

Draft

**Remedial Investigation/Feasibility Study Report
for RVAAP-67 Facility-Wide Sewers**

**Ravenna Army Ammunition Plant
Ravenna, Ohio**

**Contract No. W912QR-04-D-0028
Delivery Order No. 0001**

Volume I – Main Text and Appendices A-J

Prepared for:



**US Army Corps
of Engineers®**

**United States Army Corps of Engineers
Louisville District**

Prepared by:



**SAIC Engineering of Ohio
8866 Commons Boulevard
Twinsburg, Ohio 44087**

September 7, 2012

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13. SUPPLEMENTARY NOTES None.						
14. ABSTRACT This Remedial Investigation/Feasibility Study Report for the Facility-wide Sewers presents physical characteristics of the multiple Functional Areas within the Facility-wide Sewer system; compiles historical and newly acquired environmental data; summarizes nature and extent of contamination; evaluates contaminant fate and transport; provides human health and ecological risk assessments; identifies response actions, screening of remedial technologies and process options; develops remedial alternatives to address chemicals of concern (COCs) presenting unacceptable risk; and presents a recommended alternative to meet the remedial action objective at this AOC. To achieve National Guard Trainee and an unrestricted land use scenario for the Facility-wide Sewers, this report recommends implementing Alternative 3: Attain National Guard Trainee and Resident Farmer Land Uses ~ Excavation with Off-site Disposal. This alternative involves the removal of segments of pipes and inlets and manholes that contain contaminated sewer sediment at the Transportation Storage Area, Depot Administration Area, Load Line 2, and Load Line 3.						
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U	U	U	U	85927	19b. TELEPHONE NUMBER (Include area code) 502.315.6375	

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(Documentation to be provided once approval is issued.)

Draft

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Prepared for:

U.S. Army Corps of Engineers
600 Martin Luther King, Jr. Place
Louisville, Kentucky 40202

Prepared by:

SAIC Engineering of Ohio
8866 Commons Boulevard
Twinsburg, Ohio 44087

September 7, 2012

CONTRACTOR STATEMENT OF INDEPENDENT TECHNICAL REVIEW

Science Applications International Corporation (SAIC) has completed the Remedial Investigation/Feasibility Study Report for Soil, Sediment, and Surface Water at RVAAP-67 Facility-Wide Sewers at the Ravenna Army Ammunition Plant, Ravenna, Ohio. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of data quality objectives; technical assumptions; methods, procedures, and materials to be used; the appropriateness of data used and level of data obtained; and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing United States Army Corps of Engineers (USACE) policy.



MaryAnn Bogucki
Study/Design Team Leader

9/22/11

Date



Jed Thomas, P.E.
ITR Team Leader/ Feasibility Study Reviewer

9/22/11

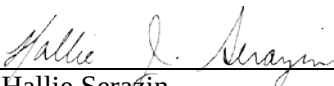
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David McCarley
Fate and Transport Reviewer

9/22/11

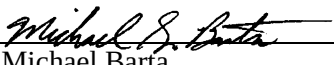
Date



Hallie Serazin
Human Health Risk Assessment Reviewer

9/22/11

Date



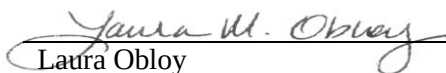
Michael Barta
Ecological Risk Assessment Reviewer

9/22/11

Date

Significant concerns and the explanation of the resolution are as follows:

Internal SAIC Independent Technical Review was conducted on the Preliminary Draft version of this document. Subsequent versions of this document (e.g., Draft and Final) incorporated changes based on the technical reviews of USACE, the Ohio Army National Guard, and the Ohio Environmental Protection Agency. Internal SAIC Independent Technical Review comments are recorded on a Document Review Record per SAIC quality assurance procedure QAAP 3.1. This Document Review Record is maintained in the project file. Changes to the report addressing the comments have been verified by the Study/Design Team Leader. As noted above, all concerns resulting from independent technical review of the project have been considered.



Laura Obloy
Principal w/ A-E firm

9/22/11

Date

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for RVAAP-67 Facility-Wide Sewers

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Ravenna, Ohio

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ACRONYMS AND ABBREVIATIONS

ACM	Asbestos-containing Material
ADR	Automated Data Review
amsl	above mean sea level
AOC	Area of Concern
ARAR	Applicable or Relevant and Appropriate Requirements
ASSHP	Abbreviated Site Safety and Health Plan
AT123D	Analytical Transient 1-, 2-, 3-Dimensional
bgs	below ground surface
BHC	Benzenhexachloride
BHHRA	Baseline Human Health Risk Assessment
BRAC	Base Realignment and Closure
CAI	Certified Asbestos Inspector
Camp Ravenna	Camp Ravenna Joint Military Training Center
CAMU	Corrective Action Management Unit
CAS	Chemical Abstract Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERL	Construction Engineering Research Laboratory
CFR	Code of Federal Regulations
CMCOC	Contaminant Migration Chemical of Concern
CMCOPC	Contaminant Migration Chemical of Potential Concern
CNS	Central Nervous System
COC	Chemical of Concern
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CSM	Conceptual Site Model
CUG	Cleanup Goal
DAF	Dilution Attenuation Factor
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DERP	Defense Environmental Restoration Program
DERR	Division of Emergency and Remedial Response
DFFO	Directors Final Findings and Orders
DLA	Defense Logistics Agency
DNB	Dinitrobenzene
DNT	Dinitrotoluene
DoD	United States Department of Defense
DOT	United States Department of Transportation
DQO	Data Quality Objective
ELAP	Environmental Laboratory Accreditation Program
EPC	Exposure Point Concentration

ACRONYMS AND ABBREVIATIONS (CONTINUED)

ERA	Ecological Risk Assessment
ERS	Ecological Risk Screening
ESA	Endangered Species Act
ESL	Ecological Screening Level
ESV	Ecological Screening Value
EU	Exposure Unit
FA	Functional Area
FAE	Functional Area Evaluation
FCR	Field Change Request
FS	Feasibility Study
FWCUG	Facility-Wide Cleanup Goal
FWGWMP	Facility-Wide Ground Water Monitoring Program
FWHHRAM	Facility-Wide Human Health Risk Assessors Manual
FWQAPP	Facility-Wide Quality Assurance Project Plan
FWS	Facility-Wide Sewers (in sample IDs)
FWSAP	Facility-Wide Sampling and Analysis Plan
gpm	gallons per minute
GRA	General Response Action
GSSL	Generic Soil Screening Level
HELP	Hydrologic Evaluation of Landfill Performance
HHRA	Human Health Risk Assessment
HHRS	Human Health Risk Screening
HI	Hazard Index
HLC	Henry's Law Constant
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
HQ	Hazard Quotient
HTRW	Hazardous, Toxic, and Radioactive Waste
IAP	Installation Action Plan
IBI	Index of Biological Integrity
ICI	Invertebrate Community Index
IDW	Investigation-Derived Waste
ILCR	Incremental Lifetime Cancer Risk
INRMP	Integrated Natural Resources Management Plan
IRA	Interim Removal Action
IRP	Installation Restoration Program
ISM	Incremental Sampling Methodology
LCS	Laboratory Control Sample
LDR	Land Disposal Restriction
LES	Lakeshore Engineering Services, Inc.
LUC	Land Use Control
MARC	Multiple Award Remediation Contract

ACRONYMS AND ABBREVIATIONS (CONTINUED)

MCL	Maximum Contaminant Level
MDC	Maximum Detected Concentration
MEC	Munitions And Explosives of Concern
MHE	Material Handling Equipment
MMRP	Military Munitions Response Program
MRS	Munitions Response Site
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MTR	Minimum Technical Requirement
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NFA	No Further Action
NGB	National Guard Bureau
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
O&M	Operation and Maintenance
OAC	Ohio Administrative Code
OHARNG	Ohio Army National Guard
Ohio EPA	Ohio Environmental Protection Agency
OHPO	Ohio Historic Preservation Office
OMZA	Outside Mixing Zone Average
OSC	United States Army Operations and Support Command
PAH	Polycyclic Aromatic Hydrocarbon
PBA	Performance-Based Acquisition
PBA08 RI	Performance-Based Acquisition 2008 Remedial Investigation
PBA08 SAP	Performance Based Acquisition 2008 Supplemental Investigation Sampling and Analysis Plan Addendum No. 1
PBT	Persistent, Bioaccumulative, and Toxic
PCB	Polychlorinated Biphenyl
PECOPC	Point Evaluation Chemical of Potential Concern
PETN	Pentaerythritol Tetranitrate
PP	Proposed Plan
PPE	Personal Protective Equipment
ppm	parts per million
PRG	Preliminary Remediation Goal
QA	Quality Assurance
QC	Quality Control
QHEI	Qualitative Habitat Evaluation Index
QSM	Quality Systems Manual
RAB	Restoration Advisory Board

ACRONYMS AND ABBREVIATIONS (CONTINUED)

RAFLU	Reasonable and Anticipated Future Land Use
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RDA	Recommended Daily Allowance
RDI	Recommended Daily Intake
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
REIMS	Ravenna Environmental Information Management System
RfD	Reference Dose
RI	Remedial Investigation
RM	River Mile
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RREL	Risk Reduction Engineering Laboratory
RSL	Regional Screening Level
RVAAP	Ravenna Army Ammunition Plant
SAIC	Science Applications International Corporation
SAP	Sampling and Analysis Plan
SESOIL	Seasonal Soil Compartment
SOR	Sum-of-Ratios
SRC	Site-related Contaminant
SRV	Sediment Reference Value
SSL	Soil Screening Level
SSSL	Site-specific Soil Screening Level
SVOC	Semi-volatile Organic Compound
SWPPP	Storm Water Pollution Prevention Plan
TACOM	United States Army Tank-Automotive and Armaments Command
TAL	Target Analyte List
TCLP	Toxicity Characteristic Leaching Procedure
TEC	Threshold Effect Concentration
TestAmerica	TestAmerica Laboratories, Inc.
TNB	Trinitrobenzene
TNT	2,4,6-Trinitrotoluene
TR	Target Risk
TU	Temporary Unit
UCL	Upper Confidence Limit
UHC	Underlying Hazardous Constituent
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

ACRONYMS AND ABBREVIATIONS (CONTINUED)

UTS	Universal Treatment Standard
UXO	Unexploded Ordnance
VCP	Vitrified Clay Pipe
VOC	Volatile Organic Compound
VSP	Vitrified Sewer Pipe
WOE	Weight-of-Evidence
WQS	Water Quality Standard
WWH	Warm Water Habitat

EXECUTIVE SUMMARY

ES.1 INTRODUCTION AND SCOPE

This Remedial Investigation (RI)/Feasibility Study (FS) report addresses the Facility-Wide Sewers area of concern (AOC) at the Ravenna Army Ammunition Plant (RVAAP). The Facility-Wide Sewers AOC is designated as RVAAP-67 under the RVAAP Installation Restoration Program (IRP). This document was prepared by Science Applications International Corporation (SAIC) under the United States Army Corps of Engineers (USACE), Louisville District, Multiple Award Remediation Contract (MARC) W912QR-04-D-0028, Delivery Order No. 0001, under a Performance-Based Acquisition (PBA). This RI/FS report was prepared in accordance with the requirements of the Ohio Environmental Protection Agency (Ohio EPA) *Director's Final Findings and Orders* (DFFO) for RVAAP, dated June 10, 2004 (Ohio EPA 2004), and conforms with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and National Contingency Plan (NCP) requirements.

This RI/FS report for Facility-Wide Sewers presents the following:

- A description of the operational history and environmental setting for the AOC.
- A summary of the field activities and results of the RI, conducted from August 2009 through August 2010.
- A description of the nature and extent of contamination.
- An evaluation of contaminant fate and transport.
- A human health risk assessment (HHRA) and an ecological risk assessment (ERA).
- Conclusions of the RI report, which form the basis for conducting the FS.
- Identification of the remedial action objective (RAO) for contaminated media at the AOC.
- Identification of applicable or relevant and appropriate requirements (ARARs).
- Identification of general response actions (GRAs) and screening of a range of remedial technologies to reduce risks to human health and the environment at the AOC from chemicals of concern (COCs) identified in the RI report.
- Development of remedial alternatives from appropriate GRAs and remedial technologies and evaluation of alternatives against criteria specified by CERCLA.

- Conclusions of the FS and a recommended alternative.

Based on the outcome of the evaluation in this report, the recommended alternative will be submitted for public review and comment in a proposed plan (PP). Public comments will be considered in the final selection of a remedy, which will be documented in a record of decision (ROD).

ES.2 AOC DESCRIPTION

ES.2.1 AOC Description and Operational History

Created in 2008, the Facility-Wide Sewers AOC is comprised of approximately 26 miles (approximately 140,200 linear ft) of IRP-eligible storm and sanitary sewers located throughout RVAAP. The general configuration of the Facility-Wide Sewers system is shown in Figure ES-1. Due to the size and structure of the AOC, it was divided into 19 Functional Areas (FAs), based on the spatial distribution of the systems and their operational characteristics. These FAs are:

FA 1: Administration Area	FA 11: Load Line 6
FA 2: Atlas Scrap Yard	FA 12: Load Line 7
FA 3: Depot Administration Area	FA 13: Load Line 8
FA 4: George Road Trunk and Connector Lines	FA 14: Load Line 9
FA 5: Inert Storage Area #6	FA 15: Load Line 10
FA 6: Load Line 1	FA 16: Load Line 11
FA 7: Load Line 2	FA 17: Load Line 12
FA 8: Load Line 3	FA 18: Sand Creek Trunk and Connector Lines
FA 9: Load Line 4	FA 19: Transportation Storage Area
FA 10: Load Line 5	

ES.2.1.1 Sanitary Sewers

The sanitary sewers at RVAAP are distributed across four drainage networks. Three of the sanitary sewer drainage networks were associated with sewage treatment plants and had a combined daily capacity of the 750,000 gallons, and the fourth network utilized a small septic and Imhoff tank system. The RI included sampling of sewer line structures (i.e., manholes). Wastewater treatment plants at RVAAP (e.g., Sand Creek Sewage Treatment Plant, George Road Sewage Treatment Plant, and the Depot Sewage Treatment Plant) were regulated under separate National Pollutant Discharge Elimination (NPDES) programs and were closed in the 1990s; thus, they are not IRP-eligible and are not included in this RI/FS. The four sanitary sewer drainage networks and their component FAs are as follows:

- George Road Sewage Treatment Plant Network:
 - Administration Area (FA 1);
 - Load Line 5 (FA 10);

- o Load Line 6 (FA 11);
 - o Load Line 7 (FA 12);
 - o Load Line 8 (FA 13);
 - o Load Line 9 (FA 14);
 - o Load Line 10 (FA 15);
 - o Load Line 11 (FA 16); and
 - o George Road Trunk and Connector Lines (FA 4).
- Sand Creek Sewage Treatment Plant Network:
 - o Atlas Scrap Yard (FA 2);
 - o Inert Storage Area #6 (FA 5);
 - o Load Line 1 (FA 6);
 - o Load Line 2 (FA 7);
 - o Load Line 3 (FA 8);
 - o Load Line 4 (FA 9);
 - o Load Line 12 (FA 7); and
 - o Sand Creek Trunk and Connector Lines (FA 18).
 - Depot Administration Area Sewage Treatment Plant Network (FA 3).
 - Transportation Storage Area (FA 19) sewage and septic system.

ES.2.1.2 Storm Sewers

Discrete storm sewer networks exist at eight FAs. The storm sewers collected runoff from drainage areas along roads, railbeds, and buildings and diverted it to ditches and drainage conveyances through outfalls. Conventional discontinuous drainage culverts beneath roads, rail lines, and utility right-of-ways are not included within the scope of the RI/FS because these structures involve surface drainage conveyances that have been or will be addressed through AOC-specific decisions for surface water and sediment media. The following FAs have discrete storm sewer networks included under the scope of the Facility-Wide Sewers RI/FS:

- Administration Area (FA 1);
- Depot Administration Area (FA 3);
- Inert Storage Area #6 (FA 5);
- Load Line 1 (FA 6);
- Load Line 2 (FA 7);
- Load Line 3 (FA 8);
- Load Line 4 (FA 9); and
- Transportation Storage Area (FA 19).

Historically, these storm and sanitary sewer systems may have received inadvertent discharges of contaminated wastewater related to the manufacturing of munitions or other industrial processes.

1 Available historical documents do not indicate any incidents or occurrences of intentional dumping or
2 discharging of contaminated wastewaters to the storm or sanitary sewers.

3
4 Due to the size and complexity of the AOC, this RI/FS report is organized into five volumes. Volume
5 I contains the Main Text that presents the purpose and scope of the RI/FS; RI sampling and
6 characterization methods; overall evaluation methods for contaminant nature and extent, contaminant
7 fate and transport, and risk assessments; RI results for each of the FAs; the complete FS; and common
8 appendices, such as sampling logs, analytical data, and the data quality control report, which pertain
9 to all FAs. Volumes II-IV contain detailed RI results and data evaluations for each of the FAs are
10 contained in respective functional area evaluations (FAEs). Volume V contains supplemental data for
11 the contaminant fate and transport, HHRA, ERA.

12 13 **ES.2.2 Data Aggregates**

14
15 For evaluation of the Facility-Wide Sewers, data were aggregated spatially by FA (as summarized
16 above) and by environmental medium. Within each FA, data collected from sanitary and storm sewer
17 systems (where both are present) were aggregated and evaluated separately because they are separate
18 systems. Within sanitary and storm sewer systems, data were further aggregated by environmental
19 medium. Environmental medium data aggregates include:

- 20 • Subsurface sewer media - including sewer sediment located within the pipes and the pipe bedding
21 material (e.g., soil, sand, or gravel used as backfill material) immediately underlying and adjacent
22 to the sewer pipes. Sewer sediment within the systems was not further differentiated into wet or
23 dry sediment based on RVAAP programmatic definitions for surface water conveyances because
24 this medium exists within enclosed pipelines. Subsurface sewer media are considered as
25 subsurface soil for the purposes of evaluations conducted in this RI.
- 26
27 • Sewer Water - consisting of standing or flowing water within the sanitary or storm sewer systems.
- 28
29 • Outfall Sediment - including wet and dry sediment located in the immediate proximity to sanitary
30 or storm sewer outfalls. This aggregate was further subdivided according to RVAAP
31 programmatic definitions of wet and dry sediment, based on observed outfall conditions and best
32 available data respective to flow at the outfalls.
- 33
34 • Outfall Water - consisting of surface water present in the immediate proximity to sanitary or
35 storm sewer outfalls.
- 36

37 **ES.2.3 Reasonable and Anticipated Future Land Use**

38
39 Reasonable and Anticipated Future Land Use (RAFLU) = Military Use and Training
40 Representative Receptor = National Guard Trainee

41
42 RVAAP is a controlled-access facility that is fenced and patrolled by security personnel. Full-time
43 Ohio Army National Guard (OHARNG), Base Realignment and Closure (BRAC) Division, and

contractor staff work at the facility. Since the Facility-Wide Sewers AOC contains 26 miles of sewer lines distributed across RVAAP, multiple future military land uses may apply. Most of the AOCs are not currently used for training for operational activities; however, the RAFLU is National Guard Training for the majority of the AOCs for which the Facility-Wide Sewers AOC traverse (i.e., Load Lines 1 through 12, Atlas Scrap Yard). Other areas (e.g., Administration Area, Depot Administration Area, Inert Storage Area #6) are currently utilized for administrative or storage functions by OHARNG.

The National Guard Trainee includes digging and mixing soil and subsurface media to a depth of 7 ft below ground surface (bgs) as part of the exposure scenario. Therefore, the RAFLU for the Facility-Wide Sewers AOC is Military Use and Training, using the National Guard Trainee as the representative receptor. Military Use and Training, in conjunction with the evaluation of Unrestricted Residential Land Use, forms the basis for identifying COCs. The Resident Farmer facility-wide cleanup goals (FWCUGs) are used to evaluate COCs for Unrestricted Residential Land Use at the AOC, as outlined in the *Guidance Document for the Evaluation of Land Use Controls* (USACE 2011a).

ES.3 FINDINGS AND RECOMMENDATIONS OF THE REMEDIAL INVESTIGATION

Limited previous investigations have been performed to characterize the storm and sanitary sewer systems at RVAAP. These investigations included qualitative field screening tests for explosives residues, limited collection of sediment and water samples from sewers and outfalls, and video surveys. These investigations focused on Load Lines 1 through 12 and were designed to provide an initial evaluation of the occurrence and distribution of contamination, rather than to fully assess contaminant nature and extent and risk. Data from historical investigations were used in the evaluations in this Facility-Wide Sewers RI/FS according to their representativeness of current conditions and degree of documented quality assurance and quality control.

Data quality objectives (DQOs) and the scope of the Facility-Wide Sewers RI are outlined in the *Sampling and Analysis Plan for the Remedial Investigation of RVAAP-67 Facility-Wide Sewers, Addendum No. 1* (herein referred to as the Facility-Wide Sewers SAP) (USACE 2009c). Field activities for the Facility-Wide Sewers RI were conducted between August 2009 and August 2010 and included visual survey inspection; video camera survey; and collection of sewer and outfall sediment, sewer and outfall water, scale/deposit, and pipe bedding samples, using discrete sampling techniques. These activities were completed using a phased approach, including an initial visual survey and two phases of sample collection (Tier 1 and Tier 2), with an intervening technical evaluation to identify remaining data gaps to be filled. A second technical evaluation following Tier 2 of the field investigation determined data were sufficient to proceed with the RI/FS, and a planned Tier 3 phase was not conducted. Facility-Wide Sewers RI field activities included:

- Visual survey inspections of 612 sanitary and storm sewers structures (manholes, storm sewer drop inlets, outfalls).

- Video camera surveys of approximately 3,810 linear ft of the sewer lines (3,430 ft and 380 ft of sanitary and storm sewer lines, respectively).
- Collection of 200 sewer sediment, 47 sewer water, 89 pipe bedding material, 58 outfall sediment, and 21 outfall water samples, using discrete sampling methods. Sample analyses included field analyses of sediment samples for 2,4,6-trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), using field test kits (positive test kit detections were submitted for off-site laboratory analysis of explosives) and off-site laboratory analyses for target analyte list (TAL) metals, explosives, propellants, pesticides, polychlorinated biphenyls (PCBs), herbicides, semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs) according to specifications in the Facility-Wide Sewers SAP.
- Collection of 9 sewer sediment samples and 11 pipe bedding samples for hexavalent chromium analysis to evaluate chromium speciation.
- Collection of suspected mineralogical scale/deposit samples from within the manholes or catch basins for laboratory analysis of explosives and TAL metals.

Findings of the visual survey and video surveys indicate the sanitary and storm sewer pipelines are largely intact. However, cracks, separations of pipe sections at joints, and root intrusion were frequently observed. These observations were within expectations, considering the age of the systems. Evidence of water infiltration was observed at discrete cracks and the majority of pipe joints (staining of pipe walls and the accumulation of scale/mineral deposits). Few points of partial or complete pipe collapse were observed. Building demolition activities have resulted in damage or infilling of surface structures associated with the systems, such as manholes and catch basins (drop inlets). In particular, demolition activities at former Load Lines 1 through 4 and Load Line 12 impacted numerous sewer structures, especially those associated with shallow storm sewers adjacent to buildings and walkways. In some instances, manhole cover assemblies had been moved aside or were missing, representing a potential physical safety hazard. Multiple manholes and storm sewer drop inlets at Load Lines 1 through 4 were infilled with rail ballast or demolition debris. Fewer structures were damaged at other FAs where building demolition activities have been completed (Load Lines 5 through 11, Atlas Scrap Yard).

ES.3.1 Summary of Contaminant Nature and Extent

This RI report evaluates all available data with respect to usability and identifies site-related contaminants (SRCs). Data were evaluated according to the aggregates described in Section ES.2.2. All available historical and Facility-Wide Sewer RI sample data were evaluated to determine suitability for use in the various key RI data screens and evaluations (nature and extent, fate and transport, risk assessment). The analytical data obtained during the Facility-Wide Sewers RI and previous investigations identified SRCs indicative of potential impacts from former RVAAP operations. Specific findings of the contaminant nature and extent evaluations for each FA are summarized in Section 5.0 of this Main Text and detailed in Section 5.0 of their respective FAEs. The

1 evaluation of contaminant nature and extent focuses on identified SRCs; summary findings are
2 presented below.

3 4 **ES.3.1.1 SRC Summary of the Facility-Wide Sewers**

- 5
6 • The primary SRCs identified in all Facility-Wide Sewers environmental media were inorganic
7 chemicals and SVOCs [primarily polycyclic aromatic hydrocarbons (PAHs)]:
8
 - 9 o Arsenic, chromium, lead, manganese, and silver were the most frequently detected inorganic
10 SRCs in sewer sediment.
 - 11
12 o Arsenic, cadmium, cobalt, lead, manganese, and zinc were the most frequently detected
13 inorganic SRCs in sewer water.
 - 14
15 o Cadmium, silver, lead, and zinc were the most frequently detected inorganic SRCs in pipe
16 bedding material.
 - 17
18 o Chromium, lead, manganese, and zinc were the most frequently detected inorganic SRCs in
19 outfall sediment. Antimony, manganese, lead, silver, and zinc were the predominant
20 inorganic SRCs in outfall water.
 - 21
22 o Detectable concentrations of hexavalent chromium were observed in 9 of 20 samples
23 collected. However, total chromium to hexavalent chromium ratios did not indicate
24 enrichment with respect to hexavalent chromium. One pipe bedding material sample location
25 at Load Line 1 exhibited a hexavalent chromium to total chromium ratio greater than 1:6
26 (14%); however, the total chromium concentration at the location was approximately
27 one-sixth the RVAAP facility-wide background concentration of 27.2 mg/kg for subsurface
28 soil pipe bedding material.
 - 29
30 o PAHs were frequently detected SRCs, as they were common to all environmental sewers
31 media in both storm and sanitary sewers at each FA.
 - 32
- 33 • Accumulations of bulk explosives residue were not observed during the Facility-Wide Sewers RI
34 sampling efforts. Unexploded ordnance (UXO) technicians reviewed video survey logs to
35 identify suspect visible deposits within pipelines. Suspect visible deposits were noted in sanitary
36 sewer line segments at the Load Line 2 FA and the Depot Administration Area FA; however,
37 subsequent sampling of these material showed that they were mineralogical in nature rather than
38 explosives residue.
- 39
40 • Analytical results showed detectable levels of explosives in sanitary and storm sewer sediment
41 and sewer water samples, particularly at the Load Line 1, 2, and 3 FAs. The most frequently
42 observed explosives were 1,2,3-trinitrobenzene (TNB); nitroglycerin; and RDX, with

nitrocellulose being the most frequently detected propellant. Pipe bedding material had very few explosive SRCs, and sanitary and storm outfall water had the least number of explosive SRCs.

- VOCs (acetone, 2-butanone, chlorobenzene, and carbon disulfide), pesticides [4,4'-dichlorodiphenyldichloroethylene (DDE); 4,4'-dichlorodiphenyldichloroethane (DDD); and gamma chlordane], and PCBs (PCB-1254 and PCB-1260) were identified as SRCs sporadically throughout the sewer media across the AOC.
- Research of historical records, visual inspection, and sampling of pipe material indicated storm and sanitary sewer systems were not constructed using asbestos-containing material (ACM). The most common construction material included vitrified clay pipe, cast iron, fired brick (manholes), and corrugated metal.

ES.3.1.2 Key Trends and Findings

The common distribution of PAHs in the sanitary and storm sewer systems and at outfalls indicate multiple sources most likely associated with runoff from railroad lines, roads, and parking lots. In addition, historical plumbing systems common to World War II era buildings, such as those at RVAAP, used asphaltic compounds (e.g., oakum) in pipe joint seals.

- The nature and extent of some inorganic SRCs indicate specific sources and associated longitudinal trends within the sewer systems at some FAs. Notable trends include:
 - o The frequent occurrence of manganese above its RVAAP facility-wide background concentration in storm and sanitary sewer media at many FAs reflects multiple source inputs to these systems. In particular, the Depot Administration Area FA and Transportation Storage Area FA had a comparatively high frequency of detection and highest concentrations of manganese in sewer media relative to other FAs within the Facility-Wide Sewers. Potential observed sources based on visual surveys and characteristics of the systems include deteriorating steel components of the systems (e.g., ladder rungs within manholes, storm sewer drop inlet grates) and metal debris that have washed into the systems over time. Visual data show infiltrating groundwater has resulted in mineralogical/scale deposits within many sewer lines, which analyses showed contained high concentrations of manganese compared to background concentrations, that potentially contribute to overall concentrations in sewer media.
 - o Lead was also frequently identified as an SRC in sewer media, indicating multiple historical sources. Notable longitudinal trends were observed in sediment along storm sewer segments in the southwest portions of the Load Line 2 and 3 FAs. Lead sources potentially included lead-based paint flaking from deteriorating buildings over time, which would wash into storm sewer drop inlets. Additionally, historical plumbing systems common to World War II era buildings, such as those at RVAAP, used lead to seal joints in cast-iron plumbing systems and may have contributed to lead observed in sewer media.

- o A longitudinal trend for mercury was observed in the George Road Sanitary Trunk and Connector Lines running from the Load Line 5 through 11 F As and through the Administration Area FA. Historical operations in these load lines involved the use of lead- and mercury-based primary explosives, and the occurrence and distribution of mercury indicates historical releases to the sanitary sewer system. Mercury was detected in sanitary sewer sediment exiting several of the fuze and booster load lines and within the trunk and connector lines that convey drainage to the Administration Area FA.
- The sporadic distribution of explosives and propellant SRCs, as compared to inorganic chemicals and PAHs, reflects the fact that former production operations and primary sources of these compounds, especially the melt pour lines at Load Lines 1-4, ceased operations decades ago, and only residual secondary sources (e.g., contaminated soil and sediment) remain as contributors. Precipitation events and groundwater infiltration with associated flushing through the systems, along with degradation processes, appear to be reducing explosives concentrations over time.
- In both storm and sanitary sewer systems, the number and concentrations of SRCs observed in the bedding material beneath pipes were comparatively lower, generally by orders of magnitude, than those observed in sewer sediment within the pipes. These findings indicate that the overall preferential migration pathway for contaminants in the sanitary and storm sewer system is laterally in the direction of flow, rather than via vertical migration to the underlying pipe bedding material. While cracks and joint separations within the sanitary sewer system are observed due to its advanced age, the pipes are generally intact; this helps to limit vertical migration from sewer sediment to the exterior of the piping system.
- In FAs where both storm and sanitary sewer systems are present, storm sewer pipe bedding material exhibited a greater number of SRCs than sanitary pipe bedding material. This observation is likely a function of the fact that storm sewer lines were deliberately constructed with unsealed or open joints to promote infiltration of storm runoff, whereas the sanitary system was constructed as a closed system with sealed joints.
- Review of sewer system construction data, field measurements, and potentiometric data indicate that portions of sanitary and storm sewers at multiple FAs lie close to or beneath the water table. These conditions promote groundwater infiltration into the sewer systems, and the pipe systems function as preferential flow pathways. Alternately, water flowing through pipes above the water table may exit the pipes through cracks and infiltrate the water table. Video surveys showed numerous instances of groundwater infiltration into the pipe systems through cracks and pipe joints, as evidenced by iron staining on pipe walls and formation of mineralogical deposits (which in some cases occluded up to 95% of the pipe). Notable evidence of the interaction between groundwater and sewer systems was observed at the Load Line 12 FA, wherein nitrate was detected in both sanitary sewer water and nearby groundwater monitoring wells, with higher concentrations in adjacent groundwater, indicating influx into the pipes.

ES.3.2 Summary of Contaminant Fate and Transport

The contaminant fate and transport evaluation assessed the potential for chemicals to leach from subsurface sewer media (i.e., sewer sediment and pipe bedding material) at the FAs and impact groundwater beneath the media and downgradient receptor locations. This evaluation was included in the decision-making process to determine whether remedial actions for subsurface sewer media may be necessary to protect groundwater resources.

Based on the results of SRC screening evaluation of subsurface sewer media, inorganic and organic SRCs exist in subsurface sewer media at the AOC. SRCs identified within each FA were further evaluated to determine if residual concentrations in sediment/soil are protective of groundwater.

The sediment and soil screening analyses and Seasonal Soil Compartment (SESOIL) contaminant leaching modeling identified SRCs that may leach from subsurface sewer media at concentrations above screening criteria [e.g., Safe Drinking Water Act Maximum Contaminant Levels, United States Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs), and FWCUGs]. These SRCs were identified as contaminant migration chemicals of potential concern (CMCOPCs) and further evaluated using Analytical Transient 1-,2-,3-Dimensional (AT123D) modeling to assess potential impacts in groundwater beneath the respective source areas and at the nearest downgradient surface water receptor locations.

Results for the AT123D modeling showed the following CMCOPCs were predicted to exceed the screening criteria in groundwater below the source area and were further modeled to the nearest respective downgradient receptor locations:

- Nitroglycerin in the Administration Area FA;
- 2,4-dinitrotoluene (DNT) and nitroglycerin in the Load Line 6 FA;
- 1,3-dinitrobenzene (DNB); 2,4-DNT; 2,6-DNT; 2-amino-4,6-DNT; 2-nitrotoluene; and RDX in the Load Line 8 FA;
- 2-nitrotoluene and pentaerythritol tetranitrate (PETN) in the Load Line 10 FA;
- 4-amino-2,6-DNT and nitroglycerin in the George Road Trunk and Connector Lines FA.
- 2-amino-4,6-DNT, 4-amino-2,6-DNT, and RDX in the Load Line 2 FA; and
- 4-amino-2,6-DNT; 1,2-dichlorobenzene; 1,3-dichlorobenzene; 1,4-dichlorobenzene; and 4-chlorobenamine in the Load Line 12 FA.

Based on modeling results, none of these chemicals noted above were predicted to exceed their respective screening criteria at selected downgradient receptor locations.

Based on results of the stepwise fate and transport screening and modeling evaluation, no SRCs were identified as contaminant migration chemicals of concern (CMCOCs) posing future impacts to groundwater (e.g., predicted concentrations in groundwater beneath the sources and at receptor locations were less than screening criteria).

ES.3.3 Summary and Conclusions of the Human Health Risk Assessment

The purpose of the preliminary data screening and risk assessment is to determine the need for conducting an FS for remediation of any portion of the piping system or outfalls for the Facility-Wide Sewers AOC. For the HHRA, all 19 FAs included samples collected from sewer lines 0-13 ft bgs, which are considered to be within the potential exposure units for the National Guard Trainee and/or Resident Farmer. At 12 of the FAs (Administration Area, Atlas Scrap Yard, Depot Administration Area, Inert Storage Area #6, Load Lines 1-4, Load Line 8, Load Line 11, Sand Creek Trunk and Connector Lines, Transportation Storage Area), the total volume of the sewer pipe system represents greater than 1% of the total mixing zone soil volume within the FA. For these FAs, a screening for chemicals of potential concern (COPCs)/COCs and a point evaluation to assess potential exposure to downstream receptors were conducted. At the remaining seven FAs (George Road Trunk and Connector Lines, Load Lines 5-7, Load Line 9, Load Line 10, Load Line 12), the total volume of the sewer pipe system represents less than 1% of the total mixing zone soil volume within the FA. At these FAs, sewer media are not considered to be a concern for direct contact; therefore, the HHRA consisted of a point evaluation to assess the potential for impacts to downstream receptors.

At 10 of the 12 FAs with a sewer pipe system volume greater than 1% of the total mixing zone soil, no COCs were identified for the National Guard Trainee or Resident Farmer because the exposure point concentration (EPC) of all COPCs is less than the adjusted FWCUGs, and the calculated sum-of-ratios (SOR) is less than 1. Manganese was identified as a COC at the Depot Administration Area FA and Transportation Storage Area FA. At both FAs, manganese was detected above the adjusted FWCUG for the National Guard Trainee in one sediment sample. At the Depot Administration Area FA, manganese was also detected above the point evaluation screening criterion in sewer sediment, sewer water, and outfall sediment, indicating the potential for migration to downstream media. Manganese has historically been, and continues to be, stored at the Transportation Storage Area FA; therefore, it was identified as a COC for sewer sediment at this FA.

Although it was not identified as a COC, lead was detected above point evaluation screening criteria in several sewer media at the Load Line 2 FA and Load Line 3 FA. Lead was not identified as a COC because the maximum detected concentration (MDC) is less than the adjusted soil guidance value; however, the point evaluation at these FAs indicates lead may downstream receptors and should be evaluated in an FS.

Various compounds were identified as exceeding point evaluation screening at all 19 FAs. However, based on multiple lines of evidence, including a geospatial analysis for downstream impacts and fate and transport modeling, none of these chemicals are impacting downstream receptors; therefore, they do not warrant evaluation in an FS.

ES.3.4 Summary and Conclusions of the Ecological Risk Assessment

The ERA evaluated potential ecological exposures from sewer soil, sediment, and water at sewer system outfalls. For the sewer ERA, only outfalls are examined quantitatively because the interior of the piping system does not represent an ecological habitat. A stepwise technical approach was followed to evaluate FAs and determine if further investigation or remediation was warranted for the respective FAs. FAs with no outfalls were eliminated from consideration in the ERA. For those FAs having outfalls, further assessment was conducted to determine if there were chemicals of potential ecological concern (COPECs) in corresponding outfall sediment and water, if there was evidence of continuing sources within the sewer system (e.g., identified human health COCs or localized sources), and if there was evidence of downstream environmental consequences related to identified COPECs at nearby biological/chemical sampling stations. Recommendations for further action or no further action (NFA) respective to the ERA were developed based on the ERA process.

The ERA for the Facility-Wide Sewers AOC concluded the following:

- The Atlas Scrap Yard FA, Load Lines 5 through 10 FAs, Load Line 12 FA, and George Road Trunk and Connector Lines FA had no active outfalls, and no quantitative ERA was performed. All nine of these FAs are recommended for NFA.
- The Administration Area FA, Inert Storage Area #6 FA, Load Line 4 FA, Load Line 11 FA, and Sand Creek Trunk and Connector Lines FA had active outfalls, and an ERA was completed that identified COPECs at some storm sewer outfalls. Sewers within these five FAs are recommended for NFA due to lack of corresponding upgradient sources or COCs within the sewer systems and lack of downgradient consequences.
- The Load Line 1 FA had multiple active outfalls with COPECs, no human health COCs within the pipe systems, and some downgradient biological/water quality evidence of consequences with respect to identified COPECs at the outfalls. Concentrations of COPECs at Load Line 1 FA outfalls have declined in concentration since 1996, which coincides with a decline of SRC concentrations inside the sewer systems. Therefore, NFA is recommended for sewers at the Load Line 1 FA.
- The Load Line 3 FA had multiple active outfalls with COPECs and no COCs within the pipe systems; however, lead was identified as a potential concern based on the HHRA point evaluation and potential to partition and migrate to surface water. Because downstream biological/water quality evaluation revealed that lead had little to no downstream consequences, NFA is recommended for the Load Line 3 FA.
- The Depot Administration Area FA and Transportation Storage Area FA had one or more active outfalls with COPECs, upgradient sources or COCs within the pipe systems (manganese), but little to no downstream consequences. NFA is recommended for both.

- The Load Line 2 FA had multiple storm sewer outfalls with COPECs and no COCs within the pipe systems; however, lead was identified as a potential concern based on the HHRA point evaluation and potential to partition and migrate to surface water. Evidence of downstream biological/water quality consequences in a receiving body (Kelly's Pond) was identified from existing studies. Therefore, the Load Line 2 FA is recommended for assessment in an FS for lead in the storm sewer lines.

ES.3.5 Recommendation of the Remedial Investigation

Historical investigations and the Facility-Wide Sewers RI adequately characterized this AOC, and further investigation is not warranted. The RI recommends proceeding to the FS phase to evaluate remedial alternatives addressing: (1) manganese in the Transportation Storage Area FA and Depot Administration Area FA sewer sediment; and (2) lead in the Load Line 2 FA and Load Line 3 FA sewer sediment. In the HHRA, manganese was identified as a COC at the Transportation Storage Area FA and Depot Administration Area FA. Although not identified as a COC in the HHRA, lead is a candidate for remediation in one storm sewer segment each at the Load Lines 2 and 3 FAs, based on the HHRA point evaluation and potential fate and transport impacts to surface water. In the ERA, lead in a storm sewer segment at the Load Line 2 FA was also identified as requiring remediation in the FS. Remediation to protect groundwater resources is not warranted for the 19 FAs based on contaminant leaching and fate and transport modeling results.

Manganese in sewer sediment at the Transportation Storage Area FA and Depot Administration Area FA requires remediation to the FWCUG of 35,100 mg/kg for subsurface sewer media to be protective for the National Guard Trainee and Resident Farmer, as presented in the HHRA. Lead was not identified as a COC, and the adjusted lead FWCUG for subsurface sewer media per the HHRA is 199,500 mg/kg, which exceeds all sewer sediment concentrations at the Load Line 2 FA and Load Line 3 FA. Therefore, to address potential surface water and ecological impacts related to lead partitioning and migration from sewer sediment to downstream surface water receptors, a calculated cleanup goal (CUG) was developed based on an analytical partitioning model. A CUG of 5,850 mg/kg was developed based on the concentration of lead in sediment that would result in a surface water discharge concentration greater than the maximum contaminant level (MCL) (0.015 mg/L). This CUG was calculated using a soil/sediment to outfall surface water dilution attenuation factor (DAF) of 390,000 L/kg. The DAF was developed using the observed concentration of lead in the sediment at Load Line 2 storm sewer inlet DB-20 (maximum observed lead concentration in storm sewer sediment) and the corresponding downstream outfall water concentration at LL2sw-311.

The evaluation conducted as part of the remedy may include refining specific areas requiring remediation to attain the CUGs at the respective FAs (Transportation Storage Area FA, Depot Administration Area FA, Load Line 2 FA, and Load Line 3 FA). This data will be evaluated to identify portions of the sewer line segments that may be excluded from remediation or additional segments that may require remediation. NFA is recommended for sewer media in the remaining 15 FAs within the Facility-Wide Sewers AOC.

ES.4 SUMMARY AND RECOMMENDATION OF THE FEASIBILITY STUDY

The FS developed the RAO, identified appropriate CUGs for remedial actions, identified ARARs, screened potential remedial technologies and process options, and developed and evaluated remedial alternatives.

ES.4.1 Remedial Action Objective and Cleanup Goals

The RAO for the Facility-Wide Sewers AOC is to prevent: (1) National Guard Trainee exposure to chemicals requiring remediation in sewer sediment above CUGs; (2) adverse ecological effects from previous AOC activities; and (3) negative groundwater impacts from contaminant migration from source media (e.g., sewer sediment).

The HHRA identified manganese at the Transportation Storage Area FA and Depot Administration Area as a COC requiring evaluation in an FS. Lead in selected storm sewer segments in the Load Line 2 FA and Load Line 3 FA was identified for remediation based on results of the HHRA point evaluation and the potential to partition and impact surface water. Additionally, the ERA identified lead in the Load Line 2 FA as requiring evaluation in an FS. Fate and transport modeling indicates remediation is not warranted to protect groundwater. Anticipated remedial activities to protect the human receptor and ecological resources will reduce the potential for contaminant migration to groundwater at all of the locations requiring remediation.

No FWCUGs are available for exposure to subsurface sewer media. FWCUGs for the National Guard Trainee and Resident Farmer exposed to soil (USACE 2010) were used along with adjustment factors presented in Section 7.0 to account for the use of soil FWCUGs with identified in subsurface sewer media mixed with soil. The locations requiring remediation and the CUGs to be protective for the appropriate receptors for manganese and lead are presented in Tables ES-1 and ES-2, respectively.

The CUGs for the National Guard Trainee are the same or lower than the CUGs for the Resident Farmer. For manganese, the CUG for the National Guard Trainee is 35,100 mg/kg, and the CUG for the Resident Farmer is 1,000,000 mg/kg.

For lead, the CUG for both the National Guard Trainee and Resident Farmer is 199,500 mg/kg. A CUG of 5,850 mg/kg was developed based on the concentration of lead in sediment that would result in a surface water discharge concentration greater than the MCL (0.015 mg/L). This CUG was calculated by assuming a soil/sediment to outfall surface water DAF of 390,000 L/kg for lead. The DAF was developed using the observed concentration of lead in the sediment at the inlet DB-20 and the corresponding downstream outfall water concentration at LL2sw-311.

Table ES-1. Locations Where Manganese Requires Remediation for Unrestricted Residential Land Use

Sample Location (Depth of pipe in inlet)	Manganese Concentration (CUG=35,100 mg/kg)
TSAsd-002(sn) (7 ft bgs)	37,600
DAAsd-006(sn) (4.3 ft bgs)	48,900

ft bgs = feet below ground surface
CUG = Cleanup Goal

Table ES-2. Locations Where Lead Requires Remediation for Unrestricted Residential Land Use

Sample Location (Depth of pipe in inlet)	Lead Concentration (CUG=5,850 mg/kg)
LL2sd-615(st) (3.5 ft bgs)	29,200
LL3sd-272(st) (2.2 ft bgs)	5,560

ft bgs = feet below ground surface
CUG = Cleanup Goal

ES.4.2 Development and Evaluation of Alternatives

After the identification of chemicals requiring remediation and the establishment of CUGs, remedial technologies were screened, and the following viable remedial alternatives developed:

- Alternative 1: No Action.
- Alternative 2: Attain Unrestricted Residential Land Use ~ In-situ Treatment Using Solidification/Stabilization.
- Alternative 3: Attain Unrestricted Residential Land Use ~ Excavation with Off-site Disposal.

These alternatives are applicable and are compared against one another to provide information of sufficient quality and quantity to justify the selection of a remedy.

The No Action alternative, required for evaluation under the NCP, provides the baseline against which other remedial alternatives are compared. This alternative assumes all current actions (e.g., access restrictions and environmental monitoring) are discontinued and assumes no future actions take place to protect human receptors or the environment. Removal or treatment of COCs at the AOC is not implemented.

Under Alternative 2, pipes/inlets/manholes would be grouted to solidify/stabilize chemicals requiring remediation. The solidification/stabilization of sewer sediment in pipes/inlets/manholes achieves

Unrestricted Residential Land Use by preventing exposure to chemicals requiring remediation for the Resident Farmer. Alternative 2 consists of pressure grouting the pipes/inlets/manholes with a stabilization/solidification agent to bind the sewer sediment, removing the surface structure (i.e., concrete/metal/tile sides manhole cover, grate) of inlets and manholes to approximately 2 ft bgs, and restoring the surface around the inlet/manhole to the surrounding conditions (i.e., vegetation, asphalt road surface). Debris from removal of the surface completion of the inlet or manhole would be transported by truck to an off-site licensed disposal facility.

Under Alternative 3, pipes/inlets/manholes of concern will be excavated, removed, and disposed at an off-site disposal facility. The excavation and removal of the contaminated sewer sediment from the pipe/inlet/manhole of concern in the AOC obtains Unrestricted Residential Land Use. Alternative 3 consists of excavating and removing the pipe/inlet/manhole co-located with the sewer sediment requiring remediation, followed by transportation by truck to an off-site licensed disposal facility.

Excavations would be backfilled with approved, clean soil from a local commercial supplier. Disturbed areas would be restored to grade, re-vegetated (using an OHARNG-approved seed mixture), and mulched. No COCs were identified in sewer and outfall water, outfall sediment, or pipe bedding material for Unrestricted Residential Land Use; therefore, NFA is required for these media. No land use controls (LUCs) or five-year reviews pursuant to CERCLA would be required because this alternative attains a level of protection for Unrestricted Residential Land Use of the AOC.

The three alternatives were compared to CERCLA threshold and balancing criteria, and a comparative analysis was completed to justify the selection of a recommended alternative for sewer sediment in the Facility-Wide Sewers. Table ES-3 summarizes the comparative analysis of the alternatives.

Table ES-3. Summary of Comparative Analysis of Remedial Alternatives

NCP Evaluation Criteria	Alternative 1: No Action		Alternative 2: Attain Unrestricted Residential Land Use ~ In-situ Treatment Using Solidification/Stabilization		Alternative 3: Attain Unrestricted Residential Land Use ~ Excavation with Off-site Disposal	
Threshold Criteria	Result		Result		Result	
1. Overall Protectiveness of Human Health and the Environment	Not protective		Protective		Protective	
2. Compliance with ARARs	Compliant		Compliant		Compliant	
Balancing Criteria	Ranking	Score	Ranking	Score	Ranking	Score
3. Long-Term Effectiveness and Permanence	Low	1	Medium	2	High	3
4. Reduction of Toxicity, Mobility, or Volume through Treatment	Low	1	High	3	Medium	2

Table ES-3. Summary of Comparative Analysis of Remedial Alternatives (continued)

NCP Evaluation Criteria	Alternative 1: No Action		Alternative 2: Attain Unrestricted Residential Land Use ~ In-situ Treatment Using Solidification/Stabilization		Alternative 3: Attain Unrestricted Residential Land Use ~ Excavation with Off-site Disposal	
5. Short-Term Effectiveness	High	3	Medium	2	Low	1
6. Implementability	High	3	Low	1	Medium	2
7. Cost	High	3	Low	1	Low	1
Balancing Criteria Score	11		9		9	

“High” = highly favorable

“Medium” = moderately favorable

“Low” = not favorable

Scoring for the Balancing Criteria is as follows: High = 3, Medium = 2, Low = 1

ARAR = Applicable or Relevant and Appropriate Requirements

NCP = National Contingency Plan

ES.4.3 Recommended Alternative

The recommended alternative for Facility-Wide Sewers is Alternative 3: Attain Unrestricted Residential Land Use ~ Excavation with Off-site Disposal. The comparative analysis of the three alternatives indicated Alternative 1 was not protective for human health and the environment; therefore, Alternative 1 was eliminated as a potential alternative. Alternatives 2 and 3 were protective of human health and the environment and are compliant with ARARs. These two alternatives also scored the same with respect to the balancing criteria. Alternative 3 was chosen as the recommended alternative due to the fact that implementability for Alternative 3 is greater than Alternative 2.

Alternative 3 involves the removal of segments of pipes, inlets, and manholes that contain contaminated sewer sediment above the CUGs surrounding the following four discrete sample locations: TSAsd-002(sn) at the Transportation Storage Area FA, DAAsd-006(sn) at the Depot Administration Area FA, LL2sd-615(st) at the Load Line 2 FA, and LL3sd-272(st) the Load Line 3 FA. The discrete sample locations at the Depot Administration Area FA and the Transportation Storage Area FA exceed the CUGs for manganese for the National Guard Trainee, which is also protective of the Resident Farmer. The discrete sample locations at Load Line 2 and Load Line 3 do not exceed the CUGs for lead for either the National Guard Trainee or Resident Farmer; however, these elevated lead concentrations were upstream of impacted surface water locations. Therefore, these locations were classified as localized source to be removed.

This alternative assumes sewer sediment removal to achieve Unrestricted Residential Land Use; therefore, LUCs and five-year reviews will not be required following the remedy. The cost for the alternative is estimated to be \$411,954.

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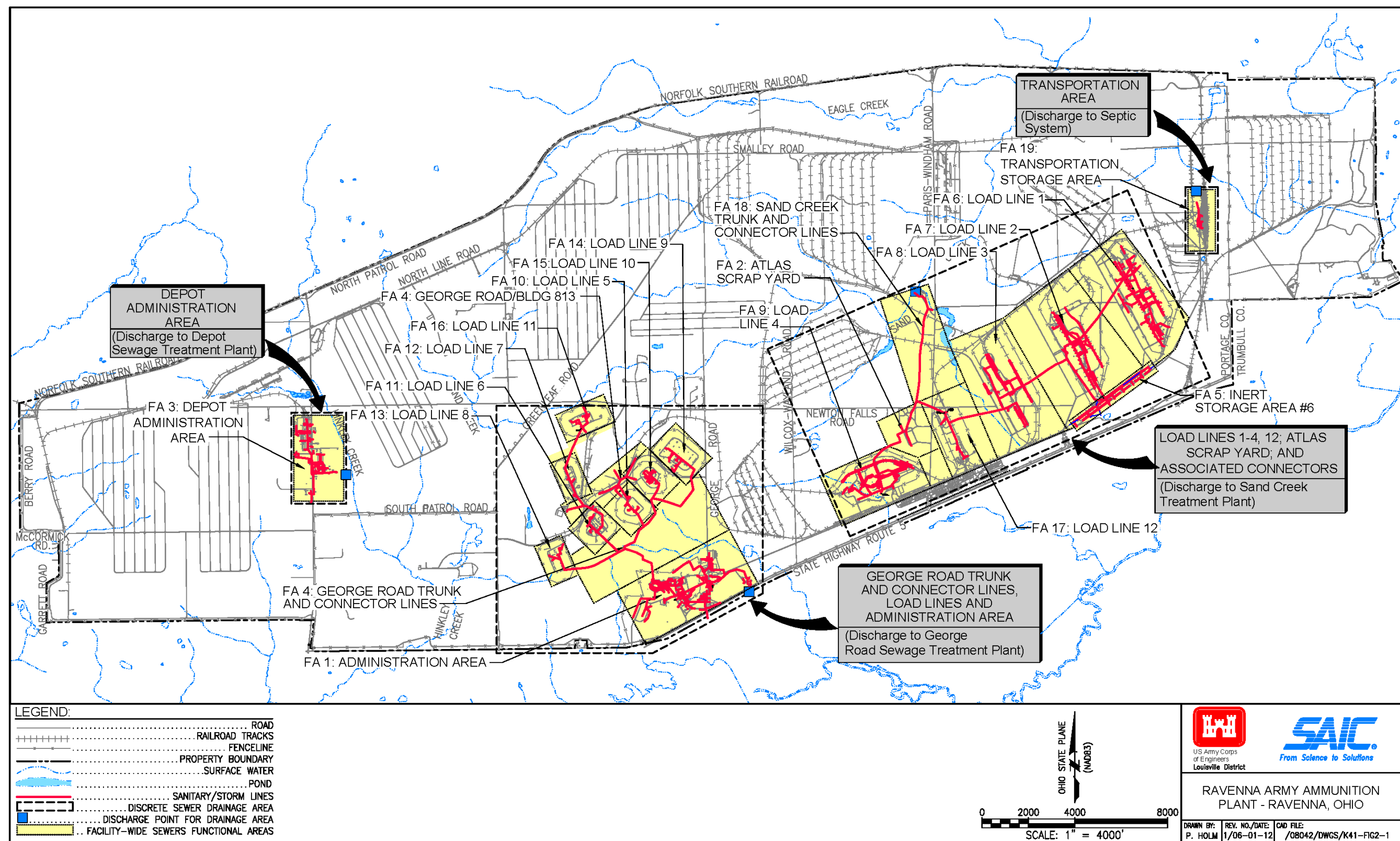


Figure ES-1. Facility-Wide Sewers Drainage Networks and Functional Areas

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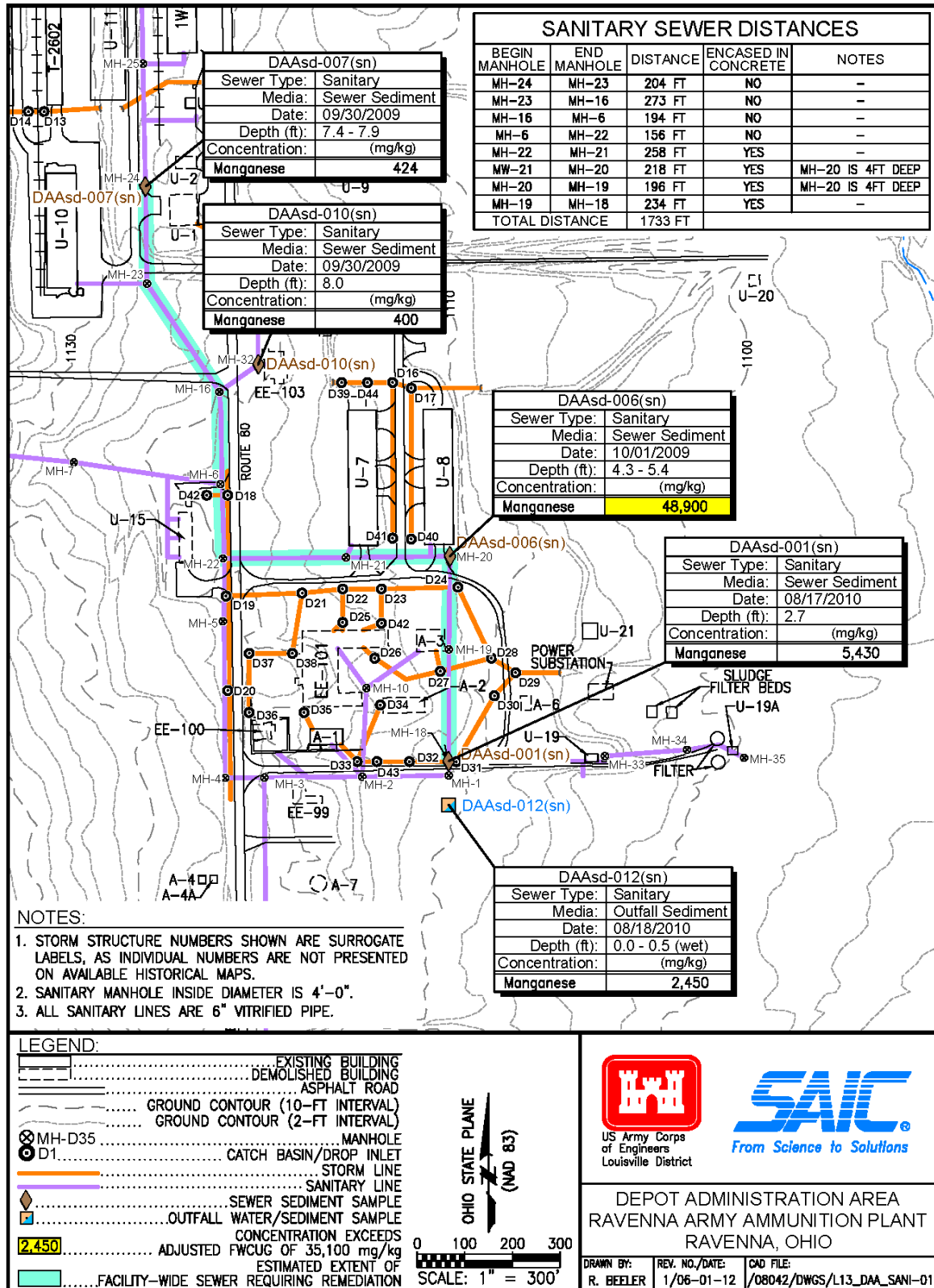


Figure ES-2. Locations in Sanitary Lines Requiring Remediation at the Depot Administration Area

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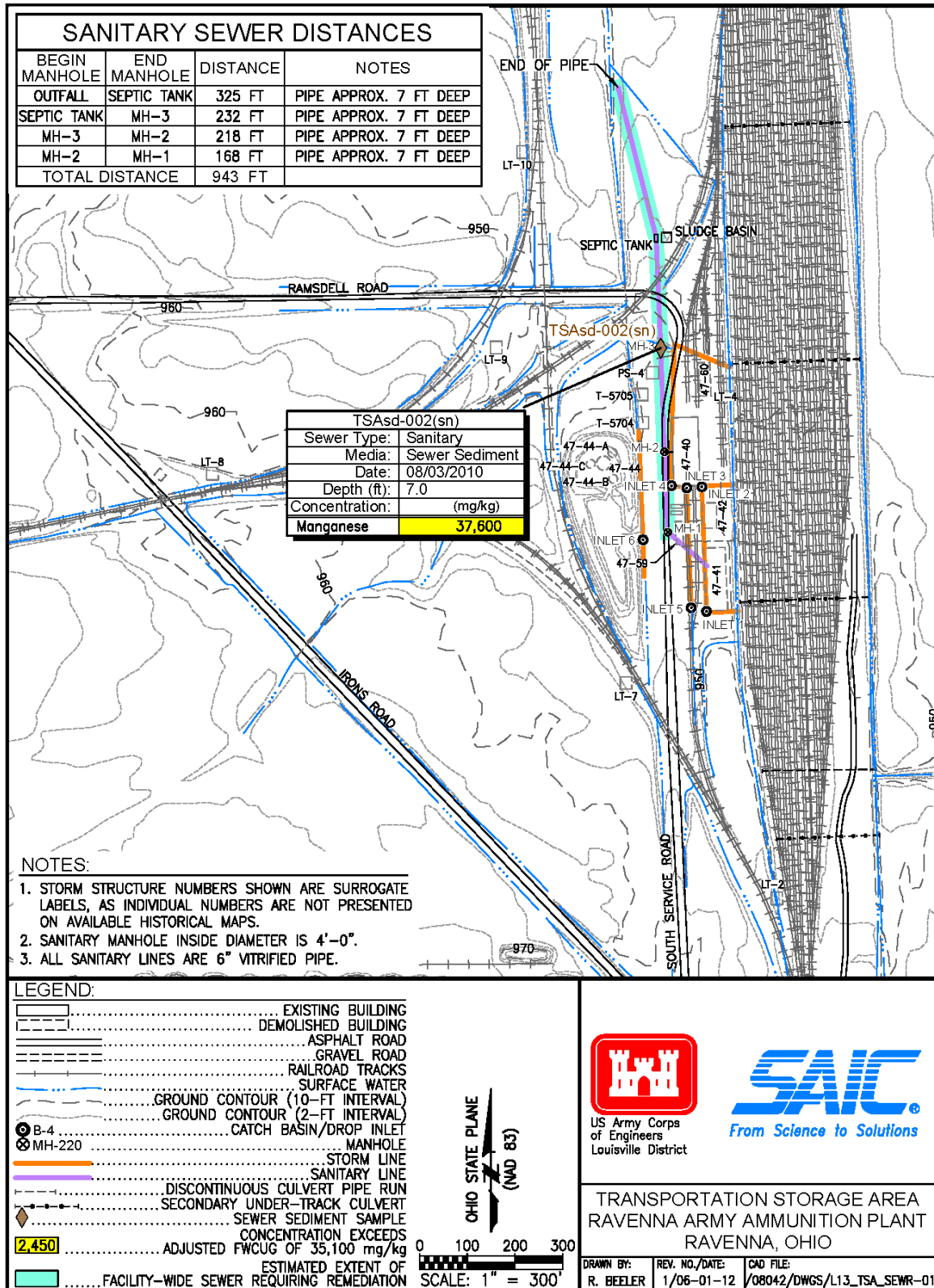


Figure ES-3. Locations in Sanitary Lines Requiring Remediation at the Transportation Storage Area

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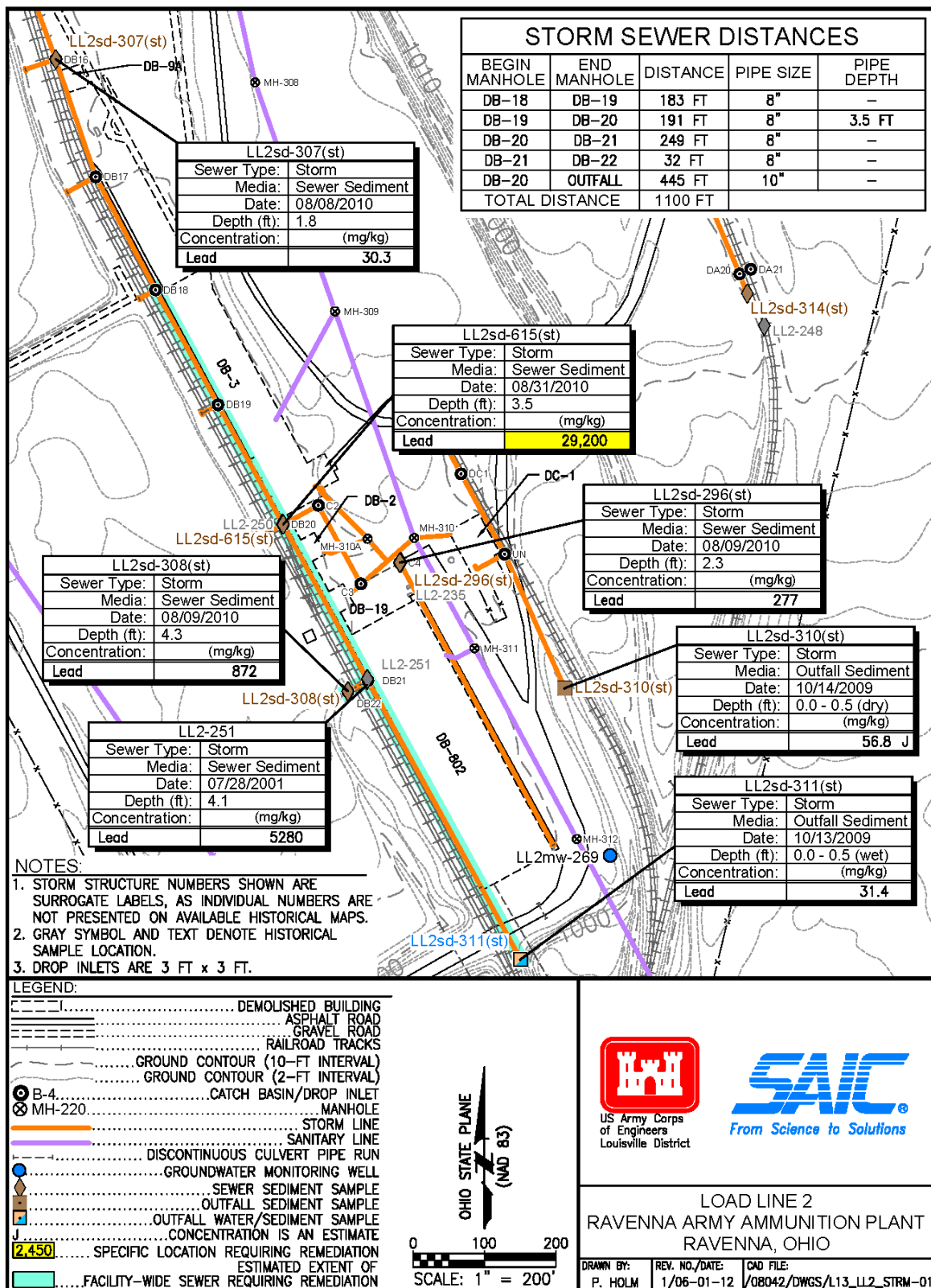


Figure ES-4. Locations in Storm Lines Requiring Remediation at Load Line 2

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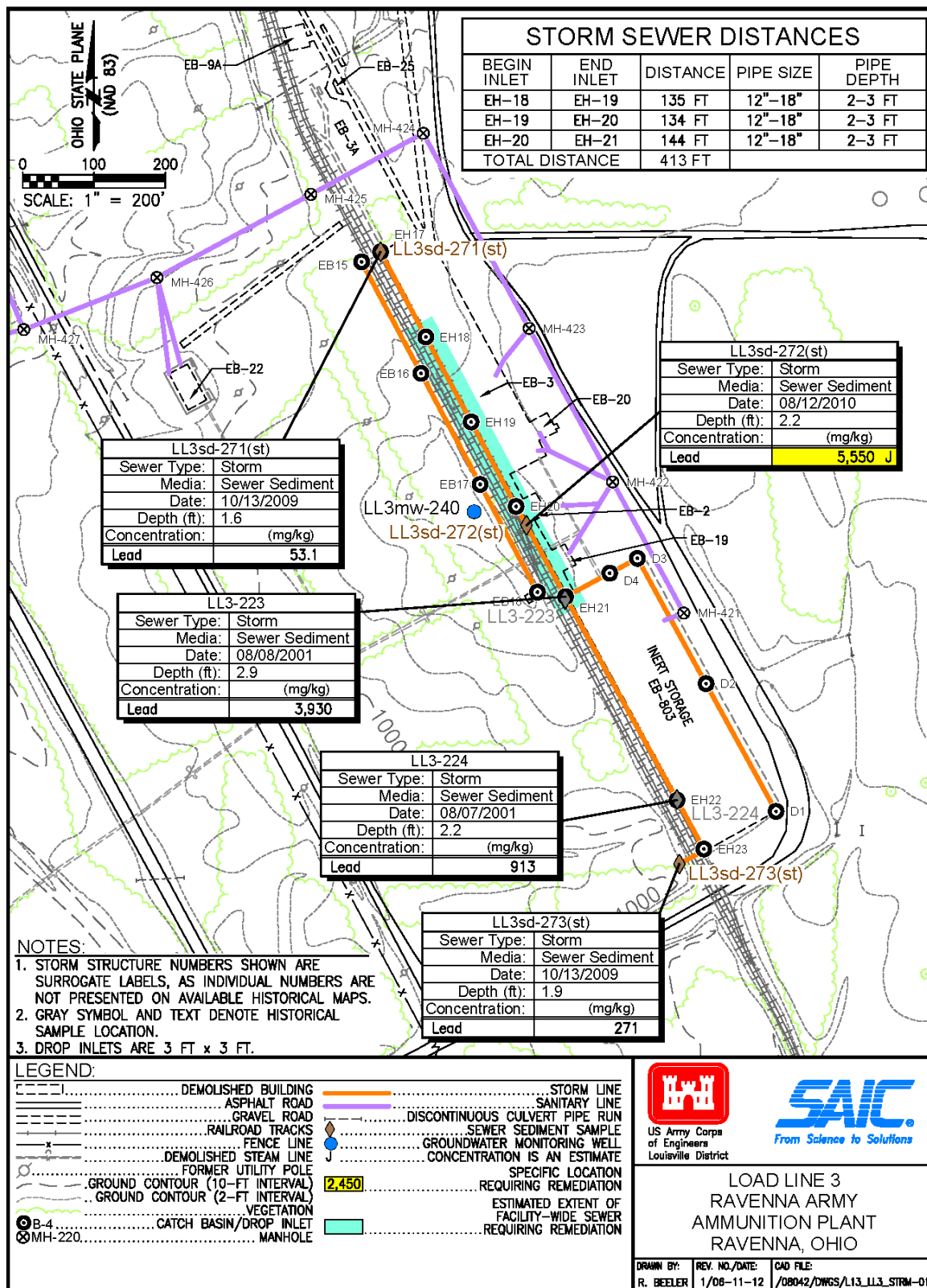


Figure ES-5. Locations in Storm Lines Requiring Remediation at Load Line 3

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1.0 INTRODUCTION

Science Applications International Corporation (SAIC) has been contracted by the United States Army Corps of Engineers (USACE), Louisville District to provide environmental services to achieve response complete, remedy in place, or site closeout, as documented in an approved Record of Decision (ROD) for the Facility-Wide Sewers area of concern (AOC) (designated as RVAAP-67) within the Ravenna Army Ammunition Plant (RVAAP) in Ravenna, Ohio (Figures 1-1 and 1-2). This work is performed in accordance with USACE, Louisville District, Multiple Award Remediation Contract (MARC) W912QR-04-D-0028, Delivery Order No. 0001, under a Performance-Based Acquisition (PBA).

Planning and performance of all elements of this PBA are in accordance with the requirements of the Ohio Environmental Protection Agency (Ohio EPA) *Director's Final Findings and Orders* (DFFO) for RVAAP, dated June 10, 2004 (Ohio EPA 2004). The DFFO requires conformance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP) to implement a remedial investigation (RI) to characterize the AOC, develop a feasibility study (FS) report (if remediation is necessary) to present and evaluate remedial alternatives addressing contamination presenting unacceptable risk to human health and the environment, present a recommended remedial alternative in a proposed plan (PP), and document stakeholder selection and acceptance of the preferred final remedy in a ROD. Figure 1-3 presents this process.

This document is a combined RI and FS report and includes:

- A description of the operational history and environmental setting for the AOC;
- A summary of the field activities and results of the tiered RI conducted from August 2009 through September 2010 at the AOC;
- A description of the nature and extent of contamination;
- An evaluation of contaminant fate and transport;
- A human health risk assessment (HHRA) and an ecological risk assessment (ERA);
- Conclusions of the RI report, which form the basis for conducting the FS;
- Identification of the remedial action objective (RAO) for contaminated media;
- Identification of applicable or relevant and appropriate requirements (ARARs);

- Identification of general response actions (GRAs) and screening of a range of remedial technologies to reduce risks to human health and the environment from identified chemicals of concern (COCs);
- Development of remedial alternatives from appropriate GRAs and remedial technologies and evaluation of alternatives against criteria specified by CERCLA; and
- Conclusions of the FS and a recommended alternative.

Based on the outcome of the evaluation in this report, the recommended alternative will be submitted for public review and comment in a PP. Public comments will be considered in the final selection of a remedy, which will be documented in a ROD.

1.1 PURPOSE

The purpose of the RI for the Facility-Wide Sewers is to supplement the data from previous sampling events to delineate the nature and extent of contamination, evaluate contaminant fate and transport, and complete an HHRA and ERA to support remedial decisions. The AOC includes approximately 26 miles of sanitary and storm sewer lines within four separate drainage networks distributed across RVAAP. The four drainage networks are the George Road Sewage Treatment Plant Network, Sand Creek Sewage Treatment Plant Network, Depot Administration Area Sewage Treatment Plant Network, and Transportation Storage Area sewage and septic system.

The RI included sampling of the sewer lines and associated structures (i.e., manholes and drop inlets), as well as outfalls from the sewer systems. As discussed in Section 1.2, the RI did not encompass sewage treatment plants or their historical effluent discharge points because they were permitted and closed under National Pollutant Discharge Elimination System (NPDES) regulations. Depending on the results of the RI, a recommendation is provided for no further action (NFA) or an FS to evaluate potential remedies and future actions. The purpose of the FS is to identify an RAO and appropriate cleanup goals (CUGs), screen remedial technologies, develop remedial alternatives to meet the RAO and attain CUGs, and perform a detailed evaluation of remedial alternatives to identify a recommended remedy.

1.2 SCOPE

The Facility-Wide Sewers AOC (designated as RVAAP-67) was created in 2008 and comprised of Installation Restoration Program (IRP)-eligible storm and sanitary sewers located throughout RVAAP. Section 2.2 discusses the configuration of the AOC and presents the locations of sewer networks within the facility, based upon available historical documents and engineering drawings. Under IRP policy, eligibility is defined as those sewers within and between AOCs that historically received AOC-related wastewater discharges prior to October 17, 1986. In December 2008, the Army issued an interim policy for Defense Environmental Restoration Program (DERP) eligibility that rescinded the October 17, 1986 date. The change in IRP policy did not affect the scope and

definition of this AOC, as no sewer systems were previously excluded on the basis of the October 17, 1986 date. Wastewater treatment plants at RVAAP (e.g., Sand Creek Sewage Treatment Plant, George Road Sewage Treatment Plant, and Depot Sewage Treatment Plant) were regulated under NPDES, were closed in the 1990s, and are not IRP-eligible. Based on the definition of IRP eligibility and available RVAAP infrastructure data, the Facility-Wide Sewers AOC is comprised of the following:

- Sanitary and storm sewer lines within Load Lines 1 through 4;
- Sanitary sewer lines within Load Lines 5 through 12;
- Sanitary and storm sewer lines within the Inert Storage Area #6, south of Load Lines 2 and 3;
- Sanitary sewer lines within Atlas Scrap Yard;
- Sanitary and storm sewer lines within the Administration Area;
- Sanitary and storm sewer lines within the Depot Administration Area;
- Sanitary and storm sewer lines within the Transportation Storage Area;
- Sanitary sewer connector lines between AOC source areas (e.g., between Load Lines 1, 2, 3, and 12); and
- Sanitary sewer trunk lines exiting AOC source areas to the former sewage treatment plants.

The following sanitary and storm sewer drainage infrastructure components are not included within the scope of the investigation:

- Former wastewater treatment plants and associated discharge lines from these facilities; and
- Conventional drainage culverts (e.g., discontinuous culverts beneath roads, rail lines, and utility right-of-ways) in association with storm water ditches or flowing streams. Within AOC source areas, these conveyances have been or will be addressed in AOC-specific investigations (and remediations, if necessary).

The following media was evaluated during the Facility-Wide Sewers RI:

- Subsurface media - Sediment and water located within the pipes and the pipe bedding material (e.g., backfill, sand, or other media) immediately underlying the sewer pipes.
- Outfall media - Sediment and water collected at outfalls where the sewer systems discharge.

The scope of this RI/FS report is to present:

- Nature and extent of contamination, fate and transport of contaminants in the environment, and risk assessments for subsurface sewer media.
- Nature and extent of contamination, fate and transport of contaminants in the environment, and risk assessments, as applicable, for sewer water contained within the sewer pipe systems.
- Nature and extent of contamination, fate and transport of contaminants in the environment, and risk assessments, as applicable, for outfall media.
- Results of the evaluation of remedial alternatives for meeting the RAO for any COCs identified in these media at the AOC.
- Recommendations for either NFA or a recommended alternative to present to the public in a PP. If remedial actions are warranted, the recommended alternative will achieve required risk reductions to protect human health and the environment and attain all ARARs. In accordance with CERCLA, remedial alternatives are to be cost effective; use permanent solutions and alternative treatment technologies to the maximum extent practicable; and satisfy the preference for treatment that reduces volume, toxicity, or mobility to the maximum practical extent.

Potential impacts to groundwater from sewer sediment and bedding material (e.g., contaminant leaching and migration to groundwater) are evaluated in this report, as protectiveness to groundwater is included in the evaluation of remedial alternatives for these media.

1.3 REASONABLE AND ANTICIPATED FUTURE LAND USE

Reasonable and Anticipated Future Land Use (RAFLU) = Military Use and Training
Representative Receptor = National Guard Trainee

RVAAP is a controlled-access facility that is fenced and patrolled by security personnel. Full-time Ohio Army National Guard (OHARNG), Base Realignment and Closure (BRAC) Division, and contractor staff work at the facility. Since the Facility-Wide Sewers AOC contains 26 miles of sewer lines distributed across RVAAP, multiple future military land uses may apply. Most of the AOCs are not currently used for training for operational activities; however, the RAFLU is National Guard Training for the majority of the AOCs for which the Facility-Wide Sewers AOC traverse (i.e., Load Lines 1 through 12, Atlas Scrap Yard). Other areas (e.g., Administration Area, Depot Administration Area, Inert Storage Area #6) are currently utilized for administrative or storage functions by OHARNG.

The National Guard Trainee includes digging and mixing soil and subsurface media to a depth of 7 ft below ground surface (bgs) as part of the exposure scenario. Therefore, the RAFLU for the Facility-Wide Sewers AOC is Military Use and Training, using the National Guard Trainee as the

representative receptor. Military Use and Training, in conjunction with the evaluation of Unrestricted Residential Land Use, forms the basis for identifying COCs. The Resident Farmer facility-wide cleanup goals (FWCUGs) are used to evaluate COCs for Unrestricted Residential Land Use at the AOC, as outlined in the *Guidance Document for the Evaluation of Land Use Controls* (USACE 2011a).

1.4 REPORT ORGANIZATION

This report is organized in accordance with Ohio EPA and United States Environmental Protection Agency (USEPA) CERCLA RI/FS guidance, as well as applicable USACE guidance. Due to the size and structure of the AOC, the four drainage networks were divided into 19 Functional Areas (FAs) based on spatial and operational characteristics. As such, this report includes a summary volume (i.e., Main Text), which presents the general AOC setting, historical investigations, RI methods and summary results, and the FS for the AOC. Detailed RI results are presented in 19 Functional Area Evaluations (FAEs), which include presentations of the sampling scope and rationale, nature and extent of contamination, contaminant fate and transport, HHRA, and ERA results for each FA in the Facility-Wide Sewers AOC.

1.4.1 Main Text and Appendices Organization

Below is a summary of the Main Text volume:

- Section 2.0 provides a description and history of RVAAP and general Facility-Wide Sewers operations.
- Section 3.0 describes the general environmental setting at RVAAP, including the geology, hydrogeology, climate, population, and ecological resources.
- Section 4.0 describes the general RI methods used for field data collection during the Facility-Wide Sewers RI and the approach to analytical data management and laboratory programs.
- Section 5.0 summarizes the data generated during the RI and summarizes the results of the contaminant nature and extent evaluation for the FAs.
- Section 6.0 presents an evaluation of contaminant fate and transport.
- Section 7.0 includes the methods and results of the HHRA and ERA.
- Section 8.0 provides the conclusions and recommendations of the RI.
- Section 9.0 outlines the development of the RAO for the chemicals and media of concern.

- Section 10.0 summarizes potential federal and state chemical-, location-, and action-specific ARARs for the potential remedial actions at the AOC.
- Section 11.0 presents GRAs and the identification and screening of technology types and process options considered for possible use in remediation.
- Section 12.0 develops remedial alternatives from technologies and process options that passed initial screening and presents an initial evaluation against effectiveness, implementability, and cost.
- Section 13.0 presents the detailed and comparative analyses of viable remedial action alternatives developed to address chemicals and media of concern at the Facility-Wide Sewers AOC, using the seven criteria specified by USEPA CERCLA guidance.
- Section 14.0 summarizes the framework for conducting the necessary agency and public involvement activities.
- Section 15.0 presents the conclusions of the FS and the recommended remedial alternative for the AOC.
- Section 16.0 provides a list of references used to develop this report. The references included in this section also apply to the FAEs.

The following common appendices, also included in the Main Text volume, present data applicable to the entire Facility-Wide Sewers AOC:

- Appendix A: Field Sampling Logs
- Appendix B: Video Survey Logs
- Appendix C: Project Quality Assurance Summary
- Appendix D: Data Quality Control Summary Report
- Appendix E: Laboratory Analytical Results and Chains-of-Custody
- Appendix F: Investigation-derived Waste Management Reports
- Appendix G: Ordnance and Explosives Avoidance Survey Report
- Appendix H: Detailed Cost Estimates
- Appendix I: Revised Technical Memorandum for Tier 2 Sampling under the Remedial Investigation at RVAAP-67 Facility-Wide Sewers (issued July 2, 2010, approved July 21, 2010)
- Appendix J: Data Evaluation of the Tier 2 Sampling Under the Remedial Investigation at RVAAP-67 Facility Wide Sewers (issued May 11, 2011, approved May 19, 2011)

1.4.2 Functional Area Organization

Each identified FA has an FAE associated with this report. The FA and associated FAE are presented below:

FAE 1: Administration Area	FAE 11: Load Line 6
FAE 2: Atlas Scrap Yard	FAE 12: Load Line 7
FAE 3: Depot Administration Area	FAE 13: Load Line 8
FAE 4: George Road Trunk and Connector Lines	FAE 14: Load Line 9
FAE 5: Inert Storage Area #6	FAE 15: Load Line 10
FAE 6: Load Line 1	FAE 16: Load Line 11
FAE 7: Load Line 2	FAE 17: Load Line 12
FAE 8: Load Line 3	FAE 18: Sand Creek Trunk and Connector Lines
FAE 9: Load Line 4	FAE 19: Transportation Storage Area
FAE 10: Load Line 5	

Each FAE presents the same components and organization as Sections 1.0-8.0 in the Main Text, with those components focusing on a specific FA. For example, Section 2.0 of FAE 1 provides a description and history of the Administration Area FA, and Section 7.0 of FAE 12 includes the results of the HHRA and ERA specific to the Load Line 7 FA.

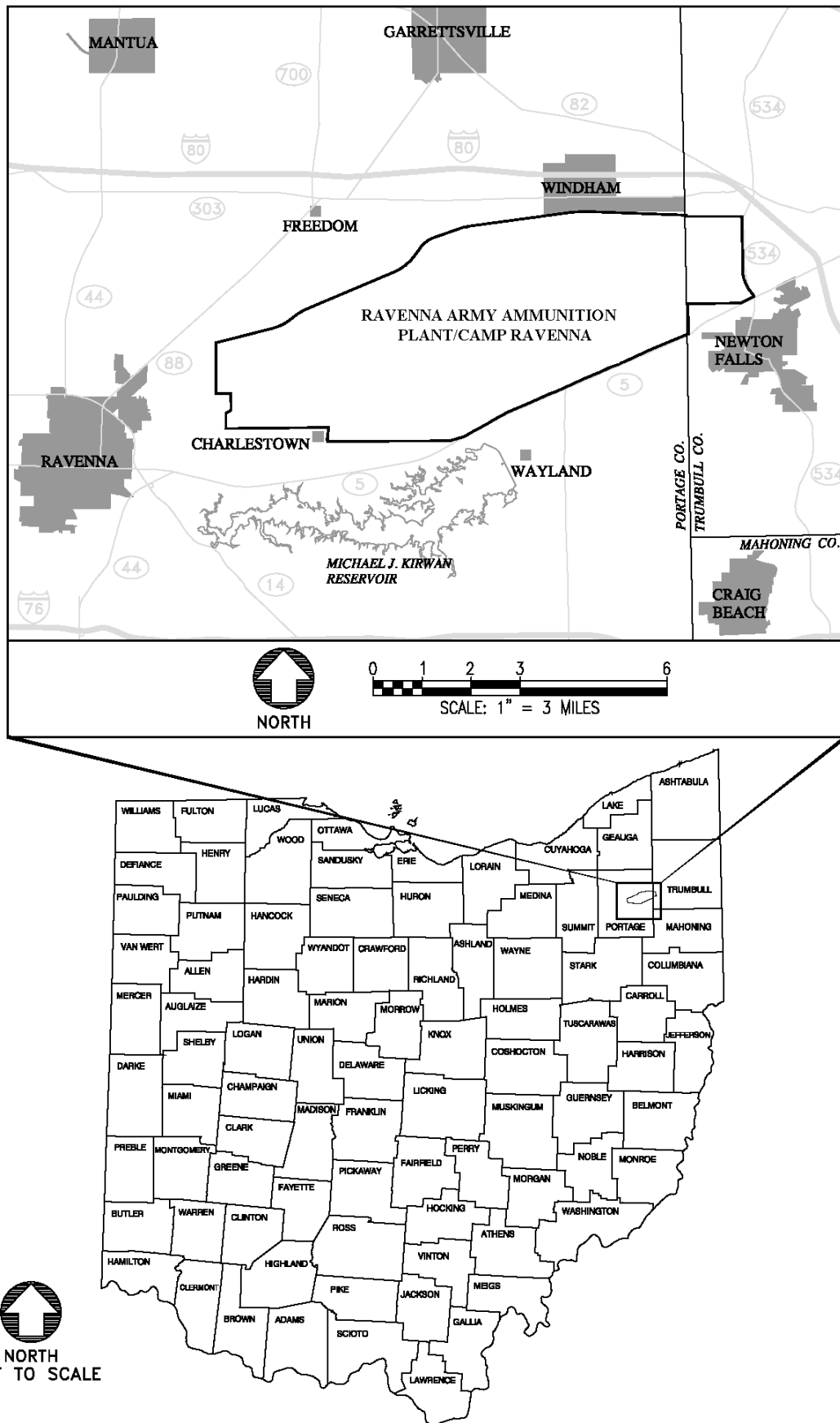


Figure 1-1. General Location and Orientation of RVAAP/Camp Ravenna

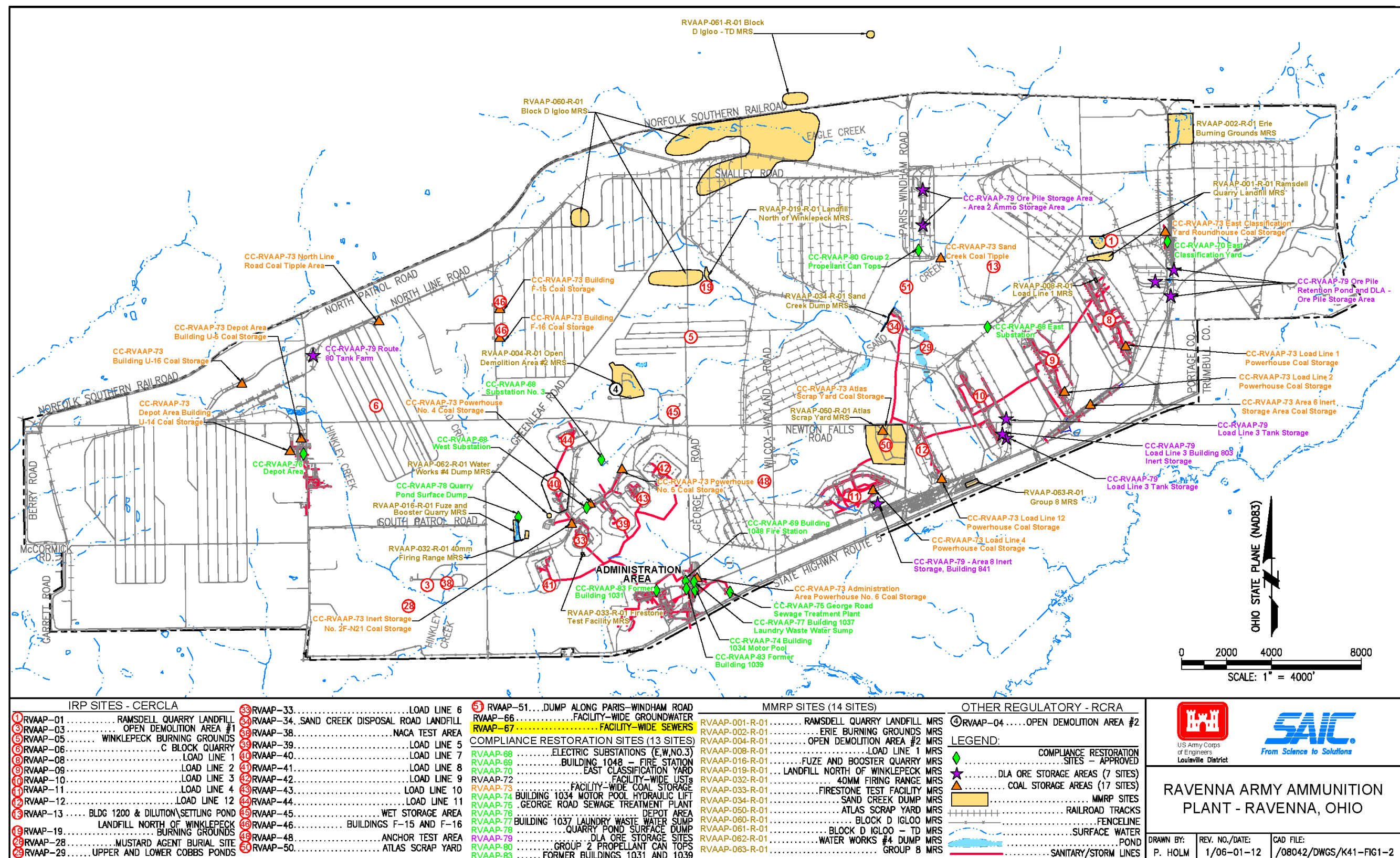
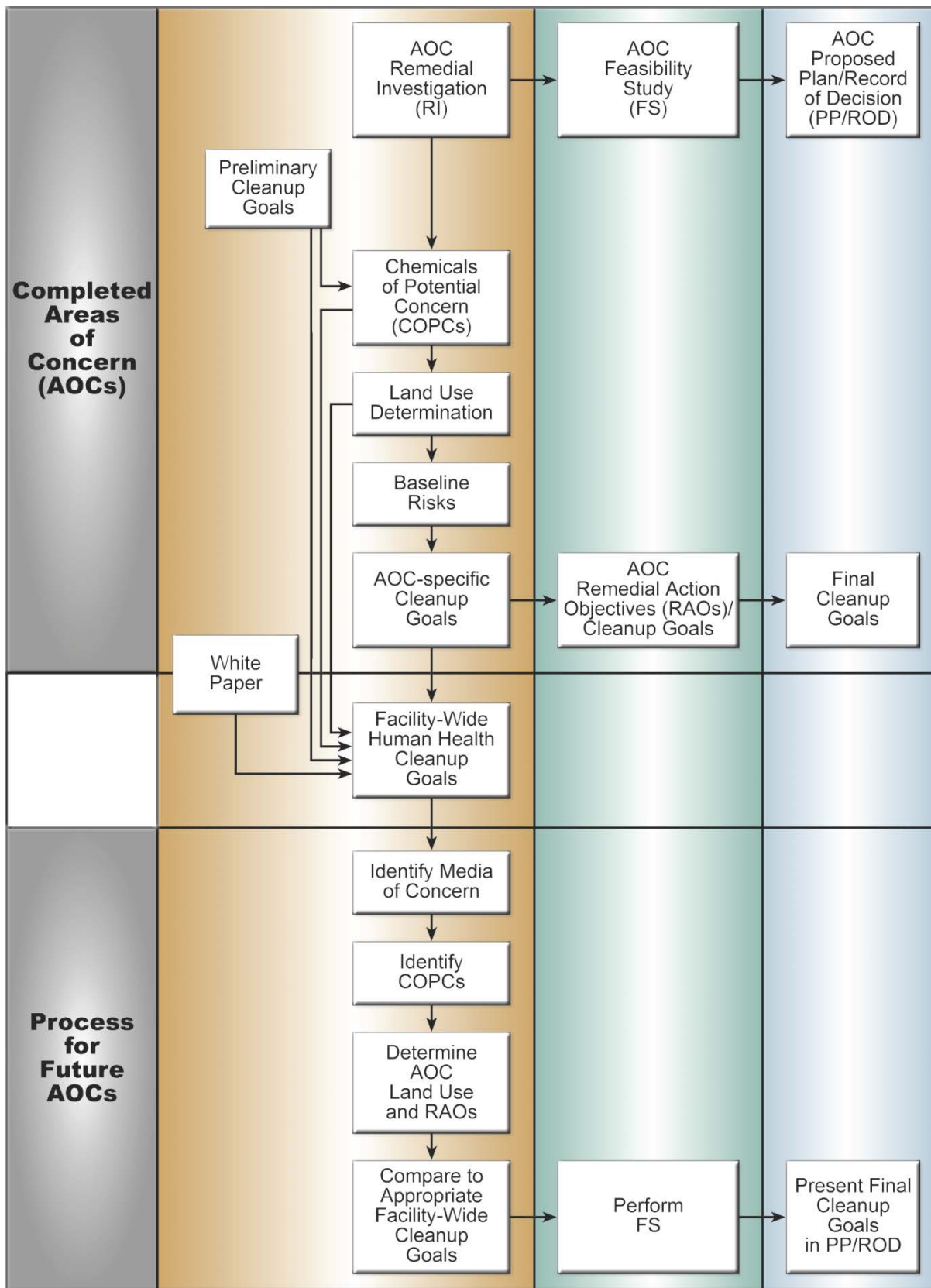


Figure 1-2. Location of AOCs at RVAAP/Camp Ravenna

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Figure 1-3. Process for Developing Remedial Decisions at RVAAP Areas of Concern

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2.0 BACKGROUND

2.1 FACILITY-WIDE BACKGROUND INFORMATION

2.1.1 General Facility Description

When the RVAAP IRP began in 1989, RVAAP was identified as a 21,419-acre facility. The property boundary was resurveyed by the Ohio Army National Guard (OHARNG) over a 2-year period (2002 and 2003), and the total acreage of the property was found to be 21,683 acres. As of June 2010, a total of 20,423 acres of the former 21,683-acre RVAAP has been transferred to the National Guard Bureau (NGB) and subsequently licensed to OHARNG for use as a military training site.

