From: Barraza, Alicia A (DEC)
To: Marcy, Eric C CIV USARMY USAMC (USA); Komoroske, Michael (DEC)
Cc: Vitolins, Andy; Bagnato, Stefan; "Steve Wood"; Baker, Douglas F CIV USARMY TACOM (US)
Subject: RE: Revised Work Plan - Watervliet Arsenal Hexavalent Chrome Release Investigation
Date: Wednesday, July 10, 2019 8:51:30 AM
Attachments: image001.png
image002.png

Eric-
This revised work plan satisfactorily addresses DEC's comments and is hereby approved. Please give DEC seven days' notice prior to the start of any work plan activities. If you have any comments, please contact me. Thanks.

Alicia Barraza
Project Manager, Environmental Remediation
New York State Department of Environmental Conservation
625 Broadway, 12th Floor, Albany, NY 12233-7016
P: (518) 402-9690 | alicia.barraza@dec.ny.gov
www.dec.ny.gov | f | t

-----Original Message-----
From: Marcy, Eric C CIV USARMY USAMC (USA) <eric.c.marcy.civ@mail.mil>
Sent: Wednesday, July 10, 2019 7:43 AM
To: Barraza, Alicia A (DEC) <alicia.barraza@dec.ny.gov>; Komoroske, Michael (DEC) <michael.komoroske@dec.ny.gov>
Cc: Vitolins, Andy <Andy.Vitolins@arcadis.com>; Bagnato, Stefan <Stefan.Bagnato@arcadis.com>; 'Steve Wood' <Stephen.C.Wood@usace.army.mil>; Baker, Douglas F CIV USARMY TACOM (US) <douglas.f.baker3.civ@mail.mil>
Subject: Revised Work Plan - Watervliet Arsenal Hexavalent Chrome Release Investigation

Good Morning Alicia,

We revised the Remedial Investigation Work Plan to incorporate the comments and requests you provided during our meeting and site walk on 26 June 2019. The Revised Work Plan is attached.

Please let me know if you have any questions.

V/R,

Eric Marcy
Environmental Protection Specialist
TAWV-IMP-E
Watervliet Arsenal

518-266-4268
eric.c.marcy.civ@mail.mil

ARCADIS Design & Consultancy for natural and built assets

US Army Corps of Engineers

PLATING AREA SITE INVESTIGATION WORK PLAN

Watervliet Arsenal
Watervliet, New York

Contract: W912DR-18-D-0004
WO: W912DR-17-F-0736
NYSDEC Spill #: 1804728

July 2019

PLATING AREA SITE INVESTIGATION WORK PLAN

Watervliet Arsenal
Watervliet, NY

Prepared for:

United States Army Corps of Engineers
Baltimore District
2 Hopkins Plaza
Room 09-F-05
Baltimore, MD 21201

Prepared by:

Arcadis U.S., Inc.
855 Route 146
Suite 210
Clifton Park
New York 12065
Tel 518 250 7300
Fax 518 250 7301

Our Ref.:

02118227.0000

Date:

8 July 2019

Andrew R. Vitolins, PG
Vice President

Stefan Bagnato, PG
Senior Geologist

VERSION CONTROL

Revision No	Date Issued	Description
0	17 June 2019	Work Plan
1	8 July 2019	Revised Work Plan

CONTENTS

FIGURES

TABLES

APPENDICES

ACRONYMS AND ABBREVIATIONS

AMSL	Above Mean Sea Level
APP	Accident Prevention Plan
CAMP	Community Air Monitoring Plan
DER	Division of Environmental Remediation
DMP	Data Management Plan
DUSR	Data Usability Summary Report
ELAP	Environmental Laboratory Approval
FFS	Focused Feasibility Study
ID	Inner Diameter
IRP	Installation Restoration Program
LNAPL	Light Non-Aqueous Phase Liquid
MMA	Main Manufacturing Area
NMT	New Medium Tube
NYCRR	New York Codes, Rules, and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OD	Outer Diameter
PID	Photoionization Detector
PVC	Polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
REARM	Renovation of Armament Manufacturing
RFI	RCRA Facility Investigation
QAPP	Quality Assurance Project Plan
SA	Siberia Area
SCO	Soil Cleanup Objective
SOP	Standard Operating Procedure
SSHP	Site Safety and Health Plan
TAL	Target Analyte List

UFP	Uniform Federal Policy
UN	United Nations
USACE	US Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WVA	Watervliet Arsenal

1 INTRODUCTION

The Watervliet Arsenal (WVA) in Watervliet, New York recently discovered a subsurface release of chromic acid plating solution in the area next to the 120-mm Gun Pit plating pit in Building 35. The release was associated with ventilation duct work that runs underground from the plating area to the air scrubber system. The WVA has conducted initial source removal activities required to conduct the necessary repairs to their plating systems. These activities have included soil excavation and focused groundwater dewatering. Observations of groundwater and initial sampling activities have confirmed that groundwater is impacted with hexavalent chromium in the area of the release.

Arcadis US, Inc. (Arcadis) has been retained by the Baltimore District of the US Army Corps of Engineers (USACE) to evaluate potential groundwater impacts from a chromic acid release at the WVA. This Work Plan was prepared to document the understanding of site conditions to-date and the activities and procedures by which the investigation scope of work, as described in the USACE Baltimore District contract No. W912DR-18-D-0004, Delivery Order No. W912DR-18-F-0736, will be conducted.

These tasks are detailed in the scope of work included in the 17 May 2019 contract modification from the USACE Baltimore District. Work will be conducted pursuant to the approval of, and coordination with, the New York State Department of Environmental Conservation (NYSDEC) and New York State Department of Health (NYSDOH), where applicable.

This Work Plan was prepared in accordance with the provisions of Chapter 4 of the NYSDEC DER-10 Technical Guidance for Site Investigation and Remediation (DER-10) guidance document. This Work Plan is supported by and used in conjunction with the Uniform Federal Policy (UFP) Quality Assurance Project Plan (QAPP), Data Management Plan (DMP), and Accident Prevention Plan (APP) submitted as Appendix A, Appendix B, and Appendix C to the Installation Restoration Program (IRP) Work Plan (PIKA-MP, JV, 2016) at WVA. The QAPP contains field and laboratory standard operating procedures (SOPs) that will be followed during execution of the Plating Area Site Investigation. Field and laboratory SOPs that are specific to the Plating Area Site Investigation and are not included in the IRP Work Plan are provided in Appendix A of this document. This Work Plan is further supported by a Site Safety and Health Plan (SSHP) specific to the scope of the Plating Area Site Investigation, which will be submitted as an APP addendum under separate cover.

2 SITE BACKGROUND

2.1 Facility Description

The WVA encompasses approximately 140 acres in and around the City of Watervliet, New York, approximately 3.5 miles northeast of the City of Albany (Figures 1-1 and 1-2). To the east of the WVA, Broadway Street and a six-lane interstate highway (I-787) separate the WVA from the Hudson River. To the west, the WVA extends beyond the limits of the City of Watervliet into the Town of Colonie. Residential areas border the WVA to the north and south.

The WVA consists of two primary areas: (1) The "Main Manufacturing Area" (MMA), where manufacturing and administrative operations occur, comprises about 125 acres, and, (2) The "Siberia Area" (SA), which is chiefly used for the storage of raw and hazardous materials, comprises about 15 acres. These areas are shown on Figure 1-2.

Building 35, also known as the Heat Treat and Metal Processing Building, and was originally constructed in 1918, with several updates thereafter. Building 35 is located along the southern property boundary of the Main Manufacturing Area at WVA (Figure 1-2). It is bounded to the east by Buildings 20 and 25, to the south by residential property, to the west by Building 110, and to the north by the WVA fire house (Buildings 21 and 22).

As described in the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) (Malcolm Pirnie, 2000), Building 35 is a single-story structure approximately 850 feet long and 600 feet wide at its widest point. A 1983 floor plan shows the building divided, east to west, into 17 bays, labeled A through S, excluding I and O. Bays C through J comprise the original extent of Building 35 and Bays H and J represent a 1942 extension. During the mid to late 1970s, Building 35 was expanded further as part of the Renovation of Armament Manufacturing (REARM) program and buildings to the east, north and west were razed to accommodate this expansion. Bays A and B and Bays K through S are extensions to the west and east, respectively, built during this period. The shop floor level is at an elevation of approximately 55 feet above mean sea level (AMSL). The east side of the building has a basement level.

There were two process pits at the south end of the building at the time of construction, formerly referred to as the West and East Pits. Extensions were added to the west, east, and north and two additional process pits were installed in 1978. A number of reconstructions/conversions have been made to the process pits since their installation.

Following is a chronology of events relating to the process pits based on available WVA drawings and information provided by WVA personnel:

- 1918 - Two pits installed during construction of Building 35.
- 1952 - West Pit converted to chrome plating of 155 mm guns.
- 1976 - East Pit converted to chrome plating of 8-inch guns.

- 1978 - New Medium Tube (NMT) Pit installed, as an extension to the 8-inch Gun Pit. This pit was used for chrome plating.
- 1979/1980 - 120mm Gun Pit constructed, but left idle.
- 1986/1987 - Chrome plating equipment installed in 120mm Gun Pit.
- 1990 - West pit converted to a furnace pit.

There are currently four process pits located at the south end of Building 35. From west to east these pits are called the 120-mm Gun Pit (a.k.a. West Pit), the Furnace Pit, the 8-inch Gun Pit (a.k.a East Pit and now the Commercial Pit), and the NMT Pit. Note that the 8-inch Gun Pit (Commercial Pit) and the NMT Pit are contiguous. The 120 pit and the Commercial pit are currently capable of conducting chromium plating operations. The NMT pit has been inoperable since the 1990s. Process pits are shown on Figure 2-1.

The Furnace Pit is 45 feet long, 20 feet wide and 30 feet deep with a 3 feet cubed sump located at the southwest corner. During conversion of this pit from chrome plating to heat treating operations in 1987, the acid resistant brick, waterproof membrane, and part of the concrete floor slab, were removed. At that time, oil was observed to be seeping through cracks in the concrete walls. A groundwater/oil collection channel is located around the walls of the pit, approximately 3 feet above the concrete floor slab, and directs groundwater/oil seepage towards the sump.

The New Medium Tube/8-inch Gun Pit is 60 feet long, 60 feet wide and approximately 40 feet deep. A small sump is located in the southwest corner which collects condensate blowdown and some groundwater seepage. The pits at Building 35 were constructed partially in overburden material and partially in bedrock. This is confirmed by a soil boring installed adjacent to the New Medium Tube Pit (East Pit) in 1978 by the ACOE. Drilling logs for this boring shows the top of bedrock at 19.5 feet below shop floor level. Drawings for the 120mm Gun Pit were not available for review at the time of this Work Plan.

Current manufacturing operations at Building 35 include cannon tube chrome plating and heat treatment in the three process pits located at the southern end of the building. Cadmium-cyanide plating, previously conducted at Building 110, was relocated to Building 35 in 1985 and discontinued in 1994. In general, however, the manufacturing processes and equipment in Building 35 is believed to have changed very little since its construction. The remainder of the main floor is occupied by machining equipment used for finishing the cannon tubes and for conducting magnaflux testing operations.

2.2 Geology/Hydrogeology

The major overburden unit identified in the MMA is fill, consisting of brown or dark gray silty sand with angular gravel. The fill material is the only unit consistently found throughout the site, with the thickest amount of fill being in the eastern portion of the MMA. Underlying the fill are the following native overburden units: a fine-grained alluvium, a coarser alluvium, and glacial till. These units are not present in all areas of the site.

The bedrock underlying the site is a black, medium-hard laminated shale, showing some characteristics of minor metamorphism. This shale is part of the Snake Hill Formation. The bedrock can be described in three ways based on the degree of weathering observed. The first is an extremely weathered zone approximately four feet thick. This extremely weathered bedrock unit was encountered at depths ranging from near ground surface to approximately 20 feet below ground surface (bgs). Beneath this extremely weathered bedrock is a zone of less weathered shale showing minimal competency. Competent bedrock is generally encountered at depths ranging from approximately 1.5 feet bgs to 18 feet bgs.

The majority of the MMA is relatively impervious to rainfall except at the residential and recreational areas of the northeastern portion of the WVA. Due to the shallow depth of bedrock and the limited amount of overburden in several areas of the WVA, groundwater is encountered within different geologic units (overburden, weathered bedrock, or bedrock) depending on the location. For instance, groundwater is encountered in the bedrock at the western end of WVA (topographic high and local recharge area); progressing eastward toward the Hudson River, groundwater is encountered in the weathered bedrock and then in the overburden deposits.

Groundwater flow in bedrock in the MMA is primarily controlled by the degree of fracturing within the bedrock itself and in the local recharge area, which is coincident with a topographic high along a bedrock ridge in the central portion of the facility. The most prominent feature on the potentiometric surface is a groundwater divide trending approximately north to south through Buildings 135 and 125. This feature appears to mirror the bedrock ridge. The primary discharge area for groundwater from the Main Manufacturing Area is the Hudson River, which is located to the east of WVA. For the area surrounding Building 25, groundwater in each of the hydrostratigraphic units flows from west to east towards the Hudson River, with a component of flow to the northeast. In the Building 40 area, groundwater in the bedrock unit flows to the east-southeast. West of the groundwater divide, shallow groundwater flow discharges toward the Kromma Kill.

2.3 Previous Investigation and Remedial Action

In August 2018, initial groundwater samples were collected from the four existing site monitoring wells closest to the release and from sumps in the 120 Pit and Commercial Pit (see Figure 2-1). None of the groundwater samples from existing monitoring wells or the 120 Pit contained hexavalent chromium at concentrations greater than the corresponding NYSDEC Class GA Groundwater Standard of 0.05 milligrams per liter (mg/L). The groundwater sample from the Commercial Pit contained hexavalent chromium at a concentration of 680 mg/L. Groundwater sample results are summarized on Table 2-1. Analytical laboratory reporting forms are provided in Appendix B.

In conjunction with the necessary repairs to their plating systems, the WVA excavated hexavalent chromium-impacted soil from the vicinity of the underground ventilation duct work in August 2018. The excavation area was dewatered by pumping out of the existing process pit sumps, with extracted water contained for shipment and disposal off-site. As shown on Figure 2-1, the excavation encompassed an area beneath Building 35 and the adjacent exterior soil around the ventilation duct work. Representative photographs of excavation activities are provided in Appendix C. The excavation extended horizontally and vertically as far as was physically possible given constraints of building/duct work construction and bedrock. The northern sidewall was constrained by the wall of 120 mm Pit, while the eastern sidewall was constrained by the wall of the adjacent utility pit. The western and southern sidewalls were constrained by the ventilation duct work/scrubber infrastructure. The excavation extended vertically to the top of bedrock at approximately 13 feet below the Building 35 main floor level. Following excavation of impacted soil, sidewall and bottom soil samples were collected at the locations shown on Figure 2-1. The eastern interior sidewall sample, collected approximately one foot above the bedrock surface but below the bottom of the utility pit sidewall, contained hexavalent chromium at a concentration greater than the 6 New York Codes, Rules, and Regulations (NYCRR) Part 375 Industrial Soil Cleanup Objective (SCO). The southern exterior sidewall and exterior bottom samples contained hexavalent chromium at concentrations greater than the 6 NYCRR Part 375 Protection of Groundwater SCO. Soil sample results are summarized on Table 2-2. Analytical laboratory reporting forms are provided in Appendix B. Prior to backfill of the excavation, an interstitial monitoring/recovery well/sump was installed in the northwest corner of the excavation area utilizing slotted 8-inch steel pipe to allow for post-excavation monitoring of groundwater conditions and possible future use for groundwater extraction and/or in-situ treatment. Two post-excavation groundwater samples were collected from this excavation area sump, which contained hexavalent chromium at concentrations of 2.7 and 1.6 mg/L, both greater than the corresponding NYSDEC Class GA Groundwater Standard. Additionally, a post-excavation groundwater sample was collected from the Commercial Pit after the sump was purged for one week. This sample contained hexavalent chromium at a concentration of 11 mg/L, which while greater than the corresponding NYSDEC Class GA Groundwater Standard, was an order of magnitude lower than the pre-excavation sample from this sump. Post-excavation groundwater sample results are summarized in Table 2-1. The excavation was backfilled with clean off-site fill material, compacted, and surface restoration completed to match pre-excavation conditions.

3 SITE INVESTIGATION

The scope of work for the site investigation is designed to further characterize the magnitude and extent of groundwater impacts associated with the chromic acid release at Building 35. The base scope of work includes geophysical survey/utility locating, installation of overburden and bedrock monitoring wells, the sampling of existing and new monitoring wells and sumps, and performance of a short-term pumping test. Surface soil sampling of the area surrounding the spill is also included to evaluate any potential direct contact exposure pathways.

An analytical laboratory approved by the New York State Department of Health (NYSDOH) under the Environmental Laboratory Approval Program (ELAP) will analyze all samples collected during the investigation. A Data Usability Summary Report (DUSR) will be prepared upon the receipt of all analytical data to ensure that the quality of the data is sufficient to evaluate remedial alternatives. Sample collection, handling activities, and QA/QC sampling will be conducted in accordance with the approved QAPP and supplemental information in Appendix A.

3.1 Geophysical Survey/Utility Clearance

A geophysical survey will be conducted at the site using electromagnetic resistivity (ERM) and ground penetrating radar (GPR) methods to locate subsurface anomalies and utilities in the proposed drilling areas. Tracing of sewer line connections from buildings on the north side of Parker Road to the sewer mainline will also be conducted if access is granted and sewer cleanouts are accessible. The locations of the identified utilities will be marked in the field and on the site base map.

Additionally, review of available WVA utility maps and submittal of a WVA Dig Permit with associated mark outs will be conducted prior to the work to evaluate potential underground utilities in the vicinity of proposed ground intrusive activities.

3.2 Surface Soil Sampling

Up to nine surface soil samples will be collected within the area shown on Figure 3-1 to evaluate potential surface exposure risk at unpaved areas within and immediately down-gradient of the release. Surface soil samples will be collected using a decontaminated trowel and/or hand auger.

Surface soil samples will be collected from the zero to two-inch interval below the vegetative cover at each of the locations. Samples will be submitted for analysis of Target Analyte List (TAL) Metals by USEPA Methods 6010 and 7471 and hexavalent chromium by USEPA Method 7196.

Following review of surface soil sampling results, the need for subsequent subsurface soil sampling at these locations will be evaluated in consultation with the NYSDEC.

3.3 Groundwater Monitoring Well Installation

Three overburden groundwater monitoring wells will be installed at the locations shown on Figure 3-1 to further evaluate whether the chromic acid release has impacted groundwater quality beyond the release area. These are the closest accessible down-gradient sampling locations that also provide sufficient spatial separation to evaluate groundwater flow. The monitoring wells will be installed using hollow-stem auger drilling methods and will be completed with flush-mount protective covers. Continuous split spoon samples will be collected during monitoring well installation to classify overburden materials. One soil sample from directly above bedrock will be collected from each well location and submitted for analysis of hexavalent chromium by USEPA Method 7196. Each well will be constructed of 2-inch inner diameter (I.D.) polyvinyl chloride (PVC) casing and screen. The final depth of each well will be the top of bedrock (based of refusal), which is estimated to be approximately 15 bgs.

Two bedrock groundwater monitoring wells will be installed at the locations shown on Figure 3-1 to evaluate whether the chromic acid release has impacted bedrock groundwater quality down-gradient of the release area. These are the closest accessible down-gradient sampling locations that best augment existing bedrock well WVA-AW-35-MW-5 and provide sufficient spatial separation to evaluate groundwater flow. The monitoring wells will be installed using hollow-stem auger and mud, water, or air rotary drilling methods and will be completed with flush-mount protective covers. Continuous split spoon samples will be collected during installation of the proposed monitoring well on the south side of Parker Road to classify overburden materials. One soil sample from directly above bedrock will be collected and submitted for analysis of hexavalent chromium by USEPA Method 7196. Each well will be constructed of 4-inch I.D. steel or PVC casing from ground surface to approximately five feet into competent bedrock (approximately 25 feet bgs) using 6 ¼ inch hollow-stem auger to the top of bedrock and a 5- 7/8 inch outer diameter (O.D.) roller bit with mud, water, or air rotary drilling techniques for the five foot rock socket. The wells will be completed to the final depth of approximately 50 feet bgs using HQ wire-line rock coring techniques or NQ coring followed by 3- 7/8 inch O.D. roller bit to ream out the hole.

Upon completion, monitoring wells will be developed to minimize turbidity in groundwater samples collected from each well and to improve their hydraulic properties.

Monitoring for volatile vapors and airborne dust will be conducted using a respirable airborne dust monitor (MIE Miniram or equivalent) and a photoionization detector (PID), respectively, during drilling activities. Monitored levels in excess of the action level established by the Safety Officer shall require mitigative action to lower dust levels. Dust control methods will include the periodic application of potable water. Details of the Community Air Monitoring Plan (CAMP) are provided in Appendix D.

3.4 Groundwater Sampling

Upon the completion of well installation and development, groundwater samples will be collected during two sampling events from the following locations:

- Three new overburden monitoring wells;
- Two new bedrock monitoring wells;
- Existing monitoring wells WVA-AW-MW-38, WVA-AW-35-MW-5, 93EM=SP-9, and 93EM-SP-11;
- Existing excavation area interstitial well/sump; and
- Existing process pit sumps (120 Pit, Commercial Pit, and NMT pit).

Prior to groundwater purging and sampling the depth to water and light non-aqueous phase liquid (LNAPL), if present, in each monitoring well will be measured using an oil/water interface probe and recorded. Groundwater sampling will be conducted in accordance with the United States Environmental Protection Agency (USEPA) Low-Flow/Low-Purge Sampling Protocol (USEPA, 1998). To the extent practicable, groundwater purging rates will be low enough to prevent significant drawdown of the groundwater level in the monitoring well. Water levels will be monitored during sampling to ensure that excessive draw down is not occurring.

Samples will be analyzed for TAL Metals by USEPA Methods 6010 and 7470 and hexavalent chromium by USEPA Method 200.7.

3.5 Pumping Test

If warranted based on evaluation of the groundwater sampling results, a short term pumping test may be conducted from the excavation area interstitial well/sump. The results of the pumping test will be used to evaluate the efficacy of groundwater extraction and/or in-situ groundwater treatment as potential remedial alternatives should site remediation be necessary.

3.6 Investigation-Derived Waste

Investigation derived wastes will be contained in U.N.-approved 55-gallon drums and staged onsite pending receipt of analytical results and disposal in accordance with federal, state, and local regulations.

3.7 Survey

Upon completion of the field investigation activities, the location and elevation of each new groundwater monitoring well installed during the investigation field activities will be surveyed to the nearest 0.01-foot vertically and 0.1-foot horizontally and will be added to an AutoCAD base map for the site. The locations of the subsurface soil samples will also be surveyed to the nearest 0.1-foot horizontally and added to the AutoCAD base map.

4 REPORTING

The results of the investigation activities will be provided to the NYSDEC in a Site Investigation report prepared based upon “DER-10 Technical Guidance for Site Investigation” (DER-10) (NYSDEC, 2010) and submitted to the NYSDEC for review and comment. The report will include the following:

- Discussion of field investigation activities.
- Discussion of the physical characteristics of the site, including groundwater flow patterns.
- Presentation of analytical results for all media sampled.
- Quality assurance/quality control evaluation of the analytical data including the results of the data quality review.
- Discussion of the nature and extent of contaminants.
- Comparison of analytical results to background concentrations and applicable regulatory standards and objectives.
- Supporting data, including analytical data packages, field log forms, and monitoring well construction diagrams.

Following review and discussion of the results and investigation report by the Arcadis, WVA, and USACE project team, and if warranted based upon the results of the investigation, a Focused Feasibility Study (FFS) Report will be prepared to evaluate potential remedial alternatives for the impacted area. The report will be prepared in accordance with DER-10 and submitted to the USACE, WVA, and the NYSDEC for review and comment. The report will summarize the results of the site investigation, identify the Remedial Action Objectives (RAOs) for the site, list and screen potential remedial technologies, and compare various remedial alternatives in accordance with the criteria listed in DER-10. A preferred remedy that is protective of public health and the environment while achieving the RAOs will be selected in consultation with the USACE, WVA, and NYSDEC.

5 SCHEDULE

The estimated schedule is presented on Figure 5-1. This schedule is subject to change based on driller availability.

6 REFERENCES

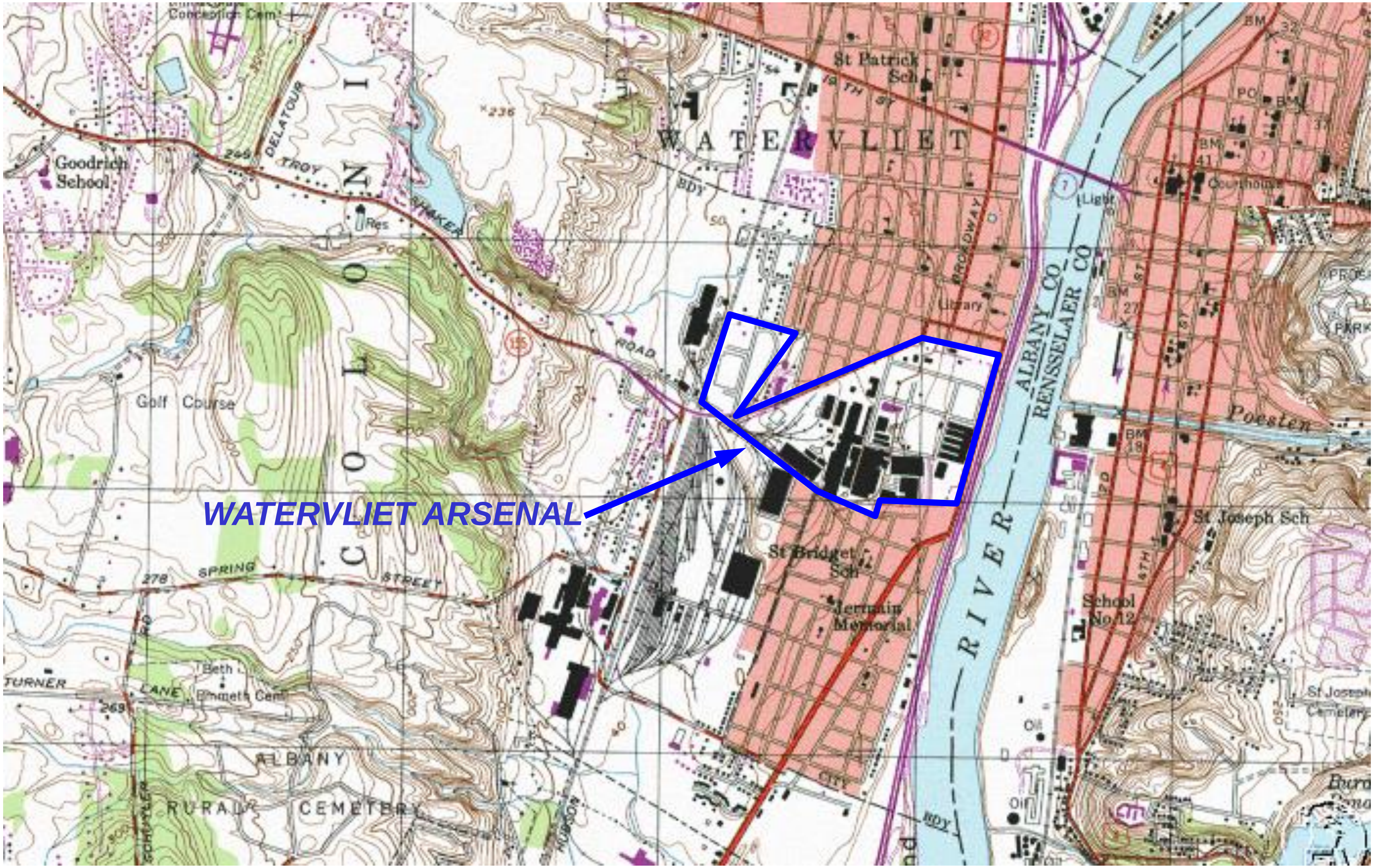
Malcolm Pirnie, 2000, Final RCRA Facility Investigation Report, Main Manufacturing Area, Watervliet Arsenal, Watervliet, New York.

