.

Water will not be added to the well once the well has been grouted and sealed. If heavy or caked sediments must be removed by washing, the water will be from the well itself.

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 obtain USACE approval regarding future development activities. 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 closeup to show the clarity of the water. The development water sample will be archived until the photograph is printed or received. 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, and temperature before, twice during, and after development at a minimum and until these values stabilize
- Field measurement of turbidity (NTU) until three consecutive measurements are less than 100 NTUs
- 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 or capacity of pump 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 or other fluid removed during development, both incremental and total

- Disposal of development water.

3.2.5 Water Level Monitoring

After the TNTB to WWTP1 sewer line piezometers have been installed for a minimum of 24 hours (and prior to groundwater sampling), groundwater levels will be measured and recorded for all 10 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 3.0).

The water elevations of all six monitoring wells will be measured at once, prior to purging the first well (see Section 3.2.7). The water levels of the 10 piezometers will also be taken at this time during the first monitoring well sampling event. This is done to provide more complete groundwater flow information in the vicinity of the TNTB to WWTP1 sewer line. The depth to water will be measured to the nearest 0.01 foot from the northern edge of the riser (inner casing) which was marked during surveying. The piezometers will be abandoned after this measurement, as described in Section 3.2.3. Therefore, the water levels of only the six 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 or peristaltic pump with Teflon-lined tubing

- Flow-through cell
- Oxygen-reduction potential (Eh), dissolved oxygen, pH, temperature, turbidity, and specific conductance water quality measurement meters
- Appropriate sample bottles and temperature-controlled container
- Plastic sheeting
- Five-gallon buckets with lids
- Photoionization detector/lower explosive limit meter
- Mason jar for calculating purge rate
- Well construction diagrams.

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

- Nylon rope
- Teflon, PVC, or 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 3.2.2), 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 3.2.3).

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, the concentration of organic vapors and hydrogen sulfide at the top of casing and in the breathing zone will be measured with a photoionization detector/lower explosive level meter. 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, and the volume of water in the casing and screen and the 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 a submersible pump (e.g., bladder pump, inertial pump) or peristaltic pump with Teflon tubing will be used to conduct the sampling. The pump (or tubing) 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. The purge rate will be set such that drawdown is never greater than 0.5 feet (6 inches), if possible. If drawdown is greater than 0.5 feet, 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 ***<u>above</u> the top of the screened interval*** and drawdown exceeds 0.5 feet even at the lowest setting of the pump, low-flow sampling cannot be conducted. In this situation, at least one volume of the standing water in the casing and annular space will be removed through iterative pumping and recovery cycles. 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; however, attempts will be made to remove more than one volume of water.

- If the pre-pumping (static) water level is ***<u>below</u> the top of the screened interval*** and drawdown exceeds 0.5 feet even at the lowest setting of the pump, low-flow sampling cannot be conducted. In this situation, at least one volume of the standing water in the casing and annular space will be removed through iterative pumping and recovery cycles. 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 parameters will be measured, including pH, Eh, temperature, turbidity, dissolved oxygen, and conductivity. When using low-flow sampling, samples can be collected once these parameters are stable. 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 follows:

  - pH ±0.1 standard units
  - Eh ±10 millivolts
  - Temperature ±1°C
  - Turbidity (three consecutive readings less than 100 NTUs)
  - Dissolved oxygen ±10 percent
  - Conductivity ±3 percent of reading.

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

- The samples will be collected so as to minimize aeration as water enters the bottle. Pumping rates will not exceed 100 mL/min for VOCs. Pumping rates for all other analyses will not exceed 500 mL/min.

- Samples for groundwater analytes will be collected in the following order: 1) VOCs; 2) nitroaromatics; 3) SVOCs; 4) dissolved metals; 5) total metals; 6) turbidity, alkalinity, total dissolved solids, total suspended solids, chloride, and sulfate; 7) nitrate; 8) cyanide; 9) hardness; and 10) ferrous iron.

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

- 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. If a well cannot be sampled without a pump, no metals sample will be collected.

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

In addition to the primary water samples, certain field QC samples will be prepared as described in succeeding paragraphs. The geologist or 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 Land Surveying

Following completion of confirmation soil sampling and piezometer/monitoring well installation, Shaw will secure the services of an Ohio-registered professional land surveyor to determine the coordinates and elevations of confirmation soil borings and monitoring well locations. The horizontal coordinates will be to the closest 0.1 foot and referenced to the Ohio State Plane Coordinate System. 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. If the 1929 Datum is not readily available, the existing local vertical datum will be used. Horizontal coordinates will be referenced to the North American Datum 1983. All survey data will be tabulated. Loop closure for survey accuracy will be within the horizontal and vertical limits given above. Once sample survey information is available, it will be entered on approved Shaw boring logs.