The current RVAAP consists of 1,260 acres scattered throughout the OHARNG Camp Ravenna Joint Military Training Center, herein referred to as Camp Ravenna. Camp Ravenna is in northeastern Ohio within Portage and Trumbull counties, approximately 3 miles east-northeast of the city of Ravenna and approximately 1 mile northwest of the city of Newton Falls. The RVAAP portions of the property are solely located within Portage County. RVAAP and Camp Ravenna occupy a parcel of property approximately 11 miles long and 3.5 miles wide, bounded by State Route 5, the Michael J. Kirwan Reservoir, and the CSX System Railroad on the south; Garrett, McCormick, and Berry roads on the west; the Norfolk Southern Railroad on the north; and State Route 534 on the east (Figures 1-1 and 1-2). Camp Ravenna is surrounded by several communities: Windham to the north, Garrettsville 6 miles to the northwest, Newton Falls 1 mile to the southeast, Charlestown to the southwest, and Wayland 3 miles to the south.

When RVAAP was operational, Camp Ravenna did not exist, and the entire 21,683-acre parcel was a government-owned, contractor-operated, industrial facility. The RVAAP IRP encompasses investigation and cleanup of past activities over the entire 21,683 acres of the former RVAAP. References to RVAAP in this document indicate the historical extent of RVAAP, which is inclusive of the combined acreages of the current Camp Ravenna and RVAAP, unless otherwise specifically stated.

Former industrial operations at RVAAP consisted of 12 munitions-assembly facilities referred to as “load lines.” Load Lines 1 through 4 were used to melt and load 2,4,6-trinitrotoluene (TNT) and Composition B into large-caliber shells and bombs. The operations on the load lines produced explosive dust, spills, and vapors that collected on the floors and walls of each building. Periodically, the floors and walls were cleaned with water and steam. Following cleaning, the wastewater containing TNT and Composition B was known as “pink water” for its characteristic color. Pink water was collected in concrete holding tanks, filtered, and pumped into unlined ditches for transport to earthen settling ponds. Load Lines 5 through 11 were used to manufacture fuzes, primers, and boosters. Potential contaminants in these load lines include lead compounds, mercury compounds, and explosives. From 1946 to 1949, Load Line 12 was used to produce ammonium nitrate for explosives and fertilizers prior to use as a weapons demilitarization facility.

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

8
9 In addition to production and demilitarization activities at the load lines, other facilities at RVAAP
10 include AOCs that were used for the burning, demolition, and testing of munitions. These burning
11 and demolition grounds consist of large parcels of open space or abandoned quarries. Potential
12 contaminants at these AOCs include explosives, propellants, inorganic chemicals, and waste oils.
13 Other types of AOCs present at RVAAP include landfills, an aircraft fuel tank testing facility, and
14 various general industrial support and maintenance facilities.

15 16 **2.1.2 Demography and Land Use**

17
18 RVAAP consists of 21,683 acres and is located in northeastern Ohio, approximately 23 miles east-
19 northeast of Akron and 30 miles west-northwest of Youngstown. RVAAP occupies east-central
20 Portage County and southwestern Trumbull County. Census projections for 2010 indicate the
21 populations of Portage and Trumbull counties are 161,419 and 210,312, respectively. Population
22 centers closest to RVAAP are Ravenna, with a population of 11,724, and Newton Falls, with a
23 population of 4,795.

24
25 The RVAAP facility is located in a rural area and is not close to any major industrial or developed
26 areas. Approximately 55% of Portage County, in which the majority of RVAAP is located, consists
27 of woodland or farmland acreage. The closest major recreational area, the Michael J. Kirwan
28 Reservoir (also known as West Branch Reservoir), is located adjacent to the western half of RVAAP,
29 south of State Route 5.

30
31 RVAAP is operated by the BRAC Division of the Army, which manages the restoration activities at
32 RVAAP. Camp Ravenna (located on the remainder of the property) is owned by NGB, which
33 licenses it to the OHARNG for use as a military training site. Training and related activities at Camp
34 Ravenna include field operations and bivouac training, convoy training, equipment maintenance,
35 C-130 aircraft drop zone operations, helicopter operations, and storage of heavy equipment.

36 37 **2.2 FACILITY-WIDE SEWERS BACKGROUND INFORMATION**

38 39 **2.2.1 Operational History**

40
41 A formal definition and boundary for the Facility-Wide Sewers AOC has not been established
42 through the RVAAP Installation Action Plan (IAP) process to date. The Facility-Wide Sewers AOC
43 (designated as RVAAP-67) was created in 2008 and is comprised of IRP-eligible storm and sanitary

sewers located throughout RVAAP, as discussed in Section 1.2. The general configuration of the Facility-Wide Sewers systems is shown in Figure 2-1.

The AOC is comprised of approximately 26 miles (approximately 140,200 linear ft) of sanitary and storm sewers. The sanitary sewers are distributed across four drainage networks. Three of the sanitary sewer drainage networks were associated with sewage treatment plants and had a combined daily capacity of the 750,000 gallons; the fourth network utilized a small septic and Imhoff tank system. The four drainage networks, their component FAs, and the FAE that contains the summary are as follows:

- George Road Sewage Treatment Plant Network:
 - o Administration Area (FAE 1);
 - o Load Line 5 (FAE 10);
 - o Load Line 6 (FAE 11);
 - o Load Line 7 (FAE 12);
 - o Load Line 8 (FAE 13);
 - o Load Line 9 (FAE 14);
 - o Load Line 10 (FAE 15);
 - o Load Line 11 (FAE 16); and
 - o George Road Trunk and Connector Lines (FAE 4).
- Sand Creek Sewage Treatment Plant Network:
 - o Atlas Scrap Yard (FAE 2);
 - o Inert Storage Area #6 (FAE 5);
 - o Load Line 1 (FAE 6);
 - o Load Line 2 (FAE 7);
 - o Load Line 3 (FAE 8);
 - o Load Line 4 (FAE 9);
 - o Load Line 12 (FAE 17); and
 - o Sand Creek Trunk and Connector Lines (FAE 18).
- Depot Administration Area Sewage Treatment Plant Network (FAE 3).
- Transportation Storage Area (FAE 19) sewage and septic system.

At the former George Road, Sand Creek, and Depot Administration Sewage Treatment Plants, sanitary sewer lines that formerly entered the facilities were plugged during closure, and flows were diverted to by-pass outfalls allowing infiltrating surface water and groundwater to discharge to surface conveyances.

The storm sewer networks are discrete systems draining individual FAs throughout RVAAP. The storm sewers collect runoff from drainage areas along roads, railbeds, and buildings, diverting it to

ditches and drainage conveyances through outfalls. The following FAs include discrete storm sewer networks (Figure 2-1):

- Administration Area (FAE 1);
- Depot Administration Area (FAE 3);
- Inert Storage Area #6 (FAE 5);
- Load Line 1 (FAE 6);
- Load Line 2 (FAE 7);
- Load Line 3 (FAE 8);
- Load Line 4 (FAE 9); and
- Transportation Storage Area (FAE 19).

Construction drawings and RI results for the sewer networks indicate the sanitary and storm systems were comprised predominantly of vitrified earthen pipe. Smaller segments of sanitary sewer force mains were constructed of cast iron pipe, ranging 4-8 inches in diameter. Other construction material utilized in the storm sewer systems were concrete pipe and perforated or corrugated metal. Available data and RI results do not indicate any of the sewer systems were constructed of asbestos-containing material (ACM). Although pipe diameters throughout the system were 4-36 inches, the majority of pipes were 8-10 inches in diameter. A summary of the physical characteristics of the sewer systems specific to each FA is presented in Section 2.1 of the respective FAE.

Historically, the sewers may have received inadvertent discharges of contaminated wastewaters from the manufacturing of munitions. Available historical documents do not indicate any incidents or occurrences of intentional dumping or discharging of contaminated wastewaters to the sanitary sewers. Storm sewer inlets adjacent to munitions production buildings potentially received explosives-contaminated water during routine cleaning of facilities. A summary of the operational history specific to each FA is presented in Section 2.2 of the respective FAE.

2.2.2 Previous Investigations

Limited previous investigations have been performed to characterize the storm and sanitary sewer systems at RVAAP. These investigations have focused on Load Lines 1 through 12 and were designed to provide an initial evaluation of contamination rather than to fully assess nature and extent.

Sampling and characterization of accumulated sediment and water within sanitary sewers and storm sewers (if present) were conducted as part of the following investigations:

- Load Line 1 Phase II RI (USACE 2003a) – storm and sanitary sewers, video surveys;
- Load Lines 2, 3, and 4 Phase II RI (USACE 2004a, 2004b, and 2004c) – storm and sanitary sewers, video surveys;

- Load Line 12 Phase II RI (USACE 2004d) – sanitary sewers present only, limited video surveys;
- Characterization of 14 AOCs at RVAAP (MKM 2007a) – sanitary sewers at Load Lines 5, 7, 8, 10, and Atlas Scrap Yard;
- Load Line 6 Phase I RI (MKM 2007b) – sanitary sewers present only;
- Load Line 9 Phase I RI (MKM 2007c) – sanitary sewers present only; and
- Load Line 11 Phase I RI (MKM 2005) – sanitary sewers present only.

In addition, the following two reports documenting studies commissioned by the U.S. Army BRAC Division evaluated the potential for explosive hazards within sanitary and storm sewer lines at Load Lines 1 through 12 and the Administration Area:

- *Summary of Findings for the Ravenna Army Ammunition Plant Sewer System* (USACE-CERL 2007); and
- *Project Completion Report for the Explosive Evaluation of Sewers* (LES 2007).

The 2007 Explosive Evaluation of Sewers included approximately 2,451 linear ft of video camera surveys of sewers lines at Load Lines 1, 3, and 4 to determine if visible accumulations of explosives were present. Both studies collected wipe samples of sewer line inverts for analysis of explosive residues, using field test kit methods (e.g., Expray[®] and DropEx). Additionally, wipe samples from video cameras used during the 2007 Explosive Evaluation of Sewers were collected. These studies did not collect samples of accumulated sediment or water within the lines for fixed-based laboratory analysis. The 2007 Explosive Evaluation of Sewers showed no accumulations of explosive compounds within the 12 load lines or the Administration Area that would present an explosion hazard; however, some samples from both studies contained detectable levels of TNT and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (LES 2007). Neither the USACE-Construction Engineering Research Laboratory (CERL) study nor the 2007 Explosive Evaluation of Sewers effort were conducted with Ohio EPA regulatory oversight or review of the associated work plans, resultant completion report, or conclusions.

A summary of the available historical data is presented in Table 2-1. A discussion of the previous investigations specific to each FA is presented in Section 2.3 of its respective FAE.

Table 2-1. Summary of Previous Sewer Investigations at RVAAP

Functional Area	Analytical Samples (# samples)		Video Survey (linear feet)		Field Screening Tests	
	Sanitary	Storm	Sanitary	Storm	(# manholes) Sanitary	(# manholes) Storm
Administration Area	None	None	None	None	26	None
Atlas Scrap Yard	22 (7 SD/15 SW)	NA	None	NA	None	NA
Depot Administration Area	None	None	None	None	None	None
George Road Trunk and Connectors	2 (0 SD/2 SW)	NA	None	NA	None	NA
Inert Storage Area #6	None	None	None	None	None	None
Load Line 1	3 (2 SD/1 SW)	4 (3 SD/1 SW)	978.7	2,372.25	23	40
Load Line 2	3 (1 SD/2 SW)	14 (12 SD/2 SW)	451.37	1,099.67	17	43
Load Line 3	3 (1 SD/2 SW)	5 (5 SD/0 SW)	457.69	1382.84	26	35
Load Line 4	8 (6 SD/2 SW)	6 (3 SD/3 SW)	567.86	1,430.61	23	56
Load Line 5	5 (1 SD/4 SW)	NA	None	NA	14	NA
Load Line 6	2 (0 SD/2 SW)	NA	None	NA	20	NA
Load Line 7	5 (0 SD/5 SW)	NA	None	NA	8	NA
Load Line 8	15 (6 SD/9 SW)	NA	None	NA	10	NA
Load Line 9	4 (2 SD/2 SW)	NA	None	NA	9	NA
Load Line 10	9 (3 SD/6 SW)	NA	None	NA	18	NA
Load Line 11	11 (5 SD/6 SW)	NA	None	NA	2	NA
Load Line 12	7 (3 SD/4 SW)	NA	224	NA	3	NA
Sand Creek Trunk and Connectors	None	NA	None	NA	NA	NA
Transportation Storage Area	None	None	None	None	5	None
Total	99 (37 SD/62 SW)	29 (23 SD/6 SW)	2,679.62	6,285.37	204	174

NA = Not Applicable; system not present
RVAAP = Ravenna Army Ammunition Plant
SD = Sewer sediment samples
SW = Sewer water samples

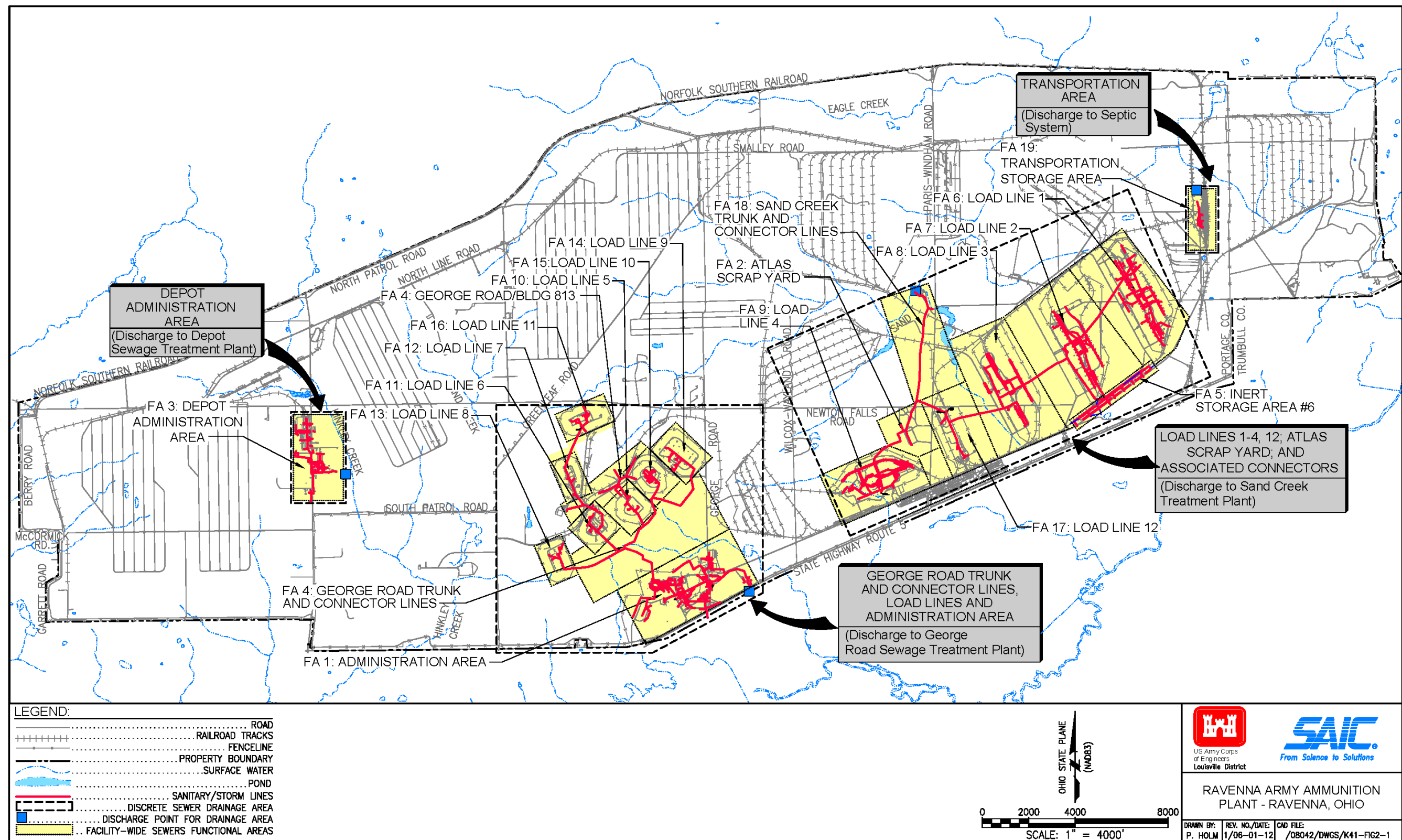


Figure 2-1. Facility-Wide Sewers Drainage Networks and Functional Areas

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3.0 ENVIRONMENTAL SETTING

This section describes the physical features, topography, geology, hydrogeology, and environmental characteristics of RVAAP that are factors in identifying the potential contaminant transport pathways, receptor populations, and exposure scenarios to evaluate human health and ecological risk. This section also presents a preliminary conceptual site model (CSM) based on AOC characteristics and historical investigation data to provide a framework for evaluating contaminant nature and extent, fate and transport, and human health and ecological risk.

3.1 RVAAP PHYSIOGRAPHIC SETTING

RVAAP is located within the Southern New York Section of the Appalachian Plateaus physiographic province (USGS 1968). This province is characterized by elevated uplands underlain primarily by Mississippian and Pennsylvanian age bedrock units that are horizontal or gently dipping. The province is characterized by its rolling topography with incised streams that have dendritic drainage patterns. The Southern New York Section has been modified by glaciation, which rounded ridges, filled major valleys, and blanketed many areas with glacially-derived unconsolidated deposits (i.e., sand, gravel, and finer-grained outwash deposits). As a result of glacial activity in this section, old stream drainage patterns were disrupted in many locales, and extensive wetland areas developed.

3.2 SURFACE FEATURES AND TOPOGRAPHY

The topography of RVAAP is gently undulating, with an overall decrease in ground elevation from a topographic high of approximately 1220 ft above mean sea level (amsl) in the far western portion of the facility to low areas approximately 930 ft amsl in the far eastern portion of the facility.

USACE mapped the facility topography in February 1998 using a 2-ft contour interval with an accuracy of 0.02 ft. USACE based the topographic information on aerial photographs taken during the spring of 1997. The USACE survey is the basis for the topographical information illustrated in figures included in this report.

A general discussion of surface features and FA-level topographic maps for each FA are presented in their respective FAE.

3.3 SOIL AND GEOLOGY

3.3.1 Regional Geology

The regional geology at RVAAP consists of horizontal to gently dipping bedrock strata of Mississippian and Pennsylvanian-age overlain by varying thicknesses of unconsolidated glacial deposits. The bedrock and unconsolidated geology at RVAAP is presented in the following subsections.

3.3.2 Soil and Glacial Deposits

Bedrock at RVAAP is overlain by deposits of the Wisconsin-age Lavery Till in the western third of the facility and the younger Hiram Till and associated outwash deposits in the eastern two-thirds of the facility (Figure 3-1). Unconsolidated glacial deposits vary considerably in their character and thickness across RVAAP, from 0 ft in some of the eastern portions of the facility to an estimated 150 ft in the south-central portion.

Thin coverings of glacial material have been completely removed as a consequence of human activities at locations such as Ramsdell Quarry. Bedrock is present at or near the ground surface in locations such as at Load Line 1 and the Erie Burning Grounds (USACE 2001a). Where this glacial material is present, its distribution and character indicate its origin as ground moraine. These tills consist of laterally discontinuous assemblages of yellow-brown, brown, and gray silty clays to clayey silts with sand and rock fragments. Lacustrine sediment from bodies of glacial-age standing water has also been encountered in the form of deposits of uniform light gray silt greater than 50-ft thick in some areas (USACE 2001a).

Soil at RVAAP is generally derived from the Wisconsin-age silty clay glacial till. Distributions of soil types are discussed and mapped in the *Soil Survey of Portage County, Ohio*, which describes soil as nearly level to gently sloping and poor to moderately well drained (USDA 1978). Much of the native soil at RVAAP was disturbed during construction activities in former production and operational areas of the facility.

The Sharon Member of the Pennsylvanian Pottsville Formation is the primary bedrock beneath RVAAP (Figure 3-2). In the western half of the facility, the upper members of the Pottsville Formation, including the Connoquenessing Sandstone (also known as the Massillon Sandstone), Mercer Shale, and uppermost Homewood Sandstone, have been found. The Berea Sandstone is present in the vicinity of the Sand Creek Sewage Treatment Plant in the east-central portion of RVAAP. The regional dip of the Pottsville Formation measured in the western portion of RVAAP is 5.0-11.5 ft per mile to the south.

3.3.3 Geologic Setting of Facility-Wide Sewers

A discussion of geology specific to each of the FAs is presented in Section 3.1 of each FAE.

3.4 HYDROGEOLOGY

3.4.1 Regional Hydrogeology

Sand and gravel aquifers are present in the buried-valley and outwash deposits in Portage County, as described in the *Phase I Remedial Investigation Report for High-Priority Areas of Concern* (USACE 1998). Generally, these saturated zones are too thin and localized to provide large quantities of water for industrial or public water supplies; however, yields are sufficient for residential water supplies.

1 Lateral continuity of these aquifers is unknown. Recharge of these units is derived from surface
2 water infiltration of precipitation and surface streams. Specific groundwater recharge and discharge
3 areas at RVAAP have not been delineated.

4
5 The thickness of the unconsolidated interval at RVAAP ranges from thin to absent in the eastern and
6 northeastern portion of RVAAP to an estimated 150 ft in the central portion of the facility. The
7 groundwater table occurs within the unconsolidated zone in many areas of the facility. Because of the
8 heterogeneous nature of the unconsolidated glacial material, groundwater flow patterns are difficult to
9 determine with a high degree of accuracy. Vertical recharge from precipitation likely occurs via
10 infiltration along root zones, desiccation cracks, and partings within the soil column. Laterally, most
11 groundwater flow likely follows topographic contours and stream drainage patterns, with preferential
12 flow along pathways (e.g., sand seams, channel deposits, or other stratigraphic discontinuities) having
13 higher permeabilities than surrounding clay or silt-rich material. Figure 3-3 illustrates facility-wide
14 potentiometric surface data in the unconsolidated interval from the January 2010 contemporaneous
15 measurement event (EQM 2010).

16
17 Within bedrock units at RVAAP, the principle water-bearing aquifer is the Sharon
18 Sandstone/Conglomerate. Depending on the existence and depth of overburden, the Sharon
19 Sandstone/Conglomerate ranges from an unconfined to a leaky artesian aquifer. Water yields from
20 on-site water supply wells completed in the Sharon Sandstone/Conglomerate ranged from 30-400
21 gallons per minute (gpm) (USATHAMA 1978). Well yields of 5-200 gpm were reported for on-site
22 bedrock wells completed in the Sharon Sandstone/Conglomerate (Kammer 1982). Other local
23 bedrock units capable of producing water include the Homewood Sandstone, which is generally
24 thinner and only capable of well yields less than 10 gpm, and the Connoquenessing Sandstone. Wells
25 completed in the Connoquenessing Sandstone in Portage County have yields of 5-100 gpm but are
26 typically less productive than the Sharon Sandstone/Conglomerate due to lower permeabilities
27 (Winslow et al. 1966).

28
29 Figure 3-4 shows the potentiometric surface within bedrock strata at RVAAP in January 2010 (EQM
30 2010). The bedrock potentiometric map shows a more uniform and regional eastward flow direction
31 than the unconsolidated zone that is not as affected by local surface topography. Due to the lack of
32 well data in the western portion of RVAAP, general flow patterns are difficult to discern. For much
33 of the eastern half of RVAAP, bedrock potentiometric elevations are higher than the overlying
34 unconsolidated potentiometric elevations, indicating an upward hydraulic gradient. This evidence
35 suggests there is a confining layer that separates the two aquifers. In the far eastern area, the two
36 potentiometric surfaces are at approximately the same elevation, suggesting hydraulic communication
37 between the two aquifers is occurring.

38
39 A general discussion of hydrogeology as applicable to sewers is presented in Section 3.2 of each
40 FAE.

3.4.2 Surface Water

RVAAP resides within the Mahoning River watershed, which is part of the Ohio River basin. The west branch of the Mahoning River is the main surface stream in the area. The west branch flows adjacent to the west end of the facility, generally in a north to south direction, before flowing into the Michael J. Kirwan Reservoir, which is located to the south of State Route 5 (Figure 1-1). The west branch flows out of the reservoir and parallels the southern RVAAP boundary before joining the Mahoning River east of RVAAP. The western and northern portions of RVAAP display low hills and a dendritic surface drainage pattern. The eastern and southern portions are characterized by an undulating to moderately level surface, with less dissection of the surface drainage. The facility is marked with marshy areas and flowing and intermittent streams whose headwaters are located in the upland areas of the facility.

The three primary watercourses that drain RVAAP are (Figure 1-2):

- South fork of Eagle Creek;
- Sand Creek; and
- Hinkley Creek.

All of these watercourses have many associated tributaries. Sand Creek, with a drainage area of 13.9 square miles, flows generally in a northeast direction to its confluence with the south fork of Eagle Creek. In turn, the south fork of Eagle Creek continues in a northerly direction for 2.7 miles to its confluence with Eagle Creek. The drainage area of the south fork of Eagle Creek is 26.2 square miles, including the area drained by Sand Creek. Hinkley Creek originates just southeast of the intersection between State Route 88 and State Route 303 to the north of the facility. Hinkley Creek, with a drainage area of 11.0 square miles, flows in a southerly direction through the facility and converges with the west branch of the Mahoning River to the south of the facility (USACE 2001a).

Approximately one-third of RVAAP meets the regulatory definition of a wetland, with the majority of the wetland areas located in the eastern portion of the facility. Wetland areas at RVAAP include seasonal wetlands, wet fields, and forested wetlands. Many of the wetland areas are the result of natural drainage or beaver activity; however, some wetland areas are associated with anthropogenic settling ponds and drainage areas.

Approximately 50 ponds are scattered throughout the facility. Many were constructed within natural drainage ways to function as settling ponds or basins for process effluent and runoff. Others are natural in origin, resulting from glacial action or beaver activity. Water bodies at RVAAP support aquatic vegetation and biota, as described in Section 3.6.2. Storm water runoff is controlled primarily by natural drainage, except in former operation areas where an extensive storm sewer network helps to direct runoff to drainage ditches and settling ponds.

A general discussion of surface water as applicable to sewers is presented for each FA in Section 3.3 of the respective FAE.

3.5 CLIMATE

The general climate of the RVAAP area is continental and characterized by moderately warm and humid summers, reasonably cold and cloudy winters, and wide variations in precipitation from year to year. Climate data for the RVAAP area presented below were obtained from available National Weather Service records for the 30-year period of record from 1971 to 2000 at the Youngstown Regional Airport, Ohio (<http://www.weather.gov/climate/xmacis.php?wfo=cle>). Wind speed data for Youngstown, Ohio, are from the National Climatic Data Center (<http://lwf.ncdc.noaa.gov/oa/climate/online/ccd/avgwind.html>) for the available 53-year period of record from 1950 to 2002.

Average annual rainfall in the RVAAP area is 38.15 inches, with the highest monthly average occurring in July (4.14 inches) and the lowest monthly average occurring in February (2.03 inches). Average annual snowfall totals approximately 52.8 inches, with the highest monthly average occurring in January (13.8 inches). Due to the influence of lake-effect snowfall events associated with Lake Erie (located approximately 35 miles to the northwest of RVAAP), snowfall totals vary widely throughout northeastern Ohio.

The average annual daily temperature in the RVAAP area is 48.8 °F, with an average daily high temperature of 58.3 °F and an average daily low temperature of 39.3 °F. The record high temperature of 100 °F occurred in July 1988, and the record low temperature of -22 °F occurred in January 1994. The prevailing wind direction at RVAAP is from the southwest, with the highest average wind speed occurring in January (11.4 miles per hour) and the lowest average wind speed occurring in August (7.4 miles per hour). Thunderstorms occur on approximately 35 days per year and are most abundant from April through August. The RVAAP area is susceptible to tornadoes; minor structural damage to several buildings on facility property occurred as the result of a tornado in 1985.

3.6 POTENTIAL RECEPTORS FOR FACILITY-WIDE SEWERS

The following sections discuss potential human and ecological receptors for the Facility-Wide Sewers.

3.6.1 Human Receptors

RVAAP is a controlled-access facility that is fenced and patrolled by security personnel. Full-time OHARNG, BRAC Division, and contractor staff work at the facility. Since the Facility-Wide Sewers AOC contains 26 miles of sewer lines distributed across RVAAP, multiple future military land uses may apply. Most of the AOCs are not currently used for training for operational activities; however, the RAFLU is National Guard Training for the majority of the AOCs for which the Facility-Wide Sewers AOC traverse (i.e., Load Lines 1 through 12, Atlas Scrap Yard). Other areas (e.g., Administration Area, Depot Administration Area, Inert Storage Area #6) are currently utilized for administrative or storage functions by OHARNG.

1 The National Guard Trainee includes digging and mixing soil and subsurface media to a depth of 7 ft
2 bgs as part of the exposure scenario. Therefore, the RAFLU for the Facility-Wide Sewers AOC is
3 Military Use and Training, using the National Guard Trainee as the representative receptor. Military
4 Use and Training, in conjunction with the evaluation of Unrestricted Residential Land Use, forms the
5 basis for identifying COCs. The Resident Farmer FWCUGs are used to evaluate COCs for
6 Unrestricted Residential Land Use at the AOC, as outlined in the *Guidance Document for the*
7 *Evaluation of Land Use Controls* (USACE 2011a).

9 **3.6.2 Ecological Receptors**

11 RVAAP has a diverse range of vegetation and habitat resources. Habitats present within the facility
12 include large tracts of closed-canopy hardwood forest, scrub/shrub open areas, grasslands, wetlands,
13 open-water ponds and lakes, and semi-improved administration areas (OHARNG 2008).

15 Vegetation at RVAAP can be grouped into three categories: herb-dominated, shrub-dominated, and
16 tree-dominated. Approximately 60% of the facility is covered with forest or tree-dominated
17 vegetation. The facility has seven forest formations, four shrub formations, eight herbaceous
18 formations, and one non-vegetated formation (OHARNG 2008).

20 Surface water features within RVAAP include a variety of streams, ponds, floodplains, and wetlands.
21 Numerous streams drain the facility, including approximately 19 miles of perennial streams. The
22 combined length of streams at the facility is 212 linear miles. Approximately 153 acres of ponds are
23 found on the facility. These ponds provide valuable wildlife habitat and support wood ducks, hooded
24 mergansers, mallards, Canada geese, and many other birds and wildlife species. Some ponds have
25 been stocked with fish and are used for fishing and hunting (OHARNG 2008).

27 Wetlands are abundant and prevalent throughout the facility. These wetland areas include seasonal
28 wetlands, wet fields, and forested wetlands. Most of the wetland areas on the facility are the result of
29 natural drainage and beaver activity; however, some wetland areas are associated with anthropogenic
30 settling ponds and drainage areas.

32 An abundance of wildlife is present on the facility; 35 species of land mammals, 214 species of birds,
33 41 species of fish, and 34 species of amphibians and reptiles have been identified. No federally-listed
34 species are known to reside at the facility, and no critical habitat occurs (OHARNG 2008). Ohio
35 state-listed plant and animal species have been identified through confirmed sightings and/or
36 biological inventories at the facility and are presented in Table 3-1.

38 The Facility-Wide Sewers AOC spans areas that range from developed and industrial (e.g., Depot
39 Administration Area, Administration Area, Inert Storage Area #6), to forested (e.g., trunk and
40 connector line segments), and includes many areas that are vegetated with herbs/grasses and
41 scrub/shrub vegetation (e.g., Load Lines 1 through 12). Additional information specific to ecological
42 resources at the AOC is included in Section 7.3. A discussion of the ecological setting for each FA is
43 presented in Section 7.3 of its respective FAE.

Table 3-1. Rare Species List

CAMP RAVENNA JOINT MILITARY TRAINING CENTER (CRJMTC) RARE SPECIES LIST 27 April 2010	
I. Species confirmed to be on CRJMTC property by biological inventories and confirmed sightings.	
A. State Endangered	
1.	American bittern, <i>Botaurus lentiginosus</i> (migrant)
2.	Northern harrier, <i>Circus cyaneus</i>
3.	Yellow-bellied Sapsucker, <i>Sphyrapicus varius</i>
4.	Golden-winged warbler, <i>Vermivora chrysoptera</i>
5.	Osprey, <i>Pandion haliaetus</i> (migrant)
6.	Trumpeter swan, <i>Cygnus buccinator</i> (migrant)
7.	Mountain Brook Lamprey, <i>Ichthyomyzon greeleyi</i>
8.	Graceful Underwing, <i>Catocala gracilis</i>
9.	Tufted Moisture-loving Moss, <i>Philonotis Fontana</i> var. <i>caespitosa</i>
10.	Bobcat, <i>Felis rufus</i>
11.	Narrow-necked Pohl's Moss, <i>Pohlia elongata</i> var. <i>elongata</i>
12.	Sandhill Crane, <i>Grus Canadensis</i> (probable nester)
13.	Bald Eagle, <i>Haliaeetus leucocephalus</i> (nesting pair)
B. State Threatened	
1.	Barn owl, <i>Tyto alba</i>
2.	Dark-eyed junco, <i>Junco hyemalis</i> (migrant)
3.	Hermit thrush, <i>Catharus guttatus</i> (migrant)
4.	Least bittern, <i>Ixobrychus exilis</i>
5.	Least flycatcher, <i>Empidonax minimus</i>
6.	<i>Psilotreta indecisa</i> (caddis fly)
7.	Simple willow-herb, <i>Epilobium strictum</i>
8.	Woodland Horsetail, <i>Equisetum sylvaticum</i>
9.	Lurking leek, <i>Plagiothecium latebricola</i>
10.	Pale sedge, <i>Carex pallescens</i>
C. State Potentially Threatened Plants	
1.	Gray Birch, <i>Betula populifolia</i>
2.	Butternut, <i>Juglans cinerea</i>
3.	Northern rose azalea, <i>Rhododendron nudiflorum</i> var. <i>roseum</i>
4.	Hobblebush, <i>Viburnum alnifolium</i>
5.	Long Beech Fern, <i>Phegopteris connectilis</i> (<i>Thelypteris phegopteris</i>)
6.	Straw sedge, <i>Carex straminea</i>
7.	Water avens, <i>Geum rivale</i>
8.	Tall St. John's wort, <i>Hypericum majus</i>
9.	Swamp oats, <i>Sphenopholis pennsylvanica</i>
10.	Shining ladies'-tresses, <i>Spiranthes lucida</i>
11.	Arbor Vitae, <i>Thuja occidentalis</i>
12.	American Chestnut, <i>Castanea dentata</i>

Table 3-1. Rare Species List (continued)

D. State Species of Concern 1. Pygmy shrew, <i>Sorex hovi</i> 2. Star-nosed mole, <i>Condyluracristata</i> 3. Woodland jumping mouse, <i>Napaeozapus insignis</i> 4. Sharp-shinned hawk, <i>Accipiter striatus</i> 5. Marsh wren, <i>Cistothorus palustris</i> 6. Henslow's sparrow, <i>Ammodramus henslowii</i> 7. Cerulean warbler, <i>Dendroica cerulea</i> 8. Prothonotary warbler, <i>Protonotaria citrea</i> 9. Bobolink, <i>Dolichonyx oryzivorus</i> 10. Northern bobwhite, <i>Colinus virginianus</i> 11. Common moorhen, <i>Gallinula chloropus</i> 12. Great egret, <i>Ardea alba</i> (migrant) 13. Sora, <i>Porzana carolina</i> 14. Virginia Rail, <i>Rallus limicola</i> 15. Creek heelsplitter, <i>Lasmigona compressa</i> 16. Eastern box turtle, <i>Terrapene carolina</i> 17. Four-toed Salamander, <i>Hemidactylium scutatum</i> 18. <i>Stenonemaithica</i> (mayfly) 19. <i>Apamea mixta</i> (moth) 20. <i>Brachyloimia algens</i> (moth) 21. Sedge wren, <i>Cistothorus platensis</i>	E. State Special Interest 1. Canada warbler, <i>Wilsonia canadensis</i> 2. Little blue heron, <i>Egretta caerulea</i> 3. Magnolia warbler, <i>Dendroica magnolia</i> 4. Northern waterthrush, <i>Seiurus noveboracensis</i> 5. Winter wren, <i>Troglodytes troglodytes</i> 6. Back-throated blue warbler, <i>Dendroica caerulescens</i> 7. Brown creeper, <i>Certhia americana</i> 8. Mourning warbler, <i>Oporornis philadelphia</i> 9. Pine siskin, <i>Carduelis pinus</i> 10. Purple finch, <i>Carpodacus purpureus</i> 11. Red-breasted nuthatch, <i>Sitta canadensis</i> 12. Golden-crowned kinglet, <i>Regulus satrapa</i> 13. Blackburnian warbler, <i>Dendroica fusca</i> 14. Blue grosbeak, <i>Guiraca caerulea</i> 15. Common snipe, <i>Gallinago gallinago</i> 16. American wigeon, <i>Anas americana</i> 17. Gadwall, <i>Anas strepera</i> 18. Green-winged teal, <i>Anas crecca</i> 19. Northern shoveler, <i>Anas clypeata</i> 20. Redhead duck, <i>Aythya americana</i> 21. Ruddy duck, <i>Oxyura jamaicensis</i> NOTE: There are currently no federally listed species or critical habitat on CRJMTC property. There are a few species currently under federal observation for listing, but none listed.

1
2

3.7 PRELIMINARY CONCEPTUAL SITE MODEL

A preliminary CSM was developed in the *Sampling and Analysis Plan for the Remedial Investigation of RVAAP-67 Facility-Wide Sewers, Addendum No. 1* (herein referred to as the Facility-Wide Sewers SAP), to develop sampling rationales and data quality objectives (DQOs) for the Facility-Wide Sewers RI (USACE 2009c). The preliminary CSM included a description of primary (active) and secondary (e.g., residual contaminants in sewer media) contaminant sources, migration pathways, contaminant discharge points, and potential receptors based on operational history and prior investigations. This preliminary CSM is summarized below.

3.7.1 Contaminant Sources

No primary contaminant sources remain at the AOC. The sanitary sewer system is no longer in use, and all associated buildings that formerly represented sources have been demolished or have had their service lines shut off. Similarly, former munitions production buildings that represented potential sources to the storm sewer systems have been demolished. In some FAs, potential primary contaminant sources remain intact, such as manufacturing, maintenance, and production support buildings at Depot Administration Area and Transportation Storage Area. In other FAs, the storm sewer network currently functions to divert drainage from building and parking lot areas that are under active use (e.g., Administration Area, Inert Storage Area #6).

Potential secondary sources (contaminated media) identified in previous investigations and further characterized during the Facility-Wide Sewers RI remain within portions of the sanitary and storm sewer networks and are described below.

3.7.1.1 Sewer Sediment and Water

Based on previous characterizations, contaminated sewer sediment and water located within the sewer pipe may represent a potential secondary source of contamination to groundwater (vertical migration) or surface water (lateral migration to outfalls). Previous analyses of sewer sediment and water under historical sewer investigations indicate the predominant analytes above screening levels are inorganic chemicals and polycyclic aromatic hydrocarbons (PAHs). Two hundred sewer sediment samples and 47 sewer water samples were collected during the Facility-Wide Sewers RI to further define the lateral extent of contamination within the sewer system.

3.7.1.2 Pipe Bedding Material

Pipe bedding material, defined as the earthen or other backfill material (e.g., sand, gravel) immediately underlying the sewer pipes, is a potential secondary source of contaminants. Releases of contaminated sewer sediment and water to the underlying pipe bedding material may occur through cracks and joint separations that have developed as a result of deterioration of, or root intrusion into, the pipes. Additionally, historical drawings indicate many storm sewer lines were intentionally constructed with gaps in the pipes at joints to promote infiltration of storm water into the underlying bedding material. The exfiltration of sewer water and sediment to the underlying material is a

primary migration pathway for contamination to leave the AOC and migrate vertically to the subsurface soil. Pipe bedding material has not been previously evaluated. Eighty-nine pipe bedding material sediment samples were collected during the Facility-Wide Sewers RI to further define the extent of vertical contamination.

3.7.1.3 Outfall Sediment and Water

Sewer outfalls, particularly within the storm sewer networks, provide points where sewer media (i.e., sewer sediment and water) discharges to the outside environment. Outfalls divert storm water runoff to natural or constructed drainage ditches or conveyances within the FAs where they occur. Media at outfall locations may be considered either wet sediment or surface soil. While most storm sewer outfalls only receive runoff following storm events, some exhibit continuous flow sourced from infiltration (e.g., groundwater) to the sewer lines. In addition, sanitary sewer lift stations (ejector stations) were equipped with emergency overflow outfalls to direct sewage to surface drainage conveyances in the event of power failures or shutdowns. Discharges to these sanitary sewer outfalls were intermittent and only occurred in the event of equipment shutdowns. At the former George Road, Sand Creek, and Depot Administration Sewage Treatment Plants, sanitary sewer lines that formerly entered the facilities were plugged during closure, and flows were diverted to by-pass outfalls allowing infiltrating surface water and groundwater to discharge to surface conveyances. Similar to sewer sediment and water, previous analyses of outfall sediment and water under historical sewer investigations indicate the predominant analytes above screening levels are inorganic chemicals and PAHs. Fifty-eight outfall sediment samples and 21 outfall water samples were collected during the Facility-Wide Sewers RI to further define the lateral extent of contamination within the sewer system.

3.7.2 Groundwater

In areas where sanitary or storm sewers lie below the water table, contaminants may enter the pipe systems through groundwater infiltration if contaminated groundwater is present. In these cases, groundwater may be considered a secondary source of contaminants. Historical groundwater data was evaluated with respect to being a potential source and also to validate contaminant leaching and groundwater transport modeling results. However, groundwater was not sampled as part of the Facility-Wide Sewers RI scope. The potential for groundwater to be a source of contamination to the sewer system and the groundwater-sewer water interactions are further evaluated for each FA in Sections 3.0 and 6.0 of its respective FAE, as applicable.

3.7.3 Migration Pathways

Contaminant migration pathways are identified for each FA and presented in its respective FAE. These pathways are based on FA characteristics and historical data, lateral migration of sewer sediment and water to outfalls (where applicable), and migration of sewer sediment and pipe bedding material contaminants to groundwater. Outfall sediment and water represent a periodic mechanism for the lateral migration of residual contaminants from sewer sediment and water within the pipe

1 systems to the drainage conveyances across the AOC. Contaminants in outfall water may migrate in
2 a dissolved phase or be adsorbed to particulates and re-suspended during periods of heavy runoff and
3 storm water flow. Leaching of sediment and pipe bedding material contaminants to groundwater,
4 with subsequent lateral migration within the groundwater system, is also a potential migration
5 pathway. The sewer system may also function as preferential pathway for groundwater infiltration
6 and flow in areas where pipe systems are below the water table. Visual observations of the sanitary
7 sewer system downstream of Load Line 2 showed continuous flow at the ejector station by-pass
8 outfall, indicating groundwater influx. Sanitary sewer systems in portions of Load Line 12 and Load
9 Line 4 were observed to be flooded, which may be due, in part, to permanent or seasonal fluctuations
10 of the water table above the pipe system. Modeling of contaminant leaching from sewer sediment
11 and pipe bedding material sources and transport via groundwater is included in this RI.

12 13 **3.7.4 Contaminant Discharge Points**

14
15 The primary contaminant discharge points from the sanitary and storm sewer networks are outfalls to
16 surface water conveyances. Discharge points for outfall sediment and water for each FA are
17 discussed in Section 3.0 of its respective FAE. Leaching of sewer sediment and pipe bedding
18 material contaminants to groundwater, with subsequent lateral migration to surface water discharge or
19 exposure points, is a potential migration pathway and further evaluated for each FA in Section 6.0 of
20 its respective FAE.

21 22 **3.7.5 Potential Receptors**

23
24 Potential human health and ecological receptors for the AOC, based on current land use, RAFLU, and
25 present-day ecological resources, are discussed in Section 3.6. Specific land uses vary for individual
26 FAs. Many of the FAs are not currently used for training or operational activities. However, the
27 OHARNG RAFLU for the majority of the areal extent of the AOC (i.e., Load Lines 1 through 12,
28 Atlas Scrap Yard), based on the anticipated training mission and utilization of Camp Ravenna, is
29 National Guard Training. Other areas (e.g., Administration Area, Depot Administration Area, Inert
30 Storage Area #6) are currently utilized for administrative or storage functions by OHARNG.
31 Therefore, the RAFLU for the Facility-Wide Sewers AOC is Military Use and Training, using the
32 National Guard Trainee as the representative receptor.

33
34 Current potential for human exposure is mitigated by the absence of permanent residents within
35 RVAAP and facility access and security controls to deter unauthorized entry. However, current and
36 future land use includes the potential for human receptor exposure, and terrestrial and aquatic
37 receptors are present at the AOC. Therefore, an HHRA and ERA were conducted as part of the
38 Facility-Wide Sewers RI.

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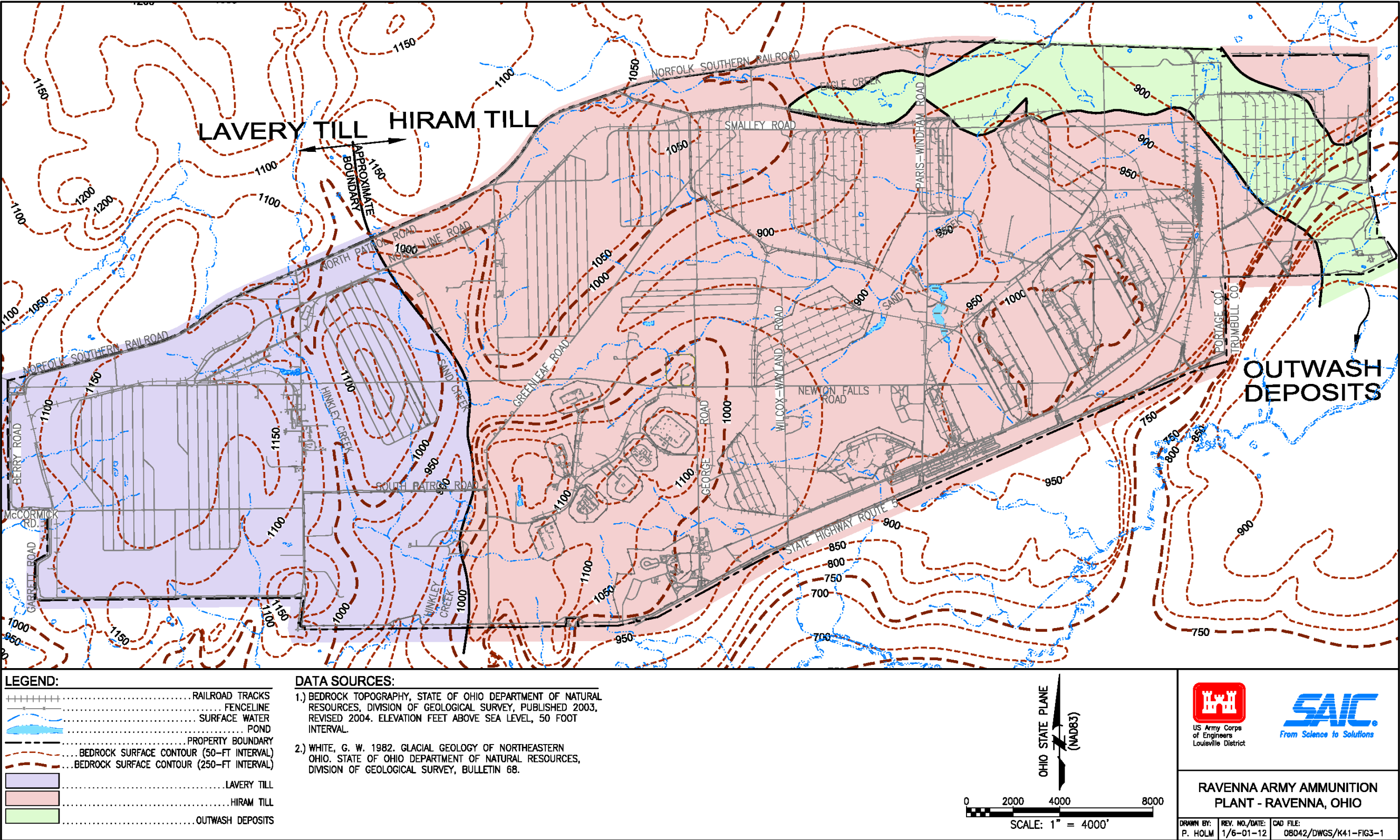


Figure 3-1. Geologic Map of Unconsolidated Deposits on RVAAP/Camp Ravenna

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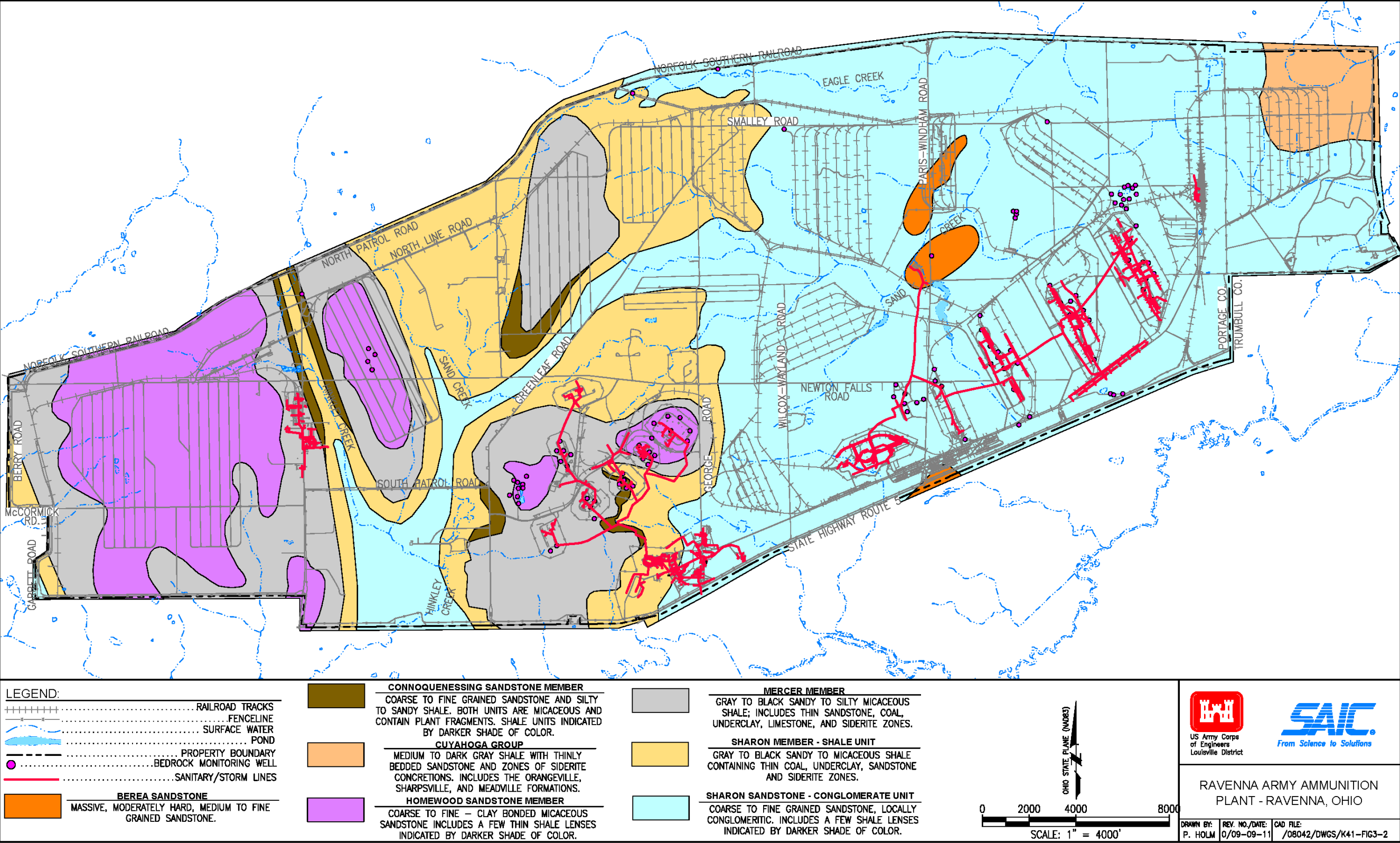


Figure 3-2. Geologic Bedrock Map and Stratigraphic Description of Units on RVAAP/Camp Ravenna

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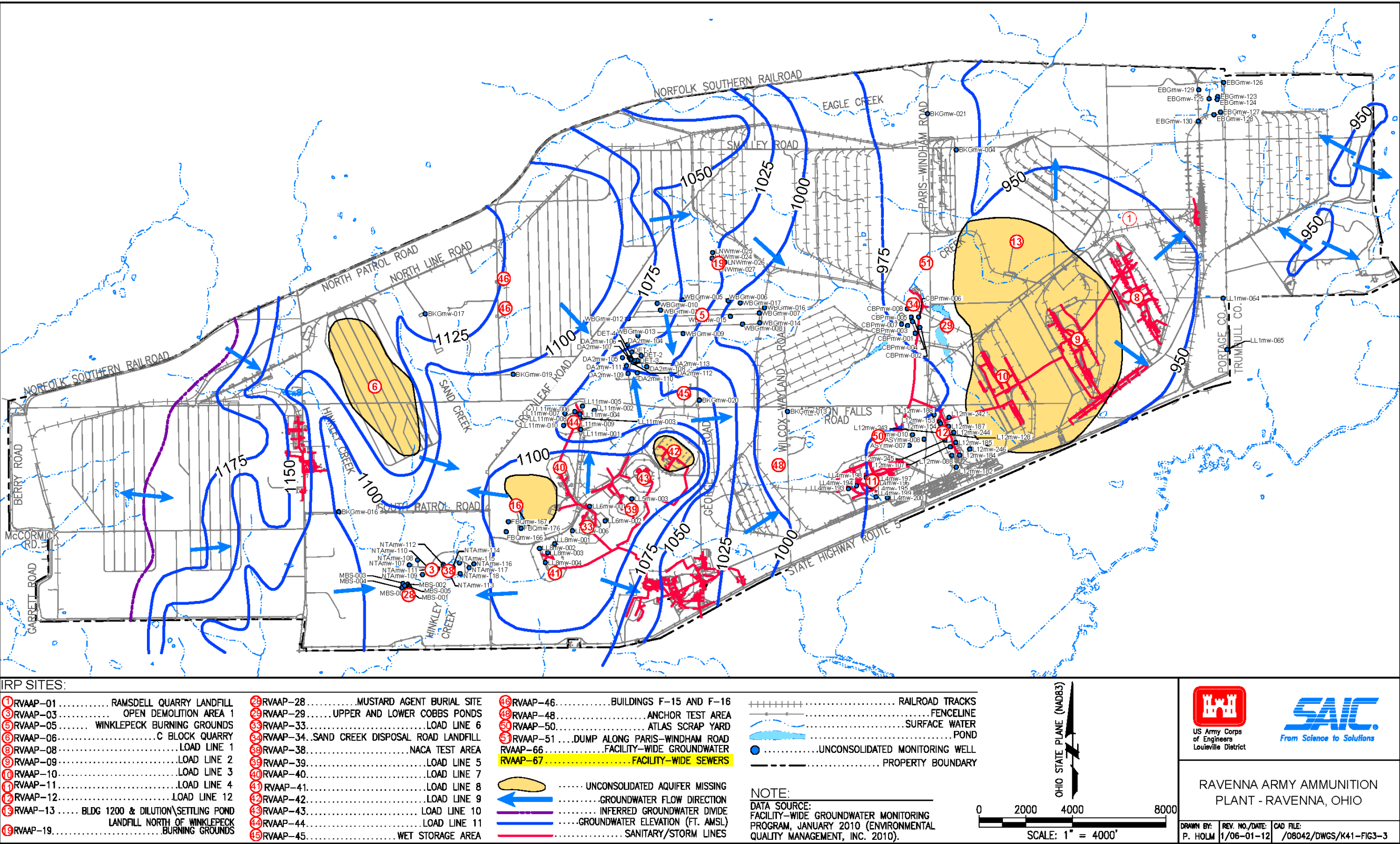


Figure 3-3. Potentiometric Surface of Unconsolidated Aquifer at RVAAP/Camp Ravenna

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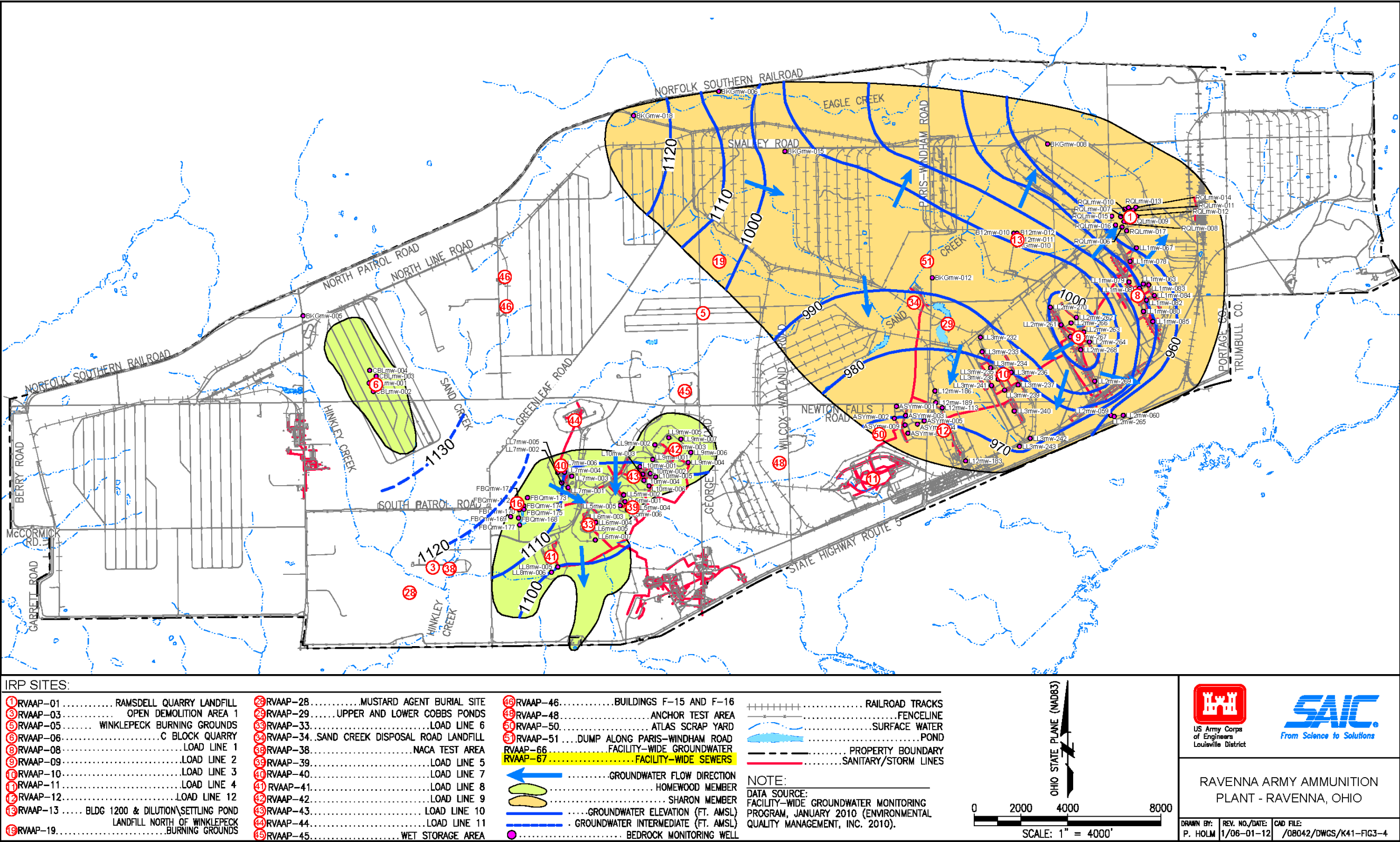


Figure 3-4. Potentiometric Surface of Bedrock Aquifers at RVAAP/Camp Ravenna

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4.0 REMEDIAL INVESTIGATION ACTIVITIES

This section presents the methods and approach used for the development of DQOs, field data collection, analytical data management, and laboratory programs for the 19 FAs that are part of the Facility-Wide Sewers AOC. The Facility-Wide Sewers RI was implemented in accordance with the Facility-Wide Sewers SAP to provide supplemental data to historical data and to support the development of this RI/FS Report. The results of the Facility-Wide Sewers RI sampling are combined with the results of previous sampling events to evaluate the nature and extent of contamination (Section 5.0), potential future impacts to groundwater (Section 6.0), and conduct risk assessments (Section 7.0) to evaluate the need for remedial alternatives.

4.1 GENERAL INVESTIGATION DECISION RULES AND SAMPLE DESIGN

Representatives of RVAAP, Ohio EPA, USACE Louisville, and Camp Ravenna reviewed and approved the Facility-Wide Sewers RI sample locations as part of the approval process for the Facility-Wide Sewers SAP in September 2009. The Facility-Wide Sewers RI, conducted in August 2009 through October 2009, January 2010, and August 2010, followed the general investigation decision rules and sample design outlined in the Facility-Wide Sewers SAP. This design included a tiered investigation conducted in several mobilizations to the FAs. Details specific for each FA are presented in its respective evaluation (FAE 1 through FAE 19).

The general decision rules outline a tiered, optimized characterization approach for the investigation. Three tiers of investigation proposed in the Facility-Wide Sewers SAP are as follows:

- Tier 1 – Investigation of the sewer lines, accumulated sediment and water within the lines, sediment and water at key outfall and AOC entry/exit points (investigation tools included visual surveys, video camera surveys, collection of samples for field screening, and fixed-based laboratory analyses);
- Tier 2 – Collection of pipeline bedding material to characterize direct exposure potential from contaminant releases via pipeline leaks and evaluate if these releases may have impacted the subsurface soil below the pipeline; and
- Tier 3 – Collection of subsurface soil data to characterize direct exposure potential from contaminant releases via pipeline leaks and evaluate if these releases may have impacted groundwater.

Due to site-specific conditions at the FAs, the application of the investigation decision rules may have varied in order to achieve the objectives of the Facility-Wide Sewers RI. During the RI, interim reviews of the field activities, findings, and results were conducted and presented in technical memorandums. These reviews facilitated decision making among the RVAAP stakeholders, which was documented in field change requests (FCRs) (FWS-01 and FWS-02), the *Revised Technical Memorandum for Tier 2 Sampling Under the Remedial Investigation at RVAAP-67 Facility-Wide*

1 Sewers (SAIC 2010) (hereafter referred to as the Tier 2 Technical Memorandum), and the *Data*
2 *Evaluation of the Tier 2 Sampling Under the Remedial Investigation at RVAAP-67 Facility Wide*
3 *Sewers* (SAIC 2011).

4 5 **4.2 TIER 1 INVESTIGATION**

6
7 The Tier 1 investigation of the sewer lines included visual surveys and sample collection of
8 accumulated sediment and water within the lines. Samples were collected for field screening and
9 fixed-based laboratory analyses. Video camera surveys were also conducted as part of Tier 1.

10 11 **4.2.1 Visual Survey Inspection**

12
13 For the development of the Facility-Wide Sewers SAP, a preliminary field reconnaissance of the
14 sanitary and storm sewer lines in the FAs was completed in December 2008, which showed many
15 storm sewer lines above the water table are still functional and convey water during periods of
16 rainfall. Flowing water, likely sourced from infiltrating groundwater, was observed in some sanitary
17 and storm sewer inverts at elevations below the water table. Portions of the sewer lines, particularly
18 within the Load Line 3 FA, Load Line 4 FA, Load Line 12 FA, and Atlas Scrap Yard FA, were
19 completely water-filled.

20
21 During the reconnaissance, undocumented storm sewer systems were discovered in the
22 Administration Area FA, Depot Administration Area FA, and Inert Storage Area #6 FA (south of the
23 Load Line 2 and 3 FAs). Prior to visual survey activities, historical drawings for the Administration
24 Area FA, Depot Administration Area FA, and Inert Area Storage Area #6 FA were obtained
25 subsequent to the Facility-Wide Sewers SAP; maps for these FAs were revised and included in FCR
26 FWS-01.

27
28 Prior to sampling activities, a comprehensive visual survey of the facility-wide storm and sanitary
29 sewer systems structures (i.e., manholes, drop inlets, catch basins, and potential outfall points) was
30 conducted by accessing known structures documented in historical RVAAP engineering data. The
31 Tier 1 visual survey inspections were completed in August 2009. A Visual Inspection Form was
32 completed for each structure surveyed to assess the overall condition of the system, including flow
33 and/or anomalies. In addition, the inspections identified potential sampling locations with
34 accumulated sediment and water present in the structures, determined potential access points, and
35 identified any potential safety hazards. During the visual survey, the historical maps were verified by
36 documenting the lines entering and exiting each structure and noting where the inaccuracies exist or
37 documenting areas where no historical drawings were available. Table 4-1 summarizes the visual
38 survey inspections for sanitary and storm sewers in each FA. All Visual Inspection Forms are
39 presented in Appendix A-1 and discussed in the respective evaluation of each FA (FAE 1 through
40 FAE 19).

Table 4-1. Summary of Visual Survey Inspections, Sanitary and Storm Sewers

Functional Area	Inspected		Located But Obstructed/ Infilled (Interior Not Inspected)		Likely Destroyed		Not Located		Total
Sanitary Sewer Structures									
Administration Area	48	61.5%	16	20.5%	4	5.1%	10	12.8%	78
Atlas Scrap Yard	16	88.9%	1	5.6%	0	0.0%	1	5.6%	18
Depot Administration Area	24	70.6%	0	0.0%	0	0.0%	10	29.4%	34
George Road Trunk and Connector Lines	52	82.5%	2	3.2%	0	0.0%	9	14.3%	63
Inert Storage Area #6	10	66.7%	1	6.7%	0	0.0%	4	26.7%	15
Load Line 1	23	67.6%	4	11.8%	7	20.6%	0	0.0%	34
Load Line 2	25	83.3%	0	0.0%	4	13.3%	1	3.3%	30
Load Line 3	25	80.6%	1	3.2%	2	6.5%	3	9.7%	31
Load Line 4	20	80.0%	2	8.0%	2	8.0%	1	4.0%	25
Load Line 5	9	90.0%	1	10.0%	0	0.0%	0	0.0%	10
Load Line 6	13	92.9%	0	0.0%	1	7.1%	0	0.0%	14
Load Line 7	5	62.5%	1	12.5%	0	0.0%	2	25.0%	8
Load Line 8	10	90.9%	0	0.0%	0	0.0%	1	9.1%	11
Load Line 9	10	76.9%	1	7.7%	0	0.0%	2	15.4%	13
Load Line 10	10	83.3%	0	0.0%	0	0.0%	2	16.7%	12
Load Line 11	5	41.7%	3	25.0%	4	33.3%	0	0.0%	12
Load Line 12	9	47.4%	0	0.0%	0	0.0%	10	52.6%	19
Sand Creek Trunk and Connector Lines	28	82.4%	0	0.0%	1	2.9%	5	14.7%	34
Transportation Storage Area	3	75.0%	0	0.0%	0	0.0%	1	25.0%	4
Totals	345	74.2%	33	7.1%	25	5.4%	62	13.3%	465
Storm Sewer Structures									
Administration Area	82	72.6%	7	6.2%	14	12.4%	10	8.8%	113
Atlas Scrap Yard	1	100.0%	0	0.0%	0	0.0%	0	0.0%	1
Depot Administration Area	36	80.0%	1	2.2%	2	4.4%	6	13.3%	45
Inert Storage Area #6	33	89.2%	1	2.7%	0	0.0%	3	8.1%	37
Load Line 1	25	37.3%	7	10.4%	35	52.2%	0	0.0%	67
Load Line 2	23	41.8%	8	14.5%	24	43.6%	0	0.0%	55
Load Line 3	25	28.7%	13	14.9%	49	56.3%	0	0.0%	87
Load Line 4	38	31.9%	13	10.9%	68	57.1%	0	0.0%	119
Transportation Storage Area	4	66.7%	2	33.3%	0	0.0%	0	0.0%	6
Totals	267	50.4%	52	9.8%	192	36.2%	19	3.6%	530
Overall									
Sanitary and Storm Totals	612	61.5%	85	8.5%	217	21.8%	81	8.1%	995

4.2.2 Sewer and Outfall Sediment Field Sampling Rationale and Methods

During Tier 1 of the Facility-Wide Sewers RI, sewer and outfall sediment samples were collected in accordance with the Facility-Wide Sewers SAP and the *Facility-Wide Sampling and Analysis Plan for Environmental Investigations* (USACE 2001a) (herein referred to as the FWSAP), using a hand-held stainless steel trowel or scoop for outfalls or shallow sewer structures (Section 4.5.2.2.1 of the

1 FWSAP). An updated version of the FWSAP was developed in February 2011 and approved by the
2 Ohio EPA; however, the Facility-Wide Sewers RI was implemented prior to approval of this updated
3 version. In the event thin deposits of sewer sediment were encountered in the deeper structures, a
4 stainless steel trowel or scoop on an extendable pole was used to gently scrape a sufficient sample
5 volume. Within the sewer structures, sampling was limited to loose sediment; fixed scale or calcified
6 deposits on the pipe/invert surfaces were not intentionally scrapped off and included with the
7 sediment (see Section 4.3.3 for details on scale/deposit sampling).

8
9 Sediment samples were collected within the sewer systems and from outfalls where sewer sediment
10 had washed out and accumulated. All sewer and outfall sediment samples were collected for target
11 analyte list (TAL) metals by fixed-based laboratory analyses and field analyses of TNT and RDX
12 using field test kits, as presented in Section 4.7.3. All positive TNT and RDX test kit detections were
13 submitted for off-site laboratory analyses of explosives (in order to provide confirmation of the field
14 test kit results) and for semi-volatile organic compounds (SVOCs) (due to the comparatively high
15 frequency of detection for these compounds).

16
17 Where possible, sediment and water samples were collected at the same location; water samples were
18 collected first, as described in Section 4.2.3. The order of analyte collection at each location was: (1)
19 explosives; (2) inorganic chemicals; (3) SVOCs; and (4) all remaining analyses as part of the 10%
20 RVAAP full suite of analytes [i.e., TAL metals, explosives, propellants (nitrocellulose and
21 nitroguanidine), SVOCs, volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and
22 pesticides].

23
24 When the primary sampling location did not yield sufficient sediment sample volume, media for the
25 subsequent analyses were collected from an immediately adjacent alternate location. For example, if
26 the primary location only contained enough sediment for the explosives analysis, the inorganic
27 chemicals sample was then collected from the first alternate location. The source locations for
28 sample collection are clearly documented in the logbook. A sediment sample collection log was
29 completed for each Tier 1 sample location and included in Appendix A-2. Details describing the
30 methods used and sample summaries are presented for each FA in their respective evaluations (FAE 1
31 through FAE 19). Analytical results for Tier 1 sediment samples are discussed in FAE 1 through
32 FAE 19.

33 34 **4.2.3 Sewer and Outfall Water Field Sampling Rationale and Methods**

35
36 Tier 1 sewer and outfall water samples were collected in accordance with the Facility-Wide Sewers
37 SAP and FWSAP using a hand-held bottle method for shallow structures (Section 4.6.2.1.1 of the
38 FWSAP) or the dipper and pond sample method for deeper structures that were not readily or safely
39 accessible (Section 4.6.2.1.2 of the FWSAP). Due to FA site-specific conditions (i.e., low flow,
40 debris, deeper structures), a peristaltic pump with disposable tubing was used to collect sewer water;
41 the “straw” method was utilized if water was collected for VOC analysis.

Water samples were collected from sanitary and storm sewer system manholes, drop inlets, and outfalls. Samples of accumulated water were co-located with sediment samples at the outfalls and at designated locations within the sewer systems where possible. The objective of collecting the co-located sediment and surface water samples was to assess the potential for contaminant migration in sewer water, evaluate potential contaminant accumulation areas, evaluate if residual contamination is partitioning to water and if these structures are acting as secondary sources, and determine if contaminants are partitioning from sewer sediment or sludge and potentially contributing to shallow groundwater or surface water contamination.

Wherever co-located sewer or outfall sediment and water samples were collected, the sewer water samples were collected first. The order of analyte collection at each location was: (1) explosives; (2) inorganic chemicals; (3) SVOCs; and (4) all remaining analyses as part of the 10% RVAAP full-suite analytes.

As with the sediment sample collection method, if the primary sampling location did not yield sufficient sample volume, water for the subsequent analyses was collected from an immediately adjacent alternate location. Although a number of water samples could not be collected as proposed in the Facility-Wide Sewers SAP (i.e., location was dry), numerous locations were subsequently revisited (i.e., after a rain event) and were still found to contain insufficient flow for sample collection. The source locations for each sample collected is documented in the logbook. A sewer water sample collection log was completed for each Tier 1 sample location and is included in Appendix A-2. Details describing the methods used and sample summaries are presented for each FA in their respective evaluations (FAE 1 through FAE 19). Analytical results of the sewer water sampling are discussed for each FA in their respective evaluations (FAE 1 through FAE 19).

4.2.4 Video Camera Survey

Video camera surveys were performed on segments of existing storm and sanitary sewer lines in order to evaluate the overall condition of the system, determine the presence of residual explosives compounds, assess the integrity of the pipe and its potential for releasing contaminants to the environment, and provide data for the evaluation of remedial alternatives. A total of 3,813.23 linear ft of the sewer lines (3429.67 ft and 383.56 ft of sanitary and storm sewer lines, respectively) were surveyed with a video camera in January 2010.

For the video camera survey, the objective was to survey as much of the total length of a sewer line segment of interest as possible, with a target minimum of 10%. For each sewer line segment, entry points for video surveys were sufficient to provide a general overall assessment of the pipeline along its reach. The video survey at each manhole or drop inlet selected for assessment continued to the maximum specified extent or until an obstruction prevented further movement. Field conditions prevented access to some of the predetermined entry points; in those instances, alternative locations were selected in the field and documented in the video survey logs (Appendix B).

1 Following each video survey, the video camera equipment was decontaminated. The
2 decontamination fluids were designated as investigation-derived waste (IDW) and placed in lined,
3 labeled, 55-gal drums that were sealed after use and staged at Building 1036.

4
5 The video camera survey results indicated the widespread occurrence of cracks, breaches due to pipe
6 deterioration/collapse, intrusion of roots, and joint separation/offsets throughout the sewer systems.
7 Infiltration was observed at discrete cracks or breaks and at the majority of pipe joints, as evidenced
8 by infiltration staining and the accumulation of scale/mineral deposits. These deposits are commonly
9 noted at the top and sides of the pipes, and the significant development of stalactite-like structures and
10 encrustations resulting in up to 95% occlusion of the cross-sectional area of the pipe was observed in
11 some locations. Although some variations in pipe conditions are noted at different parts of the
12 system, evidence of infiltration, cracking, or other defects are consistently observed. Further details
13 on the video camera surveys are presented in the FAEs for the Administration Area FA, Depot
14 Administration Area FA, George Road Trunk and Connector Lines FA, Load Line 1 FA, Load Line 2
15 FA, Load Line 3 FA, Load Line 4 FA, Load Line 5 FA, Load Line 6 FA, Load Line 7 FA, Load Line
16 8 FA, Load Line 9 FA, Load Line 10 FA, and Load Line 12 FA.

17
18 The video survey provided an updated indication of the sewer system conditions; however, it was not
19 practical to use these data to target specific pipeline breaks. The Tier 2 Technical Memorandum
20 proposed pipe bedding samples for source confirmation and segment characterization samples for
21 representation of conditions in those areas where exfiltration of potentially contaminated material
22 may have occurred. Therefore, no additional video camera surveys were recommended for the Tier 2
23 investigation.

24
25 All video surveys and still photographs were reviewed and analyzed by PIKA International, Inc. for
26 suspicious or potential energetic material. The *Unexploded Ordnance (UXO) Evaluation of Video*
27 *Survey Results Report* is presented in Appendix B.

28 29 **4.2.5 Summary of Tier 1 Investigation**

30
31 Both historical and Tier 1 sewer sediment and water data were screened against the screening levels
32 presented in Table 3-1 of the Facility-Wide Sewers SAP (USACE 2009c) to determine potential
33 locations that required additional investigation. In addition to sewer sediment and water sample
34 collection, 3,813.23 ft of the sewer line was video surveyed during Tier 1 of the RI. The video survey
35 results indicated a widespread occurrence of cracks, breaches due to pipe deterioration/collapse,
36 intrusion of roots, and joint separation/offsets throughout the sewer systems. Infiltration is observed
37 at discrete cracks or breaks and at the majority of pipe joints, as evidenced by infiltration staining and
38 the accumulation of scale/mineral deposits. These deposits are commonly noted at the top and sides
39 of the pipes, and the significant development of stalactite-like structures and encrustations resulting in
40 up to 95% occlusion of the cross-sectional area of the pipe is observed in some locations.

The Tier 2 Technical Memorandum summarized the results of the Tier 1 investigation and provided recommendations for the Tier 2 investigation. The following types of samples were recommended for collection:

- Pipe bedding material below the lines via direct-push borings or excavation;
- Sediment and water samples from manhole/catch basin or outfall locations not previously sampled or in line with Tier 1 screening exceedance sample locations; and
- Scale/deposit material from within the manholes/catch basins.

4.3 TIER 2 INVESTIGATION

The Tier 2 investigation of the sewer lines included sample collection of accumulated sediment, scale/deposits, and water within the lines and pipe bedding material. Samples were collected for field screening and fixed-based laboratory analyses. Pipe material sampling for asbestos was also conducted as part of Tier 1.

4.3.1 Sewer and Outfall Sediment Field Sampling Rationale and Methods

During Tier 2 of the Facility-Wide Sewers RI, sewer and outfall sediment samples were collected in accordance with the Facility-Wide Sewers SAP and FWSAP, using either a hand-held stainless steel trowel or scoop for outfalls and shallow sewer structures (Section 4.5.2.2.1 of the FWSAP). In the event thin deposits of sewer sediment were encountered in the deeper structures, a stainless steel trowel or scoop on an extendable pole was used to gently scrape a sufficient sample volume. Within the sewer structures, sampling was limited to loose sediment; fixed scale or calcified deposits on the pipe/invert surfaces were not intentionally scrapped off and included with the sediment (see Section 4.3.3 for details on scale/deposit sampling).

Sediment samples were collected within the sewer systems and from outfalls where sewer sediment had accumulated after being washed out of the system. All sewer and outfall sediment samples were collected for TAL metals by fixed-based laboratory analyses and field analyses of TNT and RDX, using field test kits as presented in Section 4.7.3. All positive TNT and RDX test kit detections were submitted for off-site laboratory analyses of explosives (in order to provide confirmation of the field test kit results) and SVOCs (due to the comparatively high frequency of detection for these compounds). SVOC analysis was limited to PAHs for Tier 2 samples proposed in the Tier 2 Technical Memorandum, based on Tier 1 analytical results. During Tier 2 of the Facility-Wide Sewers RI, 10 sediment samples were submitted for analysis of hexavalent chromium only in order to evaluate chromium speciation where Tier 1 results indicated total chromium exceeding the Resident Farmer FWCUG (187 mg/kg).

Where possible, sediment and water samples were collected at the same location; water samples were collected first, as described in Section 4.3.2. The order of analyte collection at each location was: (1)

explosives; (2) inorganic chemicals; (3) SVOCs; and (4) all remaining analyses as part of the 10% RVAAP full-suite analytes.

When the primary sampling location did not yield sufficient sediment sample volume, media for the subsequent analyses were collected from an immediately adjacent alternate location. For example, if the primary location only contained enough sediment for the explosives analysis, the inorganic chemicals sample was then collected from the first alternate location. The source locations for sample collection were clearly documented in the logbook. A sediment sample collection log was completed for each Tier 2 sample location and included in Appendix A-3. Details describing sample summaries and the methods used are presented for each FA in their respective evaluation (FAE 1 through FAE 19). Analytical results of the sediment sampling are discussed for each FA in its respective evaluation (FAE 1 through FAE 19).

In the event surficial access to a sewer segment of interest via drop inlet or manhole was not possible due to collapse or infilling, intrusive methods were employed during Tier 2 of the Facility-Wide Sewers RI. Equipment such as a mini excavator or portable power auger was utilized to expose the sewer pipe in order to collect samples of the material within the sewer pipe. Details describing sample summaries and the methods used are presented for each FA in its respective evaluation (FAE 1 through FAE 19). At locations where excavation methods were employed, the overlying ballast/slag and fill material (if no staining or odor was observed) was used to backfill the excavation footprint following completion of sample collection. If staining or odor was observed, the impacted soil was containerized and designated as IDW, and clean fill material was used to backfill the excavation.

4.3.2 Sewer and Outfall Water Field Sampling Rationale and Methods

Tier 2 sewer and outfall water samples were collected in accordance with the Facility-Wide Sewers SAP and FWSAP using a hand-held bottle method for shallow structures (Section 4.6.2.1.1 of the FWSAP), or the dipper and pond sample method for deeper structures that were not readily or safely accessible (Section 4.6.2.1.2 of the FWSAP). Due to FA site-specific conditions (i.e., low flow, debris, deeper structures), a peristaltic pump with disposable tubing was used to collect sewer water; the “straw” method was utilized if water was collected for VOC analysis.

Water samples were collected from sanitary and storm sewer system manholes, drop inlets, and outfalls. Samples of accumulated water were co-located with sediment samples at the outfalls and at designated locations within the sewer systems, where possible. The objective of collecting the co-located sediment and surface water samples was to assess the potential for contaminant migration in sewer water, to evaluate potential contaminant accumulation areas, to evaluate if residual contamination is partitioning to water and if these structures are acting as secondary sources, and to determine if contaminants are partitioning from sewer sediment or sludge and potentially contributing to shallow groundwater or surface water contamination.

1 Wherever co-located sewer or outfall sediment and water samples were collected, the sewer water
2 samples were collected first. The order of analyte collection at each location was: (1) explosives; (2)
3 inorganic chemicals; (3) SVOCs; and (4) all remaining analyses as part of the 10% RVAAP full-suite
4 analytes.

5
6 As with the sediment sample collection method, if the primary sampling location did not yield
7 sufficient sample volume, water for the subsequent analyses was collected from an immediately
8 adjacent alternate location. Although a number of water samples could not be collected as proposed
9 in the Facility-Wide Sewers SAP and Tier 2 Technical Memorandum (i.e., location was dry),
10 numerous locations were subsequently revisited (i.e., after a rain event) and were still found to
11 contain insufficient flow for sample collection. The source locations for each sample collected was
12 documented in the logbook. A sewer water sample collection log was completed for each Tier 2
13 sample location and included in Appendix A-3. Details describing sample summaries and the
14 methods used are presented for each FA in its respective evaluation (FAE 1 through FAE 19).
15 Analytical results of the sewer water sampling are discussed for each FA in its evaluation (FAE 1
16 through FAE 19).

17 18 **4.3.3 Sewer Scale/Deposit Sampling Rationale and Methods**

19
20 Collection of scale/deposit samples from within the manholes or catch basins was conducted to
21 characterize the composition of the sewer scale material during the Tier 2 investigation. The scale
22 sample locations were originally selected on the basis of visual inspection and video camera surveys
23 (i.e., scaling/deposits noted within the manhole or catch basin) or the observation of elevated
24 inorganic chemicals (particularly manganese) in Tier 1 sewer sediment in the absence of indications
25 of other contamination. Infiltration processes have resulted in the accumulation of deposits within the
26 sewer lines. The deposit material was likely comingled with sediment and may account for elevated
27 inorganic chemicals observed in some locations. Samples were collected by scraping the sides of the
28 pipes and inlets with a stainless steel spoon attached to the end of an extension rod. The samples
29 were submitted for fixed-based laboratory analysis of explosives and TAL metals. A sample
30 collection log was completed for each sample location; Tier 2 logs are included in Appendix A-3.
31 Analytical results of the Tier 2 scale/deposit sampling are discussed in the FAEs for the Depot
32 Administration Area FA, Load Line 2 FA, and Load Line 7 FA.

33 34 **4.3.4 Pipe Bedding Material Characterization**

35
36 Subsurface soil samples were collected to assess if the sewer line integrity was compromised by stress
37 cracking, joint separation, root intrusion, or other means that resulted in the release of contaminants to
38 pipe bedding material and soil adjacent to or underlying the sewer system pipeline. Selection of pipe
39 bedding material sampling locations for Tier 2 followed the methodology presented in Figure 3-3 of
40 the Facility-Wide Sewers SAP, where Tier 1 data from sewer sediment, water collected within the
41 sewer system, and the video camera survey logs were evaluated and reviewed.

Where the target soil sample depth did not exceed 4 ft bgs, hand augering methods were used for sample collection; if needed, a portable power auger and a mini excavator was used to assist in reaching target depths. The mini excavator was also used to expose the shallow sewer line if the sewer structure (i.e., inlet, manhole) was destroyed or infilled or if the pipe bedding material sample was co-located with an inline sediment sample proposed in the approved FCR FWS-01 (Appendix C). For sample collection greater than 4 ft bgs, hydraulic direct-push method using a Geoprobe was the primary sample collection method. H and augering and hydraulic direct-push sampling were performed in accordance with Sections 4.4.2.1.4 and 4.4.2.1.5 of the FWSAP, respectively. Soil samples collected using the Geoprobe were collected in a single use acetate liner and at a depth interval approximately 1-2 ft immediately below the sewer line. Each sample was composited and homogenized in a stainless steel bowl, with the exception of VOC samples.

A lithologic soil description was completed for each soil boring on a hazardous, toxic, and radioactive waste (HTRW) drilling log. A sample collection log was completed for each location sampled using a combination of powered auger or mini excavator and hand augering. All Tier 2 logs are included in Appendix A-3.

All pipe bedding material samples were collected for TAL metals analyses by fixed-based laboratory and for field analyses of TNT and RDX using field test kits (Section 4.7.3). Also, 30% of the samples were submitted to the fixed-based laboratory for PAH analysis in accordance with the Tier 2 Technical Memorandum. All positive TNT and RDX test kit detections were submitted for off-site laboratory analysis of explosives (in order to provide confirmation of the field results) and SVOCs (due to the comparatively high frequency of detection for these compounds). SVOC analysis was limited to PAHs for Tier 2 samples, based on Tier 1 analytical results. Additionally, several pipe bedding material samples from the Administration Area FA and Load Lines 1 and 2 FAs were submitted for chromium speciation. Analytical results of the pipe bedding material sampling are discussed for each FA in its respective evaluation (FAE 1 through FAE 19).

Subsurface borings were backfilled to the ground surface with dry bentonite chips and hydrated with the project-approved potable water. At locations where excavation methods were employed, the overlying ballast/slag and fill material (if no staining or odor) was used to backfill the excavation footprint following completion of sample collection.

4.3.5 Asbestos Analysis of Pipe Material

In order to provide characterization of sewer pipe material for potential use in future remedial design (RD) decisions, the pipe material was submitted for ACM analysis. Historical construction records indicate asbestos piping was used for water lines in some areas of RVAAP; however, there is no evidence it was used in the sewer systems. A review of available historical documents indicated sewer systems were comprised predominantly of vitrified sewer pipe (VSP) or vitrified clay pipe (VCP), with sizes ranging 6-15 inches in diameter. Limited portions of the sanitary systems utilized cast iron pipe 4-8 inches in diameter on those sections comprised of pressurized force mains. In the storm system, larger outfalls of 24-36 inches in diameter are typically comprised of concrete or

1 corrugated metal. The objective of this characterization was to verify the historical construction
2 records.

3
4 Pipe material was generally collected through non-destructive methods; only already-broken
5 fragments encountered in the field were collected. However, shallow excavation activities conducted
6 during Tier 2 resulted in the fracturing of representative sewer pipe material. Broken pipe fragments
7 were set aside with the excavator bucket for sample collection. Pipe material samples were collected
8 by a certified asbestos inspector (CAI). The results and details of this analysis are presented for the
9 Load Line 2, 3, and 4 FAs and Depot Administration Area FA in their respective evaluations (FAE 7,
10 FAE 8, FAE 9, and FAE 3).

11 12 **4.3.6 Summary of Tier 2 Investigation**

13
14 *The Data Evaluation of the Tier 2 Sampling Under the Remedial Investigation at RVAAP-67 Facility*
15 *Wide Sewers* (SAIC 2011) summarized results of the data evaluation for Tier 2. The results of Tiers 1
16 and 2 were evaluated to identify potential data gaps and assess if additional sampling is necessary to
17 complete the RI and are expanded upon in the respective FAEs. These evaluations included
18 collection of subsurface soil data to characterize direct exposure potential from contaminant releases
19 via pipeline leaks and evaluate if these releases may have impacted groundwater. As approved by the
20 RVAAP stakeholders, a Tier 3 investigation was not required, as no major data gaps existed after
21 conducting the Tier 1 and Tier 2 evaluations.

22 23 **4.4 CHANGES FROM THE WORK PLAN**

24
25 Changes to the Facility-Wide Sewers SAP were documented in two FCRs (Appendix C). FCR
26 FWS-01 presented alternative sampling locations for Tier 1 locations that were inaccessible or had
27 insufficient sewer media present and also included a reassessment for select locations where no
28 alternative sampling recommendation was proposed. FCR FWS-02 was approved to allow the
29 selection of video survey locations based on preliminary analytical data in addition to, or in lieu of,
30 field testing results. The Tier 2 Technical Memorandum presented the details and rationale of
31 additional sampling (including pipe bedding material and sewer pipe material) within each FA based
32 on the results of Tier 1 of the Facility-Wide Sewers RI. Changes made in the field based on
33 FA-specific conditions are not documented on FCRs but on field sampling logs (Appendices A-2 and
34 A-3).