New York State Department of Environmental Conservation, 2010, DER-10 Technical Guidance for Site Investigation and Remediation.

PIKA-MP JV, 2016, Installation Restoration Program Work Plan, Watervliet Arsenal, Watervliet, New York.

United States Environmental Protection Agency (USEPA), Region II, 1998. Ground Water Sampling Procedure, Low Stress (Low Flow) Purging and Sampling Standard Operating Procedure.

FIGURES



SOURCE: U.S.G.S 7.5 MIN. TROY SOUTH QUADRANGLE

US Army Corps
of Engineers
Baltimore District

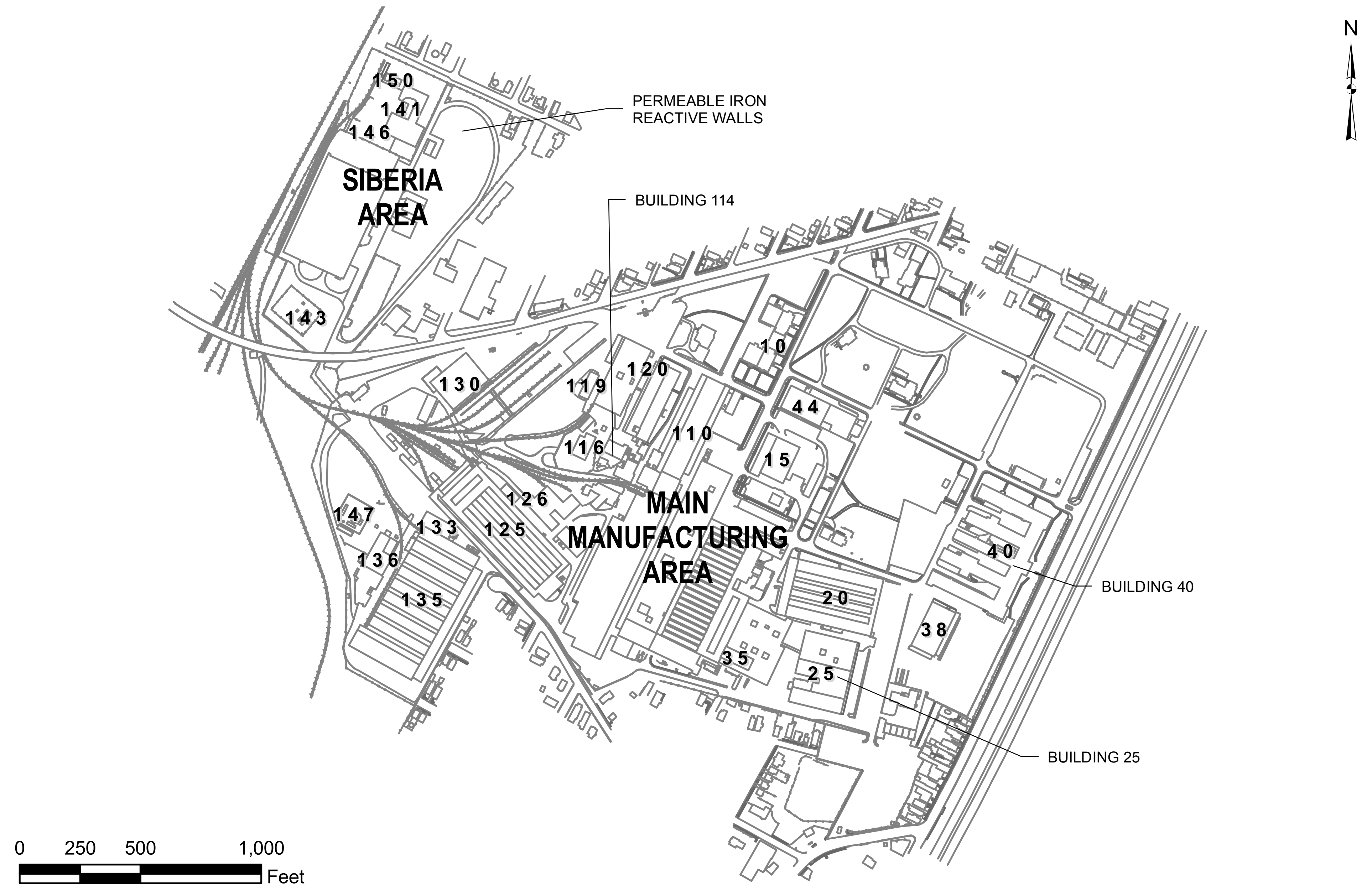
WATERVLIET ARSENAL
WATERVLIET, NEW YORK

PLATING AREA SITE INVESTIGATION

SITE LOCATION

FIGURE 1-1

G:\GISMOD\WatervlietArsenal\LTM\Figures\WVA Site Plan.mxd



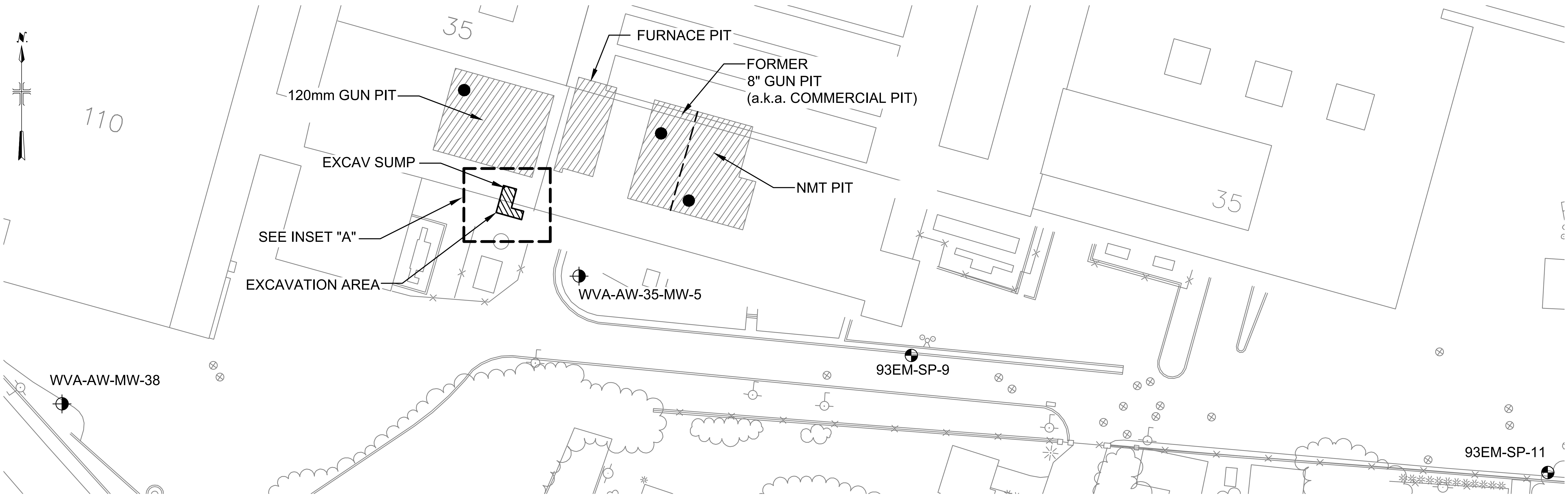
US Army Corps
of Engineers

LONG-TERM MONITORING PROGRAM
WATERVLIET ARSENAL
WATERVLIET, NEW YORK

SITE MAP

ARCADIS-MALCOLM PIRNIE

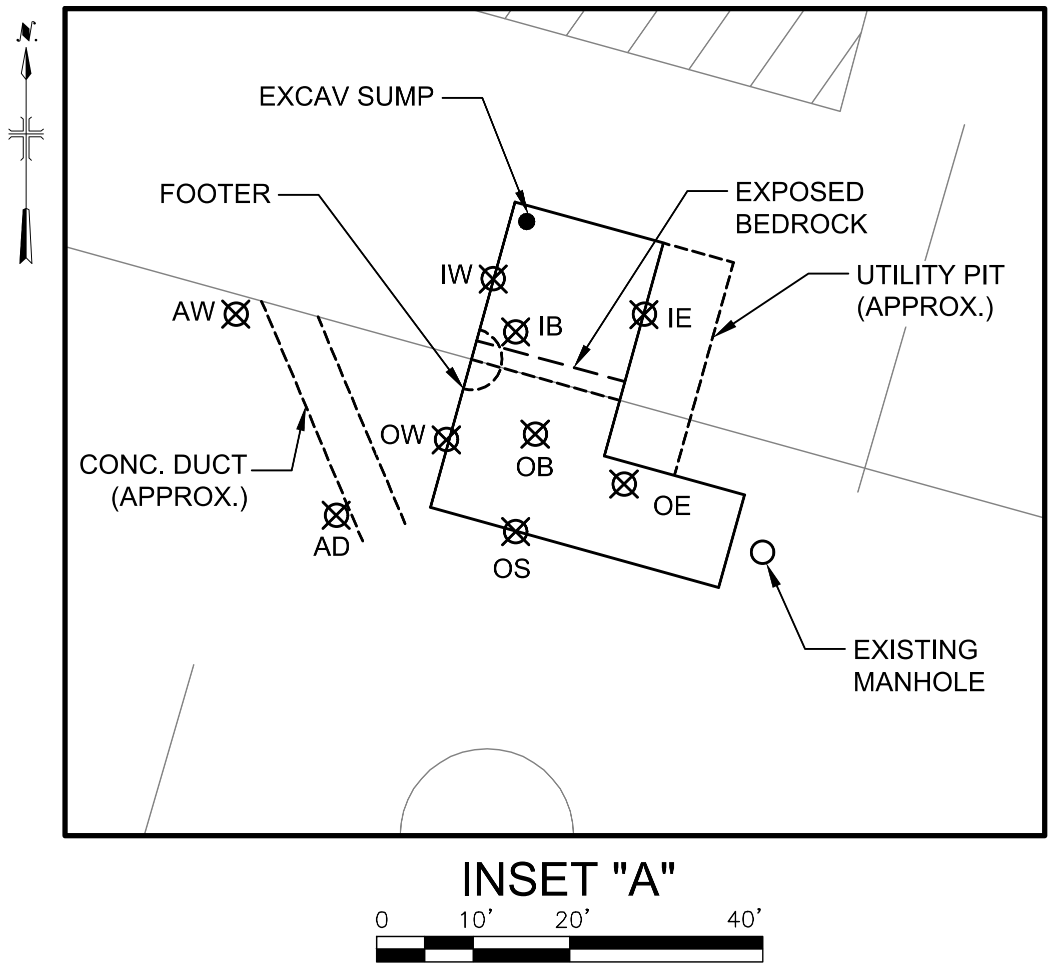
FIGURE 1-2



PLAN

LEGEND

⊗	MANHOLE
⚲	HYDRANT
○	BOLLARD
-○-	UTILITY POLE
-○-	UTILITY/LIGHT POLE
—×—×—	FENCE
◐	OVERBURDEN MONITORING WELL LOCATIONS
⊕	BEDROCK MONITORING WELL LOCATIONS
●	GROUNDWATER SUMP LOCATIONS (APPROX.)
⊠	SOIL SAMPLE LOCATIONS (APPROX.)



INSET "A"

SOIL SAMPLE NOTES:

IW - 3' OFF BOTTOM, 5' FROM NORTH PIT WALL

IE - 2' OFF BOTTOM, BELOW CONC., 5' FROM NORTH PIT WALL

OW - 4' BELOW CONC.

OE - 6" OUT FROM UTILITY PIT, BELOW CONDUIT

AW - ADJACENT TO EXISTING WALL ON WEST SIDE OF FENCE POST

AD - ADJACENT TO EXISTING DUCT

WATERVLIET ARSENAL
MAIN MANUFACTURING AREA
PLATING AREA SITE INVESTIGATION

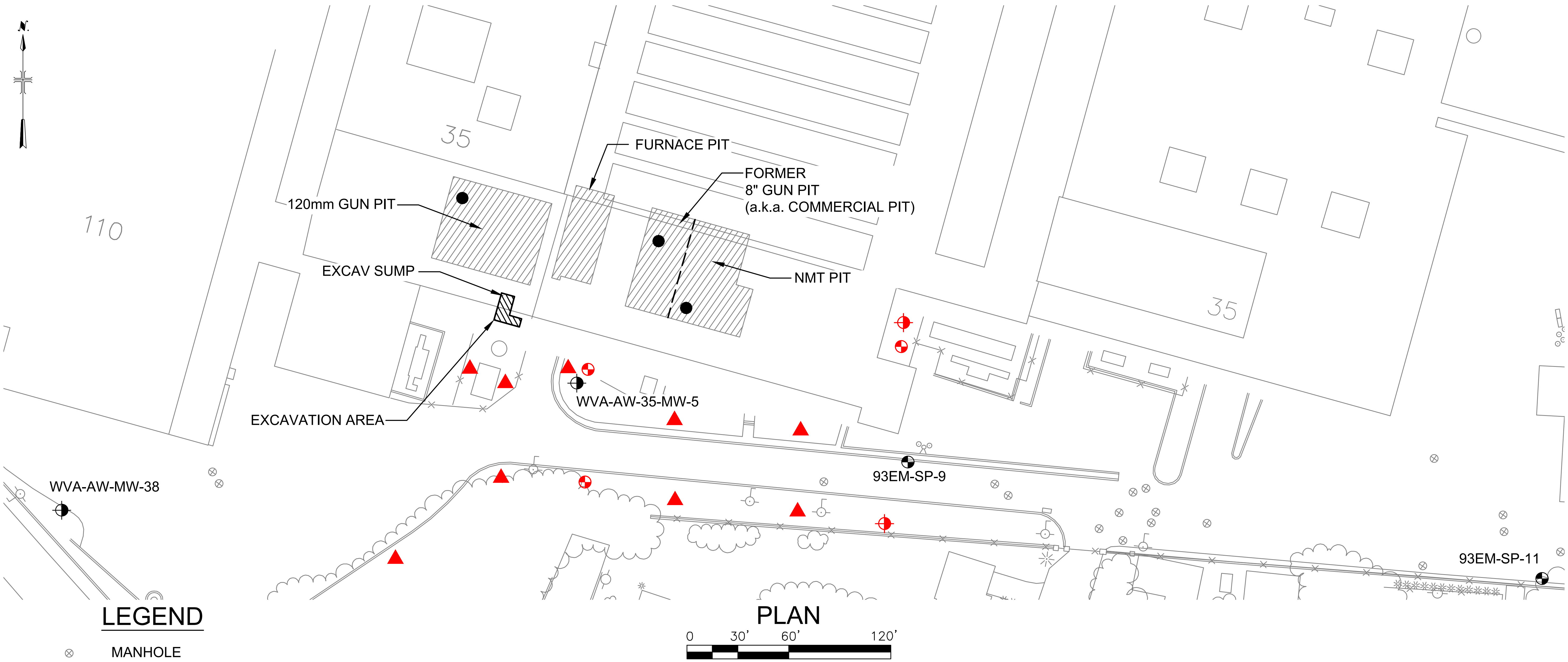
**2018 EXCAVATION AND
GROUNDWATER SAMPLING LOCATIONS**

ARCADIS Design & Consultancy for natural and built assets

FIGURE
2-1

USER: HAUSMANN FILENAME: G:\ACAD\PROJ\06261067.0000\DRAWINGS\FIGURE 2-1.DWG SAVE DATE: 6/7/2019 7:13 AM PLOT DATE: 6/17/2019 11:02 AM

USER: HAUSMANN FILENAME: G:\ACAD\PROJ\06261067.0000\DRAWINGS\FIGURE 3-1.DWG SAVE DATE: 6/27/2019 5:46 AM PLOT DATE: 6/27/2019 5:47 AM



LEGEND

- ⊗ MANHOLE
- HYDRANT
- ○ BOLLARD
- UTILITY POLE
- UTILITY/LIGHT POLE
- —×—×— FENCE
- ◐ OVERBURDEN MONITORING WELL LOCATIONS
- ⊕ BEDROCK MONITORING WELL LOCATIONS
- ● GROUNDWATER SUMP LOCATIONS (APPROX.)
- ☒ SOIL SAMPLE LOCATIONS (APPROX.)
- ◐ PROPOSED OVERBURDEN MONITORING WELL LOCATIONS
- ⊕ PROPOSED BEDROCK MONITORING WELL LOCATIONS
- ▲ PROPOSED SURFACE SOIL SAMPLE LOCATIONS

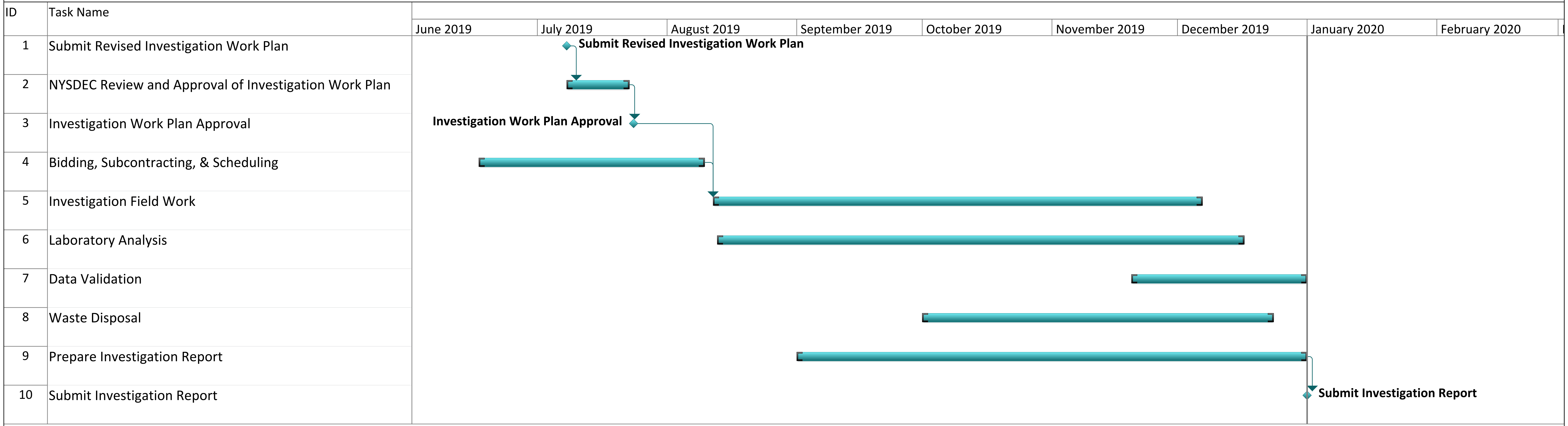
WATERVLIET ARSENAL
MAIN MANUFACTURING AREA
PLATING AREA SITE INVESTIGATION

PROPOSED SAMPLING LOCATIONS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
3-1

Figure 5-1
Anticipated Project Schedule
Plating Area Site Investigation
Watervliet Arsenal
Watervliet, New York



ID	Task Name
1	Submit Revised Investigation Work Plan
2	NYSDEC Review and Approval of Investigation Work Plan
3	Investigation Work Plan Approval
4	Bidding, Subcontracting, & Scheduling
5	Investigation Field Work
6	Laboratory Analysis
7	Data Validation
8	Waste Disposal
9	Prepare Investigation Report
10	Submit Investigation Report

TABLES

Table 2-1
Summary of August 2018 Groundwater Sump Sampling Data
Building 35 Chromic Acid Spill Evaluation
Watervliet Arsenal, Watervliet, NY

Sampling Date	Units	NYSDEC Class GA Standards	WVA-AW-MW-38 08/15/18	WVA-AW-35-MW-5 08/15/18	DUP-GW-08152018 08/15/18	93EM-SP-9 08/15/18	93EM-SP-11 08/15/18	SUMP-120Pit 08/15/18	SUMP-CommPit 08/15/18	SUMP-CommPit 08/29/18	Excav Sump 08/24/18	Excav Sump 08/28/18
ICP Metals												
Aluminum	mg/L	--	0.100 U	0.100 U	0.100 U	0.368	0.978	0.342	1 U	0.100 U	4.84	0.100 U
Antimony	mg/L	0.003	0.060 U	0.060 U	0.060 U	0.060 U	0.060 U	0.060 U	4.09	0.131	0.060 U	0.060 U
Arsenic	mg/L	0.025	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.112	0.016	0.005 U	0.005 U
Barium	mg/L	1.0	1.95	3.68	3.77	0.039	0.086	2.50	0.166	0.16	0.297	0.060
Beryllium	mg/L	0.003	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.05 U	0.005 U	0.005 U	0.005 U
Cadmium	mg/L	0.005	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.05 U	0.005 U	0.005 U	0.005 U
Calcium	mg/L	--	77.2	24.4	25.0	32.2	57.7	23.6	191	138	72.9	44.9
Chromium	mg/L	0.050	0.008	0.005 U	0.005 U	0.030	0.013	0.015	232	7.69	3.42	1.98
Cobalt	mg/L	--	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.050 U	0.5 U	0.050 U	0.050 U	0.050 U
Copper	mg/L	0.20	0.007	0.005 U	0.005 U	0.019	0.012	0.047	0.05 U	0.023	0.005 U	0.005 U
Iron	mg/L	0.30	0.124	0.050	0.050 U	0.935	1.68	6.44	0.5 U	0.139	10.6	0.050 U
Lead	mg/L	0.025	0.005 U	0.005 U	0.005 U	0.019	0.005	0.015	0.05 U	0.005 U	0.005 U	0.005 U
Magnesium	mg/L	35	31.9	7.44	7.60	2.42	18.9	7.52	38.3	32.9	17.1	11.2
Manganese	mg/L	0.30	0.171	0.114	0.117	0.069	0.453	2.48	0.739	0.020 U	0.407	0.219
Mercury	mg/L	0.0007	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U
Nickel	mg/L	0.10	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.2 U	0.020 U	0.020 U	0.020 U
Potassium	mg/L	--	20.2	20.4	20.9	2.01	13.0	24.3	12.9	23.2	16.2	8.16
Selenium	mg/L	0.010	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.05 U	0.005 U	0.005 U	0.005 U
Silver	mg/L	0.050	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.010 U	0.1 U	0.010 U	0.010 U	0.010 U
Sodium	mg/L	20.0	174	269	327	19.7	107	333	199	169	16.3	135
Thallium	mg/L	0.0005	0.011	0.014	0.016	0.010 U	0.011	0.019	0.1 U	0.010 U	0.027	0.010 U
Vanadium	mg/L	--	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.020 U	0.2 U	0.020 U	0.020 U	0.020 U
Zinc	mg/L	2.0	0.010 U	0.010 U	0.010 U	0.059	0.087	0.118	0.113	0.010 U	0.033	0.010 U
Hexavalent Chromium												
Hexavalent Chrominum	mg/L	0.050	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	680	11	2.7	1.6

Notes:

🟨 Highlighted values show detections greater than the NYSDEC Class GA Standard

Units are in milligrams per liter.

U- Not detected at reporting limit.

DUP-GW-08152018 taken from WVA-AW-35-MW-5

Table 2-2
Summary of August 2018 Excavation Soil Sampling Data
Building 35 Chromic Acid Spill Evaluation
Watervliet Arsenal, Watervliet, NY

		6 NYCRR Part 375 Industrial SCO	6 NYCRR Part 375 Protection of Groundwater SCO	ADJ Ext Wall	ADJ w. Duct	OS	OE	OW	OB	IB	IE	IW
Sampling Date	**Units**	**(ppm)**	**(ppm)**	**08/24/18**	**08/24/18**	**08/24/18**	**08/24/18**	**08/24/18**	**08/24/18**	**08/24/18**	**08/24/18**	**08/24/18**
ICP Metals												
Aluminum	µg/g	--	--	12000	11500	12600	12600	13500	12900	14700	15000	15000
Antimony	µg/g	--	--	3.20 U	3.40 U	3.90	3.20 U	3.30 U	5.86	3.50 U	27.8	3.30 U
Arsenic	µg/g	16	16	4.89	3.55	3.34	3.71	3.63	3.95	4.21	2.66	6.85
Barium	µg/g	10,000	820	73.3	75.4	93.4	101	111	87.8	110	131	148
Beryllium	µg/g	2,700	47	0.546	0.520	0.538	0.560	0.586	0.549	0.632	0.673	0.714
Cadmium	µg/g	60	7.5	1.45	1.44	1.36	1.53	1.67	1.37	1.60	1.63	1.85
Calcium	µg/g	--	--	13600	4260	16900	15300	20200	8010	17400	18600	10000
Chromium	µg/g	6,800	NS	15.6	19.4	195	31.3	19.3	394	42.6	1950	22.9
Cobalt	µg/g	--	--	7.58	7.67	7.48	7.39	8.52	7.91	9.43	10.9	10.7
Copper	µg/g	10,000	1,720	30.6	28.0	27.8	30.1	28.0	46.6	31.5	42.0	52.9
Iron	µg/g	--	--	31200	28000	27600	31300	32200	25900	34800	32100	32600
Lead	µg/g	3,900	450	15.8	14.3	24.4	17.7	14.9	23.1	25.5	34.8	49.9
Magnesium	µg/g	--	--	6240	6090	7300	7740	8590	7020	6300	7800	7240
Manganese	µg/g	10,000	2,000	423	530	880	755	1130	448	505	831	801
Mercury	µg/g	5.7	0.73	0.021 U	0.022 U	0.023	0.021 U	0.022 U	0.030	0.023 U	0.046	0.043
Nickel	µg/g	10,000	130	19.2	19.1	19.9	20.2	20.8	21.3	22.8	24.9	26.4
Potassium	µg/g	--	--	1430	1350	1620	1530	1750	1580	1560	1820	1780
Selenium	µg/g	6,800	4	0.270 U	0.280 U	0.270 U	0.260 U	0.270 U	0.280 U	0.290 U	0.280 U	0.280 U
Silver	µg/g	6,800	8.3	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	1.20 U	1.10 U	1.10 U
Sodium	µg/g	--	--	205	157	185	167	247	169	341	337	274
Thallium	µg/g	--	--	0.530 U	0.560 U	0.540 U	0.530 U	0.550 U	0.560 U	0.580 U	0.560 U	0.550 U
Vanadium	µg/g	--	--	20.3	18.9	19.3	20.4	21.2	19.2	24.8	15.8	25.4
Zinc	µg/g	10,000	2,480	68.7	111	54.5	59.1	60.2	59.3	62.9	64.1	78.5
Hexavalent Chromium												
Hexavalent Chrominum	µg/g	800	19	1.1 U	1.1 U	133	6.7	1.1 U	150	12.7	802	2.0

Notes:

🟨 Concentration exceeds corresponding 6 NYCRR Part 375 Industrial Soil Cleanup Objective (SCO)

🟧 Concentration exceeds corresponding 6 NYCRR Part 375 Protection of Groundwater Soil Cleanup Objective (SCO)

Units are in micograms per gram-dry weight
U- Not detected at reporting limit.
NS- Not specified.

APPENDIX A
Standard Operating Procedures, Field Forms, and/or Guidance Specific to Plating Area Site Investigation

TGI - BEDROCK CORE COLLECTION AND DESCRIPTION

Rev: 0

Rev Date: October 15, 2018

VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
0	October 15, 2018	All	Updated and re-written as TGI	Marc Killingstad

APPROVAL SIGNATURES

Prepared by:		10/15/2018
	Michael Cobb	Date:
Technical Expert Reviewed by:		10/15/2018
	Marc Killingstad (Technical Expert)	Date:

1 INTRODUCTION

This document describes general and/or specific procedures, methods, actions, steps, and considerations to be used and observed by Arcadis staff when performing work, tasks, or actions under the scope and relevancy of this document. This document may describe expectations, requirements, guidance, recommendations, and/or instructions pertinent to the service, work task, or activity it covers.

It is the responsibility of the Arcadis Certified Project Manager (CPM) to provide this document to the persons conducting services that fall under the scope and purpose of this procedure, instruction, and/or guidance. The Arcadis CPM will also ensure that the persons conducting the work falling under this document are appropriately trained and familiar with its content. The persons conducting the work under this document are required to meet the minimum competency requirements outlined herein, and inquire to the CPM regarding any questions, misunderstanding, or discrepancy related to the work under this document.