3.4 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 area, all direct-push locations will be hand dug or probed with an air knife to a depth of 5 feet before drilling begins and documented on the boring logs.

3.5 Site Access

All Shaw personnel and subcontractors will meet each morning at the NASA Plum Brook Station to attend the morning tailgate safety meeting, calibrate equipment, gather needed material, and replenish water. Therefore, all Shaw personnel and any subcontracted personnel involved must be U.S. citizens. 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 site will be appropriately trained and instructed by Plum Brook Station concerning site safety issues.

3.6 Abandonment

After the initial sampling of any monitoring well, the well may be abandoned if characteristics are similar to former monitoring well BED-MW27 (off-gassing of hydrogen sulfide) and requested by USACE. 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) technical guidance on sealing abandoned monitoring wells and boreholes; 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 as follows:

- Groundwater will be bailed or pumped from the monitoring well, contained, and disposed of as IDW.

- 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 the isolation casing, well screen, and well casing can not be removed, abandonment in place will be conducted. Steel isolation casing and PVC well material will be cut approximately 3 feet bgs.

- A neat cement grout will be tremied from the bottom of the well screen until undiluted grout flows from the borehole or former well at the ground surface to seal the borehole. The grout will be in the ratio of one 94-pound bag of portland cement to no more than 8.5 gallons of water and 2 to 8 percent bentonite powder.

- After 24 hours, the borehole or former well will be checked for settlement and additional grout will be 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.

4.0 Sample Analysis and Decontamination Procedures

4.1 Sample Number System

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	09	XX	XXXX	XXXX	XXXX	(XXXX)

[a]Sample type:

SS – surface soil sample
SB – subsurface soil sample
GW – groundwater sample
MS – matrix spike
MD – matrix spike duplicate

[b]Site:

WWSL1 – Waste Water Treatment Plant 1 sewer lines (note that the acronym is changed from that which appears in the rest of this SSAP to avoid possible confusion of the samples with those collected for Waste Water Treatment Plant 1, which is being investigated separately.)

[c]Depth: Only required for soil samples.

The complete sample number will be recorded by the Shaw field geologist/geotechnical engineer in the field activity daily log 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 3-1 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 8330. All applicable analyses will meet the recommended method guidance found in *Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition, Update III (EPA, 1996) and its subsequent updates. They will meet the QA/QC requirements outlined in

EM-200-1-6, *Chemical Quality Assurance for Hazardous, Toxic and Radioactive Waste (HTRW) Projects* (USACE, 1997). The analytical laboratory must comply with *Quality Systems Manual for Environmental Laboratories*, Final Version 3 (DOD, 2006). All other requested analyses must conform to their specified method(s).

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 must contact Plum Brook Station for access to a potable water source to use for decontamination. The following summarizes decontamination procedures for equipment before site entry, between borings, and before site departure:

Nonsampling equipment (direct-push rods, augers, drill rods, etc., that does not contact analytical samples):

- 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.):

- 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 isopropanol.
- Rinse with 10 percent nitric acid when sampling for metals (for glass and Teflon sampling equipment).
- 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.

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 pre-cleaned, 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 as soon as possible after collection and will be packed to minimize container breakage by using vermiculite, styrofoam peanuts, or bubble wrap to fill void spaces in the cooler. Coolers will be taped, marked, and sealed. Custody will be maintained, as described in Chapter 6.0 of the SWSAP. Samples will be cooled to a temperature of approximately $4^{\circ}C$ 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 air bill number, will be telephoned or faxed to the laboratory on the day sample shipment is initiated. If this is not possible, the laboratory will be notified the following morning.

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

ATTN: Sue Bell
Accutest Laboratories
4405 Vineland Road
Orlando, Florida 32811
P: 813-741-3338
F: 813-741-9137
C: 813-992-0090
SueB@accutest.com

6.0 Investigation-Derived Waste Management Plan

Anticipated IDW during field activities includes soil (drill cuttings), purge and development water, 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 and Groundwater

Residual subsurface soil 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 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.

6.3 Sampling Equipment and Personal Protective Equipment

Limited quantities of PPE and sampling equipment will be generated during sampling activities, including Tyvek® suits, latex or nitrile gloves, plastic sheeting, and disposable tubing. All sampling equipment and PPE will be double-bagged and disposed of in on-site Shaw dumpsters. If any of the sampling equipment and PPE appears to be grossly contaminated, it will be decontaminated prior to disposal.