35 36 **4.5 MUNITIONS AND EXPLOSIVES OF CONCERN AVOIDANCE AND FIELD RECONNAISSANCE**

37
38 The scope of the Facility-Wide Sewers RI also included munitions and explosives of concern (MEC)
39 avoidance within Munitions Response Sites (MRS) (and other areas if MEC was suspected) in order
40 to safely conduct investigation activities. MEC avoidance procedures are outlined in the Abbreviated
41 Site Safety and Health Plan (ASSHP) (USA Environmental 2009). MEC Avoidance Subcontractor
42 support staff was present during sampling activities conducted in MRS. The MEC Team Leader led
43 an initial safety briefing on MEC to train all field personnel to recognize and avoid propellants and

MEC. Daily tailgate safety briefings included reminders regarding MEC avoidance. Documentation of these safety meetings and daily activities are included in Appendix G.

Prior to beginning sampling activities, sample locations were assessed for potential MEC using visual surveys and hand-held magnetometers in the Load Line 1 MRS and Atlas Scrap Yard MRS. Once subsurface sampling (i.e., pipe bedding material sampling) began, the Foster Ferex MK 26 Ordnance Detector was lowered into the borehole to identify areas void of anomalies. No anomalies were noted during the investigation. The MEC technician remained on-site while sampling was performed to visually examine sewer media for any unusual material indicative of potential MEC or residues of explosives, including scale/deposit samples collected in the Depot Administration Area FA and Load Line 2 FA.

4.6 INVESTIGATION-DERIVED WASTE

Following collection of the samples, excess pipe bedding material, soil cuttings, and sediment were designated as IDW. Following each video survey, the video camera equipment was decontaminated. The decontamination fluids were designated as IDW. All IDW was placed in labeled, 55-gal drums that were sealed after use and staged at Building 1036. IDW reports for all media are presented in Appendix F.

4.7 ANALYTICAL PROGRAM OVERVIEW

The following sections describe the analytical program followed during the Facility-Wide Sewers RI.

4.7.1 Data Quality Objectives

Samples were collected and analyzed according to the FWSAP and Facility-Wide Sewers SAP that were prepared in accordance with USACE and USEPA guidance. The FWSAP and Facility-Wide Sewers SAP outline the organization, objectives, intended data uses, and quality assurance/quality control (QA/QC) activities to perform in order to achieve the desired DQOs for maintaining the defensibility of the data. Project DQOs were established in accordance with USEPA Region 5 guidance. Requirements for sample collection, handling, analysis criteria, target analytes, laboratory criteria, and data verification criteria for the RI are consistent with USEPA and United States Department of Defense (DoD) requirements. DQOs for this project included analytical precision, accuracy, representativeness, completeness, comparability, and sensitivity for the measurement data. Appendix D presents an assessment of the analytical program objectives.

4.7.2 Quality Assurance and Quality Control

Samples were properly packaged for shipment and transferred by courier to the laboratory for analysis. A signed chain-of-custody record (Appendix E) with sample numbers and locations was enclosed with each shipment. When transferring the possession of samples, the individuals relinquishing and receiving the samples signed, dated, and noted the time on the record. All

shipments were in compliance with applicable United States Department of Transportation (DOT) regulations for environmental samples.

QA/QC samples for this project included field blanks, trip blanks, QC field duplicates, equipment rinsate samples, QA split samples, laboratory method blanks, laboratory control samples (LCSs), laboratory duplicates, and matrix spike/matrix spike duplicate (MS/MSD) samples. Table 4-2 presents a summary of QA/QC samples utilized during the Facility-Wide Sewers RI and how each sample type was used to support the quality of the analytical data. Evaluation of QA/QC samples and their contribution to documenting the project data quality is provided in Appendix D.

Table 4-2. Summary of Facility-Wide Sewers RI QA/QC Samples

Sample Type	Rationale
Field Blank	Analyzed to determine contamination in source material that may contribute to sample contamination
Trip Blank	Analyzed to assess the potential for cross contamination of samples due to contaminant interference during sample shipment and storage
Field Duplicate	Analyzed to determine sample heterogeneity and sampling methodology reproducibility
Equipment Rinsate	Analyzed to assess the adequacy of the equipment decontamination processes for non-dedicated sampling equipment
Laboratory Method Blanks	Analyzed to assess the contamination level in the laboratory preparation and analysis process
Laboratory Duplicate Samples	Analyzed to assist in determining the analytical reproducibility and precision of the analysis for the samples of interest and provide information about the effect of the sample matrix on the measurement methodology
Matrix Spike/Matrix Spike Duplicate	
Laboratory Control Sample	Analyzed to determine the accuracy and precision of the analytical method implemented by the laboratory and to monitor the laboratory's analytical process control
QA Split	Analyzed to provide independent verification of the accuracy and precision of the principal analytical laboratory

QA = Quality Assurance

QC = Quality Control

RI = Remedial Investigation

4.7.3 Field Analyses

All sewer sediment and pipe bedding material samples were analyzed for TNT and RDX using the EnSys (Strategic Diagnostics, Inc.) field test kits (Appendix R of the Facility-Wide Sewers SAP), with the exception of samples collected within the Load Line 1 MRS and the Atlas Scrap Yard MRS. The EnSys field test kits are a commercially available, colorimetric immunoassay method (EPA SW-846 Method #8510 and #8515 for RDX and TNT, respectively). The range of the TNT test is between 1 mg/kg and 30 mg/kg, well below the FWCUG of 36.5 mg/kg for TNT. The TNT test is also able to detect trinitrobenzene (TNB) and dinitrotoluene (DNT) compounds. The RDX test is able to achieve a detection range between 1 mg/kg and 30 mg/kg, well below the FWCUG of 80.3 mg/kg. The RDX test is also able to detect octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX).

1 Positive TNT and RDX EnSys test kit detections were submitted for off-site laboratory analysis of
2 explosives and TAL metals (in order to provide confirmation of the field results) and SVOCs (due to
3 the comparatively high frequency of detection for these compounds). SVOC analysis was limited to
4 PAHs for Tier 2 samples based on Tier 1 analytical results. In addition, a minimum of 10% of the
5 sediment samples showing detects for TNT or RDX were sent to the off-site laboratory for analysis of
6 the RVAAP full suite of target analytes (VOCs, SVOCs, TAL metals, explosives, pesticides, PCBs,
7 herbicides, and propellants).

8 Samples for fixed-based laboratory analyses were also submitted for a minimum of 10% of the
9 sediment sample locations where field analytical data did not indicate the presence of contamination.
10 These samples were used to confirm the absence of contamination. All samples submitted to confirm
11 the absence of contamination were analyzed for explosives and TAL metals. Additionally, a
12 minimum of 30% of the samples were analyzed for SVOCs (limited to PAHs for Tier 2 samples), and
13 10% of the samples were analyzed for the RVAAP full suite of target analytes (VOCs, SVOCs, TAL
14 inorganic chemicals, explosives, pesticides/PCBs, herbicides, and propellants). In addition, a full
15 suite of fixed-based laboratory analyses were conducted where visual surveys indicated the likely
16 occurrence of contamination (e.g., visible explosive deposits or evidence of sheens on accumulated
17 water in the pipes).

18
19 The sample decision methodology summarized above is detailed in Section 3.2.5.1 of the
20 Facility-Wide Sewers SAP. The results of the field explosives testing are presented for each FA in
21 Section 4.2 and 4.4 in FAE 1 through FAE 19.

22
23 Additionally, field screening for organic vapors was not used to guide sampling or analytical efforts.
24 Organic vapors were monitored upon opening sewer manhole lids and in the breathing zone during
25 drilling at each subsurface soil boring location.

26 27 **4.7.4 Laboratory Analyses**

28
29 Samples collected during the Facility-Wide Sewers RI were analyzed by TestAmerica Laboratories,
30 Inc. (herein referred to as TestAmerica) of North Canton, Ohio, as a subcontractor to White Water
31 Associates, Inc., of Amasa, Michigan. QA split samples collected during the Facility-Wide Sewers
32 RI were analyzed by USACE's contracted QA laboratory, TestAmerica of University Park, Illinois.
33 Both TestAmerica laboratories are accredited by the DoD Environmental Laboratory Accreditation
34 Program (ELAP).

35
36 All analytical procedures were completed in accordance with applicable professional standards,
37 USEPA requirements, government regulations and guidelines, DoD Quality Systems Manual (QSM)
38 Version 3, USACE Louisville District analytical QA guidelines, and specific project goals and
39 requirements. In addition to these standards, strict adherence to the requirements set forth in the
40 FWSAP and Facility-Wide Sewers SAP was required of the analytical laboratories so that conditions
41 adverse to data quality would not arise. Preparation and analyses for chemical parameters were
42 performed according to the methods listed in Table 4-3.

1

Table 4-3. Summary of Facility-Wide Sewers RI Preparation and Analytical Procedures

Parameter	Soil and Sediment		Surface Water	
	Preparation	Analysis	Preparation	Analysis
Inorganic chemicals	SW-846 3050B	SW-846 6020	SW-846 3005A	SW-846 6020
Mercury	--	SW-846 7471A	--	SW-846 7470A
Explosives	--	SW-846 8330B	--	SW-846 8330B
SVOCs and PAHs	SW-846 3540C	SW-846 8270C	SW-846 3520C	SW-846 8270C
Propellants: Nitrocellulose Nitroguanidine	-- SW-846 3550A	353.2 Modified SW-846 8330M	-- SW-846 3535	353.2 Modified SW-846 8330M
VOCs	SW-846 5030B	SW-846 8260B	SW-846 5030B	SW-846 8260B
Pesticides	SW-846 3540C	SW-846 8081A	SW-846 3520C	SW-846 8081A
PCBs	SW-846 3540C	SW-846 8082	SW-846 3520C	SW-846 8082
Nitrate	--	SW-846 9056	--	SW-846 9056
Hexavalent Chromium	SW-846 3060A	SW-846 7196A	--	SW-846 7196A
Asbestos (pipe material)		EPA/600/R-93/116	--	--

2

PAH = Polycyclic Aromatic Hydrocarbon

3

PCB = Polychlorinated Biphenyl

4

RI = Remedial Investigation

5

SVOC = Semi-volatile Organic Compound

6

VOC = Volatile Organic Compound

7

-- = Preparation steps included in analytical method

8

9

SAIC is the custodian of the project files and will maintain the contents of the files for this investigation, including all relevant records, reports, logs, field notebooks, photographs, subcontractor reports, correspondence, and sample custody forms. These files will remain in a secure area under the custody of the SAIC project manager until they are transferred to USACE Louisville District and RVAAP at the end of the PBA08 project. Analytical data reports from the project laboratory will be forwarded to the USACE Louisville District laboratory data validation contractor for validation, review, and QA comparison upon request. White Water Associates, Inc. and TestAmerica will retain all original raw data (both hardcopy and electronic) in a secure area under the custody of the laboratory project manager for a minimum of seven years.

18

19

4.7.5 Data Review, Validation, and Quality Assessment

20

21

Data were produced, reviewed, and reported by the laboratory in accordance with specifications in the Facility-Wide Sewers SAP, the Louisville District analytical QA guidelines, and the laboratory's QA manual.

24

25

White Water Associates and TestAmerica performed in-house analytical data reduction under the direction of the laboratory project manager and QA officer. These individuals were responsible for assessing data quality and informing SAIC and USACE of any data considered "unacceptable" or which required caution on the part of the data user in terms of its reliability.

29

30

Final reports were generated by the laboratory project manager. Data were then delivered to SAIC for data verification. White Water Associates and TestAmerica prepared and retained full analytical

31

1 and QC documentation for the project in both paper copy and electronic storage media (e.g., compact
2 disk), as directed by the analytical methodologies employed. Laboratory reports included
3 documentation verifying analytical holding time compliance.

4
5 SAIC performed a systematic process utilizing automated data review (ADR) software for data
6 verification to ensure the precision and accuracy of the analytical data were adequate for their
7 intended use. The ADR outlier reports are included in Attachment 1 of Appendix D. This
8 verification also attempted to minimize the potential of using false-positive or false-negative results in
9 the decision-making process (i.e., to ensure accurate identification of detected versus non-detected
10 chemicals). This approach was consistent with the DQOs for the project and with the analytical
11 methods used for determining COCs and calculating risk. “Definitive Data” were reported consistent
12 with the deliverables identified in the Facility-Wide Sewers SAP. These definitive data were then
13 verified through the review process outlined in the Facility-Wide Sewers SAP and presented in
14 Appendix D.

15
16 The completeness goal for analytical data is 90%, as defined in Tables 3-1 and 3-2 of the
17 Facility-Wide Quality Assurance Project Plan (FWQAPP). The project achieved this goal by
18 producing usable results for 98.45% of the sample analyses performed and successfully collecting all
19 samples presented in the Facility-Wide Sewers SAP. In addition to the SAIC data review, a 10%
20 validation of all data will be performed by USACE to prove data usability.

5.0 NATURE AND EXTENT OF CONTAMINATION

This section presents results of the analytical data obtained during the Facility-Wide Sewers RI, the data screening process to identify site-related contaminants (SRCs) indicative of potential impacts from former operations, and nature and extent of SRCs in environmental media at the AOC. The data incorporated in this evaluation also include samples from previous investigations. This section also provides an AOC-level data screening approach and results summary. A detailed discussion of the nature and extent of contamination on an individual FA basis is presented in Section 5.0 of each FAE.

Section 5.1 presents the statistical methods and screening processes used to distinguish chemicals present at background concentrations from those present at concentrations that indicate potential impacts related to historical operations within the AOC. Section 5.2 presents a comparative evaluation of the field and laboratory analyses for explosives. Sections 5.3 and 5.4 present the results of the ACM and chromium speciation sampling, respectively.

A summary of the nature and extent of contamination at each FA is provided in Sections 5.5.1 through 5.5.19. A detailed discussion of the nature and extent of all sampled environmental media (e.g., sewer sediment, pipe bedding material, sewer water, outfall sediment, and outfall water) is presented in Section 5.2 of each FAE. A summary of analytical results for each data aggregate is presented in graphical or tabular formats in Section 5.0 of each FAE. Complete laboratory analytical data packages are presented in Appendix E.

5.1 DATA EVALUATION METHOD

Data evaluation methods utilized for the Facility-Wide Sewers AOC are consistent with those established in the *Facility-Wide Human Health Cleanup Goals for the Ravenna Army Ammunition Plant* (USACE 2010) (herein referred to as the FWCUG Report) and specified in the Facility-Wide Sewers SAP. The processes used to evaluate the analytical data involved three general steps: (1) defining data aggregates; (2) data verification, reduction, and screening; and (3) data presentation.

5.1.1 Definition of Aggregates

Data aggregates for evaluating the nature and extent of contamination were established on an FA basis and are presented in Section 5.1.1 of each FAE. For each FA, data were aggregated in three ways for the evaluation of contaminant nature and extent, human health risk, and ecological risk. The initial basic aggregation of data was by environmental media: sewer sediment, pipe bedding material, sewer water, outfall sediment, and outfall water. For each medium-specific aggregate, an evaluation was conducted to determine if further aggregation was warranted with respect to AOC characteristics, historical operations, ecological habitat, and potential future remedial strategy and land use (e.g., spatial aggregates). Data for subsurface sewer media (i.e., sewer sediment and pipe bedding material) were further aggregated based on depth and sample type for consistency with RVAAP human health risk exposure units (EUs) and guidance established in the *RVAAP Facility-Wide Human Health Risk Assessor Manual* (USACE 2005c) (herein referred to as the FWHHRAM) and FWCUG Report.

1 Data aggregates for evaluating the nature and extent of contamination were established on an FA
2 basis and are presented in Section 5.1.1 of each FAE. The basic data aggregates for each FA were
3 divided as follows, although not all sewer media were present at every FA:
4

- 5 • Sewer Sediment: This medium was evaluated at all 19 FAs. Further subdivision into sanitary
6 and storm system spatial aggregates was conducted at 8 of the 19 FAs, where storm sewers are
7 present; the remaining 11 FAs only have sanitary sewer systems.
8
- 9 • Pipe Bedding Material: Based on results of the Tier 1 sewer sediment sampling, this medium was
10 evaluated at 17 of the 19 FAs. Pipe bedding material samples were collected at both the sanitary
11 and storm systems at 5 of the 19 FAs (Depot Administration Area, Load Line 1, Load Line 2,
12 Load Line 3, and Load Line 4). Further subdivision into separate spatial aggregates for each
13 system was conducted at the five FAs where pipe bedding material was collected from both the
14 sanitary and storm systems.
15
- 16 • Sewer Water: As detailed in Section 5.5, this medium was evaluated at 17 of the 19 FAs where
17 outfalls were present. Sewer water samples were collected at both the sanitary and storm systems
18 at 4 of the 19 FAs (Administration Area, Depot Administration Area, Inert Storage Area #6, and
19 Load Line 1). Further subdivision into separate spatial aggregates for each system was conducted
20 at the four FAs where sewer water was collected from both the sanitary and storm systems.
21
- 22 • Outfall Sediment: As detailed in Section 5.5, this medium was evaluated at 10 of the 19 FAs
23 where outfalls were present. Outfall sediment samples were collected at both the sanitary and
24 storm systems at 4 of the 19 FAs (Administration Area, Depot Administration Area, Inert Storage
25 Area #6, and Load Line 1). Further subdivision into separate spatial aggregates for each system
26 was conducted at the four FAs where outfall sediment was collected from both the sanitary and
27 storm systems.
28
- 29 • Outfall Water: As detailed in Section 5.5, this medium was evaluated at 7 of the 19 FAs where
30 outfalls and sufficient water for sampling were present. Outfall water samples were collected at
31 both the sanitary and storm systems at 3 of the 19 FAs (Administration Area, Depot
32 Administration Area, and Inert Storage Area #6). Further subdivision into separate spatial
33 aggregates for each system was conducted at the three FAs where outfall sediment was collected
34 from both the sanitary and storm systems.
35

36 The subsurface sewer media (i.e., sewer sediment and pipe bedding material) data aggregates are
37 further subdivided to define human health and ecological risk EUs in the risk assessments, as
38 discussed in Section 7.0 (e.g., shallow surface soil, deep surface soil, subsurface soil).
39

5.1.2 Data Verification, Reduction, and Screening

5.1.2.1 Data Verification

Data verification was performed on 427 sewer sediment, pipe bedding material, sewer water, outfall sediment, and outfall water samples (including QC duplicates) collected during the Facility-Wide Sewers RI. Analytical results were reported by the laboratory in electronic format and loaded into the Ravenna Environmental Information Management System (REIMS) database. As discussed in Section 4.0, data verification was performed to ensure all requested data were received and complete. Data qualifiers were assigned to each result based on the laboratory QA review and verification criteria. Results were qualified as follows:

- “U” not detected;
- “UJ” not detected, reporting limit estimated;
- “J” indicates the analyte was positively identified, but the associated numerical value is an approximate concentration of the analyte in the sample;
- “R” result not usable; and
- “=” analyte present and concentration accurate.

In addition to assigning qualifiers, the verification process also selected the appropriate result to use when re-analyses or dilutions were performed. Where laboratory surrogate recovery data or laboratory QC samples were outside of analytical method specifications, the verification chemist determined whether laboratory re-analysis should be used in place of an original reported result. If the laboratory reported results for both diluted and undiluted samples, diluted sample results were used for those analytes that exceeded the calibration range of the undiluted sample. A complete discussion of verification process results is contained in the Data Quality Control Summary Report (Appendix D). The report also includes a summary table of the assigned data qualifiers and the accompanying rationale.

Independent, third-party validation of 10% of the RI data and 100% of the USACE QA laboratory data will be performed by a subcontractor to the USACE, Louisville District. Additional qualification of the RI data may be required based on the results of the validation process.

5.1.2.2 Data Reduction

The initial step in the data reduction process to identify SRCs was calculating data summary statistics. Eligible historical and current AOC data were extracted from the database. Results from QC splits, field duplicates, and rejected results were excluded from the data screening process. All analytes having at least one detected value were included in the data reduction process. Summary statistics calculated for each data aggregate included the minimum, maximum, and average (mean) detected values and the proportion of detected results to the total number of samples collected. During the calculation of mean detected values for each chemical, one-half of the reported detection limit was used as a surrogate value for non-detected results (USEPA 1989). Non-detected results with elevated

detection limits (more than five times the contract-required detection limit) were excluded from the summary statistics in order not to skew the calculation of mean values.

5.1.2.3 Data Screening

Following data reduction, the data were screened to identify SRCs using the processes outlined below. Additional screening of identified SRCs was conducted: (1) in the fate and transport evaluation (Section 6.0) to identify contaminant migration chemicals of potential concern (CMCOPCs); (2) in the HHRA to identify human health chemicals of potential concern (COPCs) and COCs (Section 7.2); and (3) in the ERA to evaluate chemicals of potential ecological concern (COPECs) (Section 7.3). Figure 5-1 illustrates the screening process to identify SRCs and COPCs in accordance with the FWCUG Report. All chemicals not eliminated during the screening steps were retained as SRCs. The steps involved in the SRC screening are summarized below:

- Data quality assessment: Data were produced, reviewed, and reported by the laboratory in accordance with specifications in the PBA08 SAP, the USACE – Louisville District analytical QA guidelines, and the laboratory’s QA manual. The results of the data quality assessment for the Facility-Wide Sewers AOC is summarized in Section 4.7.5.
- Background screening: The maximum detected concentrations (MDCs) of inorganic chemicals were compared to the RVAAP background concentrations published in the *Phase II Remedial Investigation Report for the Winklepeck Burning Grounds* (USACE 2001b). If exceedances above background concentrations occurred, the respective inorganic chemicals were retained as SRCs. Several inorganic chemicals are screened against a background concentration of 0 mg/kg (e.g., cadmium, silver), as they were not detected in the samples collected during the background study (USACE 2001b). Therefore, any detection of these inorganic chemicals, regardless of magnitude, may result in their identification as SRCs.
- Screening of essential human nutrients: Chemicals that are considered essential nutrients (e.g., calcium, chloride, iodine, iron, magnesium, potassium, phosphorous, and sodium) are an integral part of the human food supply and are often added to foods as supplements. USEPA recommends these chemicals not be evaluated unless they are grossly elevated relative to background concentrations or would exhibit toxicity at the observed concentrations at an AOC (USEPA 1989). Recommended daily allowance (RDA) and recommended daily intake (RDI) values are available for all of these chemicals. Screening values for receptors ingesting 100 mg of soil per day or 1 L of groundwater per day to meet their RDA/RDI are listed in Table 5-1. In the case of calcium, magnesium, phosphorous, potassium, and sodium, a receptor ingesting 100 mg of soil per day would receive less than the RDA/RDI value even if the soil consisted of the pure mineral (i.e., soil concentrations at 1,000,000 mg/kg). Essential nutrients detected at or below their RDA/RDI-based screening levels were eliminated as SRCs.
- Frequency of detection/weight-of-evidence (WOE) screening: Chemicals that were never detected in a given medium were eliminated as SRCs. For chemicals with at least 20 samples and

a frequency of detection of less than 5%, a WOE approach was used to determine if the chemical is AOC-related. The WOE evaluated magnitude and location (clustering) of detected results and if the distribution of detected results indicated a potential source of the chemical. If the detected results for a chemical showed: (1) no clustering; (2) concentrations were not substantially elevated relative to the detection limit; and (3) the chemical did not have an evident source, the results were considered spurious, and the chemical was eliminated from further consideration. This screening was applied to all organic and inorganic chemicals, with the exception of explosives and propellants; all detected explosives and propellants were considered as SRCs regardless of frequency of detection. Frequency-of-detection/WOE screening was applied to the storm sewer sediment data at the Load Line 4 FA, as this dataset was comprised of 20 or more samples.

Table 5-1. Recommended Daily Allowance/Recommended Daily Intake Values

Essential Human Nutrient	USDA RDA/RDI ^a Value
Calcium	1000 mg/d
Chloride ^b	3400 mg/d
Iodine	150 µg/d
Iron	8 mg/d
Magnesium	400 mg/d
Potassium ^b	4700 mg/d
Phosphorous	700 mg/d
Sodium ^b	2300 mg/d

Values were obtained from <http://fnic.nal.usda.gov> charts

^aDietary Reference intakes vary by gender and age, values present are for life stage group: Males 19-30 years.

^bAdequate Intake Value presented for nutrients for which no RDA/RDI is established.

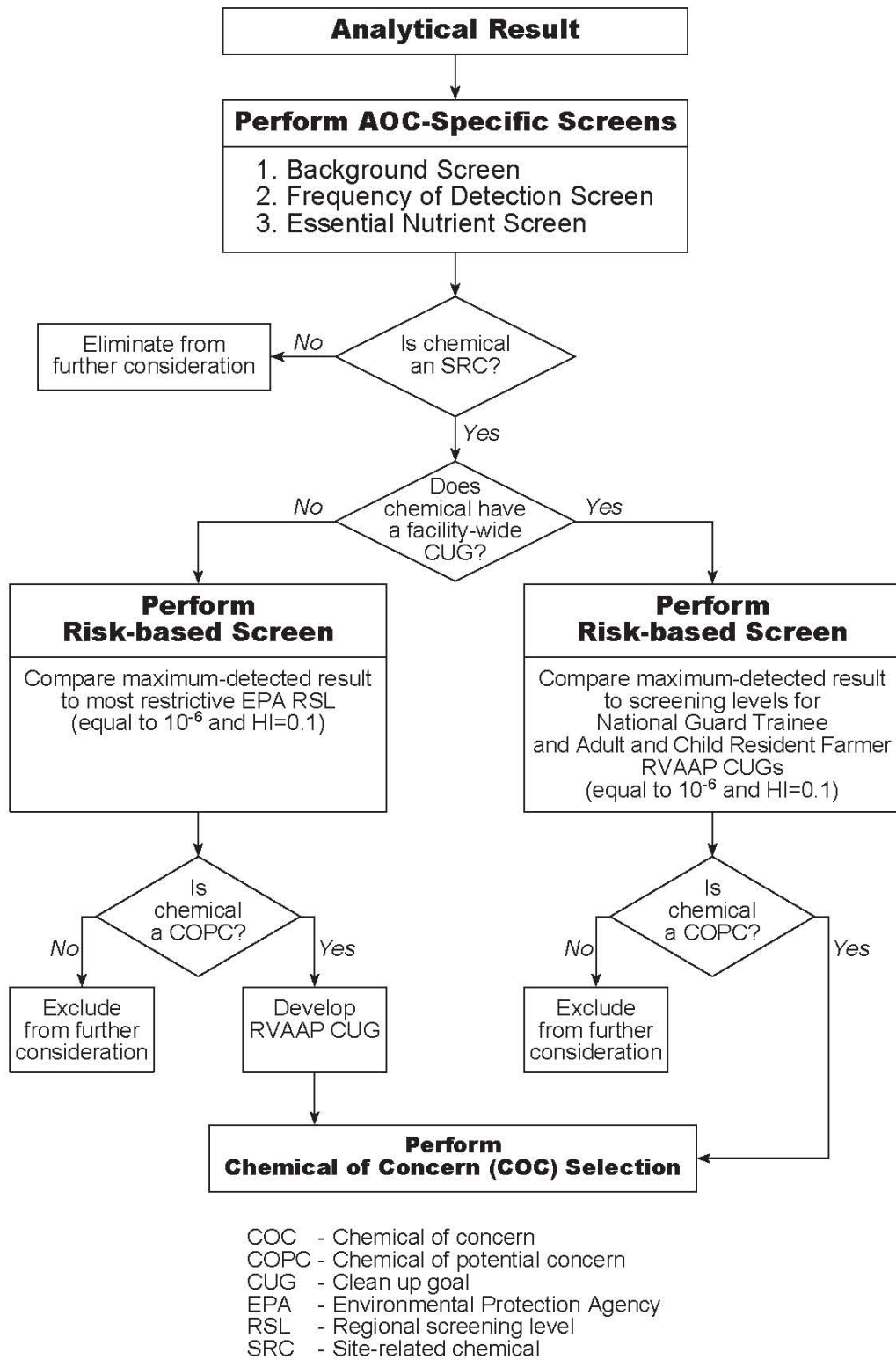
RDA/RDI = Recommended Daily Allowance/Recommended Daily Intake

mg/d = milligrams per day

µg/d = micrograms per day

USDA = United States Department of Agriculture

Process to Identify Chemicals of Potential Concern at RVAAP



G09-0060 C

5.1.3 Data Presentation

Data summary statistics and screening results for SRCs in sewer sediment, pipe bedding material, sewer water, outfall sediment, and outfall water are presented for each medium and spatial aggregate in Section 5.0 of each FAE. Analytical results for SRCs are presented by sample location on figures within each FAE. To provide an indication to the nature and extent of contamination, concentrations of SRCs that exceed the lowest FWCUG [target risk (TR) = 10^{-5} and/or hazard index (HI) = 1.0 or background concentration], based on the National Guard Trainee or Resident Farmer Adult or Child, are highlighted on the figures; these SRCs are further evaluated in Section 7.0. In the sections within each FAE addressing nature and extent of contamination for each medium (FAE Section 5.2), analytical results for SRCs are also presented in data summary tables whenever a sufficient number of detected values occurred. The complete laboratory analytical data packages are included in Appendix E.

5.1.4 Data Evaluation

As discussed in Section 2.2.2, 128 sewer sediment, sewer water, outfall sediment, and outfall water samples were collected during prior investigations. Sewer sediment, sewer water, outfall sediment, and outfall water samples were also collected during the Facility-Wide Sewers RI. The Facility-Wide Sewers RI also involved collection of pipe bedding material samples, which were not collected under the previous investigations. All available sample data were evaluated to determine suitability for use in the various key RI data screens and evaluations (nature and extent, fate and transport, risk assessment). Evaluation of data suitability for use in the Facility-Wide Sewers RI involved two primary considerations: (1) representativeness with respect to current AOC conditions; and (2) sample collection methods. All sewer media samples collected under the previous investigations and the Facility-Wide Sewers RI were collected using discrete methods.

Evaluation of data suitability for use in the Facility-Wide Sewers RI is presented on an FA basis in Section 5.1.3 of each FAE. Table 5-1 of each FAE presents the designated use for all available historical and Facility-Wide Sewers RI samples, as well as data aggregate assignments.

5.2 COMPARATIVE EVALUATION OF FIELD AND LABORATORY ANALYSIS FOR EXPLOSIVES

This section presents a comparison of the TNT and RDX field screening analysis to the results determined by the off-site analytical laboratory. As described in Section 4.7.3, field determinations of TNT and RDX via colorimetric analyses were conducted to provide real-time screening data during the field activities and to reduce the number of samples that required fixed-base laboratory analysis for explosives.

5.2.1 TNT Comparison

TNT field screening and laboratory results are presented in Table 5-2. Starting with the premise that the laboratory results are accurate relative to the presence or absence of TNT in the sample, the field

screening values provide 4% false negative information (6 of 137 samples) and 12% false positive information (17 of 137 samples). Review of laboratory results for associated explosive compounds (i.e., TNB, DNT, nitrotoluene, nitrocellulose) indicates there were minimal impacts on the field screening determinations from these compounds. Only 4 of the 17 samples with false positive results exhibited detections of other explosive compounds. Comparative studies of explosives field test kit methods confirm these screening methods typically result in a “significant positive bias,” and may be attributable to potential cross-reactivities with moisture and other non-explosive organic compounds (USEPA 1996a).

Table 5-2. Comparison of Laboratory Versus Field TNT Results

Station ^a	Sample ID ^a	TNT Laboratory Result (mg/kg)	TNT Field Result (mg/kg)	Potential Interferences for False Positive Results
ADApb-036(sn)	ADApb-036(sn)-2403-SO	0.24 U	1.4	1,3,5-Trinitrobenzene (0.011J mg/kg).
ADApb-037(sn)	ADApb-037(sn)-2404-SO	0.25 U	< 1	N/A
ADAsd-004(sn)	ADAsd-004(sn)-2068-SD	0.25 U	< 1	N/A
ADAsd-013(sn)	ADAsd-013(sn)-2077-SD	0.25 U	< 1	N/A
ADAsd-017(sn)	ADAsd-017(sn)-2080-SD	0.25 U	< 1	N/A
ADAsd-019(sn)	ADAsd-019(sn)-2082-SD	0.25 U	< 1	N/A
ADAsd-019(sn)	ADAsd-019(sn)-4017-FD	0.25 U	5.3	None
ADAsd-025(st)	ADAsd-025(st)-2088-SD	0.25 U	< 1	N/A
ADAsd-025(st)	ADAsd-025(st)-4028-FD	0.25 U	< 1	N/A
ADAsd-026(st)	ADAsd-026(st)-2089-SD	0.25 U	< 1	N/A
ADAsd-032(st)	ADAsd-032(st)-2095-SD	0.25 U	< 1	N/A
ADAsd-034(st)	ADAsd-034(st)-2097-SD	0.25 U	< 1	N/A
ADAsd-034(st)	ADAsd-034(st)-4016-FD	0.25 U	< 1	N/A
DAApb-023(sn)	DAApb-023(sn)-2408-SO	0.24 U	< 1	N/A
DAApb-024(sn)	DAApb-024(sn)-2409-SO	0.25 U	< 1	N/A
DAApb-025(sn)	DAApb-025(sn)-2410-SO	0.25 U	< 1	N/A
DAApb-026(st)	DAApb-026(st)-2411-SO	0.25 U	< 1	N/A
DAApb-026(st)	DAApb-026(st)-4083-FD	0.25 U	< 1	N/A
DAAsd-001(sn)	DAAsd-001(sn)-2119-SD	0.25 U	< 1	N/A
DAAsd-006(sn)	DAAsd-006(sn)-2123-SD	0.25 U	< 1	N/A
DAAsd-007(sn)	DAAsd-007(sn)-2124-SD	0.25 U	< 1	N/A
DAAsd-010(sn)	DAAsd-010(sn)-2127-SD	0.25 U	< 1	N/A
DAAsd-011(sn)	DAAsd-011(sn)-2128-SD	0.25 U	3.2	None
DAAsd-012(sn)	DAAsd-012(sn)-2129-SD	0.25 U	< 1	N/A
DAAsd-013(st)	DAAsd-013(st)-2130-SD	0.25 U	< 1	N/A
DAAsd-016(st)	DAAsd-016(st)-2133-SD	0.25 U	1.1	None
DAAsd-018(st)	DAAsd-018(st)-2135-SD	0.25 U	< 1	N/A

Table 5-2. Comparison of Laboratory Versus Field TNT Results (continued)

Station ^a	Sample ID ^a	TNT Laboratory Result (mg/kg)	TNT Field Result (mg/kg)	Potential Interferences for False Positive Results
DAAsd-018(st)	DAAsd-018(st)-4023-FD	0.25 U	< 1	N/A
GRLpb-015(sn)	GRLpb-015(sn)-2412-SO	0.24 U	< 1	N/A
GRLpb-016(sn)	GRLpb-016(sn)-2413-SO	0.25 U	< 1	N/A
GRLpb-017(sn)	GRLpb-017(sn)-2414-SO	0.25 U	< 1	N/A
GRLpb-018(sn)	GRLpb-018(sn)-2415-SO	0.24 U	< 1	N/A
GRLpb-019(sn)	GRLpb-019(sn)-2416-SO	0.25 U	< 1	N/A
GRLpb-020(sn)	GRLpb-020(sn)-2417-SO	0.24 U	< 1	N/A
GRLpb-021(sn)	GRLpb-021(sn)-2418-SO	0.25 U	< 1	N/A
GRLpb-022(sn)	GRLpb-022(sn)-2419-SO	0.24 U	< 1	N/A
GRLpb-023(sn)	GRLpb-023(sn)-2420-SO	0.24 U	< 1	N/A
GRLsd-005(sn)	GRLsd-005(sn)-2048-SD	0.25 U	< 1	N/A
GRLsd-007(sn)	GRLsd-007(sn)-2047-SD	0.67	< 1	N/A
GRLsd-008(sn)	GRLsd-008(sn)-2401-SD	0.25 U	< 1	N/A
GRLsd-010(sn)	GRLsd-010(sn)-2050-SD	0.25 U	< 1	N/A
GRLsd-011(sn)	GRLsd-011(sn)-2051-SD	0.25 U	< 1	N/A
GRLsd-014(sn)	GRLsd-014(sn)-2054-SD	0.25 R	< 1	N/A
L10sd-051(sn)	L10sd-051(sn)-2029-SD	0.24 U	< 1	N/A
L11pb-086(sn)	L11pb-086(sn)-2496-SO	0.25 U	< 1	N/A
L12sd-303(sn)	L12sd-303(sn)-2013-SD	0.25 U	< 1	N/A
LL11sd-062(sn)	LL11sd-062(sn)-2037-SD	0.25 U	2.7	N/A
LL11sd-062(sn)	LL11sd-062(sn)-4070-FD	0.25 U	5.9	N/A
LL1pb-703(sn)	LL1pb-703(sn)-2426-SO	0.25 U	< 1	N/A
LL1pb-705(sn)	LL1pb-705(sn)-2428-SO	0.24 U	< 1	N/A
LL1pb-706(st)	LL1pb-706(st)-2429-SO	1.1	10.6	N/A
LL1pb-707(st)	LL1pb-707(st)-2430-SO	11	30.3	N/A
LL1pb-712(st)	LL1pb-712(st)-2435-SO	0.24 U	< 1	N/A
LL1sd-453(sn)	LL1sd-453(sn)-2331-SD	0.28	< 1	N/A
LL1sd-456(sn)	LL1sd-456(sn)-2334-SD	0.25 U	< 1	N/A
LL1sd-456(sn)	LL1sd-456(sn)-4068-FD	0.25 U	< 1	N/A
LL1sd-468(st)	LL1sd-468(st)-2346-SD	0.096 J	< 1	N/A
LL1sd-470(st)	LL1sd-470(st)-2348-SD	0.24 U	< 1	N/A
LL1sd-488(st)	LL1sd-488(st)-2366-SD	0.25 U	< 1	N/A
LL1sd-712(st)	LL1sd-712(st)-2506-SD	0.25 U	< 1	N/A
LL2pb-601(sn)	LL2pb-601(sn)-2436-SO	0.15 J	< 1	N/A
LL2pb-607(st)	LL2pb-607(st)-2442-SO	0.030 J	2.0	4-Amino-2,6-DNT (0.030J mg/kg).
LL2pb-609(st)	LL2pb-609(st)-2444-SO	0.24 U	< 1	N/A

Table 5-2. Comparison of Laboratory Versus Field TNT Results (continued)

Station^a	Sample ID^a	TNT Laboratory Result (mg/kg)	TNT Field Result (mg/kg)	Potential Interferences for False Positive Results
LL2pb-610(st)	LL2pb-610(st)-2445-SO	0.029 J	< 1	N/A
LL2pb-611(st)	LL2pb-611(st)-4091-FD	0.25 U	< 1	N/A
LL2pb-611(st)	LL2pb-611(st)-2446-SO	0.25 U	< 1	N/A
LL2pb-612(st)	LL2pb-612(st)-2447-SO	2.2 J	< 1	N/A
LL2pb-615(st)	LL2pb-615(st)-2450-SO	0.24 U	< 1	N/A
LL2pb-617(st)	LL2pb-617(st)-2452-SO	1.8	2.2	N/A
LL2pb-618(st)	LL2pb-618(st)-2453-SO	0.43	< 1	N/A
LL2sd-290(sn)	LL2sd-290(sn)-2233-SD	0.25 U	1.5	None
LL2sd-291(sn)	LL2sd-291(sn)-2234-SD	0.041 J	< 1	N/A
LL2sd-297(st)	LL2sd-297(st)-2240-SD	12 J	< 1	N/A
LL2sd-297(st)	LL2sd-297(st)-4051-FD	15 J	< 1	N/A
LL2sd-298(st)	LL2sd-298(st)-2241-SD	0.13 J	< 1	N/A
LL2sd-300(st)	LL2sd-300(st)-2243-SD	0.33 J	< 1	N/A
LL2sd-304(st)	LL2sd-304(st)-2247-SD	0.25 U	< 1	N/A
LL2sd-307(st)	LL2sd-307(st)-2250-SD	0.25 U	< 1	N/A
LL2sd-604(sn)	LL2sd-604(sn)-2439-SD	0.49 U	< 1	N/A
LL3pb-276(st)	LL3pb-276(st)-2465-SO	0.8	6.1	N/A
LL3pb-501(sn)	LL3pb-501(sn)-2454-SO	0.24 U	< 1	N/A
LL3pb-502(sn)	LL3pb-502(sn)-2455-SO	0.25 U	< 1	N/A
LL3pb-503(sn)	LL3pb-503(sn)-2456-SO	0.036 J	< 1	N/A
LL3pb-504(sn)	LL3pb-504(sn)-2457-SO	0.25 U	< 1	N/A
LL3pb-505(sn)	LL3pb-505(sn)-2458-SO	0.24 U	< 1	N/A
LL3pb-506(sn)	LL3pb-506(sn)-2459-SO	0.24 U	< 1	N/A
LL3pb-506(sn)	LL3pb-506(sn)-4089-FD	0.24 U	< 1	N/A
LL3pb-507(st)	LL3pb-507(st)-2460-SO	0.038 J	< 1	N/A
LL3sd-250(sn)	LL3sd-250(sn)-2265-SD	0.25 U	< 1	N/A
LL3sd-251(sn)	LL3sd-251(sn)-2267-SD	9.2	< 1	N/A
LL3sd-256(sn)	LL3sd-256(sn)-2271-SD	0.25 U	< 1	N/A
LL3sd-256(sn)	LL3sd-256(sn)-4053-FD	0.25 U	< 1	N/A
LL3sd-270(st)	LL3sd-270(st)-2283-SD	0.24 J	1.3	N/A
LL3sd-271(st)	LL3sd-271(st)-2284-SD	0.25 U	< 1	N/A
LL3sd-271(st)	LL3sd-271(st)-4060-FD	0.25 U	< 1	N/A
LL3sd-274(st)	LL3sd-274(st)-2287-SD	1.2	< 1	N/A
LL3sd-274(st)	LL3sd-274(st)-4071-FD	2.1	< 1	N/A
LL3sd-276(st)	LL3sd-276(st)-2289-SD	30	11.1	N/A
LL3sd-279(st)	LL3sd-279(st)-2292-SD	0.39	< 1	N/A
LL3sd-280(st)	LL3sd-280(st)-2293-SD	0.25 U	< 1	N/A

Table 5-2. Comparison of Laboratory Versus Field TNT Results (continued)

Station ^a	Sample ID ^a	TNT Laboratory Result (mg/kg)	TNT Field Result (mg/kg)	Potential Interferences for False Positive Results
LL3sd-280(st)	LL3sd-280(st)-4055-FD	0.25 U	< 1	N/A
LL4pb-234(st)	LL4pb-234(st)-2476-SO	0.24 U	< 1	N/A
LL4pb-502(sn)	LL4pb-502(sn)-2471-SO	0.24 U	< 1	N/A
LL4pb-504(st)	LL4pb-504(st)-2473-SO	0.25 U	< 1	N/A
LL4pb-505(st)	LL4pb-505(st)-2474-SO	0.25 U	4.7	1,3,5-Trinitrobenzene (0.011J mg/kg).
LL4pb-509(st)	LL4pb-509(st)-4081-FD	0.24 U	< 1	N/A
LL4pb-509(st)	LL4pb-509(st)-2478-SO	0.24 U	< 1	N/A
LL4pb-511(st)	LL4pb-511(st)-2480-SO	0.25 U	< 1	N/A
LL4sd-213(sn)	LL4sd-213(sn)-2152-SD	0.25 U	< 1	N/A
LL4sd-215(sn)	LL4sd-215(sn)-2154-SD	0.25 U	< 1	N/A
LL4sd-217(sn)	LL4sd-217(sn)-2156-SD	0.030 J	< 1	N/A
LL4sd-224(st)	LL4sd-224(st)-2163-SD	0.25 U	< 1	N/A
LL4sd-224(st)	LL4sd-224(st)-4011-FD	0.25 U	1.4	None
LL4sd-233(st)	LL4sd-233(st)-2171-SD	0.25 U	< 1	N/A
LL4sd-237(st)	LL4sd-237(st)-2175-SD	0.25 U	< 1	N/A
LL4sd-258(st)	LL4sd-258(st)-2196-SD	0.25 U	< 1	N/A
LL4sd-259(st)	LL4sd-259(st)-2197-SD	0.25 U	1.9	None
LL4sd-260(st)	LL4sd-260(st)-2198-SD	0.25 U	< 1	N/A
LL5sd-045(sn)	LL5sd-045(sn)-2007-SD	0.25 R	< 1	N/A
LL6pb-092(sn)	LL6pb-092(sn)-2486-SO	0.24 U	< 1	N/A
LL6sd-062(sn)	LL6sd-062(sn)-2391-SD	0.25 U	< 1	N/A
LL7pb-091(sn)	LL7pb-091(sn)-2488-SO	0.24 U	< 1	N/A
LL7sd-053(sn)	LL7sd-053(sn)-2016-SD	0.24 U	< 1	N/A
LL8pb-096(sn)	LL8pb-096(sn)-2490-SO	0.26 U	1.6	None
LL8sd-022(sn)	LL8sd-022(sn)-2019-SD	0.25 U	< 1	N/A
LL9pb-122(sn)	LL9pb-122(sn)-2492-SO	0.25 U	< 1	N/A
LL9sd-085(sn)	LL9sd-085(sn)-2026-SD	0.24 U	< 1	N/A
LL9sd-085(sn)	LL9sd-085(sn)-4002-FD	0.25 U	< 1	N/A
SA6pb-009(sn)	SA6pb-009(sn)-2421-SO	0.25 U	1.2	1,3,5-Trinitrobenzene (0.014J mg/kg).
SA6pb-009(sn)	SA6pb-009(sn)-4088-FD	0.25 U	1.9	1,3,5-Trinitrobenzene (0.012J mg/kg).
SA6sd-002(sn)	SA6sd-002(sn)-2306-SD	0.25 U	< 1	N/A
SA6sd-003(sn)	SA6sd-003(sn)-2307-SD	0.24 U	< 1	N/A
SA6sd-007(st)	SA6sd-007(st)-2311-SD	0.25 U	< 1	N/A
SA6sd-008(st)	SA6sd-008(st)-2312-SD	0.24 U	< 1	N/A
SCTsd-004(sn)	SCTsd-004(sn)-2384-SD	0.25 U	< 1	N/A

Table 5-2. Comparison of Laboratory Versus Field TNT Results (continued)

Station ^a	Sample ID ^a	TNT Laboratory Result (mg/kg)	TNT Field Result (mg/kg)	Potential Interferences for False Positive Results
SCTsd-005(sn)	SCTsd-005(sn)-2385-SD	0.25 U	< 1	N/A
TSAsd-003(st)	TSAsd-003(st)-2320-SD	0.25 U	< 1	N/A

^aOnly samples with both laboratory analytical and field test kit results are presented

DNT = Dinitrotoluene

ID = Identification

J = estimated value less than reporting limits

N/A = Not Applicable; result is not a false positive for TNT

TNT = 2,4,6-Trinitrotoluene

U= non-detectable concentration

< = less than

5.2.2 RDX Comparison

RDX field screening and laboratory results are presented in Table 5-3. Starting with the premise that the laboratory results are accurate relative to the presence or absence of RDX in the sample, the field screening values provide 0% false negative information and 14% false positive information (20 of 141 samples). Eleven of the 20 samples with false positives results exhibited detections of other explosive compounds. Comparative studies of explosives field test kit methods confirm these screening methods typically result in a “significant positive bias” and may be attributable to potential cross-reactivities with moisture and other non-explosive organic compounds (USEPA 1996a).

Table 5-3. Comparison of Laboratory Versus Field RDX Results

Station ^a	Sample ID ^a	RDX Laboratory Result (mg/kg)	RDX Field Result (mg/kg)	Potential Interferences for False Positive Results
ADApb-036(sn)	ADApb-036(sn)-2403-SO	0.24 U	< 1	N/A
ADApb-037(sn)	ADApb-037(sn)-2404-SO	0.25 U	< 1	N/A
ADAsd-013(sn)	ADAsd-013(sn)-2077-SD	0.25 U	< 1	N/A
ADAsd-017(sn)	ADAsd-017(sn)-2080-SD	0.25 U	< 1	N/A
ADAsd-019(sn)	ADAsd-019(sn)-2082-SD	0.25 U	< 1	N/A
ADAsd-019(sn)	ADAsd-019(sn)-4017-FD	0.25 U	< 1	N/A
ADAsd-025(st)	ADAsd-025(st)-2088-SD	0.25 U	< 1	N/A
ADAsd-025(st)	ADAsd-025(st)-4028-FD	0.25 U	< 1	N/A
ADAsd-026(st)	ADAsd-026(st)-2089-SD	0.25 U	< 1	N/A
ADAsd-032(st)	ADAsd-032(st)-2095-SD	0.25 U	2.4	1,3,5-Trinitrobenzene (0.099J mg/kg), Nitroglycerin (0.015J mg/kg).
ADAsd-034(st)	ADAsd-034(st)-2097-SD	0.012 J	< 1	N/A
ADAsd-034(st)	ADAsd-034(st)-4016-FD	0.012 J	< 1	N/A
DAApb-023(sn)	DAApb-023(sn)-2408-SO	0.24 U	< 1	N/A
DAApb-024(sn)	DAApb-024(sn)-2409-SO	0.25 U	1.5	None

Table 5-3. Comparison of Laboratory Versus Field RDX Results (continued)

Station ^a	Sample ID ^a	RDX Laboratory Result (mg/kg)	RDX Field Result (mg/kg)	Potential Interferences for False Positive Results
DAApb-025(sn)	DAApb-025(sn)-2410-SO	0.25 U	< 1	N/A
DAApb-026(st)	DAApb-026(st)-2411-SO	0.25 U	< 1	N/A
DAApb-026(st)	DAApb-026(st)-4083-FD	0.25 U	1.0	None
DAAsd-001(sn)	DAAsd-001(sn)-2119-SD	0.25 U	< 1	N/A
DAAsd-006(sn)	DAAsd-006(sn)-2123-SD	0.25 U	1.2	None
DAAsd-007(sn)	DAAsd-007(sn)-2124-SD	0.25 U	< 1	N/A
DAAsd-010(sn)	DAAsd-010(sn)-2127-SD	0.25 U	< 1	N/A
DAAsd-011(sn)	DAAsd-011(sn)-2128-SD	0.25 U	< 1	N/A
DAAsd-012(sn)	DAAsd-012(sn)-2129-SD	0.25 U	< 1	N/A
DAAsd-013(st)	DAAsd-013(st)-2130-SD	0.25 U	< 1	N/A
DAAsd-016(st)	DAAsd-016(st)-2133-SD	0.25 U	< 1	N/A
DAAsd-018(st)	DAAsd-018(st)-2135-SD	0.25 U	< 1	N/A
DAAsd-018(st)	DAAsd-018(st)-4023-FD	0.25 U	< 1	N/A
GRLpb-015(sn)	GRLpb-015(sn)-2412-SO	0.24 U	< 1	N/A
GRLpb-016(sn)	GRLpb-016(sn)-2413-SO	0.25 U	< 1	N/A
GRLpb-017(sn)	GRLpb-017(sn)-2414-SO	0.25 U	< 1	N/A
GRLpb-018(sn)	GRLpb-018(sn)-2415-SO	0.24 U	< 1	N/A
GRLpb-019(sn)	GRLpb-019(sn)-2416-SO	0.25 U	< 1	N/A
GRLpb-020(sn)	GRLpb-020(sn)-2417-SO	0.24 U	< 1	N/A
GRLpb-021(sn)	GRLpb-021(sn)-2418-SO	0.25 U	1.3	None
GRLpb-022(sn)	GRLpb-022(sn)-2419-SO	0.24 U	< 1	N/A
GRLpb-023(sn)	GRLpb-023(sn)-2420-SO	0.24 U	< 1	N/A
GRLsd-005(sn)	GRLsd-005(sn)-2048-SD	0.25 U	< 1	N/A
GRLsd-007(sn)	GRLsd-007(sn)-2047-SD	0.37	3.7	N/A
GRLsd-008(sn)	GRLsd-008(sn)-2401-SD	0.25 U	< 1	N/A
GRLsd-010(sn)	GRLsd-010(sn)-2050-SD	0.25 U	< 1	N/A
GRLsd-011(sn)	GRLsd-011(sn)-2051-SD	0.25 U	< 1	N/A
GRLsd-014(sn)	GRLsd-014(sn)-2054-SD	0.25 R	1.6	None
L10sd-051(sn)	L10sd-051(sn)-2029-SD	0.24 U	< 1	N/A
L10sd-055(sn)	L10sd-055(sn)-2033-SD	0.24 U	1.2	2-Nitrotoluene (0.41J mg/kg) and PETN (19 mg/kg)
L11pb-086(sn)	L11pb-086(sn)-2496-SO	0.25 U	< 1	N/A
L12sd-303(sn)	L12sd-303(sn)-2013-SD	0.25 U	2.4	None
LL11sd-062(sn)	LL11sd-062(sn)-2037-SD	0.25 U	< 1	N/A
LL11sd-062(sn)	LL11sd-062(sn)-4070-FD	0.25 U	< 1	N/A
LL1pb-703(sn)	LL1pb-703(sn)-2426-SO	0.25 U	< 1	N/A
LL1pb-704(sn)	LL1pb-704(sn)-2427-SO	0.25 U	< 1	N/A

Table 5-3. Comparison of Laboratory Versus Field RDX Results (continued)

Station ^a	Sample ID ^a	RDX Laboratory Result (mg/kg)	RDX Field Result (mg/kg)	Potential Interferences for False Positive Results
LL1pb-705(sn)	LL1pb-705(sn)-2428-SO	0.24 U	< 1	N/A
LL1pb-706(st)	LL1pb-706(st)-2429-SO	0.24 U	< 1	N/A
LL1pb-707(st)	LL1pb-707(st)-2430-SO	0.51	< 1	N/A
LL1pb-708(st)	LL1pb-708(st)-2431-SO	0.24 U	< 1	N/A
LL1pb-710(st)	LL1pb-710(st)-2433-SO	0.25 U	< 1	N/A
LL1pb-711(st)	LL1pb-711(st)-2434-SO	0.25 U	< 1	N/A
LL1pb-711(st)	LL1pb-711(st)-4087-FD	0.24 U	< 1	N/A
LL1pb-712(st)	LL1pb-712(st)-2435-SO	0.24 U	< 1	N/A
LL1sd-453(sn)	LL1sd-453(sn)-2331-SD	0.24 U	5.3	2,4-DNT (0.14J mg/kg), 2,6-DNT (0.021J mg/kg), Nitroglycerin (0.031J mg/kg), 1,3,5-Trinitrobenzene (0.012J mg/kg), TNT (0.28 mg/kg), HMX (0.052J mg/kg), 4-Amino-2,6-DNT (0.61 mg/kg) and 2-Amino-4,6-DNT (0.34 mg/kg)
LL1sd-456(sn)	LL1sd-456(sn)-2334-SD	0.25 U	4.9	2,4-DNT (0.75J mg/kg), 2,6-DNT (0.059J mg/kg), 1,3,5-Trinitrobenzene (0.050J mg/kg), 4-Amino-2,6-DNT (0.25J mg/kg) and 2-Amino-4,6-DNT (0.12J mg/kg).
LL1sd-456(sn)	LL1sd-456(sn)-4068-FD	0.25 U	2.9	2,4-DNT (1.0 mg/kg), 1,3,5-Trinitrobenzene (0.073J mg/kg), 4-Amino-2,6-DNT (0.39 mg/kg), 2-Amino-4,6-DNT (0.18J mg/kg), HMX (0.023J mg/kg) and Nitroglycerin (8.0 mg/kg).
LL1sd-468(st)	LL1sd-468(st)-2346-SD	0.25 U	< 1	N/A
LL1sd-470(st)	LL1sd-470(st)-2348-SD	0.24 U	< 1	N/A
LL1sd-488(st)	LL1sd-488(st)-2366-SD	0.25 U	< 1	N/A
LL1sd-712(st)	LL1sd-712(st)-2506-SD	0.25 U	< 1	N/A
LL2pb-601(sn)	LL2pb-601(sn)-2436-SO	0.25 U	< 1	N/A
LL2pb-607(st)	LL2pb-607(st)-2442-SO	0.25 U	< 1	N/A
LL2pb-609(st)	LL2pb-609(st)-2444-SO	0.24 U	< 1	N/A
LL2pb-610(st)	LL2pb-610(st)-2445-SO	0.24 U	< 1	N/A
LL2pb-611(st)	LL2pb-611(st)-4091-FD	0.25 U	< 1	N/A
LL2pb-611(st)	LL2pb-611(st)-2446-SO	0.25 U	< 1	N/A
LL2pb-612(st)	LL2pb-612(st)-2447-SO	0.25 U	< 1	N/A
LL2pb-617(st)	LL2pb-617(st)-2452-SO	0.25 U	< 1	N/A

Table 5-3. Comparison of Laboratory Versus Field RDX Results (continued)

Station ^a	Sample ID ^a	RDX Laboratory Result (mg/kg)	RDX Field Result (mg/kg)	Potential Interferences for False Positive Results
LL2pb-618(st)	LL2pb-618(st)-2453-SO	0.25 U	< 1	N/A
LL2sd-290(sn)	LL2sd-290(sn)-2233-SD	0.25 U	3.4	None
LL2sd-291(sn)	LL2sd-291(sn)-2234-SD	0.25 U	< 1	N/A
LL2sd-297(st)	LL2sd-297(st)-2240-SD	7.3 J	3.5	N/A
LL2sd-297(st)	LL2sd-297(st)-4051-FD	18 J	3.7	N/A
LL2sd-298(st)	LL2sd-298(st)-2241-SD	0.25 U	< 1	N/A
LL2sd-300(st)	LL2sd-300(st)-2243-SD	0.024 J	< 1	N/A
LL2sd-304(st)	LL2sd-304(st)-2247-SD	0.25 U	< 1	N/A
LL2sd-307(st)	LL2sd-307(st)-2250-SD	0.25 U	< 1	N/A
LL2sd-604(sn)	LL2sd-604(sn)-2439-SD	0.49 U	< 1	N/A
LL3pb-276(st)	LL3pb-276(st)-2465-SO	0.25 U	< 1	N/A
LL3pb-501(sn)	LL3pb-501(sn)-2454-SO	0.24 U	< 1	N/A
LL3pb-502(sn)	LL3pb-502(sn)-2455-SO	0.25 U	< 1	N/A
LL3pb-503(sn)	LL3pb-503(sn)-2456-SO	0.25 U	< 1	N/A
LL3pb-504(sn)	LL3pb-504(sn)-2457-SO	0.25 U	< 1	N/A
LL3pb-505(sn)	LL3pb-505(sn)-2458-SO	0.24 U	< 1	N/A
LL3pb-506(sn)	LL3pb-506(sn)-2459-SO	0.24 U	< 1	N/A
LL3pb-506(sn)	LL3pb-506(sn)-4089-FD	0.24 U	< 1	N/A
LL3pb-507(st)	LL3pb-507(st)-2460-SO	0.24 U	< 1	N/A
LL3sd-250(sn)	LL3sd-250(sn)-2265-SD	0.25 U	< 1	N/A
LL3sd-251(sn)	LL3sd-251(sn)-2267-SD	0.25 U	< 1	N/A
LL3sd-256(sn)	LL3sd-256(sn)-2271-SD	0.25 U	< 1	N/A
LL3sd-256(sn)	LL3sd-256(sn)-4053-FD	0.025 J	< 1	N/A
LL3sd-270(st)	LL3sd-270(st)-2283-SD	0.25 U	< 1	N/A
LL3sd-271(st)	LL3sd-271(st)-2284-SD	0.25 U	< 1	N/A
LL3sd-271(st)	LL3sd-271(st)-4060-FD	0.25 U	< 1	N/A
LL3sd-274(st)	LL3sd-274(st)-2287-SD	0.25 U	1.5	2,6-DNT (0.016J mg/kg), Nitroglycerin (0.061J mg/kg), 1,3,5-Trinitrobenzene (0.015J mg/kg), TNT (1.2 mg/kg), 4-Amino-2,6-DNT (2.1 mg/kg) and 2-Amino-4,6-DNT (2.1 mg/kg)
LL3sd-274(st)	LL3sd-274(st)-4071-FD	0.25 U	< 1	N/A
LL3sd-276(st)	LL3sd-276(st)-2289-SD	0.24 U	4.8	1,3,5-Trinitrobenzene (0.019J mg/kg), TNT (30 mg/kg), 2-Amino-4,6-DNT (8.2 mg/kg) and Nitrocellulose (726 mg/kg)
LL3sd-279(st)	LL3sd-279(st)-2292-SD	0.25 U	< 1	N/A

Table 5-3. Comparison of Laboratory Versus Field RDX Results (continued)

Station ^a	Sample ID ^a	RDX Laboratory Result (mg/kg)	RDX Field Result (mg/kg)	Potential Interferences for False Positive Results
LL3sd-280(st)	LL3sd-280(st)-2293-SD	0.25 U	< 1	N/A
LL3sd-280(st)	LL3sd-280(st)-4055-FD	0.25 U	< 1	N/A
LL4pb-234(st)	LL4pb-234(st)-2476-SO	0.24 U	< 1	N/A
LL4pb-502(sn)	LL4pb-502(sn)-2471-SO	0.24 U	< 1	N/A
LL4pb-504(st)	LL4pb-504(st)-2473-SO	0.25 U	< 1	N/A
LL4pb-505(st)	LL4pb-505(st)-2474-SO	0.25 U	< 1	N/A
LL4pb-509(st)	LL4pb-509(st)-4081-FD	0.24 U	< 1	N/A
LL4pb-509(st)	LL4pb-509(st)-2478-SO	0.24 U	< 1	N/A
LL4pb-511(st)	LL4pb-511(st)-2480-SO	0.25 U	< 1	N/A
LL4sd-213(sn)	LL4sd-213(sn)-2152-SD	0.25 U	< 1	N/A
LL4sd-215(sn)	LL4sd-215(sn)-2154-SD	0.25 U	< 1	N/A
LL4sd-217(sn)	LL4sd-217(sn)-2156-SD	0.26 UJ	4.4	2-Nitrotoluene (0.13J mg/kg) and TNT (0.03J mg/kg)
LL4sd-224(st)	LL4sd-224(st)-2163-SD	0.25 U	< 1	N/A
LL4sd-224(st)	LL4sd-224(st)-4011-FD	0.25 U	< 1	N/A
LL4sd-233(st)	LL4sd-233(st)-2171-SD	0.25 U	< 1	N/A
LL4sd-237(st)	LL4sd-237(st)-2175-SD	0.25 U	< 1	N/A
LL4sd-258(st)	LL4sd-258(st)-2196-SD	0.25 U	< 1	N/A
LL4sd-259(st)	LL4sd-259(st)-2197-SD	0.25 U	< 1	N/A
LL4d-260(st)	LL4sd-260(st)-2198-SD	0.25 U	< 1	N/A
LL5sd-045(sn)	LL5sd-045(sn)-2007-SD	0.40 J	< 1	N/A
LL6pb-092(sn)	LL6pb-092(sn)-2486-SO	0.24 U	< 1	N/A
LL6sd-062(sn)	LL6sd-062(sn)-2391-SD	0.25 U	< 1	N/A
LL7pb-091(sn)	LL7pb-091(sn)-2488-SO	0.24 U	< 1	N/A
LL7sd-053(sn)	LL7sd-053(sn)-2016-SD	0.24 U	< 1	N/A
LL8pb-096(sn)	LL8pb-096(sn)-2490-SO	0.26 U	< 1	N/A
LL8sd-022(sn)	LL8sd-022(sn)-2019-SD	0.28 J	1.4	In addition to RDX, 1,3-Dinitrobenzene (0.055J mg/kg), 2,4-DNT (0.071J mg/kg), 2,6-DNT (0.45J mg/kg), 2-Nitrotoluene (1.1 mg/kg) and 2-Amino-4,6-DNT (0.38J mg/kg)
LL9pb-122(sn)	LL9pb-122(sn)-2492-SO	0.25 U	6.7	None
LL9sd-085(sn)	LL9sd-085(sn)-2026-SD	0.24 U	< 1	N/A
LL9sd-085(sn)	LL9sd-085(sn)-4002-FD	0.25 U	< 1	N/A
SA6pb-009(sn)	SA6pb-009(sn)-2421-SO	0.25 U	< 1	N/A
SA6pb-009(sn)	SA6pb-009(sn)-4088-FD	0.25 U	< 1	N/A
SA6sd-002(sn)	SA6sd-002(sn)-2306-SD	0.25 U	< 1	N/A

Table 5-3. Comparison of Laboratory Versus Field RDX Results (continued)

Station ^a	Sample ID ^a	RDX Laboratory Result (mg/kg)	RDX Field Result (mg/kg)	Potential Interferences for False Positive Results
SA6sd-003(sn)	SA6sd-003(sn)-2307-SD	0.24 U	< 1	N/A
SA6sd-007(st)	SA6sd-007(st)-2311-SD	0.25 U	1.0	2,4-DNT (0.53 mg/kg).
SA6sd-008(st)	SA6sd-008(st)-2312-SD	0.24 U	1.1	2,4-DNT (0.59J mg/kg), Nitroglycerin (3.0J mg/kg), and PETN (3.1 mg/kg).
SCTsd-004(sn)	SCTsd-004(sn)-2384-SD	0.25 U	< 1	N/A
SCTsd-005(sn)	SCTsd-005(sn)-2385-SD	0.017 J	< 1	N/A
TSAsd-003(st)	TSAsd-003(st)-2320-SD	0.25 U	< 1	N/A

^aOnly samples with both laboratory analytical and field test kit results are presented.

DNT = Dinitrotoluene

HMX = Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine

ID = Identification

J = estimated value less than reporting limits

mg/kg = milligrams per kilogram

N/A = Not Applicable; result is not a false positive for TNT

PETN = Pentaerythritol Tetranitrate

RDX = 1,3,5-Trinitro-1,3,5-triazacyclohexane

TNT = 2,4,6-Trinitrotoluene

U= non-detectable concentration

< = less than

2

3 5.3 ASBESTOS SAMPLE RESULTS IN PIPE MATERIAL

4

5 In order to provide characterization of the sewer pipe material for potential use in future RD
6 decisions, samples were collected for asbestos analysis to confirm nature of the pipe material is
7 consistent with historical construction records. While asbestos piping was used for water lines in
8 some areas of RVAAP, historical construction drawings did not indicate it was used in the sewer
9 system. A review of all available historical documents indicated the sewer systems were comprised
10 predominantly of VSP or VCP. Limited portions of the sanitary systems utilized cast iron pipe. In
11 the storm system, larger outfalls of 24-36 inches in diameter were typically comprised of concrete or
12 corrugated metal. Pipe material was collected through non-destructive methods only. No intentional
13 breaking of the sewer pipes for the purpose of asbestos sample collection was conducted; instead,
14 only already-broken fragments were collected. Samples were also collected where subsurface sewer
15 lines were fractured for inline sediment collection or inadvertently breached in the course of pipe
16 bedding material collection.

17

18 Four samples were submitted for analysis of asbestos. Three of the four samples were collected from
19 the storm sewer systems (Load Line 2 FA, Load Line 3 FA, and Load Line 4 FA), and the fourth
20 sample was collected from the sanitary system (Depot Administration Area FA). None of the sewer
21 pipe samples exhibited detectable asbestos content; the results were consistent with the vitrified
22 earthen material and concrete pipe used to construct the sewer systems, as shown on historical
23 drawings and results of the visual survey. The asbestos sample results are summarized in Table 5-4,
24 and the complete analytical reports are presented in Appendix E.

1

Table 5-4. Summary of Asbestos-Containing Material Samples

Sample ID:	Functional Area (Sewer System Type)	Material Description	Approximate % of Asbestos
DAAsd-025(sn)-2504-BD	Depot Administration Area (Sanitary)	Brown Non-Fibrous Material	ND
LL2sd-608(st)-2505-BD	Load Line 2 (Storm)	Grey Plaster with Paint	ND
LL3sd-276(st)-2503-BD	Load Line 3 (Storm)	Red Non-Fibrous Material	ND
LL4sd-234(st)-2502-BD	Load Line 4 (Storm)	Light Brown Non-Fibrous Material (Concrete)	ND

2 ID = Identification
3 ND = Not Detectable
4

5 **5.4 SAMPLE RESULTS FOR CHROMIUM SPECIATION**

6

7 During the Facility-Wide Sewers RI, 20 discrete chromium speciation samples were collected and
8 analyzed for hexavalent chromium and total chromium to determine the concentration ratio of
9 hexavalent chromium to total chromium in soil and identify the appropriate FWCUG for risk
10 calculations. For a ratio of hexavalent chromium to total chromium of 1:6 (14%) or less, the FWCUG
11 for total chromium will be used for health risk calculations. The results of the Facility-Wide Sewers
12 RI chromium speciation samples are presented in Table 5-5.

13

14 As shown in Table 5-5, chromium speciation samples were collected at the Administration Area FA
15 sanitary sewer system, Load Line 1 FA sanitary sewer system, Load Line 2 FA storm sewer system
16 and Load Line 3 FA storm sewer system. Chromium speciation samples were collected for pipe
17 bedding material, sewer sediment, and outfall sediment at locations where elevated total chromium
18 was observed. Total chromium was detected above its applicable background concentration at 7 of
19 the 20 stations, and hexavalent chromium was detected in 9 of the 20 samples. Only sample location
20 LL1pb-705(sn) exhibited a hexavalent to total chromium ratio greater than 1:6 (14%). However, the
21 total chromium concentration at LL1pb-705(sn) (4.5 mg/kg) was approximately one-sixth the
22 chromium background concentration (27.2 mg/kg) for pipe bedding material.

23

24

Table 5-5. Chromium Speciation Results

Sample Station	Sewer Media	Functional Area (Sewer System Type)	Hexavalent Chromium Concentration (mg/kg)	Total Chromium Concentration (mg/kg)	Hexavalent Chromium (%)
ADApb-037(sn)	Pipe Bedding Material	Administration Area (Sanitary)	0.90 U	21	NA
ADApb-038(sn)	Pipe Bedding Material	Administration Area (Sanitary)	1.1 U	13.4	NA
ADApb-040(sn)	Pipe Bedding Material	Administration Area (Sanitary)	0.41J*	12.3	3.3
ADAAsd-001(sn)	Sewer Sediment	Administration Area (Sanitary)	0.56J*	311*	0.18
LL1pb-701(sn)	Pipe Bedding Material	Load Line 1 (Sanitary)	0.95 U	8.8	NA
LL1pb-705(sn)	Pipe Bedding Material	Load Line 1 (Sanitary)	0.82J*	4.5	18.2
LL1sd-450(sn)	Sewer Sediment	Load Line 1 (Sanitary)	28.5	635J*	4.5
LL2sd-311(st)	Outfall Sediment (dry)	Load Line 2 (Storm)	1.3 U	99.1*	NA
LL2sd-314(st)	Outfall Sediment (dry)	Load Line 2 (Storm)	0.63J*	15.5	4.1
LL2pb-609(st)	Pipe Bedding Material	Load Line 2 (Storm)	0.88 U	4.7	NA
LL2pb-610(st)	Pipe Bedding Material	Load Line 2 (Storm)	0.87 U	24.9	NA
LL2pb-612(st)	Pipe Bedding Material	Load Line 2 (Storm)	0.95 U	18.8	NA
LL2pb-614(st)	Pipe Bedding Material	Load Line 2 (Storm)	0.41J*	19.1	2.1
LL2sd-296(st)	Sewer Sediment	Load Line 2 (Storm)	0.51J*	24	2.1
LL2sd-297(st)	Sewer Sediment	Load Line 2 (Storm)	2.4 U	203*	NA
LL2sd-308(st)	Outfall Sediment (dry)	Load Line 2 (Storm)	2.4J*	232*	1.0
LL3pb-272(st)	Pipe Bedding Material	Load Line 3 (Storm)	0.91 U	4.2	NA
LL3pb-511(st)	Pipe Bedding Material	Load Line 3 (Storm)	0.98J*	15.2	6.4
LL3sd-272(st)	Sewer Sediment	Load Line 3 (Storm)	32.2*	643*	5.0
LL3sd-273(st)	Sewer Sediment	Load Line 3 (Storm)	1.4J*	28.5*	4.9

* = Result exceeds background concentration. Background concentration is 27.2 mg/kg for sewer sediment and pipe bedding material and 17.4 mg/kg for dry outfall sediment.

J = estimated value less than reporting limits

mg/kg = milligrams per kilogram

NA = Not Applicable; hexavalent chromium not detected in sample

U= non-detectable concentration

5.5 SUMMARY OF CONTAMINANT NATURE AND EXTENT BY FUNCTIONAL AREA

The following sections summarize the findings of the Facility-Wide Sewers RI. A comprehensive discussion of nature and extent of contamination for sewer media is presented for each FA in Section 5.2 of its respective FAE. Table 5-6 summarizes the distribution and number of SRCs identified for each FA. As shown in Table 5-6, inorganic chemicals and SVOCs comprise the majority of SRCs identified for the AOC. Comparatively few SRCs were identified in other parameter groups (e.g., explosives, PCBs, pesticides).

5.5.1 Administration Area (FA 1)

Sewer sediment, sewer water, outfall sediment, and outfall water were evaluated for the storm and sanitary sewer systems at the Administration Area FA (Figure 5-2). Pipe bedding material was evaluated for the sanitary sewer system only. The Administration Area FA contains an extensive network of sanitary sewers which received all of the drainage from the Fuze and Booster Hill load lines and ultimately discharged to the George Road Treatment Plant. Following the shutdown of the treatment plant, the terminal discharge point of the George Road sanitary sewer network is the overflow outfall located south of the former treatment plant. The storm sewer network at the Administration Area FA consists of numerous discrete segments of sewer lines that diverted runoff from the vicinities of buildings and their associated parking lots and roads.

Sanitary Sewer

Sewer sediment exhibited the highest number of SRCs of all media analyzed within the sanitary system at the Administration Area FA, with 45 SRCs identified. SVOCs and inorganic chemicals were the predominant SRCs identified in sanitary sewer sediment with 24 and 17 analytes, respectively. Two explosives (1,3,5-TNB and nitroglycerin), one PCB (PCB-1254), and one pesticide [4,4'-dichlorodiphenyldichloroethylene (DDE)] were also identified as SRCs. Thirty-one SRCs were identified in sanitary outfall sediment at the Administration Area FA, all of which were inorganic chemicals (10 metals) and SVOCs (21 total, 16 were PAHs). Twenty-seven SRCs were identified in sanitary sewer water at the Administration Area FA: 16 inorganic chemicals (all metals), 10 SVOCs (all PAHs), and 1 explosive (RDX). The sanitary sewer media exhibiting the least SRCs were pipe bedding material (13 SRCs) and outfall water (11 SRCs).

Although all sanitary sewer media throughout the FA contained inorganic chemicals above their respective background concentrations, a smaller number of outlier samples were observed that exhibited concentrations elevated with respect to the majority of the sample population. PAHs also were detected at multiple locations through the FA, and a lesser number of explosive SRCs were also observed. Nine of the 17 inorganic SRCs in sanitary sewer sediment were detected at their maximum concentration at manhole MH-1-2, which is at the downstream end of the sanitary sewer segment draining the northern portion of the Administration Area FA, which contained the Maintenance, Equipment Repair, and Fire House buildings. For pipe bedding material, six of the nine inorganic chemicals were detected at their maximum concentrations adjacent to manhole MH-4-2 at the former

1 Key and Scale Shop. Detections of inorganic SRCs in pipe bedding material occurred at lower
2 concentrations than in the associated sewer sediment samples. Although the maximum concentration
3 of mercury in sanitary sewer sediment (27.6 mg/kg) occurred at MH-4-2, it was not detected above its
4 background concentration (0.036 mg/kg) in the underlying pipe bedding material. Detections of
5 inorganic SRCs in sanitary outfall sediment and water were consistent with those identified for sewer
6 sediment and water, respectively. SVOCs were detected in all sanitary sewer sediment samples
7 analyzed, and 13 of the 24 SVOCs were detected at their maximum concentrations at manhole
8 MH-2-1, which received drainage from the former Body Shop and the southern sanitary drainage
9 segment at the FA. SVOCs in pipe bedding material were only observed adjacent to manhole
10 MH-O19, upstream of the Administration Area FA. The 10 SVOC SRCs in sewer water were
11 observed at a manhole adjacent to the Auto and Repair Garage. None of the SVOC SRCs identified
12 in sewer water were observed in outfall water downstream of the Administration Area FA. However,
13 the SVOC SRCs identified for outfall sediment were consistent with the SRCs observed in sewer
14 sediment throughout the FA. Explosive detections were sporadic in sanitary sewer media at the
15 Administration Area FA. Although the explosives 1,3,5-TNB and nitroglycerin were identified as
16 SRCs for sewer sediment, the explosives identified as SRCs in sewer and outfall water were RDX and
17 HMX.

18
19 Sanitary sewers at the Administration Area FA continue to receive an influx of sewer sediment and
20 water sourced from multiple upstream FAs (i.e., all Fuze and Booster Hill load lines). The
21 Administration Area FA contained multiple discrete potential sources of contaminants, as many of the
22 former buildings (e.g., equipment shops, laboratory, laundry, key, and scale shop) had service
23 connection to the sanitary sewers. Additionally, demolition of multiple former buildings within the
24 FA has resulted in damage to manhole structures and the influx of surface soil and debris into the
25 sewer system. Therefore, contaminants observed in sanitary sewer media at the Administration Area
26 FA are reflective of these multiple potential source contributions. Elevated mercury concentrations
27 are observed in sewer sediment throughout the Administration Area FA and are likely sourced from
28 upstream FAs. Mercury was detected in sewer sediment exiting from the downstream end of multiple
29 Fuze and Booster Hill load lines and was detected within the trunk and connector lines that conveyed
30 this drainage to the Administration Area FA. Limited vertical migration of contaminants from within
31 the sewer lines to the underlying bedding material is observed at the Administration Area FA, as the
32 number and concentrations of SRCs observed in the pipe bedding material are comparatively lower
33 than those observed in sewer sediment within the pipes. While cracks and joint separations within the
34 sanitary sewer system were observed due to the advanced age of the system, the pipes are generally
35 intact, which also limits vertical migration outside of the piping system. The migration pathway for
36 contaminants in sewer sediment within the sanitary sewer system is laterally in the direction of flow,
37 rather than via vertical migration to the underlying pipe bedding material, as shown by the lower
38 contaminant concentrations in pipe bedding material relative to the sewer sediment. The sanitary
39 sewers at the Administration Area FA daylight at the outfall south of the former George Road
40 Treatment Plant. The SRCs observed in outfall sediment and water are generally consistent with the
41 SRCs observed in sewer media within the pipes. Sewer water occurs predominantly in association
42 with storm water and snow melt runoff entering the system through damaged or open sewer structures
43 and intermittently transporting sewer sediment to the outfall from the sanitary system.

Storm Sewer

Outfall sediment exhibited the highest number of SRCs of all media analyzed for the storm system at the Administration Area FA. Forty-three SRCs were identified for outfall sediment, with inorganic chemicals (16 metals) and SVOCs (21 total, 17 were PAHs) being the predominant SRCs observed. Five explosives (1,3,5-TNB; 2,4-DNT; 3-nitrotoluene; nitroglycerin; and RDX) and one pesticide (gamma-chlordane) were also identified as SRCs in storm outfall sediment. Thirty-five SRCs were identified in storm sewer sediment at the Administration Area FA, with inorganic chemicals (9 metals) and SVOCs (19 total, 17 were PAHs) being the predominant SRCs observed. Five VOCs (2-butanone, benzene, dimethylbenzene, ethylbenzene, and toluene) and two explosives (1,3,5-TNB and nitroglycerin) were also identified as SRCs in storm sewer sediment. Twenty-seven SRCs were identified in storm sewer water at the Administration Area FA: 19 inorganic chemicals (all metals), 7 SVOCs (6 PAHs), and 1 explosive (1,3,5-TNB). Outfall water exhibited the fewest SRCs (12 total) of storm sewer media at the Administration Area FA: 11 inorganic chemicals (all metals) and 1 SVOC [bis(2-ethylhexyl)phthalate].

SVOCs were the predominant SRCs observed in storm sewer and outfall sediment, with lesser numbers of inorganic chemicals and explosives also identified as SRCs. Sixteen of the SVOC SRCs in storm sewer sediment were detected at their maximum concentrations at storm Inlet A94, located near the main entrance to RVAAP and in a storm sewer drainage segment which predominantly received runoff from roads. Eight of the nine inorganic SRCs were also detected above their respective background concentrations at storm Inlet A94, with six of the nine SRCs detected at their maximum concentrations at this location. Eighteen of the SVOC SRCs for outfall sediment were observed at their maximum concentrations at the outfall east of storm Inlet A73 which drained the storm sewer segments in the vicinity of the former Garage building at the south portion of Administration Area FA. Although storm sewers at the Administration Area FA are comprised of multiple discrete and discontinuous pipe segments, they historically and currently receive drainage from roads and parking lots. Eleven of the 16 inorganic SRCs in storm outfall sediment were observed at their maximum concentrations at the outfall north of storm Inlet A51, located north of the former Powerhouse vicinity. Although explosives were detected in all storm outfall samples, only two of the explosive SRCs identified in storm outfall sediment were also identified as SRCs in storm sewer sediment: 1,3,5-TNB and nitroglycerin. The explosives in storm sewer sediment were detected at storm Inlet A94, located near the main entrance to RVAAP and in a storm sewer drainage segment which predominantly received runoff from roads. No propellants, pesticides, or PCBs were identified as SRCs for any storm sewer media at the Administration Area FA.

The storm sewer system at the Administration Area FA received historical and current storm water runoff from parking lots and roads and directed the runoff to open drainage conveyances throughout the FA. While portions of the storm sewer system were destroyed and infilled with surface soil and debris during demolition activities at some locations, most of the structures are still intact. The inorganic and SVOC SRCs observed in sewer and outfall sediment are sourced from the runoff from asphalt parking lots and roads. The storm sewer sediment sample location with the highest concentrations of SVOC SRCs (Inlet A94) is located in a high-traffic volume area at the entrance to

1 RVAAP and likely receives runoff in part from State Route 5. Sewer and outfall water occurs as
2 transient media at the Administration Area FA storm sewers, occurring only in association with storm
3 water runoff entering the system and channeling drainage to the outfalls throughout the FA.

4 5 **5.5.2 Atlas Scrap Yard (FA 2)**

6
7 Sanitary sewer sediment, pipe bedding material, and sewer water were evaluated at the Atlas Scrap
8 Yard FA (Figure 5-3). Storm sewers are not present at the Atlas Scrap Yard FA, as storm
9 infrastructure includes discontinuous culverts and open ditches. Sewer sediment at the Atlas Scrap
10 Yard FA exhibited the highest number of SRCs (37 total) of all media analyzed, and the predominant
11 SRCs observed were inorganic chemicals (16 SRCs) and PAHs (17 of 20 SVOC SRCs). One
12 explosive (2-amino-4,6-DNT) was also identified as an SRC in sewer sediment. Thirteen SRCs were
13 identified in sewer water at the Atlas Scrap Yard FA: eight inorganic chemicals (all metals), two
14 explosives (nitroglycerin and RDX), and three SVOCs [benz(a)pyrene, benzo(k)fluoranthene and
15 indeno(1,2,3-cd)pyrene]. Pipe bedding material exhibited the least number of SRCs (three total): one
16 inorganic chemical (cadmium) and two PAHs [benz(a)anthracene and chrysene].

17
18 Inorganic chemicals were observed in sewer media at concentrations above their respective screening
19 criteria throughout the FA. Sewer sediment collected at manhole MH-2 exhibited the highest number
20 of inorganic SRCs detected above background concentrations, with 12 of 17 SRCs. Although a pipe
21 bedding material sample was collected adjacent to MH-1 where eight inorganic chemicals were
22 observed at concentrations in excess of their respective background concentrations, only cadmium
23 was detected above its background concentration (0 mg/kg) in the underlying pipe bedding material
24 sample. Inorganic SRCs were detected in sewer water throughout the FA and with no apparent trend
25 in spatial distribution, as the majority of detections for each inorganic SRC occurred within a narrow
26 range of concentration (i.e., within the same order of magnitude). Fourteen of the PAH SRCs were
27 detected in sewer sediment at their maximum concentrations at manhole MH-14, located at a
28 downstream exit point of the FA. Since the PAHs detected at manhole MH-14 are not observed at the
29 upstream segments at the FA, the data does not indicate their source is within the sewer system at the
30 Atlas Scrap Yard FA. A large stockpile of railroad ties is present in the vicinity of this manhole, and
31 the next downstream manhole (MH-13) is entirely obscured by this pile. Detections of SVOC SRCs
32 in sewer water occurred only in two historical samples, at manholes MH-1 and MH-4, located on the
33 south drainage segment at the FA. A sheen and hydrocarbon odor was observed in this segment
34 during historical investigations and the Facility-Wide Sewers RI. Although detections of SVOCs in
35 sewer sediment were observed at manhole MH-1, none of the same SRCs were detected in sewer
36 water at this location. Pipe bedding material collected adjacent to manhole MH-1 exhibited
37 detections of benz(a)anthracene and chrysene; however, these PAHs were not detected in the
38 associated sewer sediment sample collected at MH-1. One explosive (2-amino-4,6-DNT) was
39 identified as an SRC in sewer sediment and was detected in the historical sample collected from
40 manhole MH-HD1 upstream of the Atlas Scrap Yard FA, indicating that its likely source is the
41 upstream Load Line 4 FA. Detections of explosive SRCs in sewer water were sporadic in
42 distribution, and neither of the explosives identified as SRCs in sewer water were detected in sewer
43 sediment or pipe bedding material.

1 The Atlas Scrap Yard FA no longer receives an influx of sewer material from the upstream Load Line
2 4 FA due to the shutdown of the former ejector station. Although historical investigation of the
3 sewers at Atlas Scrap Yard suggested the presence of coal tar, none was observed; however, a
4 hydrocarbon odor and sheen were noted during the Facility-Wide Sewers RI. A historical source of
5 the PAHs observed in the south drainage segment of the FA (manholes MH-1 through MH-3) may
6 have been the former boiler house or equipment garages on this sewer segment. The sanitary sewer
7 service connections to the former potential source areas at this southern segment were removed in the
8 1950s. The greatest number and highest concentrations of PAHs in sewer sediment occurred at the
9 downstream manhole (MH-14) located adjacent to a stockpile of railroad ties; the preceding upstream
10 manhole (MH-13) is entirely obscured by this stockpile. The stockpile of railroad ties may represent
11 a current source of PAHs to the sanitary sewer system. Limited vertical migration of contaminants
12 from sediment within the sewer lines to the underlying bedding material is observed at the Atlas
13 Scrap Yard FA, as the number and concentrations of SRCs observed in the pipe bedding material are
14 comparatively lower than those observed in sewer sediment within the pipes. While cracks and joint
15 separations within the sanitary sewer system are observed due to the advanced age of the system, the
16 pipes are generally intact, which limits vertical migration from sewer sediment to the exterior of the
17 piping system. The preferential migration pathway for contaminants in sewer sediment within the
18 sanitary sewer system is laterally in the direction of flow, rather than via vertical migration to the
19 underlying pipe bedding material, as shown by the lower contaminant concentrations in pipe bedding
20 material relative to the sewer sediment. Sewer water occurs as a transient media throughout the
21 majority of the FA. However, flooding of the manholes in the southern sewer segment (manholes
22 MH-1 through MH-4) is observed and associated with an obstruction to drainage, as the pipe to this
23 segment is grouted shut at MH-5. With the exception of this segment, sewer water occurs only in
24 association with storm water runoff entering the system through damaged or open sewer structures
25 and intermittently transporting sewer sediment to the downstream Sand Creek Trunk Line FA.
26

27 **5.5.3 Depot Administration Area (FA 3)**

28

29 Sewer sediment, pipe bedding material, sewer water, outfall sediment, and outfall water were
30 evaluated for the storm and sanitary sewer systems at the Depot Administration Area FA (Figure 5-4).
31 The Depot Administration Area FA contains an extensive network of sanitary sewers which
32 ultimately discharged to the Depot Sewage Treatment Plant. Following the shutdown of the treatment
33 plant, the current terminus of the sanitary sewer network is to an open ditch west of the former
34 treatment plant. The storm sewer network at the Depot Administration Area FA consists of numerous
35 discrete segments of sewer lines that each diverted runoff from the vicinities of railbeds, buildings,
36 parking lots, and roads.
37
38

Sanitary Sewer

Sewer sediment exhibited the highest number of SRCs of all media analyzed for the sanitary system at the Depot Administration Area FA, with 36 SRCs identified. SVOCs and inorganic chemicals were the predominant SRCs identified in sanitary sewer sediment with 20 and 15 analytes, respectively; 1 VOC (2-butanone) was also identified as an SRC in sewer sediment. Outfall sediment contained the second highest number of SRCs in sanitary sewer media, with a total of 25 SRCs; inorganic chemicals (4 metals) and SVOCs (20 total, 17 were PAHs) were the predominant SRCs observed, and 1 explosive (HMX) was also identified. Eighteen SRCs were identified in sanitary pipe bedding material: 3 inorganic chemicals (arsenic, cadmium, and silver) and 15 SVOCs (12 PAHs). Inorganic chemicals were the only SRCs identified in sewer water and outfall water; 19 SRCs were identified in sewer water, and only selenium was identified in outfall water.

Although inorganic chemicals were observed above their respective background concentrations in all sanitary sewer media throughout the FA, localized sources exhibiting concentrations elevated above the majority of the sample population were noted. Manganese was detected at a maximum concentration of 48,900 mg/kg in sewer sediment composited from manholes MH-20 and MH-21, located downstream of the former Shop Garage building (Building U-8). The manganese concentration at manhole MH-20 was approximately 16 times greater than the background concentration. Manganese was detected in the manhole sidewall scale sample at manhole MH-21 at 220,000 mg/kg, indicating inorganic chemicals in sewer sediment may in part be sourced from accumulations of scale and mineral deposits noted throughout the sewer system. A pipe bedding material sample was collected at the downstream side of manhole MH-20 in order to determine if the elevated inorganic chemical concentrations observed in the associated sewer sediment sample had migrated to the material below the pipe; only arsenic and cadmium were detected above background concentrations in the underlying pipe bedding material sample. All of the inorganic SRCs observed at the sanitary outfall east of manhole MH-1 (southwest of Building U-19) occurred at concentrations less than twice their respective background concentrations. SVOCs were detected in all sanitary sewer sediment samples analyzed, with 17 of the SVOC SRCs detected at their maximum concentrations at manhole MH-15 at the southern end of the sanitary sewer system and downstream of a former residential building. All 20 SVOC SRCs identified in sanitary outfall sediment at the Depot Administration Area FA were also identified as SRCs, at comparable concentrations, for sanitary sewer sediment. Although SVOCs were detected in all three sanitary pipe bedding material samples, the greatest number of SRCs and highest concentrations were observed adjacent to manhole MH-30, which is located within an asphalt parking lot at the former Dunnage Salvage building (Building U-14), and at concentrations approximately two orders of magnitude lower on average than those detected in the associated sanitary sewer.

Sanitary sewers at the Depot Administration Area FA are self-contained, as they do not receive any influx of sewer media sourced from any other FAs. The Depot Administration Area FA contained multiple discrete potential sources of contaminants, as many of the former buildings (e.g., equipment and repair shops, storage warehouses) had service connections to the sanitary sewers. Elevated manganese concentrations are observed in sewer sediment associated with manholes downstream of

1 the former Shop Garage Building (Building U-8) (manholes MH-20 and MH-21). Manganese was
2 also detected above background concentrations at the sanitary sewer outfall. Due to an observation of
3 a whitish deposit on the sidewalls of manholes MH-20 and MH-21, a sample of this material was
4 collected and analyzed for inorganic chemicals; the sample also exhibited high manganese
5 concentrations. Therefore, elevated inorganic chemicals observed in sewer sediment at the Depot
6 Administration Area FA sanitary sewers may in part be sourced from naturally occurring mineral
7 deposits within the sewer lines. Significant accumulations of mineral deposits within the pipes were
8 also observed during the video survey and generally occur at joints or cracks as a result of infiltration.
9 Limited vertical migration of contaminants from within the sewer lines to the underlying bedding
10 material is observed at the Depot Administration Area FA, as the number and concentrations of SRCs
11 (i.e., inorganic chemicals and SVOCs) observed in the pipe bedding material are comparatively lower
12 than those observed in sewer sediment within the pipes. While cracks and joint separations within the
13 sanitary sewer system are observed due to the advanced age of the system, the pipes are generally
14 intact, which also limits vertical migration to outside of the piping system. The preferential migration
15 pathway for contaminants in sewer sediment within the sanitary sewer system is laterally in the
16 direction of flow, rather than via vertical migration to the underlying pipe bedding material, as shown
17 by the lower contaminant concentrations in pipe bedding material relative to the sewer sediment.
18 Since the shutdown of the Depot Sewage Treatment Plant and rerouting of the flow, the sanitary
19 sewers at the Depot Administration Area FA daylight at the outfall east of manhole MH-1 (southwest
20 of Building U-19). The SRCs observed in outfall sediment and water are generally consistent with
21 the SRCs observed in sewer media within the pipes. Although some portions of the system are
22 flooded due to obstructions and deliberate grouting of the lines, sanitary sewer water occurs
23 predominantly in association with storm water runoff entering the system through damaged or open
24 sewer structures and intermittently transporting sewer sediment to the outfall from the sanitary
25 system.