This document is not considered to be all inclusive nor does it apply to any and all projects. It is the CPM's responsibility to determine the proper scope and personnel required for each project. There may be project- and/or client- and/or state-specific requirements that may be more or less stringent than what are described herein. The CPM is responsible for informing Arcadis and/or Subcontractor personnel of omissions and/or deviations from this document that may be required for the project. In turn, project staff are required to inform the CPM if or when there is a deviation or omission from work performed as compared to what is described herein.

In following this document to execute the scope of work for a project, it may be necessary for staff to make professional judgment decisions to meet the project's scope of work based upon site conditions, staffing expertise, state-specific requirements, health and safety concerns, etc. Staff are required to consult with the CPM when or if a deviation or omission from this document is required that has not already been previously approved by the CPM. Upon approval by the CPM, the staff can perform the deviation or omission as confirmed by the CPM.

2 SCOPE AND APPLICATION

This Technical Guidance Instruction (TGI) describes the procedures to be used to collect and describe bedrock core samples. The approach described here is applicable for subsurface investigations employing a standard wire-line or conventional diamond-bit coring approach, where the project objectives may include:

- Describing bedrock lithology, degree of weathering, fracturing, and other field-observable rock characteristics
- Evaluating relative groundwater yield of fractures or intervals to assist in well design decisions

The methodology described here is in general accordance with *ASTM Method D 2113-99, Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation*. Additional terminology standards are based on the New York Department of Transportation's *Rock Core Evaluation Manual* (NYSDOT, 2015). This approach and level of detail is appropriate for most environmental-site subsurface investigations. Given the diverse nature of bedrock, and variety of potential project objectives, the project team will review site-specific data needs prior to starting work and, if needed, adapt the field procedures.

The scope of this TGI is specific to core collection and description; it does not encompass the broader suite of tasks associated with bedrock drilling or well construction (see relevant SOP and TGIs, as needed). Note that coring work is often combined with related bedrock characterization techniques, including packer-testing, geophysical logging, FLUTe™ profiling and whole-core rock sampling. These tasks are outside of the scope of this TGI; however, if such additional work is part of the project scope, the planning and sequencing of coring will consider the requirements of those tasks.

3 PERSONNEL QUALIFICATIONS

Arcadis field personnel will have completed or are in the process of completing site-specific training as well as having current health and safety training as required by Arcadis, client, or regulations, such as 40-hour HAZWOPER training and/or OSHA HAZWOPER site supervisor training. Arcadis personnel will also have current training as specified in the Health and Safety Plan (HASP) which may include first aid, cardiopulmonary resuscitation (CPR), Blood Borne Pathogens (BBP) as needed.

In addition, Arcadis field personnel will be knowledgeable in the relevant processes, procedures, and TGIs and possess the demonstrated required skills and experience necessary to successfully complete the desired field work. The HASP and other documents will identify other training requirements or access control requirements.

Bedrock core logging will only be performed by Arcadis personnel or authorized subcontractors with a bachelor’s degree in geology or a geology-related discipline. Field personnel will complete training on this TGI in the office and/or in the field under the guidance of an experienced field geologist with at least 2 years of prior experience with bedrock core description.

Note that this TGI is written specifically for site characterization and remediation projects. When bedrock core samples are to be used for engineering purposes (e.g., foundation design, rock mechanics, design of excavation support), field staff will work under the direction of a geotechnical engineer.

4 EQUIPMENT LIST

Typically Provided by Geologist	Typically Provided by Driller
• Approved site-specific Health and Safety Plan (HASP) • Approved site-specific FIP/work plan which will include boring location map and drilling plan • Required PPE (see site-specific HASP) • Field logbook and/or rock coring logs • Permanent marking pen for labeling boxes and cores (indelible ink) • 6-foot wooden folding ruler (or similar) graduated in tenths-of-feet (not inches) • Distilled water and spray bottle for wetting and washing core • Camera and/or smart device (phone or tablet) • Pen knife (to test rock hardness) • Munsell rock color chart • Rock hammer • Plastic sheeting (e.g., Weatherall Visqueen) • Stopwatch • Carpenter’s protractor • Photoionization detector (PID) or Flame ionization detector (FID) (as appropriate, depending on site-specific constituents of concern) • Air monitoring equipment (as required) • Hand lens (optional) • 10% Hydrochloric acid solution (appropriately labeled eye-dropper for carbonate identification [optional]) • Sturdy saw horses to support core box at working height (optional)	• Core boxes • Wood blocks to separate core runs in core boxes • Rubber hammer (for tapping rock core out of core barrel)

5 CAUTIONS

- **Review relevant guidance**: Utility avoidance, drilling, decontamination, management of investigation derived waste and related tasks will be completed in accordance with a project-specific field implementation plan (FIP)/work plan and/or applicable SOPs or TGIs.
- **Use a trusted, experienced driller:** The quality of bedrock core samples often depends on the skill of the driller (e.g., at selecting the correct tooling, down-pressure and spin-rate for the type of rock and depth). An inexperienced driller will often drill more slowly and cause unnecessary mechanical breaks in the core. It is also important to use a rig equipped with a high-speed coring head. Many rotary or auger rigs are not capable of the speeds required for coring, unless modified for coring.

- **Choose a clean water supply for drilling fluid:** Water is the preferred drilling fluid when coring. The water used for drilling will be of sufficient quality to meet project objectives. Testing of water supply will be considered. Drilling muds are to be avoided, except in special cases where circulation cannot be maintained.
- **Understand your driller's plans for recirculation of drilling water:** Recirculation is common practice in coring, to limit generation of large quantities of investigation-derived waste (IDW). Water is pumped down the inside of the core barrel to cool the bit and carry rock cuttings back to the surface through the annular space outside the barrel. The return water spills into a mud tub, often designed with several baffles to help cuttings fall out of suspension. This water is then pumped back down the core barrel, or recirculated, until the sediment load is too great, then water must be replaced. Recirculation can increase the risk of cross-contamination, so caution is needed. However, coring without recirculation can quickly generate very large quantities of IDW and is often not practicable.
- **Avoid cross-contamination**: Core drilling often involves creating long open boreholes that may, at least temporarily, penetrate confining beds or create artificial connections between fracture zones at different depths. If cross-contamination is a concern at a site, work will be planned to limit the length of open sections (e.g., by telescoping casing), and limit the duration that a borehole stands open. Field crews will stop-work if dense-non-aqueous phase liquid (DNAPL) is encountered (e.g., if sheens are observed on drilling return water).

6 HEALTH AND SAFETY CONSIDERATIONS

Conduct drilling and related tasks in in accordance with a site-specific Health and Safety Plan (HASP). Review all site-specific and procedural hazards as they are provided in the HASP, and review Job Safety Analysis (JSA) documents in the field each day prior to beginning work. Appropriate personal protective equipment (PPE) will be worn at all times in line with the task and the site-specific HASP.

Note that full core boxes can be heavy and awkward to lift, depending on core-diameter and box size. Be sure to use proper bending and lifting techniques to avoid muscle strain and other potential injuries. Use two people to lift heavy core boxes whenever feasible.

Use appropriate hand protection when conducting carbonate-rock test (using dilute acid) and hardness tests (using a penknife). If site- or client-specific health and safety requirements prohibit use of fixed/folding-blade knives, an alternative steel object (e.g., nail) may be substituted.

7 PLANNING CONSIDERATIONS

Bedrock coring is the primary method available for collecting representative, minimally disturbed field samples from bedrock boreholes. The most common approach involves a cylindrical diamond-impregnated core bit attached to an outer string of drill pipe. The entire pipe is spun at a high velocity, cutting a donut-shaped hole, leaving an intact core of rock that passes through the bit into the core barrel as drilling continues deeper. At the end of a core run (typically 5 or 10-feet long), the core is snapped off by backing the tools slightly.

What coring method is appropriate for the job? There are two common bedrock coring methods that use different approaches to retrieve cores:

- **Wireline Coring**: Core samples are brought to the surface between runs using a retriever on a wire that connects to the top of the inner core-barrel and lifts it to the surface, leaving the outer barrel in place. This is the most common method and is preferred in most cases.
- **Conventional Coring**: Core is retrieved by removing the entire coring tool string from the borehole. This approach is less common, but it occasionally used for shallow boreholes where only one or two runs are required (e.g., to confirm rock at the base of overburden borehole).

What core size is appropriate? Coring tools exist in several common sizes, generally referred to by a two-letter code. The most-common dual-tube wire-line core-sizes are listed in the table below.

	Common Wireline Core Bit Sizes (inches)		
	NQ	**HQ**	**PQ**
Core Diameter	**1.88**	**2.50**	**3.34**
Hole Diameter	**2.98**	**3.78**	**4.83**

Note: conventional core sizes are denoted NX, HX or similar, and have slightly different sizing.

NQ cores are most often used in shallow geotechnical applications, while HQ core are the most common used for environmental well drilling. HQ's size is suitable for most geophysical logging techniques, and some small-diameter packer assemblies, but subsequent reaming is often (though not always) required to enlarge the borehole before a well can be set. PQ is used less frequently because the larger size adds considerable weight, but a PQ core hole can more often be used to build a monitoring well without additional reaming.

What type of rock is expected? It is critical to have a good idea of what conditions will be encountered before starting.

- Review previously completed logs.
- Check available geologic maps or water-resources reports.
- Consult other knowledgeable geologists who have experience in the area.
- Learn what bedrock units might be present, how they are commonly described, and whether they have useful diagnostic characteristics.
- Learn whether there are any key marker beds, or whether there any key confining beds that should not be penetrated.
- If needed, the field geologist will review lithologic characterization techniques specific to the types of rock expected.

What level of logging detail is required? Core description can be time-consuming; therefore, consider the project data needs and establish priorities for what aspects of the rock will be classified. For most environmental projects, highly detailed logging of lithology and petrology are unnecessary, while fractures are of paramount concern. Sometimes identifying a particular contact is critical, but minor lithologic variability is not. Establishing priorities in advance will allow the field geologist to prepare and perform efficiently in the field. *When planning, note that a single geologist often cannot keep up with the requirements of core-collection and description in real-time (e.g., as the hole is being drilled). Additional "catch-up" time is often necessary and will be considered in project planning.*

8 PROCEDURE

Core description is a multi-step process. The general sequence of work can be summarized as follows:

Stage	Activity
Rig set-up	Establish measuring points, measure tooling, establish roles and procedures with driller.
Active coring	Track drilling progress. Track water use. Watch return water for signs of impact. Conduct air monitoring. Setup and label core boxes.
Core extraction	Arrange core in box. Screen core for contaminant impacts. Mark and label core and fractures. Measure recovery. Calculate rock quality designation (RQD).
Core logging	Describe rock lithology, structure, weathering, fracturing, and other characteristics.
End of hole	Photograph core boxes. Store or dispose of core.

8.1 Before Coring Starts

Prepare for accurately tracking depths

1. Discuss with driller what reference point will be used for ground surface (e.g., the base of the mud tub) and mark it, if needed. All depths will be recorded relative to this datum.
2. Measure and mark (if needed), a fixed reference point above the ground surface that will serve as the starting/stopping point for core runs (e.g., the top of an outer casing or a vice)
3. Measure out core tooling lengths, including barrels, bits and subs, so that the depth of the barrel will be known to the nearest tenth of a foot.

Prepare for tracking water usage

1. Confirm whether the driller will be recirculating drilling water or using a continuous clean source. [NOTE: *Recirculation is a common practice in coring; however, it is not permissible for all projects and jurisdictions*].
2. Discuss with driller how water usage will be tracked. Water lost in each run will be estimated, either via a change in level of a mud tub and/or drop in level of a separate water tank.
3. Measure dimensions of mud tub and/or water tank to estimate volume. Mark graduations, if needed, so that volume changes can be estimated.

8.2 Active Coring

1. Request that the driller tag borehole with a weighted line before start of coring and periodically between runs to confirm depth.
2. Use a stopwatch (or equivalent) to time the length of each run (e.g., 40 min for 10 feet)
3. Note starting and ending water volume in tanks and/or mud tub.
4. Note the starting and ending core-run depth by noting the position of joints in the drilling string relative to the fixed reference point.
5. To the extent feasible, the driller should maintain a consistent bit pressure, water pressure, and rotational rate throughout a run, and avoid stopping or backing the tools, until the run is complete.
6. Request that driller alert you to changes in drilling condition during a run, including:
    a. Significant change in drilling rate that may indicate a change in lithology or weathering.
    b. A change in water recirculation rate that may indicate a major fracture
    c. Bit drop, which may indicate a void or highly-weathered zone.
    d. Any odors or sheens that may occur from the return water. [NOTE: *Under most drilling programs, the appearance of sheens or NAPL in the drilling water is cause to exercise stop-work authority. Drilling through a zone known to contain NAPL must be done only with CPM approval*.]
    e. Change in sediment load in return water, which may indicate a highly-weathered zone.
7. If air monitoring is required at the borehole (based on HASP and nature of contaminants present), periodically screen the driller breathing zone and return water splash zone.

8.3 Core Extraction

8.3.1 Core Handling and Labelling

In most instances, core samples will be placed directly into core-boxes by the driller. Core samples will be placed with increasing depths aligned left to right and top to bottom. If core is covered in sediment or mud, it is helpful to rinse the core with clean water before placing it in the box.

The drillers will take care not to unnecessarily break the core as they are extracting from the barrel; however, they will have to break long sections of core that overlap the box-edges, typically using a hammer.

Core and core boxes will be labeled using a heavy indelible marker (e.g., Sharpie) as follows:

What to Label	How to Label
Start and end of core runs	Label box edges or insert wooden blocks to separate runs. Label run number at top of run; e.g., “Run 2”, at the start of Run 2.

What to Label	How to Label
Vertical alignment of core	Draw short arrows on each major section of core pointing toward ground surface. (An alternate method using two parallel colored stripes is common but is challenging on wet core.)
Mechanical breaks (also called driller breaks)	Two parallel lines crossing the break at a right angle and labeled with the letter “M” (see Section 8.3.2)
Fractures (natural breaks)	A single line crossing the fracture at a right angle
Intervals with no core recovery	Insert a wooden spacer marked “No recovery” and with corresponding depth for any interval where no rock was recovered (e.g., a weathered zone that washed out, or karst void)
Sections of core removed from box	Insert a wooden spacer marked “Removed” with corresponding depth.
Core box lid (outside)	Site or project name, well or borehole ID, date drilled, box number (e.g., “1 of 5”) and start and end depth of core contained in the box. (Additional information such as site address and project number can be included, if needed.)
Core box lid (inside)	Label the same as the box exterior. If core is expected to be archived, it is common practice to also include the depths, recovery and rock quality designation (RQD) for each run contained in the box.
Core box left end	Site or project name, well or borehole ID, box number, and start and end depth of core contained in the box.

8.3.2 Assessing Natural or Mechanical Breaks

When evaluating a core, it is necessary to determine whether the observed fractures are natural or mechanical. The primary indicators to look for include:

Signs of a Natural Fracture	• Weathering on face • Oxidation of minerals adjacent to face • Clay on face (if distinct from sediment in drilling fluid) • Linear striations on face
Signs of Mechanical Break	• Absence of weathering or oxidation • Crisp edges

Other considerations when evaluating the nature of break include:

- Weak, friable rock (such as shale), will often have numerous mechanical breaks that that are indistinguishable from real ones. Judgement is required, but for the sake of RQDs, such fractures are generally considered natural.

- If the core spins on itself inside the barrel A rounded or “ground” fracture faces can sometimes occur. This can happen to either a natural or mechanical break, so other evidence is required.

Assessing the nature of fractures can be challenging and subjective. In general, where the case is uncertain, assume the fracture is natural.

8.3.3 Core Run Description

Several descriptors are made on the basis of the core-run, typically 5 or 10 feet in nominal length. Lengths and depths are best recorded to the nearest 0.1 foot.

What to Record	How to Determine
Start and end depth	Determine by tracking advancement of the core tooling, referenced to ground surface. Note that cores occasionally snap off above the drilled depth on retrieval, leaving a cored “stub” in the hole, which is typically retrieved in the next run. When this happens, the run depths and retrieved core depths will differ. Both values will be recorded. Periodic soundings are helpful to verify depth.
Recovery length and percentage	Measure the total length of recovered core. The recovery percentage is based on start and end depths of the retrieved core (i.e., do not count a stub of core left in the hole).
Rock Quality Designation (RQD)	Add up the length of unfractured core-pieces greater than 4-inches in length (where fractures are dipping, measure between the points where fractures intersect the center-line of the core). Divide by the total length of the core run (bottom minus top depth of core recovered) and record the result as a percentage. Note that most common practice is to exclude obvious mechanical breaks when assessing RQD sections. However, where it is unclear whether a break is natural or mechanic, assume it is natural for the RQD assessment.
Water Loss	Determine based on changed level in mud tub, water tank, or other method (determined in consultation with the driller before coring starts). If a sudden change in water loss is observed during the run, record the approximate depth where it occurred.
Run-Time (optional)	Stopwatch recording of the total time to core a run. This can be useful in showing transition between rock types, or that the core bit has dulled. In some cases, foot-by-foot times can be recorded by chalk-marking increments on the barrel.

8.3.4 Contaminant Screening of Core

Methods for screening for contamination while coring depend on the nature of impacts suspected. As noted above, air-monitoring at the ground surface of the borehole, and continuous visual observation of the return water while drilling generally provide the first indication of an impact.

Specific procedures for screening cores will be identified in the project FIP/work plan. Common approaches include the following:

- If NAPL may be present, fracture surfaces will be visually inspected for sheens or NAPL.
- Though field staff will NOT intentionally sniff the core, obvious odors are sometimes useful indicators. Field descriptions of odors will be general, and not attempt to specify what contaminant it smells like.
- If screening core for volatile organic compounds (VOCs) with a photo-ionization detector (PID), focus attention on fractures. With the core lying in the core-box, separate the fracture slightly, cover the opening with a gloved hand, and then insert the PID tip into the fracture aperture.
- If NAPL is suspected (e.g., based on high PID hits, or sheens in the return water), but not visible on the core, one of several commercially available NAPL-detection kits (using hydrophobic dye) may be applied to the core as a supplemental test.

As noted above, when NAPL is observed in a borehole, drilling will almost always stop to avoid dragging the impacts down—drilling deeper will occur ONLY when necessitated by the project objectives, and ONLY after consulting project leadership.

8.4 Procedures for Core Logging

Logging core includes two parts: (1) describing the nature of the rock (e.g., lithology, structure, bedding) and (2) logging observed discontinues (e.g., fractures or weathered zones).

8.4.1 Logging Rock Characteristics

The field geologist will log the following characteristics of the rock core:

What to Record	How to Describe
Depth	Note top of an interval being described, relative to ground surface. Avoid referencing depths relative to the position in the core run.
Rock type	Describe based on observation. Use terminology consistent with local mapping, if available. If the specific type cannot be determined in the field, use a more general descriptor (e.g., metamorphic).
Grain size	See chart in **Attachment 1**. For crystalline rocks, note applicable texture.
Color	Reference Munsell rock color chart. Describe matrix color and major clast color separately, if applicable.

What to Record	How to Describe
Weathering state	See terminology chart (**Attachment 1**).
Hardness	See terminology chart (**Attachment 1**).
Degree of Fracturing	See terminology chart (**Attachment 1**). Also note general characteristics of fractures (e.g., if oxidized, filled, rough or smooth, dominantly aligned with bedding/foliation, etc.). Call out depths of major fractures. (See also, Section 8.4.2)

Other observations may also be made, if appropriate to the rock type. Common supplemental observations include:

- Diagnostic minerals present
- Presence and abundance of fossils
- Particle angularity/shape, e.g., for conglomerates or breccias
- Effervesce, e.g., if testing for limestone or dolomite using a hydrochloric acid solution
- Presence of healed fractures.
- Observations of porosity, pitting, vugs, or cavities (see terminology chart in **Attachment 1**)

8.4.2 Logging Discontinuities

In addition to characterizing the rock mass (as described above), core descriptions will often identify the depth and characteristics of specific fractures and other discontinuities. In general, the following will be noted:

- Fractures (excluding mechanical breaks), including descriptors for orientation, filling, oxidation or mineralization
- Zones of notable porosity (e.g., pitting, vugs)
- Zones of intense weathering (e.g., greater than surrounding rock mass)

Discontinuities are logged either in list-form, or on a scaled-graphical log, using standard abbreviations to identify important characteristics (see **Attachment 1**).

Note that in moderately or intensely fractured rock, logging every observed fracture may not be practical, or especially useful. Generalizations such as “intensely fractured zone” are often appropriate.

8.5 Procedures to Complete after Completion of Core Hole

8.5.1 Photographing Core

All core boxes will be photographed in a systematic manner. Best practice includes the following steps:

- Place the core box in a well-lit space

- Lay a tape measure or marking stick for scale along the length of the core box
- Wet the core with a spray bottle
- Take a high-resolution photograph showing the entire core box and labeled lid from directly above or at slight angle.
- If close-ups of particular features are needed, include a visible scale and labeled notecard in the photo.
- If a color is a key diagnostic aspect, a standard color reference chart may be included in the photos.

It is generally easiest to obtain consistent, high quality photographs by taking the photos in batches (e.g., after a borehole is completed), rather than attempting to take photographs immediately after each core run.

8.5.2 Core Storage or Disposal

If core will be stored for potential future use, boxes will be moved to a central location. In general:

- Core boxes will be stored under cover, ideally indoors and somewhere where they will not need to be moved often
- Boxes will be places on pallets (or similar) to keep off the ground
- Boxes will be stacked so that the labeled ends are visible and facing the same direction
- Boxes will be stacked no more than about 3 feet high (to avoid lifting above waist level)

If core is to be discarded, do so only after reviewing notes and confirming that all important details have been recorded. Core will be disposed-of consistent with project IDW requirements. Core boxes will not be removed from a site without appropriate planning and approval.

9 WASTE MANAGEMENT

Coring may generate several types of IDW in addition to the cores themselves:

- Coring typically generates substantial quantities of drilling fluid. It is typically a mixture of water and suspended fine sediment. In most cases, this is drummed. For large jobs, roll-off or “sludge” boxes may be more economical.
- Solid rock cuttings also accumulate in the mud tub. These are typically shoveled into drums.
- Other waste streams include decontamination liquids, and disposable materials (well material packages, personal protective equipment [PPE], etc.).

Waste will be managed in accordance with the *TGI – Investigation-Derived Waste Handling and Storage,* the procedures identified in the FIP or QAPP as well as state-, federal- or client-specific requirements. Be certain that all IDW will be placed in clearly labeled, appropriate containers and documented in the field log book.

10 DATA RECORDING AND MANAGEMENT

Records generated as a result of this TGI will be controlled and maintained in the project record files in accordance with project requirements as outlined in the FIP/work plan and/or QAPP.

Core descriptions and related activities will be recorded in a field book and/or on appropriate field forms. In addition to the core description information detailed above, field notes will record personnel present on site, including driller names, drilling equipment used, significant weather conditions, and the timing of all activities.

Field forms, logs/notes (including daily field and relevant calibration logs), and digital records will be maintained by the field team lead.

Records will be transmitted to the Arcadis Project Manager and/or Task Manager, as appropriate, at the end of each day or as specified in the FIP/work plan.

Electronic data files will be sent to the project team and uploaded to the electronic project folder daily or as specified in the FIP/work plan.

Management of the original documents from the field will be completed in accordance with the site-specific QAPP.

11 REFERENCES

ASTM, 1999. Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation, D 2113-99.

New York State Department of Transportation (NYSDOT), 2015. Geotechnical Engineering Manual, Rock Core Evaluation Manual, GEM-23, Rev. 2.

12 ATTACHMENTS

Attachment 1. Bedrock Core Description Terminology

Attachment 1
Bedrock Core Description Terminology

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Bedding Thickness*

Term	Average Thickness
Massive	No visible bedding
Very Thick-Bedded	Greater than 4 ft. (> 1.2 m)
Thick-Bedded	1 ft. to 4 ft. (0.3 m to 1.2 m)
Medium-Bedded	4 in. to 12 in. (100 mm to 300 mm)
Thin-Bedded	1.2 in. to 4 in. (30 mm to 100 mm)
Very Thin-Bedded	0.5 in. to 1.2 in. (13 mm to 30 mm)
Laminated	< 0.1 in.

*For igneous and metamorphic rocks, planar features such as foliation and banding are described using same thickness designations (e.g., thin-banded).

Fracturing

Term	Length of Most Recovered Core
Unfractured	No observed fractures.
Very slightly fractured	> 3 ft. (1 m).
Slightly fractured	1 to 3 ft. (0.3 to 1 m)
Moderately fractured	0.33 to 1 ft. (0.1 to 0.3 m)
Intensely fractured	0.1 to 0.33 ft. (0.03 to 0.1 m)
Very intensely fractured	Core mostly broken; few intact core segments

Pores or Voids

Term	Pore Size
Porous	Smaller than pinhead. Presence indicated by degree of absorbency
Pitted	Pinhead to ¼ inch across.
Vug	¼ inch across to diameter of core
Cavity	Larger than core diameter

Weathering State

Term	Characteristics
Fresh	No visible signs of decomposition or discoloration
Slightly weathered	Slight discoloration inward from open fractures; otherwise fresh
Moderately weathered	Discoloration throughout. Weaker minerals such as feldspar decomposed. Strength somewhat less than fresh rock, but cores cannot be broken by hand or scraped by knife. Texture preserved.
Highly Weathered	Most minerals somewhat decomposed. Specimens can be broken by hand with effort, or shave with knife. Texture become indistinct, but fabric preserved.
Extremely weathered (saprolite)	Minerals decomposed to soil, but fabric and structure preserved
Decomposed (residual soil)	Rock fully decomposed to plastic soils. Rock fabric and structure completely destroyed.

Hardness

Term	Field Test
Soft	Can be scratched with fingernail.
Medium Hard	Easily scratched by penknife
Hard	Difficult to scratch by penknife.
Very hard	Cannot be scratched by penknife.

Grain-Size

Term	Size
Microcrystalline / Aphanitic*	No visible grains
Fine grained	0.06 - 0.25 mm
Medium grained	0.25 - 0.5 mm
Coarse grained	0.5 - 2.0 mm

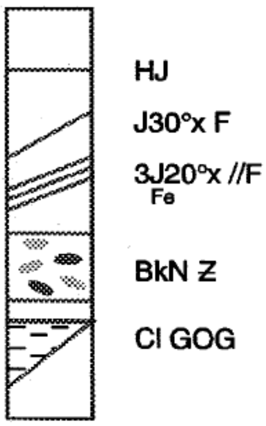
*Aphanitic applies to detrital rocks

Common Abbreviations

Abbr.	Definition	Abbr.	Definition	Abbr.	Definition
BkN	broken	JxF	joint crosses foliation	si	silt
CAL	calcareous or calcite	l	laminae	SZ	sheer zone
cl	clay	//	parallel	U	unfoliated or unstratified
F	foliation	m	mud in opening	v	vuggy
Fe	iron staining	MB	mechanical break	VJ	vertical joint
GOG	gouge	QTZ	quartz	w	weathered
HJ	horizontal joint	s	solution enlargement	WZ	weathered zone
J	joint *	S	stratification	x	crossing
J//F	joint is parallel to foliation	sa	sand	Z	Zone

* The term "joint" may indicates any natural fracture, including bedding plane fractures.

Example Graphic Log



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METHOD 3060A

ALKALINE DIGESTION FOR HEXAVALENT CHROMIUM

1.0 SCOPE AND APPLICATION

1.1 Any reference in this method to “Method 3060" refers to this version of that method, and does not refer to previously published versions (e.g., in the Second Edition of this manual). When published as a new method to SW-846, a method’s number does not include a letter suffix. Each time a method is revised and made a part of SW-846 update, it receives a suffix. However, a method reference found within the text of SW-846 methods always refers to the latest version of that method published in SW-846, even if the method number at that location does not include the appropriate letter suffix.