6.4 Investigation-Derived Waste Sampling

All soil and water IDW will be sampled at the completion of field work. Table 3-1 summarizes the analytical parameters and methods for the IDW samples. One composite soil sample will be collected after the direct-push drilling activity and one after the monitoring well installation activity. For collection of IDW composite soil samples, two or three grab samples will be collected from each piezometer core and each monitoring well split-spoon while the drilling activity is taking place. These grab samples will be composited into a new, one-gallon zip-lock bag and labeled with the boring identification. One composite IDW sample, at the completion of the drilling activity, will be collected from each of the identified boring zip-lock bags.

For collection IDW composite water samples, a 2-inch bailer will be used to collected multiple samples from 55-gallon drums used to store decontamination, development, purge, and sample water. During piezometer and well installation composite sample collection, water from each bailer will be emptied into a new or decontaminated container and IDW samples will be collected from the container. This procedure will be used for all analytes except when sampling for VOCs. In this case, water will be removed from the drum by the bailer and immediately poured into the VOA vial, from bottom of bailer.

Based upon the volume of soil and water generated during piezometer and monitoring well installation events, the present number of composite samples collected during each activity will provide representative analytical results to safely represent the media being sampled and satisfy the landfills analytical acceptance requirements. If the number of proposed borings and wells increase, the number of composite samples will also be increased to adequately represent the media being sampled.

The composite samples will then be submitted to the identified laboratory for a full toxicity characteristic leaching procedure analysis and nitroaromatics analysis. Seven-day turnaround time will be used, unless otherwise directed by the project manager. Composite samples of decontamination water from the excavation, direct-push sampling, drilling, well development, and groundwater sampling as well as purge water generated from groundwater sampling will be collected and submitted for target compound list (TCL) VOCs, TCL SVOCs, nitroaromatics, target analyte list metals, ignitability, corrosivity, reactive cyanide and sulfide, and pH.

When the analytical results are received, Shaw personnel will evaluate the results and determine off-site disposal methods. Shaw will identify possible disposal facilities; however, USACE is responsible for selecting the facility or facilities to receive the IDW.

7.0 References

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TABLES

Table 2-1

Data Quality Objectives
TNT Area B to Waste Water Treatment Plant No. 1 Sewer Line
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Potential Data Users	Available Data	Conceptual Model	Medium of Concern	Data Uses and Objectives	Data Types To Be Collected	Analytical Level
EPA OEPA DOD USACE NASA Shaw Other Contractors Possible Future Land Users	Previous environmental investigations associated with TNTB and the TNTA-WWTP1 sewer line show varying degrees of contamination in the groundwater and soil. No existing data are present for this sewer line trace.	Contaminant Source Production of TNT, DNT, and pentolite. Past DOD operations. Migration Pathways Leaking of materials in sewerlines to soil and groundwater. Leaching from soil to groundwater. Potential Contaminants of Concern Explosives	Groundwater Soil	Define site physical features and characteristics Determine nature and extent of DOD-related contamination in soil and groundwater along the sewer lines Determine chemical characteristics of contamination Evaluate fate and transport of contamination Determine if overburden groundwater underlying the AOCs is sufficient in 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 Obtain site data of quality, quantity and distribution appropriate for site characterization, risk assessment, and feasibility study.	Groundwater Nitroaromatic explosives Volatiles Semivolatiles Polychlorinated biphenyls Metals Water quality parameters Soil Nitroaromatic explosives Semivolatiles Polychlorinated biphenyls Metals Total organic carbon	Definitive data for all parameters. Screening-level data will be used for nitroaromatics.

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.
Shaw - Shaw Environmental, Inc.
DNT - Dinitrotoluene.
TNT - Trinitrotoluene.

*Analytical samples are described in Table 2-2.