26 27 **Storm Sewer**

28
29 With 31 SRCs, sewer sediment and outfall sediment both exhibited the highest number of SRCs of all
30 media analyzed for the storm system at the Depot Administration Area FA. Inorganic chemicals (9
31 and 10 SRCs in sewer sediment and outfall sediment, respectively) and SVOCs (21 and 20 SRCs in
32 sewer sediment and outfall sediment, respectively) were the predominant SRCs observed; the
33 explosive 1,3,5-TNB was also identified as an SRC in both storm sewer sediment and outfall sewer
34 sediment. Sixteen inorganic chemicals were identified as SRCs in storm sewer water, and nine metals
35 and the explosive 1,3,5-TNB were identified as SRCs in storm outfall water. Ten SRCs were
36 identified in storm pipe bedding material: two inorganic chemicals (cadmium and silver), and eight
37 SVOCs (all PAHs).

38
39 SVOCs were the predominant SRCs observed in storm sewer sediment and outfall sediment, with
40 lesser numbers of inorganic chemicals and explosives (1,3,5-TNB) also identified as SRCs.
41 Detections of SVOC SRCs were widespread throughout the FA, although the highest number and
42 greatest concentrations in both storm sewer sediment and outfall sediment occurred at the north end
43 of the Depot Administration Area FA, proximate to the former railbeds which served the former Inert

1 Storage Warehouses. A pipe bedding material sample collected adjacent to storm Inlet D7, where the
2 maximum concentrations of the SVOC SRCs were observed in sewer sediment, also exhibited
3 detections of multiple SVOCs. The SVOCs detected in the storm pipe bedding material sample were
4 approximately one to two orders of magnitude lower than those observed in the associated storm
5 sewer sediment sample. SVOCs were not identified as SRCs in storm sewer water or outfall water.
6 Detections of inorganic chemicals SRCs above their respective background concentrations were
7 observed in all storm sewer sediment and outfall sediment samples collected at the FA. The highest
8 concentrations of inorganic SRCs in both storm sewer and outfall sediment were observed within the
9 former Administration Building complex, located at the south portion of the FA. Detections of the
10 explosive 1,3,5-TNB were sporadic in storm sewer media.

11
12 The storm sewer system at the Depot Administration Area FA received historical and current storm
13 water runoff sourced from former railbeds, parking lots, and roads, and diverted the runoff to open
14 drainage conveyances throughout the FA. While portions of the storm sewer system were destroyed
15 and infilled with surface soil and debris during demolition activities at some locations, most of the
16 structures are still active and continue to channel runoff away from road and parking lots areas. The
17 inorganic and SVOC SRCs observed in sewer and outfall sediment are sourced from the runoff from
18 asphalted parking lots and roads, and the former railbeds located at the north portion of the FA.
19 Demolition activities have likely also contributed inorganic SRCs to storm sewer and outfall
20 sediment, as the highest concentrations of inorganic chemicals in these media occur in the vicinity of
21 the former Administration Building complex, which has been highly disturbed by the removal of
22 multiple structures in this area. As was observed during the Facility-Wide Sewers RI activities, sewer
23 water and outfall water occurs as transient media at the Depot Administration Area FA storm sewers,
24 occurring only in association with storm water runoff entering the system and channeling drainage to
25 the outfalls throughout the FA.

26 27 **5.5.4 George Road Trunk and Connector Lines (FA 4)**

28
29 Sanitary sewer sediment, pipe bedding material, and sewer water were evaluated at the George Road
30 Trunk and Connector Lines FA (Figure 5-5). Storm sewers are not present at the George Road Trunk
31 and Connector Lines FA, as storm infrastructure occurs only as discontinuous under-road culverts and
32 open ditches. This FA is comprised of portions of sewer lines within the George Road sanitary sewer
33 network which occurs outside of other distinct spatial areas or FAs (e.g., individual load lines at the
34 Fuze and Booster Hill, Administration Area). Included in this FA are the sanitary sewer lines along
35 Fuze and Booster Road outside of the load line areas (e.g., service lines at the Building 813 vicinity
36 and the former Waterworks) and the trunk lines south of Fuze and Booster Hill which carry sanitary
37 sewer drainage downstream to the Administration Area FA. Fifty SRCs were identified in sanitary
38 sewer sediment and were predominantly inorganic chemicals (16 SRCs), explosives (6 SRCs), and
39 SVOCs (24 SRCs, 17 were PAHs); lesser numbers of PCBs (PCB-1254), pesticides (endrin ketone),
40 propellants (nitrocellulose), and VOCs (chlorobenzene) were also identified as SRCs. Twenty-five
41 SRCs were identified in sewer water: 14 inorganic chemicals, 3 explosives (4-amino-2,6-DNT;
42 HMX; and RDX), and 8 VOCs. Pipe bedding material exhibited the least number of SRCs (18 total):

5 inorganic SRCs, (arsenic, cadmium, silver, thallium, and zinc), 10 SVOC SRCs (all PAHs), 1 explosive (1,3,5-TNB), and 2 VOCs (carbon tetrachloride and trichloroethene).

Overall, SRCs in sewer sediment at the FA occurred at higher concentrations in the samples collected in the Building 813 area than in the Fuze and Booster Hill trunk line vicinity. Five of the 16 inorganic SRCs (antimony, cadmium, copper, lead, and zinc) were detected at their maximum concentration at manhole MH-MP1 at the Building 813 area, adjacent to the ejector station. Although elevated concentrations of inorganic SRCs were observed in sewer sediment at manholes MH-MP1 and MH-BH4, pipe bedding material samples collected adjacent to the manholes at these stations did not indicate migration of these SRCs from sewer sediment to the underlying pipe bedding material has occurred to date, as a lesser number of analytes and lower concentrations were observed. Eighteen of the 20 S VOC SRCs were detected at their maximum concentration at manhole MH-WW1, downstream of the former Waterworks, west of the Building 813 area. In pipe bedding material, 9 of the 10 SVOC SRCs were detected at their maximum concentration adjacent to manhole MH-MP1 located at the former ejector station. However, SVOC concentrations in pipe bedding material at manhole MH-MP1 were approximately two orders of magnitude lower than those observed in sewer sediment. The highest frequency of explosives and propellant detections occurred at manhole MH-MP3, immediately downstream of the former boiler house, along Fuze and Booster Road and adjacent to Building 813. PCB-1254, endrin ketone, and chlorobenzene were all detected at manhole MH-BH4 located at the eastern segment of sanitary sewer along Fuze and Booster Road. All eight of the VOC SRCs were detected at the manhole MH-MP1, located at the ejector station across Fuze and Booster Road from Building 813.

The Building 813 vicinity of the George Road Trunk and Connector Lines FA receives an influx of sewer media from the Load Line 7 FA and contains a number of discrete potential source areas, such as the former metalworking building (Building 813), a small warehouse/depot area at the east end, the former Waterworks, and a former boiler house. Elevated concentrations of inorganic and SVOC SRCs are observed throughout the Building 813 area, although localized sources are noted. Migration of sewer sediment and sewer water downstream of the Building 813 area no longer occurs, as the pipe is currently capped off at manhole MH-MP1, located at the ejector station north of Load Line 5. Only SVOCs and inorganic chemicals are observed in the trunk lines that drain Fuze and Booster Hill load lines; elevated mercury concentrations are observed in sewer sediment at the downstream end of multiple Fuze and Booster Hill load lines and also are noted in the downstream Administration Area FA. Limited vertical migration of contaminants from sediment within the sewer lines to the underlying bedding material is observed at the Building 813 vicinity, as the number and concentrations of SRCs observed in the pipe bedding material are comparatively lower than those observed in sewer sediment within the pipes. While cracks and joint separations within the sanitary sewer system are observed due to the advanced age of the system, the pipes are generally intact, which limits vertical migration from sewer sediment to the exterior of the piping system. The preferential migration pathway for contaminants in sewer sediment within the sanitary sewer system is laterally in the direction of flow, rather than via vertical migration to the underlying pipe bedding material, as shown by the lower contaminant concentrations in pipe bedding material relative to the sewer sediment. Although the Building 813 area is capped off at the former ejector station, transport

of sewer sediment and water occurs from the Fuze and Booster Hill load lines to the downstream Administration Area FA.

5.5.5 Inert Storage Area #6 (FA 5)

Sewer sediment, sewer water, outfall sediment, and outfall water were evaluated for the storm and sanitary sewer systems at the Inert Storage Area #6 FA (Figure 5-6). Pipe bedding material was evaluated for the sanitary sewer system only. The Inert Storage Area #6 contains sanitary sewers which had service connections to the warehouses at this FA. Since the shutdown of the ejector station at the south end of Load Line 2, sanitary sewer drainage daylights at an overflow outfall south of the Inert Storage Area #6 and north of Kelly's Pond. The storm sewer network at the Inert Storage Area #6 consists of numerous discrete segments of sewer lines that each diverted runoff from the vicinities of buildings and their associated parking lots and roads.

Sanitary Sewer

Sewer sediment exhibited the highest number of SRCs of all media analyzed for the sanitary system at the Inert Storage Area #6 FA, with 35 SRCs identified. SVOCs and inorganic chemicals were the predominant SRCs identified in sanitary sewer sediment, with 17 and 9 analytes, respectively; 1 explosive (1,3,5-TNB), 1 propellant (nitrocellulose), 4 pesticides [4,4'-dichlorodiphenyldichloroethane (DDD); 4,4'-DDE; endrin aldehyde; and gamma-chlordane], 1 PCB (PCB-1254), and 2 VOCs (2-butanone and carbon disulfide) were also identified in sanitary sewer sediment at the FA. Only nine inorganic SRCs (all metals) were identified in outfall sediment at the sanitary outfall. Eight SRCs were identified in sanitary pipe bedding material: two inorganic chemicals (cadmium and silver), one explosive (1,3,5-TNB), and five PAHs. Nine SRCs were identified in sanitary sewer and outfall water each, all of which were inorganic chemicals or explosives.

The greatest number and generally highest concentrations of SRCs in sanitary sewer sediment were observed at manhole MH-323, located at the former ejector station at the south end of Load Line 2. This location, while evaluated under the Inert Storage Area #6 FA, is located upstream of any potential sources within the sanitary sewer system for the FA. The explosive 1,3,5-TNB, propellant nitrocellulose, three pesticides (4,4'-DDD; 4,4'-DDE; and endrin aldehyde), one PCB (PCB-1254), and two VOCs (2-butanone and carbon disulfide) were also identified as SRCs in sanitary sewer sediment at manhole MH-323. Elevated silver concentrations were detected at all three sanitary sewer sediment stations, including upstream manhole MH-323, indicating silver is sourced from Load Line 2. A pipe bedding material sample was collected adjacent to manhole MH-323; although silver was detected at a concentration of 350 mg/kg in sanitary sewer sediment, the concentration in the underlying pipe bedding material was only 0.28J mg/kg. Silver was also detected in the outfall sediment at a concentration of 122 mg/kg. SVOC SRCs were detected in all three sanitary sewer sediment samples at the Inert Storage Area #6 FA. Fourteen of the 17 SVOC SRCs were detected at their maximum concentrations at manhole MH-514 at the downstream end of the sanitary sewer system at the FA. No SVOCs were detected in sanitary sewer water at the Inert Storage Area #6 FA,

1 even though 17 SVOCs were detected in the co-located sediment sample at manhole MH-323. Five
2 PAHs were also identified as SRCs in pipe bedding material adjacent to manhole MH-323; although
3 all five PAHs were detected in the associated sewer sediment sample, concentrations in sanitary
4 sewer sediment were generally an order of magnitude greater than those observed in the underlying
5 pipe bedding material. Explosive SRCs in sewer and outfall water at the FA are likely sourced from
6 Load Line 2, as these SRCs are detected at the upstream end of the Inert Storage Area #6 at manhole
7 MH-323.

8
9 Sanitary sewers at the Inert Storage Area #6 FA currently receive an influx of sewer sediment and
10 water sourced from the upstream Load Line 2 FA. With the shutdown of the former ejector station at
11 the south end of Load Line 2, the sanitary sewer drainage is no longer pumped through the force main
12 and ultimately toward Load Line 3; instead, it flows freely south through the Inert Storage Area to the
13 sanitary overflow outfall north of Kelly's Pond. The contaminants observed in sanitary sewer media
14 at the Inert Storage Area #6 FA are consistent with those SRCs identified at the Load Line 2 FA,
15 particularly silver. Elevated concentrations of silver are observed throughout the Load Line 2 FA and
16 are likely sourced from the former radiography laboratory (Building DB-13) at the north end of Load
17 Line 2. Limited vertical migration of contaminants from within the sewer lines to the underlying
18 bedding material is observed at the Inert Storage Area #6 FA, as the number and concentrations of
19 SRCs observed in the pipe bedding material are comparatively lower than those observed in sewer
20 sediment within the pipes. While cracks and joint separations within the sanitary sewer system are
21 observed due to the advanced age of the system, the pipes are generally intact, which also limits
22 vertical migration to outside of the piping system. The preferential migration pathway for
23 contaminants in sewer sediment within the sanitary sewer system is laterally in the direction of flow,
24 rather than via vertical migration to the underlying pipe bedding material, as shown by the lower
25 contaminant concentrations in pipe bedding material relative to the sewer sediment. Sewer water at
26 the upstream FA occurs predominantly in association with storm water runoff entering the system
27 through damaged or open sewer structures, enabling the intermittent transport of sewer sediment to
28 the outfall from the sanitary system.

29 30 **Storm Sewer**

31
32 Outfall sediment exhibited the highest number of SRCs of all media analyzed for the storm system at
33 the Inert Storage Area #6 FA. Thirty-six SRCs were identified for outfall sediment: 14 inorganic
34 chemicals (all metals), 19 SVOCs (16 PAHs), and 3 explosives [2,4-DNT; nitroglycerin; and
35 pentaerythritol tetranitrate (PETN)]. Thirty-two SRCs were identified in storm sewer water: 15
36 inorganic chemicals (all metals), 16 SVOCs, and 1 explosive (RDX). Twenty-eight SRCs were
37 identified in storm outfall water at the Inert Storage Area #6 FA: 9 inorganic chemicals, 3 explosives
38 (2,4-DNT; 2-nitrotoluene; and RDX) and 16 SVOCs (13 PAHs). Storm sewer sediment exhibited the
39 fewest SRCs (20 total): 3 inorganic chemicals (beryllium, cadmium, and zinc) and 17 SVOCs (all
40 PAHs).

41
42 SVOCs and inorganic chemicals were the predominant SRCs identified in storm sewer and outfall
43 media at the Inert Storage Area #6 FA, with a lesser number of explosives also observed. Detections

of inorganic chemicals above background concentrations were observed throughout the FA in all media evaluated, with few apparent trends in distribution. SVOC SRC detections were also ubiquitous at the FA in all media. Of the 16 SVOC SRCs identified in storm sewer water, only naphthalene was not also identified in storm sewer sediment at the FA. The greatest number and highest concentrations of SVOC SRCs in storm outfall sediment occurred at the outfall at the east end of the FA, where 18 of the 19 analytes were detected at their maximum concentrations. All explosive SRC detections in outfall sediment and water were also observed at the east outfall at the Inert Storage Area #6 FA. The explosive RDX was detected in sewer water at storm Inlet MH-55, located within the southwest parking lot area at the FA, but was not detected in a co-located storm sewer sediment sample.

The storm sewer system at the Inert Storage Area #6 FA received historical and current storm water runoff from parking lots and roads surrounding the warehouses and diverted the runoff to open drainage conveyances along the edges of the FA. The majority of the storm sewer system is in good condition, as most of the structures are still active, and several exhibit evidence of recent repair work. The inorganic and SVOC SRCs observed in sewer and outfall sediment are sourced from the runoff from asphalt parking lots and roads. Sewer and outfall water are transient media at the Inert Storage Area #6 storm sewers, occurring only in association with storm water runoff entering the system and channeling drainage to the outfalls throughout the FA.

5.5.6 Load Line 1 (FA 6)

Sewer sediment, pipe bedding material, sewer water, and outfall sediment were evaluated for the storm and sanitary sewer systems at the Load Line 1 FA (Figure 5-7). The Load Line 1 FA contains sanitary sewers which collected sanitary discharge from the entirety of the load line and channeled it west to the next downstream FA (Load Line 2). A sanitary sewer overflow outfall also exists at Load Line 1 and is associated with the former ejector station. Load Line 1 also contains an extensive and unique storm sewer network that consists of numerous discrete segments of sewer lines that divert storm runoff from the vicinities of buildings and their associated parking lots, roads, and railbeds before discharging to open ditches throughout the FA.

Sanitary Sewer

Sewer sediment exhibited the highest number of SRCs of all media analyzed for the sanitary system at the Load Line 1 FA, with 40 SRCs identified. SVOCs and inorganic chemicals were the predominant SRCs identified in sanitary sewer sediment with 17 and 15 analytes, respectively; 8 explosives were also identified as SRCs. Nine SRCs were identified in sanitary pipe bedding material: two inorganic chemicals (cadmium and hexavalent chromium) and seven SVOCs (all PAHs). Only inorganic chemicals (12 metals) were identified as SRCs in outfall sediment.

Inorganic chemicals were identified as SRCs in all sewer media evaluated at the Load Line 1 FA. Detections of inorganic SRCs above their respective screening criteria were observed in all historical and Facility-Wide Sewers RI sanitary sewer sediment samples collected at the FA. Eight of the 15

1 inorganic SRCs were detected at their maximum concentration in the Facility-Wide Sewers RI sample
2 collected at manhole MH-204, at the south end of the FA, downstream of former Building CB-801.
3 A pipe bedding material sample was collected at the downstream side of manhole MH-204 in order to
4 determine if the elevated inorganic chemical concentrations observed in sanitary sewer sediment
5 sample had migrated to the material below the pipe. Although seven inorganic chemicals (antimony,
6 barium, chromium, copper, lead, mercury, and zinc) were observed in sewer sediment at MH-204 at
7 concentrations in excess of five times their respective background concentrations, none of these
8 inorganic chemicals were detected above background concentrations in the underlying pipe bedding
9 material sample. Sewer water was collected at MH-CO-#1 at the downstream exit point from the FA;
10 concentrations of three of the five inorganic SRCs were detected at lower concentrations in the
11 Facility-Wide Sewer RI sample than in the historical sample collected at this same manhole in 2000.
12 All 12 of the inorganic SRCs identified for sanitary outfall sediment were also identified as SRCs in
13 sanitary sewer sediment. SVOC SRCs were detected in all sanitary sewer sediment samples
14 analyzed, with 12 of the 17 SRCs detected at manhole MH-204 where elevated inorganic chemical
15 concentrations were also observed. Where data are available for comparison, SVOC SRC
16 concentrations in pipe bedding material were observed to be on average two orders of magnitude
17 lower than those observed in the associated sanitary sewer sediment samples. Explosives were only
18 identified as SRCs in sanitary sewer sediment and were observed at their highest detection frequency
19 (seven of eight SRCs) at manhole MH-209, which is the first manhole downstream of the melt pour
20 building complex.

21
22 The Load Line 1 FA contained multiple discrete potential sources of contaminants, as many of the
23 former buildings within the former production area had a service connection to the sanitary sewers.
24 Additionally, demolition of multiple buildings within the FA has resulted in damage to manhole
25 structures and the influx of surface soil and debris into the sewer system. Therefore, the contaminants
26 observed in sanitary sewer media at the Load Line 1 are reflective of these multiple potential source
27 contributions. Elevated inorganic chemical and SVOC concentrations are observed in sewer sediment
28 throughout the Load Line 1 FA and do not exhibit an apparent operational source. Explosives in
29 sewer sediment are likely sourced from operations at the former melt pour building complex. Limited
30 vertical migration of contaminants from within the sewer lines to the underlying bedding material is
31 observed at the Load Line 1 FA, as the number and concentrations of SRCs observed in the pipe
32 bedding material are comparatively lower than those observed in sewer sediment within the pipes.
33 While cracks and joint separations within the sanitary sewer system are observed due to the advanced
34 age of the system, the pipes are generally intact, which also limits vertical migration to outside of the
35 piping system. The preferential migration pathway for contaminants in sewer sediment within the
36 sanitary sewer system is laterally in the direction of flow, rather than via vertical migration to the
37 underlying pipe bedding material, as shown by the lower contaminant concentrations in pipe bedding
38 material relative to the sewer sediment. Sewer water occurs predominantly in association with storm
39 water runoff entering the system through damaged or open sewer structures and intermittently
40 enabling transport of sewer media to the downstream Load Line 2 FA. Although the sanitary sewer
41 system at Load Line 1 does have an outfall, the removal of the ejector station and associated plugging
42 of the pipe has eliminated this as a potential migration pathway for sewer media to exit the pipes.

Storm Sewer

Storm sewer and outfall sediment exhibited the highest number of SRCs of all media analyzed for the storm system at the Load Line 1 FA. Forty-four SRCs were identified in storm sewer sediment at the Load Line 1 FA, with inorganic chemicals (13 metals) and SVOCs (23 in total, 17 of which were PAHs) being the predominant SRCs observed. Two explosives (TNT and nitroglycerin), one PCB (PCB-1254), four pesticides (4,4'-DDE; endrin; endrin aldehyde; and gamma-chlordane), and one propellant (nitrocellulose) were also identified as SRCs in storm sewer sediment. Forty-four SRCs were identified in storm outfall sediment, with inorganic chemicals (19 metals) and SVOCs (23 in total, 17 of which were PAHs) being the predominant SRCs observed; two explosives (2,4-DNT and nitrobenzene) were also identified as SRCs. Thirty-three SRCs were identified in storm pipe bedding material: 8 explosives, 8 inorganic chemicals, 16 SVOCs (all PAHs), and 1 VOC (acetone). Seven inorganic SRCs were identified in storm sewer water at the Load Line 1 FA; no organic chemicals were observed.

Inorganic chemicals and SVOCs were the predominant SRCs observed in storm sewer media sediment, with lesser numbers of explosives and other organic chemicals also identified as SRCs. Detections of inorganic SRCs above their respective screening criteria were observed in all historical and Facility-Wide Sewers RI storm sewer and outfall sediment samples collected at the FA. Six of the 13 inorganic SRCs were detected at their maximum concentrations in the historical sewer sediment sample located at Inlet D7, adjacent to the former railbeds at the southern portion of Load Line 1. Inlet D7 was not re-sampled for sewer sediment under the Facility-Wide Sewers RI, as the surface infrastructure of this storm inlet was damaged during demolition activities, and access for sewer sediment sampling was not possible. A pipe bedding material sample was collected adjacent to Inlet D7 in order to determine if the elevated inorganic chemical concentrations observed in historical storm sewer sediment had migrated to the material below the pipe. Inorganic SRC concentrations in the pipe bedding material adjacent to Inlet D7 were elevated with respect to background concentrations but were lower than those observed in the associated sewer sediment sample. Although antimony was detected approximately 193 times greater than its background concentrations in sewer sediment, this inorganic chemical was not detected above background levels in the associated pipe bedding material sample. Seven of the 19 inorganic SRCs in outfall sediment (barium, cadmium, copper, manganese, selenium, silver, and zinc) were detected at their maximum concentration in the Facility-Wide Sewers RI sample collected at an outfall downstream of the former melt pour Building CB-4. Elevated concentrations of antimony, chromium, and lead were detected at the outfall downstream of storm manhole CB-MHD1 (at the southern end of the FA) and downstream of Inlet D7 (which exhibited the highest inorganic SRC concentrations for sewer sediment). SVOC SRCs were detected in all storm sewer sediment samples analyzed, with 16 of the 23 SVOC SRCs detected at their maximum concentrations at Inlet CB-MHB2, located downstream of the former melt pour buildings complex. Twenty-one of the 22 SVOC SRCs for outfall sediment were detected at the Outlet E Channel outfall at the south end of Load Line 1. PAH SRCs were detected in five of the six storm pipe bedding material samples, with 15 of the 16 PAH SRCs detected at their maximum concentrations in the sample collected adjacent to storm Inlet B6 at the southwest corner of former melt pour Building CB-4A. The pipe bedding material collected adjacent to Inlet B6 also exhibited

1 the greatest number of explosive SRC detections (four of six SRCs). Detections of explosives and
2 other non-SVOC organic chemicals were sporadic in distribution at the Load Line 1 FA.

3
4 Overall, the Facility-Wide Sewers RI storm sewer sediment samples exhibited fewer inorganic SRCs
5 above their respective background concentrations and at lower concentrations than the historical
6 storm sewer samples, indicating the demolition and remediation activities in the interim have resulted
7 in a removal of potential sources to the storm sewers. However, debris and surface soil have entered
8 the storm sewer system as a result of damage to the surficial sewer structures during demolition
9 activities and the infilling of damaged inlets. A greater number of explosive SRCs were identified in
10 sanitary sewer sediment than in storm sewer sediment at the FA, which may indicate the original
11 storm sewer lines at the former melt pour buildings were replaced and rehabilitated in the 1950s.
12 While relatively few SRCs were identified in pipe bedding material for the sanitary system relative to
13 the sewer sediment, the number of pipe bedding material and sewer sediment SRCs identified in the
14 pipe bedding material were comparable. This observation is likely because the storm sewer lines
15 were deliberately emplaced with open joints to promote infiltration of storm runoff, whereas the
16 sanitary system was constructed as a closed system with sealed joints, as indicated by historical
17 drawings. Sewer and outfall water occur as transient media at the Load Line 1 storm sewers in
18 association with storm water runoff entering the system and transporting this drainage through the
19 outfalls into open conveyances throughout the FA.

21 **5.5.7 Load Line 2 (FA 7)**

22
23 Sewer sediment and pipe bedding material were evaluated for the storm and sanitary sewer systems at
24 the Load Line 2 FA (Figure 5-8). Sewer water, outfall sediment, and outfall water were evaluated for
25 the storm sewer system only. The Load Line 2 FA contains sanitary sewers which collected sanitary
26 discharge from the entirety of the load line and channeled it west to the next downstream FA (Load
27 Line 3). Load Line 2 also contains an extensive and unique storm sewer network that consists of
28 numerous discrete segments of sewer lines that diverted storm runoff from the vicinities of buildings
29 and their associated parking lots, roads, and railbeds before discharging to open ditches throughout
30 the FA.

32 ***Sanitary Sewer***

33
34 Sewer sediment exhibited the highest number of SRCs of all media analyzed for the sanitary system
35 at the Load Line 2 FA, with 42 SRCs identified. SVOCs and inorganic chemicals were the
36 predominant SRCs identified in sanitary sewer sediment with 20 and 16 analytes, respectively. One
37 explosive (TNT), one PCB (PCB-1254), one pesticide (4,4'-DDE), and three VOCs (2-butanone,
38 acetone, and carbon disulfide) were also identified as SRCs in sanitary sewer sediment. Five SRCs
39 were identified in sanitary pipe bedding material: one inorganic chemical (cadmium) and four SVOCs
40 (all PAHs). As the Load Line 2 sanitary system is typically dry, sewer water samples were not
41 collected under the Facility-Wide Sewers RI, and historical samples were not screened for SRCs due
42 to the age of the sample and because water is only present intermittently within the sanitary system.

1 Although inorganic chemicals were detected above their respective background concentrations in
2 sewer sediment throughout the Load Line 2 sanitary sewers, the highest frequency of detections
3 above background concentrations (15 of 16 SRCs) were observed at manhole MH-314, located at the
4 southern end of Load Line 2 and immediately upstream of the former ejector station. Silver was
5 detected at concentrations greater than 100 mg/kg in seven of the 12 sanitary sewer sediment samples
6 at the Load Line 2 FA during the Facility-Wide Sewers RI; the distribution of silver at the FA
7 indicates the former Building DB-13 complex (former radiography laboratory) is the likely source.
8 Cadmium was the only inorganic chemical identified as an SRC in pipe bedding material. A pipe
9 bedding material sample was collected at the downstream side of manhole MH-312 in order to
10 determine if the elevated inorganic chemical concentrations observed in sewer sediment had migrated
11 to the material below the pipe. Although manganese was detected at a concentration of 86,400 mg/kg
12 in sewer sediment at manhole MH-312, it was detected at a concentration of only 309 mg/kg in the
13 underlying pipe bedding material versus a background concentration of 3,030 mg/kg. SVOC SRCs
14 were detected in all sanitary sewer sediment samples analyzed, although the highest frequency of
15 SVOC detections (19 out of 20 SVOC SRCs) occurred at manhole MH-314, upstream of the former
16 ejector station. SVOC SRCs were also detected in all four sanitary pipe bedding material samples
17 collected at the Load Line 2 FA, and all four SRCs were detected at their maximum concentrations at
18 manhole MH-312. The maximum concentrations of SVOCs in pipe bedding material were an order
19 of magnitude lower on average than those observed in sewer sediment at the Load Line 2 FA sanitary
20 system. The only explosive detected at Load Line 2 (TNT) was observed at manhole MH-334, which
21 diverted influent sanitary drainage from Load Line 1 through Load Line 2. Therefore, the TNT
22 observed at MH-334 is sourced from Load Line 1 production activities. Explosives and propellants
23 were not identified as SRCs for sanitary pipe bedding material at the Load Line 2 FA, even though
24 three of the four pipe bedding material samples were collected adjacent to the sanitary manholes
25 immediately downstream of the former melt pour building complex (former Buildings DB-4 and
26 DB-4A). Six explosives were detected in the historical sanitary sewer water samples at the Load Line
27 2 FA.

28
29 The Load Line 2 FA contained multiple discrete potential sources of contaminants, as many of the
30 former buildings within the former production area had a service connection to the sanitary sewers.
31 Additionally, demolition of multiple former buildings within the FA has resulted in damage to
32 manhole structures and the influx of surface soil and debris into the sewer system. Therefore, the
33 contaminants observed in sanitary sewer media at the Load Line 2 FA are reflective of these multiple
34 potential source contributions. Elevated inorganic chemicals and SVOC concentrations are observed
35 in sewer sediment throughout the Load Line 2 FA and generally do not exhibit an apparent
36 operational source. However, silver was detected at elevated concentrations greater than 100 mg/kg
37 in the majority of sewer sediment samples collected at Load Line 2 FA during the Facility-Wide
38 Sewers RI and is likely sourced from the former radiography laboratory at the north portion of the
39 FA, presumably at the former Building DB-13 complex. Limited vertical migration of contaminants
40 from within the sewer lines to the underlying bedding material is observed at the Load Line 2 FA, as
41 the number and concentrations of SRCs observed in the pipe bedding material are comparatively
42 lower than those observed in sewer sediment within the pipes. While cracks and joint separations
43 within the sanitary sewer system are observed due to the advanced age of the system, the pipes are

generally intact, which also limits vertical migration to outside of the piping system. The preferential migration pathway for contaminants in sewer sediment within the sanitary sewer system is laterally in the direction of flow, rather than via vertical migration to the underlying pipe bedding material, as shown by the lower contaminant concentrations in pipe bedding material relative to the sewer sediment. Sewer water occurs predominantly as storm water runoff enters the system through damaged or open sewer structures and intermittently enables transport of sewer media to the downstream FAs. With the removal of the former ejector station at the southern end of Load Line 2, sanitary sewer drainage exits the FA and flows to the sanitary overflow outfall south of the Inert Storage Area #6 FA. Transport of contaminants from Load Line 2 FA to the downstream FA is occurring, as elevated silver concentrations are detected in sewer sediment at the Inert Storage Area #6 and in outfall sediment.

Storm Sewer

Storm sewer sediment exhibited the highest number of SRCs of all media analyzed for the storm system at the Load Line 2 FA. Fifty-five SRCs were identified in storm sewer sediment at the Load Line 2 FA, with inorganic chemicals (16 metals) and SVOCs (19 total, 16 of which were PAHs) being the predominant SRCs observed. Eight explosives, two PCBs (PCB-1254 and PCB-1260), three pesticides (4,4'-DDE; endrin aldehyde; and gamma-chlordane), one propellant (nitrocellulose), and six VOCs were also identified as SRCs in storm sewer sediment. Forty SRCs were identified in storm pipe bedding material: 8 explosives, 10 inorganic chemicals (all metals), 17 SVOCs (14 of which were PAHs), three pesticides [4,4'-DDE; 4,4'-dichlorodiphenyltrichloroethane (DDT); and gamma-chlordane], one propellant (nitrocellulose), and one VOC (acetone). Forty SRCs were also identified in outfall sediment, with inorganic chemicals (17 metals) and SVOCs (22 total, 17 of which were PAHs) being the predominant SRCs observed. Sewer water and outfall water exhibited 13 and 24 SRCs, respectively, all of which were inorganic chemicals or explosives.

Inorganic chemicals and SVOCs were the predominant SRCs observed in storm sewer sediment, with lesser numbers of explosives and other organic chemicals also identified as SRCs. Detections of inorganic SRCs above their respective screening criteria were observed in all historical and Facility-Wide Sewers RI storm sewer and outfall sediment samples collected at the FA. Detections of inorganic SRCs above their respective screening criteria were observed in all storm sewer sediment samples collected at the Load Line 2 FA. Thirteen of the 16 inorganic SRCs were detected above their respective background concentrations at the Facility-Wide Sewers RI sample collected at storm sewer Inlet DB20, at the southwest corner of the former Building DB-3, at the south end of the Load Line 2, with five metals detected at their maximum concentrations at this location (antimony, chromium, cobalt, lead, and zinc). Elevated inorganic SRC concentrations were also observed in historical sample LL2-250 collected at Inlet DB20 in 2001, including lead at a concentration of 29,200 mg/kg. Elevated antimony, chromium, and lead concentrations were also observed at the outfall downstream of Inlet DB20. All of the inorganic SRCs identified in storm pipe bedding material were also identified as SRCs for storm sewer sediment, although the maximum concentrations of inorganic SRCs detected in storm pipe bedding material were lower than those observed in sewer sediment. Inorganic chemicals were also the predominant SRCs observed in sewer

1 and outfall water at the FA. SVOC SRCs were detected in all six storm sewer sediment samples in
2 the screening dataset. All 19 SVOC SRCs were detected at storm Inlet DA-7, with seven SVOCs
3 observed at their maximum concentration at this location. Inlet DA-7 was located immediately
4 adjacent to the former railbed at the east end of the FA. SVOCs were also observed in the underlying
5 pipe bedding material at the eastern railbed and were likely sourced from the infiltration of runoff.
6 The maximum concentrations of SVOCs in pipe bedding material were an order of magnitude lower
7 on average than those observed in sewer sediment at the Load Line 2 FA storm system. Explosives
8 were detected in all Facility-Wide Sewers RI and historical storm sewer sediment samples analyzed.
9 The highest concentrations of explosive SRCs for the screening dataset were at storm manhole
10 CB-MHB1, downstream of the former Building DB-10 complex at the north end of Load Line 2.
11 Five explosives were detected in pipe bedding material collected adjacent to storm manhole
12 CB-MHB1; explosives concentrations were on average one to two orders of magnitude higher in the
13 storm sewer sediment at storm manhole CB-MHB1 than in the underlying pipe bedding material.
14 Although multiple explosives were identified as SRCs in sewer and outfall water, only one explosive
15 (tetryl) was identified as an SRC in outfall sediment.

16
17 The Facility-Wide Sewers RI storm sewer sediment samples do not exhibit an apparent overall
18 temporal trend relative to the historical storm sewer samples, although significant demolition
19 activities have occurred in the interim. Debris and surface soil have entered the storm sewer system
20 as a result of damage to the surficial sewer structures during demolition activities and the infilling of
21 damaged inlets. Lead and other inorganic SRCs were detected at high concentrations in the vicinity
22 of the warehouse complex at the south end of Load Line 2 (Building DB-3 and DB-802), suggesting a
23 possible operational source of these SRCs. However, elevated inorganic chemical concentrations in
24 storm sewer media at many sample locations may be sourced from building demolition activities, as
25 disturbed surface soil debris and railroad ballast have been washed into the storm sewer at upstream
26 locations. Elevated SVOCs throughout the storm sewer system are likely associated with the former
27 railbeds at the FA, as the majority of storm inlets throughout Load Line 2 received drainage from
28 these railbeds. A comparable number of explosive SRCs were identified in storm outfall sediment as
29 were detected in storm sewer sediment, but minimal explosives were observed in the sanitary system.
30 Explosives within the storm sewer system were associated predominantly with the main storm sewer
31 line that drains to an outfall at the central portion of the former production area at Load Line 2 (i.e.,
32 CB-MHB1, CB-MHB2, and CB-MHB3) and appear to be sourced from the former Building DB-10
33 complex at the north end of Load Line 2. While relatively few SRCs were identified in pipe bedding
34 material for the sanitary system relative to the sewer sediment, the number of pipe bedding material
35 and sewer sediment SRCs identified in the pipe bedding material were comparable. This observation
36 is likely because the storm sewer lines were deliberately emplaced with open joints to promote
37 infiltration of storm runoff, while the sanitary system was constructed as a closed system with sealed
38 joints, as indicated by historical drawings. Sewer and outfall water occur as transient media at the
39 Load Line 2 storm sewers in association with storm water runoff entering the system and transporting
40 drainage through the outfalls into open conveyances throughout the FA.

5.5.8 Load Line 3 (FA 8)

Sewer sediment and pipe bedding material were evaluated for the storm and sanitary sewer systems at the Load Line 3 FA (Figure 5-9). Sewer water was only evaluated for the sanitary sewer system, as the storm inlets at the FA were dry at the time of sampling. Outfall sediment and outfall water were evaluated for the storm system only, as no sanitary system outfalls are present at the FA. The Load Line 3 FA contains sanitary sewers which collected sanitary discharge from the entirety of the load line and channeled it west to the next downstream FA (Load Line 12). The Load Line 3 FA also contains an extensive and unique storm sewer network that consists of numerous discrete segments of sewer lines that diverted storm runoff from the vicinities of buildings and their associated parking lots, roads, and railbeds before discharging to open ditches throughout the FA.

Sanitary Sewer

Sewer sediment exhibited the highest number of SRCs of all media analyzed for the sanitary system at the Load Line 3 FA, with 44 SRCs identified in total. SVOCs and inorganic chemicals were the predominant SRCs identified in sanitary sewer sediment with 21 and 16 analytes, respectively; 7 explosives were also identified as SRCs. Twenty-nine SRCs were identified in sanitary pipe bedding material: 6 inorganic chemicals, 7 explosives, 14 SVOCs (all PAHs), and 2 pesticides (4,4'-DDE and 4,4'-DDT). Thirteen SRCs were identified in sanitary sewer water at the Load Line 3 FA: 8 inorganic chemicals and 5 explosives (TNT; 2-amino-4,6-DNT; 4-amino-2,6-DNT; HMX; and RDX).

Inorganic chemicals and explosives were identified as SRCs in all sewer media evaluated at the Load Line 3 FA. SVOC SRCs were also prevalent in sewer sediment and pipe bedding material. Detections of inorganic SRCs above their respective screening criteria were observed in all historical and Facility-Wide Sewers RI sanitary sewer sediment samples collected at the FA. The highest frequency of inorganic SRC detections above background concentrations were observed at manholes MH-402, MH-417, MH-422, and MH-424. Although silver was detected at elevated concentrations at the upstream Load Line 2 FA, the influent sanitary sewer sediment concentration at manhole MH-401 was only 12J mg/kg, indicating that a source of silver to the sanitary system was present within Load Line 3 at the former Buildings EB-10 and EB-13 complex, which contained a former radiography laboratory. Fewer inorganic SRCs were identified in the underlying pipe bedding material sampled at the FA than the associated sewer sediment, at 6 and 16 SRCs, respectively. SVOCs were detected in five of the six sanitary sewer sediment samples analyzed, with 20 of the 21 SVOC SRCs detected at their maximum concentrations at MH-417, which was downstream of the northern sanitary segment containing former Buildings EB-10 and EB-13. All of the SVOC SRCs identified in pipe bedding material were also associated with the Buildings EB-10 and EB-13 complex, with all 14 SRCs detected in the sample collected adjacent to manhole MH-413. PAH SRCs were also detected in an associated sanitary sewer sediment sample collected at manhole MH-413, at concentrations one to two orders of magnitude higher than those observed in the underlying pipe bedding material. Explosive detections in sewer sediment were associated with the former shaker Building EA-6, as six of the seven explosive SRCs were detected at adjacent manhole MH-402. However, all seven explosive SRCs observed in pipe bedding material were detected at

1 their maximum concentration in the sample collected adjacent to manhole MH-413 which received
2 drainage from the former Building EB-10 and EB-13 complex at the north end of the Load Line 3.
3 All five explosives (TNT; 2-amino-4,6-DNT; 4-amino-2,6-DNT; HMX; and RDX) identified as
4 SRCs for sewer water were previously detected in sanitary sewer water in the historical samples and
5 at comparable concentrations (i.e., within the same order of magnitude) to those detected during the
6 Facility-Wide Sewers RI.

7
8 The Load Line 3 FA contained multiple discrete potential sources of contaminants, as many of the
9 former buildings within the former production area had a service connection to the sanitary sewers.
10 Additionally, demolition of multiple former buildings within the FA has resulted in damage to
11 manhole structures and the influx of surface soil and debris into the sewer system. Therefore, the
12 contaminants observed in sanitary sewer media at the Load Line 3 FA are reflective of these multiple
13 potential source contributions. Elevated inorganic chemicals and SVOC concentrations are observed
14 in sewer sediment throughout the Load Line 3 FA, with multiple localized sources. Silver was
15 detected at elevated concentrations and with a distribution that suggests influent from Load Line 2 is
16 not the sole source, but that a source of silver to the sanitary system was present within the Load Line
17 3 FA at the former Buildings EB-10 and EB-13 complex, which also contained a former radiography
18 laboratory. Limited vertical migration of contaminants from within the sewer lines to the underlying
19 bedding material is observed at the Load Line 3 FA, as the number and concentrations of SRCs
20 observed in the pipe bedding material are comparatively lower than those observed in sewer sediment
21 within the pipes. While cracks and joint separations within the sanitary sewer system are observed
22 due to the advanced age of the system, the pipes are generally intact, which also limits vertical
23 migration to outside of the piping system. The Load Line 3 FA is one of the few FAs with both storm
24 and sanitary sewer systems where a greater number of SRCs were identified in sanitary pipe bedding
25 material than storm pipe bedding material. However, the majority of the SRCs identified in sanitary
26 pipe bedding material were observed at one individual manhole (MH-413), indicating there may be a
27 significant joint offset or crack that is contributing to the migration of contaminants out of the pipe at
28 this location. The preferential migration pathway for contaminants in sewer sediment within the
29 sanitary sewer system is laterally in the direction of flow, rather than via vertical migration to the
30 underlying pipe bedding material, as shown by the lower contaminant concentrations in pipe bedding
31 material relative to the sewer sediment. Sewer water occurs predominantly as storm water runoff
32 enters the system through damaged or open sewer structures and intermittently enables transport of
33 sewer media to the downstream Load Line 12 FA.

34 35 **Storm Sewer**

36
37 Storm sewer and outfall sediment exhibited the highest number of SRCs of all media analyzed for the
38 storm system at the Load Line 3 FA. Forty-seven SRCs were identified in storm outfall sediment at
39 the Load Line 3 FA, with inorganic chemicals (15 metals) and SVOCs (21 in total, 15 of which were
40 PAHs) being the predominant SRCs observed. Seven explosives, one PCB (PCB-1254), and three
41 pesticides (4,4'-DDE; endrin aldehyde; and gamma-chlordane) were also identified as SRCs in storm
42 outfall sediment. Forty-four SRCs were identified in storm sewer sediment at the Load Line 3 FA: 16
43 inorganic chemicals, 20 SVOCs, 5 explosives, 1 PCB (PCB-1254), 1 propellant (nitrocellulose), and

1 1 VOC (2-butanone). Thirty-one SRCs were identified in storm outfall water at the Load Line 3 FA:
2 19 inorganic chemicals, 5 explosives, and 7 SVOCs (all PAHs). Pipe bedding material exhibited the
3 fewest SRCs of all storm sewer media (23 total): 3 explosives (TNT; 2,4-DNT; and
4 2-amino-4,6-DNT), 8 inorganic chemicals, 11 SVOCs (all of which were PAHs), and 1 propellant
5 (nitrocellulose).

6
7 Inorganic chemicals and SVOCs were the predominant SRCs observed in storm sewer media
8 sediment, with lesser numbers of explosives and other organic chemicals also identified as SRCs.
9 Detections of inorganic SRCs above their respective background concentrations were observed in all
10 storm sewer sediment samples collected at the Load Line 3 FA, with five metal SRCs (antimony,
11 chromium, hexavalent chromium, cobalt, and lead) detected at their maximum concentrations in
12 sewer sediment collected within the pipe in the vicinity of storm Inlet EH-20, at the former Building
13 EB-803 and EB-3 complex. Lead was detected at 5,550J mg/kg at Inlet EH-20 during the
14 Facility-Wide Sewers RI and was historically detected in the storm sewer segment at the former
15 Building EB-803 at concentrations ranging from 913 to 3,930 mg/kg. Although high lead (5,550J
16 mg/kg) and chromium (643 mg/kg) concentrations were detected in the storm sewer sediment sample
17 at Inlet EH-20, neither of these inorganic chemicals were detected above their respective background
18 concentrations in the underlying pipe bedding. Lead was detected at elevated concentrations in pipe
19 bedding material upstream of the outfall southwest of former Building EB-803 (48.3J mg/kg
20 downstream of Inlet EH23). Detections of inorganic SRCs above their respective background
21 concentrations were observed in all storm outfall sediment samples collected at the Load Line 3 FA,
22 with localized sources noted downstream of the former melt pour Buildings EB-4 and EB-4A. The
23 highest inorganic SRC concentrations in outfall water were also observed downstream of former melt
24 pour Building EB-4. Although SVOC SRCs were detected in all samples analyzed, 16 of the 20
25 SVOC SRCs in storm sewer sediment were detected at their maximum concentrations at Inlet ED1,
26 which is the northernmost structure in the storm sewer segment that diverted drainage from the
27 eastern former railbed at the Load Line 3 FA. The highest SVOC concentrations in outfall sediment
28 and water were also associated with the eastern former railbed. In pipe bedding material, 10 of the 11
29 SVOC SRCs were detected at their maximum concentrations in samples collected southwest of storm
30 Inlet EH23, downstream of former Building EB-803 and within the western railbed. For all storm
31 sewer media, elevated concentrations of explosive and propellant SRCs were predominantly
32 associated with the former melt pour Building EB-4A, particularly in the southwest storm drain
33 segment and its associated outfall. Detections of organic SRCs other than explosives and SVOCs
34 were sporadic in distribution at the Load Line 3 FA.

35
36 The Facility-Wide Sewers RI storm sewer sediment samples do not exhibit an apparent overall
37 temporal trend relative to the historical storm sewer samples, although significant demolition
38 activities have occurred in the interim. Debris and surface soil have entered the storm sewer system
39 as a result of damage to the surficial sewer structures during demolition activities and the infilling of
40 damaged inlets. Lead and other inorganic SRCs were detected at high concentrations in the vicinity
41 of the warehouse complex at the south end of Load Line 3 (Building EB-803), suggesting a possible
42 operational source of these SRCs. However, elevated inorganic chemical concentrations in storm
43 sewer media at many sample locations may be sourced from building demolition activities, as

1 disturbed surface soil debris and railroad ballast have been washed into the storm sewer at upstream
2 locations. Elevated SVOCs throughout the storm sewer system are likely associated with the former
3 railbeds at the FA, as the majority of storm inlets throughout Load Line 3 received drainage from
4 these railbeds. Explosives within the storm sewer system were associated predominantly with the
5 storm sewer line that drained the former melt pour Building EB-4A and were observed in multiple
6 sewer media in this vicinity (sewer sediment, pipe bedding material, outfall sediment). Pipe bedding
7 material exhibited approximately half of the number of SRCs identified in sewer sediment SRCs (23
8 versus 44 SRCs). Although historical drawings indicated the storm sewer lines were deliberately
9 emplaced with open joints to promote infiltration of storm runoff, it is equally likely the SRCs
10 observed in pipe bedding material at the Load Line 3 FA were sourced from infiltration of
11 contaminants into the soil surrounding the pipes. SVOC SRCs were the primary contaminants
12 observed in pipe bedding material, and the majority of the storm sewer lines at Load Line 3 are
13 shallow structures (<4 ft bgs) that were located on the edges of the former railbeds to divert runoff
14 from the tracks. Sewer and outfall water occur as transient media at the Load Line 3 FA storm
15 sewers, in association with storm water runoff entering the system and transporting drainage through
16 the outfalls into open conveyances throughout the FA.

17 18 **5.5.9 Load Line 4 (FA 9)**

19
20 Sewer sediment and pipe bedding material were evaluated for the storm and sanitary sewer systems at
21 the Load Line 4 FA (Figure 5-10). Sewer water was only evaluated for the sanitary sewer system, as
22 the storm inlets at the FA were dry at the time of sampling. Outfall sediment and outfall water were
23 evaluated for the storm system only; although a sanitary system overflow outfall exists at the FA, it
24 could not be located for sampling and is presumed destroyed. The Load Line 4 FA contains sanitary
25 sewers which collected sanitary discharge from the entirety of the load line and pumped it north to the
26 next downstream FA (Atlas Scrap Yard) via a cast iron force main. The Load Line 4 FA also
27 contains an extensive and unique storm sewer network that consists of numerous discrete segments of
28 sewer lines that diverted storm runoff from the vicinities of buildings and their associated parking
29 lots, roads, and railbeds before discharging to open ditches throughout the FA.

30 31 ***Sanitary Sewer***

32
33 Sewer sediment exhibited the highest number of SRCs of all media analyzed for the sanitary system
34 at the Load Line 4 FA, with 41 SRCs identified. SVOCs and inorganic chemicals were the
35 predominant SRCs identified in sanitary sewer sediment at 16 analytes each; 2 explosives (TNT and
36 2-nitrotoluene), 1 PCB (PCB-1260), 1 pesticide [benzenehexachloride (BHC)], 1 propellant
37 (nitrocellulose), and 4 VOCs (2-butanone, acetone, methylene chloride, and toluene) were also
38 identified as SRCs in sanitary sewer sediment. Sewer water exhibited the second highest number of
39 SRCs in sanitary sewer media, with seven in total: five inorganic chemicals and two VOCs (acetone
40 and carbon disulfide). Only three SRCs were identified in sanitary pipe bedding material, all of
41 which were inorganic chemicals (arsenic, cadmium, and zinc).

1 Although inorganic chemicals were detected above their respective background concentrations in
2 sewer sediment throughout the Load Line 4 FA sanitary sewers, the greatest number of inorganic
3 SRCs above background concentrations was observed in the Facility-Wide Sewers RI sample
4 collected at manhole MH-W4-1 and the historical sample collected at manhole MH-W4. All five
5 inorganic SRCs in pipe bedding material were detected at their maximum concentrations at manhole
6 MH-7+50, located on the force main at the downstream extent of the Load Line 4 FA; all of the metal
7 SRCs identified in sewer water were also observed at this location. The greatest frequency of SVOC
8 SRCs detections (all 16 SRCs) were observed at manhole MH-E4, downstream of the former
9 Building G5. Ten of the 16 SVOC SRCs were detected at their maximum concentrations at the
10 historical sample collected at manhole MH-W4 within the settling pond at the south end of the Load
11 Line 4 FA. Explosive SRCs were detected at their maximum concentrations at the Facility-Wide
12 Sewer RI station sample collected at manhole MH-W4-1, located at the western sewer segment
13 draining the former Building G19 complex. Detections of organic SRCs other than explosives and
14 SVOCs were sporadic in distribution.

15
16 The Load Line 4 FA contained multiple discrete potential sources of contaminants, as many of the
17 former buildings within the former production area had a service connection to the sanitary sewers.
18 Additionally, demolition of multiple former buildings within the FA has resulted in damage to
19 manhole structures and the influx of surface soil and debris into the sewer system. Therefore, the
20 contaminants observed in sanitary sewer media at the Load Line 4 are reflective of these multiple
21 potential source contributions. Elevated inorganic chemicals and SVOC concentrations are observed
22 in sewer sediment throughout the Load Line 4 FA and generally do not exhibit an apparent
23 operational source. Detections of explosive and non-SVOC organic SRCs were sporadic in
24 distribution. Limited vertical migration of contaminants from within the sewer lines to the underlying
25 bedding material is observed at the Load Line 4 FA, as the number and concentrations of SRCs
26 observed in the pipe bedding material are comparatively lower than those observed in sewer sediment
27 within the pipes. While cracks and joint separations within the sanitary sewer system are observed
28 due to the advanced age of the system, the pipes are generally intact, which also limits vertical
29 migration to the outside of the piping system. The preferential migration pathway for contaminants in
30 sewer sediment within the sanitary sewer system is laterally in the direction of flow, rather than via
31 vertical migration to the underlying pipe bedding material, as shown by the lower contaminant
32 concentrations in pipe bedding material relative to the sewer sediment. Sewer water occurs
33 predominantly in association with storm water runoff entering the system through damaged or open
34 sewer structures, and intermittently enabling transport of sewer media to the downstream FAs.
35 However, standing sewer water is present in segments of the sanitary sewers that are submerged in
36 the vicinity of the former settling pond and those segments immediately upstream of the former
37 ejector station that was removed. Due to the shutdown of the former ejector station at the Load Line
38 4 FA, the transport of contaminants from within Load Line 4 to the downstream FA is no longer
39 occurring, as the force main that connects the two areas is not operational and is capped at the former
40 ejector station.

Storm Sewer

Storm outfall sediment and sewer sediment exhibited the highest number of SRCs in the storm system at the Load Line 4 FA. Thirty-nine SRCs were identified in storm outfall sediment, with inorganic chemicals (17 metals) and SVOCs (18 in total, 16 of which were PAHs) being the predominant SRCs observed. Two propellants (nitrocellulose and nitroguanidine) and two VOCs (2-butanone and acetone) were also identified as SRCs in storm outfall sediment. Thirty-seven SRCs were identified in storm sewer sediment at the Load Line 4 FA, with inorganic chemicals (12 metals) and SVOCs (22 in total, 15 of which were PAHs) being the predominant SRCs observed. One PCB (PCB-1260), one pesticide (gamma-chlordane), and one VOC (2-butanone) were also identified as SRCs in storm sewer sediment. Pipe bedding material exhibited only 13 SRCs: 1 explosive (1,3,5-TNB), 7 inorganic chemicals, 2 SVOCs (butylbenzylphthalate and naphthalene), and 3 VOCs (1,2-dichloroethane; benzene; and toluene). Storm outfall water exhibited the least number of SRCs, eight inorganic chemicals and one explosive (RDX). As the Load Line 4 FA storm system is typically dry, sewer water samples were not collected under the Facility-Wide Sewers RI.

Inorganic chemicals and SVOCs were the predominant SRCs observed in storm sewer sediment, with lesser numbers of explosives and other organic chemicals also identified as SRCs. Detections of inorganic chemicals above their respective background concentrations were observed in all historical and Facility-Wide Sewers RI storm and outfall sewer sediment samples collected at the FA, with no apparent trends in distribution. Six of the seven inorganic SRCs were detected at their maximum concentrations at storm Inlet E-3 at the southeast corner of former Building G13. SVOC SRCs were detected in all storm sewer sediment samples analyzed, with 13 of the 22 SVOC SRCs detected at their maximum concentrations at storm Inlet M-2 at the southeast corner of the former Building G8. All 18 of the SVOC SRCs for outfall sediment were observed at their maximum concentrations at the outfall downstream of storm Inlet GA-42 which received runoff from the former railbed along the north side of the Load Line 4 FA. Explosives were not identified as SRCs in sewer outfall sediment, and only one explosive (1,3,5-TNB) was identified in pipe bedding material. Three explosives (2-amino-4,6-DNT; 4-amino-2,6-DNT; and RDX) were detected in the historical storm sewer water samples, and RDX was also identified as an SRC for outfall water.

Overall, a greater number of inorganic SRCs were observed above their respective screening criteria in the Facility-Wide Sewers RI samples than the historical samples, indicating possible impacts from site disturbance during demolition activities at the Load Line 4 FA (i.e., debris and surface soil entering the storm inlets). Debris and surface soil have entered the storm sewer system as a result of damage to the surficial sewer structures during demolition activities and the infilling of damaged inlets. Detections of inorganic chemicals above their respective background concentrations were observed in all historical and Facility-Wide Sewers RI storm sewer sediment samples collected at the FA, with no apparent operational source. However, elevated inorganic chemical concentrations in storm sewer media at many sample locations may be sourced from building demolition activities, as disturbed surface soil debris and railroad ballast have been washed into the storm sewer at upstream locations. Elevated SVOCs throughout the storm sewer system are likely associated with the former railbeds at the FA, as multiple former rail spurs were present at Load Line 4, particularly at the north

perimeter of the FA. Storm pipe bedding material exhibited a greater number of SRCs than sanitary pipe bedding material at the FA, although concentrations of SRCs in storm pipe bedding were relatively low and did not indicate significant migration of contaminants to the underlying material. This observation is likely because the storm sewer lines were deliberately emplaced with open joints to promote infiltration of storm runoff, whereas the sanitary system was constructed as a closed system with sealed joints. Sewer and outfall water occur only as transient media at the Load Line 4 storm sewers, in association with storm water runoff entering the system and transporting this drainage through the outfalls into open conveyances throughout the FA.

5.5.10 Load Line 5 (FA 10)

Sanitary sewer sediment, pipe bedding material, and sewer water were evaluated at the Load Line 5 FA (Figure 5-11). Storm sewers are not present at the Load Line 5 FA, as storm infrastructure occurs only as discontinuous, under-road culverts and open ditches. Sewer sediment at the Load Line 5 FA exhibited the highest number of SRCs (39 in total) of all media analyzed, and the predominant SRCs observed were inorganic chemicals and PAHs. Twenty-one SRCs were identified in sewer water: 20 inorganic chemicals (19 metals plus nitrate) and 1 SVOC [bis(2-ethylhexyl)phthalate]. Cadmium and silver were the only SRCs identified in pipe bedding material.

Inorganic chemicals were observed in sewer sediment at concentrations above their respective background concentrations throughout the FA, while the distribution of explosives and PAHs suggests localized sources of these contaminants. Ten of the 13 inorganic SRCs for sewer sediment were detected at their maximum concentration at manhole MH-IF8, located at the corner of former Building IF13, at the upstream portion of the FA. Concentrations of all inorganic SRCs, with the exception of mercury, were lower at the next downstream location (manhole MH-IF4) than at Building IF13. Although elevated inorganic chemical concentrations were observed in sewer sediment throughout the FA, only cadmium and silver were identified as SRCs in the underlying pipe bedding material, indicating migration outside the pipe is limited. Inorganic chemicals were the predominant SRCs observed in sewer water, with 16 of the 20 inorganic SRCs detected at their maximum concentrations at the downstream portion of the FA (manhole MH-IF3). Consistent with the observations for inorganic chemicals, although 19 SVOCs were identified as SRCs in sewer sediment, all of which were detected at manhole MH-IF4, none were observed in the pipe bedding material immediately underlying the pipe. While cracks and joint separations within the sanitary sewer system are observed due to the advanced age of the system, the pipes are generally intact, which limits vertical migration from sewer sediment to the exterior of the piping system. Seven explosives were identified as SRCs in sewer sediment at the Load Line 5 FA, all of which were detected at low, estimated concentrations at manhole MH-IF10 which received sanitary sewer drainage from the former Building IF11. Explosives were not identified as SRCs for pipe bedding material or sewer water.

Inorganic SRCs in sewer sediment and sewer water at the Load Line 5 FA occurred at higher concentrations in the Facility-Wide Sewer RI samples than the historical samples, indicating possible impacts from the demolition activities in the interim. Debris and surface soil entered the sewer

1 system during demolition activities as a result of damage to the surficial sewer structures and the
2 deliberate infilling of damaged manholes. Limited vertical migration of contaminants from within the
3 sewer lines to the underlying bedding material is observed at the Load Line 5 FA, as the number and
4 concentrations of SRCs observed in the pipe bedding material are comparatively lower than those
5 observed in sewer sediment within the pipes. The preferential migration pathway for contaminants in
6 sewer sediment within the sanitary sewer system is laterally in the direction of flow, rather than via
7 vertical migration to the underlying pipe bedding material, as shown by the lower contaminant
8 concentrations in pipe bedding material relative to the sewer sediment. Sewer water occurs as a
9 transient medium at the Load Line 5 FA, occurring only in association with storm water runoff
10 entering the system through damaged or open sewer structures and intermittently transporting sewer
11 sediment downstream into the trunk and connector lines that drain the Fuze and Booster Hill load
12 lines. Due to the shutdown of the former ejector station at the upstream end of the FA, Load Line 5
13 does not receive any influx of sewer media from upstream portions of the sanitary sewer network.

14 15 **5.5.11 Load Line 6 (FA 11)**

16
17 Sanitary sewer sediment, pipe bedding material, and sewer water were evaluated at the Load Line 6
18 FA (Figure 5-12). Storm sewers are not present at the Load Line 6 FA, as storm infrastructure occurs
19 only as discontinuous, under-road culverts and open ditches. Sewer sediment at the Load Line 6 FA
20 exhibited the highest number of SRCs (24 in total) of all media analyzed, all of which were either
21 inorganic chemicals (8 identified SRCs) or SVOCs (16 in total, 15 of which were PAHs). Eight
22 SRCs were identified in pipe bedding material: two inorganic chemicals (cadmium and silver), five
23 SVOCs (all of which were PAHs), and one VOC (toluene). Eight SRCs were also identified in sewer
24 water at the Load Line 6 FA: five inorganic chemicals and three explosives (4-amino-2,6-DNT;
25 HMX; and RDX).

26
27 Inorganic chemicals were observed in sewer sediment at concentrations above their respective
28 background concentrations throughout the FA, while the distribution of explosives and PAHs
29 suggests localized sources of these contaminants possibly associated with operations at former
30 process buildings. Six of the eight inorganic SRCs were detected at their maximum concentration in
31 sewer sediment at manhole MH-2F10, located at the corner of former Building 2F13. A longitudinal
32 trend is observed for lead within the FA, with a maximum concentration of 14,100J mg/kg detected at
33 manhole MH-1B4 located upstream of the former production area. Lead concentrations decreased to
34 593J mg/kg at the next sampled downstream manhole MH-1B2, ultimately declining below
35 background concentrations by the furthest downstream manhole (MH-2B4). Elevated lead
36 concentrations were observed in sewer sediment and water samples within the George Road Lines
37 and Load Line 7 FAs, indicating a possible contribution from sources outside and upstream of the
38 Load Line 6 FA. Mercury was detected at elevated concentrations in sewer sediment at multiple
39 manholes at the west portion of the former process area, with its maximum detection observed at
40 manhole MH-2F5 adjacent to the former Building 2F-3. Although pipe bedding material was
41 collected adjacent to manholes exhibiting the maximum concentrations of lead and mercury, the only
42 inorganic SRCs identified in the underlying pipe bedding material were cadmium and silver.

1 Sixteen SVOCs were identified as SRCs in sewer sediment; 14 were detected at their maximum
2 concentrations at manhole MH-2F10, located adjacent to the former Building 2F-13. Where detected,
3 SVOCs in pipe bedding material were at least an order of magnitude less than those observed in
4 sewer sediment, indicating limited migration beyond the sewer pipe to the underlying material.
5 Although the VOC toluene was identified as an SRC in pipe bedding material, it was not detected in
6 sewer sediment or sewer water at the FA. Two explosives (2,4-DNT and nitroglycerin) were detected
7 in sewer sediment at the Load Line 6 FA, but these analytes were not identified as SRCs because the
8 sewer pipe where the explosives were detected (manhole MH-1B4) was below the depth of all
9 receptors (>13 ft bgs). Three explosives were identified as SRCs for sewer water (4-amino-2,6-DNT;
10 RDX; and HMX); none were observed in sewer sediment at the FA. Two of the three explosives in
11 sewer water (RDX and HMX) occurred in historical and Facility-Wide Sewers RI samples at
12 comparable concentrations (i.e., within the same order of magnitude), indicating constant sources
13 over time. As RDX is also detected outside of the Load Line 6 FA (i.e., multiple stations within the
14 Load Line 7 FA, which is upstream of the Load Line 6 FA), the primary source of explosives in sewer
15 water is sourced from upstream of the Load Line 6 FA.

16
17 Inorganic SRCs in sewer water at the Load Line 6 FA occurred at higher concentrations in the
18 Facility-Wide Sewer RI samples than the historical samples, indicating possible impacts from the
19 demolition activities in the interim. Debris and surface soil entered the sewer system during
20 demolition activities as a result of damage to the surficial sewer structures and the deliberate infilling
21 of damaged manholes. Sewer sediment samples were not collected under historical investigations
22 due to the presence of insufficient material volume for sampling. As seven sewer sediment samples
23 were collected under the Facility-Wide Sewers RI, it is likely this material is sourced from the influx
24 of debris and soil into the sanitary sewers following demolition activities. Limited vertical migration
25 of contaminants from within the sewer lines to the underlying bedding material is observed at the
26 Load Line 6 FA, as the number and concentrations of SRCs observed in the pipe bedding material are
27 comparatively lower than those observed in sewer sediment within the pipes. While cracks and joint
28 separations within the sanitary sewer system are observed due to the advanced age of the system, the
29 pipes are generally intact, which limits vertical migration from sewer sediment to the exterior of the
30 piping system. The preferential migration pathway for contaminants in sewer sediment within the
31 sanitary sewer system is laterally in the direction of flow, rather than via vertical migration to the
32 underlying pipe bedding material, as shown by the lower contaminant concentrations in pipe bedding
33 material relative to the sewer sediment. Elevated lead concentrations in sewer sediment within the
34 Load Line 6 FA may be in part sourced from the upstream FAs that contribute drainage (i.e., Load
35 Line 7 and the George Road Lines along Fuze and Booster Road). Similarly, explosives in sewer
36 water (i.e., RDX and HMX) are also likely sourced from upstream FAs and persist in sewer water at
37 Load Line 6 through the downstream exit point of the FA. Mercury in sewer sediment is also
38 observed at the exit point from the Load Line 6 FA and is detected downstream at elevated
39 concentrations in the Fuze and Booster Hill trunk lines and Administration Area FAs.

5.5.12 Load Line 7 (FA 12)

Sanitary sewer sediment, pipe bedding material, and sewer water were evaluated at the Load Line 7 FA (Figure 5-13). Storm sewers are not present at the Load Line 7 FA, as storm infrastructure occurs only as discontinuous under-road culverts and open ditches. Sewer sediment at the Load Line 7 FA exhibited the highest number of SRCs (38 in total) of all media analyzed, and the predominant SRCs observed were inorganic chemicals (17 identified SRCs) and PAHs (16 of the 17 SVOC SRCs). Lesser numbers of pesticides (4,4'-DDE and 4,4'-DDT), propellants (nitrocellulose), and VOCs (methylene chloride) were also identified as SRCs in sewer sediment. Fourteen SRCs were identified in sewer water at the Load Line 7 FA: two inorganic chemicals (nickel and nitrate), four explosives (4-amino-2,6-DNT; 4-amino-2,6-DNT; HMX; and RDX) and eight SVOCs (seven of which were PAHs). Pipe bedding material exhibited the least SRCs of any sewer media at the Load Line 7 FA, with seven SRCs identified in total: two inorganic chemicals (cadmium and silver), three SVOCs [bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, and di-n-butyl phthalate], and two VOCs (benzene and toluene).

Inorganic chemicals and SVOC SRCs were observed in sewer sediment at concentrations above their respective screening criteria throughout the FA. Nine of the 17 inorganic SRCs in sewer sediment were detected at their maximum concentration at manhole MH-1B15, which is the most upstream location within Load Line 7 and the first manhole after the end of the force main exiting Load Line 11. Manganese was detected in sewer sediment at 37,100 mg/kg at manhole MH-1B15; a sidewall scale sample also collected from this location exhibited elevated manganese concentrations (12,100 mg/kg), indicating inorganic chemicals in sewer sediment may be sourced from accumulations of scale and mineral deposits noted throughout the sewer system. Significant accumulations of mineral deposits within the pipes were also observed during the video survey and generally occur at joints or cracks as a result of infiltration. Although 17 inorganic SRCs were observed in sewer sediment within the pipe, only cadmium and silver were observed above their screening level (0 mg/kg) in the underlying pipe bedding material. Detections of inorganic SRCs above background concentrations in sewer water were observed at all five manhole locations sampled; only two inorganic SRCs were identified for sewer water (nickel and nitrate). Sixteen PAHs were identified as SRCs in sewer sediment, all of which were detected at manhole MH-1B15, which is the most upstream location within the Load Line 7 FA. The highest concentrations of PAHs in sewer sediment were detected at MH-1B10, located at the downstream end of the FA and adjacent to former Buildings 1B9 and 1B10; however, this sample was not part of the screening dataset as it occurred at a depth below all receptors (>13 ft bgs). Fewer PAHs were identified as SRCs in pipe bedding material than in sewer sediment, at three and eight analytes, respectively. Additionally, although PAHs were the predominant SVOC SRC in sewer sediment, only phthalates were identified as SRCs in pipe bedding material. SVOC SRCs were detected only at manhole MH-1B13 within the central portion of the Load Line 7 former process area; they were not detected at the two upstream or two downstream manholes within the FA. A source of the SVOCs in sewer media at the Load Line 7 is not apparent, as they are ubiquitous throughout the FA. Although VOCs were detected in both sewer sediment and pipe bedding material, there was no commonality between the SRCs observed in these media. Explosives

(4-amino-2,6-DNT; 4-amino-2,6-DNT; HMX; and RDX) were identified as SRCs for sewer water but were not detected in sewer sediment or pipe bedding material.

No historical sewer sediment samples are available for a comparison of temporal trends, as no sewer sediment could be retrieved during previous investigations due to insufficient volume. As the Load Line 7 FA no longer receives influx of sewer material from the upstream Load Line 11 FA due to the shutdown of the former ejector station, the sewer sediment collected during the Facility-Wide Sewers RI may be sourced from surface soil and debris which entered the pipes during demolition activities. Limited vertical migration of contaminants from sediment within the sewer lines to the underlying bedding material is observed at the Load Line 7 FA, as the number and concentrations of SRCs observed in the pipe bedding material are comparatively lower than those observed in sewer sediment within the pipes. While cracks and joint separations within the sanitary sewer system are observed due to the advanced age of the system, the pipes are generally intact, which limits vertical migration from sewer sediment to the exterior of the piping system. The preferential migration pathway for contaminants in sewer sediment within the sanitary sewer system is laterally in the direction of flow, rather than via vertical migration to the underlying pipe bedding material, as shown by the lower contaminant concentrations in pipe bedding material relative to the sewer sediment. Sewer water within the Load Line 7 FA exhibits detections of multiple explosives, several of which (HMX and RDX) are also observed in the downstream FAs (George Road Lines and Load Line 6) that receive flow from the Load Line 7 FA. Explosives are detected in surface water at the upstream manholes at Load Line 7, suggesting these contaminants do not originate within the FA. However, RDX and HMX are not observed in sewer water at the downstream end of Load Line 11, and following the shutdown of the ejector station, Load Line 7 does not receive any flow from upstream. Sewer water occurs as a transient media at the Load Line 7 FA, occurring only in association with storm water runoff entering the system through damaged or open sewer structures and intermittently transporting sewer sediment. The source of RDX and HMX to sewer water at Load Line 7 is likely due to the inflow or infiltration of surface water runoff into damaged pipes and sewer structures, as these explosives were detected at elevated concentrations in surface water during the Characterization of 14 AOCs (MKM 2007a), under which the historical sewer water samples were contemporaneously collected.

5.5.13 Load Line 8 (FA 13)

Sanitary sewer sediment, pipe bedding material, and sewer water were evaluated at the Load Line 8 FA (Figure 5-14). Storm sewers are not present at the Load Line 8 FA, as storm infrastructure occurs only as discontinuous, under-road culverts and open ditches. Sewer sediment at the Load Line 8 FA exhibited the highest number of SRCs (35 in total), the majority of which were inorganic chemicals (12 metals) and SVOCs (17 PAHs). Six explosives were also identified as SRCs in sewer sediment. Sewer water at the Load Line 8 FA contained 20 SRCs, all of which were inorganic chemicals. Cadmium and silver were the only SRCs identified in pipe bedding material.

Detections of inorganic SRCs above their respective screening criteria were observed in all sewer sediment samples collected at the Load Line 8 FA. No overall spatial trends in inorganic SRCs

distribution are apparent for sewer sediment, although longitudinal trends are noted for individual analytes, particularly within the northeast sewer drainage segment of the FA (i.e., manholes MH-2B12 through MH-2B16). Lead exhibits a longitudinal declining trend within the northeast sewer segment, as the highest concentration in sewer sediment is noted in the upstream-most manhole (110 mg/kg at MH-2B16) and decreases with downstream distance (84.5 and 47.7 mg/kg at manholes MH-2B13 and MH-2B12, respectively). The highest SVOC and explosive SRC detections also occurred within the northeast drainage segment of the FA at manhole MH-2B13. Manhole MH-2B13 would have received sanitary sewer drainage from former Buildings 2B7, 2B8, and 2B9. Although a pipe bedding material sample was collected at manhole MH-2B13 to determine if the elevated explosives, PAH, and inorganic chemical concentrations observed in sewer sediment at this location had migrated to the underlying pipe bedding material, only cadmium and silver were detected above screening criteria in this sample. Inorganic chemicals (19 metals and nitrate) were the only SRCs identified in sewer water at the Load Line 8 FA.

Inorganic SRCs in sewer sediment and sewer water at the Load Line 8 FA generally occurred at higher concentrations in the Facility-Wide Sewer RI samples than the historical samples, indicating possible impacts from the demolition activities during the interim. Debris and surface soil entered the sewer system during demolition activities as a result of damage to the surficial sewer structures and the infilling of damaged manholes. No FAs are located upstream of Load Line 8 to potentially contribute sanitary drainage to this FA. Limited vertical migration of contaminants from within the sewer lines to the underlying bedding material is observed at the Load Line 8 FA, as the number and concentrations of SRCs observed in the pipe bedding material are comparatively lower than those observed in sewer sediment within the pipes. The preferential migration pathway for contaminants in sewer sediment within the sanitary sewer system is laterally in the direction of flow, rather than via vertical migration to the underlying pipe bedding material, as shown by the lower contaminant concentrations in pipe bedding material relative to the sewer sediment. Sewer water occurs as a transient medium at the Load Line 8 FA, occurring only in association with storm water runoff entering the system through damaged or open sewer structures and intermittently transporting sewer sediment downstream into the trunk and connector lines that drain the Fuze and Booster Hill load lines.

5.5.14 Load Line 9 (FA 14)

Sanitary sewer sediment, pipe bedding material, and sewer water were evaluated at the Load Line 9 FA (Figure 5-15). Storm sewers are not present at the Load Line 9 FA, as storm infrastructure occurs only as discontinuous, under-road culverts and open ditches. Sewer sediment at the Load Line 9 FA exhibited the highest number of SRCs (32 total, 22 of which were SVOCs) of all media analyzed. Seven inorganic chemicals, two propellants (nitrocellulose and nitroguanidine), and one VOC (methylene chloride) were also identified as SRCs for sewer sediment. Eighteen SRCs were identified in sewer water, all of which were inorganic chemicals. Two inorganic chemicals (cadmium and silver) and eight SVOCs were identified as SRCs for pipe bedding material.

1 Detections of inorganic SRCs above their respective screening criteria were observed at all sewer
2 sediment sample locations at the FA. Although elevated concentrations of mercury (110 mg/kg at
3 manhole MH-D1) were observed in historical samples at Load Line 9, the Facility-Wide Sewers RI
4 sample collected at this same location indicated substantially lower concentrations (1.9 mg/kg),
5 indicating building demolition activities during the interim may have resulted in removal of a source
6 of inorganic contaminants (i.e., mercury) to the sewer system, or flushing of these sediment to
7 downstream locations has occurred. Over the same interval, lead concentrations in sewer sediment at
8 manhole MH-D1 decreased from 300 to 91.3 mg/kg. Lead and mercury concentrations greater than
9 two times their respective background concentrations were observed in sewer sediment throughout
10 the FA, suggesting an operational source of these inorganic chemicals (i.e., historical use of mercury
11 fulminate and lead azide). Although elevated concentrations of inorganic chemicals were observed in
12 both sewer sediment and water within the pipes, migration of these sewer sediment SRCs to the
13 underlying pipe bedding material was not observed, as silver and cadmium were the only identified
14 SRCs. SVOC SRCs were identified in sewer sediment throughout the FA at both upstream and
15 downstream manhole locations and in both historical and Facility-Wide Sewers RI samples. Twelve
16 of the 22 SVOC SRCs in sewer sediment were detected at their maximum concentrations at manhole
17 MH-D1 located at the downstream end of the Load Line 9 FA; none of these SVOC SRCs were
18 detected in the underlying pipe bedding material at this location. All eight SVOC SRCs in pipe
19 bedding material were detected adjacent to manhole MH-O49, downstream of the Load Line 9 FA
20 and adjacent to Fuze and Booster Road. Concentrations of PAHs in pipe bedding material adjacent to
21 manhole MH-O49 were, on average, one to two orders of magnitude lower than those observed in
22 sewer sediment at the Load Line 9 FA. No operational source of the SVOCs at the Load Line 9 FA is
23 apparent.

24
25 Inorganic SRCs in sewer water at the Load Line 9 FA occurred at higher concentrations in the
26 Facility-Wide Sewer RI samples than the historical samples, indicating possible impacts from the
27 demolition activities during the interim. Fewer SRCs were detected in the historical sewer water
28 samples and at comparably lower concentrations. However, sewer water is transient in nature at the
29 Load Line 9 FA, and manholes are typically dry. Therefore, elevated inorganic chemical
30 concentrations in sewer water may be attributable to suspended particles carried in the intermittent
31 flow, particularly material which was flushed into the sanitary system as a result of demolition
32 activities (i.e., infilling of damaged manholes with surface soil). Debris and surface soil entered the
33 sewer system during demolition activities as a result of damage to the surficial sewer structures and
34 the infilling of damaged manholes. Limited vertical migration of contaminants from within the sewer
35 lines to the underlying bedding material is observed at the Load Line 9 FA, as the number and
36 concentrations of SRCs observed in the pipe bedding material are comparatively lower than those
37 observed in sewer sediment within the pipes. The preferential migration pathway for contaminants in
38 sewer sediment within the sanitary sewer system is laterally in the direction of flow, rather than via
39 vertical migration to the underlying pipe bedding material, as shown by the lower contaminant
40 concentrations in pipe bedding material relative to the sewer sediment. The Load Line 9 FA does not
41 receive inflow from any other upstream areas, and sanitary sewer drainage from the FA flows
42 downstream into the trunk and connector lines that drain the Fuze and Booster Hill load lines and
43 ultimately to the Administration Area FA. The elevated concentrations of mercury observed in sewer

sediment both within the Fuze and Booster Hill trunk and connector lines and the Administration Area FA may have originated from the Load Line 9 FA.

5.5.15 Load Line 10 (FA 15)

Sanitary sewer sediment, pipe bedding material, and sewer water were evaluated at the Load Line 10 FA (Figure 5-16). Storm sewers are not present at the Load Line 10 FA, as storm infrastructure occurs only as discontinuous, under-road culverts and open ditches. Sewer sediment at the Load Line 10 FA exhibited the highest number of SRCs (43 total) of all media analyzed; the predominant SRCs observed were 13 inorganic chemicals and 20 PAHs. Two explosives (2-nitrotoluene and PETN), seven pesticides, and one propellant (nitroguanidine) were also identified as SRCs in sewer sediment. Sewer water exhibited the next highest number of SRCs per media (18 total); 8 inorganic chemicals and 10 SVOCs. Three SRCs were identified in pipe bedding material, all of which were inorganic chemicals (cadmium, mercury, and silver).

Detections of inorganic SRCs above their respective screening criteria were observed at all sewer sediment sample locations at the FA. Lead was detected in sewer sediment at a maximum concentration of 2,140 mg/kg, which was 112 times the background concentration. The maximum lead concentration occurred at manhole MH-P11 within an isolated sanitary segment draining former Buildings PE-12 and PE-13 at the northeast portion of the Load Line 10 FA. Lead was not detected above its background concentration in the underlying pipe bedding material at manhole MH-P11. Lead in sewer sediment exhibits a longitudinal trend in concentration in a downstream direction through the FA, with a concentration of 287 mg/kg in sewer sediment observed at the last manhole sampled within the former process area (MH-P4). Although SVOC SRCs were detected in multiple sewer sediment samples at the Load Line 10 FA, 19 of the 20 SVOC SRCs were detected at their maximum concentration at manhole MH-P11. Both explosive SRCs in sewer sediment were also observed at manhole MH-P11. All 10 SVOC SRCs observed in sewer water were detected only at manhole MH-P12, located on the sanitary sewer segment draining the southwest portion of the former production area; however, SVOCs were not detected in any of the other sewer water samples, even at the next downstream station on the segment.

Higher concentrations and greater numbers of SRCs were observed in the Facility-Wide Sewer RI sewer water samples at the Load Line 10 FA than in the historical samples collected in 2004, indicating possible impacts from the demolition activities during the interim. Debris and surface soil entered the sewer system during demolition activities as a result of damage to the surficial sewer structures and the infilling of damaged manholes. Multiple manholes at the Load Line 10 FA were observed to be heavily damaged and deliberately backfilled with demolition debris. Limited vertical migration of contaminants from within the sewer lines to the underlying bedding material is observed at the Load Line 10 FA, as the number and concentrations of SRCs observed in the pipe bedding material are comparatively lower than those observed in sewer sediment within the pipes. The preferential migration pathway for contaminants in sewer sediment within the sanitary sewer system is laterally in the direction of flow, rather than via vertical migration to the underlying pipe bedding material, as shown by the lower contaminant concentrations in pipe bedding material relative to the

sewer sediment. Sewer water occurs as a transient media at the Load Line 10 FA, occurring only in association with storm water runoff entering the system through damaged or open sewer structures and intermittently transporting sewer sediment downstream into the trunk and connector lines that drain the Fuze and Booster Hill load lines. The Load Line 10 FA does not receive inflow from any other upstream areas, and sanitary sewer drainage from the FA flows downstream into the trunk and connector lines that drain the Fuze and Booster Hill load lines and ultimately to the Administration Area FA.

5.5.16 Load Line 11 (FA 16)

Sanitary sewer sediment, pipe bedding material, sewer water, and outfall sediment were evaluated at the Load Line 11 FA (Figure 5-17). Storm sewers are not present at the Load Line 11 FA, as storm infrastructure occurs only as discontinuous, under-road culverts and open ditches. Load Line 11 contained a sanitary sewer system overflow outfall in association with the former ejector station. Outfall sediment was collected from this sanitary overflow outfall during the historical investigations; no outfall water was collected, as the outfall was dry at the time of sample collection. Sewer sediment at the Load Line 11 FA exhibited the highest number of SRCs (31 total) of all media analyzed, and the predominant SRCs observed were inorganic chemicals (11 metals, sulfate, and sulfide) and SVOCs (15 total, 12 of which were PAHs). Two VOCs (2-butanone and acetone) and one propellant (nitrocellulose) were also identified as SRCs in sewer sediment at the Load Line 11 FA. Pipe bedding material exhibited the next highest number of SRCs (12 total): 2 inorganic chemicals (cadmium and silver) and 10 SVOCs (all PAHs). Five SRCs (manganese, nitrate, sulfate, sulfide, and acetone) were identified for sewer water, and three SRCs were identified in outfall sediment (manganese, sulfate, and sulfide).

Inorganic chemicals were observed in sewer sediment at concentrations above their respective background concentrations throughout the FA. Detections of inorganic SRCs above their respective screening criteria were observed at all seven sewer sediment samples collected at the FA. Six of the 13 inorganic SRCs were detected at their maximum concentrations at manhole MH-2A1, located at the downstream end of the western drainage segment at the FA; however, this station was not included in the SRC screening, as the sample was collected at a depth below the exposure depth of all receptors (i.e., >13 ft bgs). Elevated concentrations of lead and manganese were observed in historical sewer sediment samples throughout the FA, and manganese was the only inorganic SRC identified in both sewer water and outfall sediment. The Facility-Wide RI samples collected at these same locations indicated concentrations had declined since the previous investigation and building/sump removals in 2000. Although pipe bedding material samples were collected adjacent to manholes exhibiting elevated concentration of lead and manganese in the historical sewer sediment samples, these inorganic chemicals were not observed above background concentrations in the material underlying the pipe. All 15 SVOC SRCs in sewer sediment were detected at manhole MH-1A4, at the eastern drainage segment of the Load Line 11 FA; 2-butanone, acetone, and nitrocellulose were also observed at this location. Although a pipe bedding material sample was collected adjacent to manhole MH-1A4, no SVOCs were detected in the underlying pipe bedding material. All 10 SVOC SRCs in pipe bedding material were detected in the sample collected adjacent

1 to manhole MH-1A2 but were not detected in any of the other four pipe bedding material samples at
2 the FA.

3
4 Higher concentrations and greater numbers of inorganic SRCs were observed in the historical samples
5 collected in 2000 than in the Facility-Wide Sewer RI sewer sediment samples, indicating building
6 demolition and sump removal activities reduced the migration of contaminants to the sewers. The
7 sumps that were removed from the FA were lead-lined and represented the most likely source of the
8 lead observed in the sanitary sewer sediment. Limited vertical migration of contaminants from within
9 the sewer lines to the underlying bedding material is observed at the Load Line 11 FA, as the number
10 and concentrations of SRCs observed in the pipe bedding material are comparatively lower than those
11 observed in sewer sediment within the pipes. While cracks and joint separations within the sanitary
12 sewer system are observed due to the advanced age of the system, the pipes are generally intact,
13 which also limits vertical migration to outside of the piping system. PAHs were detected in only one
14 of the five pipe bedding material samples at the Load Line 11 FA, suggesting the sewer pipe in the
15 vicinity of manhole MH-1A2 may be damaged. Typically, the preferential migration pathway for
16 contaminants in sewer sediment within the sanitary sewer system is laterally in the direction of flow,
17 rather than via vertical migration to the underlying pipe bedding material, as shown by the lower
18 contaminant concentrations in pipe bedding material relative to the sewer sediment. However, since
19 the removal of the former ejector station at the downstream end of the FA, migration of sewer media
20 to the downstream Load Line 7 FA no longer occurs. Flow is backed up in drainage segments
21 upstream of the former manhole MH-1A1 due to the removal of the ejector station and because many
22 manholes were damaged and infilled with surface soil and debris during demolition activities.
23 Flooded manholes are observed at multiple locations throughout the FA. As the sanitary overflow
24 outfall is dry, migration of sewer media from within the pipe system to this daylight point is not
25 occurring (i.e., if this potential pathway was operable, flooding would not be observed). No upstream
26 FAs exist that could contribute an influx of sewer media into the sanitary sewers at the Load Line 11
27 FA; therefore, no migration of contaminants into or out of Load Line 11 is occurring.

28 29 **5.5.17 Load Line 12 (FA 17)**

30
31 Sanitary sewer sediment, pipe bedding material, and sewer water were evaluated at the Load Line 12
32 FA (Figure 5-18). Storm sewers are not present at the Load Line 12 FA, as storm infrastructure
33 occurs only as discontinuous, under-road culverts and open ditches. Sewer sediment at the Load Line
34 12 FA exhibited the highest number of SRCs (48 total) of all media analyzed, and the predominant
35 SRCs observed were inorganic chemicals (17 identified as SRCs) and SVOCs (26 total, 16 of which
36 were PAHs). Additionally, four explosives (TNT; 2,4-DNT; 2,6-DNT; and 4-amino-2,6-DNT) and
37 one PCB (PCB-1260) were also identified as SRCs in sewer sediment. Thirty-two SRCs were
38 identified in sewer water at the Load Line 12 FA: 16 inorganic chemicals, 14 explosives, 1 SVOC
39 [bis(2-ethylhexyl)phthalate], and 1 pesticide (heptachlor epoxide). Despite the high numbers of SRCs
40 identified in the sewer sediment and water within the pipes, only four SRCs were identified in the
41 underlying pipe bedding material: two inorganic chemicals (cadmium and silver), and two SVOCs
42 [benzo(g,h,i)perylene and phenanthrene].

SVOCs were the predominant contaminants observed in sewer sediment and were detected in all sample locations at the Load Line 12 FA, with 21 of the 26 SVOC SRCs detected at their maximum concentration in the Facility-Wide Sewers RI sample collected at manhole MH-505. SVOC concentrations at manhole MH-505 under the Facility-Wide Sewers RI were approximately two times greater than those observed in the historical sample collected at this manhole in 2000. Manhole MH-505 is located at the downstream end of the Load Line 12 FA, and the SVOCs observed at this location may have been originally sourced from the former powerhouse complex, although this source area has since been removed (i.e., the powerhouse and associated structures were demolished). The pipe bedding material sample collected at MH-505 exhibited SVOC detections of only benzo(g,h,i)perylene and phenanthrene and at concentrations approximately two orders of magnitude lower than those detected in the adjacent sewer sediment sample. While cracks and joint separations within the sanitary sewer system are observed due to the advanced age of the system, the pipes are generally intact, which limits vertical migration from sewer sediment to the exterior of the piping system. Elevated inorganic SRCs concentrations were also observed at the southern end of the FA, at manhole MH-505, in the vicinity of the former powerhouse. Silver was detected in sewer sediment collected throughout the FA, including at manholes located upstream of the Load Line 12 former production area. Explosive SRCs in sewer sediment were detected in manholes MH-504A and MH-505 at the south end of the Load Line 12 FA, downstream of the former powerhouse complex. Although only 4 explosives had been identified as SRCs in sewer sediment, 14 explosives and the propellant nitrocellulose were identified as SRCs in sewer water.

Although elevated concentrations of silver in sewer sediment were observed throughout the Load Line 12 FA, the maximum concentration was detected at a location upstream of the former production area. Elevated silver concentrations were also observed in sewer sediment at the Load Line 2 FA and the Load Line 3 FA, which are immediately upstream of the Load Line 12 FA. Silver was also observed within the Sand Creek Trunk Line FA, which is located downstream of the Load Line 12 FA. However, due to the shutdown of the former ejector station and removal of the associated manhole at the upstream end of the FA, migration from the Load Line 12 FA to downstream FAs is no longer occurring. The removal of the ejector station has also resulted in complete flooding of the sewer lines at the Load Line 12 FA. Groundwater infiltration may contribute explosives to sewer water at the FA; 14 explosives were identified as SRCs in sewer water, although only 4 were identified as SRCs in sewer sediment. Additionally, as only four explosives were detected in sewer water at the upstream end of the Load Line 12 FA, an upstream source of these explosives to sewer water is not likely. Historical investigations at Load Line 12 indicate the presence of explosives in groundwater. Although migration of groundwater into the pipes may be occurring, limited vertical migration of contaminants from within the sewer lines to the underlying bedding material is observed at the Load Line 12 FA, as the number and concentrations of SRCs observed in the pipe bedding material are comparatively lower than those observed in sewer sediment within the pipes. Typically, the preferential migration pathway for contaminants in sewer sediment within the sanitary sewer system is laterally in the direction of flow, rather than via vertical migration to the underlying pipe bedding material, as shown by the lower contaminant concentrations in pipe bedding material relative to the sewer sediment. However, no migration of contaminants within the sewer system from the Load Line 12 FA to downstream FAs is possible due to the removal of the ejector station. The Load

Line 12 FA may still receive an influx of sewer media from the sanitary systems at the upstream melt pour load lines (i.e., Load Lines 1, 2, and 3).