1.2 Method 3060 is an alkaline digestion procedure for extracting hexavalent chromium [Cr(VI)] from soluble, adsorbed, and precipitated forms of chromium compounds in soils, sludges, sediments, and similar waste materials. To quantify total Cr(VI) in a solid matrix, three criteria must be satisfied: (1) the extracting solution must solubilize all forms of Cr(VI), (2) the conditions of the extraction must not induce reduction of native Cr(VI) to Cr(III), and (3) the method must not cause oxidation of native Cr(III) contained in the sample to Cr(VI). Method 3060 meets these criteria for a wide spectrum of solid matrices. Under the alkaline conditions of the extraction, minimal reduction of Cr(VI) or oxidation of native Cr(III) occurs. The addition of Mg^{2+} in a phosphate buffer to the alkaline solution has been shown to suppress oxidation, if observed. The accuracy of the extraction procedure is assessed using spike recovery data for soluble and insoluble forms of Cr(VI) (e.g., $K_2Cr_2O_7$ and $PbCrO_4$), coupled with measurement of ancillary soil properties, indicative of the potential for the soil to maintain a Cr(VI) spike during digestion, such as oxidation reduction potential (ORP), pH, organic matter content, ferrous iron, and sulfides. Recovery of an insoluble Cr(VI) spike can be used to assess the first two criteria, and method-induced oxidation is usually not observed except in soils high in Mn and amended with soluble Cr(III) salts or freshly precipitated $Cr(OH)_3$.

1.3 The quantification of Cr(VI) in Method 3060 digests should be performed using a suitable technique with appropriate accuracy and precision, for example Method 7196 (colorimetrically by UV-VIS spectrophotometry) or Method 7199 (colorimetrically by ion chromatography (IC)). Analytical techniques such as IC with inductively coupled plasma - mass spectrometric (ICP-MS) detection, high performance liquid chromatography (HPLC) with ICP-MS detection, capillary electrophoresis (CE) with ICP-MS detection, etc. may be utilized once performance effectiveness has been validated.

2.0 SUMMARY OF METHOD

2.1 This method uses an alkaline digestion to solubilize both water-insoluble (with the exception of partial solubility of barium chromate in some soil matrices, see Reference 10.9) and water soluble Cr(VI) compounds in solid waste samples. The pH of the digestate must be carefully adjusted during the digestion procedure. Failure to meet the pH specifications will necessitate redigestion of the samples.

2.2 The sample is digested using 0.28M Na_2CO_3/0.5M NaOH solution and heating at 90-95°C for 60 minutes to dissolve the Cr(VI) and stabilize it against reduction to Cr(III).

2.3 The Cr(VI) reaction with diphenylcarbazide is the most common and reliable method for analysis of Cr(VI) solubilized in the alkaline digestate. The use of diphenylcarbazide has been well established in the colorimetric procedure (Method 7196), in rapid-test field kits, and in the ion chromatographic method for Cr(VI) (Method 7199). It is highly selective for Cr(VI) and few interferences are encountered when it is used on alkaline digestates.

2.4 For additional information on health and safety issues relating to chromium, refer to References 10.7 and 10.10.

3.0 INTERFERENCES

3.1 When analyzing a sample digest for total Cr(VI), it is appropriate to determine the reducing/oxidizing tendency of each sample matrix. This can be accomplished by characterization of each sample for additional analytical parameters, such as pH (Method 9045), ferrous iron (ASTM Method D3872-86), sulfides (Method 9030), and Oxidation Reduction Potential (ORP) (ASTM Method D 1498-93 - aqueous samples). Method 9045 (Section 7.2 of Method 9045) is referenced as the preparatory method for soil samples. The ORP and temperature probes are inserted directly into the soil slurry. The displayed ORP value is allowed to equilibrate and the resulting measurement is recorded. Other indirect indicators of reducing/oxidizing tendency include Total Organic Carbon (TOC), Chemical Oxygen Demand (COD), and Biological Oxygen Demand (BOD). Analysis of these additional parameters establishes the tendency of Cr(VI) to exist or not exist in the unspiked sample(s) and assists in the interpretation of QC data for matrix spike recoveries outside conventionally accepted criteria for total metals.

3.2 Certain substances, not typically found in the alkaline digests of soils, may interfere in the analytical methods for Cr(VI) following alkaline extraction if the concentrations of these interfering substances are high and the Cr(VI) concentration is low. Refer to Methods 7196 and 7199 for a discussion of the specific agents that may interfere with Cr(VI) quantification. Analytical techniques that reduce bias caused by co-extracted matrix components may be applicable in correcting these biases after validation of their performance effectiveness.

3.3 For waste materials or soils containing soluble Cr(III) concentrations greater than four times the laboratory Cr(VI) reporting limit, Cr(VI) results obtained using this method may be biased high due to method-induced oxidation. The addition of Mg^{2+} in a phosphate buffer to the alkaline extraction solution has been shown to suppress this oxidation. If an analytical method for Cr(VI) is used that can correct for possible method induced oxidation/reduction, then the Mg^{2+} addition is optional. The presence of soluble Cr(III) can be approximated by extracting the sample with deionized water (ASTM methods D4646-87, D5233-92, or D3987-85) and analyzing the resultant leachate for both Cr(VI) and total Cr. The difference between the two values approximates soluble Cr(III).

4.0 APPARATUS AND MATERIALS

4.1 Digestion vessel: borosilicate glass or quartz with a volume of 250 mL.

4.2 Graduated Cylinder: 100-mL or equivalent.

4.3 Volumetric Flasks: Class A glassware, 1000-mL and 100-mL, with stoppers or equivalent.

4.4 Vacuum Filtration Apparatus.

4.5 Filter membranes (0.45 µm). Preferably cellulosic or polycarbonate membranes. When vacuum filtration is performed, operation should be performed with recognition of the filter membrane breakthrough pressure.

4.6 Heating Device - capable of maintaining the digestion solution at 90-95°C with continuous auto stirring capability or equivalent.

4.7 Volumetric pipettes: Class A glassware, assorted sizes, as necessary.

4.8 Calibrated pH meter.

4.9 Calibrated balance.

4.10 Temperature measurement device (with NIST traceable calibration) capable of measuring up to 100°C (e.g. thermometer, thermistor, IR sensor, etc.).

4.11 An automated continuous stirring device (e.g. magnetic stirrer, motorized stirring rod, etc.), one for each digestion being performed.

5.0 REAGENTS

5.1 Nitric acid: 5.0 M HNO_3, analytical reagent grade or spectrograde quality. Store at 20-25°C in the dark. Do not use concentrated HNO_3 to make up 5.0 M solution if it has a yellow tinge; this is indicative of photoreduction of NO_3^- to NO_2, a reducing agent for Cr(VI).

5.2 Sodium carbonate: Na_2CO_3, anhydrous, analytical reagent grade. Store at 20-25°C in a tightly sealed container.

5.3 Sodium hydroxide: NaOH, analytical reagent grade. Store at 20-25°C in a tightly sealed container.

5.4 Magnesium Chloride: $MgCl_2$ (anhydrous), analytical reagent grade. A mass of 400 mg $MgCl_2$ is approximately equivalent to 100 mg Mg^{2+}. Store at 20-25°C in a tightly sealed container.

5.5 Phosphate Buffer:

5.5.1 K_2HPO_4: analytical reagent grade.

5.5.2 KH_2PO_4: analytical reagent grade.

5.5.3 0.5M K_2HPO_4/0.5M KH_2PO_4 buffer at pH 7: Dissolve 87.09 K_2HPO_4 and 68.04 g KH_2PO_4 into 700 mL of reagent water. Transfer to a 1L volumetric flask and dilute to volume.

5.6 Lead Chromate: $PbCrO_4$, analytical reagent grade. The insoluble matrix spike is prepared by adding 10-20 mg of $PbCrO_4$ to a separate sample aliquot. Store under dry conditions at 20-25°C in a tightly sealed container.

5.7 Digestion solution: Dissolve 20.0 ± 0.05 g NaOH and 30.0 ± 0.05 g Na_2CO_3 in reagent water in a one-liter volumetric flask and dilute to the mark. Store the solution in a tightly capped polyethylene bottle at 20-25°C and prepare fresh monthly. The pH of the digestion solution must be checked before using. The pH must be 11.5 or greater, if not, discard.

5.8 Potassium dichromate, $K_2Cr_2O_7$, spiking solution (1000 mg/L Cr(VI)): Dissolve 2.829 g of dried (105°C) $K_2Cr_2O_7$ in reagent water in a one-liter volumetric flask and dilute to the mark. Alternatively, a 1000 mg/L Cr(VI) certified primary standard solution can be used (Fisher AAS standard or equivalent). Store at 20-25°C in a tightly sealed container for use up to six months.

5.8.1 Matrix spiking solution (100 mg/L Cr(VI)): Add 10.0 mL of the 1000 mg Cr(VI)/L made from $K_2Cr_2O_7$ spiking solution (Section 5.8) to a 100 mL volumetric flask and dilute to volume with reagent water. Mix well.

5.9 Reagent Water - Reagent water will be free of interferences. Refer to Chapter One for a definition of reagent water.

6.0. SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 Samples must have been collected using a sampling plan that addresses the considerations discussed in Chapter Nine of this manual.

6.2 Samples should be collected using devices and placed in containers that do not contain stainless steel (e.g., plastic or glass).

6.3 Samples should be stored field-moist at 4 ± 2°C until analysis.

6.4 Hexavalent chromium has been shown to be quantitatively stable in field-moist soil samples for 30 days from sample collection. In addition, Cr(VI) has also been shown to be stable in the alkaline digestate for up to 168 hours after extraction from soil.

6.5 Hexavalent chromium solutions or waste material that are generated should be disposed of properly. One approach is to treat all Cr(VI) waste materials with ascorbic acid or other reducing agent to reduce the Cr(VI) to Cr(III). For additional information on health and safety issues relating to chromium, the user is referred to References 10.7 and 10.10.

7.0 PROCEDURE

7.1 Adjust the temperature setting of each heating device used in the alkaline digestion by preparing and monitoring a temperature blank [a 250 mL vessel filled with 50 mLs digestion solution (Section 5.7)]. Maintain a digestion solution temperature of 90-95°C as measured with a NIST-traceable thermometer or equivalent.

7.2 Place 2.5 ± 0.10 g of the field-moist sample into a clean and labeled 250 mL digestion vessel. The sample should have been mixed thoroughly before the aliquot is removed.

For the specific sample aliquot that is being spiked (Section 8.5), the spike material should be added directly to the sample aliquot at this point. (Percent solids determination, U.S. EPA CLP SOW for Organic Analysis, OLM03.1, 8/94 Rev.) should be performed on a separate aliquot in order to calculate the final result on a dry-weight basis).

7.3 Add 50 mL ± 1 mL of digestion solution (Section 5.7) to each sample using a graduated cylinder, and also add approximately 400 mg of $MgCl_2$ (Section 5.4) and 0.5 mL of 1.0M phosphate buffer (Section 5.5.3). For analytical techniques that can correct for oxidation/reduction of Cr, the addition of Mg^{2+} is optional. Cover all samples with watch glasses.

7.4 Stir the samples continuously (unheated) for at least five minutes using an appropriate stirring device.

7.5 Heat the samples to 90-95°C, then maintain the samples at 90-95°C for at least 60 minutes with continuous stirring.

7.6 Gradually cool, with continued agitation, each solution to room temperature. Transfer the contents quantitatively to the filtration apparatus; rinsing the digestion vessel with 3 successive portions of reagent water. Transfer the rinsates to the filtration apparatus. Filter through a 0.45µm membrane filter. Rinse the inside of the filter flask and filter pad with reagent water and transfer the filtrate and the rinses to a clean 250-mL vessel.

NOTE: The remaining solids and filter paper resulting from filtration of the matrix spike in Section 7.6 should be saved for possible use in assessing low Cr(VI) matrix spike recoveries. See Section 8.5.2. for additional details. Store the filtered solid at 4 ± 2°C.

7.7 Place an appropriate stirring device into the sample digest beaker, place the vessel on a stirrer, and, with constant stirring, slowly add 5.0 M nitric acid solution to the beaker dropwise. Adjust the pH of the solution to 7.5 ± 0.5 if the sample is to be analyzed using Method 7196 (adjust the pH accordingly if an alternate analytical method is to be used; i.e. 9.0 ± 0.5 if Method 7199 is to be used) and monitor the pH with a pH meter. If the pH of the digest should deviate from the desired range, discard the solution and redigest. If overshooting the desired pH range occurs repeatedly, prepare diluted nitric acid solution and repeat digestion procedure. If a flocculent precipitate should form, the sample should be filtered through a 0.45 µm membrane filter. If the filter becomes clogged using the 0.45 µm filter paper, a larger size filter paper (Whatman GFB or GFF) may be used to prefilter the samples.

CAUTION: CO_2 will be evolved. This step should be performed in a fume hood.

7.8 Remove the stirring device and rinse, collecting the rinsate in the beaker. Transfer quantitatively the contents of the vessel to a 100 mL volumetric flask and adjust the sample volume to 100 mL (to the mark for the volumetric flask) with reagent water. Mix well.

7.9 The sample digestates are now ready to be analyzed. Determine the Cr(VI) concentration in mg/kg by a suitable technique with appropriate accuracy and precision, for example Method 7196 (colorimetrically by UV-VIS spectrophotometry) or Method 7199 (colorimetrically by ion chromatography (IC)). Another analytical technique such as IC with inductively coupled plasma - mass spectrometric (ICP-MS) detection, high performance liquid chromatography (HPLC) with ICP-

MS detection, capillary electrophoresis (CE) with ICP-MS detection, etc. may be utilized once performance effectiveness has been validated.

7.10 CALCULATIONS

7.10.1 Sample Concentration

$$\text{Concentration} = \frac{A \times D \times E}{B \times C}$$

where: A = Concentration observed in the digest (µg/mL)
B = Initial moist sample weight (g)
C = % Solids/100
D = Dilution Factor
E = Final digest volume (mL)

7.10.2 Relative Percent Difference

$$\text{RPD} = \frac{(S - D)}{[(S + D)/2]}$$

where: S = Initial sample result
D = Duplicate sample result

7.10.3 Spike Recovery

$$\text{Percent Recovery} = \frac{(SSR - SR)}{SA} \times 100$$

where: SSR = Spike sample result
SR = Sample (unspiked) result
SA = Spike added

8.0 QUALITY CONTROL

8.1 The following Quality Control (QC) analyses must be performed per digestion batch as discussed in Chapter One.

8.2 A preparation blank must be prepared and analyzed with each digestion batch, as discussed in Chapter One and detected Cr(VI) concentrations must be less than the method detection limit or one-tenth the regulatory limit or action level, whichever is greater or the entire batch must be redigested.

8.3 Laboratory Control Sample (LCS): As an additional determination of method performance, utilize the matrix spike solution prepared in Section 5.8.1 or the solid matrix spiking agent $PbCrO_4$ (Section 5.6) to spike into 50 mL of digestion solution (Section 5.7). Alternatively, the use of a certified solid reference material (if available) is recommended. Recovery must be within the certified acceptance range or a recovery range of 80% to 120% or the sample batch must be reanalyzed.

8.4 A separately prepared duplicate soil sample must be analyzed at a frequency of one per batch as discussed in Chapter One. Duplicate samples must have a Relative Percent Difference (RPD) of $\leq$ 20%, if both the original and the duplicate are $\geq$ four times the laboratory reporting limit. A control limit of ± the laboratory reporting limit is used when either the original or the duplicate sample is < four times the laboratory reporting limit.

8.5 Both soluble and insoluble pre-digestion matrix spikes must be analyzed at a frequency of one each per batch of $\leq$ 20 field samples. The soluble matrix spike sample is spiked with 1.0 mL of the spiking solution prepared in Section 5.8.1 (equivalent to 40 mg Cr(VI)/Kg)) or at twice the sample concentration, whichever is greater. The insoluble matrix spike is prepared by adding 10-20 mg of $PbCrO_4$ (Section 5.6) to a separate sample aliquot. It is used to evaluate the dissolution during the digestion process. Both matrix spikes are then carried through the digestion process described in Section 7.0. More frequent matrix spikes must be analyzed if the soil characteristics within the analytical batch appear to have significant variability based on visual observation. An acceptance range for matrix spike recoveries is 75-125%. If the matrix spike recoveries are not within these recovery limits, the entire batch must be rehomogenized/redigested/reanalyzed. If upon reanalysis, the matrix spike is not within the recovery limits, but the LCS is within criteria specified in Section 8.3, information such as that specified on Figures 1 and 2 and in Section 3.1 should be carefully evaluated . The Cr(VI) data may be valid for use despite the perceived "QC failure." The information shown on Figure 1 and discussed below is provided to interpret ancillary parameter data in conjunction with data on spike recoveries.

8.5.1 First measure the pH (Method 9045) and Oxidation Reduction Potential (ORP) (ASTM Method D 1498-93 - aqueous samples, Method 9045 preparatory for soil samples), in the field if possible. If not possible, the measurements are to be made in the laboratory prior to the determination of the spike recovery data. When and where the measurements are taken must be noted by the analyst. Adjust the ORP measurement based on reference electrode correction factor to yield Eh values. The pH and Eh values should be plotted on Figure 2 in order to give an initial indication of the sample's reducing/oxidizing nature. Upon completion of the analysis of the analytical batch, the LCS should be evaluated. If the LCS is not within 80 - 120% recovery or the certified acceptance range, then the entire analytical batch (plus the QC samples) should be redigested and reanalyzed. If the LCS was within acceptance criteria and the pre-digestion matrix spike recoveries for Cr(VI) were less than the acceptance range minimum (75%), this indicates that the soil samples reduced Cr(VI) (e.g., anoxic sediments), and no measurable native Cr(VI) existed in the unspiked sample (assuming the criteria in Section 8.3 are met). Such a result indicates that the combined and interacting influences of ORP, pH and reducing agents (e.g., organic acids, Fe^{2+} and sulfides) caused reduction of Cr(VI) spikes. Characterize each matrix spike sample for additional analytical parameters, such as ferrous iron (ASTM Method D3872-86), and sulfides (Method 9030). Laboratory measurements of pH and ORP should also be performed to confirm the field measurements. Other indirect indicators of reducing/oxidizing tendency include Total Organic Carbon (TOC), Chemical Oxygen Demand (COD), and Biological Oxygen Demand (BOD). Analysis of these additional parameters assists in evaluating the tendency of Cr(VI) to exist or not exist in the unspiked sample(s) and assists in the interpretation of QC data for matrix spike recoveries outside conventionally accepted criteria for total metals.

A value of Eh-pH below the bold diagonal line on Fig. 2 indicates a reducing soil for Cr(VI). The downward slope to the right indicates that the Eh value, at which Cr(VI) is expected to be reduced, decreases with increasing pH. The solubility and quantity of organic constituents influence reduction of Cr(VI). The presence of H_2S or other strong odors indicates a reducing environment for Cr(VI). In general, acidic conditions accelerate reduction of Cr(VI) in soils, and alkaline conditions tend to stabilize Cr(VI) against reduction. If pre-digestion matrix spike recovery is not within the recovery limits, the reductive nature of the sample must be documented. This is done by plotting the Eh and pH data on the Eh-pH diagram (Fig. 2) to see if spike recovery is or is not expected in the soil. If the data point falls below the Cr(VI)-Cr(III) line on the diagram, then the data is not qualified or rejected. The sample is reducing for Cr(VI). If the data point falls above the line, then the sample is capable of supporting Cr(VI). In this case, technical error may be responsible for the poor spike recovery, and the extraction should be repeated, along with the Eh and pH measurements. If re-extraction results in a poor spike recovery again, then the data is qualified. At this point, review of other soil characteristics, such as levels of pH, Eh, TOC, sulfides, Fe(II), is appropriate to understand why poor spike recovery occurred. This extra review of these soil properties is only necessary if the unspiked sample contains detectable Cr(VI).

8.5.2 If a low or zero percent pre-digestion matrix spike recovery is obtained, an alternate approach can be used to determine the potential contribution of the sample matrix to Cr(VI) reduction. This approach consists of performing a mass balance, whereby total chromium is analyzed (Method 3052) for two samples: (1) a separate unspiked aliquot of the sample previously used for spiking, and (2) the digested solids remaining after the alkaline digestion and filtration of the matrix spike (i.e., the filtered solids from the matrix spike in Section 7.6).

The difference between the total chromium measurements should be approximately equal to the amount of the spike added to the matrix spike. If the LCS (Section 8.3) met the acceptance criteria and the Cr(VI) spike is accounted for in the filtered solids as total chromium, it is likely that the reduction of the Cr(VI) to insoluble Cr(III) resulted from the reducing matrix of the original sample subjected to Cr(VI) spiking.

8.6 A post-digestion Cr(VI) matrix spike must be analyzed per batch as discussed in Chapter One. The post-digestion matrix spike concentration should be equivalent to 40 mg/kg or twice the sample concentration observed in the unspiked aliquot of the test sample, whichever is greater.

8.6.1 Dilute the sample aliquot to a minimum extent, if necessary, so that the absorbance reading for both the unspiked sample aliquot and spiked aliquot are within the initial calibration curve.

8.6.2 A guideline for the post-digestion matrix spike recovery is 85-115%. If not achieved, consider the corrective actions/guidance on data use specified in Section 8.5 or the Method of Standard Additions (MSA) as specified in Section 8.0 of Method 7000. If the MSA technique is applied post digestion and no spike is observed from the MSA, these results indicate that the matrix is incompatible with Cr(VI) and no further effort on the part of the laboratory is required. These digestates may contain soluble reducing agents for Cr(VI), such as fulvic acids.

9.0 METHOD PERFORMANCE

9.1 A commercial laboratory analyzed soil/sediment samples containing Cr(VI) with the results found in Table 1.

10.0 REFERENCES

10.1 United States Environmental Protection Agency, 1982. Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods. SW-846, Second Edition. Office of Solid Waste and Emergency Response, Washington, D.C.

10.2 New Jersey Department of Environmental Protection and Energy (NJDEPE). NJDEPE Modified Methods 3060/7196. 1992.

10.3 Vitale, R., G. Mussoline, J. Petura, B. James, 1993. A Method Evaluation Study of an Alkaline Digestion (Modified Method 3060) Followed by Colorimetric Determination (Method 7196) for the Analysis for Hexavalent Chromium in Solid Matrices. Environmental Standards, Inc. Valley Forge, PA 19482.

10.4 Zatka, V.J., 1985. Speciation of Hexavalent Chromium in Welding Fumes Interference by Air Oxidation of Chromium. J. Ray Gordon Research Laboratory, INCO Limited, Sheridan Park, Mississauga, Ontario L5K 1Z9, Am. Ind. Hyg. Assoc. J., 46(6) : 327-331.

10.5 ASTM (American Society for Testing and Materials), 1981. Standard Practice for Oxidation Reduction Potential of Water. ASTM Designation:D1498-93.

10.6 Vitale, R.J., Mussoline, G.R., Petura, J.C. and James, B.R. 1994. Hexavalent Chromium Extraction from Soils: Evaluation of an Alkaline Digestion Method. J. Environ. Qual. 23:1249-1256.

10.7 U.S. Department of Health and Human Services - Agency for Toxic Substances and Disease Registry. Toxicological Profile for Chromium. April, 1993.

10.8 Vitale, R.J., Mussoline, G.R., Petura, J.C. and James, B.R. 1995. Hexavalent Chromium Quantification in Soils: An Effective and Reliable Procedure. Am. Env. Lab., April Ed.

10.9 James, B.R., Petura, J.C., Vitale, R.J., and Mussoline, G.R. 1995. Hexavalent Chromium Extraction form Soils: A Comparison of Five Methods. Environ. Sci. Technol. 29:2377-2381.

10.10 U.S. Environmental Protection Agency. 1993. IRIS: A continuously updated electronic database maintained by the U.S. Environmental Protection Agency. National Library of Medicine, Bethesda, MD.

10.11 ASTM (American Society for Testing and Materials), 1981. Standard Test Method for Ferrous Iron in Iron Oxides. ASTM Designation:D3872-86.

10.12 ASTM (American Society for Testing and Materials), 1981. Standard Test Method for 24-h Batch-Type Measurement of Contaminant Sorption by Soil and Sediments. ASTM Designation:D4646-87.

10.13 ASTM (American Society for Testing and Materials), 1981. Standard Test Method for Single Batch Extraction Method for Waters. ASTM Designation:D5233-92.

10.14 ASTM (American Society for Testing and Materials), 1981. Standard Test Method for Shake Extraction of Solid Waste with Water. ASTM Designation:D3987-85.

10.15 U.S. EPA Contract Laboratory Program, Statement of Work for Organic Analysis, Multimedia Multiconcentration Document, OLM03.1, 8/94 Rev.