Table 2-2

Groundwater and Soil Analytical Samples
TNT Area B to Waste Water Treatment Plant No. 1 Sewer Line
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Parameters	Field samples	QA/QC Samples	Rinsates	Source Water	Trip Blanks	Matrix Spike/Duplicates
Test Pit Soil Samples						
Parameters	**Field samples**	**QA/QC Samples[c]**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	34	3	3	1	NA	3/3
Direct-Push Soil Samples						
Parameters	**Field samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	26	3	3	1	NA	3/3
TCL SVOCs	20	2	2	1	NA	2/2
PCBs	20	2	2	1	NA	2/2
TAL Metals	20	2	2	1	NA	2/2
Total Organic Carbon	1	NA	NA	NA	NA	NA
Piezometer Samples						
Parameters	**Field samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	10	2	2	NA	NA	2
Monitoring Well Samples[a]						
Parameters	**Field samples**	**QA/QC Samples**	**Rinsates**	**Source Water**	**Trip Blanks**	**Matrix Spike/Duplicates**
Nitroaromatics	12	2	2	2	NA	2
TCL VOCs	12	2	2	2	2	2
TCL SVOCs	12	2	2	2	NA	2
PCBs	12	2	2	2	NA	2
TAL Metals, Total	12	2	2	2	NA	2
TAL Metals, Dissolved	12	NA	NA	NA	NA	NA
Water Quality Parameters[b]	12	NA	NA	NA	NA	NA

TCL - Target compound list; VOC - Volatile organic compound; SVOC - semivolatile organic compound; TAL - target analyte list
PCB - Polychlorinated biphenyl; QA - Quality assurance; QC - Quality control.

[a] Quantities are based on two rounds of sampling.
[b] Groundwater quality parameters are identified on Table 3-1 with a superscript "c" that corresponds to footnote "c."
[c] QA/QC samples are defined as Field Splits and Field Duplicates.

Table 3-1

Analytical Parameters and Methods
TNT Area B to Waste Water Treatment Plant No. 1 Sewer Line
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

Sample Matrix	Analytical Parameters	Analytical Method[b]
Groundwater	TCL VOCs	SW-846 5030B/8260B[a]
	TCL SVOCs	SW-846 3510C/8270C[a]
	Nitroaromatics	SW-846 3535/8330[a]
	PCBs	SW-846 3510C/8082[a]
	Total TAL Metals	SW-846 3005A/6010B/7470A[a]
	Dissolved TAL Metals	SW-846 3005A/6010B/7470A[a]
	Turbidity[c]	MCAWW 180.1[b]
	Alkalinity[c]	MCAWW 310.1[b]
	Hardness[c]	MCAWW 130.2[b]
	Total Dissolved Solids[c]	MCAWW 160.1[b]
	Total Suspended Solids[c]	MCAWW 160.2[b]
	Chloride[c]	MCAWW 325.3[b]
	Cyanide, total[c]	SW-846 9010A/9012[a]
	Nitrate/Nitrite[c]	MCAWW 353.2[b]
	Oxidation-reduction Potential (ORP)[c]	ASTM D1498-08[e]
	Sulfate[c]	MCAWW 375.3[b]
	Ferrous Iron	Hach test kit
Soil	TCL SVOCs	SW-846 3541/8270C[a]
	Nitroaromatics	SW-846 8330[a]
	PCBs	SW-846 3541/8082[a]
	TAL Metals	SW-846 3050B/6010B/7471A[a]
	TOC	Lloyd-Kahn
	Nitroaromatic screening	SW-846-8515
Solid IDW	TCLP VOCs	SW-846 1311/5030B/8260B[a]
	TCLP SVOCs	SW-846 1311/3510C/8270C[a]
	TCLP Metals	SW-846 1311/3010A/6010B/7470A[a]
	Nitroaromatics	SW-846 8330[a]
	Ignitability	SW-846 1010[a]
	Corrosivity	SW-846 1110[a]
	Reactivity	7.3.3.2/7.3.4.2[a]
Liquid IDW	TCL VOCs	SW-846 5030B/8260B[a]
	TCL SVOCs	SW-846 3510C/8270C[a]
	Total TAL Metals	SW-846 3005A/6010B/7470A[a]
	Nitroaromatics	SW-846 8330[a]
	Ignitability	SW-846 1010[a]
	Corrosivity	SW-846 1110[a]
	Reactivity	7.3.3.2/7.3.4.2[a]

TCL - Target compound list; VOC - Volatile organic compound; SVOC - Semivolatile organic compound; TAL - Target analyte list
PCB - Polychlorinated biphenyl; TCLP - Toxicity characteristic leaching procedure; IDW - Investigation-derived waste.

[a]Analyses found in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods,* EPA Publication, Third Edition.
[b]Analyses found in *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79-020, March 1983 and subsequent revisions.
[c] Water quality parameter.
[d] American Society for Testing and Materials.