5.5.18 Sand Creek Trunk Lines (FA 18)

Sanitary sewer sediment, outfall sediment, and outfall water were evaluated at the Sand Creek Trunk Line FA (Figure 5-19), which consists of the main trunk line that conveyed sanitary drainage from Atlas Scrap Yard and Load Lines 1, 2, 3, 4, and 12 northward to the former Sand Creek Sewage Treatment Plant. The sanitary sewer outfall at the FA is currently the final discharge point from the Sand Creek Treatment Plant sanitary sewer network, as the flow was rerouted upon the shutdown of the treatment plant. Storm sewers are not present at this FA, as storm infrastructure occurs only as discontinuous, under-road culverts and open ditches. Sewer sediment at the Sand Creek Trunk Line FA exhibited the highest number of SRCs (15 total) of all media analyzed. The predominant SRCs observed in sewer sediment were six inorganic chemicals (all metals) and eight SVOCs (seven of which were PAHs), although one pesticide (4,4'-DDT) was also detected. Inorganic chemicals were the predominant SRCs observed in outfall sediment and water, although one VOC (acetone) was detected in outfall water.

The Sand Creek Trunk Line FA receives inflow of sewer sediment and transient sewer water sourced from Atlas Scrap Yard and Load Line 4. Since removal of the ejector station and associated capping of the pipe at the north end of Load Line 12, drainage from Load Lines 1, 2, 3, and 12 no longer flows northward. Inorganic SRCs at concentrations above background were observed at all sewer sediment sample locations, as well as in outfall sediment. Silver was detected at its maximum concentration of 58.8 mg/kg at MH-29, the final manhole in the Sand Creek Treatment Plant sanitary sewer network before the outfall, and exhibited a declining concentration trend in the upstream direction. Elevated silver concentrations were observed in sewer sediment at the Load Line 2, 3 and 12 FAs and were likely sourced from the former radiology labs at Load Lines 2 and 3. As the Sand Creek Trunk Line no longer receives drainage from the Load Line 2, 3 and 12 FAs, the highest concentrations of silver are observed at the downstream end of the line, as they have been flushed downstream over time, and there have been no additional contributions from the upstream former source areas. However, concentrations of silver in the outfall sediment (0.3J mg/kg) are substantially lower than those observed in the sewer sediment (58.8 mg/kg at MH-29), possibly due to the age of the outfall relative to the age of the sewer system (i.e., the outfall represents a recent rerouting of flow subsequent to the final shutdown of the treatment plant, following decades of use). With the exception of nickel, all of the inorganic SRCs identified in outfall sediment were also SRCs in sewer sediment at the FA. All eight SVOC SRCs and the pesticide 4,4'-DDT were detected at their maximum concentrations at manhole MH-29, the last manhole before the outfall from the sanitary system, located at the downstream end of the FA. As the SVOC SRCs were not detected in upstream manhole MH-23, possible sources of these contaminants are from the former railbeds or the Central Burn Pits. Although the sanitary sewers are generally a closed system, runoff, surface debris, and soil may enter the pipe system through damaged or eroded manhole structures. The SRCs observed in outfall water were generally consistent with those detected in sewer sediment and outfall sediment.

5.5.19 Transportation Storage Area (FA 19)

Sanitary sewer sediment, storm sewer sediment, and sanitary outfall sediment were evaluated at the Transportation Storage Area FA (Figure 5-20). The Transportation Storage Area FA contains only a limited segment of sanitary sewers, which serviced several buildings, and a storm system that diverted drainage away from the immediate vicinity of the building and parking lot areas. Both sewer systems at the Transportation Storage Area FA are isolated, as they neither receive inflow from nor drain effluent to other FAs.

Sanitary Sewer

Inorganic chemicals were the only SRCs identified for sanitary sewer sediment and sanitary outfall sediment. The outfall sediment sample was collected from the sludge bed at the downstream end of the sanitary sewer system, which is a point where the sanitary sewer pipe system daylights. Fourteen inorganic SRCs were identified in the sanitary sewer sediment sample collected at manhole MH-3, which is the most downstream location of the three sanitary sewer manholes present at the FA. Manganese was detected at a concentration of 37,600 mg/kg at manhole MH-3, which is approximately 12.4 times its background concentration of 3,030 mg/kg. Manganese was not one of the six inorganic SRCs identified at the sanitary sewer sludge bed sample location. Although Defense Logistics Agency (DLA) stockpiles of manganese ore were located at the southern end of the Transportation Storage Area FA, a mechanism of transport of manganese to the sanitary sewer system is not apparent, as the sanitary sewer only had service connections to the former Office Building and Locomotive Service Building.

Storm Sewer

The predominant SRCs in storm sewer sediment were SVOCs (19 total, 16 of which were PAHs), inorganic chemicals (7 SRCs), and 1 explosive (4-amino-2,6-DNT). The storm sewer sediment sample was collected Inlet 1, located on a segment that drained the Locomotive Service Building, Boiler House and Coal Bin, and the Office Building. PAHs were the predominant SRCs identified at storm sewer Inlet 1 and were likely sourced from the surrounding railbeds, parking lots, and roads. The storm sewers at the Transportation Storage Area FA currently receive and divert drainage from railbed and road area into the open ditchlines throughout the FA.

Table 5-6. Summary of Facility-Wide Sewers SRCs per Functional Area and Media

Functional Area	System Type	Sewer Sediment							Sewer Water							Pipe Bedding Material							Outfall Sediment							Outfall Water						
		Inorganic chemicals	Explosives	SVOCs	PCBs	Pesticides	Propellants	VOCs	Inorganic chemicals	Explosives	SVOCs	PCBs	Pesticides	Propellants	VOCs	Inorganic chemicals	Explosives	SVOCs	PCBs	Pesticides	Propellants	VOCs	Inorganic chemicals	Explosives	SVOCs	PCBs	Pesticides	Propellants	VOCs	Inorganic chemicals	Explosives	SVOCs	PCBs	Pesticides	Propellants	VOCs
Administration Area	Sanitary	17	2	24	1	1	0	0	16	1	10	0	0	0	0	9	1	3	0	0	0	0	10	0	21	0	0	0	0	8	2	1	0	0	0	0
	Storm	9	2	19	0	0	0	5	19	1	7	0	0	0	0	--	--	--	--	--	--	--	16	5	21	0	1	0	0	11	0	1	0	0	0	0
Atlas Scrap Yard	Sanitary	16	1	20	0	0	0	0	8	2	3	0	0	0	0	1	0	2	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Depot Administration Area	Sanitary	15	0	20	0	0	0	1	19	0	0	0	0	0	0	3	0	15	0	0	0	0	4	1	20	0	0	0	0	1	0	0	0	0	0	0
	Storm	9	1	21	0	0	0	0	16	0	0	0	0	0	0	2	0	8	0	0	0	0	10	1	20	0	0	0	9	1	0	0	0	0	0	
George Road Lines	Sanitary	16	6	24	1	1	1	1	14	3	0	0	0	0	8	5	1	10	0	0	0	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Inert Storage Area #6	Sanitary	9	1	17	1	4	1	2	4	5	0	0	0	0	0	2	1	5	0	0	0	0	9	0	0	0	0	0	8	1	0	0	0	0	0	
	Storm	3	0	17	0	0	0	0	15	1	16	0	0	0	0	--	--	--	--	--	--	--	14	3	19	0	0	0	0	9	3	16	0	0	0	0
Load Line 1	Sanitary	15	8	17	0	0	0	0	5	0	0	0	0	0	0	2	0	7	0	0	0	0	12	0	0	0	0	0	--	--	--	--	--	--	--	
	Storm	13	2	22	1	4	1	0	7	0	0	0	0	0	0	8	8	16	0	0	0	1	19	2	23	0	0	0	0	--	--	--	--	--	--	--
Load Line 2	Sanitary	16	1	20	1	1	0	3	--	--	--	--	--	--	--	1	0	4	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Storm	16	8	19	2	3	1	6	8	5	0	0	0	0	0	10	8	17	0	3	1	1	17	1	22	0	0	0	0	18	6	0	0	0	0	
Load Line 3	Sanitary	16	7	21	0	0	0	0	8	5	0	0	0	0	0	6	7	14	0	2	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Storm	16	5	20	1	0	1	1	--	--	--	--	--	--	--	8	3	11	0	0	1	0	15	7	21	1	3	0	0	19	5	7	0	0	0	
Load Line 4	Sanitary	16	2	16	1	1	1	4	5	0	0	0	0	0	2	3	0	0	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Storm	12	0	22	1	1	0	1	--	--	--	--	--	--	--	7	1	2	0	0	0	3	17	0	18	0	0	2	2	8	1	0	0	0	0	
Load Line 5	Sanitary	13	7	19	0	0	0	0	20	0	1	0	0	0	0	2	0	0	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
Load Line 6	Sanitary	8	0	16	0	0	0	0	5	3	0	0	0	0	0	2	0	5	0	0	0	1	--	--	--	--	--	--	--	--	--	--	--	--	--	
Load Line 7	Sanitary	17	0	17	0	2	1	1	2	4	8	0	0	0	0	2	0	3	0	0	0	2	--	--	--	--	--	--	--	--	--	--	--	--	--	
Load Line 8	Sanitary	12	6	17	0	0	0	0	20	0	0	0	0	0	0	2	0	0	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
Load Line 9	Sanitary	7	0	22	0	0	2	1	18	0	0	0	0	0	0	2	0	8	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
Load Line 10	Sanitary	13	2	20	0	7	1	0	8	0	10	0	0	0	0	3	0	0	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
Load Line 11	Sanitary	13	0	15	0	0	1	2	4	0	0	0	0	0	1	2	0	10	0	0	0	0	3	0	0	0	0	0	--	--	--	--	--	--	--	
Load Line 12	Sanitary	17	4	26	1	0	0	0	16	14	1	0	1	0	0	2	0	2	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	
Sand Creek Lines	Sanitary	6	0	8	0	1	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	0	0	0	0	0	5	0	0	0	0	0	1	
Transportation Storage Area	Sanitary	14	0	0	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	0	0	0	0	0	--	--	--	--	--	--	--	
	Storm	7	1	19	0	0	0	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

PCB = Polychlorinated Biphenyl

SRC = Site-related Contaminant

SVOC = Semi-volatile Organic Compound

VOC = Volatile Organic Compound

-- = Medium is not present at the function area

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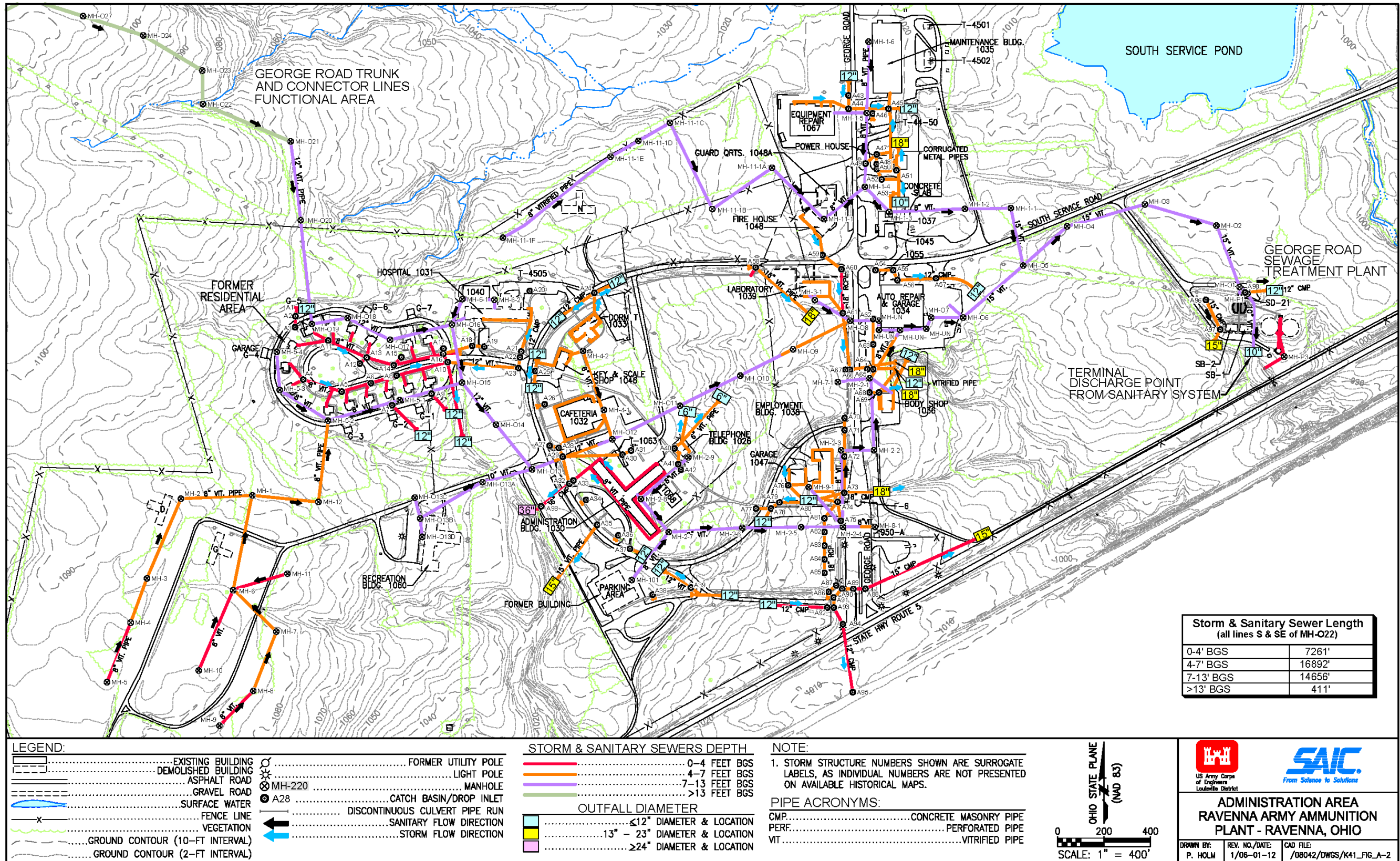


Figure 5-2. Characteristics of the Sanitary and Storm Sewers at the Administration Area Functional Area

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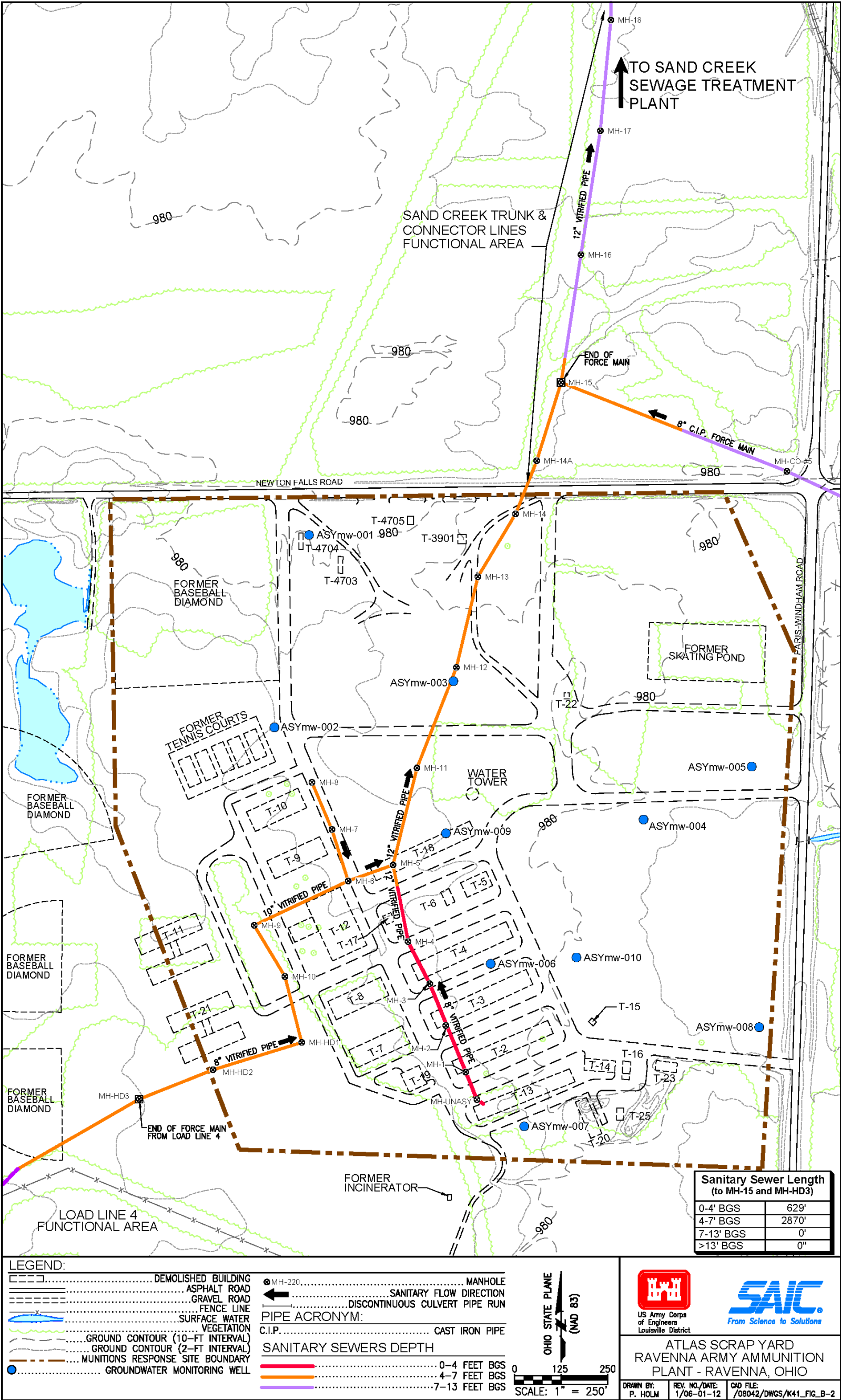


Figure 5-3. Characteristics of the Sanitary Sewers at Atlas Scrap Yard Functional Area

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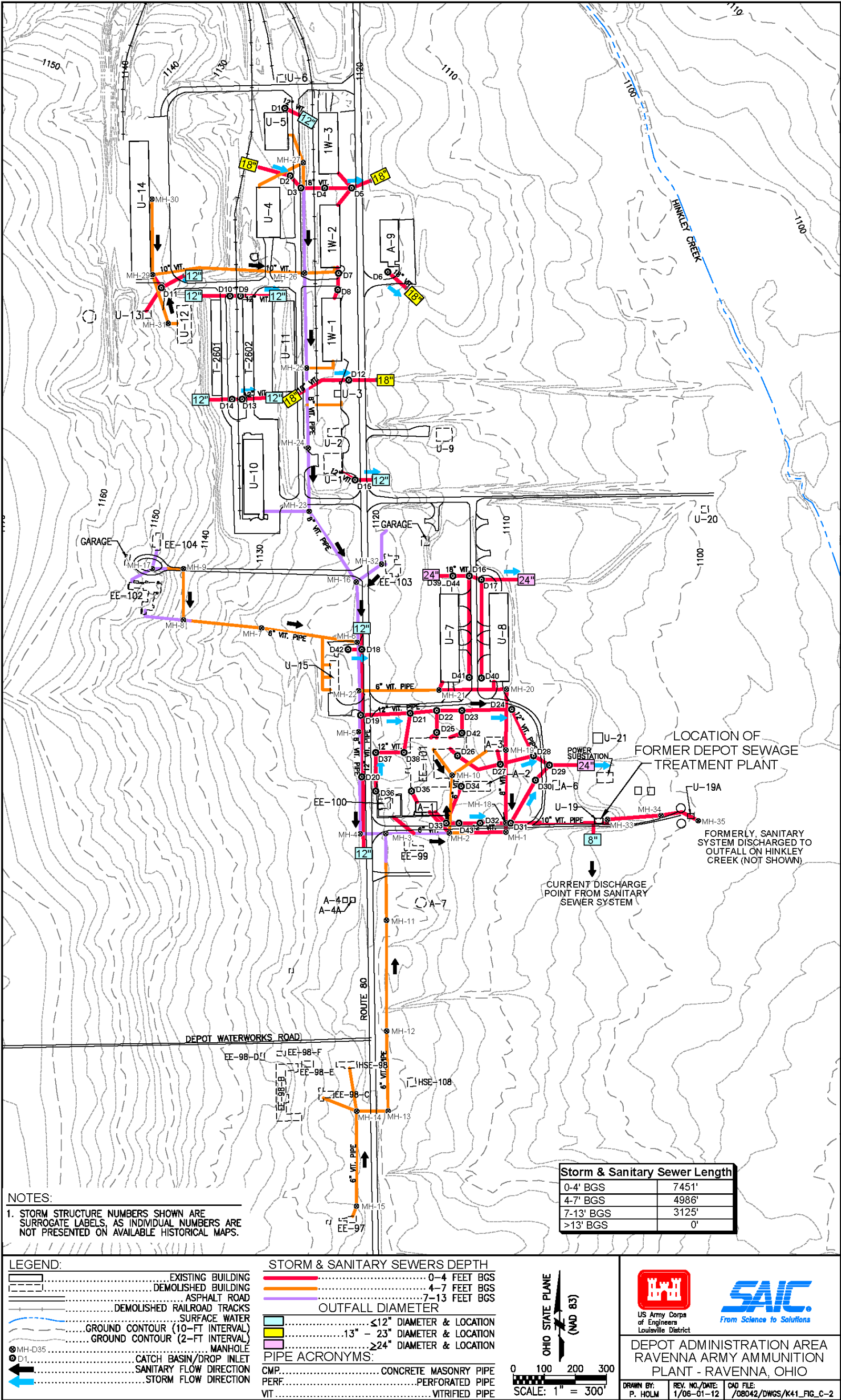


Figure 5-4. Characteristics of the Sanitary and Storm Sewers at the Depot Administration Area Functional Area

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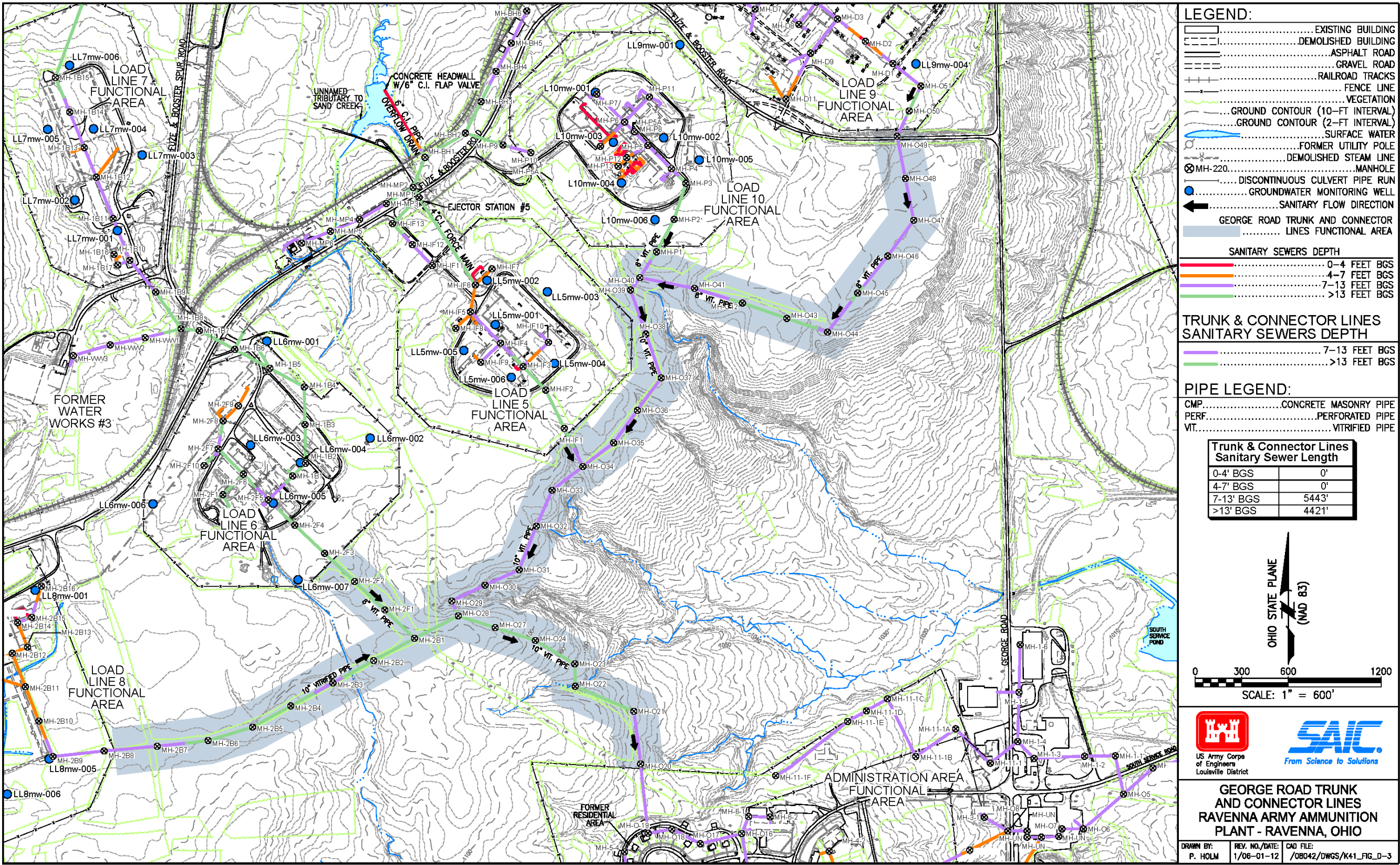


Figure 5-5. Characteristics of the Sanitary Sewers at the George Road Trunk and Connector Lines Functional Area

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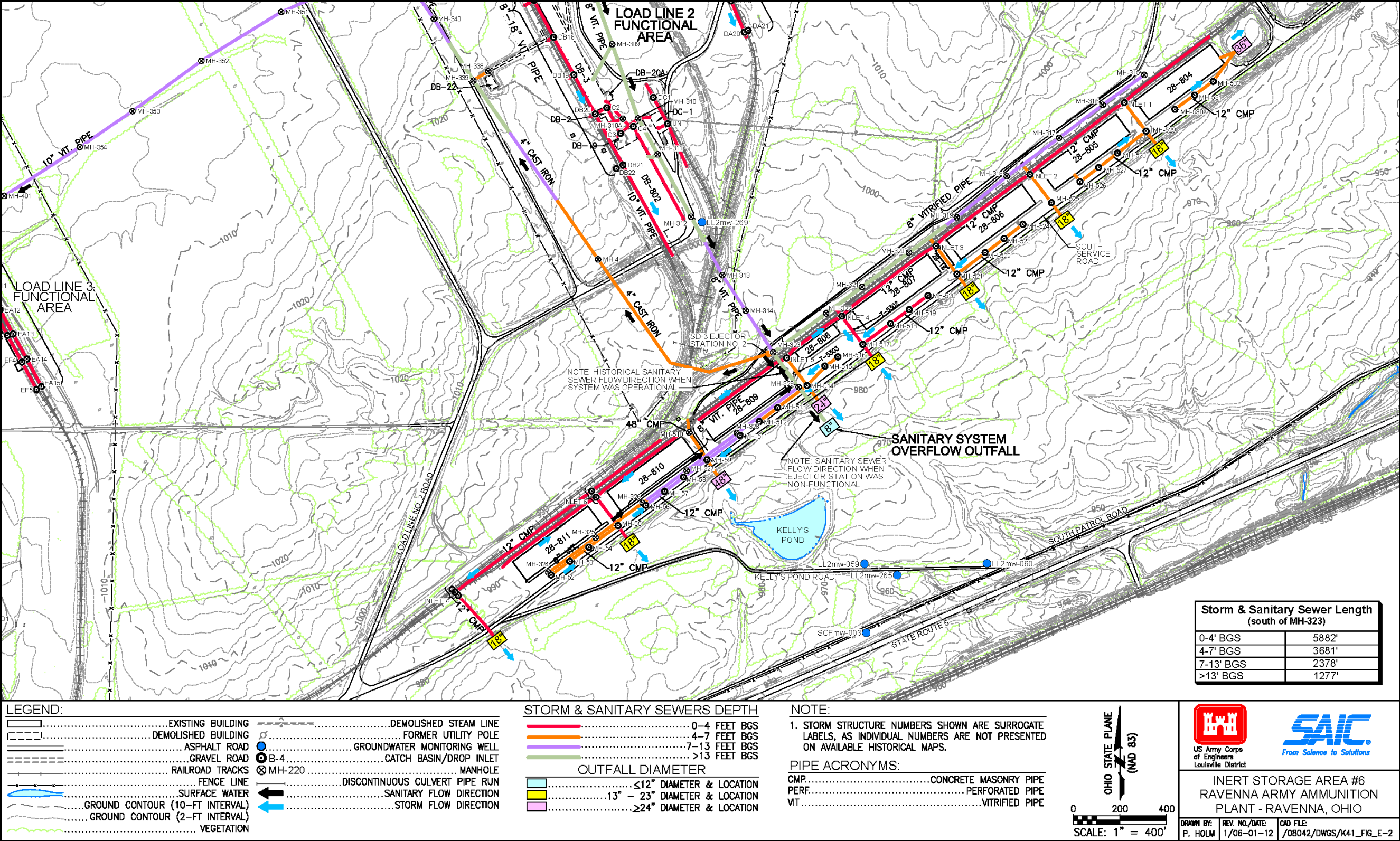


Figure 5-6. Characteristics of the Sanitary and Storm Sewers at the Inert Storage Area #6 Functional Area

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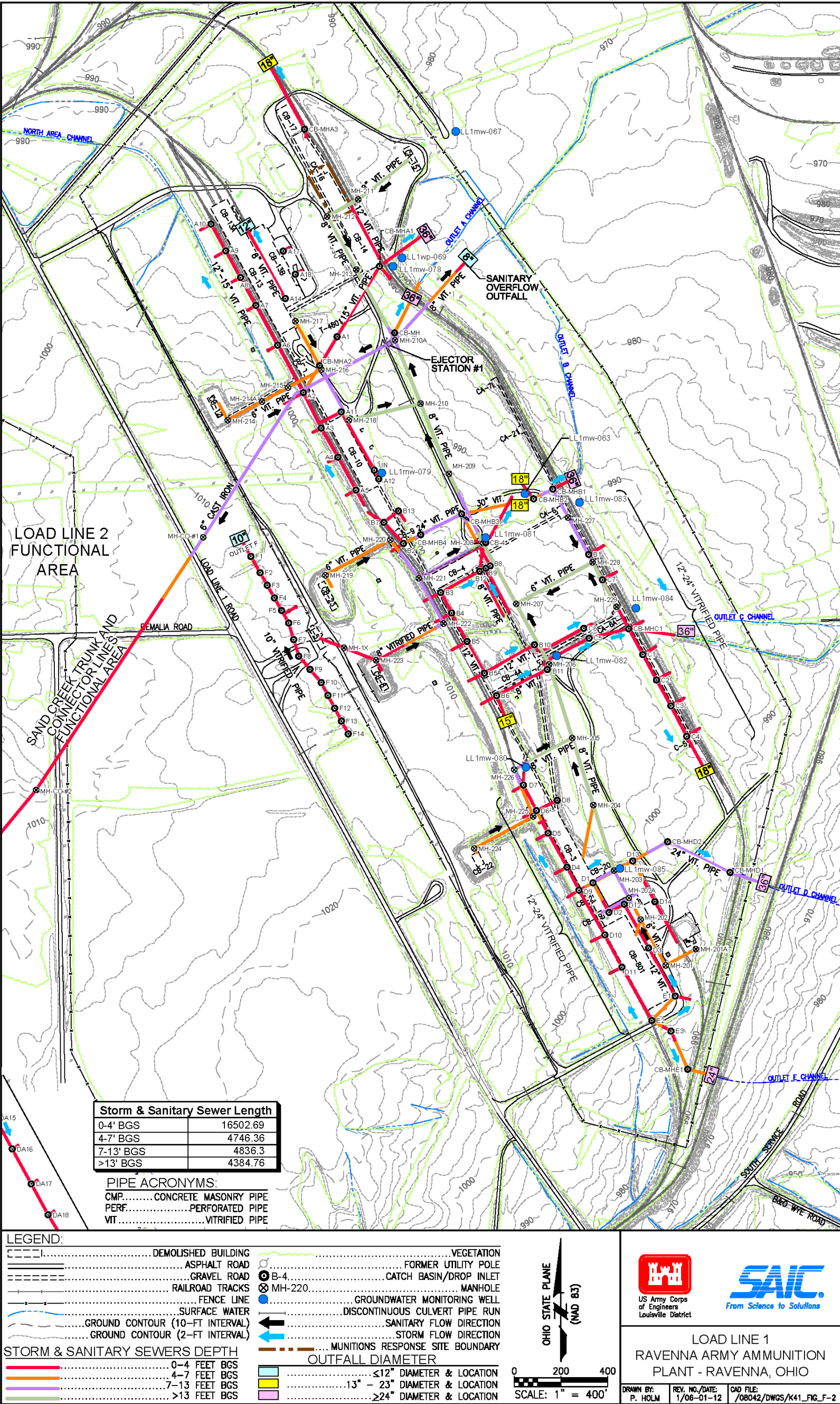


Figure 5-7. Characteristics of the Sanitary and Storm Sewers at Load Line 1 Functional Area

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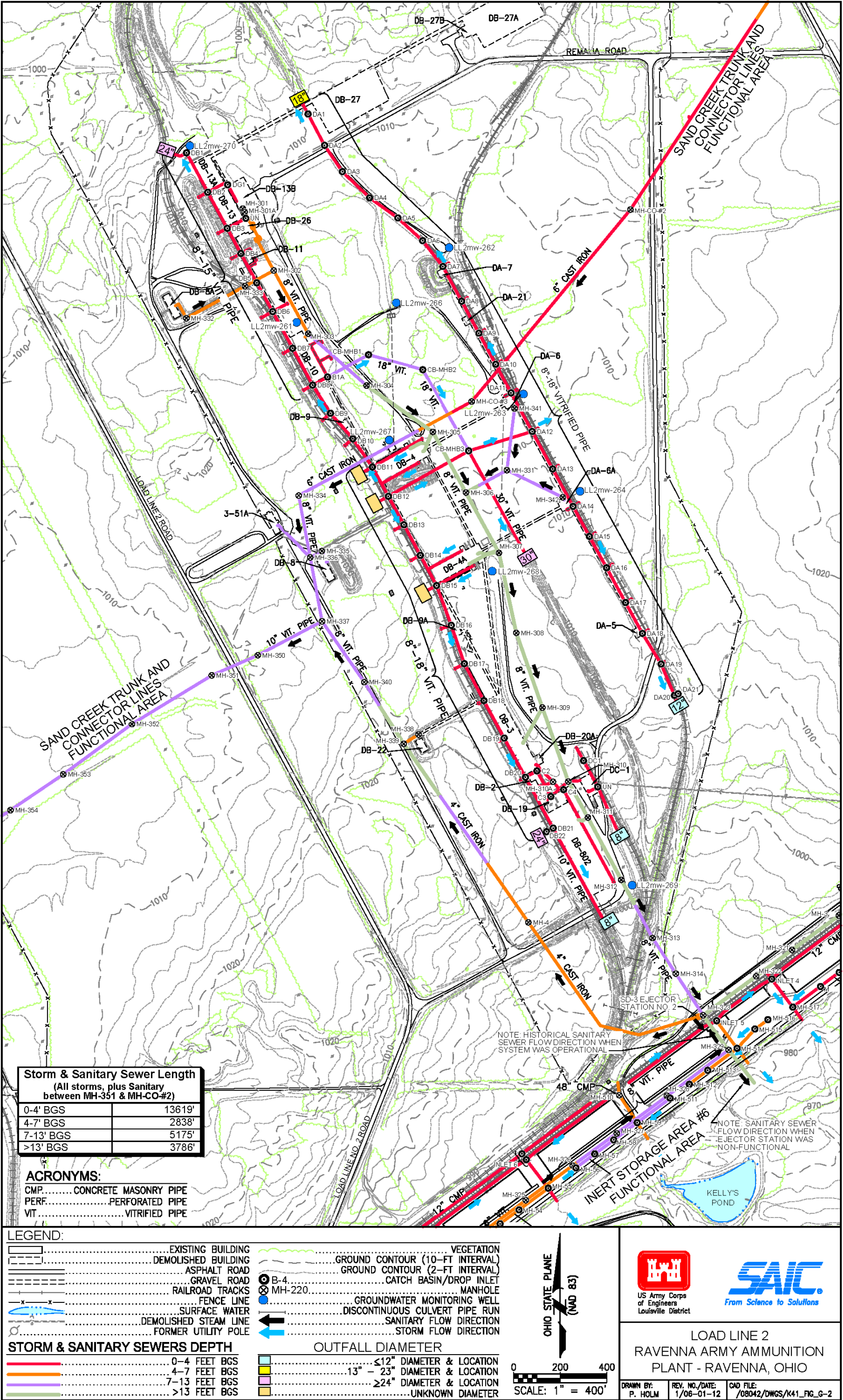


Figure 5-8. Characteristics of the Sanitary and Storm Sewers at Load Line 2 Functional Area

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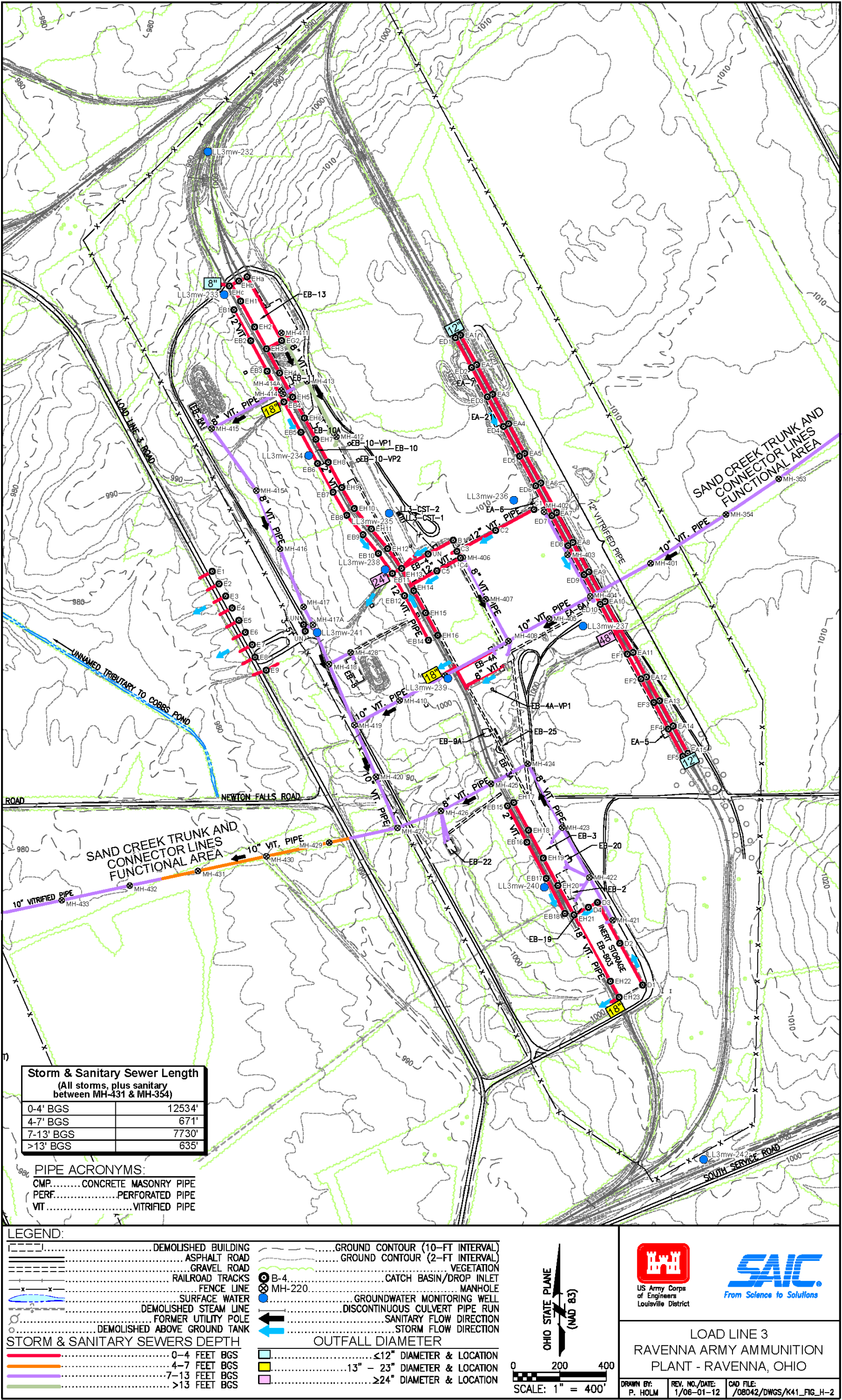


Figure 5-9. Characteristics of the Sanitary and Storm Sewers at Load Line 3 Functional Area

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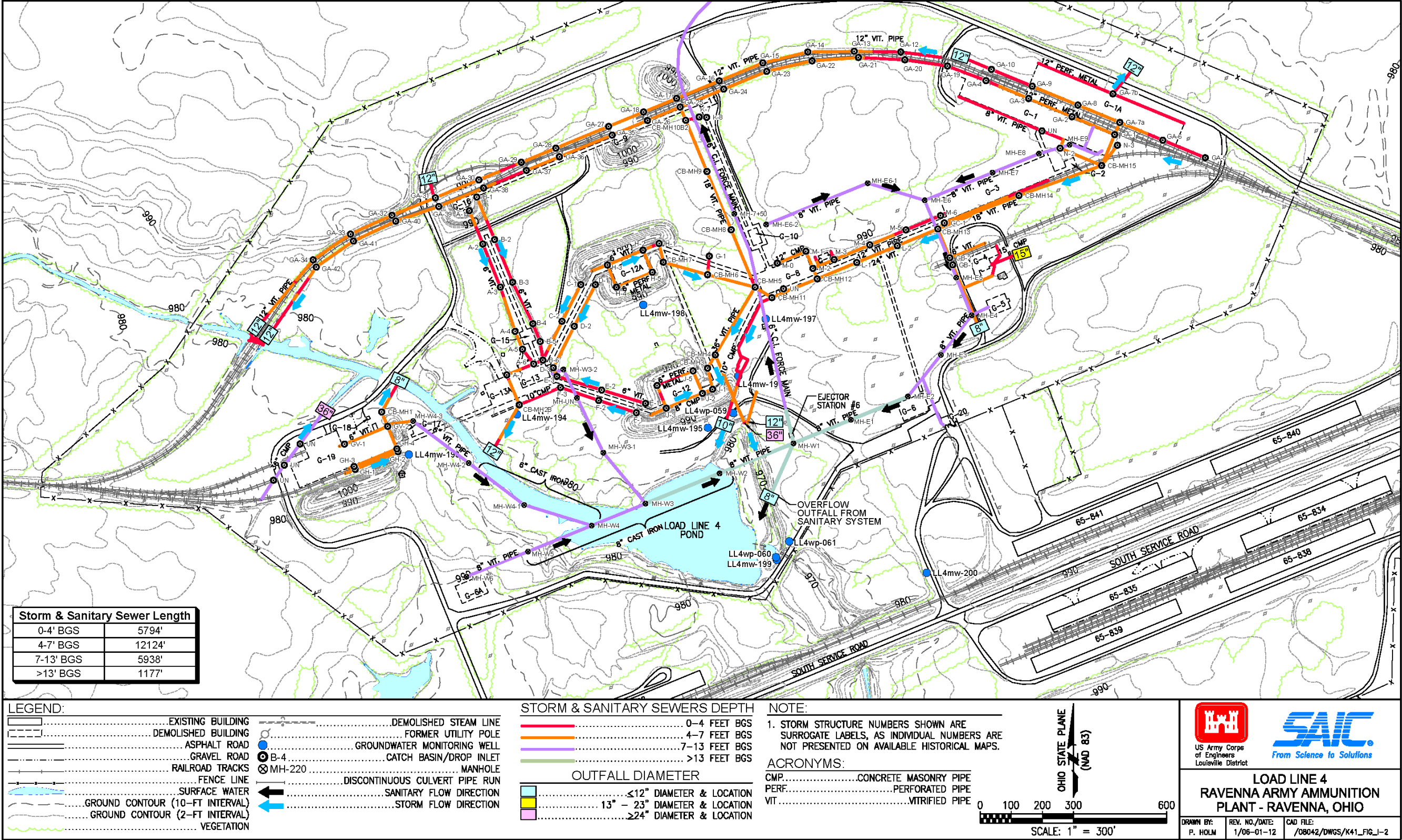


Figure 5-10. Characteristics of the Sanitary and Storm Sewers at Load Line 4 Functional Area

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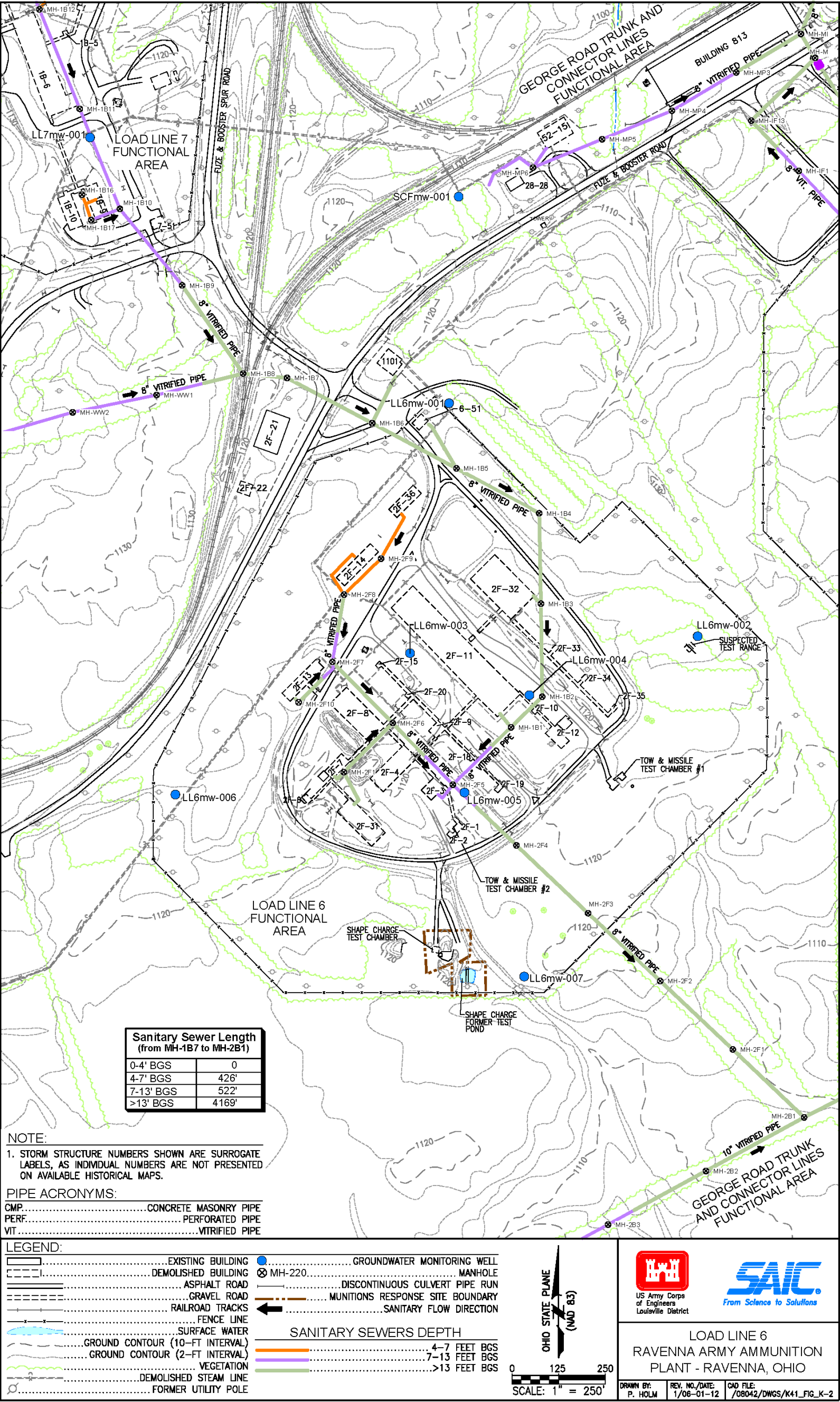


Figure 5-12. Characteristics of the Sanitary Sewers at Load Line 6 Functional Area

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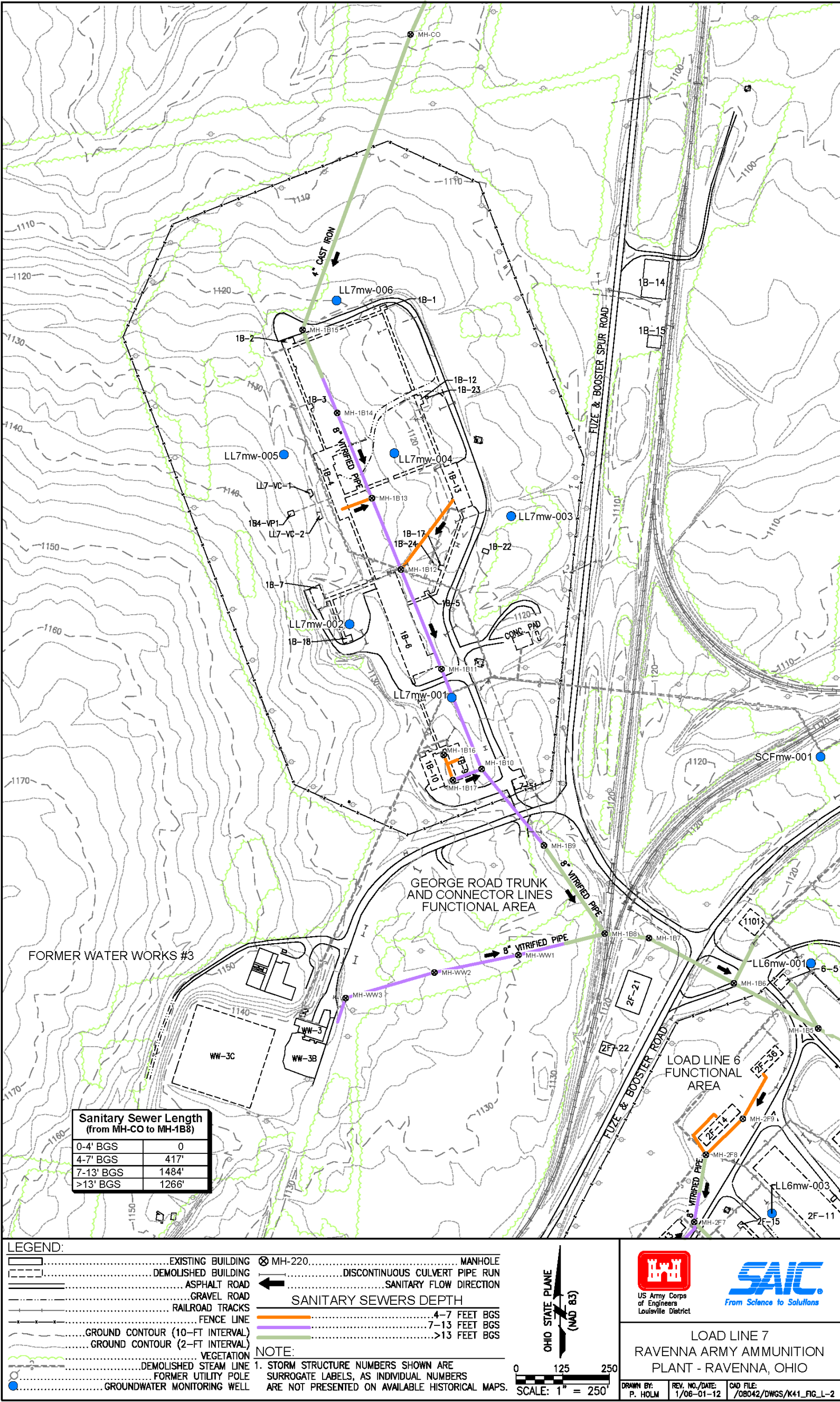


Figure 5-13. Characteristics of the Sanitary Sewers at Load Line 7 Functional Area

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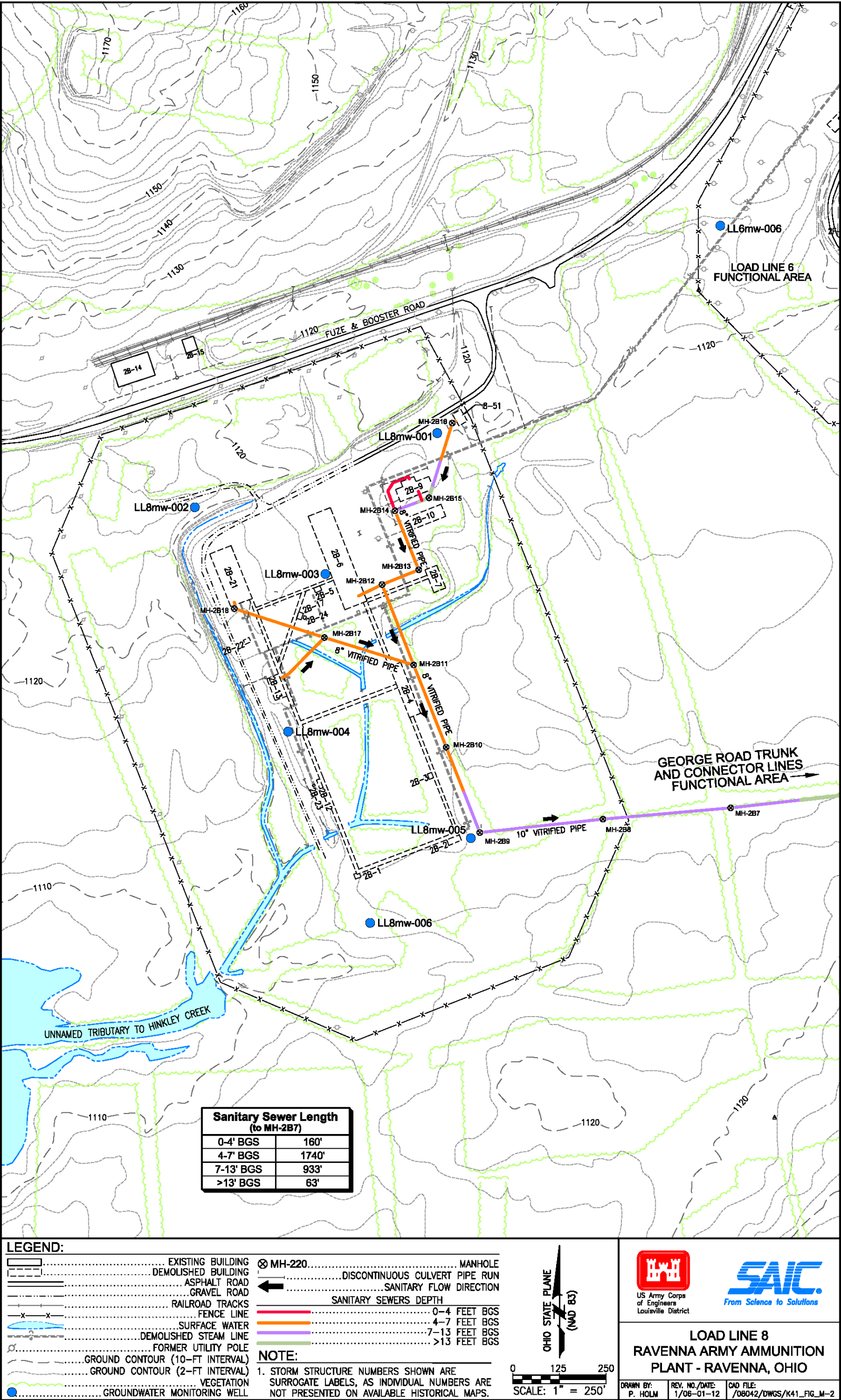


Figure 5-14. Characteristics of the Sanitary Sewers at Load Line 8 Functional Area

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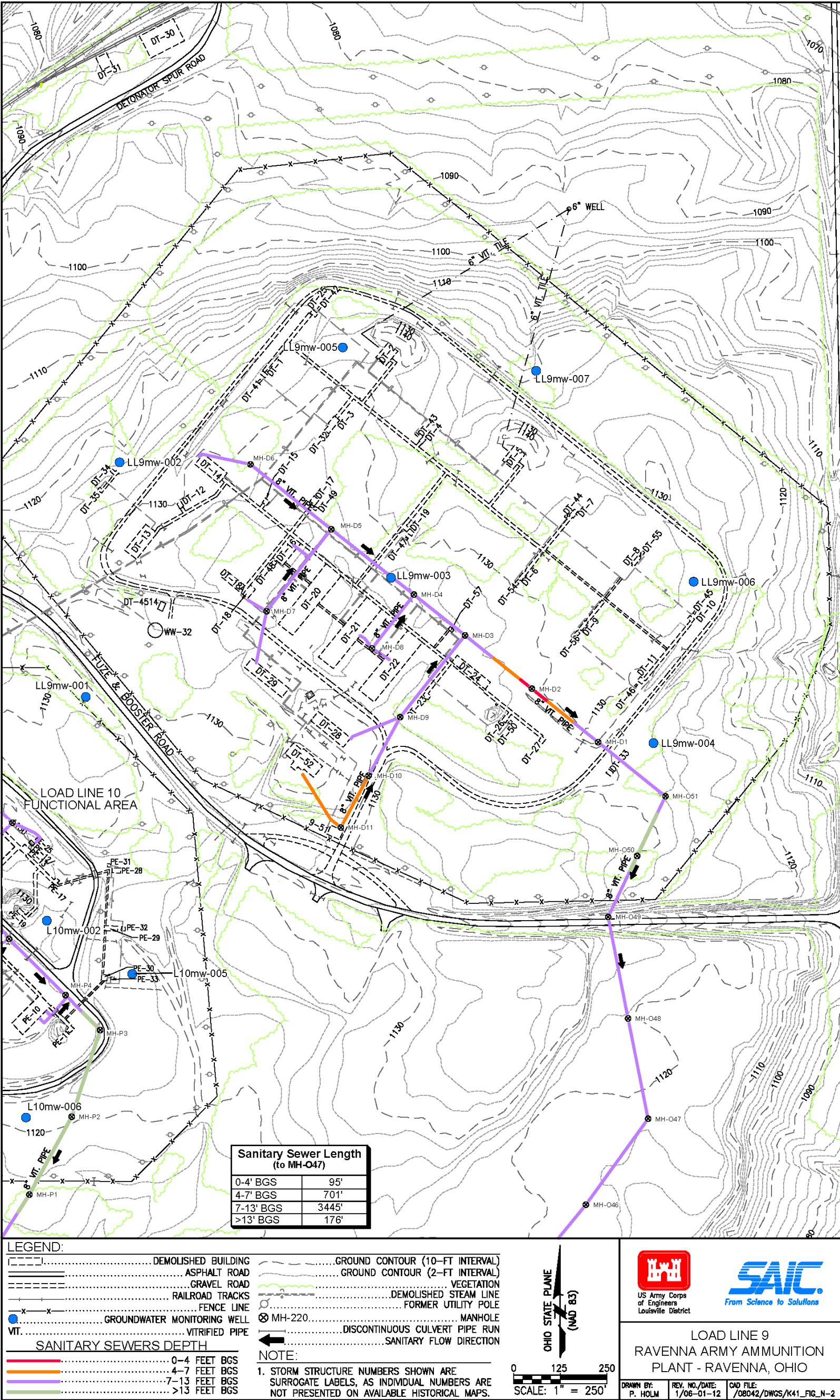


Figure 5-15. Characteristics of the Sanitary Sewers at Load Line 9 Functional Area

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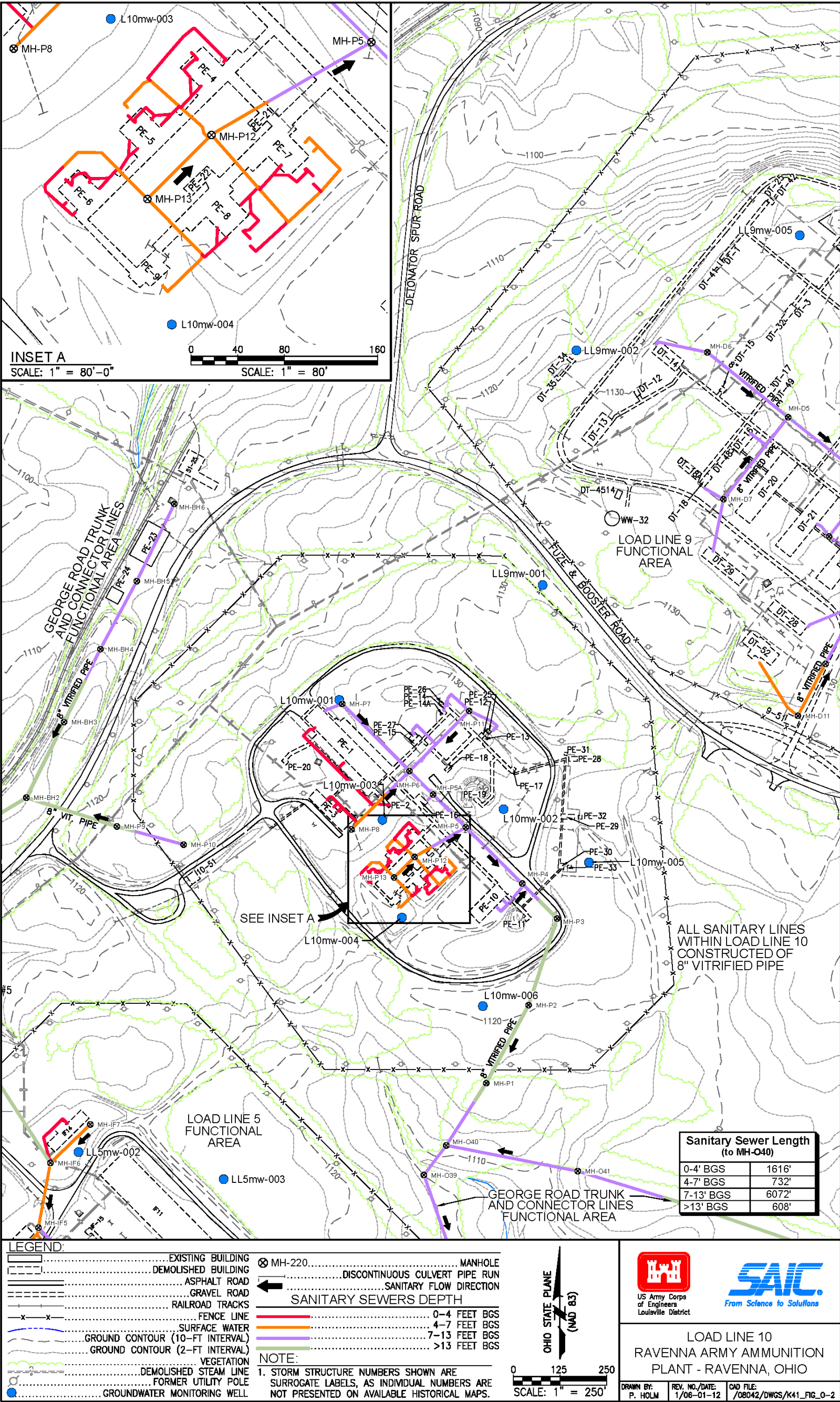


Figure 5-16. Characteristics of the Sanitary Sewers at Load Line 10 Functional Area

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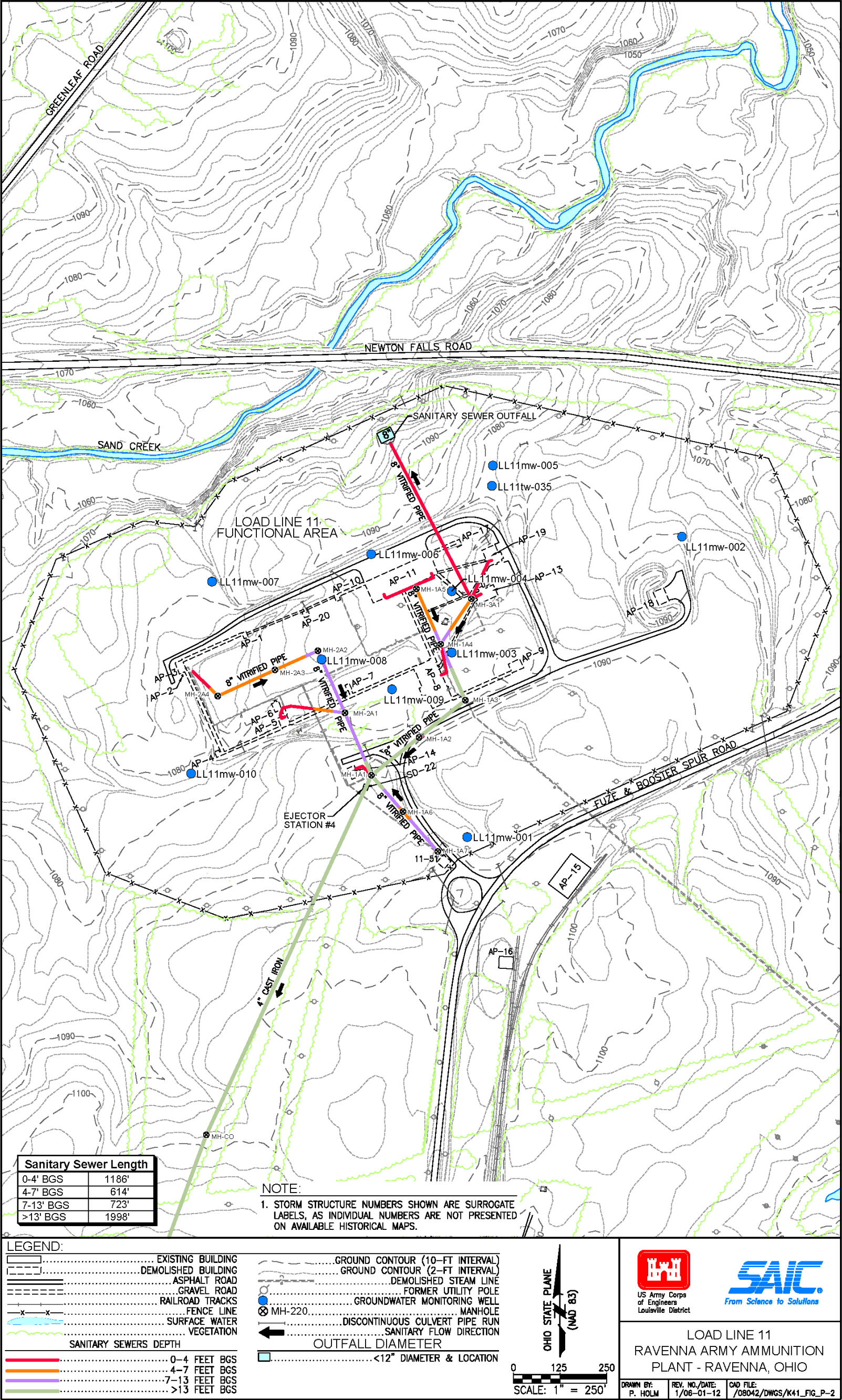


Figure 5-17. Characteristics of the Sanitary Sewers at Load Line 11 Functional Area

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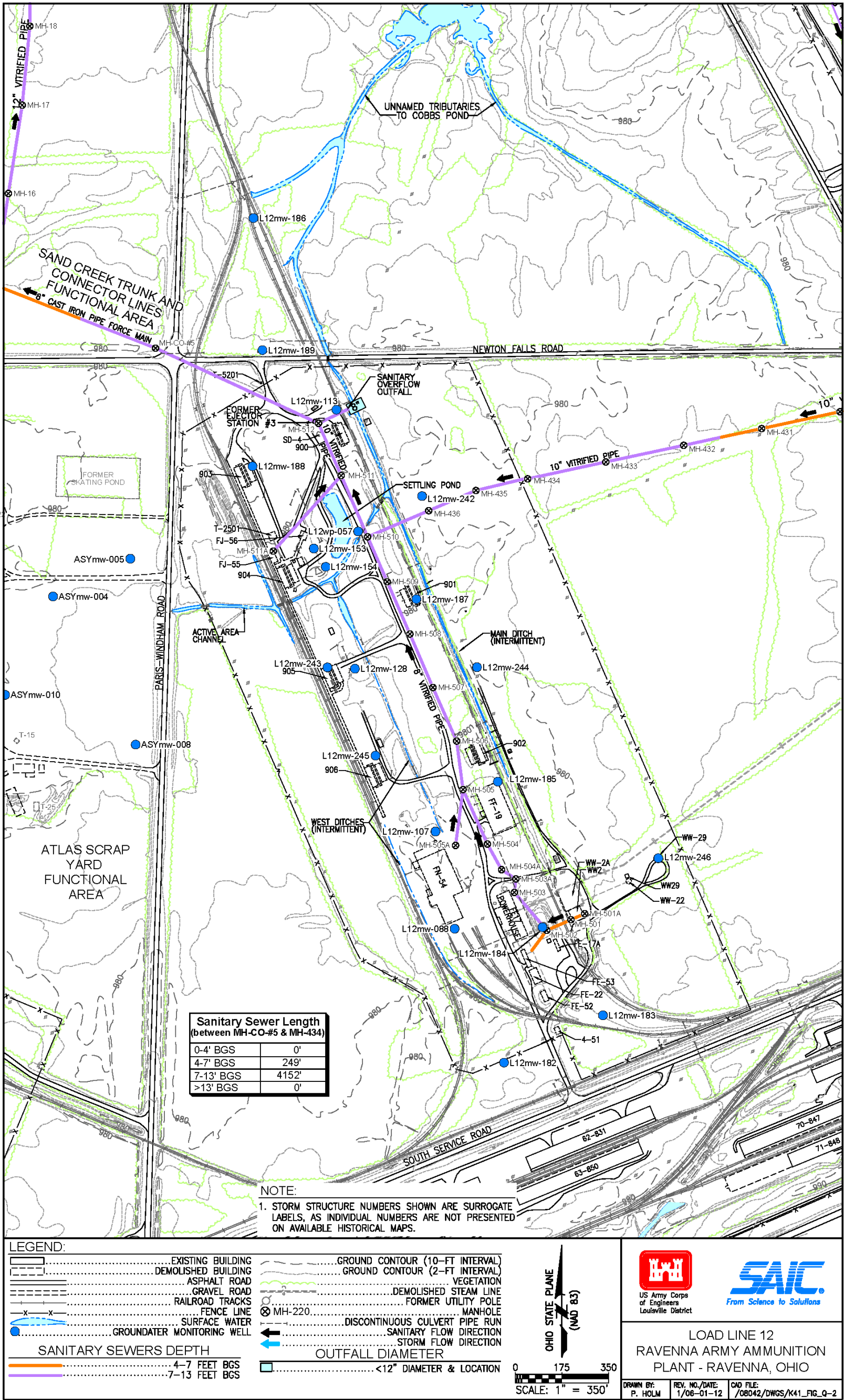
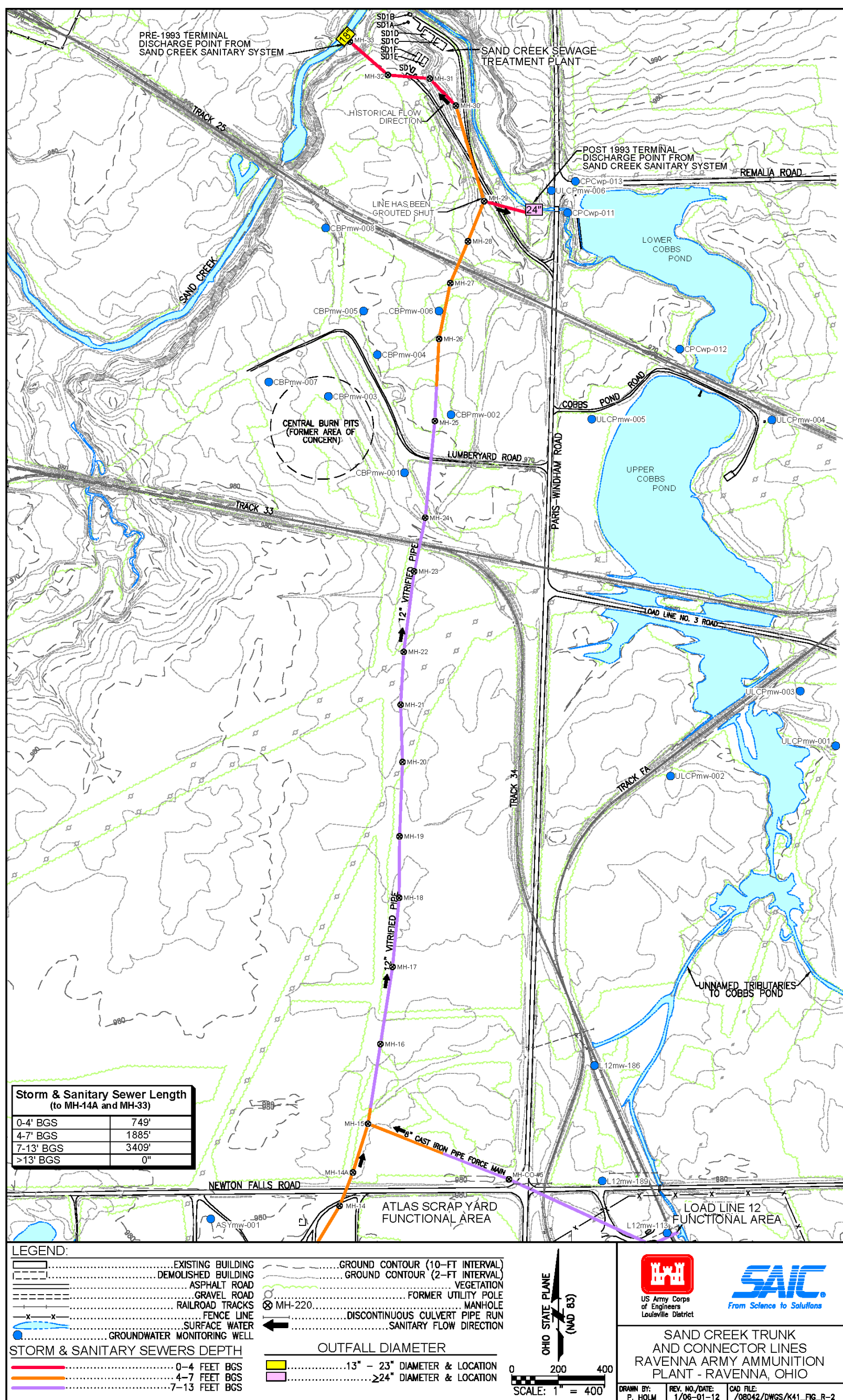


Figure 5-18. Characteristics of the Sanitary Sewers at Load Line 12 Functional Area

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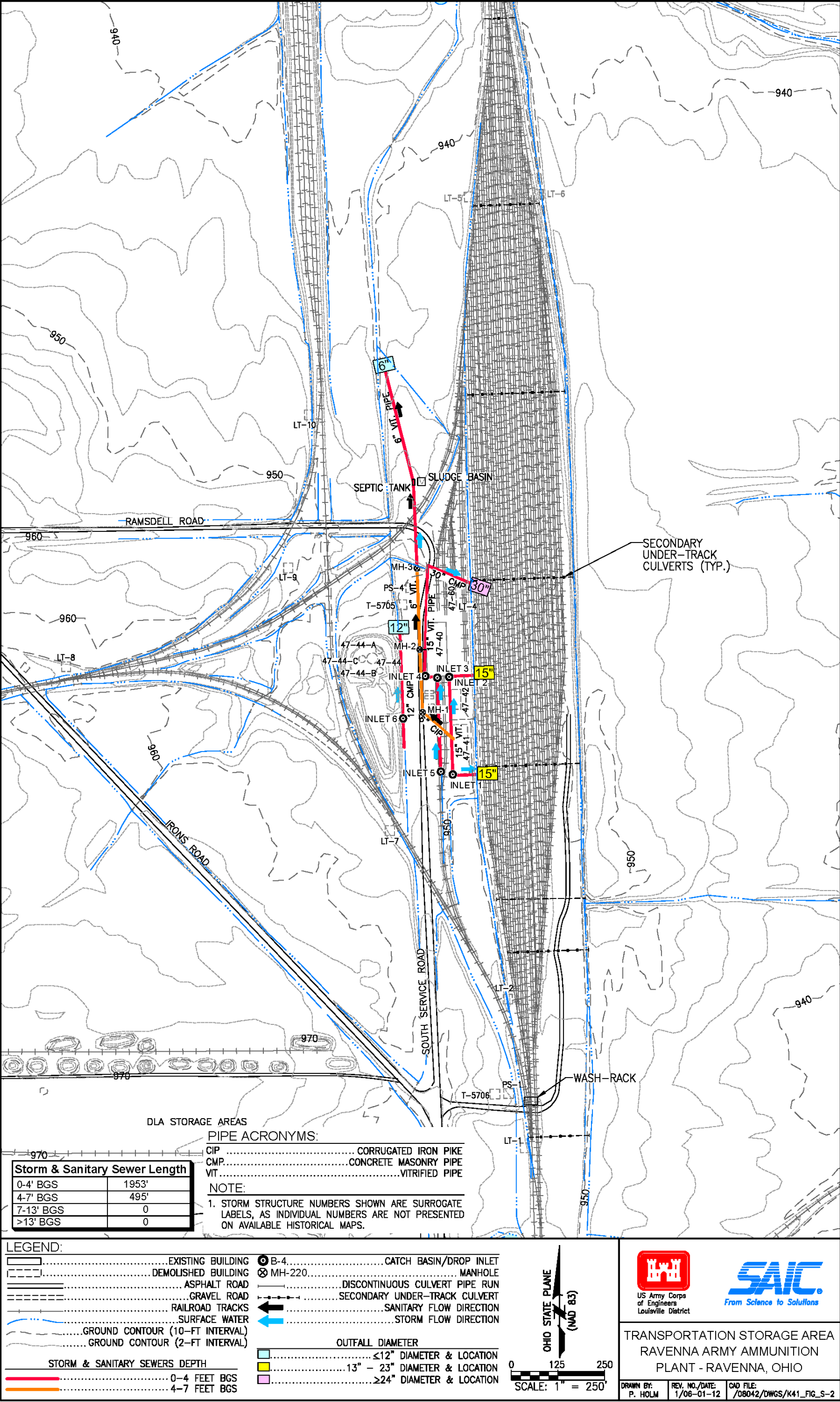


Figure 5-20. Characteristics of the Sanitary and Storm Sewers at the Transportation Storage Area Functional Area

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6.0 CONTAMINANT FATE AND TRANSPORT

Contaminant fate and transport evaluation assesses the potential for chemicals to leach from subsurface sewer media (i.e., sewer sediment and pipe bedding material) at the FAs and impact groundwater beneath the media and downgradient receptor locations. This evaluation is included in the decision-making process to determine whether remedial actions of subsurface sewer media may be necessary to protect groundwater resources. Only SRCs found in the subsurface sewer media are evaluated in the fate and transport assessment for the individual FAs.

Computer-based contaminant fate and transport analyses were performed to predict the rate of contaminant migration through the vadose zone soil to groundwater (i.e., transport media) and to conservatively estimate future contaminant concentrations beneath an FA. Fate and transport modeling was used to simulate vertical transport of chemicals from the subsurface sewer media containing maximum observed SRCs to groundwater, as well as mixing of leachate with the saturated groundwater system beneath the source area (i.e., FA). A summary of the principles of contaminant fate and transport, along with the summary of the fate and transport modeling results for the 19 FAs, are presented in this section.

Section 6.1 describes the physical and chemical properties of all SRCs found in the subsurface sewer media at the 19 FAs. Section 6.2 presents a conceptual model for contaminant fate and transport. Section 6.3 describes modeling approach that was used for the contaminant fate and transport evaluation for the Facility-Wide Sewers. Section 6.4 summarizes the overall results of fate and transport modeling and presents contaminant migration chemicals of concern (CMCOs). The summary and conclusions of the fate and transport analyses are presented in Section 6.5.

6.1 PHYSICAL AND CHEMICAL PROPERTIES OF SITE-RELATED CONTAMINANTS

A list of SRCs from the 19 FAs are presented in Tables 6-1 and 6-2. SRCs were developed in Section 5.0 for the individual FAs. These inorganic (Table 6-1) and organic (Table 6-2) SRCs are in continuous chemical and physical interaction with ambient subsurface environments. The observed distributions of chemical concentrations in the environment are the result of these interactions. These interactions also determine the chemical fate of these material. Chemicals released into the environment are susceptible to several degradation pathways, including hydrolysis, oxidation, reduction, isomerization, photolysis, photo-oxidation, biotransformation, and biodegradation. Transformation products resulting from these processes may behave differently than their parent chemical in the environment.

The migration of chemicals is governed by the physical and chemical properties of the chemicals and the surface and subsurface media through which the chemicals are transferred. In general, chemicals and structures with similar physical and chemical characteristics will show similar patterns of transformation, transport, or attenuation in the environment. Solubility, vapor pressure data, chemical partitioning coefficients, degradation rates, and Henry's Law Constant (HLC) provide information that can be used to evaluate contaminant mobility in the environment. Partitioning coefficients are

1 used to assess the relative affinities of chemicals for solution or solid phase adsorption. However, the
2 synergistic effects of multiple migrating chemicals and the complexity of soil/water interactions,
3 including pH, oxidation-reduction potential (Eh), grain size, and clay mineral variability, are typically
4 unknown.

5
6 The physical properties of the chemicals defined as SRCs in the environmental media are summarized
7 in Tables 6-1 and 6-2. The properties are used to assess the anticipated behavior of each chemical
8 under environmental conditions and are used as input parameters to mathematical models for
9 predicting contaminant mass behavior in the environmental media.

Table 6-1. Physical and Chemical Properties of Inorganic SRCs for the Subsurface Sewer Media at RVAAP

Analyte	K _d (L/kg)	Reference	HLC (atm-m ³ /mol)	Reference	Molecular Weight	Solubility (mg/L)	Reference	Cw (mg/L)	SSL Type	Generic SSL	Reference
<i>Inorganic chemicals</i>											
Aluminum	1.50E+03	a	NA	-	2.70E+01	-	-	3.65E+01	RSL	5.50E+04	d
Antimony	4.50E+01	b	NA	-	1.22E+02	-	-	6.00E-03	MCL	2.70E-01	d
Arsenic	2.90E+01	b	NA	-	7.49E+01	-	-	1.00E-02	MCL	2.90E-01	d
Barium	4.10E+01	b	NA	-	1.37E+02	-	-	2.00E+00	MCL	8.20E+01	d
Beryllium	7.90E+02	b	NA	-	9.01E+00	-	-	4.00E-03	MCL	3.20E+00	d
Cadmium	7.50E+01	b	NA	-	1.12E+02	-	-	5.00E-03	MCL	3.80E-01	d
Chromium	1.90E+01	b	NA	-	5.20E+01	-	-	1.00E-01	MCL	1.80E+05	d
Chromium, hexavalent	1.90E+01	b	NA	-	5.20E+01	-	-	4.30E-05	RSL	8.30E-04	d
Cobalt	5.50E+02	c	NA	-	5.89E+01	-	-	1.10E-02	RSL	4.90E-01	d
Copper	2.20E+01	a	NA	-	6.36E+01	-	-	1.30E+00	MCL	4.60E+01	d
Iron	8.00E+02	c	NA	-	5.59E+01	-	-	2.60E+01	RSL	6.40E+02	d
Lead	5.50E+02	c	NA	-	2.07E+02	-	-	1.50E-02	MCL	1.40E+01	d
Manganese	1.80E+02	c	NA	-	5.49E+01	-	-	8.76E-01	RSL	5.70E+01	d
Mercury	5.20E+01	b	1.14E-02	d	2.01E+02	6.00E-02	d	2.00E-03	MCL	1.00E-01	d
Nickel	6.50E+01	b	NA	-	5.87E+01	-	-	7.30E-01	RSL	4.80E+01	d
Selenium	5.00E+00	b	NA	-	7.90E+01	-	-	5.00E-02	MCL	2.60E-01	d
Silver	8.30E+00	b	NA	-	1.08E+02	-	-	1.80E-01	RSL	1.60E+00	d
Thallium	7.10E+01	b	NA	-	2.04E+02	-	-	2.00E-03	MCL	1.40E-01	d
Vanadium	1.00E+03	b	NA	-	5.09E+01	-	-	2.60E-03	RSL	2.60E+00	d
Zinc	6.20E+01	b	NA	-	6.54E+01	-	-	1.10E+01	RSL	6.80E+02	d
Sulfate	0.00E+00	-	NA	-	9.81E+01	soluble	-	2.50E+02	SMCL	NA	-
Sulfide	0.00E+00	-	NA	-	3.41E+01	soluble	-	NA	NA	NA	-

a Baes and Sharp 1983. "A Proposal for Estimation of Soil Leaching and Leaching Constants for Use in Assessment Models." *Journal of Environmental Quality* 12, pp. 17-28.

b United States Environmental Protection Agency (USEPA) 1996b. Soil Screening Guidance assuming a neutral pH: *Technical Background Document*, May 1996.

c Sheppard and Thibault 1990. "Default soil/liquid partition coefficients, K_{ds}, for four major soil types: a compendium." *Health Physics* 59:471-482.

d USEPA RSL May 2010. Found at: <http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm>

atm-m³/mol = atmospheres relative to mols per cubic meter

L/kg = Liters per kilogram

Cw = target groundwater concentration (either MCL or RSL)

MCL = Clean Water Act Drinking Water Maximum Contaminant Level

HLC = Henry's Law Constant

mg/L = milligrams per liter

K_d = Distribution coefficient

NA = Not Applicable

RSL = USEPA Regional Screening Levels (USEPA 2010)

SMCL = Secondary MCL

SRC = Site-related Contaminant

SSL = Soil Screening Level

Table 6-2. Physical and Chemical Properties of Organic SRCs for the Subsurface Sewer Media at RVAAP

Analyte	K _{oc} (L/kg)	Reference	HLC (atm-m ³ /mol)	Reference	Molecular Weight	Solubility (mg/L)	Reference	Diffusion Coefficient in Air (cm ² /sec)	Reference	Diffusion Coefficient in Water (cm ² /sec)	Reference	C _w (mg/L)	SSL Type	Generic SSL (mg/kg)	Reference
Explosives															
1,3-Dinitrobenzene	3.52E+02	e	4.90E-08	e	1.68E+02	5.33E+02	e	4.85E-02	e	9.21E-06	e	3.70E-03	RSL	3.30E-03	e
1,3,5-Trinitrobenzene	1.68E+03	e	6.50E-09	e	2.13E+02	2.78E+02	e	2.90E-02	e	7.69E-06	e	1.10E+00	RSL	3.90E+00	e
2,4,6-Trinitrotoluene	2.81E+03	e	2.08E-08	e	2.27E+02	1.15E+02	e	2.95E-02	e	7.92E-06	e	2.20E-03	RSL	1.30E-02	e
2,4-Dinitrotoluene	5.76E+02	e	5.40E-08	e	1.82E+02	2.00E+02	e	3.75E-02	e	7.90E-06	e	2.20E-04	RSL	2.90E-04	e
2,6-Dinitrotoluene	5.87E+02	e	7.47E-07	e	1.82E+02	1.82E+02	e	3.70E-02	e	7.76E-06	e	3.70E-02	RSL	5.00E-02	e
4-Amino-2,6-Dinitrotoluene	2.83E+02	e	1.62E-10	e	1.97E+02	3.19E+02	e	5.61E-02	e	6.55E-06	e	7.30E-02	RSL	5.60E-02	e
2-Amino-4,6-Dinitrotoluene	2.83E+02	e	1.62E-10	e	1.97E+02	3.19E+02	e	5.61E-02	e	6.55E-06	e	7.30E-02	RSL	5.60E-02	e
2-Nitrotoluene	3.71E+02	e	5.10E-04	e	1.37E+02	6.50E+02	e	5.88E-02	e	8.67E-06	e	3.10E-04	RSL	2.90E-04	e
3-Nitrotoluene	3.63E+02	e	9.30E-06	e	1.37E+02	5.00E+02	e	5.87E-02	e	8.65E-06	e	3.70E-03	RSL	3.40E-03	e
HMX	5.32E+02	e	8.67E-10	e	2.96E+02	5.00E+00	e	4.28E-02	e	5.00E-06	e	1.80E+00	RSL	2.30E+00	e
Nitrocellulose	1.00E+01	e	3.29E-23	e	3.87E+02	1.00E+06	e	3.58E-02	e	4.18E-06	e	1.10E+05	RSL	2.40E+04	e
Nitroglycerin	1.16E+02	e	8.66E-08	e	2.27E+02	1.38E+03	e	2.90E-02	e	7.74E-06	e	4.00E-03	RSL	1.63E-03	e
Nitroguanidine	2.07E+01	e	4.49E-12	e	1.04E+02	4.40E+03	e	8.59E-02	e	1.00E-05	e	3.70E+00	RSL	8.80E-01	e
PETN	6.48E+02	e	1.20E-11	e	3.16E+02	4.30E+01	e	2.58E-02	e	6.77E-06	e	1.70E-02	RSL	2.50E-02	e
RDX	8.91E+01	e	2.01E-11	e	2.22E+02	5.97E+01	e	3.12E-02	e	8.50E-06	e	6.10E-04	RSL	2.30E-04	e
Semi-volatile Organic Compounds															
1,2-Dichlorobenzene	3.83E+02	e	1.92E-03	e	1.47E+02	1.56E+02	e	5.62E-02	e	8.92E-06	e	6.00E-01	MCL	5.80E-01	e
1,2,4-Trichlorobenzene	1.36E+03	e	1.42E-03	e	1.81E+02	4.90E+01	e	3.96E-02	e	8.40E-06	e	7.00E-02	MCL	2.00E-01	e
1,3-Dichlorobenzene	3.75E+02	RAIS	1.92E-03	RAIS	1.47E+02	1.25E+02	RAIS	5.58E-02	RAIS	8.85E-06	RAIS	NA	-	NA	-
1,4-Dichlorobenzene	3.75E+02	e	2.41E-03	e	1.47E+02	8.13E+01	e	5.50E-02	e	8.68E-06	e	7.50E-02	MCL	7.20E-02	e
2-Methylnaphthalene	2.48E+03	e	5.18E-04	e	1.42E+02	2.46E+01	e	5.24E-02	e	7.78E-06	e	1.50E-01	RSL	7.50E-01	e
2,4,6-Trichlorophenol	1.78E+03	e	2.60E-06	e	1.97E+02	8.00E+02	e	3.10E-02	e	8.10E-06	e	6.10E-03	RSL	2.30E-02	e
3+4-Methylphenol (Cresols)	3.07E+02	e	1.20E-06	e	1.08E+02	2.59E+04	e	8.37E-02	e	9.78E-06	e	9.30E-01	RSL	7.60E-01	e
4-Chlorobenzenamine	1.13E+02	e	1.16E-06	e	1.28E+02	3.90E+03	e	7.04E-02	e	1.03E-05	e	3.40E-04	RSL	1.40E-04	e
Acenaphthene	5.03E+03	e	1.84E-04	e	1.54E+02	3.90E+00	e	5.06E-02	e	8.33E-06	e	2.20E+00	RSL	2.20E+01	e
Acenaphthylene ^a	7.40E+03	f	1.19E-05	e	1.52E+02	1.61E+01	RAIS	4.50E-02	RAIS	6.98E-06	RAIS	1.10E+00	RSL	1.20E+02	e
Anthracene	1.64E+04	e	5.56E-05	e	1.78E+02	4.34E-02	e	3.90E-02	e	7.85E-06	e	1.10E+01	RSL	3.60E+02	e
Benz(a)anthracene	1.77E+05	e	1.20E-05	e	2.28E+02	9.40E-03	e	5.09E-02	e	5.94E-06	e	2.90E-05	RSL	1.00E-02	e
Benz(a)pyrene	5.87E+05	e	4.57E-07	e	2.52E+02	1.62E-03	e	4.76E-02	e	5.56E-06	e	2.00E-04	MCL	2.40E-01	e

Table 6-2. Physical and Chemical Properties of Organic SRCs for the Subsurface Sewer Media at RVAAP (continued)

Analyte	K _{oc} (L/kg)	Reference	HLC (atm·m ³ /mol)	Reference	Molecular Weight	Solubility (mg/L)	Reference	Diffusion Coefficient in Air (cm ² /sec)	Reference	Diffusion Coefficient in Water (cm ² /sec)	Reference	Cw (mg/L)	SSL Type	Generic SSL (mg/kg)	Reference
Benzo(b)fluoranthene	5.99E+05	e	6.57E-07	e	2.52E+02	1.50E-03	e	4.76E-02	e	5.56E-06	e	2.90E-05	RSL	3.50E-02	e
Benzo(g,h,i)perylene ^b	1.07E+07	f	1.40E-07	f	2.76E+02	2.60E-04	RAIS	NA	RAIS	NA	RAIS	1.10E+00	RSL	1.20E+02	e
Benzo(k)fluoranthene	5.87E+05	e	5.84E-07	e	2.52E+02	8.00E-04	e	4.76E-02	e	5.56E-06	e	2.90E-04	RSL	3.50E-01	e
Bis(2-ethylhexyl)phthalate	1.20E+05	e	2.70E-07	e	3.91E+02	2.70E-01	e	1.73E-02	e	4.18E-06	e	6.00E-03	RSL	1.40E+00	e
Butyl benzyl phthalate	7.16E+03	e	1.26E-06	e	3.12E+02	2.69E+00	e	2.08E-02	e	5.17E-06	e	3.50E-02	RSL	5.10E-01	e
Carbazole	9.16E+03	RAIS	1.53E-08	RAIS	1.67E+02	1.80E+00	RAIS	6.26E-02	RAIS	7.31E-06	RAIS	NA	-	NA	-
Chrysene	1.81E+05	e	5.23E-06	e	2.28E+02	2.00E-03	e	2.61E-02	e	6.75E-06	e	2.90E-03	RSL	1.10E+00	e
Di-n-butyl phthalate	1.16E+03	e	1.81E-06	e	2.78E+02	1.12E+01	e	2.14E-02	e	5.33E-06	e	3.70E+00	RSL	9.20E+00	e
Di-n-octyl phthalate	9.98E+08	f	3.45E-14	f	3.91E+02	3.00E+00	f	3.50E-02	-	NA	-	NA	-	NA	-
Dibenz(a,h)anthracene	1.91E+06	e	1.41E-07	e	2.78E+02	2.49E-03	e	4.46E-02	e	5.21E-06	e	2.90E-06	RSL	1.10E-02	e
Dibenzofuran	9.16E+03	e	2.13E-04	e	1.68E+02	3.10E+00	e	4.10E-02	e	7.38E-06	e	3.70E-02	RSL	6.80E-01	e
Diethyl phthalate	1.05E+02	e	6.10E-07	e	2.22E+02	1.08E+03	e	2.61E-02	e	6.72E-06	e	2.90E+01	RSL	1.20E+01	d
Fluoranthene	5.55E+04	e	8.86E-06	e	2.02E+02	2.60E-01	e	2.76E-02	e	7.18E-06	e	1.50E+00	RSL	1.60E+02	e
Fluorene	9.16E+03	e	9.62E-05	e	1.66E+02	1.69E+00	e	4.40E-02	e	7.89E-06	e	1.50E+00	RSL	2.70E+01	e
Indeno(1,2,3-cd)pyrene	1.95E+06	e	3.48E-07	e	2.76E+02	1.90E-04	e	4.48E-02	e	5.23E-06	e	2.90E-05	RSL	1.20E-01	e
Naphthalene	1.54E+03	e	4.40E-04	e	1.28E+02	3.10E+01	e	6.05E-02	e	8.38E-06	e	6.20E-03	RSL	4.70E-04	e
Phenanthrene ^c	1.82E+04	f	3.93E-05	f	1.78E+02	1.15E+00	RAIS	3.45E-02	RAIS	6.69E-06	RAIS	1.10E+00	RSL	1.20E+02	e
Pyrene	5.43E+04	e	1.19E-05	e	2.02E+02	1.35E-01	e	2.78E-02	e	7.25E-06	e	1.10E+00	RSL	1.20E+02	e
Volatile Organic Compounds															
Acetone	2.36E+00	e	3.50E-05	e	5.81E+01	1.00E+06	e	1.06E-01	e	1.15E-05	e	2.20E+01	RSL	4.50E+00	e
2-Butanone (MEK)	4.51E+00	e	5.69E-05	e	7.21E+01	2.23E+05	e	9.14E-02	e	1.02E-05	e	7.10E+00	RSL	1.50E+00	e
Benzene	1.46E+02	e	5.55E-03	e	7.81E+01	1.79E+03	e	8.95E-02	e	1.03E-05	e	5.00E-03	MCL	2.60E-03	e
Dimethylbenzene (xylene, mixture)	3.83E+02	e	5.18E-03	e	1.06E+02	1.06E+02	e	8.47E-02	e	9.90E-06	e	1.00E+01	MCL	9.80E+00	e
Ethylbenzene	4.46E+02	e	7.88E-03	e	1.06E+02	1.69E+02	e	6.85E-02	e	8.46E-06	e	7.00E-01	MCL	7.80E-01	e
Methylene chloride	2.17E+01	e	3.25E-03	e	8.49E+01	1.30E+04	e	9.99E-02	e	1.25E-05	e	5.00E-03	MCL	1.30E-03	e
Toluene	2.34E+02	e	6.64E-03	e	9.21E+01	5.26E+02	e	7.78E-02	e	9.20E-06	e	1.00E+00	MCL	6.90E-01	e
Pesticides/PCBs															
4,4'-DDD	1.18E+05	e	6.60E-06	e	3.20E+02	9.00E-02	e	4.06E-02	e	4.74E-06	e	2.80E-04	RSL	6.60E-02	e
BHC	2.81E+03	e	5.14E-06	e	2.91E+02	2.40E-01	e					3.70E-05	RSL	2.20E-04	e
4,4'-DDE	1.18E+05	e	4.16E-05	e	3.18E+02	4.00E-02	e	4.08E-02	e	4.76E-06	e	2.00E-04	RSL	4.70E-02	e

Table 6-2. Physical and Chemical Properties of Organic SRCs for the Subsurface Sewer Media at RVAAP (continued)

Analyte	K _{oc} (L/kg)	Reference	HLC (atm-m ³ /mol)	Reference	Molecular Weight	Solubility (mg/L)	Reference	Diffusion Coefficient in Air (cm ² /sec)	Reference	Diffusion Coefficient in Water (cm ² /sec)	Reference	Cw (mg/L)	SSL Type	Generic SSL (mg/kg)	Reference
4,4'-DDT	1.69E+05	e	8.32E-06	e	3.54E+02	5.50E-03	e	3.79E-02	e	4.43E-06	e	2.00E-04	RSL	6.70E-02	e
Dieldrin	2.01E+04	e	1.00E-05	e	3.81E+02	1.95E-01	e	2.33E-02	e	6.01E-06	e	4.20E-06	RSL	1.70E-04	e
Endosulfan I	6.76E+03	e	6.50E-05	e	4.07E+02	3.25E-01	e	2.25E-02	e	5.76E-06	e	2.20E-01	RSL	3.00E+00	e
PCB-1254	1.31E+05	e	2.83E-04	e	3.26E+02	4.30E-02	e	4.01E-02	e	4.68E-06	e	3.40E-05	RSL	8.80E-03	e
PCB-1260	1.31E+05	e	2.83E-04	e	3.95E+02	1.44E-02	e	3.53E-02	e	4.12E-06	e	3.40E-05	RSL	8.80E-03	e
alpha-Chlordane ^d	3.38E+04	e	4.86E-05	e	4.10E+02	5.60E-02	e	3.44E-02	e	4.02E-06	e	2.00E-03	MCL	1.40E-01	e
gamma-Chlordane ^d	3.38E+04	e	4.86E-05	e	4.10E+02	5.60E-02	e	3.44E-02	e	4.02E-06	e	2.00E-03	MCL	1.40E-01	e

a Pyrene was used as a surrogate for acenaphthylene

b Pyrene was used as a surrogate for benzo(g,h,i)perylene

c Pyrene was used as a surrogate for phenanthrene

d Chlordane was used as a surrogate for gamma-chlordane

BHC = Beta-hexachlorobenzene

Cw = Target groundwater concentration (either MCL or RSL)

DDD = Dichlorodiphenyldichloroethane

DDE = Dichlorodiphenyldichloroethylene

DDT = Dichlorodiphenyltrichloroethane

HLC = Henry's Law Constant

HMX = Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine

K_{oc} = Organic carbon partition coefficient

MCL = Clean Water Act Drinking Water Maximum Contaminant Level

NA = Not Applicable

PCB = Polychlorinated Biphenyl

PETN = Pentaerythritol Tetranitrate

RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine

RSL = USEPA Regional Screening Level (USEPA 2010)

SRC = Site-related Contaminant

SSL = Soil Screening Level

Specified References:

e United States Environmental Protection Agency (USEPA) RSL May 2010. Found at: <http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm>

f USEPA 1994. Risk Reduction Engineering Laboratory (RREL) Treatability Database, Ver. 5.0, Office of Research and Development, Cincinnati, OH.