TABLE 1
SINGLE LABORATORY METHOD EVALUATION DATA

Sample Type	Eh (mV)[b]	pH[d]	S^{2-} (ppm)[c]	Mean Native Cr(VI) Conc. (mg/kg)	Mean Cr(VI) Spike Conc. (mg/kg)	Matrix Spike Recovery Range,%
COPR[a]/Soil Blends	550	7.4	<10.0	4.1	42.0	89.8-116
Loam	620	6.4	<10.0	ND	62.5	65.0-70.3
Clay	840	3.0	<10.0	ND	63.1	37.8-71.1
COPR[a]	460	7.4	<10.0	759	813	85.5-94.8
Anoxic Sediment	-189	7.2	25.0	ND	381	0
Quartz Sand	710	5.3	<10.0	ND	9.8	75.5-86.3

Source: Reference 10.3

Notes:

ND	-	Not detected
a	-	COPR - chromite ore processing residue
b	-	Corrected for the reference electrode, laboratory field moist measurement
c	-	Field measurement
d	-	Laboratory field moist measurement

FIGURE 1
QUALITY CONTROL FLOW CHART

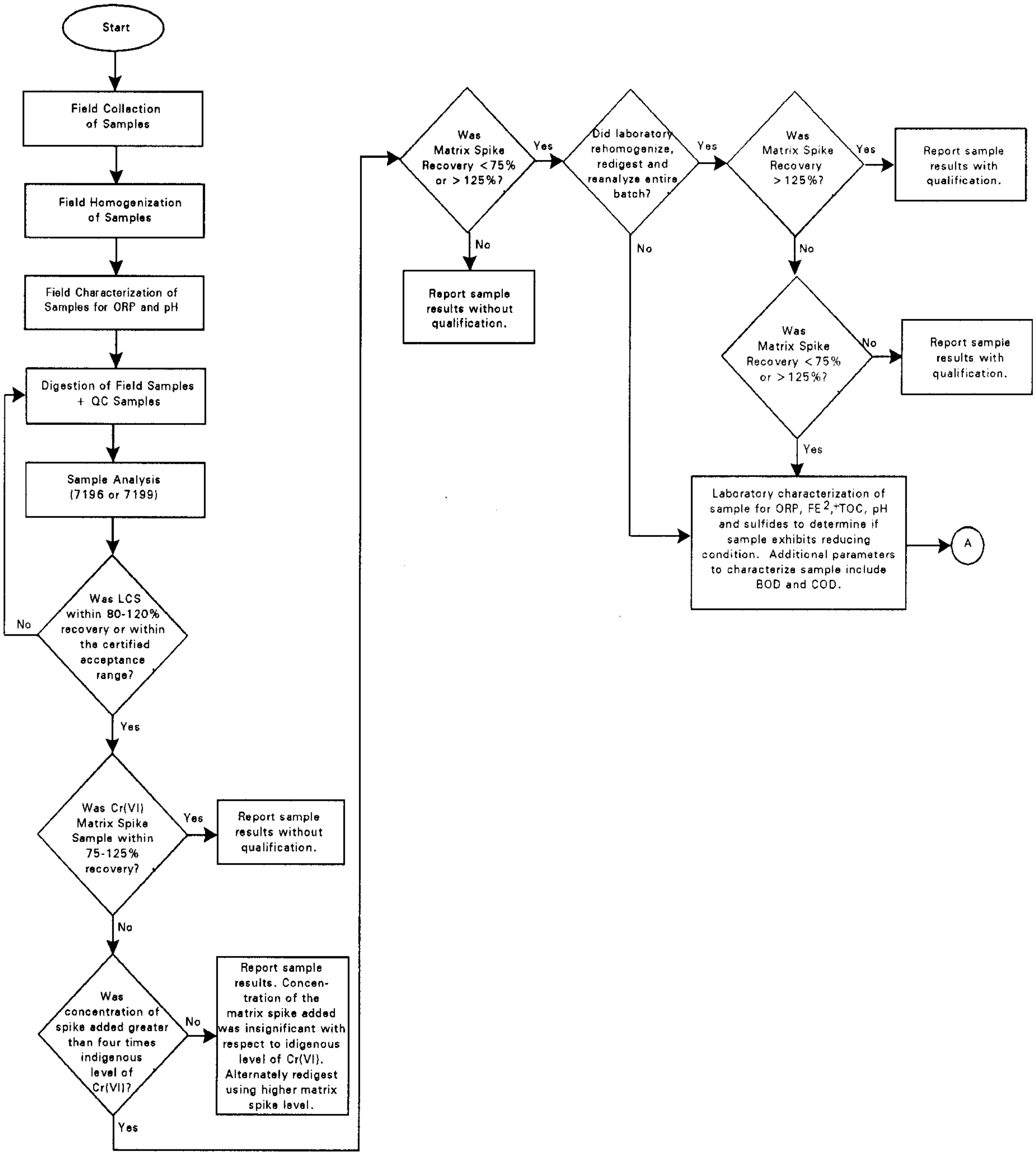


FIGURE 1
QUALITY CONTROL FLOW CHART (Continued)

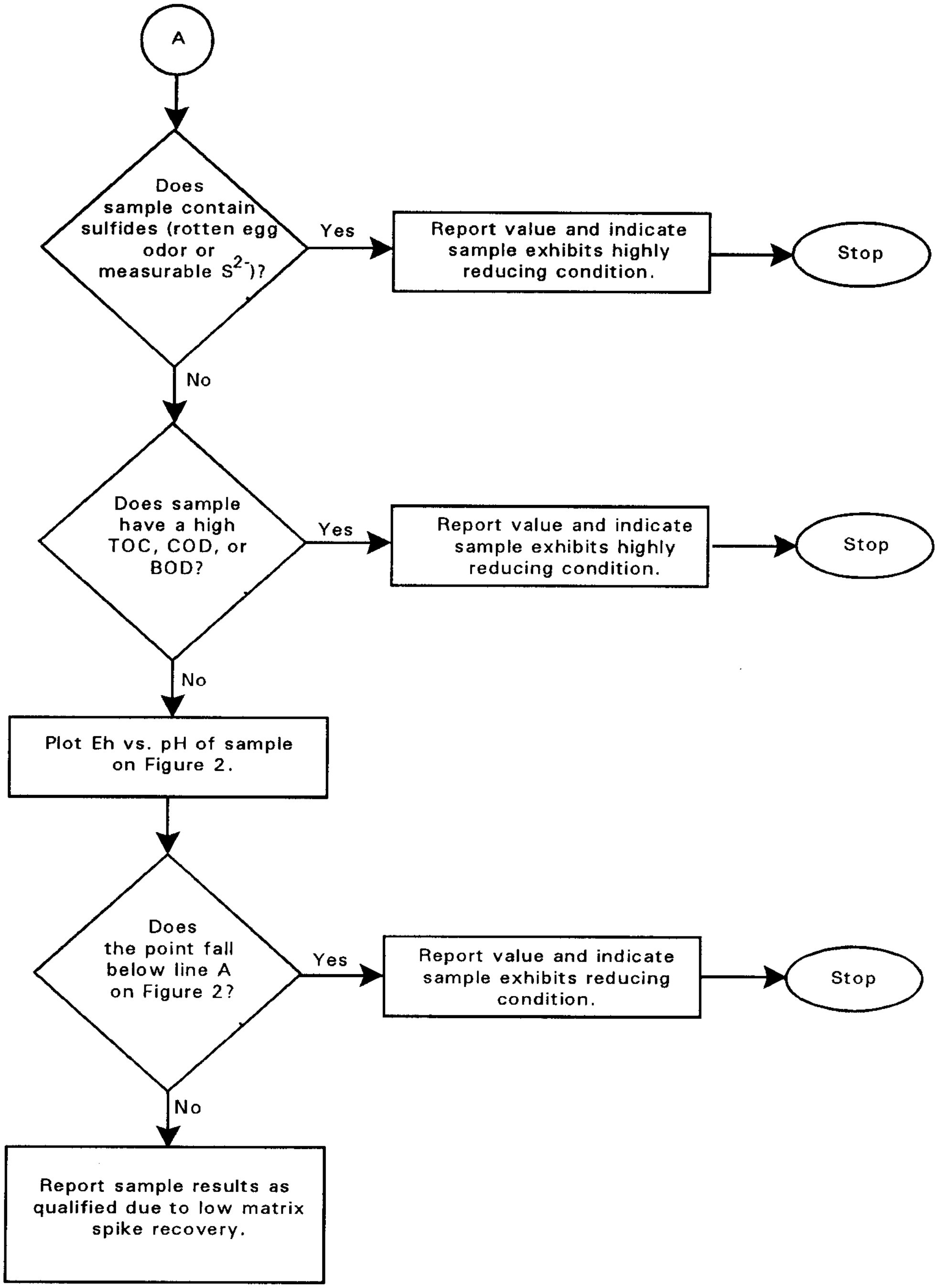
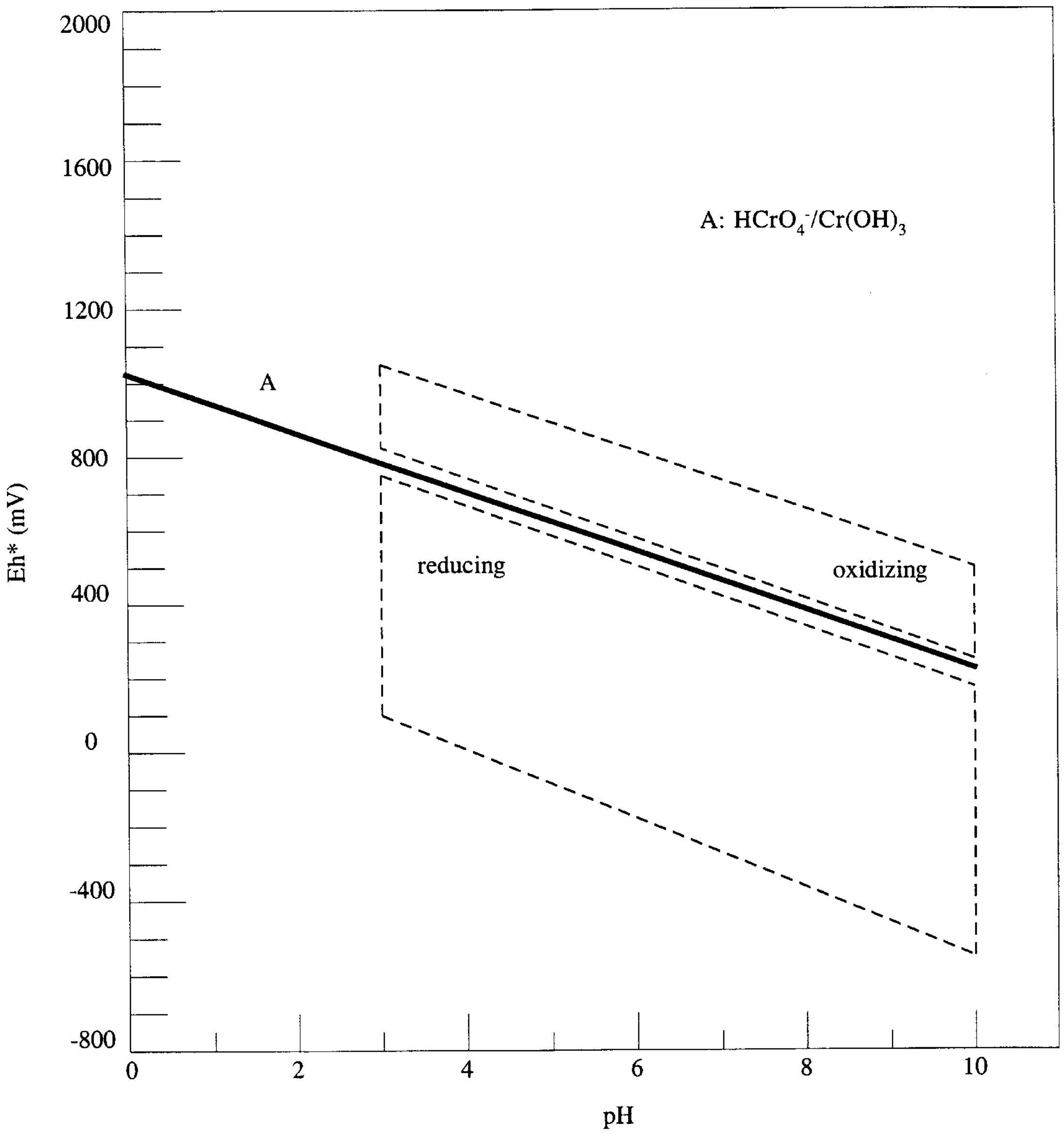


FIGURE 2
Eh/pH PHASE DIAGRAM

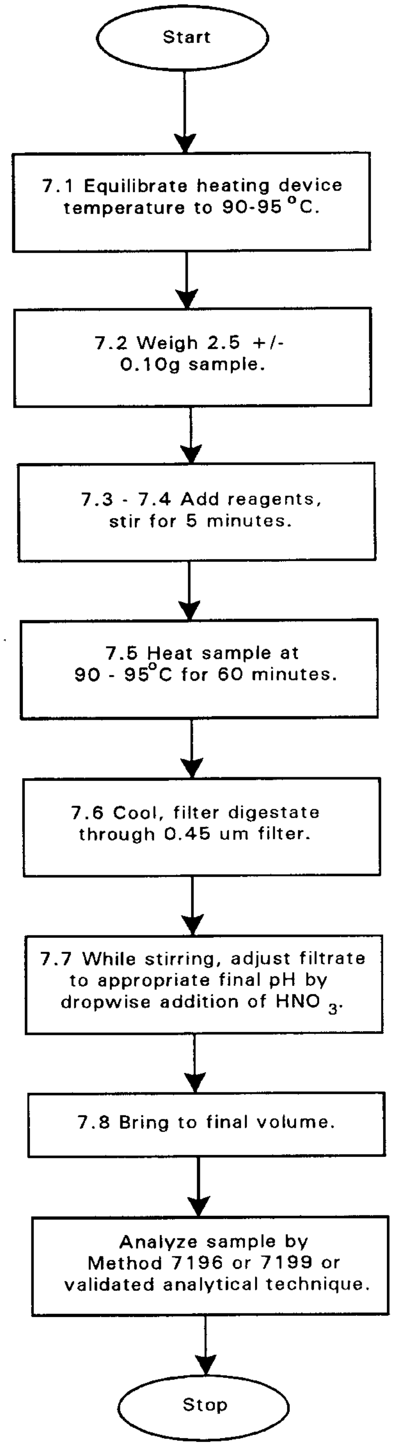
The dashed lines define Eh-pH boundaries commonly encountered in soils and sediments.



* Note the Eh values plotted on this diagram are corrected for the reference electrode voltage: 244 mV units must be added to the measured value when a separate calomel electrode is used, or 199 mV units must be added if a combination platinum electrode is used.

METHOD 3060A

ALKALINE DIGESTION FOR HEXAVALENT CHROMIUM



METHOD 7196A

CHROMIUM, HEXAVALENT (COLORIMETRIC)

1.0 SCOPE AND APPLICATION

1.1 Method 7196 is used to determine the concentration of dissolved hexavalent chromium [Cr(VI)] in EP/TCLP characteristic extracts and ground waters. This method may also be applicable to certain domestic and industrial wastes, provided that no interfering substances are present (see Paragraph 3.1 below).

1.2 Method 7196 may be used to analyze samples containing from 0.5 to 50 mg of Cr(VI) per liter.

2.0 SUMMARY OF METHOD

2.1 Dissolved hexavalent chromium, in the absence of interfering amounts of substances such as molybdenum, vanadium, and mercury, may be determined colorimetrically by reaction with diphenylcarbazide in acid solution. A red-violet color of unknown composition is produced. The reaction is very sensitive, the absorbancy index per gram atom of chromium being about 40,000 at 540 nm. Addition of an excess of diphenylcarbazide yields the red-violet product, and its absorbance is measured photometrically at 540 nm.

3.0 INTERFERENCES

3.1 The chromium reaction with diphenylcarbazide is usually free from interferences. However, certain substances may interfere if the chromium concentration is relatively low. Hexavalent molybdenum and mercury salts also react to form color with the reagent; however, the red-violet intensities produced are much lower than those for chromium at the specified pH. Concentrations of up to 200 mg/L of molybdenum and mercury can be tolerated. Vanadium interferes strongly, but concentrations up to 10 times that of chromium will not cause trouble.

3.2 Iron in concentrations greater than 1 mg/L may produce a yellow color, but the ferric iron color is not strong and difficulty is not normally encountered if the absorbance is measured photometrically at the appropriate wavelength.

4.0 APPARATUS AND MATERIALS

4.1 Colorimetric equipment: One of the following is required: _Either_ a spectrophotometer, for use at 540 nm, providing a light path of 1 cm or longer, _or_ a filter photometer, providing a light path of 1 cm or longer and equipped with a greenish-yellow filter having maximum transmittance near 540 nm.

5.0 REAGENTS

5.1 Reagent water: Reagent water should be monitored for impurities.

5.2 Potassium dichromate stock solution: Dissolve 141.4 mg of dried potassium dichromate, $K_2Cr_2O_7$ (analytical reagent grade), in reagent water and dilute to 1 liter (1 mL = 50 ug Cr).

5.3 Potassium dichromate standard solution: Dilute 10.00 mL potassium dichromate stock solution to 100 mL (1 mL = 5 ug Cr).

5.4 Sulfuric acid, 10% (v/v): Dilute 10 mL of distilled reagent grade or spectrograde quality sulfuric acid, H_2SO_4, to 100 mL with reagent water.

5.5 Diphenylcarbazide solution: Dissolve 250 mg 1,5-diphenylcarbazide in 50 mL acetone. Store in a brown bottle. Discard when the solution becomes discolored.

5.6 Acetone (analytical reagent grade): Avoid or redistill material that comes in containers with metal or metal-lined caps.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 All samples must have been collected using a sampling plan that addresses the considerations discussed in Chapter Nine of this manual.

6.2 Since the stability of Cr(VI) in extracts is not completely understood at this time, the analysis should be carried out as soon as possible.

6.3 To retard the chemical activity of hexavalent chromium, the samples and extracts should be stored at 4°C until analyzed. The maximum holding time prior to analysis of the samples or extracts is 24 hr. The 24 hr holding time begins after extraction.

7.0 PROCEDURE

7.1 Color development and measurement: Transfer 95 mL of the extract to be tested to a 100-mL volumetric flask. Add 2.0 mL diphenylcarbazide solution and mix. Add H_2SO_4 solution to give a pH of 2 ± 0.5, dilute to 100 mL with reagent water, and let stand 5 to 10 min for full color development. Transfer an appropriate portion of the solution to a 1-cm absorption cell and measure its absorbance at 540 nm. Use reagent water as a reference. Correct the absorbance reading of the sample by subtracting the absorbance of a blank carried through the method (see Note below). An aliquot of the sample containing all reagents except diphenylcarbazide should be prepared and used to correct the sample for turbidity (i.e., a turbidity blank). From the corrected absorbance, determine the mg/L of chromium present by reference to the calibration curve.

NOTE: If the solution is turbid after dilution to 100 mL in Step 7.1, above, take an absorbance reading before adding the carbazide reagent and correct the absorbance reading of the final colored solution by subtracting the absorbance measured previously.

7.2 Preparation of calibration curve:

7.2.1 To compensate for possible slight losses of chromium during digestion or other operations of the analysis, treat the chromium standards by the same procedure as the sample. Accordingly, pipet a chromium standard solution in measured volumes into 250-mL beakers or conical flasks to generate standard concentrations ranging from 0.5 to 5 mg/L Cr(VI) when diluted to the appropriate volume.

7.2.2 Develop the color of the standards as for the samples. Transfer a suitable portion of each colored solution to a 1-cm absorption cell and measure the absorbance at 540 nm. As reference, use reagent water. Correct the absorbance readings of the standards by subtracting the absorbance of a reagent blank carried through the method. Construct a calibration curve by plotting corrected absorbance values against mg/L of Cr(VI).

7.3 Verification:

7.3.1 For every sample matrix analyzed, verification is required to ensure that neither a reducing condition nor chemical interference is affecting color development. This must be accomplished by analyzing a second 10-mL aliquot of the pH-adjusted filtrate that has been spiked with Cr(VI). The amount of spike added should double the concentration found in the original aliquot. Under no circumstances should the increase be less than 30 µg Cr(VI)/liter. To verify the absence of an interference, the spike recovery must be between 85% and 115%.

7.3.2 If addition of the spike extends the concentration beyond the calibration curve, the analysis solution should be diluted with blank solution and the calculated results adjusted accordingly.

7.3.3 If the result of verification indicates a suppressive interference, the sample should be diluted and reanalyzed.

7.3.4 If the interference persists after sample dilution, an alternative method (Method 7195, Coprecipitation, or Method 7197, Chelation/Extraction) should be used.

7.4 Acidic extracts that yield recoveries of less than 85% should be retested to determine if the low spike recovery is due to the presence of residual reducing agent. This determination shall be performed by first making an aliquot of the extract alkaline (pH 8.0-8.5) using 1 N sodium hydroxide and then respiking and analyzing. If a spike recovery of 85-115% is obtained in the alkaline aliquot of an acidic extract that initially was found to contain less than 5 mg/L Cr(VI), one can conclude that the analytical method has been verified.

7.5 Analyze all extracts, all samples analyzed as part of a delisting petition, and all samples that suffer from matrix interferences by the method of standard additions (see Method 7000, Section 8.7).

8.0 QUALITY CONTROL

8.1 All quality control data should be maintained and available for easy reference or inspection. Refer to Chapter One for more information.

8.2 Dilute samples if they are more concentrated than the highest standard or if they fall on the plateau of a calibration curve.

8.3 Employ a minimum of one blank per sample batch to determine if contamination or any memory effects are occurring.

8.4 Verify calibration with an independently prepared check standard every 15 samples.

8.5 Run one matrix spike replicate or one replicate sample for every ten samples. A duplicate sample is a sample brought through the whole sample preparation and analytical process. Refer to Chapter One for more information concerning matrix spikes and matrix spike duplicates.

8.6 The method of standard additions (see Method 7000, Section 8.7) shall be used for the analysis of all extracts, on all analyses submitted as part of a delisting petition, and whenever a new sample matrix is being analyzed.

9.0 METHOD PERFORMANCE

9.1 The data shown in Table 1 were obtained from records of state and contractor laboratories. The data are intended to show the precision of the combined sample preparation and analysis method.

10.0 REFERENCES

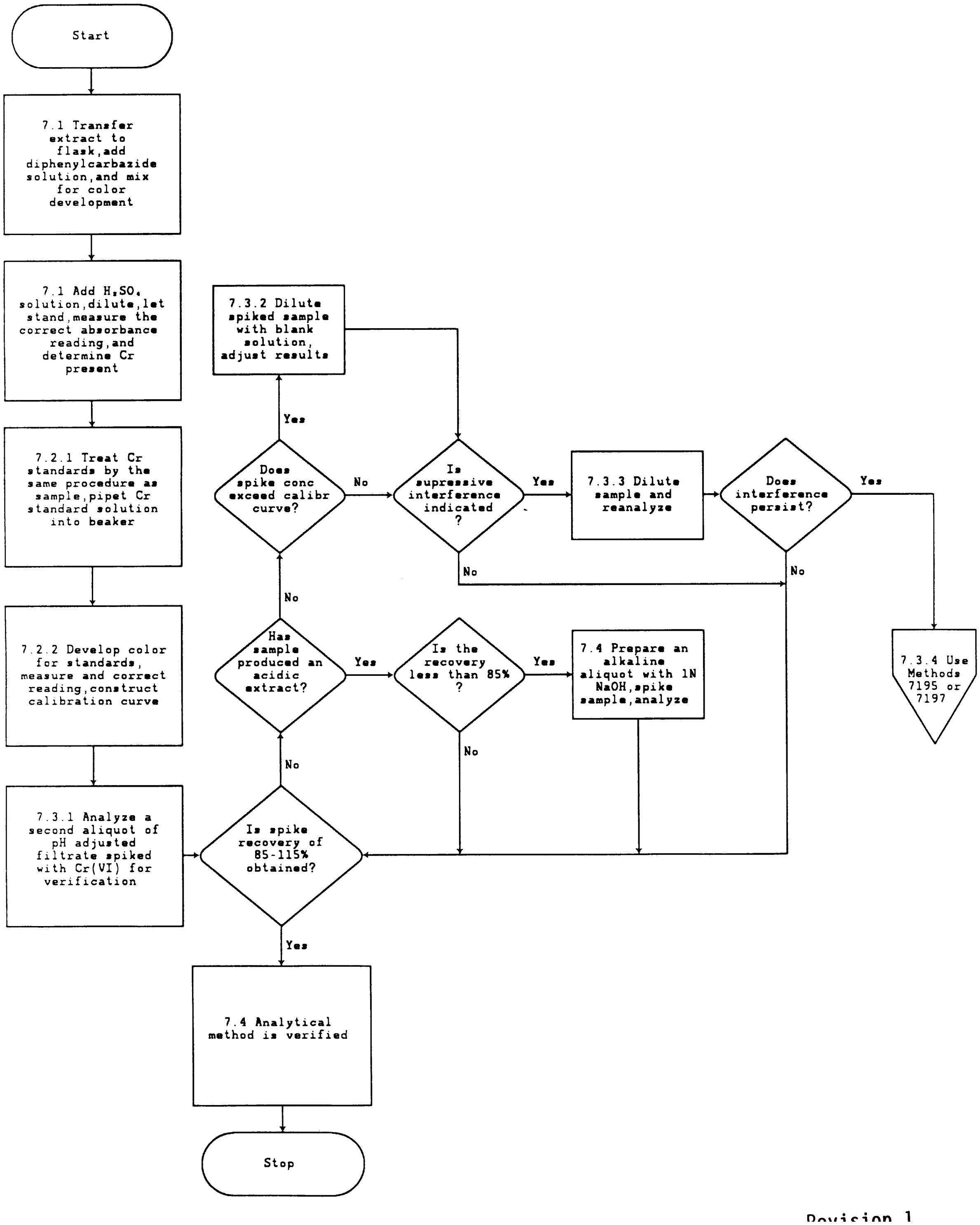
1. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-82-055, December 1982, Methods 218.4 and 218.5.

2. Gaskill, A., Compilation and Evaluation of RCRA Method Performance Data, Work Assignment No. 2, EPA Contract No. 68-01-7075, September 1986.

TABLE 1. METHOD PERFORMANCE DATA

Sample Matrix	Preparation Method	Laboratory Replicates
Wastewater treatment sludge	Not known	0.096, 0.107 ug/g
Sediment from chemical storage area	3060	115, 117 ug/g

METHOD 7196A
CHROMIUM, HEXAVALENT (COLORIMETRIC)



Revision 1

APPENDIX B
Laboratory Reporting Forms for 2018 Excavation and Groundwater Sampling

Adirondack Environmental Services, Inc.®

Experience is the solution
314 North Pearl Street ♦ Albany, New York 12207
(800) 848-4983 ♦ (518) 434-4546 ♦ Fax (518) 434-0891

June 17, 2019

Andy Vitolins
Arcadis
855 Route 146, Suite 210
Clifton Park, NY 12065
TEL: (518) 250-7382

Work Order No: 180815099
PO#: 02118217.0000

RE: Watervliet Arsenal

Dear Andy Vitolins:

Adirondack Environmental Services, Inc received 7 samples on 8/15/2018 for the analyses presented in the following report.

Please see case narrative for specifics on analysis.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

Tara Daniels

ELAP#: 10709

Tara Daniels
Laboratory Director

CLIENT:	Arcadis	**Date:** *17-Jun-19*
Project:	Watervliet Arsenal	
Lab Order:	180815099	

Sample containers were supplied by Adirondack Environmental Services.

At the request of client, this is an updated report to correct sample identification for sample 180815099-001 to SUMP-120 PIT-08152018.

Definitions - RL: Reporting Limit DF: Dilution factor

Qualifiers:	ND : Not Detected at reporting limit	C: CCV below acceptable Limits
	J: Analyte detected below quantitation limit	C+: CCV above acceptable Limits
	B: Analyte detected in Blank	S: LCS Spike recovery is below acceptable limits
	X : Exceeds maximum contamination limit	S+: LCS Spike recovery is above acceptable limits
	H: Hold time exceeded	Z: Duplication outside acceptable limits
	N: Matrix Spike below acceptable limits	T : Tentatively Identified Compound-Estimated
	N+: Matrix Spike is above acceptable limits	E :Above quantitation range-Estimated

Note : All Results are reported as wet weight unless noted

The results relate only to the items tested. Information supplied by the client is assumed to be correct.