Table 5-1

Analytical Methods, Preservatives, and Holding Times
TNT B to WWTP No. 1 Sewer Line
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

(Page 1 of 2)

Matrix	Parameter	Analytical Method	Sample Container*	Preservation Requirements	Holding Time
Groundwater	TCL VOCs	SW-846 5030B/8260B	(3) 40 ml VOA vial	Cool to 4°C, HCL to pH <2	14 days
	TCL SVOCs	SW-846 3510C/8270C	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	Nitroaromatics	SW-846 3535/8330	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	PCBs	SW-846 3510C/8082	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	Total TAL Metals	SW-846 3005A/6010B/7470A	(1) 500 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months (28 days for Hg)
	Dissolved TAL Metals	SW-846 3005A/6010B/7470A	(1) 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 HDPE	Cool to 4°C	48 hours
	TDS/TSS	MCAWW 160.1/160.2			7 days
	Alkalinity	MCAWW 310.1			14 days
	Sulfate	MCAWW 375.3			28 days
	Chloride	MCAWW 325.3			28 days
	Nitrate/Nitrite	MCAWW 353.2	(1) 500 mL HDPE	Cool to 4°C, H_2SO_4 to pH>2	28 days
	Total Cyanide	SW-846 9010A/9012	(1) 500 mL HDPE	Cool to 4°C, NaOH to pH >2	14 days
	Hardness	MCAWW 310.1	(1) 500 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months
	ORP	ASTM D1498-08	NA	NA	Performed in field
	Ferrous Iron	Hach test kit	NA	NA	Performed in field
Soil	TCL SVOCs	SW-846 3541/8270C	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	14 days extraction/40 days
	Nitroaromatics	SW-846 8330			14 days extraction/40 days
	PCBs	SW-846 3541/8082			14 days extraction/40 days
	TAL Metals	SW-846 3050B/6010B/7471A			6 months (28 days for Hg)
	TOC	Lloyd-Kahn			28 days
	Nitroaromatics (screening)	SW-846 8518	(1) poly bag	Cool to 4°C	ASAP

Table 5-1

Analytical Methods, Preservatives, and Holding Times
TNT B to WWTP No. 1 Sewer Line
Remedial Investigation
Former Plum Brook Ordnance Works, Sandusky, Ohio