RAIS = Risk Assessment Information System

6.1.1 Chemical Factors Affecting Fate and Transport

The water solubility of a chemical is a measure of the saturated concentration of the chemical in water at a given temperature and pressure. The tendency for a chemical to be transported by groundwater is directly related to its solubility and is inversely related to both its tendencies to adsorb to soil and to volatilize from water (OGE 1988). Chemicals with high water solubilities tend to desorb from soil, are less likely to volatilize from water, and are susceptible to biodegradation. The water solubility of a chemical varies with temperature, pH, and the presence of other dissolved chemicals (including organic carbon and humic acids).

The octanol-water partition coefficient (K_{ow}) can be used to estimate the tendency for a chemical to partition between environmental phases of different polarities. The K_{ow} is a laboratory-determined ratio of the concentration of a chemical in the n-octanol phase of a two-phase system to the concentration in the water phase. Chemicals with $\log K_{ow}$ values less than 1 are highly hydrophilic, while chemicals with $\log K_{ow}$ values greater than 4 will partition to soil particles (Lyman et al. 1990).

The water/organic carbon partition coefficient (K_{oc}) is a measure of the tendency of an organic chemical to partition between water and organic carbon in the soil. The K_{oc} is defined as the ratio of the absorbed chemical per unit weight of organic carbon to the aqueous solute concentration. This coefficient can be used to estimate the degree to which an organic chemical will adsorb to soil and, thus, not migrate with groundwater. The higher the K_{oc} value, the greater is the tendency of the chemical to partition into soil (OGE 1988). The sorption coefficient (K_d) is calculated by multiplying the K_{oc} value by the fraction of organic carbon in the soil.

Vapor pressure is a measure of the pressure at which a chemical and its vapor are in equilibrium. The value can be used to determine the extent to which a chemical would travel in air, as well as the rate of volatilization from soil and solution (OGE 1988). In general, chemicals with vapor pressures lower than 10^{-7} mm mercury will not be present in the atmosphere or air spaces in soil in significant amounts, while chemicals with vapor pressures higher than 10^{-2} mm mercury will exist primarily in the air (Dragun 1988).

The HLC value for a chemical is a measure of the ratio of the chemical's vapor pressure to its aqueous solubility. The HLC value can be used to make general predictions about the chemical's tendency to volatilize from water. Substances with HLC values less than 10^{-7} atm-m³/mol will generally volatilize slowly, while chemicals with a HLC greater than 10^{-3} atm-m³/mol will volatilize rapidly (Lyman et al. 1990).

6.1.2 Biodegradation

Organic chemicals with differing chemical structures will biodegrade at different rates. Primary biodegradation consists of any biologically-induced structural change in an organic chemical. Complete biodegradation is the biologically-mediated degradation of an organic chemical into carbon

dioxide, water, oxygen, and other metabolic inorganic products (Dragun 1988). The first order biodegradation rate of an organic chemical is proportional to the concentration:

$$-dC/dt = kC \quad (\text{Equation 6-1})$$

Where:

C = concentration

t = time

k = biodegradation rate constant = $\ln 2 / t_{1/2}$

$t_{1/2}$ = biodegradation half-life

The biodegradation half-life is the time necessary for half of the chemical to degrade. The biodegradation rate of an organic chemical is generally dependent on the presence and population size of soil microorganisms that are capable of degrading the chemical. However, it should be noted that in order to develop conservative results with respect to groundwater impact, the fate and transport analyses for the FAs do not account for any loss due to biodegradation.

6.1.3 Inorganic Chemicals

Inorganic chemicals detected in soil samples are associated with both the aqueous phase and with leachable metal ions on soil particles. The transport of these material from unsaturated soil to the underlying water table is controlled by the physical processes of precipitation, percolation, chemical interaction with the soil, and downward transport of metal ions by continued percolation. The chemistry of inorganic interaction with percolating precipitation and varying soil conditions is complex and includes numerous chemical transformations that may result in altered oxidation states, ion exchange, adsorption, precipitation, or complexation. The chemical reactions, which are affected by environmental conditions (e.g., pH, oxidation/reduction conditions, type and amount of organic matter, clay content, and the presence of hydrous oxides), may act to enhance or reduce the mobility and toxicity of the metal ions. In general, these reactions are reversible and add to the variability commonly observed in distributions of inorganic chemicals in soil.

The chemical form of an inorganic chemical determines its solubility and mobility in the environment; however, chemical speciation is complex and difficult to delineate in routine laboratory analysis. Inorganic chemicals in soil are commonly found in several forms, including dissolved concentrations in soil pore water, metal ions occupying exchange sites on inorganic soil chemicals (adsorbed to inorganic soil chemicals), metal ions associated with insoluble organic matter, precipitated inorganic chemicals as pure or mixed solids, and metal ions present in the structure of primary or secondary minerals.

The dissolved (aqueous) fraction and its equilibrium sorbed fraction are of primary importance when considering the migration potential of metals through soil. Of the inorganic chemicals that are likely to form, chlorides, nitrates, and nitrites are commonly the most soluble. Sulfate, carbonate, and hydroxides generally have low to moderate solubility. Soluble chemicals are transported in aqueous form subject to attenuation, whereas less soluble chemicals remain as a precipitate and limit the

overall dissolution of the metal ions. The solubility of the metal ions is also regulated by ambient chemical conditions, including pH and oxidation/reduction.

The attenuation of metal ions in the environment can be estimated numerically using the retardation factor (R), dispersion in higher flow systems (high conductivity environments), and diffusion in low conductivity environments. R defines the extent to which the velocity of the contaminant is slowed, which is largely derived from K_d . The retardation factor is calculated using the following equation:

$$R = 1 + (K_d \rho_b) / \theta_w \quad (\text{Equation 6-2})$$

Where:

ρ_b = the soil bulk dry density (g/cm^3)

θ_w = soil moisture content (dimensionless)

Metal ion concentrations in the environment do not attenuate by natural or biological degradation because of the low volatility and solubility of the ions. Inorganic chemicals may be biotransformed or bioconcentrated through microbial activity.

6.1.4 Organic Chemicals

Organic chemicals, such as SVOCs or VOCs, detected in soil may be transformed or degraded in the environment by various processes, including hydrolysis, oxidation/reduction, photolysis, volatilization, biodegradation, or biotransformation. The half-life of organic chemicals in the transport media can vary from minutes to years, depending on environmental conditions and the structures of the chemicals. Some types of organic chemicals are very stable, and degradation rates can be very slow (e.g., characterized by half-lives on the order of years). Organic degradation may either enhance (through the production of more toxic byproducts) or reduce (through concentration reduction) the toxicity of a chemical in the environment.

6.1.5 Explosives-Related Chemicals

Several explosive chemicals were detected in subsurface sewer media at multiple FAs. Microbiological and photochemical transformation may affect the fate and transport of explosive chemicals in the environment. For example, based on the results of culture studies involving the removal of TNT (USABRDL 1989) by activated sludge microorganisms, it has been concluded that TNT undergoes biotransformation but not biodegradation (USABRDL 1989). The biotransformation of TNT occurs with the microbial reduction of the nitro groups, typically under anaerobic conditions. Beneficial bacteria in these reactions include *pseudomonas*, *escherichia*, *bacillus*, *citrobacter*, *enterobacter*, *klebsiella*, *veillonella*, and *clostridium* (USACHPPM 2000). It has been found that anaerobic metabolism occurs in two stages (Funk et al. 1993). The first stage is the reductive stage in which TNT is reduced to its amino derivatives. In the second stage, degradation to non-aromatic products begins after the reduction of the third nitro group. The biotransformation rate of TNT has been found to be rapid at most sites (ERDC 2007) and may be increased with the presence of carbon (USACHPPM 2000). Fungi and photolysis can also biotransform TNT. The predominant

1 transformation products due to photolysis of TNT are 1,3,5-TNB; 4,6-dinitroanthranil;
2 2,4,6-trinitrobenzaldehyde; and 2,4,6-trinitrobenzotrinitrile (USACHPPM 2000). The biotransformation
3 pathway for TNT is shown in Figure 6-1 (Kaplan and Kaplan 1982).

4
5 The biotransformation of 2,4-DNT has been systematically studied in laboratory cell cultures. The
6 biotransformation pathway is shown in Figure 6-2 (McCormick, et al. 1978). The reduction products
7 include the same amino and azoxy derivatives as observed with TNT biotransformation. As with
8 TNT and DNT, the principal mode of microbial transformation of the nitroaromatic compounds TNB
9 and 1,3-dinitrobenzene (DNB) is reduction of nitro groups to form amino groups. TNB is a
10 photolytic product of TNT, but will not undergo further photolysis. TNB will also resist hydrolysis.
11 The breakdown of TNB is primarily through microbial degradation (USACHPPM 2001a).

12
13 Limited information exists regarding biotransformation or biodegradation of RDX and HMX. RDX
14 has a natural degradation rate typically in the range of months but may take years in more arid
15 environments (ERDC 2007). One pilot study conducted by USACE (USACE 2004e) evaluated
16 treatment of pink water waste using an anaerobic, fluidized-bed, granular activated carbon bioreactor
17 indicated RDX biodegradation in the presence of ethanol. Such data may be useful for evaluating
18 potential use of enhanced bioremediation as a remedial option. Figure 6-3 (McCormick et al. 1981)
19 shows the biotransformation pathway for RDX. A conservative biodegradation rate of 5.00E-04 per
20 day was used for RDX (ANRCP 1999). The biotransformation, primarily by anaerobic degradation
21 (ERDC 2007), of HMX occurs at a slow rate in the environment (USACHPPM 2001b). HMX is
22 primarily broken down by photolysis and has a photolytic rate constant of 0.15 days (USEPA 1988b).
23 Breakdown products of HMX include nitrate, nitrite, and formaldehyde (USACHPPM 2001b).
24 Figure 6-4 (ATSDR 1997) shows the biotransformation pathway for HMX.

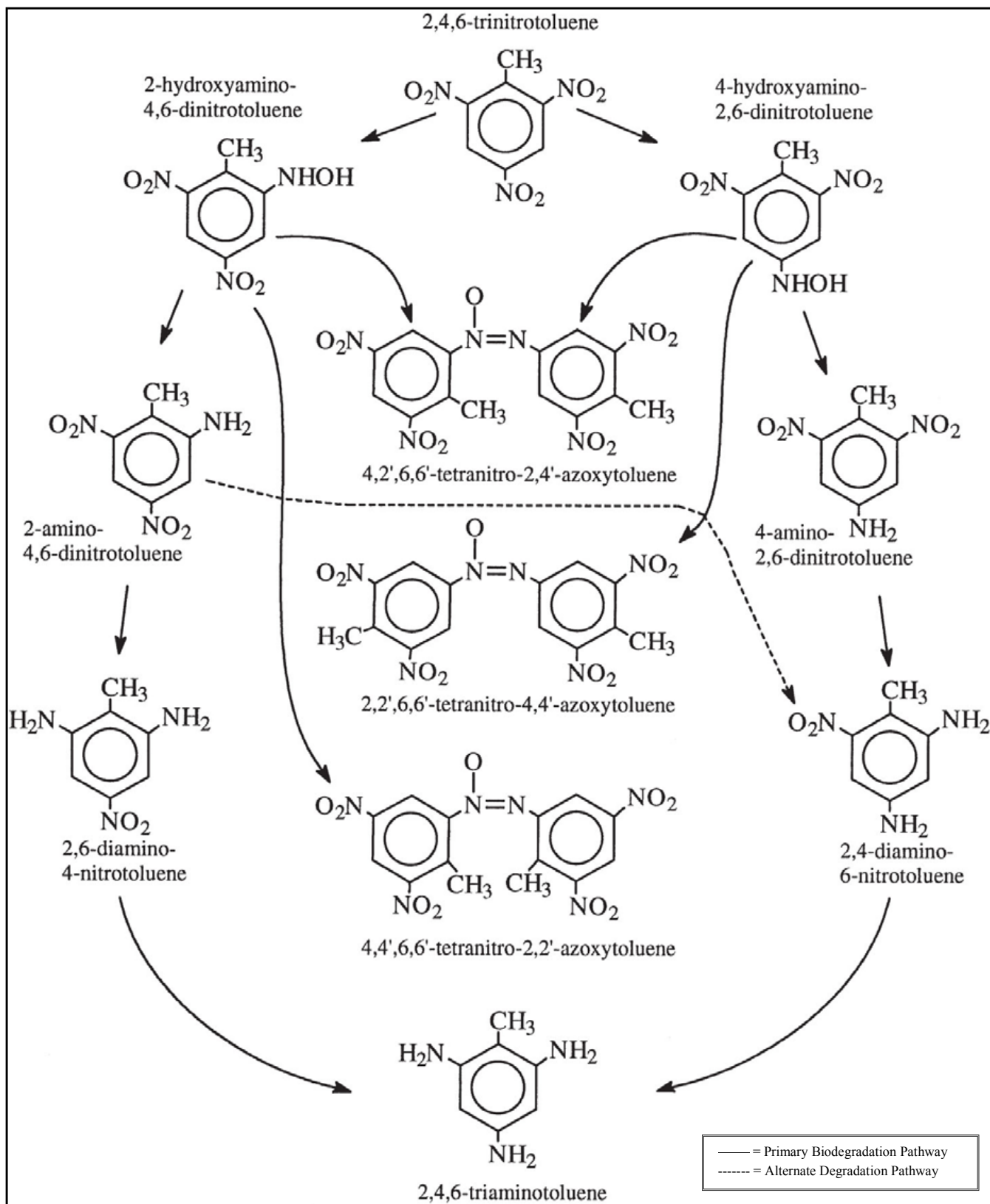


Figure 6-1. TNT Biotransformation Pathway

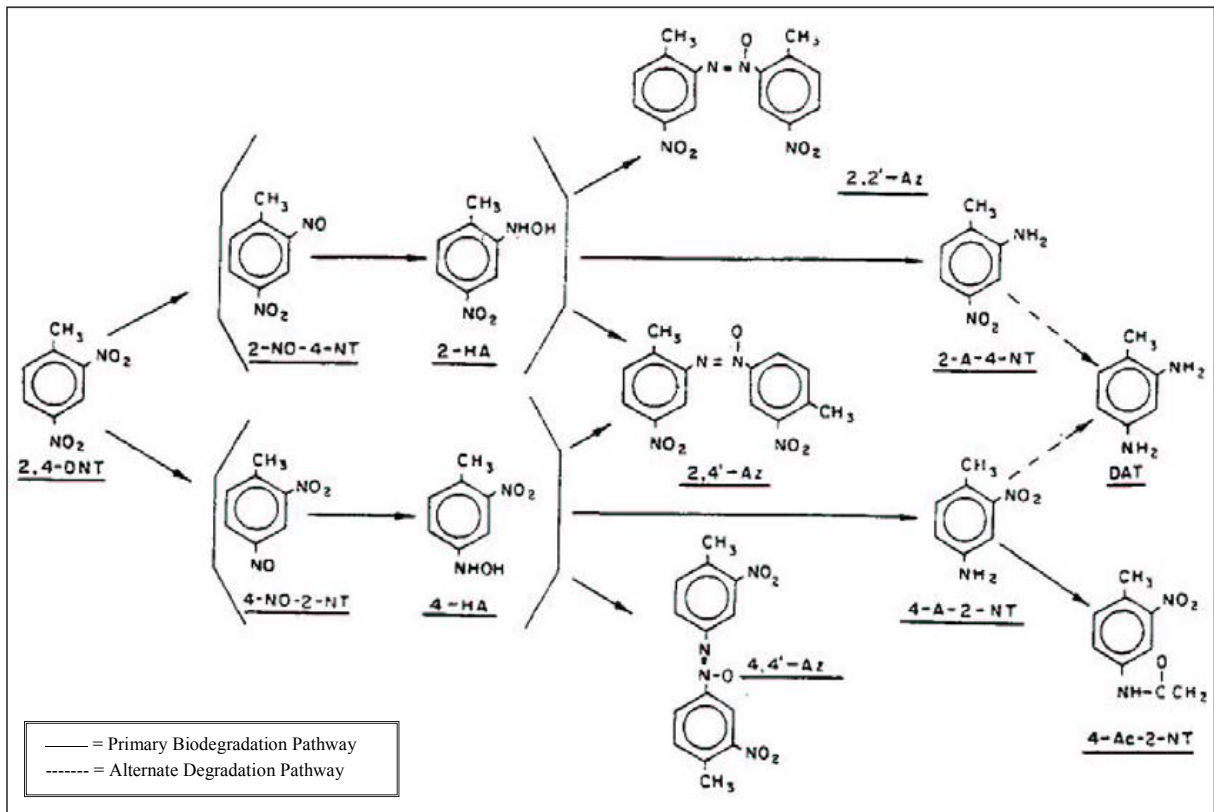


Figure 6-2. 2,4-DNT Biotransformation Pathway

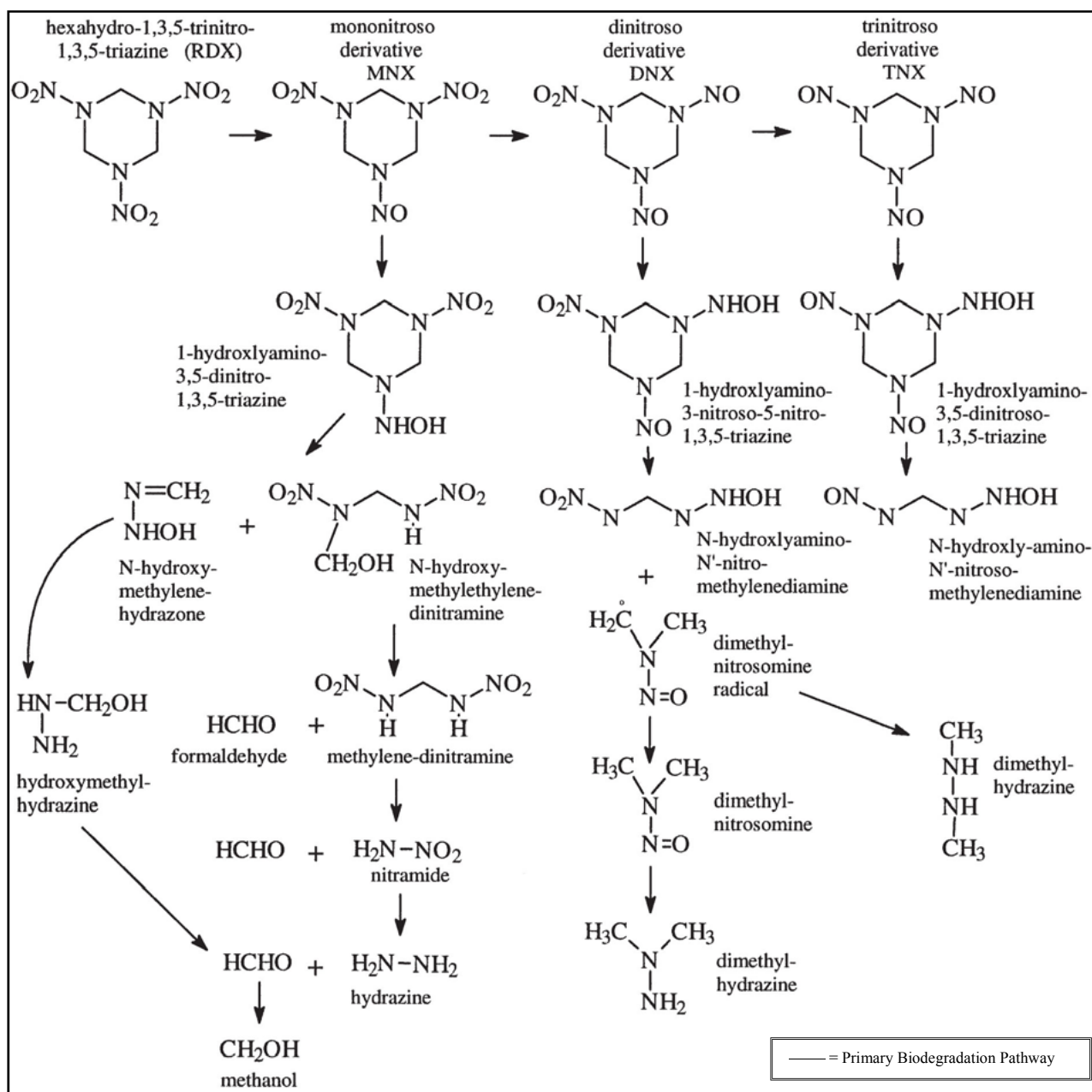


Figure 6-3. RDX Biotransformation Pathway

6.2 CONCEPTUAL MODEL FOR FATE AND TRANSPORT

The CSM, which defines the framework for fate and transport modeling, describes conditions at the FAs, including the contaminant sources, surface and subsurface hydrogeologic conditions, contaminant migration and pathways, and the contaminant release mechanisms.

Site conditions described in Sections 2.0 through Section 5.0 include contaminant source information, the surrounding geologic and hydrologic conditions, and the magnitude of SRCs and their current spatial distribution. Information from the preliminary CSM presented in Section 3.7 and the nature and extent evaluation in Section 5.0 were used to develop the CSM for fate and transport modeling by identifying SRCs and migration pathways. The CSM is based on information and data collected for historical investigations, this RI report, and informed assumptions about the FA. Assumptions contained in the CSM are reiterated throughout this section. The better the information and the greater the accuracy of the assumptions, the more accurately the CSM describes the FA and the more reliable the fate and transport modeling predictions can be. A summary of the salient elements of the CSM that apply to fate and transport modeling are summarized below.

6.2.1 Contaminant Sources

No primary contaminant sources are located at the FAs. Secondary sources (contaminated media) identified in previous investigations and further characterized during the Facility-Wide Sewers RI are described below. Based on previous characterizations, contaminated sewer sediment and water located within the sewer pipe may represent a potential secondary source of contamination to groundwater (vertical migration) or surface water (lateral migration to the nearest surface water body). Pipe bedding material, defined as the earthen material immediately underlying the sewer pipes, is also a potential secondary source of contaminants. Releases of contaminated sewer sediment and water to the underlying pipe bedding material may occur through cracks and joint separations that have developed as a result of deterioration of the pipes with age. The percolation of sewer water and sediment to the underlying material is a primary migration pathway for contamination to leave an FA and migrate vertically to the subsurface soil.

6.2.2 Hydrogeology

Descriptions of FA-specific hydrogeology as applicable to subsurface sewer media is provided in Section 3.2 of each FAE. A generalized discussion of the facility's hydrology is presented in Section 3.4 and is briefly summarized here.

- The topography of RVAAP is gently undulating, with an overall decrease in ground elevation from a topographic high of approximately 1220 ft amsl in the far western portion of the facility to low areas of approximately 930 ft amsl in the far eastern portion of the facility.
- The thickness of the unconsolidated interval at RVAAP ranges from thin to absent in the eastern and northeastern portion of RVAAP to an estimated 150 ft in the central portion of the facility.

1 The groundwater table occurs within the unconsolidated zone in many areas of the facility.
2 Because of the heterogeneous nature of the unconsolidated glacial material, groundwater flow
3 patterns are difficult to determine with a high degree of accuracy.
4

- 5 • Vertical recharge from precipitation likely occurs via infiltration along root zones, desiccation
6 cracks, and partings within the soil column. Laterally, most groundwater flow likely follows
7 topographic contours and stream drainage patterns, with preferential flow along pathways (e.g.,
8 sand seams, channel deposits, or other stratigraphic discontinuities) having higher permeabilities
9 than surrounding clay or silt-rich material. This is evident on the facility-wide potentiometric
10 surface map (Figure 3-3), which was developed using the water level data of the unconsolidated
11 interval collected in 2010.
12
- 13 • Within bedrock units at RVAAP, the principle water-bearing aquifer is the Sharon
14 Sandstone/Conglomerate. Depending on the existence and depth of overburden, the Sharon
15 Sandstone/Conglomerate ranges from an unconfined to a leaky artesian aquifer. The bedrock
16 potentiometric map (Figure 3-4) shows a more uniform and regional eastward flow direction than
17 the unconsolidated zone because it is not as affected by local surface topography.
18

19 **6.2.3 Contaminant Release Mechanisms and Migration Pathways**

20

21 Leaching of sewer sediment and pipe bedding material chemicals to groundwater, with subsequent
22 lateral migration to a surface water receptor, represents a potential contaminant release mechanism
23 and migration pathway. Groundwater discharge to surface water features (e.g., via base flow to
24 streams or springs) may occur at FAs. Potential groundwater discharge locations, where present, are
25 further evaluated per FA in Section 6.0 of each FAE. Groundwater was not sampled or evaluated as
26 part of this report.
27

28 One of the principal migration pathways at the FAs is percolation through the unsaturated soil to the
29 water table (i.e., vertical leaching of chemicals from soil/sediment into groundwater). However,
30 because of the very heterogeneous nature of the unconsolidated glacial material, groundwater flow
31 patterns within the unconsolidated soil are difficult to predict. Precipitation that does not leave an FA
32 as surface runoff percolates into the subsurface. Some of the infiltrating water leaves this
33 environment via evapotranspiration after little or no vertical migration. The remainder of the water
34 percolates into the water table. The rate of percolation is controlled by soil cover, ground slope,
35 saturated conductivity of the soil, and meteorological conditions. Figure 6-5 illustrates the
36 contaminant migration conceptual model.

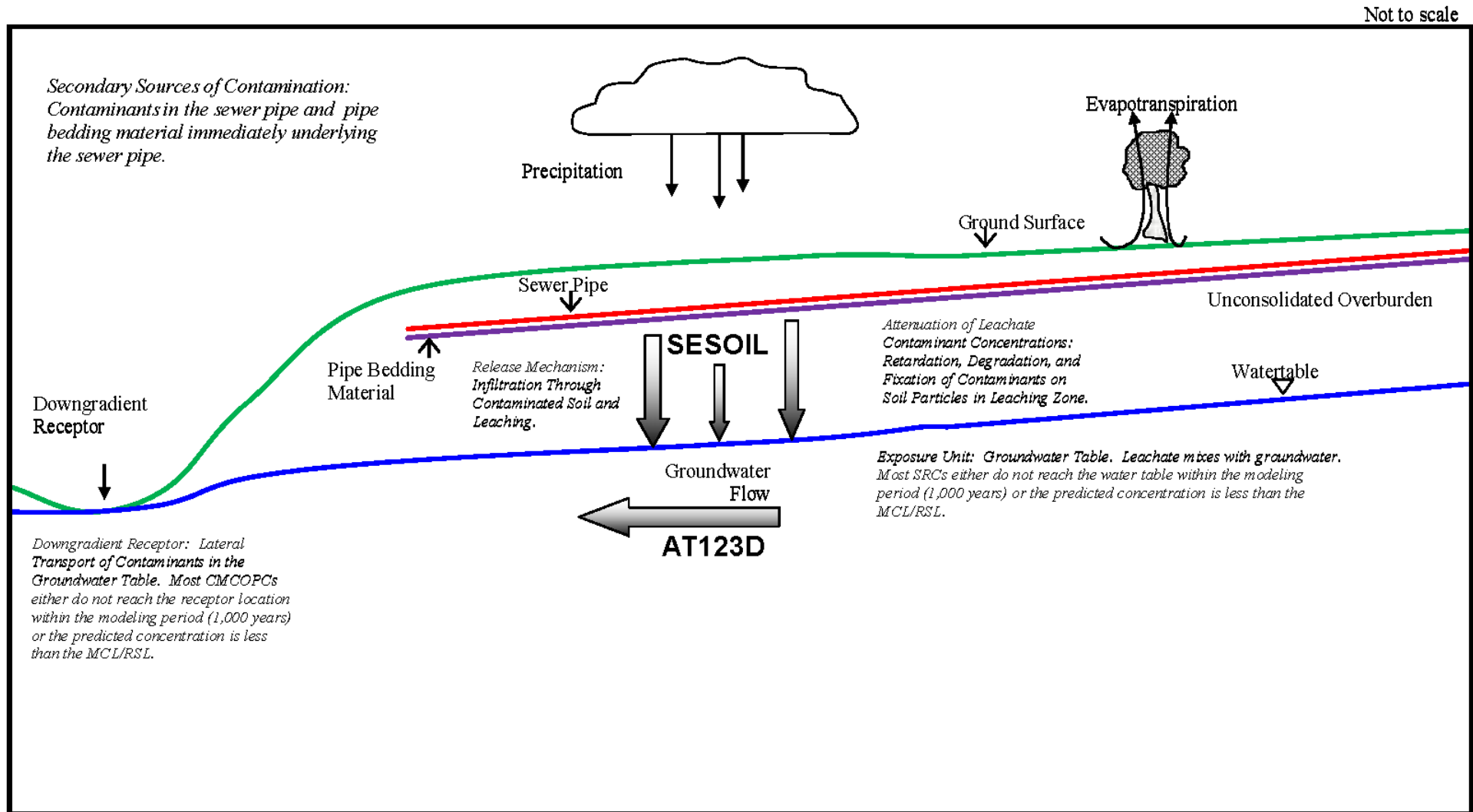


Figure 6-5. Contaminant Migration Conceptual Model

1 Once the contaminant leachate percolates through the soil and reaches the water table, it migrates
2 with the local groundwater and discharges at the downgradient streams. Groundwater flow likely
3 occurs along preferential pathways (e.g., sand seams, channel deposits, or other stratigraphic
4 discontinuities) having higher permeabilities. For inorganic chemicals, lateral migration through
5 groundwater is very limited due to their high retardation by the bedrock material (USACE 2003a).

6
7 Additional factors that affect the leaching rate include a chemical's solubility, sorption capacity
8 (expressed by the K_d), and the amount of percolation. Insoluble chemicals will precipitate out of
9 solution in the subsurface or remain in insoluble forms with little leaching.

10
11 Another factor that affects whether a chemical will reach the water table through percolation of
12 precipitation is the chemical's rate of decay. Most of the organic chemicals decay at characteristic
13 rates that are proportional to the chemical's half-life. For a given percolation rate, those chemicals
14 with long half-lives have a greater potential for contaminating groundwater than do those with shorter
15 half-lives. For this analysis, the rate of decay/half-life was not considered.

16
17 Contaminant releases through gaseous emissions and airborne particulates are not significant for this
18 media because of the subsurface nature of the media. Also, the areas are generally vegetated, located
19 in a humid and temperate climate, and soil moisture content is typically high, which prevents
20 dust-borne contaminant migration. Therefore, there is likely little to no gaseous emission, and
21 contaminant levels in the air pathway are minor to nonexistent.

22 23 **6.2.4 Water Budget**

24
25 The potential for contaminant transport begins with precipitation. Percolation is the driving
26 mechanism for leaching of soil/sediment chemicals to groundwater. The actual amount of rainwater
27 available for flow and percolation to groundwater is highly variable and depends on soil type and
28 climatic conditions. A water balance calculation can be used as a tool to quantitatively account for all
29 components of the hydrologic cycle. The quantified elements of the water balance are used for inputs
30 to the soil leaching and groundwater transport models discussed later. The components of a simple
31 steady-state water balance model include precipitation (P), evapotranspiration (ET), surface runoff
32 (Sr), and groundwater recharge or percolation (q). These terms are defined as follows:

$$33 \qquad \qquad \qquad P = ET + Sr + q \qquad \qquad \qquad \text{(Equation 6-3)}$$

34
35 \qquad \qquad \qquad \text{or}

$$36 \qquad \qquad \text{Rainwater available for flow} = Sr + q = P - ET \qquad \qquad \text{(Equation 6-4)}$$

37
38 It is expected that loss of runoff also occurs in the form of evaporation. The remaining water after
39 runoff and evaporation is available for percolation, which includes loss to the atmosphere by
40 evapotranspiration. The water balance estimations were developed using the Hydrologic Evaluation
41 of Landfill Performance (HELP) model (USEPA 1994). See Table 6-3 for parameters used in the
42 HELP model to develop the water budget estimates used in the evaluation. Calculations using

precipitation and temperature data for a 100-year period were generated synthetically using coefficients for Cleveland, Ohio.

The annual average water balance estimates indicate an evapotranspiration of 28% (10.3 inches) of total precipitation (37 inches). The remaining 72% (27 inches) of rainwater is available for surface water runoff and percolation to groundwater. Of the 27 inches of water available for runoff or percolation, groundwater recharge (percolation) accounts for 13% (3.6 inches), and surface runoff (along topography to nearest surface water bodies) accounts for the remaining 87% (23.4 inches).

Table 6-3. Climatic Data from SESOIL for Sanitary and Storm Sewers at RVAAP

Month	Air Temp (°C)	Cloud Cover	Humidity	Albedo	Evapotranspiration ^a (cm/day)	Precipitation (cm)	Duration (days)	Storms per Month	Model Days in Month
October	12	0.60	0.70	0.17	0.00	6.46	0.42	5.33	30.4
November	5.22	0.70	0.75	0.24	0.00	7.4	0.53	6.67	30.4
December	-1.06	0.80	0.75	0.31	0.00	7.06	0.57	6.14	30.4
January	-2.94	0.80	0.80	0.3	0.00	7.06	0.61	5.69	30.4
February	-2.33	0.70	0.75	0.32	0.00	5.76	0.53	5.09	30.4
March	2.33	0.70	0.70	0.29	0.00	8.26	0.55	7.14	30.4
April	9.11	0.70	0.70	0.19	0.00	8.83	0.48	7.4	30.4
May	14.61	0.60	0.70	0.16	0.00	8.46	0.45	7.15	30.4
June	19.89	0.60	0.70	0.16	0.00	9.07	0.36	6.57	30.4
July	21.89	0.50	0.70	0.16	0.00	9.8	0.3	6.06	30.4
August	21.11	0.55	0.70	0.16	0.00	8.14	0.3	6.06	30.4
September	17.67	0.55	0.70	0.16	0.00	7.85	0.4	5.44	30.4

^aData calculated in SESOIL model. 0.00 indicates evapotranspiration is calculated from other climatic data.

1996 data from Youngstown, Ohio, Weather Service Office - Airport Station.

cm/day = centimeter per day

RVAAP = Ravenna Army Ammunition Plant

SESOIL = Seasonal Soil Compartment

6.3 SOIL AND SEDIMENT SCREENING ANALYSIS

Soil and sediment screening analyses are evaluations performed to identify SRCs with the potential to leach to groundwater as CMCOPCs. The soil leachability analysis is a seven-step screening process. The steps of the screening analysis for each FA include the following:

1. Identify the SRCs for sample aggregates of interest that are defined in the nature and extent evaluation for the FA.
2. Compare the maximum concentration of SRCs with generic soil screening levels (GSSLs) to develop initial CMCOPCs.
3. Develop a site-specific dilution attenuation factor (DAF) applicable to the AOC using the *Field Sampling and Selecting On-Site Analytical Methods for Explosives in Soil* (USEPA 1996a) and compare the maximum concentration of initial CMCOPCs with site-specific soil screening levels

(SSSLs) (GSSL multiplied by the site-specific DAF) to refine the initial CMCOPCs. During evaluations of several of the FAs it was observed that because of the nature of the areal extent of the FA, the FA-specific DAFs were generally close to 1.0. Therefore, this step did not add any value to the screening analysis and was eliminated from the screening process.

4. Estimate the contaminant vertical migration travel time to reach the water table and eliminate the initial CMCOPCs that take more than 1,000 years to migrate from the source area to the water table.
5. Estimate the contaminant lateral migration travel time to the downgradient receptor location and eliminate the remaining initial CMCOPCs that take more than 1,000 years to migrate from the location in groundwater beneath the source area to the downgradient receptor location. The initial CMCOPCs that have lateral travel times less than 1,000 years require additional evaluation using fate and transport models that are discussed in Steps 6 and 7.
6. Conduct Seasonal Soil Compartment (SESOIL) modeling for all initial CMCOPCs and compare the predicted maximum leachate concentration with appropriate screening criteria to identify final CMCOPCs.
7. Conduct Analytical Transient 1-, 2-, 3-Dimensional (AT123D) modeling for all final CMCOPCs and compare the predicted groundwater concentration beneath the source and at the downgradient receptor location with appropriate screening criteria to identify final CMCOs.

Steps 1 through 5 are considered Screen I and do not include any fate and transport modeling. Steps 6 and 7 involve contaminant fate and transport modeling and are considered Screen II. The CMCOs are defined as the chemicals with potential to leach to groundwater and migrate to downgradient receptor locations at a concentration exceeding the FWCUGs for the FA-specific receptors, facility-wide background concentrations, and maximum contaminant level/regional screening level (MCL/RSI). If a predicted chemical concentration was lower than at least one of these three screening goals at the downgradient receptor locations, the chemical was not a CMCO.

6.3.1 Sediment/Soil Screening Analysis

The first step of sediment/soil screening analysis is the development of SRCs. SRC development is presented in Section 5.0 of each FAE.

The second step of the screening process involves comparing the maximum concentrations of the SRCs with MCL-based GSSLs. The GSSLs were developed for Superfund sites for contaminant migration to groundwater (USEPA 1996b; USEPA 2010). The GSSL is defined as the concentration of a constituent in soil that represents a level of contamination below which there is no concern for impacts to groundwater under CERCLA, provided conditions associated with soil screening levels (SSLs) are met. Generally, if contaminant concentrations in soil fall below the GSSL, and there are no groundwater receptors of concern or anticipated exposures, no further study or action is warranted for that area. If

the GSSL for a chemical is not available, the USEPA risk-based (USEPA 2010) SSL for soil for groundwater migration is used. If neither the USEPA GSSL nor the USEPA risk-based SSL for a chemical is available, no further evaluation of the chemical is performed, and it is eliminated from the list of the initial CMCOPCs. However, some chemicals were assigned surrogates by risk assessors because the chemical without an SSL is similar to another chemical with an SSL.

The third step of the soil screening process involves comparing the maximum contaminant concentrations with the SSSLs. The SSSL is defined as the GSSL multiplied by the FA-specific DAF. In the derivation of the GSSLs, direct partitioning is used, assuming groundwater is in contact with the chemicals in soil and the groundwater concentration is equal to the leachate concentration. However, as leachate moves through soil, contaminant concentrations are attenuated by adsorption and degradation. When the leachate reaches the water table, dilution by groundwater further reduces leachate concentrations. This reduction in concentration can be expressed by a DAF. The DAFs can vary based on FA-specific characteristics (e.g., hydrogeologic properties, contaminated source area, depth to contamination). As described in the *Soil Screening Guidance: Technical Background Document* (USEPA 1996b), contaminant dilution in groundwater is estimated at each FA from an FA-specific DAF. The DAF, which is defined as the ratio of soil leachate concentration to receptor point concentration, is minimally equal to 1. Dilution in groundwater is derived from a simple mixing zone equation (Equation 6-5) and relies upon estimation of the mixing zone depth (Equation 6-6).

$$DAF = 1 + \frac{(K \times i \times d)}{(q \times L)} \quad \text{(Equation 6-5)}$$

Where:

- DAF = dilution attenuation factor
- K = aquifer hydraulic conductivity (m/yr)
- i = horizontal hydraulic gradient (m/m)
- q = percolation rate (m/yr)
- L = source length parallel to groundwater flow (m)
- d = mixing zone depth (m) (which is defined below)

$$d = \sqrt{0.0112 \times L^2} + d_a \times \left[1 - \exp\left(\frac{-L \times q}{K \times i \times d_a}\right) \right] \quad \text{(Equation 6-6)}$$

Where:

- d_a = aquifer thickness (m)
- $d \leq d_a$

As stated above, if the aquifer thickness is less than the calculated mixing zone depth, the aquifer thickness is used for “d” in the DAF calculation. It should be noted that the purpose of this screen is not to identify the contaminants that may pose risk at downgradient locations but to target those contaminants that may pose the greatest problem if they migrate from the AOC. Generally, if contaminant concentrations in soil fall below the SSSL, and there are no groundwater receptors of

concern or anticipated exposures, no further study or action is warranted for that area. During evaluations of several of the FAs it was observed that because of the nature of the areal extent of the FAs, the FA-specific DAFs were generally close to 1.0. Therefore, the development of an SSSL, based on an FA-specific DAF, did not add any value to the screening analysis and was eliminated from this screening process.

The fourth step of the soil screening process involves eliminating from further consideration those initial CMCOPCs identified in the SSSL (since the SSSL screen was eliminated, the initial CMCOPCs were based on GSSL screen) evaluation which require more than 1,000 years to leach through the unsaturated zone before reaching the water table. The time period of 1,000 years was conservatively selected to evaluate eventual migration of the contaminant front to the water table despite uncertainties in vadose zone hydraulic parameters and groundwater recharge over time. Additionally, USACE suggests a screening value of 1,000 years be used due to the high uncertainty associated with predicting conditions beyond that time frame (USACE 2003a). Therefore, the initial CMCOPCs at the selected sources are screened against a travel time greater than 1,000 years. The travel time in this screen is the time required for a CMCOPC to migrate vertically from the base of the soil interval detected above its background concentration to the water table. This distance is the leaching zone (Lz), which varies across the FA based on the varying depths of soil/sediment sample concentrations above the facility-wide background concentrations and the elevation of the water table. A conservative value of Lz is always used, based on the minimum distance above the water table for the FA. The estimated travel time for each initial CMCOPC to reach the water table is determined using the following equations:

$$T_{LC} = \frac{Lz \times R}{V_p} \quad (\text{Equation 6-7})$$

Where:

T_{LC} = leachate travel time to the water table (year)

Lz = thickness of attenuation zone (ft)

R = retardation factor (dimensionless)

V_p = pore water velocity (ft/year)

and

$$V_p = \frac{q}{\theta_w} \quad (\text{Equation 6-8})$$

Where:

q = percolation rate (ft/year)

θ_w = fraction of total porosity that is filled by water

If the travel time for a chemical from a source area to the water table exceeds 1,000 years, the chemical is eliminated from the list of initial CMCOPCs.

The fifth step of the soil screening process involves eliminating from further consideration those initial CMCOPCs identified in the SSSL and T_{LC} evaluation which require more than 1,000 years to

reach the downgradient receptor location. The estimated travel time for each initial CMCOPC to reach the downgradient receptor location is determined using the following equation:

$$T_{RC} = \frac{(x_{\min} \times R)}{(V_s)} \quad (\text{Equation 6-9})$$

Where:

T_{RC} = groundwater travel time to receptor location (yr)

$x_{\min}$ = minimum distance to receptor location (ft)

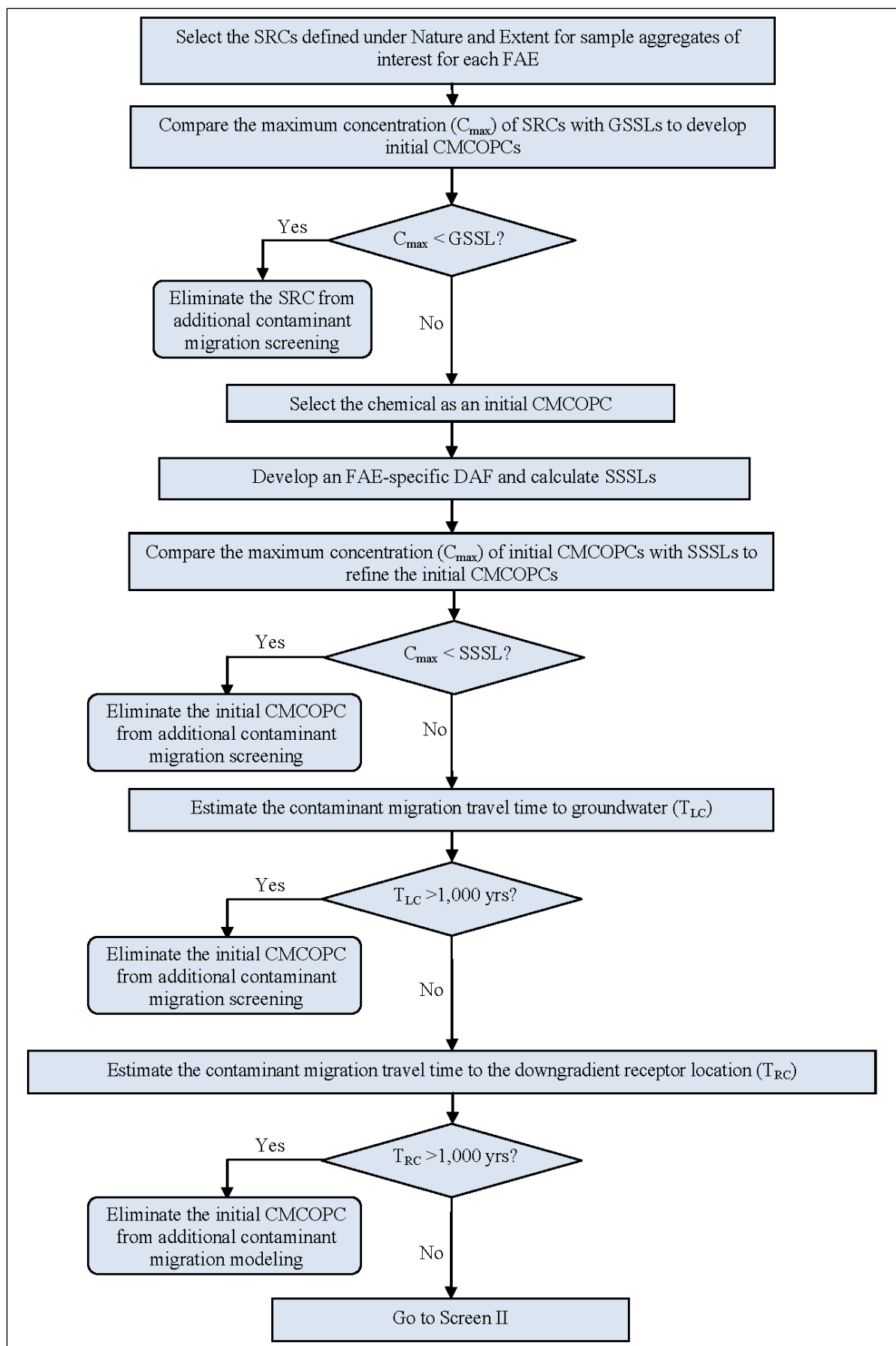
R = retardation factor (dimensionless)

V_s = groundwater seepage velocity (ft/year)

Initial CMCOPCs with travel times less than 1,000 years to the downgradient receptor location are retained for further evaluation in Screen II, as discussed in Section 6.4. The steps of the sediment/soil screening analysis are presented in the flow chart shown in Figure 6-6.

6.3.2 Limitations and Assumptions of Soil/Sediment Screening Analysis

Acceptable soil concentrations for individual chemicals are highly FA-specific. The GSSLs used in this screening are based on a number of default assumptions chosen to be protective of human health for most FA conditions (USEPA 1996b). These GSSLs are expected to be more conservative than SSSLs based on FA conditions. The conservative assumptions included in this analysis are: (1) no adsorption in the unsaturated zone or in the aquifer; (2) no biological or chemical degradation in the soil or in the aquifer; and (3) contamination is uniformly distributed throughout the source. However, the GSSL does not incorporate the existence of contamination already present within the aquifer.



1

Figure 6-6. Facility-Wide Sewers Fate and Transport Modeling Approach – Screen I

6.4 FATE AND TRANSPORT MODELING

Contaminant fate and transport modeling is performed for initial CMCOPCs based on the conceptual model for the individual FA, as discussed in Section 6.1 of each FAE. SESOIL modeling was performed for chemicals identified as the initial CMCOPCs from the results of Screen I (i.e., soil screening analysis) for each FA. The SESOIL modeling was performed to predict concentrations of chemicals in the leachate immediately beneath the selected source areas and just above the water table. If the predicted leachate concentration of a CMCOPC exceeded its MCL/RSL, facility-wide background concentration, and FWCUG for AOC receptors, the AT123D model was performed to predict the groundwater concentrations directly beneath the source and downgradient at designated receptor locations. The downgradient receptor location is the closest surface water body feature downgradient of the source areas.

6.4.1 Modeling Approach

Contaminant transport includes the movement of water and dissolved material from the source areas to groundwater. This occurs as rainwater infiltrates from the surface and percolates through the area of contamination, its surrounding soil, and into the saturated zone. The downward movement of water driven by gravitational potential, capillary pressure, and other components of total fluid potential mobilizes the chemicals and carries them through the soil into the mixing zone with the water table. Lateral transport within the unconsolidated zone is controlled by the groundwater gradient. Vertical transport (evaluated with the SESOIL model) through the overburden to the water table and horizontal transport (evaluated with the AT123D model) through the unconsolidated zone to downgradient receptor locations are illustrated in Figure 6-5.

The output of the contaminant fate and transport modeling is presented as the expected maximum concentration of modeled chemicals at the selected receptor locations. For SESOIL, the receptor location is the groundwater table beneath the source area. For this analysis, the sampling location with maximum concentration of the initial CMCOPC was always considered as the source of contamination based on the results of the soil screening analysis. A separate SESOIL analysis was performed for each initial CMCOPC from each FA.

The predicted maximum leachate concentration just above the water table, derived from the SESOIL modeling results, was compared against FWCUGs for the AOC-specific receptors, facility-wide background concentrations, and MCL/RSL. If the predicted maximum leachate concentration of an initial CMCOPC was higher than the FWCUG, facility-wide background concentration, and MCL/RSL, the CMCOPC was further evaluated using the AT123D model to predict future maximum concentrations in groundwater beneath the source, as well as at the receptor locations if applicable. If a predicted maximum leachate concentration was lower than the screening goals, the chemical was no longer considered a CMCOPC. The predicted maximum concentration in groundwater directly below the source areas and at the receptor locations, predicted by AT123D modeling, was compared against the FWCUGs, facility-wide background concentrations, and MCL/RSL. If the predicted maximum concentration of a CMCOPC was higher than the FWCUG, facility-wide background concentration,

1 and MCL/RSL, the chemical would be identified as a C MCOC. If a predicted maximum
2 concentration in groundwater directly below the source areas and at the receptor location is lower than
3 the screening criteria, the chemical is not a CMCO.

4 5 **6.4.2 Model Applications**

6
7 The SESOIL model (GSC 1998) used for leachate modeling, when applicable, estimates pollutant
8 concentrations in the soil profile following introduction via direct application and/or interaction with
9 transport media. The AT123D model (DOE 1992) is an analytical groundwater pollutant fate and
10 transport model. It computes the spatial-temporal concentration distribution of waste in the aquifer
11 system and predicts the transient spread of a contaminant plume through a groundwater aquifer. The
12 application of both models is discussed in the following subsections.

13 14 **6.4.2.1 SESOIL Modeling**

15
16 The SESOIL model defines the soil column as compartments extending from the ground surface
17 through the unsaturated zone to the upper level of the saturated soil zone or top of bedrock. Processes
18 simulated in SESOIL are categorized in three cycles: the hydrologic cycle, sedimentation cycle, and
19 pollutant cycle. Each cycle is a separate submodule in the SESOIL code. The hydrologic cycle
20 includes rainfall, surface runoff, percolation, soil-water content, evapotranspiration, and groundwater
21 recharge. The sediment washload cycle includes erosion and sediment transport. The pollutant cycle
22 includes convective transport, volatilization, adsorption/desorption, and degradation/decay. A
23 contaminant in SESOIL can partition in up to four phases (liquid, adsorbed, air, and pure).

24
25 Data requirements for SESOIL are not extensive and utilize a minimum of AOC-specific soil and
26 chemical parameters and monthly or seasonal meteorological values as input. Outputs of the SESOIL
27 model include pollutant concentrations at various soil depths and pollutant loss from the unsaturated
28 soil zone in terms of surface runoff, percolation to groundwater, volatilization, and degradation. The
29 mathematical representations in SESOIL generally consider the rate at which the modeled processes
30 occur, the interaction of different processes with each other, and the initial conditions of both the
31 waste area and the surrounding subsurface matrix material.

32
33 The input data for SESOIL can be grouped into four types: climatic data, chemical data, soil data, and
34 application data. There are 61 separate parameters contained in these four data groups. Wherever
35 possible, FA-specific parameter values were used for the modeling. However, certain parameters
36 were not available for the source areas and were estimated based on pertinent scientific literature,
37 geochemical investigations, and checks for consistency between model results and historical data.
38 Conservative estimates were used when a range of values existed or parameter values were not
39 available.

6.4.2.2 Climate Data

The climatic data file of SESOIL consists of an array of mean monthly temperature, mean monthly cloud cover fraction, average monthly relative humidity, reflectivity of the earth's surface (i.e., shortwave albedo), average daily evapotranspiration, monthly precipitation, mean number of storm events per month, mean duration of rainfall, and mean length of rainy season. The climatic data that are applicable for all FAs are presented in Table 6-3. These data were taken from the Youngstown Weather Service Air Port Office, Ohio, weather station as it was determined to be most appropriate, corresponding to the latitude and the longitude at RVAAP.

6.4.2.3 Chemical Data

The pollutant fate cycle of SESOIL focuses on the various chemical transport and transformation processes that may occur in the soil zone. These processes include volatilization/diffusion, adsorption/desorption, cation exchange, biodegradation and hydrolysis, and metal complexation. The distribution coefficients (K_{ds}) for inorganic chemicals were obtained from the *Soil Screening Guidance: Technical Background Document* assuming a neutral pH of 7, unless otherwise stated (USEPA 1996b). The organic carbon-based water partition coefficients (K_{oc}) values were also obtained from the *Soil Screening Guidance: Technical Background Document* (USEPA 1996b), unless otherwise stated. The K_{ds} for organic chemicals were estimated from K_{oc} using the relationship $K_d = (f_{oc})(K_{oc})$, where f_{oc} = soil organic carbon content mass fraction obtained from FA-specific measurements. These values are presented in Section 6.0 of each FAE. In general, biodegradation rates are not applicable for inorganic CMCOPCs, and biodegradation was not considered for the organic chemicals in this evaluation.

6.4.2.4 Soil Data

The soil data file of SESOIL contains input parameters describing the physical characteristics of the subsurface soil within each FA and are presented in Section 6.0 of each FAE. The parameters include soil bulk density, intrinsic permeability, soil disconnectedness index, soil porosity, organic carbon content, and cation exchange capacity. The soil disconnectedness index is a parameter that relates the soil permeability to the moisture content. FA-specific data were used from geotechnical samples collected within the FA or from a nearby FA if there were no geotechnical data from a particular FA. However, there is no measurement method for the soil disconnectedness index or a measured value of the Freundlich exponent. Thus, SESOIL default values were used for these two parameters.

An average intrinsic permeability for the vadose zone representing the unconsolidated zone above the water table was calibrated using the percolation rate of 3.6 inches/year as the calibration target. The model was calibrated against the percolation rate by varying the intrinsic permeability and by keeping all other FA-specific geotechnical parameters fixed. The final hydrogeologic parameter values for each FA are presented in Section 6.0 of each FAE. The soil porosity was set to the FA-specific value. The intrinsic permeability, calibrated in SESOIL to the percolation rate (determined from a water

balance estimated in HELP), was generally found to match the FA-specific measurements from geotechnical samples.

In SESOIL, the soil disconnectedness index replaces the moisture retention curves (or characteristic curves) used by other unsaturated zone leaching models. The SESOIL User's Guide defines this parameter to be the exponent relating the “wetting” and “drying” time-dependent permeability of soil to its saturated permeability (Hetrick and Scott 1993). This “one variable” approach of using soil disconnectedness index in SESOIL simplifies the data estimation process and reduces computational time. In addition, this parameter was calibrated for four different soil types ranging from sandy loam to clay (Hetrick et al. 1986), and calibrated values fell within the default range specified in the SESOIL User's Guide.

6.4.2.5 Source Terms

Analytical subsurface sewer media data collected at an FA were used as source terms for SESOIL modeling. All samples collected at different depth intervals were compiled to provide a detailed loading option for the SESOIL model. The samples with the maximum soil/sediment concentration for each CMCOPC were used as source term concentrations for the SESOIL model.

6.4.2.6 Application Data

Four different layering schemes were developed for sample areas due to varying thicknesses of the loading and leaching zones based on soil sample data and depth to water from a potentiometric map. Each model consisted of four layers of varying thicknesses. Depending on the location of the FA and the analyte being modeled, the top three layers varied between contaminant loading layers and leaching layers. Details of the layers utilized in this modeling are presented in the individual FAEs.

6.4.3 SESOIL Modeling Results

SESOIL modeling was performed for initial CMCOPCs from each FA that had the potential to reach the water table and migrate laterally to the downgradient receptor location within 1,000 years, as determined from Screen I. The results are summarized by the drainage networks that include: (1) the George Road Treatment Plant Network consisting of the Administration Area FA, the George Road Trunk and Connector Lines FA, and the FAs for Load Lines 5 through 11; (2) the Sand Creek Treatment Plant Network consisting of the Atlas Scrap Yard FA, the Inert Storage Area #6 FA, the FAs for Load Lines 1 through 4, the Load Line 12 FA, and the Sand Creek Trunk and Connector Lines FA; (3) the Depot Administration Area FA; and (4) the Transportation Storage Area FA. Tables 6-4, 6-5, and 6-6 present the results for George Road Treatment Plant Network, the Sand Creek Treatment Plant Network, and the Transportation Storage Area, respectively. SRCs from the Load Line 5 FA, Load Line 1 FA, Load Line 3 FA, Depot Administration Area FA, and Transportation Storage Area FA were eliminated through Screen I; therefore, these FAs are not included in their respective SESOIL result tables. Tables 6-4, 6-5, and 6-6 present the predicted peak leachate concentrations beneath the source areas relative to the sample area locations and the

1 corresponding time of the peak leachate concentrations. The FWCUGs, facility-wide background
2 concentrations, and MCL/RSL values for the CMCOPCs are also shown in these tables for
3 comparison purposes. The following CMCOPCs with the maximum leachate concentrations below
4 the source and just above the water table exceeding their respective screening criteria were selected as
5 the final CMCOPCs for AT123D modeling:

- 6
- 7 • 3-Nitrotoluene, nitroglycerin, RDX, 1,4-dichlorobenzene, and 4-chlorobenzenamine from the
8 Administration Area FA;
- 9
- 10 • 2,4-DNT and nitroglycerin from the Load Line 6 FA;
- 11
- 12 • Methylene chloride from the Load Line 7 FA;
- 13
- 14 • 1,3-DNB; 2,4-DNT; 2,6-DNT; 2-amino-4,6-DNT; 2-nitrotoluene; and RDX from the Load line 8
15 FA;
- 16
- 17 • Naphthalene from the Load Line 9 FA;
- 18
- 19 • 2-Nitrotoluene and PETN from the Load Line 10 FA;
- 20
- 21 • Sulfate from the Load Line 11 FA;
- 22
- 23 • 4-Amino-2,6-DNT; nitroglycerin; 1,2-dichlorobenzene; 1,3-dichlorobenzene; and
24 1,4-dichlorobenzene from the George Road Trunk and Connector Lines FA;
- 25
- 26 • Selenium; 1,3-DNB; 2-amino-4,6-DNT; 4-amino-2,6-DNT; nitroglycerin; and RDX from the
27 Load Line 7 FA; and
- 28
- 29 • 4-Amino-2,6-DNT; 1,2-dichlorobenzene; 1,3-dichlorobenzene; 1,4-dichlorobenzene; and
30 4-chlorobenzenamine from the Load Line 12 FA.
- 31

32 No CMCOPCs were identified for Transportation Storage Area based on SESOIL modeling results.
33

Table 6-4. Summary of SESOIL Modeling Results for George Road Treatment Plant Network Subsurface Sewer Media

Initial CMCOPC	Chemical Type	Maximum Soil Concentration (mg/kg)	Sample Location	Maximum Depth of Contamination (ft bgs)	Depth to Groundwater (ft bgs)	Predicted C _{leachate, max} Beneath the Source (mg/L)	Time Required to Reach C _{leachate, max} (years)	MCL/ RSL (mg/L)	FWCUG (mg/L) ^a		Facility-Wide Background Unconsolidated Groundwater (mg/L)	Final CMCOPC? ^b (yes/no)
									National Guard Trainee	Resident Farmer Adult		
Administration Area (FA 1)												
3-Nitrotoluene	Explosive	7.20E-02	ADAsd-026(st)-2089-SD	0.5	13	5.38E-03	68	3.70E-03	None	None	None	Yes
Nitroglycerin	Explosive	9.90E-01	ADAsd-025(st)-2088-SD	7.7	13	5.81E-01	14	4.00E-03	5.40E-02	5.01E-03	None	Yes
RDX	Explosive	3.00E-02	ADAsd-034(st)-2097-SD	0.5	13	7.92E-03	22	6.10E-04	8.34E-03	7.74E-04	None	Yes
1,4-Dichlorobenzene	SVOC	3.30E-01	ADAsd-016(sn)-2079-SD	8.4	13	4.46E-02	31	7.50E-02	None	None	None	No
4-Chlorobenzenamine	SVOC	2.90E-02	ADAsd-005(sn)-2069-SD	11.7	13	3.24E-02	5	3.40E-04	None	None	None	Yes
Load Line 6 (FA 11)												
2,4-Dinitrotoluene	Explosive	2.10E-02	LL6sd-062(sn)-2391-SD	17.5	17.5	2.71E-02	1	2.20E-04	1.29E-03	1.20E-04	None	Yes
Nitroglycerin	Explosive	3.00E-01	LL6sd-062(sn)-2391-SD	17.5	17.5	8.09E-01	1	4.00E-03	5.40E-02	5.01E-03	None	Yes
1,4-Dichlorobenzene	SVOC	1.30E-01	LL6sd-061(sn)-2390-SD	16.0	17.5	8.22E-02	4	7.50E-02	None	None	None	Yes
Load Line 7 (FA 12)												
Methylene chloride	VOC	7.50E-03	LL7sd-053(sn)-2016-SD	6.0	17.5	5.25E-03	8	5.00E-03	5.75E-02	5.34E-03	None	Yes
Load Line 8 (FA 13)												
1,3-Dinitrobenzene	Explosive	5.50E-02	LL8sd-022(sn)-2019-SD	7	10.5	4.39E-02	10	3.70E-03	3.28E-03	3.65E-04	None	Yes
2,4-Dinitrotoluene	Explosive	7.10E-02	LL8sd-022(sn)-2019-SD	7	10.5	3.58E-02	14	2.20E-04	1.29E-03	1.20E-04	None	Yes
2,6-Dinitrotoluene	Explosive	4.50E-01	LL8sd-022(sn)-2019-SD	7	10.5	2.29E-01	14	3.70E-02	1.31E-03	1.22E-04	None	Yes
2-Amino-4,6-dinitroto luene	Explosive	3.80E-01	LL8sd-022(sn)-2019-SD	7	10.5	3.25E-01	9	7.30E-02	6.55E-03	7.30E-04	None	Yes
2-Nitrotoluene	Explosive	1.10E+00	LL8sd-022(sn)-2019-SD	7	10.5	6.09E-01	10	3.10E-04	3.99E-03	3.70E-04	None	Yes
RDX	Explosive	2.80E-01	LL8sd-022(sn)-2019-SD	7	10.5	7.09E-01	5	6.10E-04	8.34E-03	7.74E-04	None	Yes
Load Line 9 (FA 14)												
Naphthalene	SVOC	6.70E-02	LL9sd-081(sn)-2022-SD	9.5	9.5	3.59E-02	1	6.20E-03	None	None	None	Yes
Methylene Chloride	VOC	3.10E-03	LL9sd-085(sn)-2026-SD	9	9.5	4.10E-03	1	5.00E-03	5.75E-02	5.34E-03	None	No
Load Line 10 (FA 15)												
2-Nitrotoluene	Explosive	4.10E-01	L10sd-055(sn)-2033-SD	11	12.5	3.82E-01	5	3.10E-04	3.99E-03	3.70E-04	None	Yes
PETN	Explosive	1.90E+01	L10sd-055(sn)-2033-SD	11	12.5	1.63E+01	6	1.70E-02	None	None	None	Yes
Load Line 11 (FA 16)												
Sulfate	Inorganic	7.72E+02	LL11sd-009-0001-SD	7	11	8.00E+02	4	2.50E+02	None	None	None	Yes

Table 6-4. Summary of SESOIL Modeling Results for George Road Treatment Plant Network Subsurface Sewer Media (continued)

Initial CMCOPC	Chemical Type	Maximum Soil Concentration (mg/kg)	Sample Location	Maximum Depth of Contamination (ft bgs)	Depth to Groundwater (ft bgs)	Predicted C _{leachate, max} Beneath the Source (mg/L)	Time Required to Reach C _{leachate, max} (years)	MCL/ RSL (mg/L)	FWCUG (mg/L) ^a		Facility-Wide Background Unconsolidated Groundwater (mg/L)	Final CMCOPC? ^b (yes/no)
									National Guard Trainee	Resident Farmer Adult		
George Road Trunk and Connector Lines located outside of the previously listed FAs (FA 4)												
4-Amino-2,6-dinitro toluene	Explosive	5.10E-01	GRLsd-008(sn)-2401-SD	7	21	2.85E-01	24	7.30E-02	6.55E-03	7.30E-04	None	Yes
Nitroglycerin	Explosive	2.20E+00	GRLsd-014(sn)-2054-SD	5	21	1.97E+00	16	4.00E-03	5.40E-02	5.01E-03	None	Yes
1,2-Dichlorobenzene	SVOC	7.70E+00	GRLsd-005(sn)-2048-SD	13	21	2.29E+00	20	6.00E-01	None	None	None	Yes
1,3-Dichlorobenzene ^c	SVOC	2.10E+00	GRLsd-005(sn)-2048-SD	13	21	6.35E-01	20	7.50E-02	None	None	None	Yes
1,4-Dichlorobenzene	SVOC	5.10E+00	GRLsd-005(sn)-2048-SD	13	21	1.44E+00	20	7.50E-02	None	None	None	Yes

^aThe FWCUG is based on a target risk of 10^{-6} and a Hazard Index of 0.1.

^bThe Final CMCOPC was identified comparing predicted maximum leachate concentration to MCL/RSL, FWCUGs, and facility-wide background. A constituent is an initial CMCOPC if its predicted leachate concentration exceeds its screening criteria (MCL/RSL, FWCUGs, or facility-wide background) within 1,000 years.

^cThe RSL is derived from 1,4-dichlorobenzene.

CMCOPC = Contaminant Migration Chemical of Potential Concern

FA = Functional Area

ft bgs = feet below ground surface

FWCUG = Facility-Wide Cleanup Goal

MCL = Maximum Contaminant Level

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

PETN = Pentaerythritol Tetranitrate

RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine

RSL = Regional Screening Level

SESOIL = Seasonal Soil Compartment

SVOC = Semi-volatile Organic Compound

VOC = Volatile Organic Compound

Bold = CMCOPCs exceeding MCL/RSL, FWCUGs, and/or facility-wide background

2

3

Table 6-5. Summary of SESOIL Modeling Results for Sand Creek Treatment Plant Network Subsurface Sewer Media

Initial CMCOPC	Chemical Type	Maximum Soil Concentration (mg/kg)	Sample Location	Maximum Depth of Contamination (ft bgs)	Depth to Groundwater (ft bgs)	Predicted C _{leachate, max} Beneath the Source (mg/L)	Time Required to Reach C _{leachate, max} (years)	MCL/ RSL (mg/L)	FWCUG (mg/L) ^a		Facility-Wide Background Unconsolidated Groundwater (mg/L)	Final CMCOPC? ^b (yes/no)
									National Guard Trainee	Resident Farmer Adult		
Atlas Scrap Yard (FA 2)												
2-Amino-4,6-Dinitroto luene	Explosive	1.20E-01	ASYsd-002-SD	1.0	13	1.19E-02	35	7.30E-02	6.55E-03	7.30E-04	None	Yes
Inert Storage Area #6 (FA 5)												
2-Butanone (MEK)	VOC	2.50E+00	SA6sd-002(sn)-2306-SD	18	21	3.43E+00	7	7.10E+00	None	None	None	No
Load Line 2 (FA 7)												
Selenium	Inorganic chemical	3.00E+00	LL2sd-297(st)-2240-SD	10	10	8.06E-01	7	5.00E-02	None	None	None	Yes
1,3-Dinitrobenzene	Explosive	2.20E-02	LL2pb-617(st)-2452-SO	4	10	1.37E-03	151	3.70E-03	3.28E-03	3.65E-04	None	Yes
4-Amino-2,6-dinitroto luene	Explosive	5.00E+00	LL2sd-297(st)-2240-SD	10	10	4.25E+00	7	7.30E-02	6.55E-03	7.30E-04	None	Yes
2-Amino-4,6-dinitroto luene	Explosive	1.60E+01	LL2sd-297(st)-2240-SD	10	10	1.33E+00	7	7.30E-02	6.55E-03	7.30E-04	None	Yes
Nitroglycerin	Explosive	4.40E-01	LL2sd-615(st)-2504-SD	10	10	7.98E-02	52	4.00E-03	5.40E-02	5.01E-03	None	Yes
RDX	Explosive	7.30E+00	LL2sd-297(st)-2240-SD	10	10	5.59E+00	3	6.10E-04	8.34E-03	7.74E-04	None	Yes
3+4-Methylphenol	SVOC	1.70E-01	LL2sd-306(st)-2249-SD	4	10	1.22E-02	132	9.30E-01	None	None	None	No
Load Line 12 (FA 17)												
4-Amino-2,6-dinitroto luene	Explosive	1.70E-01	L12sd-218-0655-SD	8	10	6.54E-02	30	7.30E-02	6.55E-03	7.30E-04	None	Yes
1,2-Dichlorobenzene	SVOC	3.20E+01	L12sd-303(sn)-2013-SD	11	12	6.83E+00	14	6.00E-01	None	None	None	Yes
1,3-Dichlorobenzene ^c	SVOC	9.00E+00	L12sd-303(sn)-2013-SD	11	12	1.94E+00	14	7.50E-02	None	None	None	Yes
1,4-Dichlorobenzene	SVOC	2.20E+01	L12sd-303(sn)-2013-SD	11	12	4.39E+00	14	7.50E-02	None	None	None	Yes
4-Chlorobenzenamine	SVOC	7.20E-01	L12sd-303(sn)-2013-SD	11	12	7.43E-01	5	3.40E-04	None	None	None	Yes

^aThe FWCUG is based on a target risk of 10^{-6} and a Hazard Index of 0.1.

^bThe Final CMCOPC was identified comparing predicted maximum leachate concentration to MCL/RSL, FWCUGs, and facility-wide background. A constituent is an initial CMCOPC if its predicted leachate concentration exceeds its screening criteria (MCL/RSL, FWCUGs, or facility-wide background) within 1,000 years.

^cThe RSL is derived from 1,4-dichlorobenzene.

CMCOPC = Contaminant Migration Chemical of Potential Concern

FA = Functional Area

ft bgs = feet below ground surface

FWCUG = Facility-Wide Cleanup Goal

MCL = Maximum Contaminant Level

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine

RSL = Regional Screening Level

SESOIL = Seasonal Soil Compartment

Bold = CMCOPCs exceeding MCL/RSL, FWCUGs, and/or facility-wide background

SVOC = Semi-volatile Organic Compound

VOC = Volatile Organic Compound

Table 6-6. Summary of SESOIL Modeling Results for Transportation Storage Area Drainage Network Subsurface Sewer Media

Initial CMCOPC	Maximum Soil Concentration (mg/kg)	Sample Location	Maximum Depth of Contamination (ft bgs)	Depth to Groundwater (ft bgs)	Predicted $C_{\text{leachate, max}}$ Beneath the Source (mg/L)	Time Required to Reach $C_{\text{leachate, max}}$ (years)	MCL/ RSL (mg/L)	FWCUG (mg/L) ^a		Facility-Wide Background Unconsolidated Groundwater (mg/L)	Final CMCOPC? ^b (yes/no)
								National Guard Trainee	Resident Farmer Adult		
Semi-volatile Organic Compounds											
3+4-Methylphenol	4.60E-01	TSAsd-003(st)-2320-SD	2	10	1.95E-01	26	9.30E-01	None	None	None	No

^a The FWCUG is based on a target risk of 10^{-6} and a Hazard Index of 0.1.

^b The Final CMCOPC was identified comparing predicted maximum leachate concentration to MCL/RSL, FWCUGs, and facility-wide background. A constituent is an initial CMCOPC if its predicted leachate concentration exceeds its screening criteria (MCL/RSL, FWCUGs, or facility-wide background) within 1,000 years.

CMCOPC = Contaminant Migration Chemical of Potential Concern

ft bgs = feet below ground surface

FWCUG = Facility-Wide Cleanup Goal

MCL = Maximum Contaminant Level

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

RSL = Regional Screening Level

SESOIL = Seasonal Soil Compartment

2

3

6.4.4 AT123D Modeling in the Saturated Zone

The fate and transport processes accounted for in the AT123D model include advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a chemical in three dimensions in the groundwater resulting from a mass release over a source area (point, line, area, or volume source). The model can handle instantaneous, as well as continuous, source loadings of CMCOPC concentrations. A T123D is frequently used by the scientific and technical community to perform quick and conservative estimates of groundwater plume movement in space and time. SESOIL and AT123D are linked in a software package (RISKPRO) so that mass loading to the groundwater predicted by SESOIL can be directly transferred to AT123D. Therefore, AT123D was chosen to predict the maximum concentration of chemicals in groundwater after mixing with the leachate and the future concentrations for the chemicals in groundwater at the receptor locations. The receptor location is defined as the nearest downgradient groundwater exit point into surface water bodies (e.g., creeks or tributaries). Figure 6-7 shows the locations of all 19 FAs and their downgradient receptor locations. The receptor locations for all of the FAs are also summarized in Table 6-7.

The FA-specific hydrogeologic parameter values used in this modeling are provided in each FAE. A discussion of model assumptions and limitations is presented in Section 6.4.6.

The detailed input and output of AT123D modeling is provided in Attachment A.

6.4.5 AT123D Modeling Results

AT123D modeling was performed for the final CMCOPCs from the FAs using contaminant loading results from SESOIL. Results of AT123D modeling are shown in Table 6-8 and 6-9 as the predicted groundwater concentration beneath the source area and at the selected downgradient receptor locations (i.e., groundwater exit points in surface water). The distance to the downgradient receptor was based on the distance along the groundwater flow direction to the closest surface water body from the FA boundary (see Figure 6-7). If the maximum predicted concentration of a CMCOPC exceeded its screening criteria, the CMCOPC was modeled to the nearest downgradient receptor. As shown in Tables 6-8 and 6-9, the following constituents were predicted to exceed the screening criteria below the source area and were modeled to the their respective downgradient receptor locations:

- Nitroglycerin from the Administration Area FA;
- 2,4-DNT and nitroglycerin from the Load Line 6 FA;
- 1,3-DNB; 2,4-DNT; 2,6-DNT; 2-amino-4,6-DNT; 2-nitrotoluene; and RDX from the Load Line 8 FA;
- 2-Nitrotoluene and PETN from the Load Line 10 FA;

- 1 • 4-Amino-2,6-DNT and nitroglycerin from the George Road Trunk and Connector Lines FA;
- 2
- 3 • 2-Amino-4,6-DNT; 4-amino-2,6-DNT; and RDX from the Load Line 2 FA; and
- 4
- 5 • 4-Amino-2,6-DNT; 1,2-dichlorobenzene; 1,3-dichlorobenzene; 1,4-dichlorobenzene; and
- 6 4-chlorobenamine from the Load Line 12 FA.
- 7

8 None of these constituents were predicted to exceed the screening criteria at the downgradient
9 receptor locations; therefore, they were eliminated as CMCOs.

10
11 Based on the fate and transport evaluation, all SRCs identified in the subsurface sewer media sample
12 aggregates are eliminated as posing future impacts to groundwater.

Table 6-7. Summary of Downgradient Receptor Locations for all Facility-Wide Sewer Functional Areas

FA #	Functional Area Name	Drainage Network	Downgradient Groundwater Exit Point/Receptor Location
1	ADA	George Road Treatment Plant	Unnamed tributary to the Mahoning River
2	ASY	Sand Creek Treatment Plant	Unnamed tributary to Sand Creek, unnamed tributary to Cobbs Pond, and unnamed tributary to the Mahoning River
3	DAA	Depot Administration Area	Hinkley Creek
4	GRL	George Road Treatment Plant	Unnamed tributary to Sand Creek
5	SA6	Sand Creek Treatment Plant	Mahoning River
6	Load Line 1	Sand Creek Treatment Plant	Unnamed tributary to Sand Creek
7	Load Line 2	Sand Creek Treatment Plant	Unnamed tributary to Sand Creek
8	Load Line 3	Sand Creek Treatment Plant	Unnamed tributary to Cobbs Pond
9	Load Line 4	Sand Creek Treatment Plant	Unnamed tributary to the Mahoning River
10	Load Line 5	George Road Treatment Plant	Unnamed tributary to the Mahoning River
11	Load Line 6	George Road Treatment Plant	Unnamed tributary to the Mahoning River
12	Load Line 7	George Road Treatment Plant	Unnamed tributary to Sand Creek
13	Load Line 8	George Road Treatment Plant	Unnamed tributary to Hinkley Creek
14	Load Line 9	George Road Treatment Plant	Unnamed tributary to Sand Creek and unnamed tributary to the Mahoning River
15	Load Line 10	George Road Treatment Plant	Unnamed tributary to Sand Creek and unnamed tributary to the Mahoning River
16	Load Line 11	George Road Treatment Plant	Unnamed tributary to Sand Creek
17	Load Line 12	Sand Creek Treatment Plant	Unnamed tributary to Cobbs Pond
18	SCT	Sand Creek Treatment Plant	Unnamed tributary to Cobbs Pond and Sand Creek
19	TSA	Transportation Storage Area	Unnamed tributary to the Mahoning River

ADA = Administration Area

ASY = Atlas Scrap Yard

DAA = Depot Administration Area

FA = Functional Area

GRL = George Road Trunk and Connector Lines

SA6 = Inert Storage Area #6

SCT = Sand Creek Trunk and Connector Lines

TSA = Transportation Storage Area

2

3

4

Table 6-8. Summary of AT123D Modeling Results George Road Treatment Plant Network Subsurface Sewer Media

Final CMCOPC	Chemical Type	Maximum Leachate Concentration ^a (mg/L)	Maximum Groundwater Concentrations ^b (C _{MAX}) at the Source (mg/L)	Maximum Groundwater Concentrations ^b (C _{MAX}) at the Downgradient Receptor (mg/L)	Distance to Downgradient Receptor (ft)	MCL/RSL (mg/L)	FWCUG (mg/L) ^c		Facility-Wide Background Bedrock Groundwater (mg/L)	Final CMCOC? ^d (yes/no)
							National Guard Trainee	Resident Farmer		
Administration Area (FA 1)										
3-Nitrotoluene	Explosive	5.38E-03	1.92E-04	1.98E-07	1,485	3.70E-03	None	None	None	No
Nitroglycerin	Explosive	5.81E-01	1.41E-02	9.51E-06	2,499	4.00E-03	5.40E-02	5.01E-03	None	No
RDX	Explosive	7.92E-03	1.76E-04	2.33E-07	1,938	6.10E-04	8.34E-03	7.74E-04	None	No
4-Chlorobenzenamine	SVOC	3.24E-02	2.02E-04	2.89E-07	2,672	3.40E-04	None	None	None	No
Load Line 6 (FA 11)										
1,4-Dichlorobenzene	SVOC	8.22E-02	7.57E-04	3.24E-06	1,500	7.50E-02	None	None	None	No
2,4-Dinitrotoluene	Explosive	2.71E-02	2.32E-04	1.38E-07	1,500	2.20E-04	1.29E-03	1.20E-04	None	No
Nitroglycerin	Explosive	8.09E-01	4.17E-03	5.14E-06	1,500	4.00E-03	5.40E-02	5.01E-03	None	No
Load Line 7 (FA 12)										
Methylene chloride	VOC	5.25E-03	1.82E-04	3.91E-07	2,000	5.00E-03	5.75E-02	5.34E-03	None	No
Load Line 8 (FA 13)										
1,3-Dinitrobenzene	Explosive	4.39E-02	3.87E-03	3.56E-06	500	3.70E-03	3.28E-03	3.65E-04	None	No
2,4-Dinitrotoluene	Explosive	3.58E-02	3.59E-03	2.80E-06	500	2.20E-04	1.29E-03	1.20E-04	None	No
2,6-Dinitrotoluene	Explosive	2.29E-01	2.29E-02	1.76E-05	500	3.70E-02	1.31E-03	1.22E-04	None	No
2-Amino-4,6-dinitrotoluene	Explosive	3.25E-01	2.85E-02	2.62E-05	500	7.30E-02	6.55E-03	7.30E-04	None	No
2-Nitrotoluene	Explosive	6.09E-01	5.36E-02	6.19E-05	500	3.10E-04	3.99E-03	3.70E-04	None	No
RDX	Explosive	7.09E-01	4.91E-02	6.24E-05	500	6.10E-04	8.34E-03	7.74E-04	None	No
Load Line 9 (FA14)										
Naphthalene	SVOC	3.59E-02	2.47E-04	1.84E-07	1,500	6.20E-03	None	None	None	No
Load Line 10 (FA 15)										
2-Nitrotoluene	Explosive	3.82E-01	4.65E-02	3.30E-05	500	3.10E-04	3.99E-03	3.70E-04	None	No
PETN	Explosive	1.63E+01	2.19E+00	1.03E-03	500	1.70E-02	None	None	None	No
Load Line 11 (FA 16)										
Sulfate	Inorganic Chemicals	8.00E+02	8.94E+01	6.22E-02	650	2.50E+02	None	None	None	No

Table 6-8. Summary of AT123D Modeling Results George Road Treatment Plant Network Subsurface Sewer Media (continued)

Final CMCOPC	Chemical Type	Maximum Leachate Concentration ^a (mg/L)	Maximum Groundwater Concentrations ^b (C _{MAX}) at the Source (mg/L)	Maximum Groundwater Concentrations ^b (C _{MAX}) at the Downgradient Receptor (mg/L)	Distance to Downgradient Receptor (ft)	MCL/RSL (mg/L)	FWCUG (mg/L) ^c		Facility-Wide Background Bedrock Groundwater (mg/L)	Final CMCOC? (yes/no)
							National Guard Trainee	Resident Farmer		
George Road Trunk and Connector Lines located outside of the previously listed FAs (FA 4)										
4-Amino-2,6-dinitrotoluene	Explosive	2.85E-01	1.16E-02	0.00E+00	2,500	7.30E-02	6.55E-03	7.30E-04	None	No
Nitroglycerin	Explosive	1.97E+00	6.40E-02	0.00E+00	2,500	4.00E-03	5.40E-02	5.01E-03	None	No
1,2-Dichlorobenzene	SVOC	2.29E+00	9.13E-02	0.00E+00	2,500	6.00E-01	None	None	None	No
1,3-Dichlorobenzene ^e	SVOC	6.35E-01	2.53E-02	0.00E+00	2,500	7.50E-02	None	None	None	No
1,4-Dichlorobenzene	SVOC	1.44E+00	5.73E-02	0.00E+00	2,500	7.50E-02	None	None	None	No

^aRepresents SESOIL predicted maximum leachate concentration just above the water table.

^bThe receptor concentration was estimated using the results from SESOIL for soil sample and sediment screening analysis for sediment samples and applying AT123D model.

^cThe FWCUG is based on a target risk of 10⁻⁶ and a Hazard Index of 0.1.

^dThe CMCOC was identified comparing predicted concentration in groundwater to MCL/RSL, FWCUGs, and facility-wide background. A constituent is a CMCOC if its predicted concentration in groundwater exceeds its screening criteria (MCL/RSL, FWCUGs, or facility-wide background) within 1,000 years.

^eThe RSL is derived from 1,4-dichlorobenzene.