CLIENT:	Arcadis	**Client Sample ID:**	SUMP-120 PIT-08152018
Work Order:	**180815099**	**Collection Date:**	8/15/2018 8:50:00 AM
Reference:	Watervliet Arsenal /	**Lab Sample ID:**	180815099-001
PO#:	02118217.0000	**Matrix:**	AQUEOUS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS - EPA 200.7 REV 4.4						Analyst: **KH**
(Prep: - 8/16/2018)						
Aluminum	**0.342**	0.100		mg/L	1	8/16/2018 1:26:00 PM
Antimony	**ND**	0.060		mg/L	1	8/16/2018 1:26:00 PM
Arsenic	**ND**	0.005		mg/L	1	8/16/2018 1:26:00 PM
Barium	**2.50**	0.010		mg/L	1	8/16/2018 1:26:00 PM
Beryllium	**ND**	0.005		mg/L	1	8/16/2018 1:26:00 PM
Cadmium	**ND**	0.005		mg/L	1	8/16/2018 1:26:00 PM
Calcium	**23.6**	0.050		mg/L	1	8/16/2018 1:26:00 PM
Chromium	**0.015**	0.005		mg/L	1	8/16/2018 1:26:00 PM
Cobalt	**ND**	0.050		mg/L	1	8/16/2018 1:26:00 PM
Copper	**0.047**	0.005		mg/L	1	8/16/2018 1:26:00 PM
Iron	**6.44**	0.050		mg/L	1	8/16/2018 1:26:00 PM
Lead	**0.015**	0.005		mg/L	1	8/16/2018 1:26:00 PM
Magnesium	**7.52**	0.050		mg/L	1	8/16/2018 1:26:00 PM
Manganese	**2.48**	0.020		mg/L	1	8/16/2018 1:26:00 PM
Nickel	**ND**	0.020		mg/L	1	8/16/2018 1:26:00 PM
Potassium	**24.3**	0.050		mg/L	1	8/16/2018 1:26:00 PM
Selenium	**ND**	0.005		mg/L	1	8/16/2018 1:26:00 PM
Silver	**ND**	0.010		mg/L	1	8/16/2018 1:26:00 PM
Sodium	**333**	0.500		mg/L	10	8/16/2018 1:37:00 PM
Thallium	**0.019**	0.010		mg/L	1	8/16/2018 1:26:00 PM
Vanadium	**ND**	0.020		mg/L	1	8/16/2018 1:26:00 PM
Zinc	**0.118**	0.010		mg/L	1	8/16/2018 1:26:00 PM
MERCURY - EPA 245.1 REV 3.0						Analyst: **AVB**
(Prep: E245.1 - 8/16/2018)						
Mercury	**ND**	0.0002		mg/L	1	8/16/2018 1:20:55 PM
HEXAVALENT CHROMIUM - SM3500-CR B-2011						Analyst: **DAA**
Chromium, Hexavalent	**ND**	0.02		mg/L	1	8/15/2018 5:15:00 PM

CLIENT:	Arcadis	**Client Sample ID:**	SUMP-COMMPIT-08152018
Work Order:	**180815099**	**Collection Date:**	8/15/2018 9:00:00 AM
Reference:	Watervliet Arsenal /	**Lab Sample ID:**	180815099-002
PO#:	02118217.0000	**Matrix:**	AQUEOUS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS - EPA 200.7 REV 4.4 (Prep: - 8/16/2018)						Analyst: **KH**
Aluminum	**ND**	1.00		mg/L	10	8/16/2018 3:14:00 PM
Antimony	**4.09**	0.600		mg/L	10	8/16/2018 3:14:00 PM
Arsenic	**0.112**	0.050		mg/L	10	8/16/2018 3:14:00 PM
Barium	**0.166**	0.100		mg/L	10	8/16/2018 3:14:00 PM
Beryllium	**ND**	0.050		mg/L	10	8/16/2018 3:14:00 PM
Cadmium	**ND**	0.050		mg/L	10	8/16/2018 3:14:00 PM
Calcium	**191**	0.500		mg/L	10	8/16/2018 3:14:00 PM
Chromium	**232**	0.500		mg/L	100	8/16/2018 3:18:00 PM
Cobalt	**ND**	0.500		mg/L	10	8/16/2018 3:14:00 PM
Copper	**ND**	0.050		mg/L	10	8/16/2018 3:14:00 PM
Iron	**ND**	0.500		mg/L	10	8/16/2018 3:14:00 PM
Lead	**ND**	0.050		mg/L	10	8/16/2018 3:14:00 PM
Magnesium	**38.3**	0.500		mg/L	10	8/16/2018 3:14:00 PM
Manganese	**0.739**	0.200		mg/L	10	8/16/2018 3:14:00 PM
Nickel	**ND**	0.200		mg/L	10	8/16/2018 3:14:00 PM
Potassium	**12.9**	0.500		mg/L	10	8/16/2018 3:14:00 PM
Selenium	**ND**	0.050		mg/L	10	8/16/2018 3:14:00 PM
Silver	**ND**	0.100		mg/L	10	8/16/2018 3:14:00 PM
Sodium	**199**	0.500		mg/L	10	8/16/2018 3:14:00 PM
Thallium	**ND**	0.100		mg/L	10	8/16/2018 3:14:00 PM
Vanadium	**ND**	0.200		mg/L	10	8/16/2018 3:14:00 PM
Zinc	**0.113**	0.100		mg/L	10	8/16/2018 3:14:00 PM
MERCURY - EPA 245.1 REV 3.0 (Prep: E245.1 - 8/16/2018)						Analyst: **AVB**
Mercury	**ND**	0.0002		mg/L	1	8/16/2018 1:22:36 PM
HEXAVALENT CHROMIUM - SM3500-CR B-2011						Analyst: **DAA**
Chromium, Hexavalent	**680**	100		mg/L	5000	8/15/2018 5:15:00 PM

CLIENT:	Arcadis	**Client Sample ID:**	WVA-AW-MN-38-08152018
Work Order:	**180815099**	**Collection Date:**	8/15/2018 3:55:00 PM
Reference:	Watervliet Arsenal /	**Lab Sample ID:**	180815099-003
PO#:	02118217.0000	**Matrix:**	AQUEOUS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS - EPA 200.7 REV 4.4						Analyst: **KH**
(Prep: - 8/16/2018)						
Aluminum	**ND**	0.100		mg/L	1	8/16/2018 1:43:00 PM
Antimony	**ND**	0.060		mg/L	1	8/16/2018 1:43:00 PM
Arsenic	**ND**	0.005		mg/L	1	8/16/2018 1:43:00 PM
Barium	**1.95**	0.010		mg/L	1	8/16/2018 1:43:00 PM
Beryllium	**ND**	0.005		mg/L	1	8/16/2018 1:43:00 PM
Cadmium	**ND**	0.005		mg/L	1	8/16/2018 1:43:00 PM
Calcium	**77.2**	0.050		mg/L	1	8/16/2018 1:43:00 PM
Chromium	**0.008**	0.005		mg/L	1	8/16/2018 1:43:00 PM
Cobalt	**ND**	0.050		mg/L	1	8/16/2018 1:43:00 PM
Copper	**0.007**	0.005		mg/L	1	8/16/2018 1:43:00 PM
Iron	**0.124**	0.050		mg/L	1	8/16/2018 1:43:00 PM
Lead	**ND**	0.005		mg/L	1	8/16/2018 1:43:00 PM
Magnesium	**31.9**	0.050		mg/L	1	8/16/2018 1:43:00 PM
Manganese	**0.171**	0.020		mg/L	1	8/16/2018 1:43:00 PM
Nickel	**ND**	0.020		mg/L	1	8/16/2018 1:43:00 PM
Potassium	**20.2**	0.050		mg/L	1	8/16/2018 1:43:00 PM
Selenium	**ND**	0.005		mg/L	1	8/16/2018 1:43:00 PM
Silver	**ND**	0.010		mg/L	1	8/16/2018 1:43:00 PM
Sodium	**174**	0.500		mg/L	10	8/16/2018 2:00:00 PM
Thallium	**0.011**	0.010		mg/L	1	8/16/2018 1:43:00 PM
Vanadium	**ND**	0.020		mg/L	1	8/16/2018 1:43:00 PM
Zinc	**ND**	0.010		mg/L	1	8/16/2018 1:43:00 PM
MERCURY - EPA 245.1 REV 3.0						Analyst: **AVB**
(Prep: E245.1 - 8/16/2018)						
Mercury	**ND**	0.0002		mg/L	1	8/16/2018 1:24:17 PM
HEXAVALENT CHROMIUM - SM3500-CR B-2011						Analyst: **DAA**
Chromium, Hexavalent	**ND**	0.02		mg/L	1	8/15/2018 5:15:00 PM

Adirondack Environmental Services, Inc

Date: *17-Jun-19*

CLIENT:	Arcadis	**Client Sample ID:**	93EM-SP-9-08152018
Work Order:	**180815099**	**Collection Date:**	8/15/2018 3:40:00 PM
Reference:	Watervliet Arsenal /	**Lab Sample ID:**	180815099-004
PO#:	02118217.0000	**Matrix:**	AQUEOUS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS - EPA 200.7 REV 4.4						Analyst: **KH**
(Prep: - 8/16/2018)						
Aluminum	**0.368**	0.100		mg/L	1	8/16/2018 2:05:00 PM
Antimony	**ND**	0.060		mg/L	1	8/16/2018 2:05:00 PM
Arsenic	**ND**	0.005		mg/L	1	8/16/2018 2:05:00 PM
Barium	**0.039**	0.010		mg/L	1	8/16/2018 2:05:00 PM
Beryllium	**ND**	0.005		mg/L	1	8/16/2018 2:05:00 PM
Cadmium	**ND**	0.005		mg/L	1	8/16/2018 2:05:00 PM
Calcium	**32.2**	0.050		mg/L	1	8/16/2018 2:05:00 PM
Chromium	**0.030**	0.005		mg/L	1	8/16/2018 2:05:00 PM
Cobalt	**ND**	0.050		mg/L	1	8/16/2018 2:05:00 PM
Copper	**0.019**	0.005		mg/L	1	8/16/2018 2:05:00 PM
Iron	**0.935**	0.050		mg/L	1	8/16/2018 2:05:00 PM
Lead	**0.019**	0.005		mg/L	1	8/16/2018 2:05:00 PM
Magnesium	**2.42**	0.050		mg/L	1	8/16/2018 2:05:00 PM
Manganese	**0.069**	0.020		mg/L	1	8/16/2018 2:05:00 PM
Nickel	**ND**	0.020		mg/L	1	8/16/2018 2:05:00 PM
Potassium	**2.01**	0.050		mg/L	1	8/16/2018 2:05:00 PM
Selenium	**ND**	0.005		mg/L	1	8/16/2018 2:05:00 PM
Silver	**ND**	0.010		mg/L	1	8/16/2018 2:05:00 PM
Sodium	**19.7**	0.050		mg/L	1	8/16/2018 2:05:00 PM
Thallium	**ND**	0.010		mg/L	1	8/16/2018 2:05:00 PM
Vanadium	**ND**	0.020		mg/L	1	8/16/2018 2:05:00 PM
Zinc	**0.059**	0.010		mg/L	1	8/16/2018 2:05:00 PM
MERCURY - EPA 245.1 REV 3.0						Analyst: **AVB**
(Prep: E245.1 - 8/16/2018)						
Mercury	**ND**	0.0002		mg/L	1	8/16/2018 1:25:59 PM
HEXAVALENT CHROMIUM - SM3500-CR B-2011						Analyst: **DAA**
Chromium, Hexavalent	**ND**	0.02		mg/L	1	8/15/2018 5:15:00 PM

CLIENT:	Arcadis	**Client Sample ID:**	93EM-SP-11-08152018
Work Order:	**180815099**	**Collection Date:**	8/15/2018 3:03:00 PM
Reference:	Watervliet Arsenal /	**Lab Sample ID:**	180815099-005
PO#:	02118217.0000	**Matrix:**	AQUEOUS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS - EPA 200.7 REV 4.4						Analyst: **KH**
(Prep: - 8/16/2018)						
Aluminum	**0.978**	0.100		mg/L	1	8/16/2018 2:08:00 PM
Antimony	**ND**	0.060		mg/L	1	8/16/2018 2:08:00 PM
Arsenic	**ND**	0.005		mg/L	1	8/16/2018 2:08:00 PM
Barium	**0.086**	0.010		mg/L	1	8/16/2018 2:08:00 PM
Beryllium	**ND**	0.005		mg/L	1	8/16/2018 2:08:00 PM
Cadmium	**ND**	0.005		mg/L	1	8/16/2018 2:08:00 PM
Calcium	**57.7**	0.050		mg/L	1	8/16/2018 2:08:00 PM
Chromium	**0.013**	0.005		mg/L	1	8/16/2018 2:08:00 PM
Cobalt	**ND**	0.050		mg/L	1	8/16/2018 2:08:00 PM
Copper	**0.012**	0.005		mg/L	1	8/16/2018 2:08:00 PM
Iron	**1.68**	0.050		mg/L	1	8/16/2018 2:08:00 PM
Lead	**0.005**	0.005		mg/L	1	8/16/2018 2:08:00 PM
Magnesium	**18.9**	0.050		mg/L	1	8/16/2018 2:08:00 PM
Manganese	**0.453**	0.020		mg/L	1	8/16/2018 2:08:00 PM
Nickel	**ND**	0.020		mg/L	1	8/16/2018 2:08:00 PM
Potassium	**13.0**	0.050		mg/L	1	8/16/2018 2:08:00 PM
Selenium	**ND**	0.005		mg/L	1	8/16/2018 2:08:00 PM
Silver	**ND**	0.010		mg/L	1	8/16/2018 2:08:00 PM
Sodium	**107**	0.500		mg/L	10	8/16/2018 2:36:00 PM
Thallium	**0.011**	0.010		mg/L	1	8/16/2018 2:08:00 PM
Vanadium	**ND**	0.020		mg/L	1	8/16/2018 2:08:00 PM
Zinc	**0.087**	0.010		mg/L	1	8/16/2018 2:08:00 PM
MERCURY - EPA 245.1 REV 3.0						Analyst: **AVB**
(Prep: E245.1 - 8/16/2018)						
Mercury	**ND**	0.0002		mg/L	1	8/16/2018 1:27:41 PM
HEXAVALENT CHROMIUM - SM3500-CR B-2011						Analyst: **DAA**
Chromium, Hexavalent	**ND**	0.02		mg/L	1	8/15/2018 5:15:00 PM

Adirondack Environmental Services, Inc

Date: *17-Jun-19*

CLIENT:	Arcadis	**Client Sample ID:**	WVA-AW-35-MW-S-08152018
Work Order:	**180815099**	**Collection Date:**	8/15/2018 3:55:00 PM
Reference:	Watervliet Arsenal /	**Lab Sample ID:**	180815099-006
PO#:	02118217.0000	**Matrix:**	AQUEOUS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS - EPA 200.7 REV 4.4						Analyst: **KH**
(Prep: - 8/16/2018)						
Aluminum	**ND**	0.100		mg/L	1	8/16/2018 2:43:00 PM
Antimony	**ND**	0.060		mg/L	1	8/16/2018 2:43:00 PM
Arsenic	**ND**	0.005		mg/L	1	8/16/2018 2:43:00 PM
Barium	**3.68**	0.010		mg/L	1	8/16/2018 2:43:00 PM
Beryllium	**ND**	0.005		mg/L	1	8/16/2018 2:43:00 PM
Cadmium	**ND**	0.005		mg/L	1	8/16/2018 2:43:00 PM
Calcium	**24.4**	0.050		mg/L	1	8/16/2018 2:43:00 PM
Chromium	**ND**	0.005		mg/L	1	8/16/2018 2:43:00 PM
Cobalt	**ND**	0.050		mg/L	1	8/16/2018 2:43:00 PM
Copper	**ND**	0.005		mg/L	1	8/16/2018 2:43:00 PM
Iron	**0.050**	0.050		mg/L	1	8/16/2018 2:43:00 PM
Lead	**ND**	0.005		mg/L	1	8/16/2018 2:43:00 PM
Magnesium	**7.44**	0.050		mg/L	1	8/16/2018 2:43:00 PM
Manganese	**0.114**	0.020		mg/L	1	8/16/2018 2:43:00 PM
Nickel	**ND**	0.020		mg/L	1	8/16/2018 2:43:00 PM
Potassium	**20.4**	0.050		mg/L	1	8/16/2018 2:43:00 PM
Selenium	**ND**	0.005		mg/L	1	8/16/2018 2:43:00 PM
Silver	**ND**	0.010		mg/L	1	8/16/2018 2:43:00 PM
Sodium	**269**	0.500		mg/L	10	8/16/2018 2:48:00 PM
Thallium	**0.014**	0.010		mg/L	1	8/16/2018 2:43:00 PM
Vanadium	**ND**	0.020		mg/L	1	8/16/2018 2:43:00 PM
Zinc	**ND**	0.010		mg/L	1	8/16/2018 2:43:00 PM
MERCURY - EPA 245.1 REV 3.0						Analyst: **AVB**
(Prep: E245.1 - 8/16/2018)						
Mercury	**ND**	0.0002		mg/L	1	8/16/2018 1:29:23 PM
HEXAVALENT CHROMIUM - SM3500-CR B-2011						Analyst: **DAA**
Chromium, Hexavalent	**ND**	0.02		mg/L	1	8/15/2018 5:15:00 PM

CLIENT:	Arcadis	**Client Sample ID:**	DUP-GW-08152018
Work Order:	**180815099**	**Collection Date:**	8/15/2018
Reference:	Watervliet Arsenal /	**Lab Sample ID:**	180815099-007
PO#:	02118217.0000	**Matrix:**	AQUEOUS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS - EPA 200.7 REV 4.4						Analyst: **KH**
(Prep: - 8/16/2018)						
Aluminum	**ND**	0.100		mg/L	1	8/16/2018 3:00:00 PM
Antimony	**ND**	0.060		mg/L	1	8/16/2018 3:00:00 PM
Arsenic	**ND**	0.005		mg/L	1	8/16/2018 3:00:00 PM
Barium	**3.77**	0.010		mg/L	1	8/16/2018 3:00:00 PM
Beryllium	**ND**	0.005		mg/L	1	8/16/2018 3:00:00 PM
Cadmium	**ND**	0.005		mg/L	1	8/16/2018 3:00:00 PM
Calcium	**25.0**	0.050		mg/L	1	8/16/2018 3:00:00 PM
Chromium	**ND**	0.005		mg/L	1	8/16/2018 3:00:00 PM
Cobalt	**ND**	0.050		mg/L	1	8/16/2018 3:00:00 PM
Copper	**ND**	0.005		mg/L	1	8/16/2018 3:00:00 PM
Iron	**ND**	0.050		mg/L	1	8/16/2018 3:00:00 PM
Lead	**ND**	0.005		mg/L	1	8/16/2018 3:00:00 PM
Magnesium	**7.60**	0.050		mg/L	1	8/16/2018 3:00:00 PM
Manganese	**0.117**	0.020		mg/L	1	8/16/2018 3:00:00 PM
Nickel	**ND**	0.020		mg/L	1	8/16/2018 3:00:00 PM
Potassium	**20.9**	0.050		mg/L	1	8/16/2018 3:00:00 PM
Selenium	**ND**	0.005		mg/L	1	8/16/2018 3:00:00 PM
Silver	**ND**	0.010		mg/L	1	8/16/2018 3:00:00 PM
Sodium	**327**	0.500		mg/L	10	8/16/2018 3:04:00 PM
Thallium	**0.016**	0.010		mg/L	1	8/16/2018 3:00:00 PM
Vanadium	**ND**	0.020		mg/L	1	8/16/2018 3:00:00 PM
Zinc	**ND**	0.010		mg/L	1	8/16/2018 3:00:00 PM
MERCURY - EPA 245.1 REV 3.0						Analyst: **AVB**
(Prep: E245.1 - 8/16/2018)						
Mercury	**ND**	0.0002		mg/L	1	8/16/2018 1:31:05 PM
HEXAVALENT CHROMIUM - SM3500-CR B-2011						Analyst: **DAA**
Chromium, Hexavalent	**ND**	0.02		mg/L	1	8/15/2018 5:15:00 PM

Adirondack
Environmental Services Inc.

314 North Pearl Street
Albany, NY 12207
518-434-4546 / 518-434-0891 FAX

EXPERIENCE IS THE SOLUTION

CHAIN OF CUSTODY RECORD

AES Work Order#: 180815099

A full service analytical research laboratory offering solutions to environmental concerns

Client Name: Arcadis U.S., Inc.	Address: 855 Route 146, Suite 210, Clifton Park, NY 12065	
Send Report to: Andy Vitolins	Project Name (Location): Watervliet Arsenal	Samplers Name: Aubrey Thomas
Client Phone #: 518-250-7359 Client Email: andy.vitolins@arcadis.com	Client PO #: 02118217.0000	Samplers Signature:

AES Sample Number	Client Sample Identification & Location	Date Sampled	Time A=am P=pm		Sample Type Matrix	C	G	Number of Cont's	Analysis
001	SUMP-110PIT-08152018	8-15-18	0850	[✓ A] P	AQ		X	2	TAL Metals, Hex Chrome
002	SUMP-COMMPIT-08152018		0900	[✓ A] P					
003	WVA-AW-MW-38-08152018		1555	A [✓ P]					
004	93EM-SP-9-08152018		1540	A [✓ P]					
005	93EM-SP-11-08152018		1503	A [✓ P]					
006	WVA-AW-35-MW-S-08152018		1355	A [✓ P]					
007	DUP-GW-08152018		—	A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					

8-15-2018

Shipment Arrived Via:
FedEx UPS Client AES Other:________

Turnaround Time Requested:
1 Day 3 Day Normal 24 hrs
2 Day 5 Day
NOTE: Samples received after 3:30pm are considered next business day.

Special Instructions/Remarks:
Hexavalent Chromium
First sample @ 0850
08152018

Relinquished by: (Signature) Arcadis	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received for Laboratory by:	Date 8/15/18	Time 4:31 Pm

Sample Temperature	Properly Preserved	Received Within Holding Times
Ambient ~ [✓ Chilled]	[✓ Y] N	[✓ Y] N
Notes: 13°C	Notes:	

Demo
180815099

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TERMS, CONDITIONS & LIMITATIONS

All service rendered by the **Adirondack Environmental Services, Inc.** are undertaken and all rates are based upon the following terms:

(a) Neither **Adirondack Environmental Services, Inc.**, nor any of its employees, agents or sub-contractors shall be liable for any loss or damage arising out of **Adirondack Environmental Services, Inc.'s** performance or nonperformance, whether by way of negligence or breach of contract, or otherwise, in any amount greater than twice the amount billed to the customer for the work leading to the claim of the customer. Said remedy shall be the sole and exclusive remedy against **Adirondack Environmental Services, Inc.** arising out of its work.

(b) All claims made must be in writing within forty-five (45) days after delivery of the **Adirondack Environmental Services, Inc.** report regarding said work or such claim shall be deemed or irrevocably waived.

(c) **Adirondack Environmental Services, Inc.** reports are submitted in writing and are for our customers only. Our customers are considered to be only those entities being billed for our services. Acquisition of an **Adirondack Environmental Services, Inc.** report by other than our customer does not constitute a representation of **Adirondack Environmental Services, Inc.** as to the accuracy of the contents thereof.

(d) In no event shall **Adirondack Environmental Services, Inc.**, its employees, agents or sub-contractors be responsible for consequential or special damages of any kind or in any amount.

(e) No deviation from the terms set forth herein shall bind **Adirondack Environmental Services, Inc.** unless in writing and signed by a Director of **Adirondack Environmental Services, Inc.**

(f) Results pertain only to items analyzed. Information supplied by client is assumed to be correct. This information may be used on reports and in calculations and **Adirondack Environmental Services, Inc.** is not responsible for the accuracy of this information.

(g) Payments by Credit Card/Purchase Cards are subject to a 3% additional charge.

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August 27, 2018

Andy Vitolins
Arcadis
855 Route 146, Suite 210
Clifton Park, NY 12065
TEL: (518) 250-7382

Work Order No: 180824037

RE: Watervliet Arsenal

Dear Andy Vitolins:

Adirondack Environmental Services, Inc received 1 sample on 8/24/2018 for the analyses presented in the following report.

Please see case narrative for specifics on analysis.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

Krzysztof Trafalski
Laboratory Manager

ELAP#: 10709

Adirondack Environmental Services, Inc

CASE NARRATIVE

CLIENT:	Arcadis	**Date:** *27-Aug-18*
Project:	Watervliet Arsenal	
Lab Order:	180824037	

Sample containers were supplied by Adirondack Environmental Services.

Definitions - RL: Reporting Limit DF: Dilution factor

Qualifiers:		
	ND : Not Detected at reporting limit	C: CCV below acceptable Limits
	J: Analyte detected below quantitation limit	C+: CCV above acceptable Limits
	B: Analyte detected in Blank	S: LCS Spike recovery is below acceptable limits
	X : Exceeds maximum contamination limit	S+: LCS Spike recovery is above acceptable limits
	H: Hold time exceeded	Z: Duplication outside acceptable limits
	N: Matrix Spike below acceptable limits	T : Tentatively Identified Compound-Estimated
	N+: Matrix Spike is above acceptable limits	E :Above quantitation range-Estimated

Note : All Results are reported as wet weight unless noted

The results relate only to the items tested. Information supplied by the client is assumed to be correct.

Adirondack Environmental Services, Inc

Date: *27-Aug-18*

CLIENT:	Arcadis	**Client Sample ID:**	Excav Sump
Work Order:	**180824037**	**Collection Date:**	8/24/2018 1:45:00 PM
Reference:	Watervliet Arsenal /	**Lab Sample ID:**	180824037-001
PO#:		**Matrix:**	WATER

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS - EPA 200.7 REV 4.4 **(Prep: - 8/27/2018)**						Analyst: **KH**
Aluminum	**4.84**	0.100		mg/L	1	8/27/2018 1:40:00 PM
Antimony	**ND**	0.060		mg/L	1	8/27/2018 1:40:00 PM
Arsenic	**ND**	0.005		mg/L	1	8/27/2018 1:40:00 PM
Barium	**0.297**	0.010		mg/L	1	8/27/2018 1:40:00 PM
Beryllium	**ND**	0.005		mg/L	1	8/27/2018 1:40:00 PM
Cadmium	**ND**	0.005		mg/L	1	8/27/2018 1:40:00 PM
Calcium	**72.9**	0.050		mg/L	1	8/27/2018 1:40:00 PM
Chromium	**3.42**	0.005		mg/L	1	8/27/2018 1:40:00 PM
Cobalt	**ND**	0.050		mg/L	1	8/27/2018 1:40:00 PM
Copper	**ND**	0.005		mg/L	1	8/27/2018 1:40:00 PM
Iron	**10.6**	0.050		mg/L	1	8/27/2018 1:40:00 PM
Lead	**ND**	0.005		mg/L	1	8/27/2018 1:40:00 PM
Magnesium	**17.1**	0.050		mg/L	1	8/27/2018 1:40:00 PM
Manganese	**0.407**	0.020		mg/L	1	8/27/2018 1:40:00 PM
Nickel	**ND**	0.020		mg/L	1	8/27/2018 1:40:00 PM
Potassium	**16.2**	0.050		mg/L	1	8/27/2018 1:40:00 PM
Selenium	**ND**	0.005		mg/L	1	8/27/2018 1:40:00 PM
Silver	**ND**	0.010		mg/L	1	8/27/2018 1:40:00 PM
Sodium	**16.3**	0.050		mg/L	1	8/27/2018 1:40:00 PM
Thallium	**0.027**	0.010		mg/L	1	8/27/2018 1:40:00 PM
Vanadium	**ND**	0.020		mg/L	1	8/27/2018 1:40:00 PM
Zinc	**0.033**	0.010		mg/L	1	8/27/2018 1:40:00 PM
MERCURY - EPA 245.1 REV 3.0 **(Prep: E245.1 - 8/27/2018)**						Analyst: **AVB**
Mercury	**ND**	0.0002		mg/L	1	8/27/2018 1:03:30 PM
HEXAVALENT CHROMIUM - SM3500-CR B-2011						Analyst: **DAA**
Chromium, Hexavalent	**2.7**	1.0		mg/L	50	8/24/2018 3:45:00 PM

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CHAIN OF CUSTODY RECORD

AES Work Order # 180824037

A full service analytical research laboratory offering solutions to environmental concerns

Client Name: ARCADIS U.S, INC,

Address: 855 ROUTE 146, SUITE 210 CLIFTON PARK, NY 12065

Send Report To: ANDY VITOLINS

Project Name (Location): WATERVLIET ARSENAL

Samplers: (Names) STEFAN BAGNATO

Client Phone No: 518-250-7300

Client Email: andy.vitolins@arcadis.com

PO Number: 02112217.0000

Samplers: (Signature)

AES Sample Number	Client Sample Identification & Location	Date Sampled	Time	A=a.m. P=p.m.	Sample Type Matrix	Comp	Grab	Number of Cont's	Analysis Required
001	EXCAV SUMP	8/24/18	1345	A [✓ P]	WATER		X	2	TAL METALS HEX. CHROME
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					

Shipment Arrived Via:

FedEx UPS Client AES Other:____________

CC Report To / Special Instructions/Remarks:

stefan.bagnato@arcadis.com

Turnaround Time Request:

☒ 1 Day ☐ 3 Day ☐ Normal

☐ 2 Day ☐ 5 Day

Note: Samples received after 3:30 pm are considered next business day

Relinquished by: (Signature)	Received by: (Signature)	Date/Time
Relinquished by: (Signature)	**Received by: (Signature)**	**Date/Time**
Relinquished by: (Signature)	**Received for Laboratory by:**	**Date/Time**
		8/24/18 2:10pm

TEMPERATURE

Ambient or [✓ Chilled]

Notes: 21°C

AES Bottles

Y ☒ N ☐

PROPERLY PRESERVED

[✓ Y] N

Notes:____________

RECEIVED WITHIN HOLDING TIMES

[✓ Y] N

Notes:____________

WHITE - Lab Copy **YELLOW** - Sampler Copy

Adirondack Environmental Services,

180824037

Adirondack
Environmental Services Inc.®
Experience is the solution
314 North Pearl Street • Albany, New York 12207 • (518) 434-4546 • Fax (518) 434-0891

TERMS, CONDITIONS & LIMITATIONS

All service rendered by the **Adirondack Environmental Services, Inc.** are undertaken and all rates are based upon the following terms:

(a) Neither **Adirondack Environmental Services, Inc.,** nor any of its employees, agents or sub-contractors shall be liable for any loss or damage arising out of **Adirondack Environmental Services, Inc.'s** performance or nonperformance, whether by way of negligence or breach of contract, or otherwise, in any amount greater than twice the amount billed to the customer for the work leading to the claim of the customer. Said remedy shall be the sole and exclusive remedy against **Adirondack Environmental Services, Inc.** arising out of its work.

(b) All claims made must be in writing within forty-five (45) days after delivery of the **Adirondack Environmental Services, Inc.** report regarding said work or such claim shall be deemed or irrevocably waived.

(c) **Adirondack Environmental Services, Inc.** reports are submitted in writing and are for our customers only. Our customers are considered to be only those entities being billed for our services. Acquisition of an **Adirondack Environmental Services, Inc.** report by other than our customer does not constitute a representation of **Adirondack Environmental Services, Inc.** as to the accuracy of the contents thereof.

(d) In no event shall **Adirondack Environmental Services, Inc.,** its employees, agents or sub-contractors be responsible for consequential or special damages of any kind or in any amount.