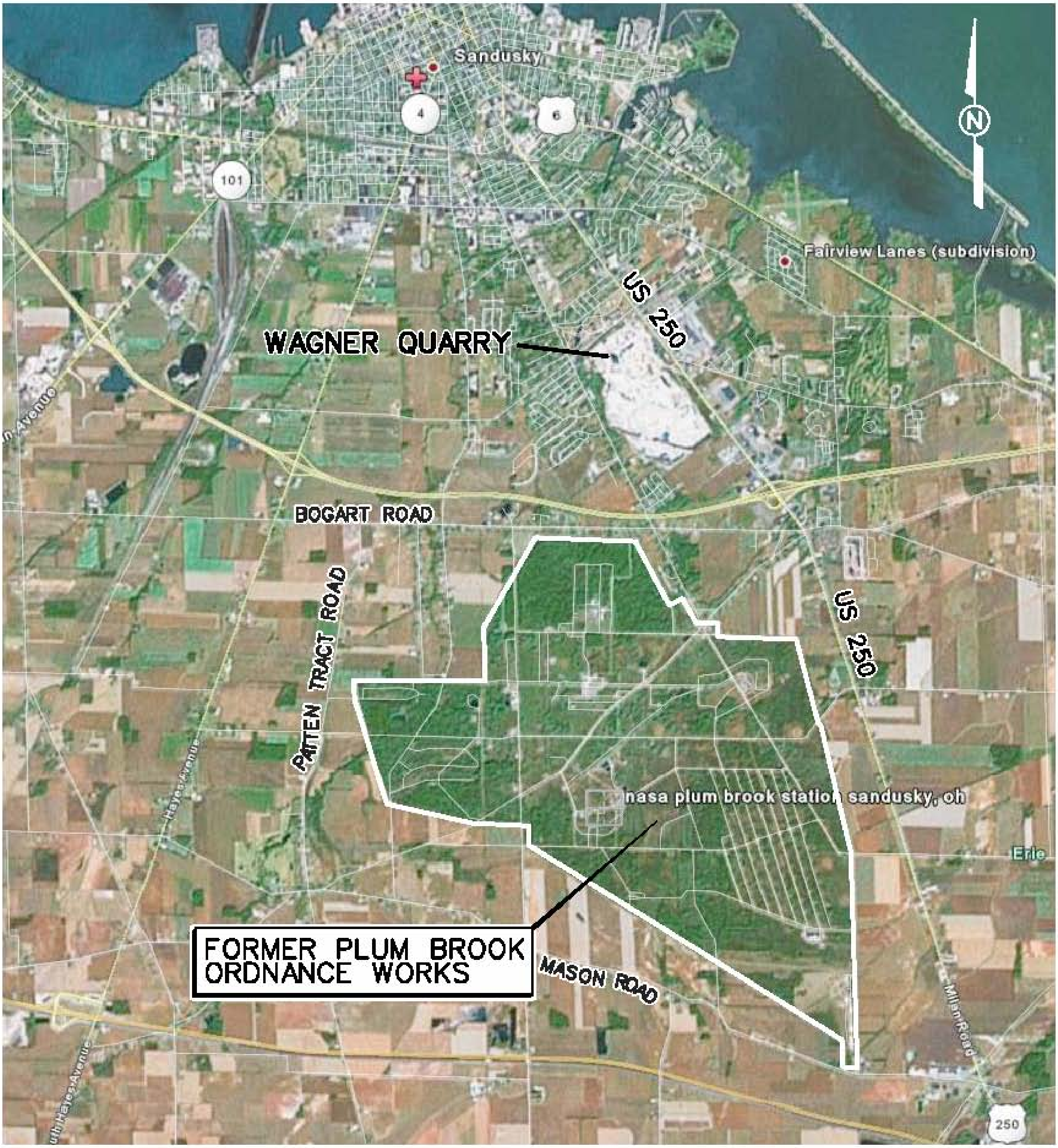
Matrix	Parameter	Analytical Method	Sample Container*	Preservation Requirements	Holding Time
Liquid IDW	TCL VOCs	SW-846 5030B/8260B	(3) 40 ml VOA vial	Cool to 4°C, HCL to pH <2	14 days
	TCL SVOCs	SW-846 3510C/8270C	(2) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	Nitroaromatics	SW-846 3535/8330	(1) 1 L amber glass	Cool to 4°C	7 days extraction/40 days
	TAL Metals	SW-846 3005A/6010B/7470A	(1) 500 mL HDPE	Cool to 4°C, HNO_3 to pH <2	6 months (28 days for Hg)
	Ignitability	SW-846 1010	(1) 1 L Amber	Cool to 4°C	ASAP
	pH	SW-846 9045B			
	Corrosivity	SW-846 1110			
	Reactive Cyanide	7.3.3/7.3.4			
	Reactive Sulfide	7.3.3/7.3.4			
Soil IDW	TCLP VOCs	SW-846 1311/5030B/8260B	(1) 8 oz CWM glass with Teflon-lined lid	Cool to 4°C	7 days TCLP extraction/14 days extraction
	TCLP SVOCs	SW-846 1311/3510C/8270C			7 days TCLP extraction/14 days extraction/40 days
	TCLP Metals	SW-846 1311/3010A/6010B/7470A			7 days TCLP extraction/14 days /ext./6 months (28 days for Hg)
	Nitroaromatics	SW-846 8330			14 days extraction/40 days
	Ignitability	SW-846 1010			ASAP
	Corrosivity	SW-846 1110			ASAP
	Reactive Cyanide	7.3.3/7.3.4			ASAP
	Reactive Sulfide	7.3.3/7.3.4			ASAP

°C - Degrees Celsius.
CWM - Clear wide mouth.
H_2SO_4 - Sulfuric acid.
HCl - 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 - Investigative-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



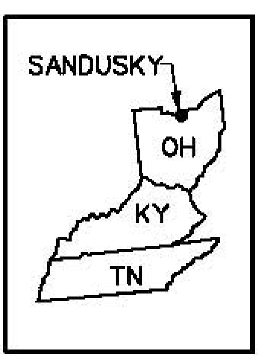


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FIGURE 1-1
PBOW VICINITY MAP

TNTB TO WWTP1 SEWER LINE SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental & Infrastructure, Inc.