AT123D = Analytical Transient 1-, 2-, 3-Dimensional

CMCOC = Contaminant Migration Chemical of Concern

CMCOPC = Contaminant Migration Chemical of Potential Concern

FA = Functional Area

FWCUG = Facility-Wide Cleanup Goal

MCL = Maximum Contaminant Level

mg/L = milligrams per liter

PETN = Pentaerythritol Tetranitrate

RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine

RSL = Regional Screening Level

SESOIL = Seasonal Soil Compartment

SVOC = Semi-volatile Organic Compound

VOC = Volatile Organic Compound

Bold = Constituents with predicted maximum groundwater concentrations at the source exceeding the screening criteria

Table 6-9. Summary of AT123D Modeling Results Sand Creek Treatment Plant Network Subsurface Sewer Media

Final CMCOPC	Chemical Type	Maximum Leachate Concentration ^a (mg/L)	Maximum Groundwater Concentrations ^b (C _{MAX}) at the Source (mg/L)	Maximum Groundwater Concentrations ^b (C _{MAX}) at the Downgradient Receptor (mg/L)	Distance to Downgradient Receptor (ft)	MCL/RSL (mg/L)	FWCUG (mg/L) ^c		Facility-Wide Background Bedrock Groundwater (mg/L)	Final CMCOC? ^d (yes/no)
							National Guard Trainee	Resident Farmer		
Atlas Scrap Yard (FA 2)										
2-Amino-4,6-dinitrotoluene	Explosive	1.19E-02	4.09E-04	2.45E-08	1,000	7.30E-02	6.55E-03	7.30E-04	None	No
Load Line 2 (FA 7)										
Selenium	Inorganic	8.06E-01	1.65E-02	2.30E-05	500	5.00E-02	None	None	None	No
1,3-Dinitrobenzene	Explosive	1.37E-03	2.32E-05	1.16E-07	500	3.70E-03	3.28E-03	3.65E-04	None	No
4-Amino-2,6-dinitrotoluene	Explosive	4.25E+00	8.64E-02	1.64E-07	500	7.30E-02	6.55E-03	7.30E-04	None	No
2-Amino-4,6-dinitrotoluene	Explosive	1.33E+00	2.70E-02	5.10E-08	500	7.30E-02	6.55E-03	7.30E-04	None	No
Nitroglycerin	Explosive	7.98E-02	1.68E-03	6.58E-06	500	4.00E-03	5.40E-02	5.01E-03	None	No
RDX	Explosive	5.59E+00	8.19E-02	8.42E-05	500	6.10E-04	8.34E-03	7.74E-04	None	No
Load Line 12 (FA 17)										
4-Amino-2,6-dinitrotoluene	Explosive	6.54E-02	1.48E-02	4.61E-05	125	7.30E-02	6.55E-03	7.30E-04	None	No
1,2-Dichlorobenzene	SVOC	6.83E+00	1.31E+00	5.79E-03	125	6.00E-01	None	None	None	No
1,3-Dichlorobenzene ^e	SVOC	1.94E+00	3.76E-01	1.67E-03	125	7.50E-02	None	None	None	No
1,4-Dichlorobenzene	SVOC	4.39E+00	8.60E-01	4.01E-03	125	7.50E-02	None	None	None	No
4-Chlorobenzenamine	SVOC	7.43E-01	9.22E-02	4.19E-04	125	3.40E-04	None	None	None	No

^aRepresents SESOIL predicted maximum leachate concentration just above the water table.

^bThe receptor concentration was estimated using the results from SESOIL for soil sample and sediment screening analysis for sediment samples and applying AT123D model.

^cThe FWCUG is based on a target risk of 10⁻⁶ and a Hazard Index of 0.1.

^dThe CMCOC was identified comparing predicted concentration in groundwater to MCL/RSL, FWCUGs, and facility-wide background. A constituent is a CMCOC if its predicted concentration in groundwater exceeds its screening criteria (MCL/RSL, FWCUGs, or facility-wide background) within 1,000 years.

^eThe RSL is derived from 1,4-dichlorobenzene.

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CMCOC = Contaminant Migration Chemical of Concern

CMCOPC = Contaminant Migration Chemical of Potential Concern

FA = Functional Area

FWCUG = Facility-Wide Cleanup Goal

MCL = Maximum Contaminant Level

mg/L = milligrams per liter

RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine

RSL = Regional Screening Level

SESOIL = Seasonal Soil Compartment

SVOC = Semi-volatile Organic Compound

Bold = Constituents with predicted maximum groundwater concentrations at the source exceeding the screening criteria

6.4.6 Limitations/Assumptions

In general, a conservative modeling approach was used, which may overestimate the contaminant concentration in the leachate for migration from observed sediment/soil concentrations. Assumptions used in this analysis are as follows:

- The use of K_d and R_d to describe the reaction term of the transport equation assumes that an equilibrium relationship exists between the solid-phase and solution-phase concentrations and that the relationship is linear and reversible.
- Since FA-specific data are not available, the K_d values and K_{oc} values used in this analysis for all of the CMCOPCs represent literature or calculated values and may not represent conditions at the AOC.
- The K_d for inorganic chemicals used here assumed a neutral pH of 7. The K_d for inorganic chemicals varies with pH; therefore, if FA-specific pH measurements are greater than 7, the K_d and calculated screening parameters (such as the retardation factor) will deviate from those presented here.
- All samples inside or outside of the sanitary and or storm sewers are currently available for leaching through soil media.
- Biodegradations have been ignored in all analyses.
- Flow and transport in the vadose zone is one-dimensional (i.e., only in the vertical direction).
- The modeling used the current soil/sediment concentrations that were collected approximately 65 years after historical operations were terminated at the AOC. Therefore, it does not account for chemicals that have already leached to groundwater.
- Flow and transport are not affected by density variations.
- The maximum concentration value was used as the source term concentration for SESOIL model layers; this is a conservative assumption that is expected to produce higher leachate concentrations for the CMCOPCs than the average condition.
- The water balance represents an overall average rainwater recharge and assumes an even distribution of percolation in the modeled area. An average water balance assumes some areas will have higher or lower recharge based on the heterogeneity of the soil and varying topography.

The inherent uncertainties associated with using these assumptions must be recognized. K_d values are highly sensitive to changes in the major chemistry of the solution phase. Therefore, it is important that the values be measured or estimated under conditions that will represent as closely as possible

those of the contaminant plume. Deviations from actual AOC-specific parameter values from assumed literature values may significantly affect contaminant fate predictions. It is also important to note that the contaminant plume will change over time and will be affected by multiple solutes that are present at the AOC. The effects of heterogeneity and anisotropy are not addressed in these simulations.

The discrepancy between the contaminant concentrations measured in the field and the values predicted by the model could be investigated by performing sensitivity analyses on the model input parameters that have the most influence on the model predictions. These parameters are: (1) biodegradation rate constants for organic chemicals; (2) saturated hydraulic conductivity; (3) soil porosity; (4) f_{oc} for organic chemicals; (5) K_d for inorganic chemicals; and (6) longitudinal, transverse, and vertical dispersivity values. Generally, higher biodegradation rates will produce lower concentrations, and lower rates will produce higher concentrations for organic chemicals, without impacting the results of the inorganic chemicals. Higher hydraulic conductivity and dispersivity cause higher advection and dispersion, thereby producing lower peaks near the source area but increasing the migration distance. The reverse is true with lower hydraulic conductivity and dispersivity values. Higher f_{oc} values have a similar effect on organic chemicals as higher K_d has on inorganic chemicals – they decrease the mobility of the chemicals as well as produce lower concentrations in groundwater.

SUMMARY AND CONCLUSIONS

Based on the results of the historical and Facility-Wide Sewers RI sampling activities of subsurface sewer media, inorganic and organic SRCs exist in subsurface soil and sediment at the AOC. These SRCs were further evaluated to determine if residual concentrations in sediment/soil are protective of groundwater.

Conclusions of the soil/sediment screening, leachate modeling, and groundwater modeling are as follows:

- The following constituents were identified as initial CMCOPCs based on soil/sediment screening and travel time analyses and were selected for SESOIL modeling:
 - o 3-Nitrotoluene; nitroglycerin; RDX; 1,4-dichlorobenzene; and 4-chlorobenzenamine from the Administration Area FA;
 - o 2,4-DNT; nitroglycerin; and 1,4-dichlorobenzene from the Load Line 6 FA;
 - o Methylene chloride from the Load Line 7 FA;
 - o 1,3-DNB; 2,4-DNT; 2,6-DNT; 2-amino-4,6-DNT; 2-nitrotoluene; and RDX from the Load Line 8 FA;

- o Naphthalene and methylene chloride from the Load Line 9 FA;
- o 2-Nitrotoluene and PETN from the Load Line 10 FA;
- o Sulfate from the Load Line 11 FA;
- o 4-Amino-2,6-DNT; nitroglycerin; 1,2-dichlorobenzene; 1,3-dichlorobenzene; and 1,4-dichlorobenzene from the George Road Trunk and Connector Lines FA;
- o 2-Amino-4,6-DNT from the Atlas Scrap Yard FA;
- o 2-Butanone from the Inert Storage Area #6 FA;
- o Selenium; 1,3-DNB; 2-amino-4,6-DNT; 4-amino-2,6-DNT; nitroglycerin; RDX; and 3+4-methylphenol from the Load Line 2 FA;
- o 4-Amino-2,6-DNT; 1,2-dichlorobenzene; 1,3-dichlorobenzene; 1,4-dichlorobenzene; and 4-chlorobenzenamine from the Load Line 12 FA; and
- o 3+4-Methylphenol from the Transportation Storage Area FA.
- Based on the results of the SESOIL modeling, the maximum concentration for the following chemicals in leachate directly below the source and above the water table were above their respective screening criteria. AT123D modeling was performed to predict the maximum concentration of the final CMCOPCs in groundwater after mixing with the leachate.
 - o 3-nitrotoluene; nitroglycerin; RDX; and 4-chlorobenzenamine from the Administration Area FA;
 - o 2,4-DNT; nitroglycerin; and 1,4-dichlorobenzene from the Load Line 6 FA;
 - o Methylene chloride from the Load Line 7 FA;
 - o 1,3-DNB; 2,4-DNT; 2,6-DNT; 2-amino-4,6-DNT; 2-nitrotoluene; and RDX from the Load Line 8 FA;
 - o Naphthalene from the Load Line 9 FA;
 - o 2-nitrotoluene and PETN from the Load Line 10 FA;
 - o Sulfate from the Load Line 11 FA;

- o 4-amino-2,6-DNT; nitroglycerin; 1,2-dichlorobenzene; 1,3-dichlorobenzene; and 1,4-dichlorobenzene from the George Road Trunk and Connector Lines FA;
 - o 2-amino-4,6-DNT from the Atlas Scrap Yard FA;
 - o Selenium; 1,3-DNB; 2-amino-4,6-DNT; 4-amino-2,6-DNT; nitroglycerin; and RDX from the Load Line 2 FA; and
 - o 4-amino-2,6-DNT; 1,2-dichlorobenzene; 1,3-dichlorobenzene; 1,4-dichlorobenzene; and 4-chlorobenzenamine from the Load Line 12 FA.
- The AT123D model predicted maximum concentrations of the following final CMCOPCs in groundwater beneath the source areas exceeded the screening criteria but did not exceed the screening criteria at the downgradient receptor locations:
 - o Nitroglycerin from the Administration Area FA;
 - o 2,4-DNT and nitroglycerin from the Load Line 6 FA;
 - o 1,3-DNB; 2,4-DNT; 2,6-DNT; 2-amino-4,6-DNT; 2-nitrotoluene; and RDX from the Load Line 8 FA;
 - o 2-Nitrotoluene and PETN from the Load Line 10 FA;
 - o 4-Amino-2,6-DNT and nitroglycerin from the George Road Trunk and Connector Lines FA;
 - o 2-amino-4,6-DNT; 4-amino-2,6-DNT; and RDX from the Load Line 2 FA; and
 - o 4-amino-2,6-DNT; 1,2-dichlorobenzene; 1,3-dichlorobenzene; 1,4-dichlorobenzene; and 4-chlorobenzenamine from the Load Line 12 FA.
- Based on the sediment and soil screening analyses and fate and transport modeling, all SRCs found in the subsurface sewer media and evaluated through the stepwise fate and transport screening evaluation are eliminated as posing future impacts to groundwater.

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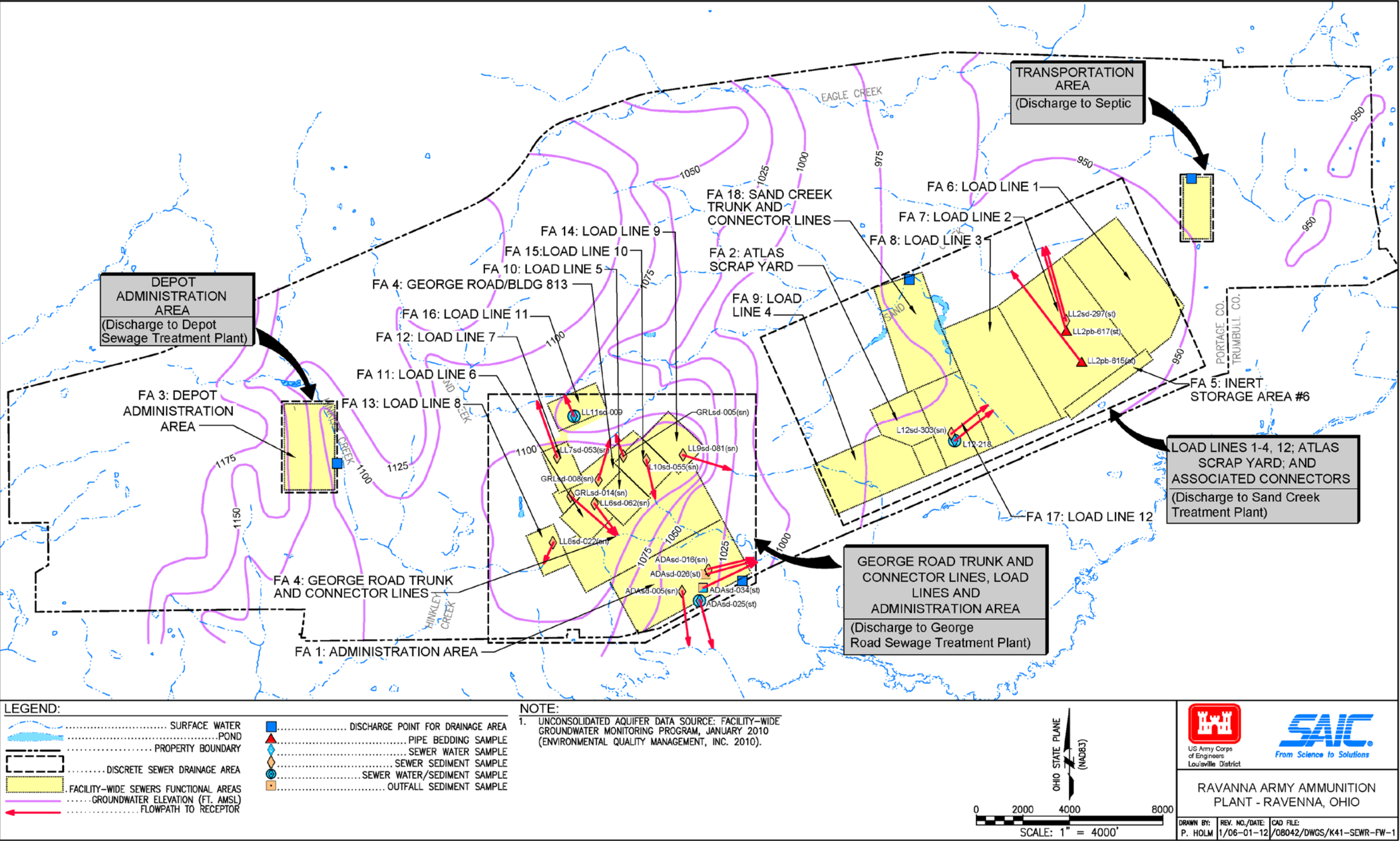


Figure 6-7. Facility-Wide Sewers Functional Areas Showing Downgradient Receptor Locations for AT123D Modeling

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7.0 RISK ASSESSMENT

The HHRA and ERA for the Facility-Wide Sewers addresses the 19 FAs located throughout the facility. The FAs represent distinct portions of the sewer systems within AOCs, other former operational areas, and connecting lines (e.g., trunk lines) between former operational areas or to sewage treatment plants. The purpose of the preliminary data screening and risk assessments is to determine the need for conducting an FS for potential remediation of any portions of the piping systems or outfalls.

7.1 DATA EVALUATION FOR HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS

The purpose of the data evaluation is to develop a set of chemical data suitable for use in the HHRA and ERA. Data were evaluated to establish data aggregates and identify a list of SRCs.

Section 5.1 includes a summary of the types of data available for characterization of the nature and extent of contamination in the sewers. Data were grouped (aggregated) by FA, exposure medium, sewer type (sanitary or storm), and pipe depth. Up to three types of potential exposure media are present in the sewer system at each FA:

- Sediment in the sewer pipes and soil/bedding material immediately under the pipes (collectively referred to as subsurface sewer media);
- Water in the sewer pipes (sewer water); and
- Soil, sediment, and water at pipe outfalls.

Sediment at pipe outfalls was classified as either dry sediment (soil) or wet sediment (sediment), as described in Section 5.0.

7.1.1 Data Aggregates

7.1.1.1 Subsurface Sewer Media

As discussed in Sections 1.2 and 5.1, subsurface sewer media include sediment within the pipes, as well as pipe bedding material that was placed beneath pipes during installation (e.g., backfill soil, sand, or other media). Sewer sediment includes both dry and inundated (wet) sediment accumulations within the pipe systems, and a distinction between wet and dry sediment per RVAAP programmatic definitions is not made. Subsurface sewer media are classified as soil in the data screening for the contaminant nature and extent evaluation and this HHRA. Consequently, subsurface sewer media were aggregated by the following depth intervals at each FA, consistent with the classification as soil, since different future receptors are assumed to be exposed to subsurface soil media at different depths:

- Surface soil is defined as 0-1 ft bgs (shallow surface soil) for the Resident Farmer (Adult and Child) receptor. This depth interval is also most appropriate for evaluating potential risk to ecological receptors. No sewer lines are located above 1 ft bgs; therefore, this interval is not evaluated for subsurface sewer media.
- Deep surface soil is defined as 0-4 ft bgs for the National Guard Trainee. Samples collected from sewer lines located 0-4 ft bgs were included in this interval.
- Subsurface soil is defined as 4-7 ft bgs for the National Guard Trainee. Samples collected from sewer lines located 4-7 ft bgs were included in this interval.
- Subsurface soil is defined as 1-13 ft bgs for the Resident Farmer. Samples collected from sewer lines located 1-13 ft bgs were included in this interval.

7.1.1.2 Sewer Water Data

Sewer water includes accumulated or flowing water within pipe systems resulting from storm flow, infiltrating surface water, or groundwater infiltration. Sewer water is considered separately from outfall water in the HHRA because sewer water is within a contained structure, and the exposure pathways differ from those at outfall discharge points. However, data screening for the contaminant nature and extent evaluation and this HHRA uses surface water screening criteria because outfalls are the primary discharge points for sewer water in most cases, and the majority of pipe systems lie above the groundwater table. Water samples were collected from sanitary and storm sewer system manholes and drop inlets. Samples of accumulated water were co-located with sediment samples, where possible.

At some sample locations, sufficient water volume was not available to meet analytical requirements; therefore, sampling was completed at the next closest alternate location. For example, if the primary location only contained enough water for the explosives analysis, the inorganic chemical sample was collected from the first alternate location. A number of water samples could not be collected as proposed in the Facility-Wide Sewers SAP because the location was dry even when revisited after a rain event.

Sewer water data were aggregated by FA.

7.1.1.3 Outfall Water and Sediment Data

As discussed in Sections 1.2 and 5.1, sediment and water collected at storm and sanitary sewer system outfalls are collectively referred to as outfall media. Because outfall media lie outside of enclosed pipe systems, they are addressed in the Facility-Wide Sewers RI as conventional sediment and surface water media. The RVAAP programmatic definitions of dry sediment (soil) and wet sediment (sediment) are applied for the purposes of data screening for outfall sediment, based on visual observations of outfall conditions during the Facility-Wide Sewers RI and/or historical observations if

1 available. Outfall media samples were collected as close as practical to the discharge point. Samples
2 of accumulated water were co-located with sediment samples at the outfalls where possible. Outfall
3 water samples could not be collected at a number of locations as planned in the Facility-Wide Sewers
4 SAP because they were dry. Numerous outfall locations were revisited after rain events and were still
5 found to contain insufficient flow for sample collection.

7 7.1.2 Identification of SRCs

8
9 Section 5.1 presents the statistical methods and screening criteria used to identify SRCs present at
10 concentrations that indicate potential impacts related to historical operations within the areas. The
11 purpose of the identification of SRCs is to determine the presence or absence of contamination that is
12 site-related and above naturally-occurring levels. The SRC screen followed the three steps outlined in
13 the FWCUG Report and is summarized below:

- 14
15 • Background screening: The MDC of naturally-occurring inorganic chemicals were compared to
16 facility-wide background concentrations for RVAAP, originally published in the *Phase II*
17 *Remedial Investigation Report for Winklepeck Burning Grounds* (USACE 2001b) and
18 summarized in the FWCUG Report. Inorganic chemicals detected above background screening
19 values (BSVs) or that have no BSVs were retained as potential SRCs. Background
20 concentrations are not available specifically for sewer media. Sample results for subsurface
21 sewer media were compared to subsurface soil background concentrations. Sample results for
22 sewer water and outfall water were compared to surface water background concentrations.
23 Outfall sediment sample results were compared to the lower of surface soil or sediment
24 background concentrations.
- 25
26 • Screening of essential human nutrients: Chemicals considered essential nutrients (e.g., calcium,
27 chloride, iodine, iron, magnesium, potassium, phosphorous, and sodium) are an integral part of
28 the human food supply and are often added to foods as supplements. USEPA recommends these
29 chemicals not be evaluated provided they are: (1) present at low concentrations (i.e., only slightly
30 elevated above naturally occurring levels); and (2) toxic only at very high doses (i.e., much higher
31 than those that could be associated with contact at the AOC) (USEPA 1989). Essential nutrients
32 detected near or below their RDA/RDI-based screening levels were eliminated as SRCs.
- 33
34 • Frequency of detection screening: The FWCUG Report allows for screening based on frequency
35 of detection, where analytes detected in less than 5% of the samples can be screened out from
36 further consideration. For analytes (other than explosives and propellants) having a frequency of
37 detection of less than 5%, a WOE approach was used to determine if the chemical is
38 AOC/EU-related. The magnitude and clustering of the detections and the potential source of the
39 chemical are evaluated. Chemicals detected only at low concentrations in less than 5% of the
40 samples from a given medium are excused from further consideration, unless their presence is
41 expected based on historical information about the AOC or is likely to identify the existence of a
42 localized source.

Details of the SRC screening for each FA are provided in Attachment B.

7.2 HUMAN HEALTH RISK ASSESSMENT

The HHRA presents COCs that may pose potential health risks to humans resulting from exposure to contamination at each FA. The HHRA was conducted as part of the Facility-Wide Sewers RI and is based on the methods from the FWCUG Report, *Guidance Document for the Evaluation of Land Use Controls* (USACE 2011a), and *Revised Final United States Army Corps of Engineers Ravenna Army Ammunition Plant (RVAAP) Position Paper for the Application and Use of Facility-Wide Human Health Cleanup Goals* (USACE 2012j), modified for application to subsurface sewers, as described in Section 7.2.1.

7.2.1 Approach

Recently, the RVAAP project team (i.e., Ohio EPA and USACE Louisville District) proposed an approach for efficient risk-based decision making at RVAAP that incorporates past experience gained through previously completed work. To accomplish this goal of streamlined risk-based decision making, the FWCUG Report was developed to support the environmental remediation of the remaining AOCs at RVAAP to complete final transfer of the land to OHARNG. The FWCUG Report contains calculated FWCUGs and guidance for their application to accelerate the decision-making process for the remaining AOCs, taking advantage of the many risk assessment inputs and decisions for the facility that have been agreed to by stakeholders through the application of the CERCLA processes over the past 10 years. Most of the agreed-to risk assessment methods have been documented in the FWHHRAM and follow standard USEPA approved risk assessment guidance. This includes the Process to Identify RVAAP Chemicals of Potential Concern (presented in Figure 5-1), the use of TR of 1E-06 and HQ of 0.1 to identify COPCs, and TR of 1E-05 and HQ of 1.0 to identify COCs.

The approach to risk-based decision-making described in the FWCUG Report is as follows:

1. Using the risk assessment process presented in the FWHHRAM (and included in the Final White Paper provided in Appendix A of the FWCUG Report), develop FWCUGs for all COPCs identified from the facility-wide dataset at RVAAP.
2. Perform RI characterization sampling and analysis to establish the baseline chemical concentrations within an AOC.
3. Perform data analysis and mapping to identify SRCs and COPCs following the process presented in Figure 5-1 (Figure 1-2 in the FWCUG Report), determine EUs, and calculate exposure point concentrations (EPCs) for each COPC, following the requirements for performing these tasks as spelled out in the FWHHRAM and further clarified in the USACE-developed position paper (USACE 2012j) and *Guidance Document for the Evaluation of Land Use Controls* (USACE 2011a).

1 4. Compare EPCs to the FWCUGs to determine COCs.

2
3 5. Perform the FS, PP, and ROD to address any identified COCs.

4
5 Step 1 of this process (develop FWCUGs) has been completed in the FWCUG Report. The results of
6 Step 2 (RI characterization sampling) and Step 3 (mapping and data analysis to identify SRCs) are
7 presented in Sections 4.0 and 5.0 of this RI report and are summarized in Section 7.1.

8
9 The remainder of Step 3 (identification of COPCs) and Step 4 (determine COCs) follow the four steps
10 for a streamlined risk assessment (also shown in Figure 1-3): identify media of concern, identify
11 COPCs, determine AOC land use and appropriate receptors, and compare to appropriate FWCUGs to
12 identify COCs. The streamlined risk assessment approach described in the FWCUG Report is
13 applicable to five exposure media: surface soil, subsurface soil, surface water, sediment, and
14 groundwater. Neither the FWCUG Report nor the FWHHRAM address the unusual case of potential
15 exposure to contaminated media in subsurface sewer systems. The approach used to apply the risk
16 assessment process to the Facility-Wide Sewers is described for each of the three sewer exposure
17 media in Sections 7.2.1.1 (subsurface sewer media), 7.2.1.2 (sewer water), and 7.2.1.3 (outfall
18 sediment/soil and outfall water). Groundwater is present at RVAAP but will be evaluated (including
19 risk assessment) in a separate document, as described in Section 1.2.

20 21 **7.2.1.1 Subsurface Sewer Media**

22
23 Sewer sediment samples were collected from pipe locations accessible from the surface (i.e., in drop
24 inlets or manholes) and from remote sewer pipe locations accessible only via excavation. Pipe
25 bedding samples were collected from under both sanitary and storm sewer lines.

26
27 Exposure to contaminants in subsurface sewer media can occur one of four ways:

- 28
29 1. A receptor can climb into the sewer via a drop inlet or manhole and be exposed directly to sewer
30 sediment at those locations; however, the receptor cannot be directly exposed to remote sewer
31 sediment from a manhole or pipe bedding material below the pipe. The accessibility of manholes
32 and drop inlets varies across the AOC, from relatively easy to completely inaccessible due to
33 pipeline collapse or infilling. Exposure to sediment at accessible manholes is generally limited to
34 workers collecting environmental samples. Exposures for such workers are minimized through
35 use of personal protective equipment (PPE) and are not included in the risk assessment. An
36 individual can climb into an accessible manhole and contact sewer sediment. This type of acute,
37 one-time exposure is not included in the risk assessment but is addressed where potential
38 localized sources are present at high enough concentrations to represent an acute risk.
- 39
40 2. Workers can be exposed while conducting storm line work (e.g., replacing a section of pipe) to
41 maintain storm water controls in FAs where OHARNG will maintain support facilities (i.e., Inert
42 Storage Area #6, Depot Administration Area, and Administration Area). This type of work also
43 represents a potential acute exposure, as storm sewer maintenance is not a routine activity.

3. Sewer sediment and pipe bedding material may be dug up and mixed with overlying soil as a result of National Guard Training activities, installation/maintenance of utilities, or the construction of structures having a basement, as shown in Figure 7-1. This digging and mixing could result in chronic exposure to National Guard Trainees or Residential receptors. Because this exposure results in mixing of the material in or directly under the sewer pipe into the overlying soil, exposure at FAs having few sewer pipelines and/or FAs where most of the sewers are located fairly deep will be negligible.
4. Contaminants may migrate vertically from the sewer pipe, through the pipe bedding material, and into groundwater or horizontally to outfalls with subsequent exposure at the outfall.

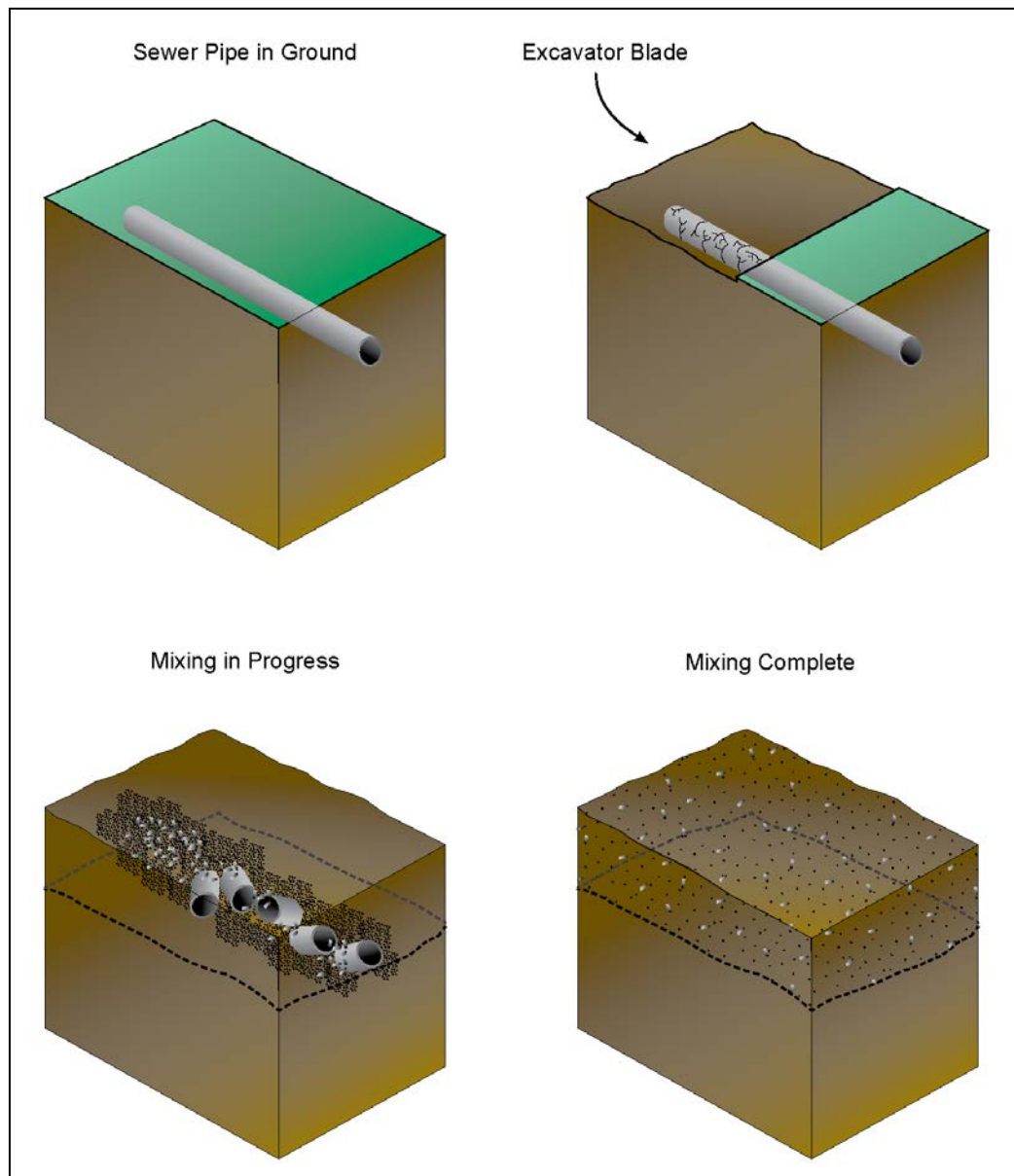


Figure 7-1. Mixing of Subsurface Sewer Media into Surrounding Soil

Potential exposures associated with a receptor climbing into a manhole or replacing a section of sewer pipe are of limited frequency (generally a one-time occurrence) and short in duration (minutes to hours). Potential exposures associated with intentional or unintentional digging into sewer lines and mixing the subsurface media into the overlying soil are potentially long-term because the resulting contaminated soil is assumed to remain accessible at the surface. Thus, this mixing scenario is the primary focus of the identification of COPCs and COCs in the HHRA. However, potential impacts from all four exposure scenarios are considered in the approach for evaluating subsurface sewer media, as shown in Figures 7-2 and 7-3. Potential risks associated with chronic exposure to mixed pipe material and overlying soil is evaluated through the identification of COPCs, while the potential for risks associated with acute exposures and contaminant migration are evaluated in the point evaluation. Decision criteria for identifying what type of evaluation is appropriate for a given FA or segment of pipe and the identification of COPCs in subsurface sewer media are defined below and in Figure 7-2.

- If a section of sewer pipe is more than 13 ft bgs, it is deeper than established RVAAP EUs (e.g., the Resident Farmer is exposed up to 13 ft bgs); therefore, it is assumed there will be no direct contact with the subsurface sewer media in the pipe segment. On this basis, sewer pipe segments deeper than 13 ft bgs were eliminated from further consideration in the HHRA. However, an evaluation of individual samples (point evaluation) collected from pipe segments deeper than 13 ft bgs (i.e., outside of the EU) was conducted in order to assess whether pipe segments may represent contaminant sources to downgradient receptors.
 - o The point evaluation identifies subsurface sewer media concentrations greater than the lowest soil FWCUG for the National Guard Trainee and Resident Farmer at a TR of 1E-04 or target hazard quotient (HQ) of 3.0, whichever is lower. Use of these soil FWCUGs results in a very conservative screen of subsurface sewer media.
 - o Points with elevated concentrations are further evaluated to determine their potential to impact downgradient receptors.
- If the total volume of the sewer pipe system at an FA (length x cross-sectional area) is less than 1% of the total volume of soil within the sewer pipe mixing zone at the FA, exposure associated with digging up the pipe is considered negligible even if the entire pipe was filled with contaminated sediment and mixed into the overlying soil. Since most pipes contain less than 1 inch of sediment, this is a very conservative approach. The soil mixing zone is defined as the area 12 ft wide, as deep as the pipe, and as long as the pipe. The 12-ft width is based on a tank or tracked vehicle width and represents the potential area of disturbance if the pipe and overlying soil were disturbed by mounted training activities. The 12-ft width also encompasses typical utility construction activities, such as excavations using backhoes or excavators. Details of the pipe and mixing volume calculations are shown in Figure 7-4. The FAs having a pipe volume less than 1% of the overlying soil mixing volume are listed in Table 7-1. For these FAs, the subsurface sewer media were eliminated from further consideration for screening of COPCs and

1 COCs in the HHRA. However, a point evaluation was conducted, as outlined above, to evaluate
2 potential impacts to downstream receptors and potential acute exposures.
3

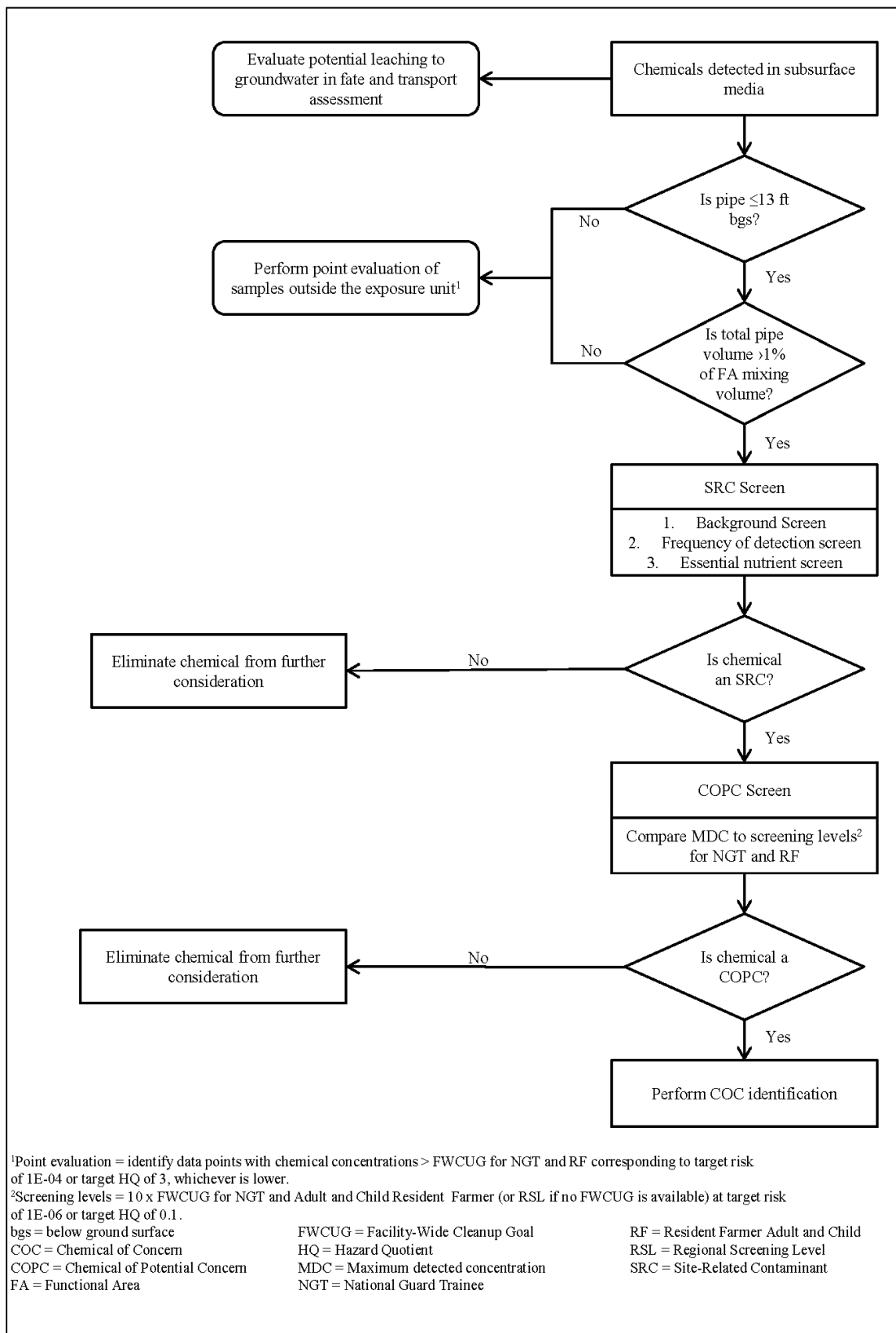


Figure 7-2. Process to Identify Chemicals of Potential Concern in Subsurface Sewer Media

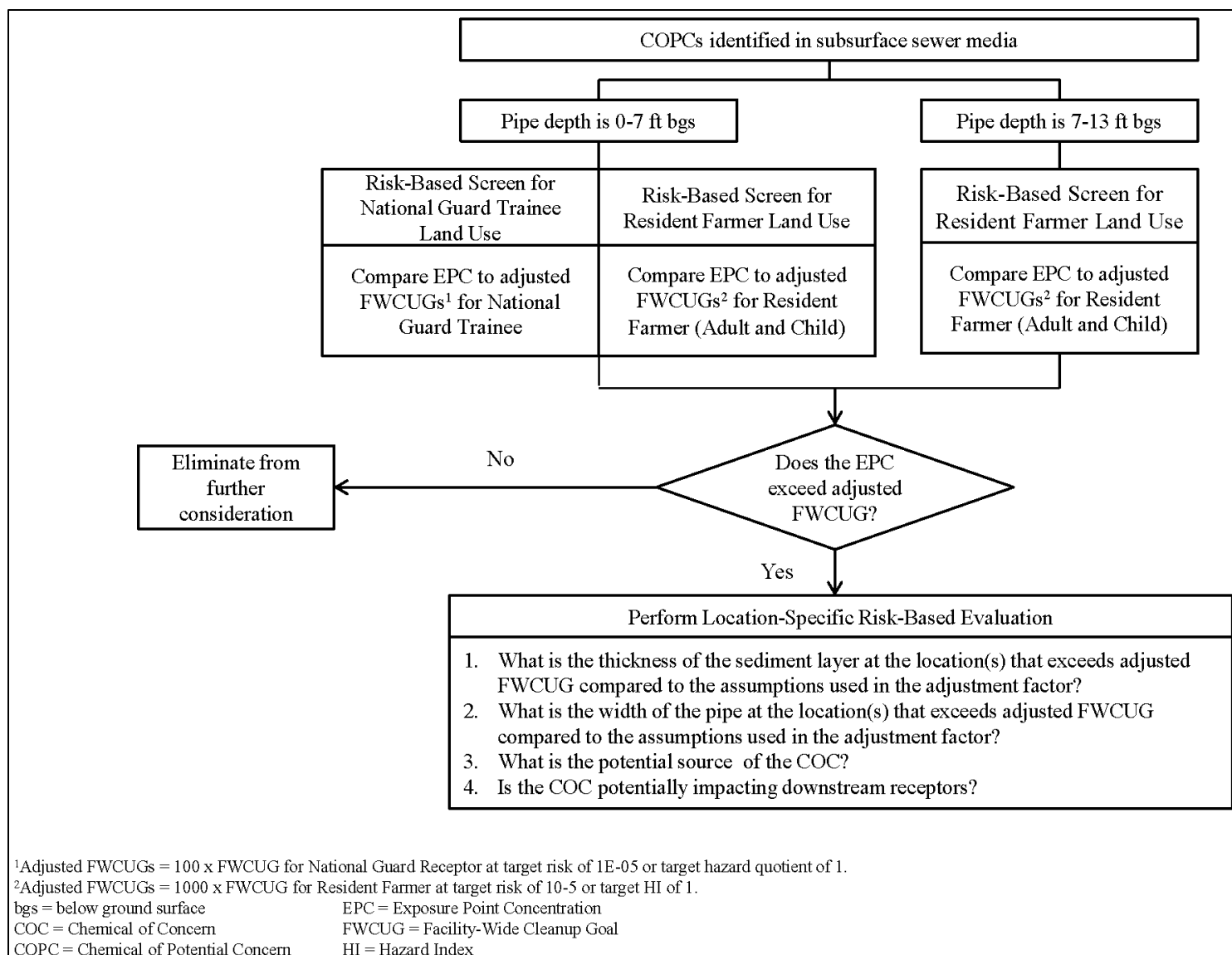


Figure 7-3. Process to Identify Chemical of Concern in Subsurface Sewer Media

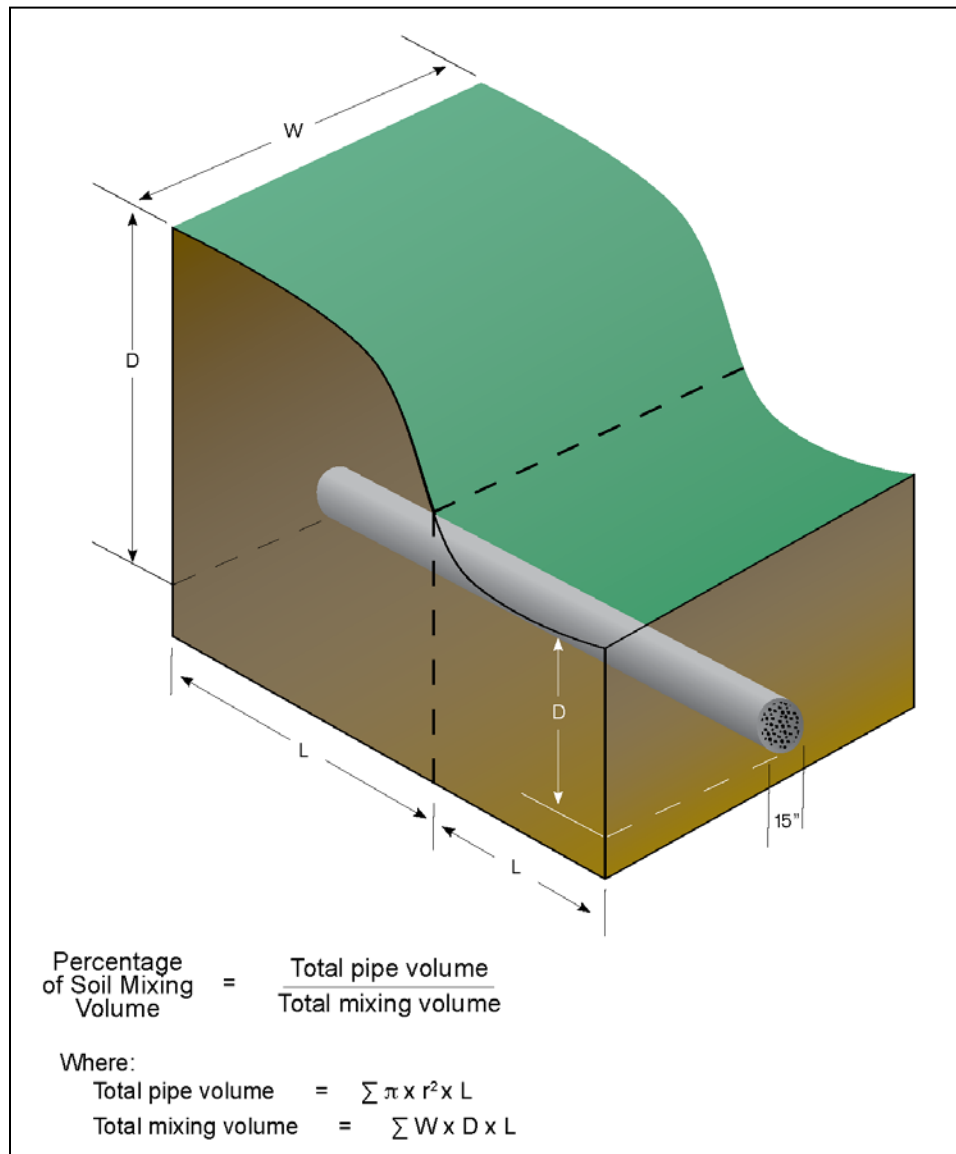


Figure 7-4. Pipe Volume as Percent of Overlying Soil Volume

Table 7-1. Pipe Volume as a Percentage of Overlying Soil Mixing Volume

Pipe Volume < 1% of Mixing Volume	Pipe Volume ≥ 1% of Mixing Volume
FA 4: George Road Trunk Lines and Connectors FA 10: Load Line 5 FA 11: Load Line 6 FA 12: Load Line 7 FA 14: Load Line 9 FA 15: Load Line 10 FA 17: Load Line 12	FA 1: Administration Area FA 2: Atlas Scrap Yard FA 3: Depot Administration Area FA 5: Inert Storage Area #6 FA 6: Load Line 1 FA 7: Load Line 2 FA 8: Load Line 3 FA 9: Load Line 4 FA 13: Load Line 8 FA 16: Load Line 11 FA 18: Sand Creek Trunk Lines FA 19: Transportation Storage Area

- For all sewer pipes located less than 13 ft bgs and where the total sewer pipe volume represents 1% or more of the overlying soil mixing volume, COPC and COC screens were conducted as described in the remainder of this section.

Identification of COPCs in Subsurface Sewer Media

COPCs were identified as a subset of the SRCs (summarized in Section 7.1.4 of each FAE) present at concentrations that indicate potential impacts to human receptors. The COPC screen followed the approach specified in the FWCUG Report, with an adjustment for the application of soil FWCUGs to subsurface sewer media mixed with soil.

For the determination of COPCs, the MDC of all SRCs were screened against adjusted chemical-specific soil FWCUGs at a target cancer risk level of 1E-06 and non-carcinogenic target HQ of 0.1 for the Resident Farmer Adult, Resident Farmer Child, and National Guard Trainee. If no FWCUGs exist for an SRC, the USEPA residential RSL (from RSL table dated May 2010) was used for this screen. No reference dose (RfD) or cancer potency factors are available for acenaphthylene, benzo(g,h,i)perylene, or phenanthrene; therefore, the RSL for pyrene was used for these PAHs (NDEP 2006).

The screening level soil FWCUGs at a TR of 1E-06 or target HQ of 0.1, whichever is lower, were adjusted by multiplying by a factor of 10. This order of magnitude adjustment factor of 10 accounts for a reasonable worst-case assumption that if 1 inch of pipe sediment is present at the shallowest EU depth of 4 ft (48 inches) bgs and the soil column directly above that sediment (i.e., 40 inches of overlying soil) is disturbed to access the pipe, the pipe sediment will be mixed into the soil at a ratio of 1:48. Sediment thickness observed in most of the sewer pipes was 1 inch or less. At many sewer sampling locations, insufficient sediment volume was present for meeting sampling requirements, and additional sediment had to be collected from an alternate location.

Details of the COPC screening are provided for each FA in its FAE. COPC screening tables include all carcinogenic and non-carcinogenic risk-based FWCUG or RSL values and the final adjusted screening value for each chemical.

Identification of COCs in Subsurface Sewer Media

COCs were identified as a subset of the COPCs present at concentrations that indicate the need for evaluation in an FS. Per the FWCUG Report, the first step in identifying COCs is the identification of appropriate receptors.

RVAAP is a controlled-access facility that is fenced and patrolled by security personnel. Full-time OHARNG, BRAC Division, and contractor staff work at the facility. Since the Facility-Wide Sewers AOC contains 26 miles of sewer lines distributed across RVAAP, multiple future military land uses may apply. Most of the AOCs are not currently used for training for operational activities; however, the RAFLU is National Guard Training for the majority of the AOCs for which the Facility-Wide

1 Sewers AOC traverse (i.e., Load Lines 1 through 12, Atlas Scrap Yard). Other areas (e.g.,
2 Administration Area, Depot Administration Area, Inert Storage Area #6) are currently utilized for
3 administrative or storage functions by OHARNG.

4
5 The National Guard Trainee includes digging and mixing soil and subsurface media to a depth of 7 ft
6 bgs as part of the exposure scenario. Therefore, the RAFLU for the Facility-Wide Sewers AOC is
7 Military Use and Training, using the National Guard Trainee as the representative receptor. Military
8 Use and Training, in conjunction with the evaluation of Unrestricted Residential Land Use, forms the
9 basis for identifying COCs. The Resident Farmer FWCUGs are used to evaluate COCs for
10 Unrestricted Residential Land Use at the AOC, as outlined in the *Guidance Document for the*
11 *Evaluation of Land Use Controls* (USACE 2011a).

12
13 The COC screen followed the approach specified in the FWCUG Report, with an adjustment for the
14 application of soil FWCUGs to subsurface sewer media mixed with soil.

- 15
- 16 • For all COPCs identified in pipe segments located 0-4 and 4-7 ft bgs, a comparison to adjusted
17 FWCUGs for a National Guard Trainee was conducted.
 - 18
 - 19 • For all COPCs identified in pipe segments located 1-13 ft bgs, COCs were identified based on
20 comparison to adjusted FWCUGs for the Resident Farmer because this depth interval is
21 applicable only to the Resident Farmer.
 - 22

23 The comparison to FWCUGs and determination of COCs follows guidance presented in the *United*
24 *States Army Corps of Engineers Ravenna Army Ammunition Plant (RVAAP) Position Paper for the*
25 *Application and Use of Facility-Wide Human Health Cleanup Goals* (USACE 2012j). The screening
26 process is as follows:

- 27
- 28 • Select FWCUGs corresponding to a TR of 1E-05 and target HQ of 1.0 for: (1) the National Guard
29 Trainee to evaluate the RAFLU; and (2) the Resident Farmer Adult and Child to evaluate
30 Unrestricted Residential Land Use.
 - 31
 - 32 • Report all carcinogenic and non-carcinogenic based FWCUGs for each COPC for all appropriate
33 receptors (i.e., National Guard Trainee and Resident Farmer Adult and Child).
 - 34
 - 35 • Report critical effect and target organ for each of the non-carcinogenic based FWCUGs.
 - 36
 - 37 • Complete a comparison of the selected FWCUG to the EPC including a sum-of-ratios (SOR):
38
 - 39 o For non-carcinogens, compare the EPC to the target HQ FWCUG. Sum the ratios of
40 EPC/FWCUG for COPCs that affect similar target organs or do not have an identified target
41 organ.
 - 42

- o For carcinogens, compare the EPC to the TR FWCUG. Sum the ratios of EPC/FWCUG for all carcinogens.
- The COPC is identified as a COC for a given receptor:
 - o If the EPC exceeds the more protective FWCUG for either the 1E-05 target cancer risk or the 1.0 target HQ; or
 - o If the SOR for all carcinogens or all non-carcinogens that may affect the same organ is greater than 1. Chemicals contributing at least 10% to the SOR are also considered COCs. Chemicals contributing greater than 5% but less than 10% to the SOR must be further evaluated before being eliminated as COCs.

The EPC was either the 95% upper confidence limit (UCL) of the mean or the MDC for all subsurface sewer media data collected within a specific depth interval (i.e., 0-4, 4-7, and 1-13 ft bgs), whichever value was lowest. If the 95% UCL could not be determined, the EPC was the MDC.

The process for calculating FWCUGs is a rearrangement of the cancer risk or non-cancer hazard equations, with the goal of obtaining the concentration that will produce a specific risk or hazard level. For example, the FWCUG for arsenic in soil at the cancer risk level of 1E-05 for the National Guard Trainee is the concentration of arsenic in soil that produces a risk of 1E-05 when using the exposure parameters specific to the National Guard Trainee receptor exposed to soil.

For carcinogens, risk is expressed as the probability that an individual will develop cancer over a lifetime as a result of exposure to the carcinogen. Cancer risk from exposure to contamination is expressed as the increased chance of cancer above the normal background rate of cancer. In the United States, the background chance of contracting cancer is a little more than 3 in 10, or 3E-01 (American Cancer Society 2003). The calculated incremental lifetime cancer risks (ILCRs) are compared to the range specified in the NCP of 10^{-6} to 10^{-4} , or 1 in 1 million to 1 in 10,000 exposed persons developing cancer (USEPA 1990). Cancer risks below 10^{-6} are considered acceptable; cancer risks above 10^{-4} are considered unacceptable. The range between 10^{-6} and 10^{-4} is of concern, and any decisions to address risks further in this range, either through additional study or engineered control measures, should account for the uncertainty in the risk estimates. The Ohio EPA Division of Environmental Response and Revitalization (DERR) Remedial Response program has adopted a human health cumulative ILCR goal within this range of 1E-5 to be used as the level of acceptable excess cancer risk and for the development of remediation goals for an AOC. The DERR notes the defined risk goal should be applied as a goal and recognizes the need to retain flexibility during the evaluation and selection of remedial alternatives.

In addition to developing cancer from exposure to chemicals, an individual may experience other toxic effects. The term “toxic effects” is used here to describe a wide variety of systemic effects ranging from minor irritations, such as eye irritation and headaches, to more substantial effects, such as kidney or liver disease and neurological damage. The risks associated with toxic (i.e.,

1 non-carcinogenic) chemicals are evaluated by comparing an estimated exposure (i.e., intake or dose)
2 from AOC media to an acceptable exposure expressed as an RfD. The RfD is the threshold level
3 below which not ox ic effects are expected to occur in a population, including sensitive
4 subpopulations. The ratio of intake over the RfD is the HQ (USEPA 1989).

5
6 The SOR is used to account for the potential additive effects from exposure to multiple chemicals that
7 can cause the same effect (e.g., cancer) or affect the same target organ. Cancer risk is assumed to be
8 additive for all carcinogens. Non-cancer risk is assumed to be additive for chemicals with similar
9 sites of toxicological action (i.e., target organ such as liver or critical effect such as adversely
10 affecting the ability to reproduce) or having no specified target organ or critical effect. This approach
11 compares the EPC of each COPC to the FWCUG to determine a ratio. The sum of these individual
12 ratios is then compared to 1. The SOR method is based on the principle that a ratio greater than 1
13 represents unacceptable cumulative exposure (i.e., above FWCUGs if adjusted for exposure to
14 multiple COPCs), and a ratio less than or equal to 1 represents acceptable cumulative exposure (i.e.,
15 below FWCUGs if adjusted for exposure to multiple COPCs).

16
17 As noted previously, no FWCUGs are available for exposure to subsurface sewer media. FWCUGs
18 for the National Guard Trainee and Resident Farmer exposed to soil (USACE 2010) were used along
19 with the following adjustment factors to account for the use of soil FWCUGs to identify COCs in
20 subsurface sewer media mixed with soil.

- 21
- 22 • The FWCUGs for the National Guard Trainee at a TR of 1E-05 or target HQ of 1.0, whichever is
23 lower, were multiplied by a factor of 100. This order of magnitude adjustment factor of 100
24 accounts for a reasonable worst-case assumption that if 1 inch of pipe sediment coats the bottom
25 half of a 24-inch diameter pipe and the soil column directly above the pipe is disturbed or dug
26 along a 12-ft width due to tank operations or other training or construction activities, the sediment
27 will be mixed into the soil at a ratio of about 1:190 if soil is mixed to a depth of 4 ft bgs and 1:335
28 if the soil is mixed to a depth of 7 ft bgs, as shown in Figure 7-5.
 - 29
30 • The FWCUGs for the Resident Farmer at a TR of 1E-05 or target HQ of 1.0, whichever is lower,
31 were multiplied by a factor of 1000. This order of magnitude adjustment factor of 1000 accounts
32 for a reasonable worst-case assumption that if 1 inch of pipe sediment coats the bottom half of a
33 24-inch diameter pipe and the soil column directly above the pipe is disturbed to 13 ft bgs to build
34 the basement of a 2000 ft² home, the sediment will be mixed into the soil at a ratio of about
35 1:2,300 as shown in Figure 7-6.
- 36

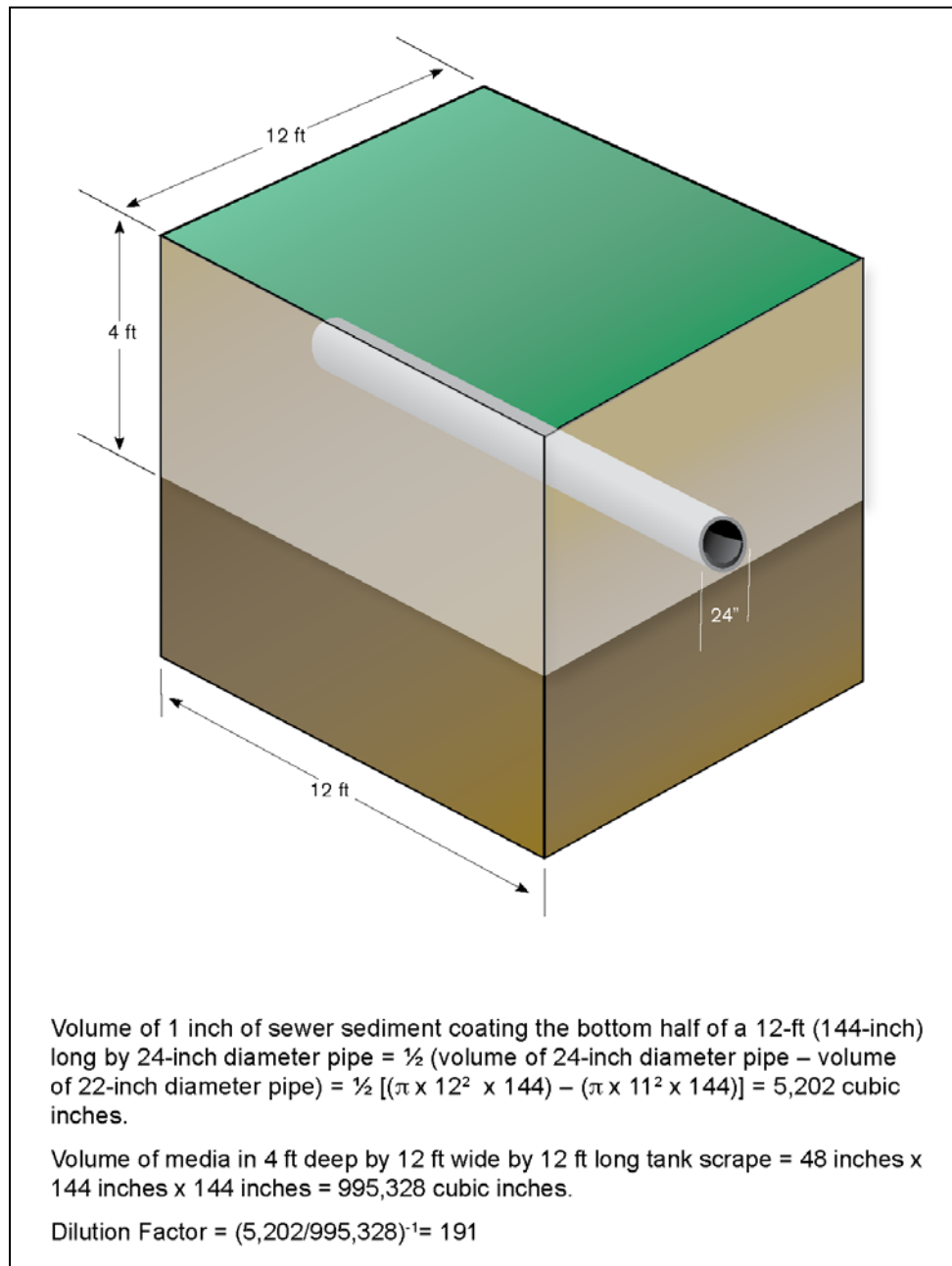


Figure 7-5. Soil Facility-Wide Cleanup Goal Adjustment Factor for National Guard Trainee Receptor Exposed to Subsurface Sewer Media

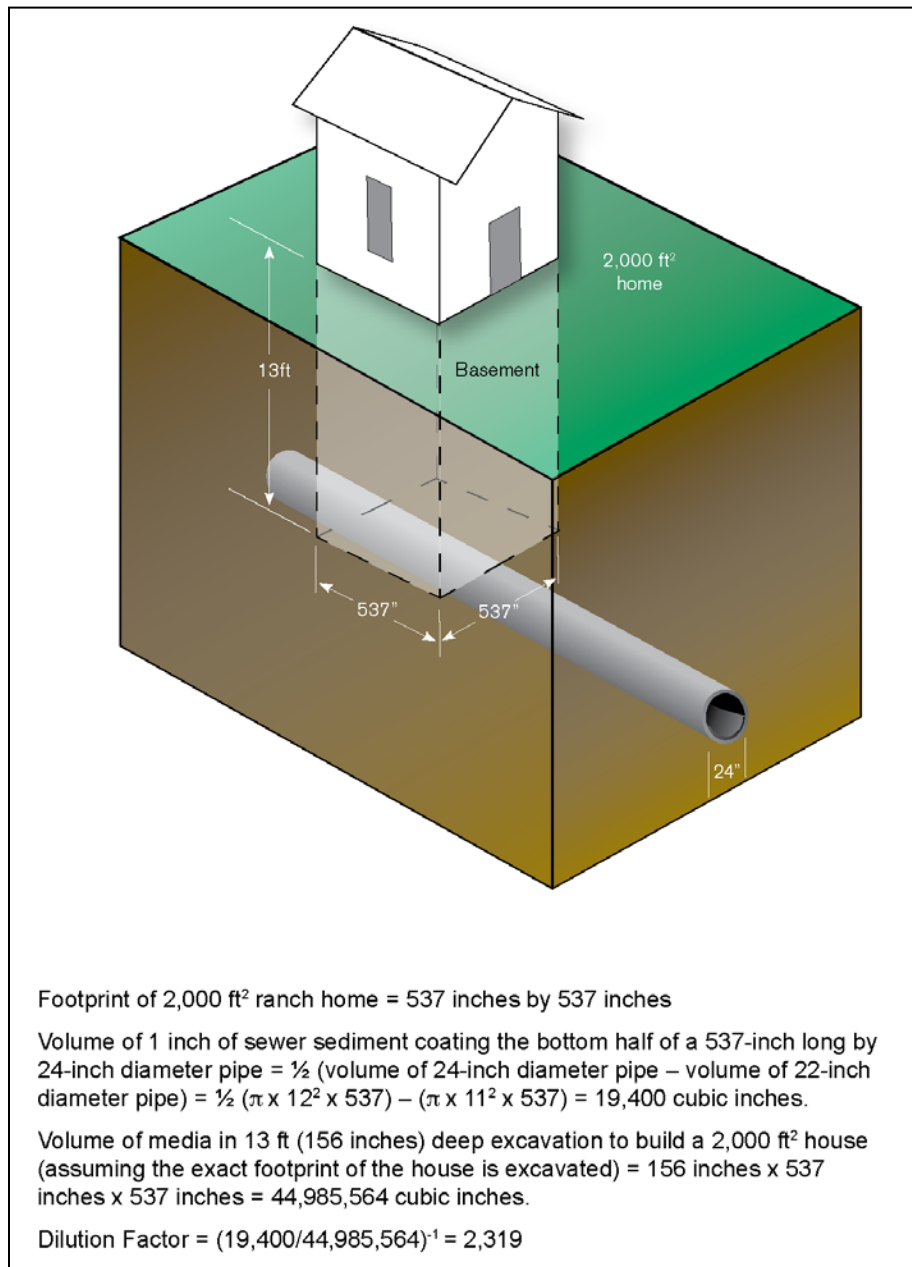


Figure 7-6. Soil Facility-Wide Cleanup Goal Adjustment Factor for Resident Farmer Receptor Exposed to Subsurface Sewer Media

Sediment thickness in most of the sewer pipes was observed to be 1 inch or less, with some areas of thicker sediment and many areas with no sediment. Pipe diameters throughout the system ranged from 4 inches (typically cast iron force mains) to 36 inches (large outfalls), with the majority of pipes being 8-10 inches in diameter; therefore, the assumption of 1 inch of sediment coating the bottom half of a 24-inch pipe for the entire Facility-Wide Sewers AOC is conservative.

FWCUGs for the National Guard Trainee and Resident Farmer exposed to soil (USACE 2010) for all COPCs identified in subsurface sewer media at the Facility-Wide Sewers AOC, along with the critical

effect or target organ associated with the toxicity values used to calculate these soil FWCUGs, are provided in Table 7-2.

Table 7-2. Soil FWCUGs Corresponding to an HQ of 1.0 and Target Risk of 1E-05 for Subsurface Sewer Media

COPC	Critical Effect or Target Organ	FWCUG (mg/kg)			
		National Guard Trainee		Resident Farmer ^a	
		HQ = 1.0	TR = 1E-05	HQ = 1.0	TR = 1E-05
Inorganic Chemicals					
Aluminum	Neurotoxicity in offspring	34960	--	73798	--
Antimony	Longevity, blood glucose and cholesterol	1753	--	28.2	--
Arsenic	Skin	1140	27.8	20.2	4.25
Chromium ^a					
Chromium, hexavalent	Stomach, liver/kidney	56.1	16.4	199	1874
Chromium, trivalent	NOAEL	1,000,000	--	81,473	--
Cobalt	NS	140	70.3	1313	8030
Lead	--	--	--	--	--
Manganese	CNS	351	--	2927	--
Mercury	CNS ^b	1722	--	22.7	--
Silver	Gastrointestinal tract ^c , skin, mucous membranes, eyes, and death	31,049	--	386	--
Sulfate	--	--	--	--	--
Sulfide	--	--	--	--	--
Explosives					
2,4-DNT	Neurotoxicity, blood, liver, ischemic heart disease, nausea, reproductive system ^d	6,519	134	128	7.53
4-Amino-2,6-DNT	Not available	1,237	--	15.4	--
Semi-volatile Organic Compounds					
1,3-Dichlorobenzene	--	--	--	--	--
Benz(a)anthracene	NA	--	47.7	--	2.21
Benz(a)pyrene	NA	--	4.77	--	0.221
Benzo(b)fluoranthene	NA	--	47.7	--	2.21
Dibenz(a,h)anthracene	NA	--	4.77	--	0.221
Indeno(1,2,3-cd)pyrene	NA	--	47.7	--	2.21
Polychlorinated Biphenyls					
PCB-1254	Meibomian glands	54.9	34.6	1.2	2.03

^aResident Farmer FWCUGs are the smaller of the Adult or Child values for each COPC and endpoint (non-cancer and cancer).

^bHand tremor, memory disturbance, objective autonomic dysfunction

^cAbdominal pain, diarrhea, vomiting, shock, convulsions, skin, mucous membranes, eyes, and death

^dNeurotoxicity, heinz bodies, biliary tract hyperplasia, ischemic heart disease, hematological effects, cyanosis, anemia, leukocytosis, neurological, dizziness, insomnia, nausea, blood, liver, nervous system, reproductive system

CNS = Central Nervous System

COPC = Chemical of Potential Concern

DNT = Dinitrotoluene

FWCUG = Facility-Wide Cleanup Goal

HQ = Hazard Quotient

NA = not applicable, no non-cancer effects evaluated.

NOAEL = No Observed Adverse Effect Level

NS = Not specified

PCB = Polychlorinated Biphenyl

PETN = Pentaerythritol Tetranitrate

TR = Target Risk

-- = No FWCUG available for this endpoint

Details of the identification of COCs for each FA are provided in the FAEs, and results are summarized in Section 7.2.2.

7.2.1.2 Water in Sewer Pipes

The streamlined risk assessment approach described in the FWCUG Report is applicable to five exposure media (surface soil, subsurface soil, surface water, sediment, and groundwater). Neither the FWCUG Report nor the FWHHRAM addresses the unusual case of potential exposure to contaminated water located inside subsurface sewer lines. The approach used for evaluating sewer water is shown in Figure 7-7 and described below.

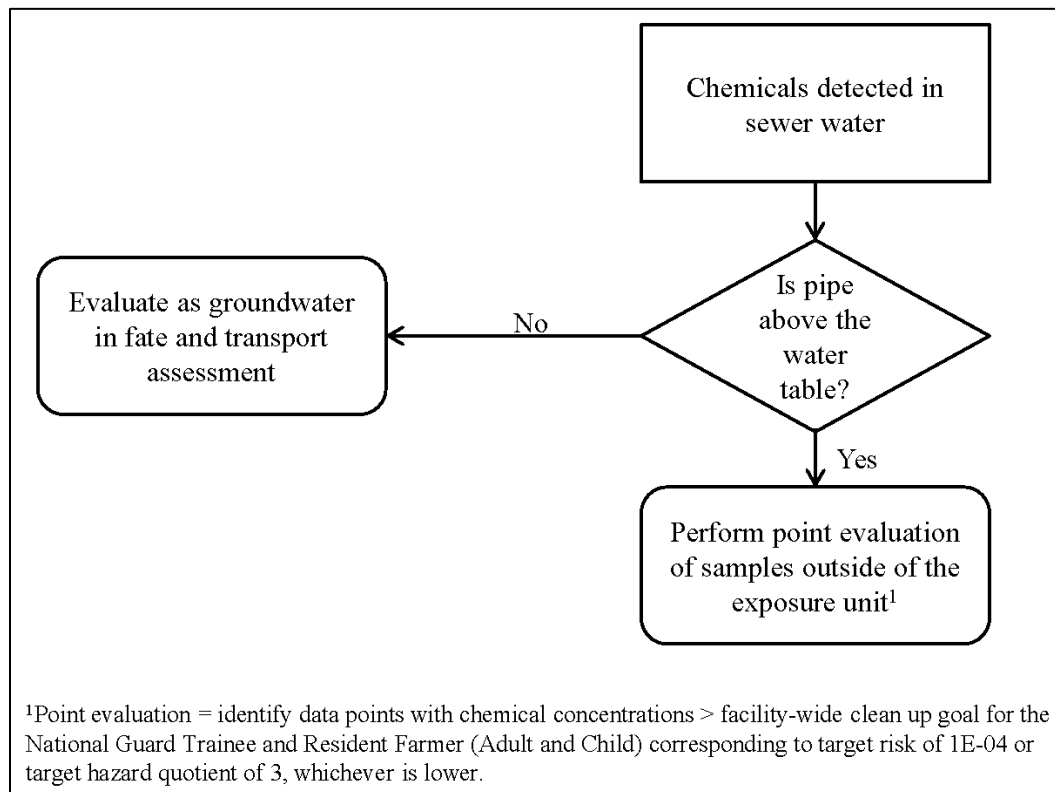


Figure 7-7. Process to Evaluate Sewer Water at RVAAP

Water within sewer pipes located below the water table is assumed to represent groundwater, and a separate evaluation of exposure risk to water in these pipe segments was not conducted. However, as discussed in the fate and transport modeling approach, sewer water data for pipe segments below the water table were used to validate groundwater modeling results. Groundwater will be evaluated (including risk assessment) in a separate document, as described in Section 1.2. A preliminary field reconnaissance of sanitary and storm sewer lines was completed in December 2008. Flowing water, likely sourced from infiltrating groundwater, was observed in some sanitary and storm sewer inverts at elevations below the water table. The extent of water observed in sewer lines and their location relative to groundwater is described for each FA in Section 3.2 of its FAE and summarized in Table 7-3.

Observations indicate water within the sewer pipe systems located above the water table is generally transient and discharges at outfalls. Additionally, if a sewer pipe containing water was dug up, the water would be released to the surrounding soil and would not be available for exposure as water. Therefore, sewer water is not an exposure medium for direct contact by receptors; however, a point evaluation was conducted. The point evaluation assumes sewer water will ultimately daylight at an outfall; therefore, sewer water concentrations were compared to the lowest surface water FWCUG for the National Guard Trainee and Resident Farmer at a TR of 1E-04 or target HQ of 3.0, whichever is lower. Use of surface water FWCUGs results in a very conservative screen of water present intermittently inside sewer pipes. Points within the sewers with elevated concentrations were further evaluated to determine their potential to impact downstream receptors and potential acute exposures (e.g., if a receptor climbed into a flooded pipe).

Table 7-3. Water Observations in Sewer Lines

Functional Area		Sanitary Sewers	Storm Sewers	Outfalls
<i>Sewers are generally located above the water table and mostly dry</i>				
FA 1	Administration Area	x	x	x
FA 3	Depot Administration Area	x	x	x
FA 6	Load Line 1	x ^a	x	x
FA 7	Load Line 2	x ^b	x	x
FA 10	Load Line 5	x ^c	--	--
FA 12	Load Line 7	x	--	--
FA 13	Load Line 8	x ^d	--	--
FA 14	Load Line 9	x	--	--
FA 15	Load Line 10	x	--	--
FA 18	Sand Creek Trunk and Connector Lines	x	--	x
FA 19	Transportation Storage Area	x	x	x
<i>Portions of sewers contain water due to obstructions, not groundwater</i>				
FA 4	George Road Trunk and Connector Lines	x	--	--
FA 8	Load Line 3	x	x	x
<i>Some sewer segments are located below the water table, and portions contain infiltrated groundwater</i>				
FA 2	Atlas Scrap Yard	x	--	--
FA 5	Inert Storage Area #6	x	x	x
FA 9	Load Line 4	x	x	x
FA 11	Load Line 6	x	--	--
FA 16	Load Line 11	x	--	x
FA 17	Load Line 12	x	--	--

^aAll sewer lines above water table with the potential exception of sanitary sewer segment at manholes MH226 to MH-205.

^bAll sewer lines are above the water table with the potential exception of the sanitary sewers in the southern portion of the FA.

^cThe sewer segment at manholes MH-1F1, MH-1F2, and MH-1F3 is close to the water table and may be periodically below the water table during high rainfall periods.

^dThe sewer segment at manholes MH-2B9 and MH-2B10 may be periodically close to the water table during high rainfall periods. The sewer segment encompassed by MH-2B17 and MH-2B18 may exhibit surface water infiltration.

x = Sewer type is present at this functional area

-- Sewer type is not present at this functional area

FA = Functional Area

7.2.1.3 Sediment and Water at Sewer Outfalls

Sewer outfalls, particularly within the storm sewer networks, provide points where sewer media (i.e., sediment and water) may daylight to the outside environment. A preliminary field reconnaissance of sanitary and storm sewer lines completed in December 2008 showed many storm sewer lines above the water table are still functional and convey water during periods of rainfall.

Outfalls divert storm water runoff to natural or constructed drainage ditches or conveyances. While most outfalls only receive runoff following storm events, a few exhibit continuous flow sourced from infiltration (e.g., groundwater) to the sewer lines (see Table 7-3). Sediment samples collected at outfalls were identified as either dry sediment (soil) or wet sediment (sediment), depending on whether water was present and as defined in Section 5.0. The approach for evaluating sediment and water at the sewer outfalls is shown in Figure 7-8 and described below.

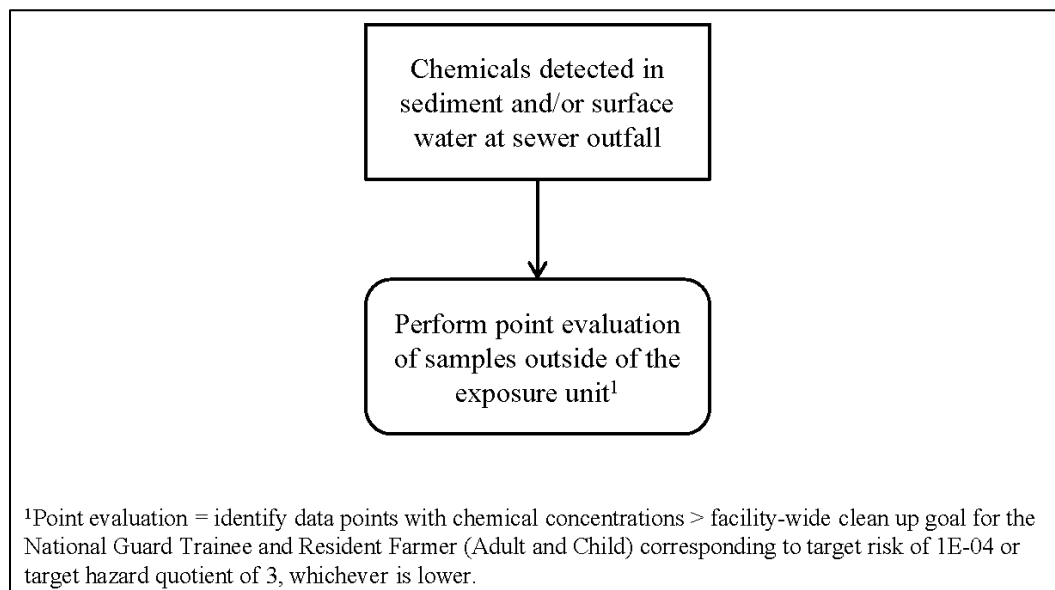


Figure 7-8. Process to Evaluate Sediment and Surface Water in Sediment at Sewer Outfalls

The scope of the Facility-Wide Sewers RI includes only the outfalls; drainage ditches, culverts, and streams are not included in the AOC. These surface water conveyances have been, or will be, addressed in AOC-specific evaluations. Because of their small size, soil/sediment and water at individual sewer outfalls are not considered exposure media for direct contact by receptors, except in the context of a point evaluation. A point evaluation was conducted for all outfall soil/sediment and water. The point evaluation identified outfall soil/sediment or water concentrations greater than the lowest sediment or surface water FWCUG for the National Guard Trainee and Resident Farmer at a TR of 1E-04 or target HQ of 3.0, whichever is lower. Points with elevated concentrations were further evaluated to determine their potential to impact downstream receptors.

The HHRA includes a discussion of the HHRA results (if available) for sediment and surface water downstream of the outfall at the AOCs where the outfall is located.

7.2.2 Summary of Results

This section presents a summary of the results and recommendations of the HHRA's conducted for the 19 FAs that are part of the Facility-Wide Sewers AOC. Details are provided for each FA in its respective FAE.

All 19 FAs included samples collected from sewer lines located 0-13 ft bgs, which is considered to be within the potential EUs for the National Guard Trainee and/or Resident Farmer. At 12 of the FAs (Administration Area, Atlas Scrap Yard, Depot Administration Area, Inert Storage Area #6, Load Line 1, Load Line 2, Load Line 3, Load Line 4, Load Line 8, Load Line 11, Sand Creek Trunk and Connector Lines, and the Transportation Storage Area), the total volume of the sewer pipe system represents $\geq 1\%$ of the total mixing zone soil volume within the FA. For these FAs, both a screening for COPCs/COCs and a point evaluation were conducted. At the remaining seven FAs (George Road Trunk and Connector Lines, Load Line 5, Load Line 6, Load Line 7, Load Line 9, Load Line 10, and Load Line 12), the total volume of the sewer pipe system represents less than 1% of the total mixing zone soil volume within the FA. At these FAs, sewer media are not considered to be a concern for direct contact; therefore, the HHRA consisted of a point evaluation to assess the potential for impacts to downstream receptors.

7.2.2.1 Summary of COPC and COC screening

The identification of COPCs and COCs focused on potential exposures associated with intentional or unintentional digging into sewer lines and mixing the subsurface media (sewer sediment and pipe bedding material) into the overlying soil.

COPCs were identified as a subset of the SRCs (summarized in Section 7.1.4 of each FAE) present at concentrations that indicate potential impacts to human receptors. The COPC screen followed the approach specified in the FWCUG Report, with an adjustment for the application of soil FWCUGs to subsurface sewer media mixed with soil. COPCs identified for each of the 19 FAs are summarized in Table 7-4.

COCs were identified as a subset of the COPCs present at concentrations that indicate the need for evaluation in an FS. At 10 of the 12 FAs with a sewer pipe system volume $\geq 1\%$ of the total mixing zone soil, no COCs were identified for either the National Guard Trainee or Resident Farmer because the EPC of all COPCs was less than the adjusted FWCUGs, and the calculated SOR is less than 1. Manganese was identified as a COC at the Depot Administration Area FA and at the Transportation Storage Area FA. At both of these FAs, manganese was detected above the adjusted FWCUG for the National Guard Trainee in one pipe sediment sample. At the Depot Administration Area FA, manganese was also detected above the point evaluation screening criterion in sewer sediment, sewer water, and outfall sediment, indicating the potential for migration to downstream media. Manganese has historically been, and continues to be, stored at the Transportation Storage Area FA. COCs identified for evaluation in an FS are summarized in Table 7-5.

Table 7-4. Summary of COPCs in Subsurface Sewer Media

	Functional Area											
	Administration Area	Atlas Scrap Yard	Depot Administration Area	Inert Storage Area #6	Load Line 1	Load Line 2	Load Line 3	Load Line 4	Load Line 8	Load Line 11	Sand Creek Trunk Lines	Transportation Storage Area
Inorganic chemicals												
Aluminum	--	X	--	--	--	X	--	--	--	--	--	--
Antimony	--	--	--	--	X	X	X	--	--	--	--	--
Arsenic	X	X	X	--	X	X	X	X	X	X	--	X
Chromium ^a	X	X	X	--	X	X	X	X	--	--	--	X
Chromium, hexavalent	--	--	--	--	--	--	X	--	--	--	--	--
Cobalt	--	--	--	--	--	X	--	X	--	--	--	--
Lead	--	--	--	--	--	X	X	--	--	--	--	--
Manganese	X	--	X	X	--	X	X	X	X	X	--	X
Mercury	X	--	--	--	--	X	--	--	--	--	--	--
Silver	--	--	--	--	--	--	X	--	--	--	--	--
Sulfate	--	--	--	--	--	--	--	--	--	X	--	--
Sulfide	--	--	--	--	--	--	--	--	--	X	--	--
Explosives												
2,4-DNT	--	--	--	--	X	--	--	--	--	--	--	--
4-Amino-2,6-DNT	--	--	--	--	--	X	--	--	--	--	--	--
Semi-volatile Organic Compounds												
1,3-Dichlorobenzene	--	--	--	--	--	--	--	X	--	--	--	--
Benz(a)anthracene	X	--	X	--	X	X	X	X	X	--	--	X
Benz(a)pyrene	X	X	X	X	X	X	X	X	X	--	--	X
Benzo(b)fluoranthene	X	X	X	--	X	X	X	X	X	--	--	X
Dibenz(a,h)anthracene	X	X	X	--	X	X	X	X	X	--	--	X
Indeno(1,2,3-cd)pyrene	X		X	--	X	X	--	--	X	--	--	--
Pesticides and PCBs												
PCB-1254	--	--	--	--	X	X	X	--	--	--	--	--

^aTotal chromium was evaluated using the screening values for hexavalent chromium.

COPC = Chemical of Potential Concern

DNT = Dinitrotoluene

PCB = Polychlorinated Biphenyl

X = Chemical is a Chemical of Potential Concern

-- = Chemical is not Chemical of Potential Concern

Table 7-5. Summary of COCs in Subsurface Sewer Media

Chemical of Concern	Functional Area			
	Depot Administration Area FA	Load Line 2 FA	Load Line 3 FA	Transportation Storage Area FA
<i>National Guard Trainee</i>				
None				
<i>Resident Farmer</i>				
Lead	--	X	X	--
Manganese	X	--	--	X

COC = Chemical of Concern

FA = Functional Area

-- = Not a chemical of concern in Functional Area.

7.2.2.2 Summary of Point Evaluation

All sampled media (sewer sediment; pipe bedding material; sewer water; and outfall water, soil, and sediment) at all 19 FAs were subject to a point evaluation. The purpose of the point evaluation was to assess potential impacts to downstream receptors resulting from migration of contaminated media and the potential for acute exposures within sewer pipes and at outfalls.

Various chemicals were detected above the screening criteria used as a starting point for the point evaluation at all 19 FAs; however, the evaluation of all lines of evidence (e.g., potential for migration to other media, accessibility of contaminated sample locations) resulted in the conclusion that most of these chemicals/locations do not represent an acute exposure risk, and they are not impacting downstream receptors; therefore, they do not warrant further evaluation in an FS.

Lead was detected above point evaluation screening criteria in several sewer media at the Load Line 2 FA and Load Line 3 FA. Lead was not identified as a COC because the MDC concentrations are less than the adjusted soil guidance value; however, the point evaluation at these FAs indicated lead may represent a localized source that could impact downstream receptors and should be evaluated in an FS.

7.3 ECOLOGICAL RISK ASSESSMENT

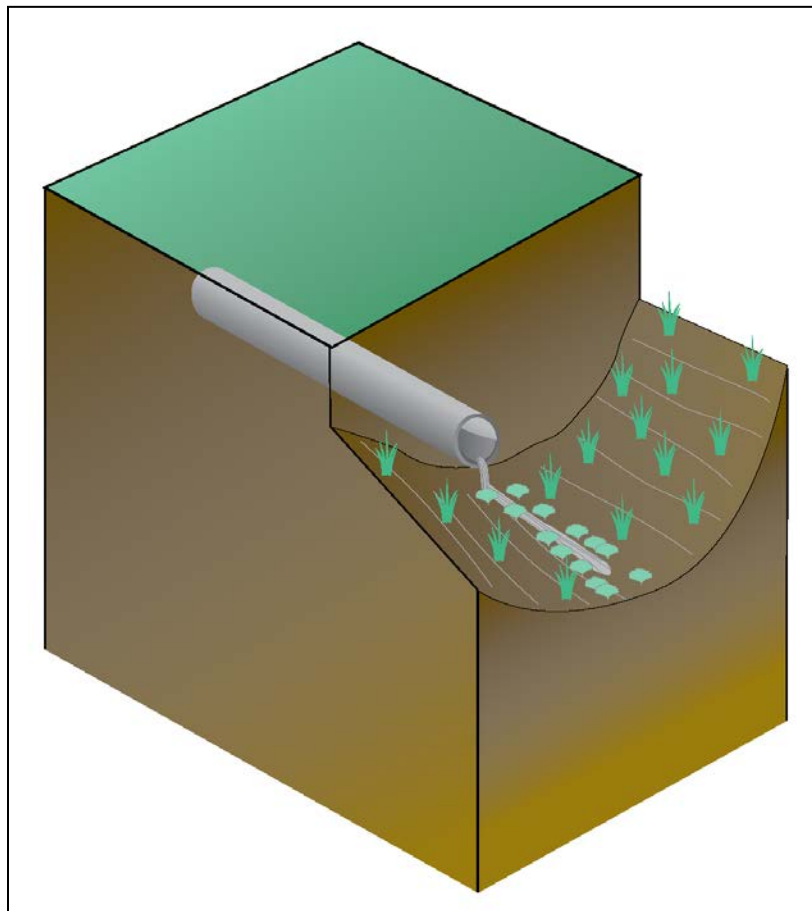
7.3.1 Introduction

The ERA evaluates potential exposures related to the Facility-Wide Sewers AOC, specifically the sewer soil, sediment, and water at pipe outfalls. The process for evaluation was developed in collaboration with USACE and Ohio EPA.

7.3.2 Scope and Objective

The sewer system consists of two parts: underground piping systems and outfalls to the environment adjacent to these systems. The objective of the screening and ERA is to determine the need for remediation of the piping system and/or outfalls.

1
2 The Facility-Wide Sewers AOC does not constitute a conventional ecological habitat. Conventional
3 ecological habitat means a place, locality, territory, or natural setting that provides the food and cover
4 required for an organism to make its home. Habitat also means a unit of nature in which not just one
5 organism can live temporarily but in which other organisms of the same species can live near each
6 other to assure propagation and interact with different species, such as in food chains. Organisms are
7 known to spend most or all of their life cycle in conventional and viable habitat. In contrast, the
8 Facility-Wide Sewers AOC consists of about 26 miles (approximately 136,900 ft) of underground,
9 horizontal drainage pipes. Only the outfalls provide an opportunity for exposure of contaminants in
10 soil, sediment, and water to vegetation and wildlife species (Figure 7-9).
11



12
13 **Figure 7-9. Depiction of Typical Outfall Used in the Quantitative ERA for the Sewer System**
14

15 The majority of the sewer lines in the storm and sanitary system are 8 inches or 12 inches in diameter
16 and occur at depths greater than 4 ft bgs. Larger diameter pipes (10-12 inches or more) occur
17 predominantly as sanitary connector/trunk lines at major storm outfalls and typically occur at depths
18 at or greater than 10 ft bgs. Thus, the pipe diameters could accommodate several species of smaller
19 animals (e.g., mice, ground squirrels, opossums, rabbits, and snakes), but almost all the system is
20 below ground and has very limited access to the surface. The Facility-Wide Sewers AOC is an
21 engineered system designed to serve a different function from providing pseudo-habitat to organisms;

1 neither the underground sewer system nor the few entrances to it constitute conventional ecological
2 habitat. Both by design and circumstance, there is a lack of ecological resources (e.g., light, food
3 sources, chance of finding a mate). Therefore, the lack of suitability of the sewers as an ecological
4 habitat is not as much a function of the dimensions of the pipes as is their inhospitable internal
5 conditions.

6
7 The majority of the sewer lines have only occasional access points to the surface and little to no light.
8 Manholes, catch basins, and drop inlets consist of vertical pipes or steep-sided invert and are not
9 typically viable access points for wildlife. Some wildlife may be able to enter a small portion of the
10 storm sewer system through pipe outfalls, but such entry would likely be an occasional event to seek
11 temporary cover from weather conditions or to escape from a predator. From the viewpoint of viable
12 habitat, including the ability to support the life cycles of organisms, the Facility-Wide Sewers AOC
13 falls very short of anything but a fleeting place for occasional organisms in a small part of the
14 network; there is inadequate and non-viable habitat, little to no light for vision, and no provision for
15 permanent food within the sewer system. Organisms could not live and propagate in this
16 subterranean system of drains and pipes.

17
18 Considering the piping portions of Facility-Wide Sewers AOC are not viable habitat, there is no need
19 for an ERA to address accumulated sewer sediment and water within the pipe lines. With the lack of
20 permanent habitat and receptors, there is no exposure pathway and no ecological risk inside the
21 piping system.

22
23 Potential contamination of subsurface soil and groundwater adjacent to the sewer lines (e.g., through
24 leaks or line breaks) are not included in the ERA. The majority of biological activity occurs in the
25 upper few inches of soil. Virtually all of the Facility-Wide Sewers AOC occurs below the active
26 biological zone (0-1 ft bgs), and over half occurs at depths greater than 7 ft bgs. Under the RVAAP
27 *Facility-Wide Ecological Risk Assessment Work Plan* (USACE 2003c), subsurface soil and
28 groundwater are typically not addressed as an exposure medium for ecological receptors.