(e) No deviation from the terms set forth herein shall bind **Adirondack Environmental Services, Inc.** unless in writing and signed by a Director of **Adirondack Environmental Services, Inc.**

(f) Results pertain only to items analyzed. Information supplied by client is assumed to be correct. This information may be used on reports and in calculations and **Adirondack Environmental Services, Inc.** is not responsible for the accuracy of this information.

(g) Payments by Credit Card/Purchase Cards are subject to a 3% additional charge.

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314 North Pearl Street ♦ Albany, New York 12207
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August 28, 2018

Andy Vitolins
Arcadis
855 Route 146, Suite 210
Clifton Park, NY 12065
TEL: (518) 250-7382

Work Order No: 180824021

RE: Watervliet Arsenal

Dear Andy Vitolins:

Adirondack Environmental Services, Inc received 9 samples on 8/24/2018 for the analyses presented in the following report.

Please see case narrative for specifics on analysis.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

Krzysztof Trafalski
Laboratory Manager

ELAP#: 10709

CLIENT:	Arcadis	**Date:** *28-Aug-18*
Project:	Watervliet Arsenal	
Lab Order:	180824021	

Sample containers were supplied by Adirondack Environmental Services.

Definitions - RL: Reporting Limit DF: Dilution factor

Qualifiers:		
	ND : Not Detected at reporting limit	C: CCV below acceptable Limits
	J: Analyte detected below quantitation limit	C+: CCV above acceptable Limits
	B: Analyte detected in Blank	S: LCS Spike recovery is below acceptable limits
	X : Exceeds maximum contamination limit	S+: LCS Spike recovery is above acceptable limits
	H: Hold time exceeded	Z: Duplication outside acceptable limits
	N: Matrix Spike below acceptable limits	T : Tentatively Identified Compound-Estimated
	N+: Matrix Spike is above acceptable limits	E :Above quantitation range-Estimated

Note : All Results are reported as wet weight unless noted

The results relate only to the items tested. Information supplied by the client is assumed to be correct.

CLIENT: Arcadis
Project: Watervliet Arsenal

LabWork Order: 180824021
PO#:

Lab SampleID: 180824021-001
Client Sample ID: ADJ Ext Wall

Collection Date: 8/24/2018
Matrix: SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-EPA 6010C						Analyst: **WB**
(Prep: SW3050B - 8/24/2018)						
Aluminum	**12000**	53.0		µg/g-dry	10	8/27/2018 2:32:13 PM
Antimony	**ND**	3.20		µg/g-dry	1	8/27/2018 2:27:48 PM
Arsenic	**4.89**	0.270		µg/g-dry	1	8/27/2018 2:27:48 PM
Barium	**73.3**	0.530		µg/g-dry	1	8/27/2018 2:27:48 PM
Beryllium	**0.546**	0.270		µg/g-dry	1	8/27/2018 2:27:48 PM
Cadmium	**1.45**	0.270		µg/g-dry	1	8/27/2018 2:27:48 PM
Calcium	**13600**	270		µg/g-dry	10	8/27/2018 2:32:13 PM
Chromium	**15.6**	0.270		µg/g-dry	1	8/27/2018 2:27:48 PM
Cobalt	**7.58**	2.70		µg/g-dry	1	8/27/2018 2:27:48 PM
Copper	**30.6**	0.270		µg/g-dry	1	8/27/2018 2:27:48 PM
Iron	**31200**	270		µg/g-dry	100	8/27/2018 4:18:15 PM
Lead	**15.8**	0.270		µg/g-dry	1	8/27/2018 2:27:48 PM
Magnesium	**6240**	270		µg/g-dry	10	8/27/2018 2:32:13 PM
Manganese	**423**	0.530		µg/g-dry	1	8/27/2018 2:27:48 PM
Nickel	**19.2**	2.70		µg/g-dry	1	8/27/2018 2:27:48 PM
Potassium	**1430**	27.0		µg/g-dry	1	8/27/2018 2:27:48 PM
Selenium	**ND**	0.270		µg/g-dry	1	8/27/2018 2:27:48 PM
Silver	**ND**	1.10		µg/g-dry	1	8/27/2018 2:27:48 PM
Sodium	**205**	27.0	B	µg/g-dry	1	8/27/2018 2:27:48 PM
Thallium	**ND**	0.530		µg/g-dry	1	8/27/2018 2:27:48 PM
Vanadium	**20.3**	2.70		µg/g-dry	1	8/27/2018 2:27:48 PM
Zinc	**68.7**	0.530		µg/g-dry	1	8/27/2018 2:27:48 PM
MERCURY - SW 7471B						Analyst: **AVB**
(Prep: SW7471B - 8/24/2018)						
Mercury	**ND**	0.021		µg/g-dry	1	8/24/2018 3:53:46 PM
HEXAVALENT CHROMIUM - SW 7196A (3060A)						Analyst: **DAA**
(Prep: SW3060A - 8/27/2018)						
Chromium, Hexavalent	**ND**	1.1	S	µg/g-dry	1	8/28/2018 11:30:00 AM
MOISTURE CONTENT-ASTM D2216 (NOT ELAP CERTIFIED)						Analyst: **TSZ**
Percent Moisture	**5.8**	0.1		wt%	1	8/24/2018

CLIENT: Arcadis
Project: Watervliet Arsenal

LabWork Order: **180824021**
PO#:

Lab SampleID: 180824021-002 **Collection Date:** 8/24/2018
Client Sample ID: ADJ w. Duct **Matrix:** SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-EPA 6010C						Analyst: **WB**
(Prep: SW3050B - 8/24/2018)						
Aluminum	**11500**	56.0		µg/g-dry	10	8/27/2018 2:47:30 PM
Antimony	**ND**	3.40		µg/g-dry	1	8/27/2018 2:36:25 PM
Arsenic	**3.55**	0.280		µg/g-dry	1	8/27/2018 2:36:25 PM
Barium	**75.4**	0.560		µg/g-dry	1	8/27/2018 2:36:25 PM
Beryllium	**0.520**	0.280		µg/g-dry	1	8/27/2018 2:36:25 PM
Cadmium	**1.44**	0.280		µg/g-dry	1	8/27/2018 2:36:25 PM
Calcium	**4260**	280		µg/g-dry	10	8/27/2018 2:47:30 PM
Chromium	**19.4**	0.280		µg/g-dry	1	8/27/2018 2:36:25 PM
Cobalt	**7.67**	2.80		µg/g-dry	1	8/27/2018 2:36:25 PM
Copper	**28.0**	0.280		µg/g-dry	1	8/27/2018 2:36:25 PM
Iron	**28000**	280		µg/g-dry	100	8/27/2018 4:28:13 PM
Lead	**14.3**	0.280		µg/g-dry	1	8/27/2018 2:36:25 PM
Magnesium	**6090**	280		µg/g-dry	10	8/27/2018 2:47:30 PM
Manganese	**530**	0.560		µg/g-dry	1	8/27/2018 2:36:25 PM
Nickel	**19.1**	2.80		µg/g-dry	1	8/27/2018 2:36:25 PM
Potassium	**1350**	28.0		µg/g-dry	1	8/27/2018 2:36:25 PM
Selenium	**ND**	0.280		µg/g-dry	1	8/27/2018 2:36:25 PM
Silver	**ND**	1.10		µg/g-dry	1	8/27/2018 2:36:25 PM
Sodium	**157**	28.0	B	µg/g-dry	1	8/27/2018 2:36:25 PM
Thallium	**ND**	0.560		µg/g-dry	1	8/27/2018 2:36:25 PM
Vanadium	**18.9**	2.80		µg/g-dry	1	8/27/2018 2:36:25 PM
Zinc	**111**	0.560		µg/g-dry	1	8/27/2018 2:36:25 PM
MERCURY - SW 7471B						Analyst: **AVB**
(Prep: SW7471B - 8/24/2018)						
Mercury	**ND**	0.022		µg/g-dry	1	8/24/2018 3:55:28 PM
HEXAVALENT CHROMIUM - SW 7196A (3060A)						Analyst: **DAA**
(Prep: SW3060A - 8/27/2018)						
Chromium, Hexavalent	**ND**	1.1	S	µg/g-dry	1	8/28/2018 11:30:00 AM
MOISTURE CONTENT-ASTM D2216 (NOT ELAP CERTIFIED)						Analyst: **TSZ**
Percent Moisture	**11.0**	0.1		wt%	1	8/24/2018

CLIENT:	Arcadis	**LabWork Order:**	**180824021**
Project:	Watervliet Arsenal	**PO#:**	

Lab SampleID:	180824021-003	**Collection Date:**	8/24/2018
Client Sample ID:	OS	**Matrix:**	SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-EPA 6010C						Analyst: **WB**
(Prep: SW3050B - 8/24/2018)						
Aluminum	**12600**	54.0		µg/g-dry	10	8/27/2018 2:55:53 PM
Antimony	**3.90**	3.20		µg/g-dry	1	8/27/2018 2:51:29 PM
Arsenic	**3.34**	0.270		µg/g-dry	1	8/27/2018 2:51:29 PM
Barium	**93.4**	0.540		µg/g-dry	1	8/27/2018 2:51:29 PM
Beryllium	**0.538**	0.270		µg/g-dry	1	8/27/2018 2:51:29 PM
Cadmium	**1.36**	0.270		µg/g-dry	1	8/27/2018 2:51:29 PM
Calcium	**16900**	270		µg/g-dry	10	8/27/2018 2:55:53 PM
Chromium	**195**	0.270		µg/g-dry	1	8/27/2018 2:51:29 PM
Cobalt	**7.48**	2.70		µg/g-dry	1	8/27/2018 2:51:29 PM
Copper	**27.8**	0.270		µg/g-dry	1	8/27/2018 2:51:29 PM
Iron	**27600**	270		µg/g-dry	100	8/27/2018 4:31:28 PM
Lead	**24.4**	0.270		µg/g-dry	1	8/27/2018 2:51:29 PM
Magnesium	**7300**	270		µg/g-dry	10	8/27/2018 2:55:53 PM
Manganese	**880**	5.40		µg/g-dry	10	8/27/2018 2:55:53 PM
Nickel	**19.9**	2.70		µg/g-dry	1	8/27/2018 2:51:29 PM
Potassium	**1620**	27.0		µg/g-dry	1	8/27/2018 2:51:29 PM
Selenium	**ND**	0.270		µg/g-dry	1	8/27/2018 2:51:29 PM
Silver	**ND**	1.10		µg/g-dry	1	8/27/2018 2:51:29 PM
Sodium	**185**	27.0	B	µg/g-dry	1	8/27/2018 2:51:29 PM
Thallium	**ND**	0.540		µg/g-dry	1	8/27/2018 2:51:29 PM
Vanadium	**19.3**	2.70		µg/g-dry	1	8/27/2018 2:51:29 PM
Zinc	**54.5**	0.540		µg/g-dry	1	8/27/2018 2:51:29 PM
MERCURY - SW 7471B						Analyst: **AVB**
(Prep: SW7471B - 8/24/2018)						
Mercury	**0.023**	0.022		µg/g-dry	1	8/24/2018 3:57:11 PM
HEXAVALENT CHROMIUM - SW 7196A (3060A)						Analyst: **DAA**
(Prep: SW3060A - 8/27/2018)						
Chromium, Hexavalent	**133**	54.0	S	µg/g-dry	50	8/28/2018 11:30:00 AM
MOISTURE CONTENT-ASTM D2216 (NOT ELAP CERTIFIED)						Analyst: **TSZ**
Percent Moisture	**7.0**	0.1		wt%	1	8/24/2018

CLIENT:	Arcadis	**LabWork Order:**	**180824021**
Project:	Watervliet Arsenal	**PO#:**	

Lab SampleID:	180824021-004	**Collection Date:**	8/24/2018
Client Sample ID:	OE	**Matrix:**	SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-EPA 6010C						Analyst: **WB**
(Prep: SW3050B - 8/24/2018)						
Aluminum	**12600**	53.0		µg/g-dry	10	8/27/2018 3:04:21 PM
Antimony	**ND**	3.20	N	µg/g-dry	1	8/27/2018 2:59:57 PM
Arsenic	**3.71**	0.260	N	µg/g-dry	1	8/27/2018 2:59:57 PM
Barium	**101**	0.530	NZ	µg/g-dry	1	8/27/2018 2:59:57 PM
Beryllium	**0.560**	0.260		µg/g-dry	1	8/27/2018 2:59:57 PM
Cadmium	**1.53**	0.260	N	µg/g-dry	1	8/27/2018 2:59:57 PM
Calcium	**15300**	260		µg/g-dry	10	8/27/2018 3:04:21 PM
Chromium	**31.3**	0.260	Z	µg/g-dry	1	8/27/2018 2:59:57 PM
Cobalt	**7.39**	2.60		µg/g-dry	1	8/27/2018 2:59:57 PM
Copper	**30.1**	0.260		µg/g-dry	1	8/27/2018 2:59:57 PM
Iron	**31300**	260		µg/g-dry	100	8/27/2018 4:34:46 PM
Lead	**17.7**	0.260		µg/g-dry	1	8/27/2018 2:59:57 PM
Magnesium	**7740**	260		µg/g-dry	10	8/27/2018 3:04:21 PM
Manganese	**755**	5.30	Z	µg/g-dry	10	8/27/2018 3:04:21 PM
Nickel	**20.2**	2.60	Z	µg/g-dry	1	8/27/2018 2:59:57 PM
Potassium	**1530**	26.0		µg/g-dry	1	8/27/2018 2:59:57 PM
Selenium	**ND**	0.260	N	µg/g-dry	1	8/27/2018 2:59:57 PM
Silver	**ND**	1.10	N	µg/g-dry	1	8/27/2018 2:59:57 PM
Sodium	**167**	26.0	B	µg/g-dry	1	8/27/2018 2:59:57 PM
Thallium	**ND**	0.530	N	µg/g-dry	1	8/27/2018 2:59:57 PM
Vanadium	**20.4**	2.60		µg/g-dry	1	8/27/2018 2:59:57 PM
Zinc	**59.1**	0.530		µg/g-dry	1	8/27/2018 2:59:57 PM
MERCURY - SW 7471B						Analyst: **AVB**
(Prep: SW7471B - 8/24/2018)						
Mercury	**ND**	0.021		µg/g-dry	1	8/24/2018 3:58:52 PM
HEXAVALENT CHROMIUM - SW 7196A (3060A)						Analyst: **DAA**
(Prep: SW3060A - 8/27/2018)						
Chromium, Hexavalent	**6.7**	1.1	S	µg/g-dry	1	8/28/2018 11:30:00 AM
MOISTURE CONTENT-ASTM D2216 (NOT ELAP CERTIFIED)						Analyst: **TSZ**
Percent Moisture	**5.4**	0.1		wt%	1	8/24/2018

Adirondack Environmental Services, Inc

Date: *28-Aug-18*

CLIENT: Arcadis
Project: Watervliet Arsenal

LabWork Order: **180824021**
PO#:

Lab SampleID: 180824021-005
Client Sample ID: OW
Collection Date: 8/24/2018
Matrix: SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-EPA 6010C						Analyst: **WB**
(Prep: SW3050B - 8/24/2018)						
Aluminum	**13500**	55.0		µg/g-dry	10	8/27/2018 3:25:24 PM
Antimony	**ND**	3.30		µg/g-dry	1	8/27/2018 3:21:08 PM
Arsenic	**3.63**	0.270		µg/g-dry	1	8/27/2018 3:21:08 PM
Barium	**111**	0.550		µg/g-dry	1	8/27/2018 3:21:08 PM
Beryllium	**0.586**	0.270		µg/g-dry	1	8/27/2018 3:21:08 PM
Cadmium	**1.67**	0.270		µg/g-dry	1	8/27/2018 3:21:08 PM
Calcium	**20200**	270		µg/g-dry	10	8/27/2018 3:25:24 PM
Chromium	**19.3**	0.270		µg/g-dry	1	8/27/2018 3:21:08 PM
Cobalt	**8.52**	2.70		µg/g-dry	1	8/27/2018 3:21:08 PM
Copper	**28.0**	0.270		µg/g-dry	1	8/27/2018 3:21:08 PM
Iron	**32200**	270		µg/g-dry	100	8/27/2018 4:41:22 PM
Lead	**14.9**	0.270		µg/g-dry	1	8/27/2018 3:21:08 PM
Magnesium	**8590**	270		µg/g-dry	10	8/27/2018 3:25:24 PM
Manganese	**1130**	5.50		µg/g-dry	10	8/27/2018 3:25:24 PM
Nickel	**20.8**	2.70		µg/g-dry	1	8/27/2018 3:21:08 PM
Potassium	**1750**	27.0		µg/g-dry	1	8/27/2018 3:21:08 PM
Selenium	**ND**	0.270		µg/g-dry	1	8/27/2018 3:21:08 PM
Silver	**ND**	1.10		µg/g-dry	1	8/27/2018 3:21:08 PM
Sodium	**247**	27.0	B	µg/g-dry	1	8/27/2018 3:21:08 PM
Thallium	**ND**	0.550		µg/g-dry	1	8/27/2018 3:21:08 PM
Vanadium	**21.2**	2.70		µg/g-dry	1	8/27/2018 3:21:08 PM
Zinc	**60.2**	0.550		µg/g-dry	1	8/27/2018 3:21:08 PM
MERCURY - SW 7471B						Analyst: **AVB**
(Prep: SW7471B - 8/24/2018)						
Mercury	**ND**	0.022		µg/g-dry	1	8/24/2018 4:03:59 PM
HEXAVALENT CHROMIUM - SW 7196A (3060A)						Analyst: **DAA**
(Prep: SW3060A - 8/27/2018)						
Chromium, Hexavalent	**ND**	1.1	S	µg/g-dry	1	8/28/2018 11:30:00 AM
MOISTURE CONTENT-ASTM D2216 (NOT ELAP CERTIFIED)						Analyst: **TSZ**
Percent Moisture	**8.4**	0.1		wt%	1	8/24/2018

CLIENT: Arcadis
Project: Watervliet Arsenal
LabWork Order: 180824021
PO#:

Lab SampleID: 180824021-006
Client Sample ID: OB
Collection Date: 8/24/2018
Matrix: SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-EPA 6010C						Analyst: **WB**
(Prep: SW3050B - 8/24/2018)						
Aluminum	**12900**	56.0		µg/g-dry	10	8/27/2018 3:40:38 PM
Antimony	**5.86**	3.30		µg/g-dry	1	8/27/2018 3:36:12 PM
Arsenic	**3.95**	0.280		µg/g-dry	1	8/27/2018 3:36:12 PM
Barium	**87.8**	0.560		µg/g-dry	1	8/27/2018 3:36:12 PM
Beryllium	**0.549**	0.280		µg/g-dry	1	8/27/2018 3:36:12 PM
Cadmium	**1.37**	0.280		µg/g-dry	1	8/27/2018 3:36:12 PM
Calcium	**8010**	280		µg/g-dry	10	8/27/2018 3:40:38 PM
Chromium	**394**	0.280		µg/g-dry	1	8/27/2018 3:36:12 PM
Cobalt	**7.91**	2.80		µg/g-dry	1	8/27/2018 3:36:12 PM
Copper	**46.6**	0.280		µg/g-dry	1	8/27/2018 3:36:12 PM
Iron	**25900**	280		µg/g-dry	100	8/27/2018 4:44:42 PM
Lead	**23.1**	0.280		µg/g-dry	1	8/27/2018 3:36:12 PM
Magnesium	**7020**	280		µg/g-dry	10	8/27/2018 3:40:38 PM
Manganese	**448**	0.560		µg/g-dry	1	8/27/2018 3:36:12 PM
Nickel	**21.3**	2.80		µg/g-dry	1	8/27/2018 3:36:12 PM
Potassium	**1580**	28.0		µg/g-dry	1	8/27/2018 3:36:12 PM
Selenium	**ND**	0.280		µg/g-dry	1	8/27/2018 3:36:12 PM
Silver	**ND**	1.10		µg/g-dry	1	8/27/2018 3:36:12 PM
Sodium	**169**	28.0	B	µg/g-dry	1	8/27/2018 3:36:12 PM
Thallium	**ND**	0.560		µg/g-dry	1	8/27/2018 3:36:12 PM
Vanadium	**19.2**	2.80		µg/g-dry	1	8/27/2018 3:36:12 PM
Zinc	**59.3**	0.560		µg/g-dry	1	8/27/2018 3:36:12 PM
MERCURY - SW 7471B						Analyst: **AVB**
(Prep: SW7471B - 8/24/2018)						
Mercury	**0.030**	0.022		µg/g-dry	1	8/24/2018 4:05:41 PM
HEXAVALENT CHROMIUM - SW 7196A (3060A)						Analyst: **DAA**
(Prep: SW3060A - 8/27/2018)						
Chromium, Hexavalent	**150**	56.0	S	µg/g-dry	50	8/28/2018 11:30:00 AM
MOISTURE CONTENT-ASTM D2216 (NOT ELAP CERTIFIED)						Analyst: **TSZ**
Percent Moisture	**10.4**	0.1		wt%	1	8/24/2018

CLIENT:	Arcadis	**LabWork Order:**	**180824021**
Project:	Watervliet Arsenal	**PO#:**	

Lab SampleID:	180824021-007	**Collection Date:**	8/24/2018
Client Sample ID:	IB	**Matrix:**	SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-EPA 6010C						Analyst: **WB**
(Prep: SW3050B - 8/24/2018)						
Aluminum	**14700**	58.0		µg/g-dry	10	8/27/2018 3:48:52 PM
Antimony	**ND**	3.50		µg/g-dry	1	8/27/2018 3:44:37 PM
Arsenic	**4.21**	0.290		µg/g-dry	1	8/27/2018 3:44:37 PM
Barium	**110**	0.580		µg/g-dry	1	8/27/2018 3:44:37 PM
Beryllium	**0.632**	0.290		µg/g-dry	1	8/27/2018 3:44:37 PM
Cadmium	**1.60**	0.290		µg/g-dry	1	8/27/2018 3:44:37 PM
Calcium	**17400**	290		µg/g-dry	10	8/27/2018 3:48:52 PM
Chromium	**42.6**	0.290		µg/g-dry	1	8/27/2018 3:44:37 PM
Cobalt	**9.43**	2.90		µg/g-dry	1	8/27/2018 3:44:37 PM
Copper	**31.5**	0.290		µg/g-dry	1	8/27/2018 3:44:37 PM
Iron	**34800**	290		µg/g-dry	100	8/27/2018 4:47:57 PM
Lead	**25.5**	0.290		µg/g-dry	1	8/27/2018 3:44:37 PM
Magnesium	**6300**	290		µg/g-dry	10	8/27/2018 3:48:52 PM
Manganese	**505**	0.580		µg/g-dry	1	8/27/2018 3:44:37 PM
Nickel	**22.8**	2.90		µg/g-dry	1	8/27/2018 3:44:37 PM
Potassium	**1560**	29.0		µg/g-dry	1	8/27/2018 3:44:37 PM
Selenium	**ND**	0.290		µg/g-dry	1	8/27/2018 3:44:37 PM
Silver	**ND**	1.20		µg/g-dry	1	8/27/2018 3:44:37 PM
Sodium	**341**	29.0	B	µg/g-dry	1	8/27/2018 3:44:37 PM
Thallium	**ND**	0.580		µg/g-dry	1	8/27/2018 3:44:37 PM
Vanadium	**24.8**	2.90		µg/g-dry	1	8/27/2018 3:44:37 PM
Zinc	**62.9**	0.580		µg/g-dry	1	8/27/2018 3:44:37 PM
MERCURY - SW 7471B						Analyst: **AVB**
(Prep: SW7471B - 8/24/2018)						
Mercury	**ND**	0.023		µg/g-dry	1	8/24/2018 4:10:46 PM
HEXAVALENT CHROMIUM - SW 7196A (3060A)						Analyst: **DAA**
(Prep: SW3060A - 8/27/2018)						
Chromium, Hexavalent	**12.7**	1.2	S	µg/g-dry	1	8/28/2018 11:30:00 AM
MOISTURE CONTENT-ASTM D2216 (NOT ELAP CERTIFIED)						Analyst: **TSZ**
Percent Moisture	**13.8**	0.1		wt%	1	8/24/2018

Adirondack Environmental Services, Inc

Date: *28-Aug-18*

CLIENT: Arcadis
Project: Watervliet Arsenal

LabWork Order: **180824021**
PO#:

Lab SampleID: 180824021-008
Client Sample ID: IE

Collection Date: 8/24/2018
Matrix: SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-EPA 6010C						Analyst: **WB**
(Prep: SW3050B - 8/24/2018)						
Aluminum	**15000**	56.0		µg/g-dry	10	8/27/2018 3:57:20 PM
Antimony	**27.8**	3.40		µg/g-dry	1	8/27/2018 3:52:57 PM
Arsenic	**2.66**	0.280		µg/g-dry	1	8/27/2018 3:52:57 PM
Barium	**131**	0.560		µg/g-dry	1	8/27/2018 3:52:57 PM
Beryllium	**0.673**	0.280		µg/g-dry	1	8/27/2018 3:52:57 PM
Cadmium	**1.63**	0.280		µg/g-dry	1	8/27/2018 3:52:57 PM
Calcium	**18600**	280		µg/g-dry	10	8/27/2018 3:57:20 PM
Chromium	**1950**	2.80		µg/g-dry	10	8/27/2018 3:57:20 PM
Cobalt	**10.9**	2.80		µg/g-dry	1	8/27/2018 3:52:57 PM
Copper	**42.0**	0.280		µg/g-dry	1	8/27/2018 3:52:57 PM
Iron	**32100**	280		µg/g-dry	100	8/27/2018 4:51:15 PM
Lead	**34.8**	0.280		µg/g-dry	1	8/27/2018 3:52:57 PM
Magnesium	**7800**	280		µg/g-dry	10	8/27/2018 3:57:20 PM
Manganese	**831**	5.60		µg/g-dry	10	8/27/2018 3:57:20 PM
Nickel	**24.9**	2.80		µg/g-dry	1	8/27/2018 3:52:57 PM
Potassium	**1820**	28.0		µg/g-dry	1	8/27/2018 3:52:57 PM
Selenium	**ND**	0.280		µg/g-dry	1	8/27/2018 3:52:57 PM
Silver	**ND**	1.10		µg/g-dry	1	8/27/2018 3:52:57 PM
Sodium	**337**	28.0	B	µg/g-dry	1	8/27/2018 3:52:57 PM
Thallium	**ND**	0.560		µg/g-dry	1	8/27/2018 3:52:57 PM
Vanadium	**15.8**	2.80		µg/g-dry	1	8/27/2018 3:52:57 PM
Zinc	**64.1**	0.560		µg/g-dry	1	8/27/2018 3:52:57 PM
MERCURY - SW 7471B						Analyst: **AVB**
(Prep: SW7471B - 8/24/2018)						
Mercury	**0.046**	0.022		µg/g-dry	1	8/24/2018 4:12:29 PM
HEXAVALENT CHROMIUM - SW 7196A (3060A)						Analyst: **DAA**
(Prep: SW3060A - 8/27/2018)						
Chromium, Hexavalent	**802**	56.0	S	µg/g-dry	50	8/28/2018 11:30:00 AM
MOISTURE CONTENT-ASTM D2216 (NOT ELAP CERTIFIED)						Analyst: **TSZ**
Percent Moisture	**10.7**	0.1		wt%	1	8/24/2018

CLIENT: Arcadis
Project: Watervliet Arsenal
LabWork Order: 180824021
PO#:

Lab SampleID: 180824021-009 **Collection Date:** 8/24/2018
Client Sample ID: IW **Matrix:** SOIL