STARTING DATE: 05/18/09 | DATE LAST REV.: | DRAFT. CHCK. BY: C. BENTLEY | INITIATOR: C. ANGLIN | 132457_ssap_001.dgn

DRAWN BY: C. BENTLEY | DRAWN BY: | ENGR. CHCK. BY: | PROJ. MGR.: S. DOWNEY | PROJ. NO.: 132457

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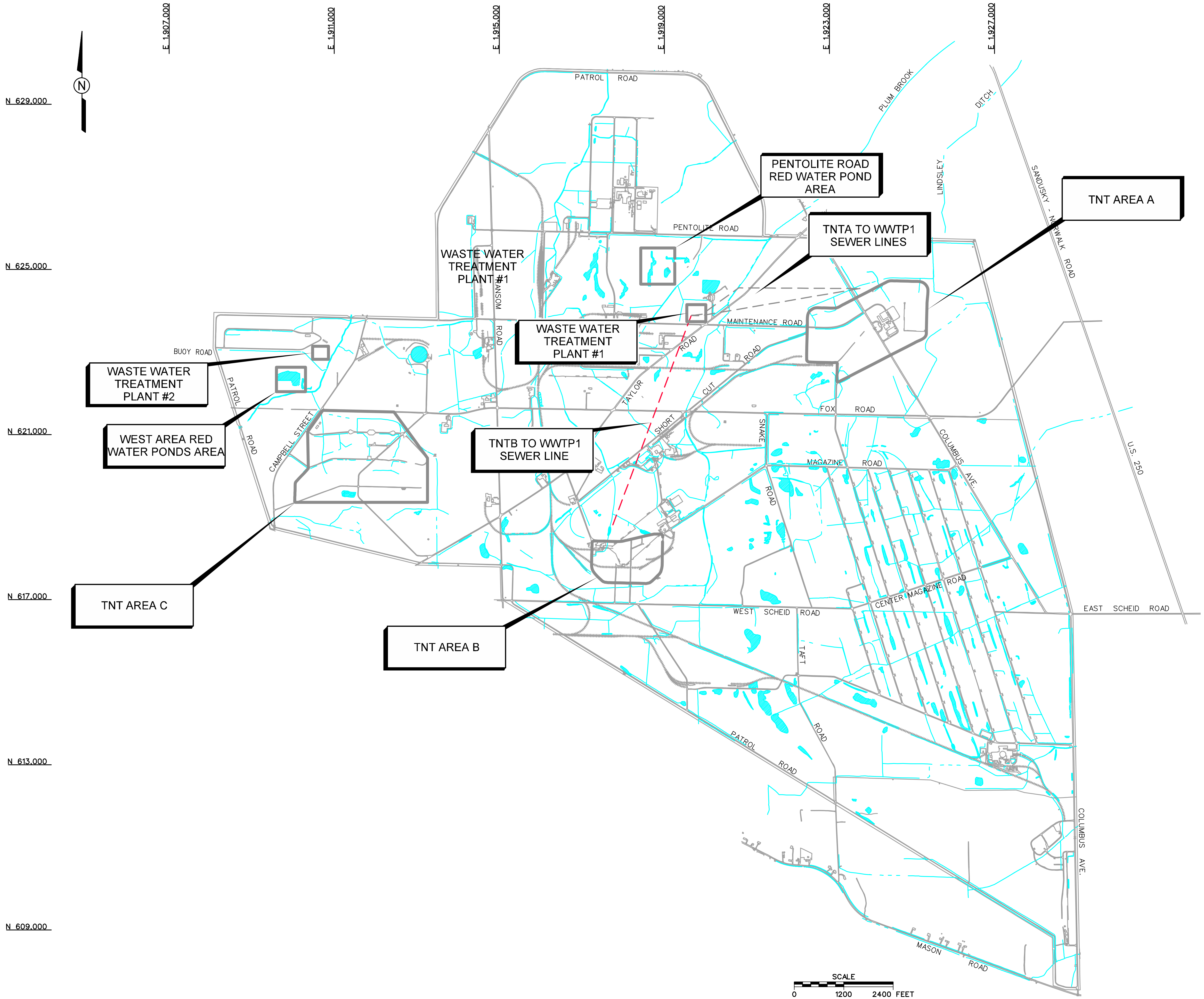

LEGEND

AREA OF CONCERN

BUILDINGS

RAILROAD

SURFACE WATER

DITCH

FENCE (PBOW BOUNDARY)

FIGURE 1-2
LOCATION MAP

TNTB TO WWTP1 SEWER LINE SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw® Shaw Environmental & Infrastructure, Inc.

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INITIATOR: C. ANGLIN
PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY: C. BENTLEY
ENGR. CHCK. BY:
DATE LAST REV.:
DRAWN BY:
STARTING DATE: 06/03/09
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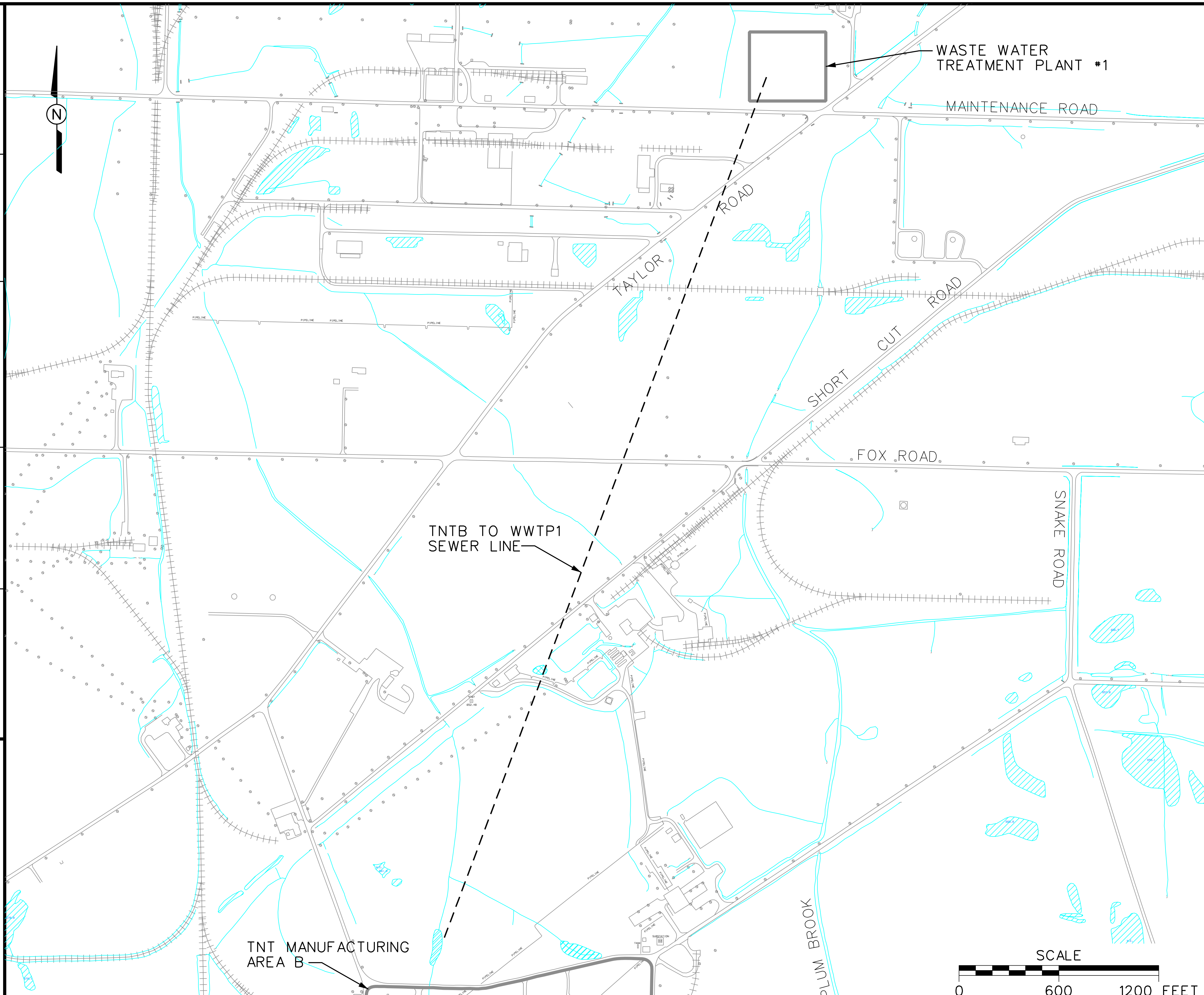

LEGEND:

— — — — APPROXIMATE LOCATION OF SEWER LINE (BASED ON HISTORIC DOCUMENTATION)

FIGURE 1-3
APPROXIMATE LOCATION OF TNTB TO WWTP1 SEWER LINE

TNTB TO WWTP1 SEWER LINE SSAP
FORMER PLUM BROOK ORDNANCE WORKS
NASA PLUM BROOK STATION
SANDUSKY, OHIO

Shaw Environmental & Infrastructure, Inc.

132457_ssap_003.dgn
PROJ. NO.: 132457
INITIATOR: C. ANGLIN
PROJ. MGR.: S. DOWNEY
DRAFT. CHCK. BY: C. BENTLEY
ENGR. CHCK. BY:
DATE LAST REV.:
DRAWN BY:
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