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS-EPA 6010C						Analyst: **WB**
(Prep: SW3050B - 8/24/2018)						
Aluminum	**15000**	55.0		µg/g-dry	10	8/27/2018 4:05:45 PM
Antimony	**ND**	3.30		µg/g-dry	1	8/27/2018 4:01:24 PM
Arsenic	**6.85**	0.280		µg/g-dry	1	8/27/2018 4:01:24 PM
Barium	**148**	0.550		µg/g-dry	1	8/27/2018 4:01:24 PM
Beryllium	**0.714**	0.280		µg/g-dry	1	8/27/2018 4:01:24 PM
Cadmium	**1.85**	0.280		µg/g-dry	1	8/27/2018 4:01:24 PM
Calcium	**10000**	280		µg/g-dry	10	8/27/2018 4:05:45 PM
Chromium	**22.9**	0.280		µg/g-dry	1	8/27/2018 4:01:24 PM
Cobalt	**10.7**	2.80		µg/g-dry	1	8/27/2018 4:01:24 PM
Copper	**52.9**	0.280		µg/g-dry	1	8/27/2018 4:01:24 PM
Iron	**32600**	280		µg/g-dry	100	8/27/2018 4:54:34 PM
Lead	**49.9**	0.280		µg/g-dry	1	8/27/2018 4:01:24 PM
Magnesium	**7240**	280		µg/g-dry	10	8/27/2018 4:05:45 PM
Manganese	**801**	5.50		µg/g-dry	10	8/27/2018 4:05:45 PM
Nickel	**26.4**	2.80		µg/g-dry	1	8/27/2018 4:01:24 PM
Potassium	**1780**	28.0		µg/g-dry	1	8/27/2018 4:01:24 PM
Selenium	**ND**	0.280		µg/g-dry	1	8/27/2018 4:01:24 PM
Silver	**ND**	1.10		µg/g-dry	1	8/27/2018 4:01:24 PM
Sodium	**274**	28.0	B	µg/g-dry	1	8/27/2018 4:01:24 PM
Thallium	**ND**	0.550		µg/g-dry	1	8/27/2018 4:01:24 PM
Vanadium	**25.4**	2.80		µg/g-dry	1	8/27/2018 4:01:24 PM
Zinc	**78.5**	0.550		µg/g-dry	1	8/27/2018 4:01:24 PM
MERCURY - SW 7471B						Analyst: **AVB**
(Prep: SW7471B - 8/24/2018)						
Mercury	**0.043**	0.022		µg/g-dry	1	8/24/2018 4:14:12 PM
HEXAVALENT CHROMIUM - SW 7196A (3060A)						Analyst: **DAA**
(Prep: SW3060A - 8/27/2018)						
Chromium, Hexavalent	**2.0**	1.1	SN+	µg/g-dry	1	8/28/2018 11:30:00 AM
MOISTURE CONTENT-ASTM D2216 (NOT ELAP CERTIFIED)						Analyst: **TSZ**
Percent Moisture	**9.2**	0.1		wt%	1	8/24/2018

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CHAIN OF CUSTODY RECORD

AES Work Order # 180824021

A full service analytical research laboratory offering solutions to environmental concerns

Client Name: ARCADIS U.S. INC.	**Address:** 855 ROUTE 146, SUITE 210 CLIFTON PARK, NY 12065		
Send Report To: ANDY VITOLINS	**Project Name (Location)**		**Samplers: (Names)** STEFAN BAGNATO
Client Phone No: 518-250-7300	**Client Email:** andy.vitolins@arcadis.com	**PO Number:** 02118217.0002	**Samplers: (Signature)**

AES Sample Number	Client Sample Identification & Location	Date Sampled	Time A=a.m. P=p.m.		Sample Type Matrix	Comp	Grab	Number of Cont's	Analysis Required
001	ADJ EXT WALL	8/24/18	0910	[✓ A] P	SOIL		X	1	TAL METALS HEX. CHROME
002	ADJ W. DUCT	↓	0915	[✓ A] P	↓		↓	↓	↓
003	OS	↓	0930	[✓ A] P	↓		↓	↓	↓
004	OE	↓	0935	[✓ A] P	↓		↓	↓	↓
005	OW	↓	0940	[✓ A] P	↓		↓	↓	↓
006	OB	↓	0945	[✓ A] P	↓		↓	↓	↓
007	IB	↓	0950	[✓ A] P	↓		↓	↓	↓
008	IE	↓	0955	[✓ A] P	↓		↓	↓	↓
009	IW	↓	1000	[✓ A] P	↓		↓	↓	↓
				A P					
				A P					
				A P					
				A P					
				A P					

Shipment Arrived Via:

FedEx UPS [✓ Client] AES Other:__________

CC Report To / Special Instructions/Remarks:
stefan.bagnato@arcadis.com

Turnaround Time Request:

☒ 1 Day ☐ 3 Day ☐ Normal
☐ 2 Day ☐ 5 Day

Note: Samples received after 3:30 pm are considered next business day

Relinquished by: (Signature)	**Received by: (Signature)**	**Date/Time**
Relinquished by: (Signature)	**Received by: (Signature)**	**Date/Time**
Relinquished by: (Signature)	**Received for Laboratory by:**	**Date/Time** 8/24/18 10:50Am

TEMPERATURE Ambient or [✓ Chilled] Notes: 13°C	**AES Bottles** Y ☒	N ☐	**PROPERLY PRESERVED** [✓ Y] N Notes:	**RECEIVED WITHIN HOLDING TIMES** [✓ Y] N Notes:

WHITE - Lab Copy **YELLOW - Sampler Copy**

Adirondack Environmental Services

180824021

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TERMS, CONDITIONS & LIMITATIONS

All service rendered by the **Adirondack Environmental Services, Inc**. are undertaken and all rates are based upon the following terms:

(a) Neither **Adirondack Environmental Services, Inc.,** nor any of its employees, agents or sub-contractors shall be liable for any loss or damage arising out of **Adirondack Environmental Services, Inc.'s** performance or nonperformance, whether by way of negligence or breach of contract, or otherwise, in any amount greater than twice the amount billed to the customer for the work leading to the claim of the customer. Said remedy shall be the sole and exclusive remedy against **Adirondack Environmental Services, Inc.** arising out of its work.

(b) All claims made must be in writing within forty-five (45) days after delivery of the **Adirondack Environmental Services, Inc.** report regarding said work or such claim shall be deemed or irrevocably waived.

(c) **Adirondack Environmental Services, Inc.** reports are submitted in writing and are for our customers only. Our customers are considered to be only those entities being billed for our services. Acquisition of an **Adirondack Environmental Services, Inc.** report by other than our customer does not constitute a representation of **Adirondack Environmental Services, Inc.** as to the accuracy of the contents thereof.

(d) In no event shall **Adirondack Environmental Services, Inc.,** its employees, agents or sub-contractors be responsible for consequential or special damages of any kind or in any amount.

(e) No deviation from the terms set forth herein shall bind **Adirondack Environmental Services, Inc.** unless in writing and signed by a Director of **Adirondack Environmental Services, Inc.**

(f) Results pertain only to items analyzed. Information supplied by client is assumed to be correct. This information may be used on reports and in calculations and **Adirondack Environmental Services, Inc.** is not responsible for the accuracy of this information.

(g) Payments by Credit Card/Purchase Cards are subject to a 3% additional charge.

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August 29, 2018

Andy Vitolins
Arcadis
855 Route 146, Suite 210
Clifton Park, NY 12065
TEL: (518) 250-7382

Work Order No: 180828055

RE: Watervliet Arsenal
WVA

Dear Andy Vitolins:

Adirondack Environmental Services, Inc received 1 sample on 8/28/2018 for the analyses presented in the following report.

Please see case narrative for specifics on analysis.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

Krzysztof Trafalski
Laboratory Manager

ELAP#: 10709

Adirondack Environmental Services, Inc

CASE NARRATIVE

CLIENT:	Arcadis	**Date:** *29-Aug-18*
Project:	Watervliet Arsenal	
Lab Order:	180828055	

Sample containers were supplied by Adirondack Environmental Services.

These samples were received under ambient conditions. Chilling process was started following receipt at laboratory.

Definitions - RL: Reporting Limit DF: Dilution factor

Qualifiers:		
	ND : Not Detected at reporting limit	C: CCV below acceptable Limits
	J: Analyte detected below quantitation limit	C+: CCV above acceptable Limits
	B: Analyte detected in Blank	S: LCS Spike recovery is below acceptable limits
	X : Exceeds maximum contamination limit	S+: LCS Spike recovery is above acceptable limits
	H: Hold time exceeded	Z: Duplication outside acceptable limits
	N: Matrix Spike below acceptable limits	T : Tentatively Identified Compound-Estimated
	N+: Matrix Spike is above acceptable limits	E :Above quantitation range-Estimated

Note : All Results are reported as wet weight unless noted

The results relate only to the items tested. Information supplied by the client is assumed to be correct.

Adirondack Environmental Services, Inc

Date: *29-Aug-18*

CLIENT: Arcadis
Work Order: **180828055**
Reference: Watervliet Arsenal / WVA
PO#:

Client Sample ID: Excav Sump
Collection Date: 8/28/2018 3:10:00 PM
Lab Sample ID: 180828055-001
Matrix: WATER

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS - EPA 200.7 REV 4.4						Analyst: **SM**
(Prep: - 8/29/2018)						
Aluminum	**ND**	0.100		mg/L	1	8/29/2018
Antimony	**ND**	0.060		mg/L	1	8/29/2018
Arsenic	**ND**	0.005		mg/L	1	8/29/2018
Barium	**0.060**	0.010		mg/L	1	8/29/2018
Beryllium	**ND**	0.005		mg/L	1	8/29/2018
Cadmium	**ND**	0.005		mg/L	1	8/29/2018
Calcium	**44.9**	0.050		mg/L	1	8/29/2018
Chromium	**1.98**	0.005		mg/L	1	8/29/2018
Cobalt	**ND**	0.050		mg/L	1	8/29/2018
Copper	**ND**	0.005		mg/L	1	8/29/2018
Iron	**ND**	0.050		mg/L	1	8/29/2018
Lead	**ND**	0.005		mg/L	1	8/29/2018
Magnesium	**11.2**	0.050		mg/L	1	8/29/2018
Manganese	**0.219**	0.020		mg/L	1	8/29/2018
Nickel	**ND**	0.020		mg/L	1	8/29/2018
Potassium	**8.16**	0.050		mg/L	1	8/29/2018
Selenium	**ND**	0.005		mg/L	1	8/29/2018
Silver	**ND**	0.010		mg/L	1	8/29/2018
Sodium	**135**	0.500		mg/L	10	8/29/2018
Thallium	**ND**	0.010		mg/L	1	8/29/2018
Vanadium	**ND**	0.020		mg/L	1	8/29/2018
Zinc	**ND**	0.010		mg/L	1	8/29/2018
MERCURY - EPA 245.1 REV 3.0						Analyst: **AVB**
(Prep: E245.1 - 8/29/2018)						
Mercury	**ND**	0.0002		mg/L	1	8/29/2018 1:05:30 PM
HEXAVALENT CHROMIUM - SM3500-CR B-2011						Analyst: **DAA**
Chromium, Hexavalent	**1.6**	1.0		mg/L	50	8/29/2018 12:09:00 PM

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CHAIN OF CUSTODY RECORD

AES Work Order # 180828055

Client Name: Arcadis US Inc.	**Address:** 855 Route 146, Suite 210 Clifton Park, NY		
Send Report To: Andy Vitolins	**Project Name (Location)** WVA		**Samplers: (Names)** Andy Vitolins
Client Phone No: 518-250-7300	**Client Email:** andy.vitolins@arcadis.com	**PO Number:** 02118217.0000	**Samplers: (Signature)**

AES Sample Number	Client Sample Identification & Location	Date Sampled	Time A=a.m. P=p.m.		Sample Type Matrix	Comp	Grab	Number of Cont's	Analysis Required
001	Excav Sump	8/28/18	3:10	A [✓ P]	AQ		x	2	TAL Metals Hex Chrome
	~~SUMP Comm Pit~~	↓		A [✓ P]	~~↓~~		~~x~~	~~2~~	~~↓~~
				A P					
				A P					
				A P					
				A P					
				A P					
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				A P					
				A P					
				A P					
				A P					
				A P					
				A P					

Shipment Arrived Via:

FedEx UPS [✓ Client] AES Other:________

CC Report To / Special Instructions/Remarks:

stefan.bagnato@arcadis.com

Turnaround Time Request:

☒ 1 Day ☐ 3 Day ☐ Normal
☐ 2 Day ☐ 5 Day

Note: Samples received after 3:30 pm are considered next business day

Relinquished by: (Signature)	**Received by: (Signature)**	**Date/Time**
Relinquished by: (Signature)	**Received by: (Signature)**	**Date/Time**
Relinquished by: (Signature)	**Received for Laboratory by:**	**Date/Time** 8/28/18 3:33 Pm

TEMPERATURE	AES Bottles	PROPERLY PRESERVED	RECEIVED WITHIN HOLDING TIMES
[✓ Ambient] or Chilled Notes: 23° C	Y ☒ N ☐	[✓ Y] N Notes:________	[✓ Y] N Notes:________

WHITE - Lab Copy **YELLOW - Sampler Copy**

Adirondack Environmental Servi

180828055

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(a) Neither **Adirondack Environmental Services, Inc.,** nor any of its employees, agents or sub-contractors shall be liable for any loss or damage arising out of **Adirondack Environmental Services, Inc.'s** performance or nonperformance, whether by way of negligence or breach of contract, or otherwise, in any amount greater than twice the amount billed to the customer for the work leading to the claim of the customer. Said remedy shall be the sole and exclusive remedy against **Adirondack Environmental Services, Inc.** arising out of its work.

(b) All claims made must be in writing within forty-five (45) days after delivery of the **Adirondack Environmental Services, Inc.** report regarding said work or such claim shall be deemed or irrevocably waived.

(c) **Adirondack Environmental Services, Inc.** reports are submitted in writing and are for our customers only. Our customers are considered to be only those entities being billed for our services. Acquisition of an **Adirondack Environmental Services, Inc.** report by other than our customer does not constitute a representation of **Adirondack Environmental Services, Inc.** as to the accuracy of the contents thereof.

(d) In no event shall **Adirondack Environmental Services, Inc.**, its employees, agents or sub-contractors be responsible for consequential or special damages of any kind or in any amount.

(e) No deviation from the terms set forth herein shall bind **Adirondack Environmental Services, Inc.** unless in writing and signed by a Director of **Adirondack Environmental Services, Inc.**

(f) Results pertain only to items analyzed. Information supplied by client is assumed to be correct. This information may be used on reports and in calculations and **Adirondack Environmental Services, Inc.** is not responsible for the accuracy of this information.

(g) Payments by Credit Card/Purchase Cards are subject to a 3% additional charge.

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August 30, 2018

Andy Vitolins
Arcadis
855 Route 146, Suite 210
Clifton Park, NY 12065
TEL: (518) 250-7382

Work Order No: 180829023

RE: Watervliet Arsenal
WVA

Dear Andy Vitolins:

Adirondack Environmental Services, Inc received 1 sample on 8/29/2018 for the analyses presented in the following report.

Please see case narrative for specifics on analysis.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

Krzysztof Trafalski
Laboratory Manager

ELAP#: 10709

CLIENT:	Arcadis	**Date:** *30-Aug-18*
Project:	Watervliet Arsenal	
Lab Order:	180829023	

Sample containers were supplied by Adirondack Environmental Services.

These samples were received under ambient conditions. Chilling process was started following receipt at laboratory.

Definitions - RL: Reporting Limit DF: Dilution factor

Qualifiers:		
	ND : Not Detected at reporting limit	C: CCV below acceptable Limits
	J: Analyte detected below quantitation limit	C+: CCV above acceptable Limits
	B: Analyte detected in Blank	S: LCS Spike recovery is below acceptable limits
	X : Exceeds maximum contamination limit	S+: LCS Spike recovery is above acceptable limits
	H: Hold time exceeded	Z: Duplication outside acceptable limits
	N: Matrix Spike below acceptable limits	T : Tentatively Identified Compound-Estimated
	N+: Matrix Spike is above acceptable limits	E :Above quantitation range-Estimated

Note : All Results are reported as wet weight unless noted

The results relate only to the items tested. Information supplied by the client is assumed to be correct.

Adirondack Environmental Services, Inc

Date: *30-Aug-18*

CLIENT:	Arcadis	**Client Sample ID:**	Sump- CommPit
Work Order:	**180829023**	**Collection Date:**	8/29/2018 10:15:00 AM
Reference:	Watervliet Arsenal / WVA	**Lab Sample ID:**	180829023-001
PO#:		**Matrix:**	AQUEOUS

Analyses	Result	RL	Qual	Units	DF	Date Analyzed
ICP METALS - EPA 200.7 REV 4.4 (Prep: - 8/29/2018)						Analyst: **SM**
Aluminum	**ND**	0.100		mg/L	1	8/30/2018 4:09:00 PM
Antimony	**0.131**	0.060		mg/L	1	8/30/2018 4:09:00 PM
Arsenic	**0.016**	0.005		mg/L	1	8/30/2018 4:09:00 PM
Barium	**0.160**	0.010		mg/L	1	8/30/2018 4:09:00 PM
Beryllium	**ND**	0.005		mg/L	1	8/30/2018 4:09:00 PM
Cadmium	**ND**	0.005		mg/L	1	8/30/2018 4:09:00 PM
Calcium	**138**	0.050		mg/L	1	8/30/2018 4:09:00 PM
Chromium	**7.69**	0.005		mg/L	1	8/30/2018 4:09:00 PM
Cobalt	**ND**	0.050		mg/L	1	8/30/2018 4:09:00 PM
Copper	**0.023**	0.005		mg/L	1	8/30/2018 4:09:00 PM
Iron	**0.139**	0.050		mg/L	1	8/30/2018 4:09:00 PM
Lead	**ND**	0.005		mg/L	1	8/30/2018 4:09:00 PM
Magnesium	**32.9**	0.050		mg/L	1	8/30/2018 4:09:00 PM
Manganese	**ND**	0.020		mg/L	1	8/30/2018 4:09:00 PM
Nickel	**ND**	0.020		mg/L	1	8/30/2018 4:09:00 PM
Potassium	**23.2**	0.050		mg/L	1	8/30/2018 4:09:00 PM
Selenium	**ND**	0.005		mg/L	1	8/30/2018 4:09:00 PM
Silver	**ND**	0.010		mg/L	1	8/30/2018 4:09:00 PM
Sodium	**169**	0.500		mg/L	10	8/30/2018 4:13:00 PM
Thallium	**ND**	0.010		mg/L	1	8/30/2018 4:09:00 PM
Vanadium	**ND**	0.020		mg/L	1	8/30/2018 4:09:00 PM
Zinc	**0.011**	0.010		mg/L	1	8/30/2018 4:09:00 PM
MERCURY - EPA 245.1 REV 3.0 (Prep: E245.1 - 8/30/2018)						Analyst: **AVB**
Mercury	**ND**	0.0002		mg/L	1	8/30/2018 12:39:47 PM
HEXAVALENT CHROMIUM - SM3500-CR B-2011						Analyst: **DAA**
Chromium, Hexavalent	**11**	1.0		mg/L	50	8/29/2018 12:09:00 PM

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314 North Pearl Street
Albany, New York 12207
518-434-4546/434-0891 FAX

CHAIN OF CUSTODY RECORD

AES Work Order # 180829023

A full service analytical research laboratory offering solutions to environmental concerns

Client Name: Arcadis	**Address:** 855 Route 146 Suite 210 Clifton Park	
Send Report To: Andy Vitolins	**Project Name (Location)** WVA	**Samplers: (Names)** Andy Vitolins
Client Phone No: 518-250-7300	**Client Email:** andy.vitolins@arcadis.com	**PO Number:** 02118217.0000
Samplers: (Signature)		

AES Sample Number	Client Sample Identification & Location	Date Sampled	Time A=a.m. P=p.m.		Sample Type: Matrix	Comp	Grab	Number of Cont's	Analysis Required
	~~CommPit - Sump~~			A P					
001	SUMP-CommPit	8/29/18	1015	[✓ A] P	AQ		x	2	Hex Chrome TAL Metals
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					
				A P					

Shipment Arrived Via:
FedEx UPS Client AES Other:________

Turnaround Time Request:
☒ 1 Day ☐ 3 Day ☐ Normal
☐ 2 Day ☐ 5 Day
Note: Samples received after 3:30 pm are considered next business day

CC Report To / Special Instructions/Remarks:
Stefan Bagnato

Relinquished by: (Signature)	**Received by: (Signature)**	**Date/Time** 8/29/18 1032
Relinquished by: (Signature)	**Received by: (Signature)**	**Date/Time**
Relinquished by: (Signature)	**Received for Laboratory by:**	**Date/Time** 8/29/18 10:31 Am

TEMPERATURE [✓ Ambient] or Chilled Notes: 23°C	**AES Bottles** Y ☒ N ☐	**PROPERLY PRESERVED** [✓ Y] N Notes:________	**RECEIVED WITHIN HOLDING TIMES** [✓ Y] N Notes:________

WHITE - Lab Copy **YELLOW - Sampler Copy**

Adirondack Environmental Services

180829023

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TERMS, CONDITIONS & LIMITATIONS

All service rendered by the **Adirondack Environmental Services, Inc**. are undertaken and all rates are based upon the following terms:

(a) Neither **Adirondack Environmental Services, Inc.,** nor any of its employees, agents or sub-contractors shall be liable for any loss or damage arising out of **Adirondack Environmental Services, Inc.'s** performance or nonperformance, whether by way of negligence or breach of contract, or otherwise, in any amount greater than twice the amount billed to the customer for the work leading to the claim of the customer. Said remedy shall be the sole and exclusive remedy against **Adirondack Environmental Services, Inc.** arising out of its work.

(b) All claims made must be in writing within forty-five (45) days after delivery of the **Adirondack Environmental Services, Inc.** report regarding said work or such claim shall be deemed or irrevocably waived.

(c) **Adirondack Environmental Services, Inc.** reports are submitted in writing and are for our customers only. Our customers are considered to be only those entities being billed for our services. Acquisition of an **Adirondack Environmental Services, Inc.** report by other than our customer does not constitute a representation of **Adirondack Environmental Services, Inc.** as to the accuracy of the contents thereof.

(d) In no event shall **Adirondack Environmental Services, Inc.**, its employees, agents or sub-contractors be responsible for consequential or special damages of any kind or in any amount.

(e) No deviation from the terms set forth herein shall bind **Adirondack Environmental Services, Inc.** unless in writing and signed by a Director of **Adirondack Environmental Services, Inc.**

(f) Results pertain only to items analyzed. Information supplied by client is assumed to be correct. This information may be used on reports and in calculations and **Adirondack Environmental Services, Inc.** is not responsible for the accuracy of this information.

(g) Payments by Credit Card/Purchase Cards are subject to a 3% additional charge.

APPENDIX C
2018 Excavation Photolog

Project Photographs

2018 Excavation
Building 35 Chromic Acid Spill
Watervliet Arsenal
Watervliet, New York

Photo: 1

Date:
8/24/2018

Description:
Westward view of interior portion of excavation

Location:
WVA Building 35

Photo: 2

Date:
8/24/2018

Description:
Southward view of excavation beneath building and footer

Location:
WVA Building 35

Project Photographs

2018 Excavation
Building 35 Chromic Acid Spill
Watervliet Arsenal
Watervliet, New York

Photo: 3

Date:

8/24/2018

Description:

Northward/downward view of interior portion of excavation and location of IW and IE sidewall samples and IB bottom sample

Location:

WVA Building 35

Photo: 4

Date:

8/24/2018

Description:

Westward view of exterior portion of excavation and utility pit

Location:

WVA Building 35

Project Photographs

2018 Excavation
Building 35 Chromic Acid Spill
Watervliet Arsenal
Watervliet, New York

Photo: 5

Date:

8/24/2018

Description:

Eastward view of exterior portion of excavation and location of OE sidewall sample

Location:

WVA Building 35

Project Photographs

2018 Excavation
Building 35 Chromic Acid Spill
Watervliet Arsenal
Watervliet, New York

Photo: 6

Date:

8/24/2018

Description:

Southward view of exterior portion of excavation and location of OS sidewall sample

Location:

WVA Building 35

Project Photographs

2018 Excavation
Building 35 Chromic Acid Spill
Watervliet Arsenal
Watervliet, New York

Photo: 7

Date:

8/24/2018

Description:

Westward view of exterior portion of excavation and location of OW sidewall sample

Location:

WVA Building 35

Project Photographs

2018 Excavation
Building 35 Chromic Acid Spill
Watervliet Arsenal
Watervliet, New York

Photo: 8

Date:

8/24/2018

Description:

Eastward view of ventilation duct work, exterior portion of excavation, and location of AW soil sample

Location:

WVA Building 35

Project Photographs

2018 Excavation
Building 35 Chromic Acid Spill
Watervliet Arsenal
Watervliet, New York

Photo: 9

Date:

8/24/2018

Description:

Northward/downward view of ventilation duct work, and location of AD soil sample

Location:

WVA Building 35

Project Photographs

2018 Excavation
Building 35 Chromic Acid Spill
Watervliet Arsenal
Watervliet, New York

Photo: 10

Date:

8/24/2018

Description:

Westward view of interstitial well being installed in the NW corner of excavation

Location:

WVA Building 35

Project Photographs

2018 Excavation
Building 35 Chromic Acid Spill
Watervliet Arsenal
Watervliet, New York

Photo: 11

Date:

8/24/2018

Description:

Westward view of interstitial well and backfill of excavation

Location:

WVA Building 35

APPENDIX D
Community Air Monitoring Plan

COMMUNITY AIR MONITORING PLAN
PLATING AREA SITE INVESTIGATION
WARERVLIET ARSENAL
WATERVLIET, NEW YORK

To provide a measure of protection for any potential downwind receptors, and to confirm that work activities do not generate airborne contaminants, Arcadis will conduct continuous monitoring for volatile organic compounds (VOCs) and particulate matter (dust) during all ground intrusive activities at the site. Monitoring will be conducted at the upwind and downwind perimeter of each work area.

VOC MONITORING, RESPONSE LEVELS, AND ACTIONS

Volatile organic compounds (VOCs) will be monitored on a continuous basis during all ground intrusive activities. Upwind concentrations will be measured at the start of each workday and periodically thereafter to establish background conditions. VOC monitoring will be conducted using a MiniRae 3000 photoionization detector (PID), or equivalent. The PID will be calibrated at least daily using the span calibration gas recommended by the manufacturer. The PID will calculate 15-minute running average concentrations. These averages will be compared to the action levels specified below.

Action Levels

- If the ambient air concentration of total organic vapors at the downwind perimeter of the work area or exclusion zone exceeds 5 parts per million (ppm) above background for the 15-minute average, work activities will be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 5 ppm over background, work activities will resume with continued monitoring.

- If total organic vapor levels at the downwind perimeter of the work area or exclusion zone persist at levels in excess of 5 ppm over background but less than 25 ppm, work activities will be halted, the source of vapors identified, corrective actions taken to abate emissions, and monitoring continued. After these steps, work activities will resume provided that the total organic vapor level 200 feet downwind of the exclusion zone or half the distance to the nearest potential receptor or residential/commercial structure, whichever is less - but in no case less than 20 feet, is below 5 ppm over background for the 15-minute average.

- If the organic vapor level is above 25 ppm at the perimeter of the work area, all work activities will be stopped.

All 15-minute average readings will be recorded and be available for review by the New York State Department of Environmental Conservation (NYSDEC) or the NYS Department of Health (DOH). Instantaneous readings, if any, used for decision purposes will also be recorded.

PARTICULATE MONITORING, RESPONSE LEVELS, AND ACTIONS

Particulate concentrations will be monitored continuously at the downwind perimeter of the each work area during all ground intrusive activities. Real-time monitoring equipment capable of measuring particulate matter less than 10 micrometers in size (PM-10) and capable of integrating over a period of 15 minutes (or less) will be used for the particulate monitoring. The equipment will be equipped with an audible alarm to indicate exceedance of the action levels summarized below. Any fugitive dust migration will also be visually assessed during all work activities.

Action Levels

- If the downwind PM-10 particulate level is 0.1 milligrams per cubic meter (mg/m3) greater than background (upwind perimeter) for the 15-minute period or if airborne dust is observed leaving the work area, then dust suppression techniques will be employed. Work will continue with dust suppression techniques provided that downwind PM-10 particulate levels do not exceed 0.15 mg/m3 above the upwind level and provided that no visible dust is migrating from the work area.

- If, after implementation of dust suppression techniques, downwind PM-10 particulate levels are greater than 0.15 mg/m3 above the upwind level, work will be stopped and a re-evaluation of activities initiated. Work will resume provided that dust suppression measures and other controls are successful in reducing the downwind PM-10 particulate concentration to within 0.15 mg/m^3 of the upwind level and in preventing visible dust migration.

All particulate monitoring measurements readings will be recorded and made available for NYSDEC and NYSDOH review.

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