29
30 During RVAAP operations, storm water and sanitary sewer effluent flowed through the Facility-Wide
31 Sewers AOC; infiltrating groundwater and storm water still flow through many portions of the lines.
32 Storm sewer systems discharged to outfalls at ditch lines. The sanitary sewer systems were largely
33 contained, although emergency overflow outfalls to ditch lines or small streams were located at
34 several lift stations. The storm water, sanitary water, groundwater, and any entrained sediment could
35 emerge into a ditch, stream, or pond. If the emerging water and sediment were contaminated, aquatic
36 and other life at these outfalls could be exposed. However, ecological risks for these media have
37 been, or are currently being, evaluated as part of sediment and water ecological risk evaluations under
38 specific CERCLA investigations at most of the primary source AOCs (e.g., Atlas Scrap Yard, Load
39 Lines 1 through 12). When contamination of sewer lines is discovered in the RI at facilities not
40 designated as AOCs (e.g., Inert Warehouse Storage Area #6 FA, Administration Area FA, Depot
41 Administration Area FA, Transportation Storage Area FA), some additional technical factors for
42 outfall sediment or water may be required. When a location is identified with high contaminant
43 exposure potential and the presence of important ecological resources, one or more technical

considerations from Section 4.8 of the PBA08 SAP are applied. Since only the outfalls (but not the sewer lines) can have a viable habitat, only the outfalls require a quantitative ERA.

7.3.3 Overview of Outfalls

The outfalls from the underground piping system are open to light and habitat (i.e., the environment where exposure could occur), though each outfall occupies only a very small area (a few square feet). The outfalls release water and occasional sediment from inside the piping system to the environment. Due to the possibility of exposure to receptors at the outfall and downstream of the outfall, an ERA was conducted for chemicals detected at the outfalls. A summary of selected characteristics of Facility-Wide Sewers AOC outfalls at RVAAP are included in Table 7-6.

Table 7-6. Summary Characteristics of the Sewer System Outfalls at RVAAP

Characteristics	Details
Outfall categories	There are two outfall categories associated with Facility-Wide Sewers AOC: storm sewer system outfalls and sanitary sewer systems outfalls.
Functional areas with outfalls	Ten FAs contain outfalls. For FAs containing outfalls, the number of outfalls at each functional area ranges from 33 (Administrative Area FA) to 1 (Load Line 11 FA). The Atlas Scrap Yard FA; Load Lines 5, 6, 7, 8, 9, 10, 12 FAs; and George Road Trunk and Connector Line FA have no identified and sampled outfalls. Most outfalls are associated with the storm sewer systems (e.g., Administrative Area, Load Line 1). The sanitary sewer system contains few outfalls, and most were created when sewage treatment plants and ejector stations were closed/removed and by-passed.
Total number of outfalls	There are 118 identified outfalls within the FAs. Fifty-one key outfalls were selected to represent various drainage segments and were sampled as part of the RI and/or historical investigations.
Outfall pipe diameters	Outfall pipe diameters vary from 6 to 48 inches in diameter. The majority of outfalls are 8 inches or 12 inches in diameter.
Availability and timing of sampling	Some functional areas have historical and current available data (e.g., Load Lines 1, 2, 3, and 4). Historical samples were collected between 2000 and 2005. For Load Line 1, data from 1996 were also used. Current samples under the Facility-Wide Sewers RI were collected in late 2009 and early 2010.
Downstream environments	Most outfalls have intermittent flow during precipitation events or periods of snow melt and discharge to small drainage conveyances or ditches, feeding small tributary watersheds. A few outfalls were observed to have potentially continuous flow sourced from groundwater; these instances are primarily associated with bypassed sanitary sewer systems (e.g., south of the former Load Line 2 ejector station). Some functional areas have available sediment and water sample data from drainage conveyances at various distances downstream of the outfall. Most functional areas have nearby facility-wide surface water quality/biological sampling stations in major receiving streams.

AOC = Area of Concern

FA = Functional Area

RI = Remedial Investigation

RVAAP = Ravenna Army Ammunition Plant

7.3.4 Methods

There is no known guidance for sewer assessment. Although habitat is defined as being only a few square feet of space, the method for this ERA proceeds in good faith that outfalls should be evaluated with individual ERAs. The Ohio EPA ERA guidance has been used to assist in the development of methods and benchmarks and has resulted in COPECs; however, while conventional methods serve as a guide, and benchmarks are standard, the method differs from convention to accommodate the atypical ecological habitat. The methods for this sewer outfall ERA include the definition/evaluation of habitat and contamination [similar to a Level I Scoping ERA of *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2008)] and COPEC identification (similar to Level II Screening ERA of the same guidance). In addition, descriptions of potential upgradient sources and downgradient effects are provided where applicable. Ohio EPA-approved persistent, bioaccumulative, and toxic (PBT), sediment reference value (SRV), background, and ecological screening value (ESV) methods and values have been used. The ERA methods have also relied on biological/water quality measurements from the *Facility-Wide Biological and Water Quality Study* (USACE 2005a), a study performed by USACE and Ohio EPA.

The ERA of the sewer outfalls consists of five steps (Figure 7-10). Although sewer outfalls are not typical ecological habitat, the ERA steps follow the logic used in the *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2008) for environments such as fields, forests, ponds, and streams.

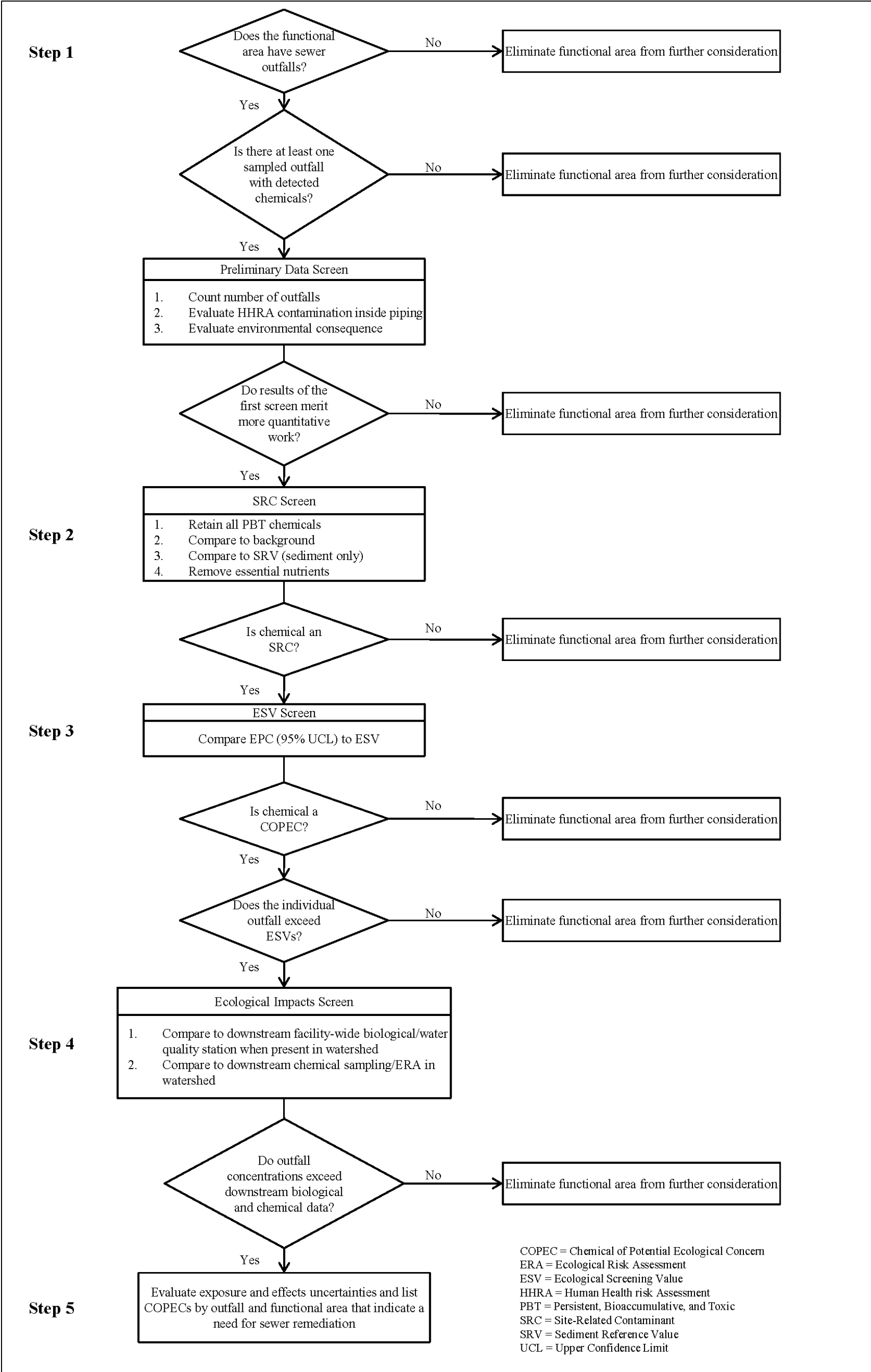


Figure 7-10. Identification and Evaluation of COPECs for Sediment and Water at Sewer Outfalls

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7.3.4.1 Step 1

Step 1 is to screen the 19 FAs for the presence of outfalls. Those FAs without any outfalls are eliminated from further consideration. FAs with outfalls are eliminated from further consideration when:

- There are only one or two outfalls (unless these outfalls are heavily contaminated);
- There is evidence within the piping system that chemicals have no to little human health risk (no COCs); and
- There is no evidence of downstream environmental consequences at nearby biological/chemical sampling stations.

7.3.4.2 Step 2

Step 2 is to apply an SRC screen to all detected chemicals. Chemicals are eliminated as SRCs when detected concentrations:

- Are below background concentrations;
- Have a frequency of detection less than 1/20 (unless the chemical is an explosive); or
- Are essential nutrients to plants and animals (calcium, magnesium, iron, potassium, sodium).

PBT compounds are also identified in Step 2 and are retained as COPECs throughout the process. This screening step identifies chemicals that exceed background concentrations and the SRVs and are PBT compounds listed in *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2008).

7.3.4.3 Step 3

Step 3 is to compare the EPC to ESVs of the remaining chemicals. The EPC is the smaller of the 95% UCL of the mean and the maximum. Summary statistics were developed for the combined outfalls at FAs with sufficient sample population size. For the majority of the sewer datasets, the EPC is the MDC because of the small number of samples. Additionally, the methods accommodate a mean concentration of an SRC to be used in some comparisons.

The latest ESVs were gathered from the preferred sources listed in the *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2008). If more than one value was available, the preferred, and often more (or most) conservative ESV was used.

Next, specific outfalls acting as the source of COPECs identified in the first part of Step 3 are identified by comparing the detected concentration of each COPEC at each outfall to the ESVs. This step shows two things regarding each outfall:

- The upgradient and possible sub-portion of the internal piping system associated with the most COPECs, with the implication that a source (i.e., in-pipe COC) of ecological risk is present for the outfall; and
- The downgradient environment near an outfall receiving the most COPECs, with the implication that ecological risk could be present in that part of the outfall/environment, and further study may be needed in the downstream environment.

The result of this step is a list of COPECs by outfall for each FA.

7.3.4.4 Step 4

Step 4 is to determine if there is evidence of ecological risk upstream and downstream of the outfall. The area upstream of the outfalls is within the sewer pipes. The upstream evaluation noted the presence of human health COCs in the piping system because no ERA was conducted for the interior of the sewers. Evidence of downstream environmental harm was determined as follows:

- Identify a nearby biological/surface water station and determine any impairment of the five metrics – sediment quality, surface water quality, fish composition, macroinvertebrate composition, and habitat quality for a stream station – from the *Facility-Wide Biological and Water Quality Study* (USACE 2005a). Metrics for a pond station are similar. If these metrics are favorable, it is concluded that there is no ecological consequence of having mathematically projected COPECs at the outfalls.
- If impairment is found, or if there is no biological station available in the watershed, the concentrations of the COPECs at the outfall(s) are compared to the possible presence of the same chemicals in downstream sampling station(s) or in an historical ERA (if available) to better determine a source.

Thus, the comparison is made between (1) the presence of current COPECs in outfall media to (2) the biological/sediment and water quality at a nearby and downgradient sampling station from the *Facility-Wide Biological and Water Quality Study* (USACE 2005a). Also, an historical ERA can be used if there is no biological/water quality station.

7.3.4.5 Step 5

Step 5 is to list the COPECs at each FA that may have downstream environmental consequences. Step 5 also includes an evaluation of the uncertainty in the ERA. Exposure and toxicity information is considered and includes:

- The approximate percent contribution of the outfall compared to the rest of the watershed;
- The change in concentration through time at an outfall;

- The technical strength of information about chemical exceedances at the outfall and consequence at the downstream station; and
- Other technical information used to temper the uncertainty.

The ERA results are presented in a list of chemicals by outfall and by FA that may require evaluation in an FS for media inside the sewer system.

7.3.5 Overview of COPECs at Each Functional Area

COPECs were identified at 9 of the 10 FAs where outfalls were sampled using the methods and data detailed in Section 7.3.4 and shown in Figure 7-10. A COPEC was a chemical whose concentration exceeded the background concentration, SRV for sediment, and ESV, or was noted as a PBT chemical. COPECs lacking ESVs for comparison were also included. Both inorganic chemicals and organic chemicals qualified.

Ten of the 19 FAs had measured outfalls, detected chemicals, and COPECs. Table 7-7 provides a summary of COPECs at each FA. The FAs with the highest numbers of COPECs for soil were the Load Line 1 FA, Load Line 3 FA, and Load Line 4 FA. The FAs with the most COPECs found in sediment were the Inert Storage Area #6 FA, Depot Storage Area FA, and Administration Area FA. The FAs with the highest numbers of COPECs for water were the Load Line 3 FA and Inert Storage Area #6 FA. The most frequent inorganic COPECs were cadmium, copper, lead, manganese, mercury, selenium, and zinc. PAHs were the most commonly found organic COPECs.

Table 7-7. Summary of COPECs at Functional Area Outfalls

Functional Area	Medium	Number of COPECs with ESV to EPC Ratios of 1 or Greater ^a	COPECs with ESV to EPC Ratios of 10 or Greater
Administration Area FA	Soil	13	Aluminum, mercury, and zinc
	Sediment	26	Lead, mercury, silver, and many PAHs
	Water	0	None
Depot Administration Area FA	Soil	NA	None
	Sediment	28	Many PAHs
	Water	0	None
Inert Storage Area # 6 FA	Soil	NA	None
	Sediment	33	Silver and many PAHs
	Water	6	None
Load Line 1 FA	Soil	15	Antimony, copper, lead, manganese, mercury, and zinc
	Sediment	NA	None
	Water	NA	None
Load Line 2 FA	Soil	11	Antimony, cadmium, copper, lead, mercury, and zinc
	Sediment	7	Copper
	Water	4	Aluminum, copper, and manganese

1

Table 7-7. Summary of COPECs at Functional Area Outfalls (continued)

Functional Area	Medium	Number of COPECs with ESV to EPC Ratios of 1 or Greater^a	COPECs with ESV to EPC Ratios of 10 or Greater
Load Line 3 FA	Soil	15	Mercury and zinc
	Sediment	20	Copper, silver, zinc, and 4,4-DDE
	Water	7	Aluminum, manganese, and zinc
Load Line 4 FA	Soil	14	Antimony, copper, manganese, and mercury
	Sediment	6	None
	Water	0	None
Load Line 11 FA	Soil	NA	None
	Sediment	2	None
	Water	NA	None
Sand Creek Trunk and Connector Lines FA	Soil	NA	None
	Sediment	1	None
	Water	0	None
Transportation Administration Area FA	Soil	5	Mercury
	Sediment	NA	None
	Water	NA	None

2 ^aAlso includes COPECs with no ESV or PBT status with ratio less than 1

3 NA = medium not available for sampling

4 COPEC = Chemical of Potential Ecological Concern

5 DDE = Dichlorodiphenyldichloroethylene

6 EPC = Exposure Point Concentration

7 ESV = Ecological Screening Value

8 PAH = Polycyclic Aromatic Hydrocarbon

9 PBT = Persistent, Bioaccumulative, and Toxic

10

11 **7.3.6 Overview of Findings and Recommendations for All Functional Areas**

12

13 This section provides the contaminant situation and environmental condition for each of the 19 FAs
14 (Table 7-8). Details are found in the respective FAE sections and their respective attachments.

15 Further, this section provides the final recommendation for each of the 19 FAs.

16

Table 7-8. Overview of Findings Reported for Each Functional Area with Recommendations

Functional Area	Field Situation and Conditions with Justification for Completion of Ecological Risk Screening	Recommendation for Ecological Risk
Administration Area	Presence of outfalls with COPECs but no upgradient (i.e., in-pipe) COCs, and downgradient biological/water quality conditions favorable.	No Further Action
Atlas Scrap Yard	No outfalls, no quantitative ERA possible, and no ecological risk from sewers.	No Further Action
Depot Administration Area	Presence of outfalls with COPECs, upgradient (i.e., in-pipe) COCs (manganese), but little to no downgradient evidence of a consequence from COPECs.	No Further Action
George Road Trunk and Connector Lines	No active outfalls, only one overflow outfall that could not be located, no quantitative ERA possible, and no ecological risk from sewers.	No Further Action
Inert Storage Area #6	Multiple outfalls with COPECs, no upgradient (i.e., in-pipe) COCs, some downgradient evidence of a biological/water quality consequence of COPECs, but downgradient COPECs originate from non-sewer causes associated with this particular AOC.	No Further Action
Load Line 1	Multiple outfalls with COPECs, but no upgradient (i.e., in-pipe) COC and no reserves of lead or other chemicals, similar COPECs with a few hazard quotients greater than 1 in downstream resource.	No Further Action
Load Line 2	Multiple outfalls with COPECs, no upgradient (i.e., in-pipe) COCs, but high upgradient lead concentrations and many downstream biological/water quality study exceedances including lead exceedance.	Assessment in Feasibility Study for lead in the storm sewer lines.
Load Line 3	Multiple outfalls with COPECs, no upgradient (i.e., in-pipe) COCs, but lead has high concentrations, little to no downstream consequences.	No Further Action
Load Line 4	Presence of outfalls with COPECs, but no upgradient (i.e., in-pipe) COCs, and downgradient biological/water quality conditions favorable.	No Further Action
Load Line 5	No outfalls, no quantitative ERA possible, and no ecological risk from sewers.	No Further Action
Load Line 6	No outfalls, no quantitative ERA possible, and no ecological risk from sewers.	No Further Action
Load Line 7	No outfalls, no quantitative ERA possible, and no ecological risk from sewers.	No Further Action
Load Line 8	No outfalls, no quantitative ERA possible, and no ecological risk from sewers.	No Further Action
Load Line 9	No outfalls, no quantitative ERA possible, and no ecological risk from sewers.	No Further Action
Load Line 10	No outfalls, no quantitative ERA possible, and no ecological risk from sewers.	No Further Action
Load Line 11	One outfall with few COPECs, but no upgradient (i.e., in-pipe) COCs, and downgradient biological/water quality conditions favorable.	No Further Action
Load Line 12	No outfalls, no quantitative ERA possible, and no ecological risk from sewers.	No Further Action
Sand Creek Trunk and Connector Lines	One outfall with no COPEC, no upgradient (i.e., in-pipe) COCs, and downgradient biological/water quality conditions favorable.	No Further Action
Transportation Storage Area	One outfall with COPECs, upgradient COCs (manganese), but little to no evidence of a downgradient consequence of any COPEC.	No Further Action

AOC = Area of Concern

COC = Chemical of Concern

COPEC = Chemical of Potential Ecological Concern

ERA = Ecological Risk Assessment

7.3.7 Summary and Recommendations

The *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2008) has been used to assist in development of methods and benchmarks for sewer outfalls and has resulted in COPECs; however, while conventional methods serve as a guide and benchmarks are standard, the method differs from convention to accommodate the atypical ecological habitat.

There are 19 FAs; 9 contain no outfalls, and no quantitative ERA is necessary with no ecological risk from sewers. In 9 of the remaining 10 FAs, COPECs were identified in sewer soil, sediment, and water. Both inorganic chemicals and organic chemicals were identified as COPECs. The most common inorganic COPECs are cadmium, copper, lead, manganese, mercury, selenium, and zinc, while the most common organic COPECs are PAHs. Nine of the 10 remaining FAs are NFA largely because there are no upgradient (i.e., in-pipe) HHRA COCs, and downgradient conditions are favorable for biological/surface water measurements per the *Facility-Wide Biological and Water Quality Study* (USACE 2005a). The Load Line 2 FA is the only FA that has many COPECs at outfalls, poor downgradient biological/surface water conditions, and large amounts of lead in the upgradient sewer system; an FS and remediation are recommended for the Load Line 2 FA.

8.0 REMEDIAL INVESTIGATION CONCLUSIONS AND RECOMMENDATIONS

8.1 INTRODUCTION

The RI report for the Facility-Wide Sewers presents a detailed analysis of historical and newly acquired environmental data. The following sections summarize the major findings of the nature and extent of contamination, modeling of contaminant fate and transport, HHRA, and ERA. This section concludes with recommendations with respect to the need for any further characterization under the RI phase of work and, for each FA media evaluated in the RI, whether to proceed to the FS phase of the RI/FS process.

8.2 SUMMARY OF DATA IN THE REMEDIAL INVESTIGATION

Limited previous investigations have been performed to characterize the storm and sanitary sewer systems at RVAAP. These investigations have focused on Load Lines 1 through 12 and were designed to provide an initial evaluation of the occurrence of contamination rather than to fully assess nature and extent.

Sampling and characterization of accumulated sediment and water within some sanitary sewers, and storm sewers if present, were conducted as part of the following investigations:

- Load Line 1 Phase II RI (USACE 2003a) – storm and sanitary sewers, video surveys;
- Load Lines 2, 3, and 4 Phase II RI (USACE 2004a, 2004b, and 2004c) – storm and sanitary sewers, video surveys;
- Load Line 12 Phase II RI (USACE 2004d) – sanitary sewers present only, limited video surveys;
- Characterization of 14 AOCs (MKM 2007a) – sanitary sewers at Load Lines 5, 7, 8, 10, and Atlas Scrap Yard;
- Load Line 6 Phase I RI (MKM 2007b) – sanitary sewers present only;
- Load Line 9 Phase I RI (MKM 2007c) – sanitary sewers present only; and
- Load Line 11 Phase I RI (MKM 2005) – sanitary sewers present only.

In addition, two studies commissioned by the United States Army BRAC Division evaluated the potential for explosive hazards within sanitary and storm sewer lines at Load Lines 1 through 12 and the Administration Area:

- Summary of Findings for the Ravenna Army Ammunition Plant Sewer System (USACE-CERL 2007); and
- Project Completion Report for the Explosive Evaluation of Sewers (LES 2007).

Both studies collected wipe samples of sewer line inverts and video cameras for analysis of TNT and/or RDX using field test kit methods (e.g., Exspray and DropEx). These studies did not collect samples of accumulated sediment or water within the lines for fixed-based laboratory analysis. The 2007 Explosive Evaluation of Sewers showed no accumulations of explosive compounds within the 12 Load Lines or the Administration Area that would present an explosion hazard (LES 2007).

Sewer sediment, sewer water, pipe bedding material, outfall sediment, and outfall water samples were collected during the Facility-Wide Sewers RI. All available sample data were evaluated to determine suitability for use in the various key RI data screens and evaluations (nature and extent, fate and transport, risk assessment). The use of certain samples was limited to nature and extent evaluation and analysis of temporal trends, and these samples were not included in quantitative data screening or risk assessment calculations. Evaluation of data suitability for use in the Facility-Wide Sewers RI involved two primary considerations: (1) representativeness with respect to current AOC conditions; and (2) sample collection methods. All samples from the historical and Facility-Wide Sewers RI datasets were collected via discrete sample collection methods.

8.3 SUMMARY OF NATURE AND EXTENT

The analytical data obtained during the Facility-Wide Sewers RI and from previous investigations identified SRCs indicative of potential impacts from former operations and assessed the nature and extent of SRCs in environmental media at the AOC. The initial basic aggregation of data was by environmental media: sewer sediment, pipe bedding material, sewer water, outfall sediment, and outfall water. One hundred twenty-eight sewer sediment, sewer water, outfall sediment, and outfall water samples were collected during prior investigations. Three hundred eighty-seven sewer sediment, sewer water, outfall sediment, and outfall water samples were collected during the Facility-Wide Sewers RI. Only 8 of the 19 FAs had storm sewers present. The remaining 11 FAs had storm infrastructure occurring only as discontinuous under-road culverts and open ditches. The Facility-Wide Sewers RI included collection of pipe bedding material samples, which were not collected under the previous investigations. All available sample data were evaluated to determine suitability for use in the various key RI data screens and evaluations (nature and extent, fate and transport, risk assessment).

Sewer sediment exhibited the highest number of SRCs overall for both sanitary and storm sewers, with all 19 sanitary sewers exhibiting the highest number of SRCs in sewer sediment. Sixteen of the 19 FAs exhibited the highest number of SRCs in the storm sewer sediment. The Atlas Scrap Yard FA and Inert Storage Area #6 FA storm sewers had the highest number of SRCs in outfall sediment, and the Depot Administration FA storm sewer had both sewer sediment and outfall sediment with the same number of SRCs. Sewer water contained the second highest number of SRCs overall for both

1 sanitary and storm sewers, with outfall sediment exhibiting the third highest number of SRCs since
2 the majority of the FAs did not have storm sewer systems. Outfall water exhibited the lowest number
3 of SRCs in five of the FAs, and three FAs each had the lowest SRCs in three different media (Inert
4 Storage Area #6 FA with storm sewer sediment, Load Line 2 FA with storm sewer water, and Load
5 Line 3 FA with storm sewer pipe bedding material). Two FAs had two different media with a similar
6 (low) number of SRCs: Inert Storage Area #6 FA sanitary sewer outfall water (nine SRCs) and pipe
7 bedding material (eight SRCs) and Sand Creek Trunk and Connector Lines FA sanitary sewer outfall
8 water (six SRCs) and outfall sediment (five SRCs).

10 In all cases, the number and concentrations of SRCs observed in the pipe bedding material are
11 comparatively lower by orders of magnitude than those observed in sewer sediment within the pipes
12 for both sewer and storm systems. The preferential migration pathway for contaminants in sewer
13 sediment within the sanitary and storm sewer systems is laterally in the direction of flow, rather than
14 via vertical migration to the underlying pipe bedding material, as shown by the lower contaminant
15 concentrations in pipe bedding material relative to the sewer sediment. While cracks and joint
16 separations within the sanitary sewer system are observed due to the advanced age of the system, the
17 pipes are generally intact, which limits vertical migration from sewer sediment to the exterior of the
18 piping system. In many cases, storm pipe bedding material exhibited a greater number of SRCs than
19 sanitary pipe bedding material at the FAs, although concentrations of SRCs in storm pipe bedding
20 were also relatively low and did not indicate significant migration of contaminants to the underlying
21 material. This observation is likely a function of the fact that the storm sewer lines were deliberately
22 emplaced with open joints to promote infiltration of storm runoff, while the sanitary system was
23 constructed as a closed system with sealed joints.

25 The Facility-Wide Sewers RI found the predominant SRCs were inorganic chemicals and SVOCs
26 (primarily PAHs) for the majority of the media in both sanitary and storm sewer systems. Both
27 sanitary and storm sewer sediment had inorganic chemicals and PAHs as the predominant SRCs,
28 except for the Inert Storage Area #6 FA storm sewer sediment (with only SVOCs) and Transportation
29 Storage Area FA (with only inorganic chemicals). Arsenic, chromium, lead, manganese, and silver
30 were the most frequently detected inorganic SRCs while the majority of the detected SVOCs were
31 PAHs. Outfall sediment also had inorganic chemicals and SVOCs as the predominant SRCs for both
32 sanitary and storm sewer systems except for five FAs where inorganic chemicals were the
33 predominant SRCs. The most frequent inorganic chemicals detected were chromium, lead, and
34 manganese, while PAHs were the most detected SVOCs.

36 Sanitary and storm sewer water had inorganic chemicals as the predominant SRCs, with arsenic,
37 cadmium, cobalt, lead, and manganese detected most often in sanitary sewer water and lead,
38 manganese, and zinc detected most often in storm sewer water. However, in three FAs
39 [Administration Area FA, Inert Storage Area #6 FA (storm sewer only), and Load Line 10 FA
40 (sanitary sewer only)], both inorganic chemicals and SVOCs (the majority PAHs) were predominant
41 SRCs. Four FAs had inorganic chemicals (antimony, manganese, and silver) as the predominant
42 SRCs in sanitary sewer outfall water, and four FAs had inorganic chemicals as the predominant SRCs
43 for storm sewer outfall water (chromium, lead, manganese, and zinc). For two FAs, storm sewer

1 outfall water had both inorganic chemicals and SVOCs (the majority PAHs) as the predominant
2 SRCs.

3
4 The majority of the time, pipe bedding material had inorganic chemicals and SVOCs as either the
5 predominant SRCs or the only SRCs for both sanitary and storm sewer systems. However, in four
6 instances, inorganic chemicals were the only SRCs in the pipe bedding material. Inorganic chemicals
7 detected most frequently were cadmium and silver, then lead and zinc, and SVOCs were primarily
8 PAHs.

9
10 Sanitary and storm sewer sediment had the highest number of explosive SRCs (9 in storm sewer and
11 8 in sanitary sewer FAs), with sanitary and storm sewer water having the second highest number of
12 explosive SRCs (14 in sanitary sewer and 5 each in three storm sewer FAs). Pipe bedding material
13 had very few explosive SRCs, and sanitary and storm outfall water had the least number of explosive
14 SRCs. The most frequently observed explosives were 1,2,3-TNB; nitroglycerin; and RDX.
15 Nitrocellulose was the most frequently detected propellant. VOCs (acetone, 2-butanone,
16 chlorobenzene, and carbon disulfide), pesticides (4,4'-DDE; 4,4'-DDD; and gamma chlorodane), and
17 PCBs (PCB-1254 and PCB-1260) were sporadic throughout the sewer media across the AOC.

18
19 SVOC SRCs were predominant in most sanitary sewer and storm sewer media; however, a few
20 specific FAs were found to have inorganic SRCs as localized sources. The Depot Administration
21 Area FA had the most frequent detects with the highest concentrations of manganese occurring in
22 sanitary sewer sediment, sanitary outfall sediment, sanitary sewer water, storm sewer sediment, and
23 storm sewer outfall sediment. Lead had a high frequency of detects at high concentrations in this FA
24 for sanitary sewer sediment, sanitary sewer water, storm sewer outfall sediment, and storm sewer
25 water. The Transportation Area FA had high levels of manganese in the sanitary sewer sediment.

26
27 Load Line 2 FA had the highest frequency and concentrations of manganese in sanitary sewer
28 sediment, storm outfall sediment, and storm outfall water. Lead was also predominant in the Load
29 Line 2 FA in sanitary sewer sediment, sanitary sewer water, storm sewer water, and storm outfall
30 sediment. The Load Line 3 FA had detected high concentrations of manganese in sanitary sewer
31 sediment and lead in sanitary sewer sediment and storm outfall water.

32 33 **8.4 SUMMARY OF CONTAMINANT FATE AND TRANSPORT**

34
35 Contaminant fate and transport evaluation assessed the potential for chemicals to leach from
36 subsurface sewer media (i.e., sewer sediment and pipe bedding material) at the FAs and impact
37 groundwater beneath the media and at downgradient receptor locations. This evaluation was included
38 in the decision-making process to determine whether remedial actions of subsurface sewer media may
39 be necessary to protect groundwater resources. Only SRCs found in the subsurface sewer media were
40 evaluated in the fate and transport assessment.

41
42 Based on the results of the historical and Facility-Wide Sewers RI sampling activities of subsurface
43 sewer media, inorganic and organic SRCs exist in subsurface soil and sediment at the AOC. These

SRCs were further evaluated to determine if residual concentrations in sediment/soil are protective of groundwater.

8.4.1 George Road Treatment Plant Network

Ten explosive compounds, five SVOCs, one VOC, and one inorganic chemical were identified as initial CMCOPCs based on soil/sediment screening and travel time analyses and were selected for SESOIL modeling. The explosives compounds included 1,3-DNB (Load Line 8 FA), 2,4-DNT (Load Line 6 FA and Load Line 8 FA), 2,6-DNT (Load Line 8 FA), 2-amino-4,6-DNT (Load Line 8 FA), 2-nitrotoluene (Load Line 8 FA and Load Line 10 FA), 3-nitrotoluene (Administration Area FA), 4-amino-2,6-DNT (George Road Trunk and Connector Lines FA), nitroglycerin (Administration Area FA, George Road Trunk and Connector Lines FA, and Load Line 6 FA), PETN (Load Line 10 FA), and RDX (Administration Area FA and Load Line 8 FA). The SVOCs included 1,2-dichlorobenzene (George Road Trunk and Connector Lines FA), 1,3-dichlorobenzene (George Road Trunk and Connector Lines FA), 1,4-dichlorobenzene (Administration Area FA, George Road Trunk and Connector Lines FA, Load Line 6 FA), 4-chlorobenzenamine (Administration Area FA), and naphthalene (Load Line 9 FA). The only VOC (methylene chloride) is from the Load Line 7 FA and the Load Line 9 FA, and the only inorganic chemical (sulfate) is from the Load Line 11 FA. Results of SESOIL modeling indicated all the initial CMCOPCs except 1,4-dichlorobenzene from the Load Line 6 FA and methylene chloride from the Load Line 9 FA would be expected to leach to the water table with concentrations exceeding their respective groundwater criteria and were identified as final CMCOPCs for further evaluation using AT123D modeling.

The AT123D model predicted maximum concentrations of the final CMCOPCs and indicated only the explosive compounds [i.e., 1,3-DNB (Load Line 8 FA); 2,4-DNT (Load Line 6 FA and Load Line 8 FA); 2,6-DNT (Load Line 8 FA); 2-amino-4,6-DNT (Load Line 8 FA); 2-nitrotoluene (Load Line 8 FA and Load Line 10 FA); 4-amino-2,6-DNT (George Road Trunk and Connector Lines FA); nitroglycerin (Administration Area FA, George Road Trunk and Connector Lines FA, and Load Line 6 FA); and PETN (Load Line 10 FA)] were found in groundwater beneath the source areas exceeding the screening criteria. However, lateral transport modeling of these CMCOPCs indicated they would not exceed the screening criteria at the downgradient receptor locations.

8.4.2 Sand Creek Treatment Plant Network

Five explosive compounds, five SVOCs, one VOC, and one inorganic compound were identified as initial CMCOPCs based on soil/sediment screening and travel time analyses and were selected for SESOIL modeling. The explosives compounds included 1,3-DNB (Load Line 2 FA); 2-amino-4,6-DNT (Atlas Scrap Yard FA and Load Line 2 FA); 4-amino-2,6-DNT (Load Line 2 FA and Load Line 12 FA); nitroglycerin (Load Line 2 FA); and RDX (Load Line 2 FA). Among the SVOCs, 1,2-dichlorobenzene; 1,3-dichlorobenzene; 1,4-dichlorobenzene; and 4-chlorobenzenamine were from the Load Line 12 FA, and 3+4-methylphenol was from the Load Line 2 FA. The only VOC (2-butanone) is from the Inert Storage Area #6 FA, and the only inorganic chemical (selenium) is from the Load Line 2 FA. Results of SESOIL modeling indicated all initial CMCOPCs except

2-butanone from the Inert Storage Area #6 FA and 3+4-methylphenol from the Load Line 2 FA would be expected to leach to the water table with the concentrations exceeding their respective groundwater criteria and were identified as final CMCOPCs for further evaluation using AT123D modeling.

The AT123D model predicted maximum concentrations of the final CMCOPCs and indicated all SVOCs from the Load Line 12 FA and three explosive compounds [2-amino-4,6-DNT (Load Line 2 FA); 4-amino-2,6-DNT (Load Line 2 FA and Load Line 12 FA); and RDX (Load Line 12 FA)] were found in groundwater beneath the source areas exceeding the screening criteria. However, lateral transport modeling of these CMCOPCs indicated they would not exceed the screening criteria at downgradient receptor locations.

8.4.3 Transportation Storage Area Drainage Network

Only 3+4-methylphenol was identified as an initial CMCOPC based on soil/sediment screening and travel time analyses and was selected for SESOIL modeling. However, results of SESOIL modeling indicated that 3+4-methylphenol would not be expected to leach to the water table with the concentrations exceeding its groundwater criteria.

8.4.4 Depot Administration Area Treatment Plant Network

Based on the soil/sediment screening and travel time analyses, none of the SRCs from this area were identified as initial CMCOPCs for further evaluation using SESOIL and AT123D modeling.

Based on the sediment and soil screening analyses and fate and transport modeling, all SRCs found in the subsurface sewer media and evaluated through the stepwise fate and transport screening evaluation presented here are eliminated as posing future impacts to groundwater.

8.5 SUMMARY AND CONCLUSIONS OF THE HUMAN HEALTH RISK ASSESSMENT

The purpose of the preliminary data screening and risk assessment is to determine the need for conducting an FS for remediation of any portion of the piping system or outfalls for the Facility-Wide Sewers. For the HHRA, all 19 FAs included samples collected from sewer lines 0-13 ft bgs, which are considered to be within the potential exposure units for the National Guard Trainee and/or Resident Farmer. At 12 of the FAs (Administration Area, Atlas Scrap Yard, Depot Administration Area, Inert Storage Area #6, Load Lines 1-4, Load Line 8, Load Line 11, Sand Creek Trunk and Connector Lines, Transportation Storage Area), the total volume of the sewer pipe system represents $\geq 1\%$ of the total mixing zone soil volume within the FA. For these FAs, a screening for COPCs/COCs and a point evaluation to assess potential exposure to downstream receptors were conducted. At the remaining seven FAs (George Road Trunk and Connector Lines, Load Lines 5-7, Load Line 9, Load Line 10, Load Line 12), the total volume of the sewer pipe system represents $< 1\%$ of the total mixing zone soil volume within the FA. At these FAs, sewer media are not considered to

be a concern for direct contact; therefore, the HHRA consisted of a point evaluation to assess the potential for impacts to downstream receptors.

At 10 of the 12 FAs with a sewer pipe system volume $\geq 1\%$ of the total mixing zone soil, no COCs were identified for the National Guard Trainee or Resident Farmer because the EPC of all COPCs is less than the adjusted FWCUGs. Manganese was identified as a COC at the Depot Administration Area FA and Transportation Storage Area FA. At both FAs, manganese was detected above the adjusted FWCUG for the National Guard Trainee in one sediment sample. At the Depot Administration Area FA, manganese was also detected above the point evaluation screening criterion in sewer sediment, sewer water, and outfall sediment, indicating the potential for migration to downstream media. Manganese was historically stored at the Transportation Storage Area FA; therefore, it was identified as a COC for sewer sediment at this FA.

Although not identified as a COC, lead was detected above point evaluation screening criteria in several sewer media at the Load Line 2 FA and the Load Line 3 FA. Lead was not identified as a COC because the MDC concentrations are less than the adjusted soil guidance value; however, the point evaluation at these FAs indicates lead may represent a localized source that could impact downstream receptors and should be evaluated in an FS.

Various compounds were identified as exceeding point evaluation screening at all 19 FAs. However, based on multiple lines of evidence, including a geospatial analysis for downstream impacts and fate and transport modeling, none of these chemicals are impacting downstream receptors; therefore, they do not warrant evaluation in an FS.

8.6 SUMMARY AND CONCLUSIONS OF THE ECOLOGICAL RISK ASSESSMENT

The ERA evaluated potential ecological exposures from sewer soil, sediment, and water at pipe outfalls. For the sewer ERA, only outfalls were examined quantitatively because the interior of the piping system does not represent an ecological habitat. A stepwise technical approach was followed to evaluate FAs and determine if further investigation or remediation was warranted at the respective FAs. The steps are as follows:

Step 1 screened the 19 FAs for the presence of outfalls. FAs were eliminated from further consideration if they were not found to have any outfalls, there were only one or two outfalls (unless these outfalls were heavily contaminated), there was evidence within the piping system that chemicals have little to no human health risk (no COCs), and if there was no evidence of downstream environmental consequences at nearby biological/chemical sampling stations.

Step 2 applied an SRC screen to all detected chemicals. Chemicals were eliminated as SRCs when detected concentrations were below background concentrations, had a frequency of detection less than 1/20 (unless the chemical was an explosive), or were essential nutrients to plants and animals (calcium, magnesium, iron, potassium, sodium). PBT compounds were also identified in Step 2 and were retained as COPECs throughout the process.

1 Step 3 compared the EPC to ESVs of the remaining chemicals. The latest ESVs listed in the
2 *Guidance for Conducting Ecological Risk Assessments* (Ohio EPA 2008) were used. If more than
3 one value was available, the preferred (and often more conservative) ESV was used. Additionally,
4 specific outfalls acting as the source of COPECs identified in the first part of Step 3 were identified
5 by comparing the detected concentration of each COPEC at each outfall to the ESVs.

6
7 Step 4 determined if there was evidence of ecological risk upstream and downstream of the outfall.
8 The area upstream of the outfalls is within the sewer pipes. The upstream evaluation noted the
9 presence of human health COCs in the piping system because no ERA was conducted for the interior
10 of the sewers. The downstream evaluation determined if there was evidence of downstream
11 environmental consequences related to identified COPECs by evaluating data from nearby
12 biological/chemical sampling stations.

13
14 Step 5 listed the COPECs at each FA that may have downstream environmental consequences. Step 5
15 also included an evaluation of the uncertainty in the ERA.

16
17 This evaluation is conducted for each FA in its respective FAE. The results of these evaluations are
18 summarized in Table 7-8.

19
20 Several FAs (Atlas Scrap Yard FA, Load Line 5 FA, Load Line 6 FA, Load Line 7 FA, Load Line 8
21 FA, Load Line 9 FA, Load Line 10 FA, Load Line 12 FA, and George Road Trunk and Connector
22 Lines FA) had no outfalls. Thus, no quantitative ERA was possible, and there was no ecological risk
23 from sewers. All nine of these are recommended for NFA.

24
25 The Administration Area FA, Inert Storage Area #6 FA, Load Line 4 FA, Load Line 11 FA, and Sand
26 Creek Trunk and Connector Lines FA had outfalls with or without COPECs, no upgradient (i.e.,
27 in-pipe) COCs, and downgradient biological/water quality conditions were favorable or downgradient
28 COPECs originated from non-sewer sources; all five FAs are recommended for NFA due to lack of
29 upgradient COCs and downgradient consequences.

30
31 The Load Line 1 FA had multiple outfalls with COPECs, no upgradient (i.e., in-pipe) COCs, and
32 some downgradient biological/water quality evidence of consequences of COPECs. Concentrations
33 in outfalls have declined since 1996, which coincides with the lack of COCs inside the piping system;
34 therefore, the Load Line 1 FA is recommended for NFA.

35
36 The Load Line 3 FA had multiple outfalls with COPECs and no upgradient (i.e., in-pipe) COCs, but a
37 point evaluation revealed upgradient lead had high concentrations. However, downstream
38 biological/water quality evaluation revealed that lead had little to no downstream consequences.
39 Therefore, the Load Line 3 FA is recommended for NFA.

40
41 The Depot Administration Area FA and Transportation Storage Area FA had one or more outfalls
42 with COPECs, one upgradient (i.e., in-pipe) COC (manganese), and little to no downstream
43 consequences. Both FAs are being recommended for NFA.

1 The Load Line 2 FA had multiple outfalls with COPECs, no upgradient (i.e., in-pipe) COCs, high
2 upgradient lead concentrations per point evaluation, and much evidence of downstream
3 biological/water quality study exceedances of lead and other inorganic chemicals. The Load Line 2
4 FA is recommended for assessment in an FS for lead in the sewer lines.

5 6 **8.7 RECOMMENDATION OF THE REMEDIAL INVESTIGATION**

7
8 Historical investigations and the Facility-Wide Sewers RI adequately characterized this AOC, and
9 further investigation is not warranted. The RI recommends proceeding to the FS phase to evaluate
10 remedial alternatives addressing: (1) manganese at the Transportation Storage Area FA and Depot
11 Administration Area FA in sewer sediment; and (2) lead in sewer sediment at the Load Line 2 FA and
12 Load Line 3 FA. In the HHRA, manganese was identified as a COC at the Transportation Storage
13 Area FA and Depot Administration Area FA. Although not identified as a COC in the HHRA, lead is
14 a candidate for remediation in one storm sewer segment at each of the Load Lines 2 and 3 FAs based
15 on the HHRA point evaluation and potential fate and transport impacts to surface water. In the ERA,
16 lead in the Load Line 2 FA was also identified as requiring evaluation in the FS. Remediation to
17 protect groundwater resources is also not warranted for the 19 FAs, based on contaminant leaching
18 and fate and transport modeling results.

19
20 Manganese in sewer sediment at the Transportation Storage Area FA and Depot Administration Area
21 FA requires remediation to the CUG of 35,100 mg/kg for subsurface sewer media to be protective for
22 the National Guard Trainee and Resident Farmer, as presented in the HHRA. The adjusted lead CUG
23 for soil per the HHRA is 199,500 mg/kg, which exceeds all sewer sediment concentrations at the
24 Load Line 2 FA and Load Line 3 FA. To address surface water and ecological impacts related to lead
25 migration from sewer sediment to surface water, a calculated cleanup was developed based on an
26 analytical partitioning model. A CUG of 5,850 mg/kg was developed based on the concentration of
27 lead in sediment that would result in a surface water discharge concentration greater than the MCL
28 (0.015 mg/L). This CUG was calculated by assuming a soil/sediment to outfall surface water DAF of
29 390,000 L/kg for lead. The DAF was developed using the observed concentration of lead in the
30 sediment at the inlet DB-20 and the corresponding downstream outfall water concentration at
31 LL2sw-311.

32
33 The evaluation conducted as part of the remedy can include refining specific areas requiring
34 remediation to attain the CUGs at the four FAs (Transportation Storage Area FA, Depot
35 Administration Area FA, Load Line 2 FA, and Load Line 3 FA). This evaluation will show that
36 specific areas in the FA can be excluded from remediation. NFA is recommended for sewer media in
37 the remaining 15 FAs at the Facility-Wide Sewers.

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9.0 REMEDIAL ACTION OBJECTIVE, CLEANUP GOALS, AND VOLUME CALCULATIONS

This section presents the RAO, appropriate CUGs for remedial actions, and volume estimates of media requiring remediation to attain specific land use scenarios. The RAO is in accordance with the NCP and CERCLA RI/FS guidance, specifying receptors, exposure routes, and desired exposure levels. CUGs establish acceptable exposure levels protective of human health and the environment and consider potential land uses. The CUGs also provide the basis for screening, evaluating, and selecting a remedial alternative.

This section also presents the estimated volume of media requiring remediation identified in the RI. The medium identified as having COCs was sewer sediment within the Facility-Wide Sewers. The sewer sediment was evaluated as subsurface sewer media, which is a combination of sewer sediment and pipe bedding material. For all instances that a COC was identified as requiring remediation, sample results from sewer sediment was the reason the COC was identified. Therefore, this FS will focus on addressing sewer sediment requiring remediation within the specified pipes/inlets/manholes. Addressing co-located pipe segments, drop inlets, and manholes may be part of the remedy. The volume estimates present the estimated quantity and location of media requiring remediation to attain a specific land use scenario.

9.1 REASONABLE AND ANTICIPATED FUTURE LAND USE

Since the Facility-Wide Sewers AOC contains 26 miles of sewer lines distributed across RVAAP, multiple future military land uses may apply. Most of the AOCs are not currently used for training for operational activities; however, the RAFLU is National Guard Training for the majority of the AOCs for which the Facility-Wide Sewers AOC traverse (i.e., Load Lines 1 through 12, Atlas Scrap Yard). Other areas (e.g., Administration Area, Depot Administration Area, Inert Storage Area #6) are currently utilized for administrative or storage functions by OHARNG. The National Guard Trainee includes digging and mixing soil and subsurface media to a depth of 7 ft bgs as part of the exposure scenario. Therefore, the RAFLU for the Facility-Wide Sewers AOC is Military Use and Training, using the National Guard Trainee as the representative receptor.

Residential land use is not anticipated at RVAAP or at this AOC; however, an Unrestricted Residential Land Use scenario is developed and evaluated. For the purpose of this RI/FS report, CUGs established for the Resident Farmer provides the requisite level of protectiveness for Unrestricted Residential Land Use.

9.2 REMEDIAL ACTION OBJECTIVE

The RAO for Facility-Wide Sewers is to prevent: (1) National Guard Trainee exposure to chemicals requiring remediation in sewer sediment above CUGs; (2) adverse ecological effects from previous AOC activities; and (3) negative groundwater impacts from contaminant migration from source media (e.g., sewer sediment).

The RI recommended evaluation of remedial alternatives to address: (1) manganese at the Transportation Storage Area FA and Depot Administration Area FA in sewer sediment; and (2) lead in sewer sediment at the Load Line 2 FA and Load Line 3 FA. In the HHRA, manganese was identified as a C OC at the Transportation Storage Area FA and Depot Administration Area FA. Although not identified as a COC in the HHRA, lead is a candidate for remediation in one storm sewer segment at both the Load Line 2 and Load Line 3 FAs based on the HHRA point evaluation and potential fate and transport impacts to surface water. In the ERA, lead in the Load Line 2 FA was also identified as requiring evaluation of remedial alternatives.

9.3 REMEDIAL ACTION CLEANUP GOALS

No FWCUGs are available for exposure to subsurface sewer media. FWCUGs for the National Guard Trainee and Resident Farmer exposed to soil (USACE 2010) were used along with adjustment factors presented in Section 7.0 to account for the use of soil FWCUGs with identified in subsurface sewer media mixed with soil. The locations requiring remediation and the CUGs to be protective for the appropriate receptors for manganese and lead are presented in Tables 9-1 and 9-2, respectively.

The CUGs for the National Guard Trainee are the same or lower than the CUGs for the Resident Farmer. For manganese, the CUG for the National Guard Trainee is 35,100 mg/kg, and the CUG for the Resident Farmer is 1,000,000 mg/kg.

For lead, the CUG for both the National Guard Trainee and Resident Farmer is 199,500 mg/kg. A CUG of 5,850 mg/kg was developed based on the concentration of lead in sediment that would result in a surface water discharge concentration greater than the MCL (0.015 mg/L). This CUG was calculated by assuming a soil/sediment to outfall surface water DAF of 390,000 L/kg for lead. The DAF was developed using the observed concentration of lead in the sediment at the inlet DB-20 and the corresponding downstream outfall water concentration at LL2sw-311.

Table 9-1. Locations Where Manganese Requires Remediation for Unrestricted Residential Land Use

Sample Location (Depth of pipe in inlet)	Manganese Concentration (CUG=35,100 mg/kg)
TSAsd-002(sn) (7 ft bgs)	37,600
DAAsd-006(sn) (4.3 ft bgs)	48,900

ft bgs = feet below ground surface
CUG = Cleanup Goal

Table 9-2. Locations Where Lead Requires Remediation for Unrestricted Residential Land Use

Sample Location (Depth of pipe in inlet)	Lead Concentration (CUG=5,850 mg/kg)
LL2sd-615(st) (3.5 ft bgs)	29,200
LL3sd-272(st) (2.2 ft bgs)	5,560

ft bgs = feet below ground surface
CUG = Cleanup Goal

9.4 VOLUME CALCULATIONS OF MEDIA REQUIRING REMEDIATION

As recommended in the HHRA, the discrete sample areas requiring remediation for Unrestricted Residential Land Use are locations DAAsd-006(sn) (4.3 ft bgs) at the Depot Administration Area FA, TSAsd-002(sn) (7 ft bgs) at the Transportation Storage Area FA, LL2sd-615(st) (3.5 ft bgs) at the Load Line 2 FA, and LL3sd-272(st) (2.2 ft bgs) at the Load Line 3 FA. The volume estimate of sewer sediment requiring remediation is presented in Table 9-3. The segment of pipe requiring remediation was delineated by going upstream and downstream from the location with an elevated concentration until one of the following occurs:

1. Sample data indicated COC concentrations were below the CUG; or
2. The pipe ended at an outlet [i.e., surface water discharge (ditch)] or inlet (i.e., storm catch basin or drop inlet).

Sample points (manholes/inlets) between the locations above and below the CUGs without data were assumed to require remediation. Therefore, the volume calculations assume the entirety of sewer sediment in that section of pipe or individual inlet requires remediation, as delineated by existing data. These extents for the Depot Administration Area FA, Transportation Storage Area FA, Load Line 2 FA, and Load Line 3 FA are presented in Figures 9-1, 9-2, 9-3, and 9-4, respectively.

Table 9-3. Estimated Volume Requiring Remediation

Functional Area	Media	Depth of Pipe or Manhole (ft bgs)	Length of Pipe (ft)	Diameter (inches)	Number of 3 ft by 3 ft Inlets	Number of Manholes	Diameter of Pipe or Manhole (ft)	In Situ		In Situ with Constructability ¹		Ex Situ ^{1,2}	
								Volume (ft ³)	Volume (yd ³)	Volume (ft ³)	Volume (yd ³)	Volume (ft ³)	Volume (yd ³)
Depot Administration Area FA	Sewer Sediment in pipe	5	1733	6	0	9	4	16,869	625	19,400	718	23,280	862
Transportation Storage Area FA	Sewer Sediment in pipe	7	943	6	1	3	4	14,895	552	17,129	634	20,555	761
Load Line 2 FA	Sewer Sediment in Manhole/ Inlet	5	1100	10	5	0	NA	9,003	333	10,353	383	12,424	460
Load Line 3 FA	Sewer Sediment in Manhole/ Inlet	4	415	18	4	0	NA	3,049	113	3,506	130	4,207	156
Total			4191	NA	10	12	NA	43,816	1,623	50,388	1,865	60,446	2,239

This volume calculation assumes the entirety of the length of pipe or manhole will require removal.

¹Includes 15% constructability factor

²Includes 20% swell factor

ft³ = cubic feet

ft bgs = feet below ground surface

NA = Not Applicable

yd³ = cubic yard

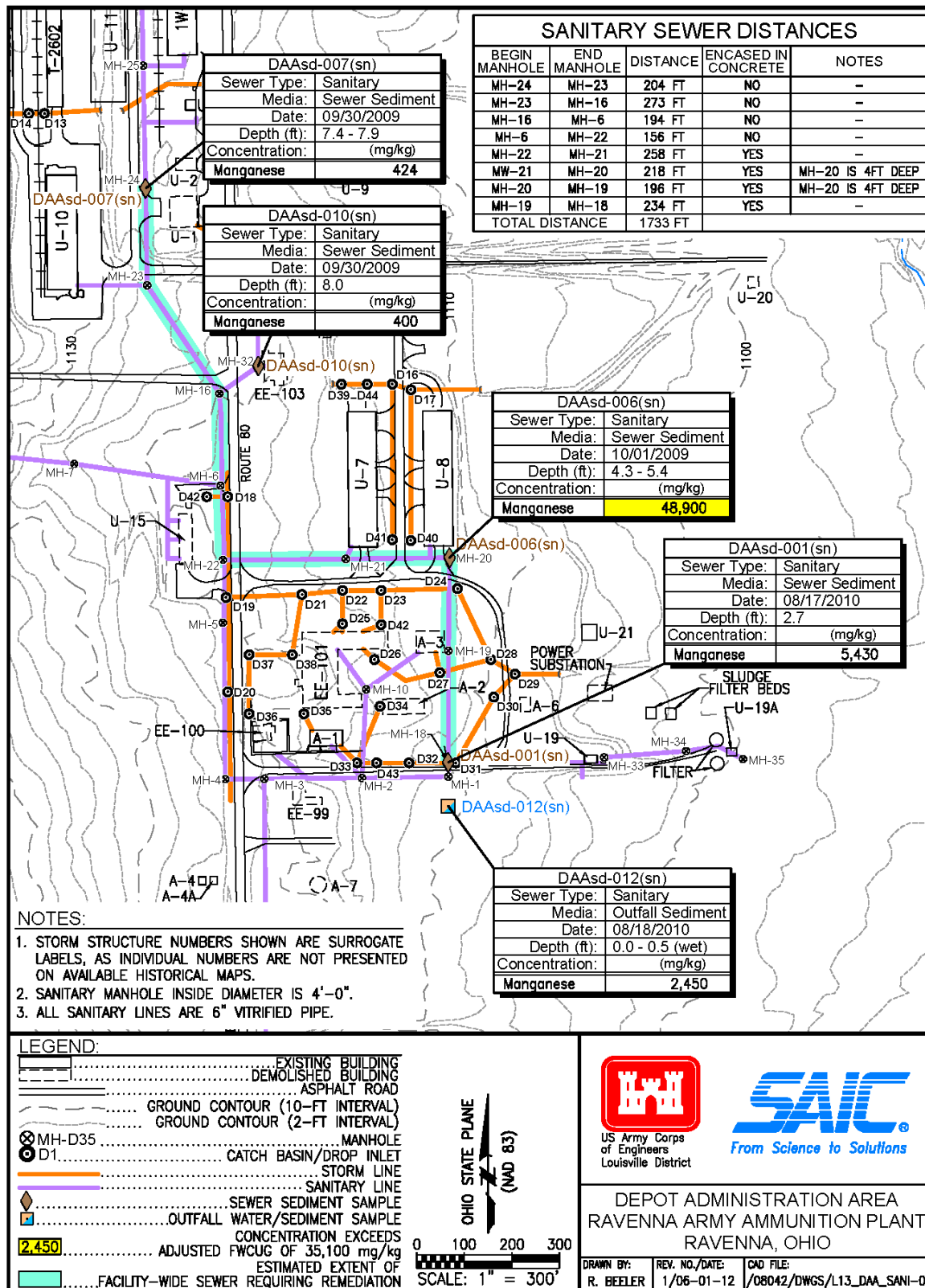


Figure 9-1. Locations in Sanitary Lines Requiring Remediation at the Depot Administration Area Functional Area

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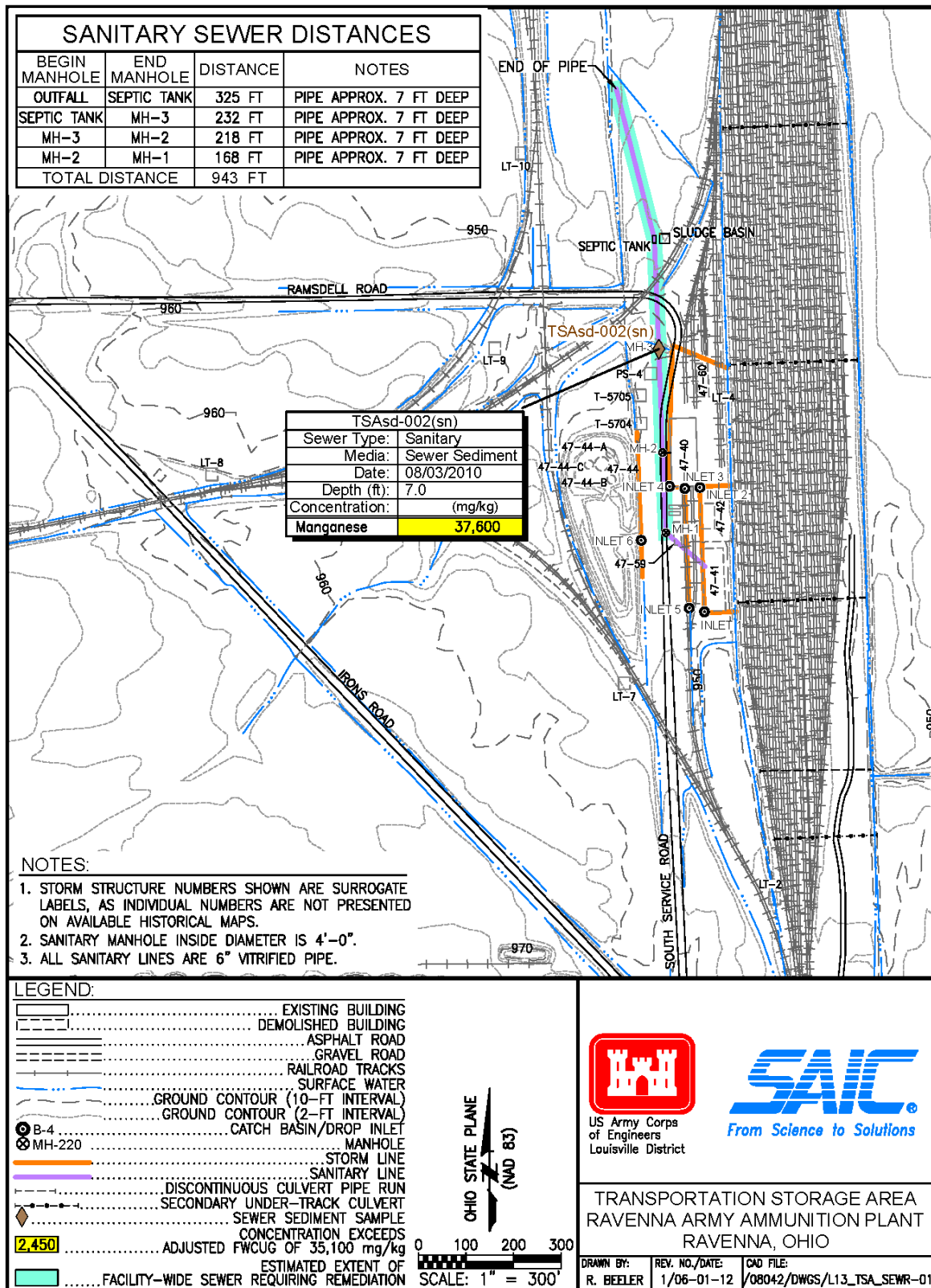


Figure 9-2. Locations in Sanitary Lines Requiring Remediation at the Transportation Storage Area Functional Area

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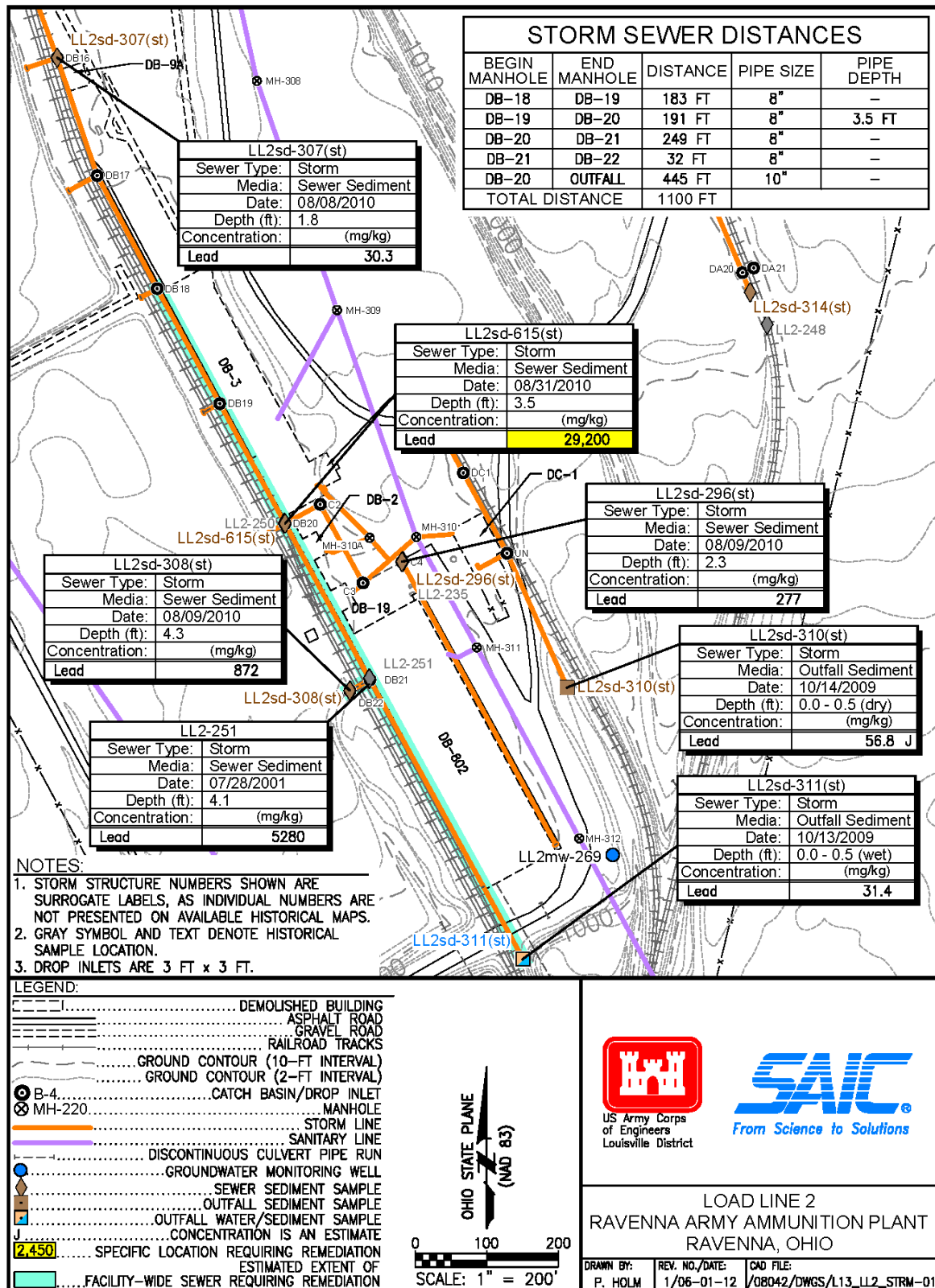


Figure 9-3. Locations in Storm Lines Requiring Remediation at the Load Line 2 Functional Area

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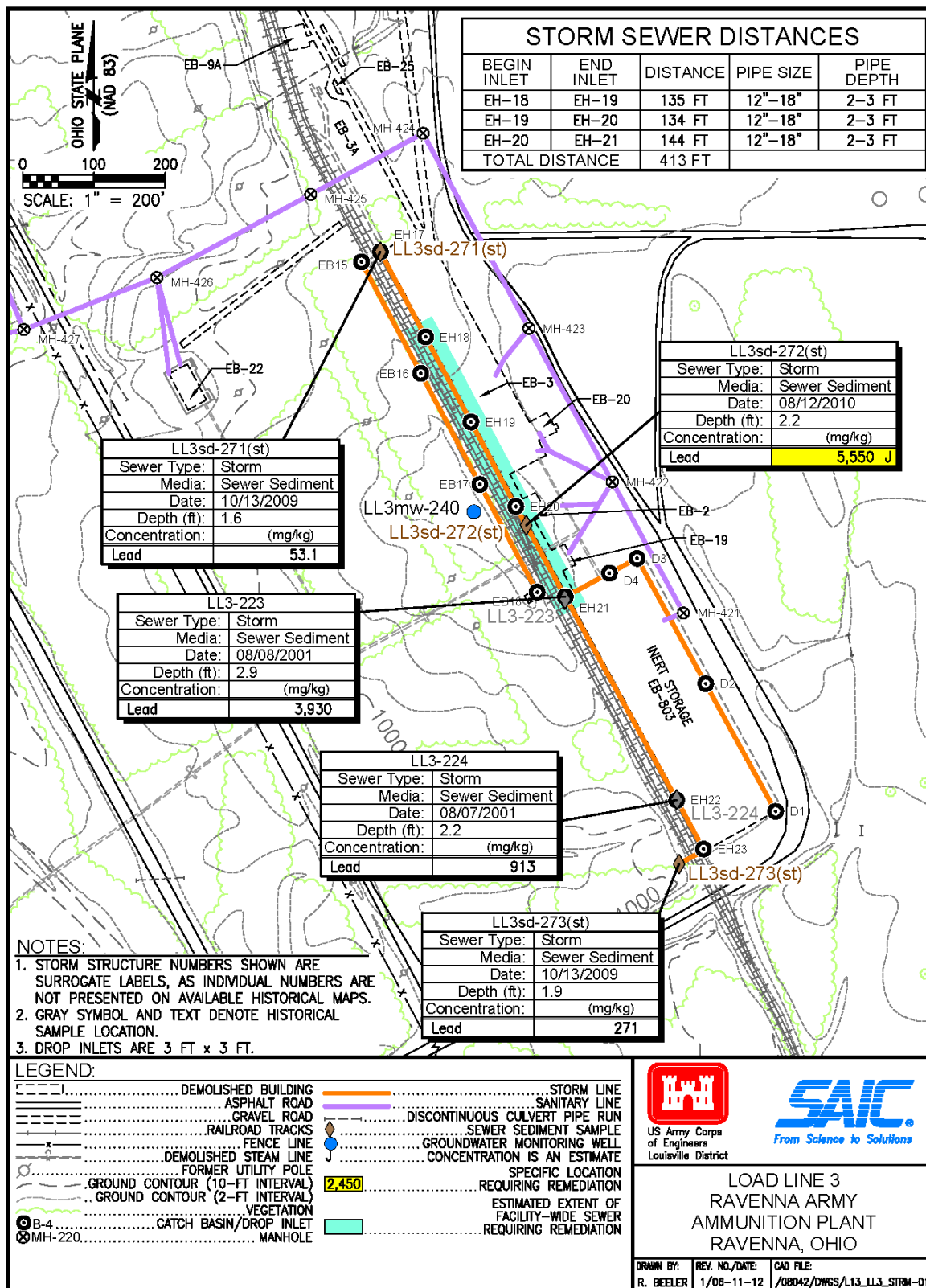


Figure 9-4. Locations in Storm Lines Requiring Remediation at the Load Line 3 Functional Area

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10.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

10.1 INTRODUCTION

CERCLA Section 121 specifies remedial actions must comply with requirements or standards under federal or more stringent state environmental laws that are “applicable or relevant and appropriate to the hazardous substances or particular circumstances at the AOC.” Inherent in the interpretation of ARARs is the assumption that protection of human health and the environment is ensured. This section summarizes potential federal and state chemical-, location-, and action-specific ARARs for the potential remedial actions at the AOC.

ARARs include those federal and state regulations that are designed to protect the environment. Applicable requirements are “those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site” [40 Code of Federal Regulations (CFR) 300.5]. USEPA has stated in the NCP that applicable requirements are those requirements that would apply if the response action were not taken under CERCLA.

Relevant and appropriate requirements are “those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site such that their use is well suited to the particular site” (40 CFR 300.5).

In the absence of federal or state-promulgated regulations, there are many criteria, advisories, guidance values, and proposed standards that are not legally binding but may serve as useful guidance for setting protective cleanup levels. These are not potential ARARs but are to-be-considered guidance [40 CFR 300.400(g)(3)].

CERCLA remedial response actions at an AOC must comply only with the substantive requirements of a regulation [CERCLA Section 121(e)]. Substantive requirements are those that pertain directly to the actions or conditions at an AOC, while administrative requirements facilitate their implementation. USEPA recognizes that certain administrative requirements (e.g., consultation with state agencies, reporting) are accomplished through state involvement and public participation. These administrative requirements should also be observed if they are useful in determining cleanup standards at the AOC (55 CFR 8757).

Although remedial actions for AOCs at National Priorities List (NPL) sites must comply only with the substantive requirements of federal or state environmental regulations, the Ohio Revised Code does not provide a similar permit waiver for actions conducted under the Ohio EPA Remedial Response Program Policy. The Ohio EPA's DERR Policy DERR-00-RR-034 states, "it has been DERR's policy to require responsible parties to acquire and comply with all necessary permits, including the substantive and administrative requirements." However, a DFFO was entered into on June 10, 2004, that provided certain exemptions from the Ohio Administrative Code (OAC) administrative requirements and required groundwater monitoring and remediation at RVAAP to be performed under the CERCLA process. The DFFO includes provisions for compliance resulting in the potential negation of all provided exemptions within the DFFO in the event non-compliant activities are identified.

10.2 POTENTIAL ARARS

USEPA classifies ARARs as chemical-specific, action-specific, and location-specific to provide guidance for identifying and complying with ARARs (USEPA 1988a).

- Chemical-specific ARARs are health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, allow numerical values to be established. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.
- Action-specific ARARs are rules, such as performance or design or other activity-based rules, which place requirements or limitations on actions.
- Location-specific ARARs are rules that place restrictions on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations.

As explained in the following paragraph, rules from each of these categories are ARARs only to the extent that they relate to the degree of cleanup.

CERCLA Section 121 governs cleanup standards at CERCLA sites. ARARs originate in the subsection of CERCLA that specifies the degree of cleanup at each AOC, CERCLA Section 121(d). In Section 121(d)(2), CERCLA expressly directs that ARARs are to address specific contaminants of concern at each AOC, specifying the level of protection to be attained by any chemicals remaining at the AOC. CERCLA Section 121(d)(2) provides that with respect to hazardous substances, pollutants, or contaminants remaining on-site at the completion of a remedial action, an ARAR is:

"Any standard, requirement, criteria, or limitation under any Federal environmental law ... or any promulgated standard, requirement, criteria, or limitation under a State environmental or facility siting law that is more stringent than any Federal standard, requirement, criteria, or limitation."

1 CERCLA Section 121(d)(2) further states that the remedial action attains a level of control
2 established in rules determined to be ARARs.

3
4 In some cases, most ARARs will be chemical-specific. Action- or location-specific requirements will
5 be ARARs to the extent that they establish standards addressing contaminants of concern that will
6 remain at the AOC. In addition, CERCLA Section 121(d)(1) directs that remedial actions taken to
7 achieve a degree of cleanup that is protective of human health and the environment are to be relevant
8 and appropriate under the circumstances presented by the release. Accordingly, any chemical-,
9 action-, or location-specific requirements will be ARARs to the extent they ensure the degree of
10 cleanup will be protective of human health and the environment under the circumstances presented by
11 the release. An evaluation of the regulatory requirements has shown there are no chemical-specific
12 ARARs for the chemicals identified in various media at the AOC.

13
14 In summary, chemical-, action-, or location-specific requirements will be ARARs to the extent that
15 they establish standards protective of human health and the environment for chemicals that will
16 remain on-site after the remedial action and ensure protection of site works and the environment
17 during remedy implementation. Requirements identified as chemical-specific ARARs must ensure a
18 degree of cleanup that is protective of human health and the environment under the circumstances
19 presented by the release.

20 21 **10.2.1 Potential Chemical-Specific ARARs**

22
23 The environmental media of concern evaluated in this FS is sewer sediment. A review of the
24 regulations indicates there are no potential chemical-specific ARARs for any of the contemplated
25 alternatives due to the media and COCs. No regulations were identified that included specific
26 chemical concentrations in sewer sediment or requirements that would be a potential ARAR to drive
27 the remedial action process.

28 29 **10.2.2 Potential Action-Specific ARARs**

30
31 Under the No Action Alternative, no activities would be conducted at the AOC; therefore, no
32 action-specific ARARs are identified for this alternative.

33
34 As discussed in Section 11.0, a portion of the alternatives evaluated include potential excavation and
35 disposal of contaminated environmental media at the AOC. Implementation of this alternative
36 triggers potential ARARs associated with land disturbance and emission controls. The OAC
37 3745-15-07 requires that nuisance air pollution emissions be controlled. This includes the control of
38 potential fugitive dust from excavation activities associated with the potential removal of the
39 pipes/inlets/manholes. In addition, any construction (i.e., soil disturbance activities that would
40 encompass over 1 acre in size) would trigger the storm water requirements found at 40 CFR Part 450.
41 These requirements mandate that erosion and sedimentation control measures be designed and
42 implemented to control erosion and sediment run-off.

1 Because excavation would include the generation and management of contaminated media, the
2 requirements of the Resource Conservation and Recovery Act (RCRA) would be considered potential
3 ARARs for this activity. The RCRA requirements mandate that a generator must determine whether
4 a material is (or contains in the case of environmental media) a hazardous waste under OAC
5 3745-52-11. If a material is determined to be or contain a listed hazardous waste, or exhibits a
6 hazardous waste characteristic, additional management requirements under RCRA must be followed
7 as an ARAR under CERCLA.

8
9 These requirements include how hazardous waste is stored, treated, transported, and disposed. These
10 RCRA requirements are generally not considered to be chemical-specific ARARs because they do not
11 relate directly to the degree of cleanup or to specific chemicals. In addition to the substantive
12 requirements associated with the management and storage of material that is also RCRA hazardous
13 waste (or found to contain such waste), some RCRA requirements prescribe standards for disposal of
14 hazardous material. These include: (1) land disposal restrictions (LDRs) prohibiting disposal of
15 specific chemicals until they are treated to a specified level or by a specific treatment technology; and
16 (2) minimum technical requirements (MTRs) for land disposal units.

17
18 USEPA cautions that LDRs should not be used to determine site-specific cleanup levels (USEPA
19 2002). The purpose of LDRs is to require appropriate treatment of RCRA hazardous waste that is to
20 be land disposed of to minimize short and long-term threats to human health or the environment,
21 based on available technology. Performing treatment to meet LDR standards is different from the
22 CERCLA approach to remediation, which is analyzing risk and then developing cleanup standards
23 based on the risk present, and may result in cleanup levels that are different from those of a risk-based
24 approach. Nevertheless, if RCRA hazardous waste is generated from the CERCLA action and are
25 land disposed of on-site, the material must meet the standards established in the LDRs.

26
27 In order for LDRs to be triggered as potential ARARs, RCRA hazardous waste must be present. This
28 requires: (1) the waste material contains contaminants that derive from RCRA-listed waste or exhibit
29 a characteristic of RCRA hazardous waste; and (2) that the waste material is managed in a way that
30 “generates” hazardous waste. Several methods of waste material management that do not “generate”
31 hazardous waste, and so do not trigger LDRs, are available for use. These methods include the AOC
32 approach, use of a staging pile, use of a storage or treatment corrective action management unit
33 (CAMU), or use of a temporary unit (TU).

34
35 If waste material is managed in a manner that generates hazardous waste, such as removing it to an
36 aboveground container and then redepositing the material within the land unit for disposal, then LDRs
37 become potential ARARs. LDRs attach to the waste at the time it is removed from the unit under an
38 AOC approach or at the time the waste material is excavated and lifted out of the unit. Potential LDR
39 ARARs in Ohio are variances from treatment standards in OAC Section 3745-270-44, LDR standards
40 for contaminated debris in OAC Section 3745-270-45, Universal Treatment Standards (UTS) in OAC
41 Section 3745-270-48, and Alternative LDR Treatment Standards for Contaminated Soil in OAC
42 Section 3745-270-49.

Ohio has adopted the alternative soil treatment standards as promulgated by USEPA in its Phase IV LDR rule, effective August 1998. The rules provide that if RCRA hazardous waste is present, the material must meet one of two sets of LDRs before being disposed of in a land unit: (1) the UTS; or (2) the contaminated soil (technology-based treatment) standards promulgated in Phase IV of the LDRs, whichever is greater. Or, if a generator so chooses, he may use the generic treatment standards in OAC Section 3745-270-40 which apply to all hazardous waste. Only the alternative soil treatment standards are explained in this document. This alternative treatment standard may be relevant to the sediment in the piping since the regulatory definition of soil includes soil mixtures with liquid (i.e., sewer sediment). Under the alternative soil treatment standards, all soil subject to treatment must be treated as follows:

1. For non-metals, treatment must achieve 90% reduction in total constituent concentration [primary constituent for which the waste is characteristically hazardous as well as for any organic or inorganic chemical underlying hazardous constituent (UHC)], subject to item three below.
2. For contaminants in soil (e.g., inorganic chemicals, carbon disulfide, cyclohexanone, and methanol), treatment must achieve 90% reduction in constituent concentrations as measured in leachate from the treated media [tested according to the Toxicity Characteristic Leaching Procedure (TCLP)] or 90% reduction in total constituent concentrations (when a inorganic chemical removal treatment technology is used), subject to item three below.
3. When treatment of any constituent subject to treatment to a 90% reduction standard would result in a concentration less than 10 times the UTS for that constituent, treatment to achieve constituent concentrations less than 10 times the UTS is not required. This is commonly referred to as "90% capped by 10xUTS."
4. USEPA and Ohio EPA have established a site-specific variance from the soil treatment standards, which can be used when treatment to concentrations of hazardous constituents greater (i.e., higher) than those specified in the soil treatment standards minimizes short- and long-term threats to human health and the environment. In this way, on a case-by-case basis, risk-based LDR treatment standards approved through a variance process could supersede the soil treatment standards. Any variance granted cannot rely on capping, containment, or other physical or institutional controls.

Treatment standards are similar to LDR standards for contaminated soil, although alternative and adjusted standards may be approved or required by the Director, as long as the adjusted standard is protective of human health and the environment.

In the event solid waste material is found to be contaminated but not a RCRA hazardous waste, management and disposal of this material would be subject to the requirements associated with the management and disposal of solid waste within the state of Ohio. The requirements found at OAC Section 3745-27-05 would be potential ARARs for the disposal of non-hazardous contaminated waste

1 material generated during excavation and subsequent disposal at an off-site location. The potential
2 action-specific ARARs for the AOC are provided in Table 10-1.
3

Table 10-1. Potential Action-Specific ARARs

Media and Citation	Description of Requirement	Potential ARAR Status	Standard
Prohibition of air pollution nuisances (e.g., fugitive dust) OAC Section 3745-15-07	These rules prohibit a release of nuisance air pollution that endanger health, safety, or welfare of the public or cause personal injury or property damage.	Applies to any activity that could result in the release of a nuisance air pollutant. This would include dust from excavation or waste management processes.	Any person undertaking an activity is prohibited from emitting nuisance air pollution.
Storm water requirements at construction sites 40 CFR Part 450	These rules require that storm water controls be employed at construction sites that exceed 1 acre in size.	Applies to any construction activity that exceeds 1 acre in size.	Persons undertaking construction activities (including grubbing and land clearing) at an AOC where the construction footprint is over 1 acre in size must design and implement erosion and run-off controls.
Generation of contaminated waste material (i.e., soil, sediment, or debris) OAC Section 3745-52-11	These rules require that a generator determines whether a material generated is a hazardous waste.	Applies to any material that is or contains a solid waste. Must be characterized to determine whether the material is or contains a hazardous waste.	Any person that generates a waste as defined must use prescribed methods to determine if waste is considered characteristically hazardous.
Management of contaminated waste material that is or contains a hazardous waste OAC Sections 3745-52-30 through 3745-52-34	These rules require that hazardous waste is properly packaged, labeled, marked, and accumulated on-site pending on-site or off-site disposal.	Applies to any hazardous waste, or media containing a hazardous waste, that is generated from on-site activities.	All hazardous waste must be accumulated in a compliant manner that includes proper marking, labeling, and packaging in accordance with the specified regulations. This includes inspection of containers or container areas where hazardous waste is accumulated on-site.
Acquisition and use of manifests for hazardous waste shipments to off-site treatment, storage, or disposal facilities OAC Sections 3745-52-20 through -3745-52-23	These rules require that a Uniform Hazardous Waste Manifest be used for any off-site shipment of hazardous waste.	Applies to any shipment of hazardous waste to an off-site facility for treatment, storage, or disposal.	Requires a generator who transports or offers for transportation hazardous waste for off-site treatment, storage, or disposal to prepare a uniform hazardous waste manifest.

Table 10-1. Potential Action-Specific ARARs (continued)

Media and Citation	Description of Requirement	Potential ARAR Status	Standard
Soil contaminated with RCRA hazardous waste OAC Section 3745-270-48 UTS OAC Section 3745-270-49 Soil	These rules prohibit land disposal of RCRA hazardous waste subject to them, unless the waste is treated to meet certain standards that are protective of human health and the environment. Standards for treatment of hazardous waste-contaminated soil prior to disposal are set forth in the two cited rules. Use of the greater of either technology-based standards or UTS is prescribed.	LDRs apply only to RCRA hazardous waste. These rules are considered for ARAR status only upon generation of a RCRA hazardous waste. If any soil is determined to be RCRA hazardous and will be disposed of on-site, this rule is potentially applicable to disposal of the soil. These rules may be relevant to the sewer sediment since the regulatory definition of soil includes soil mixtures with liquid (i.e., sediment).	All soil subject to treatment must be treated as follows: 1) For non-metals, treatment must achieve 90% reduction in total constituent concentration (primary constituent for which the waste is characteristically hazardous as well as for any organic or metal UHC), subject to three below. 2) For metals, carbon disulfide, cyclohexanone, and methanol, treatment must achieve 90% reduction in constituent concentrations as measured in leachate from the treated media (tested according to the TCLP) or 90% reduction in total constituent concentrations (when a metal removal treatment technology is used), subject to three below. 3) When treatment of any constituent subject to treatment to a 90% reduction standard would result in a concentration less than 10 times the UTS for that constituent, treatment to achieve constituent concentrations less than 10 times the UTS is not required. This is commonly referred to as "90% capped by 10xUTS."

Table 10-1. Potential Action-Specific ARARs (continued)

Media and Citation	Description of Requirement	Potential ARAR Status	Standard
Debris Contaminated with RCRA Hazardous Waste OAC Section 3745-270-45	These rules prescribe conditions and standards for land disposal of debris contaminated with RCRA hazardous waste. Debris subject to this requirement for characteristic RCRA contamination that no longer exhibits the hazardous characteristic after treatment does not need to be disposed of as a hazardous waste. Debris contaminated with listed RCRA contamination remains subject to hazardous waste disposal requirements.	If RCRA hazardous debris is disposed of on-site, these rules are potentially applicable to disposal of the debris.	Standards are extraction or destruction methods prescribed in OAC Section 3745-400-45. Treatment residues continue to be subject to RCRA hazardous waste requirements.
Soil/Debris Contaminated with RCRA Hazardous Waste – Variance OAC Section 3745-270-44	The Director will recognize a variance approved by the USEPA from the alternative treatment standards for hazardous contaminated waste material.	Potentially applicable to RCRA hazardous waste material that is generated and placed back into a unit and that will be land disposed of on-site.	Where the treatment standard is expressed as a concentration in a waste and the waste cannot be treated to the specific level, the generator may petition for a variance. A site-specific variance from the soil treatment standards can be used when treatment to concentrations of hazardous constituents greater (i.e., higher) than those specified in the soil treatment standards minimizes short- and long-term threats to human health and the environment. In this way, on a case-by-case basis, risk-based LDR treatment standards approved through a variance process could supersede the soil treatment standards.
Solid waste material that is contaminated but not a hazardous waste for disposal. OAC Section 3745-27-05	Establishes standard for disposal of solid waste within the state of Ohio.	Potentially applicable to contaminated solid waste material disposed of off-site under the state solid waste disposal requirements.	Establishes the allowable methods of solid waste disposal and prohibits management by open burning or dumping.

AOC = Area of Concern
ARAR = Applicable or Relevant and Appropriate Requirements
CFR = Code of Federal Regulations

LDR = Land Disposal Restrictions
OAC = Ohio Administrative Code
RCRA = Resource Conservation and Recovery Act

TCLP = Toxicity characteristic leaching procedure
UHC = Underlying Hazardous Constituent
USEPA = United States Environmental Protection Agency
UTS = Universal Treatment Standard

10.2.3 Potential Location-Specific ARARs

Location requirements included those established for potential remedial activities conducted within wetlands, within a floodplain area, or with respect to species. Generally, for wetlands and floodplains, rules require alternatives to remedial activity within the sensitive area be pursued; if that is not feasible, adverse effects from any actions taken within the sensitive area must be mitigated to the extent possible. These requirements do not relate to specific chemicals nor do they further change the degree of cleanup in the sense of protecting human health or the environment from the effects of harmful substances. Rather, their purpose is to protect the sensitive areas (i.e., ecological areas or areas that include cultural resources and/or sites of historical/archeological significance) to the extent possible. Under CERCLA Section 121(d), relevance and appropriateness are related to the circumstances presented by the release of hazardous substances, with the goal of attaining a degree of cleanup and control of further release that ensures protection of human health and the environment. Due to the size of the sewers footprint, sensitive resources (e.g., wetlands), endangered species (including habitat), or areas that include cultural or historically significant items/structures may exist either within or adjacent to the AOCs where remediation may occur. The potential location-specific ARARs for the AOC are provided in Table 10-2.

In addition to the requirements identified as ARARs, any action taken by the Federal Government must be conducted in accordance with requirements established under the National Environmental Policy Act (NEPA), Endangered Species Act (ESA), National Historic Preservation Act (NHPA), and federal and state wetlands and floodplains construction and placement of material considerations, even though these laws and rules do not establish standards, requirements, limitations, or criteria relating to the degree of cleanup for chemicals remaining on-site at the close of the response actions. In addition, consultation with the Ohio Historic Preservation Office will be conducted as part of any action.

Table 10-2. Potential Location-Specific ARARs

Media and Citation	Description of Requirement	Potential ARAR Status	Standard
Presence of wetlands as defined in 10 CFR 1022.4(v).	Establishes the requirements to evaluate any action taken within a wetland to ensure that impacts are minimized or averted as required in 10 CFR 1022.3 (a) – (d).	Potentially applicable for activities that result in the impact of a wetland as defined.	To the extent possible, avoid the long- and short-term adverse effects associated with destruction, occupancy, and modification of wetlands. Measures to mitigate adverse effects of actions in a wetland include, but are not limited to, minimum grading requirements, runoff controls, design and construction constraints, and protection of ecologically sensitive areas in 10 CFR 1022.12(a)(3). To the extent practicable, take action to minimize destruction, loss, or degradation of wetlands and to preserve, restore, and enhance the nature and beneficial value of wetlands. Potential effects of any new construction in wetlands that are not in a floodplain shall be evaluated to identify and, as appropriate, implement alternative actions that may avoid or mitigate adverse impacts on wetlands.
16 U.S.C. 1531 et seq., Sect. 7(a)(2) (U.S. Threatened and Endangered Species Act) ORC 1518.02 Endangered Plant Species ORC 1531.25 Endangered Animal Species	Establishes requirements for the protection of T&E species and their habitat.	Applicable to sites where endangered species or critical habitat is encountered.	Actions that jeopardize the existence of a listed species or result in the destruction or adverse modification of critical habitat must be avoided or reasonable and prudent mitigation measures taken. The lead agency must determine whether T&E species or their critical habitat are present and conduct informal consultation with the U.S. Fish and Wildlife Service.

ARAR = Applicable or Relevant and Appropriate Requirements

CFR = Code of Federal Regulations

ORC = Ohio Revised Code

T&E = Threatened and Endangered

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11.0 TECHNOLOGY TYPES AND PROCESS OPTIONS

This section identifies and describes the GRAs which may be implemented to achieve the remedial goals. In addition, this section summarizes the remedial technologies and process options available to address chemicals requiring remediation, as identified in Section 9.0 of this report.

The procedure for identifying and screening potential remedial technologies followed the method established in the USEPA guidance document, *Guidance for Conducting Remedial Investigation/Feasibility Studies Under CERCLA* (USEPA 1988a). This guidance document provides the framework for identifying and screening all available remedial technologies to the most appropriate technologies available, based on the chemicals requiring remediation and AOC characteristics (e.g., pipe, manhole).

11.1 GENERAL RESPONSE ACTION

GRAs are actions which may be implemented to satisfy the RAO. The actions may be individual or a combination of responses. As sewer sediment is the only medium with chemicals requiring further evaluation per the risk assessment, the following GRAs are applicable and are defined in greater detail in subsequent sections:

- No Action;
- Land use controls (LUCs)/five-year reviews;
- Containment;
- Removal;
- Treatment; and
- Disposal/handling.

11.1.1 No Action

No Action is required for evaluation under the NCP and is the baseline to which other remedial alternatives are compared. No Action may provide an appropriate alternative if no unacceptable risks are present at the AOC. This GRA provides a baseline against which to compare other, more proactive alternatives. No action is taken at the AOC to reduce any hazard to human health or the environment. Any existing actions, such as restrictions or monitoring, are discontinued.

11.1.2 Land Use Controls and Five-Year Reviews

LUCs are non-engineering measures, such as administrative or legal controls, used to prevent or limit exposure to hazardous substances. LUCs do not reduce contaminant volume or toxicity. LUCs are used to supplement engineering controls and are a necessary component of the final remedy.

If LUCs are selected as a component of a remedial alternative for achieving anything other than unrestricted land use, the effectiveness of the remedy must undergo five-year reviews. The primary

goal of the five-year reviews is to evaluate the implementation and performance of the remedy to determine if the remedy is or will be protective of human health and the environment. Five-year reviews are discontinued when the remedy achieves CUGs for residential use and unrestricted release.

11.1.3 Containment

Containment of the sewer sediment will prevent direct contact by human and ecological receptors. Containment technologies (i.e., capping) are applicable to the medium of concern (sewer sediment). Traditional capping technology would be specific to preventing contact with sewer sediment. Caps may range from native soil covers, clay, asphalt, and concrete to multilayered caps consisting of various layers of soil and synthetic material. The level of the cap is dependent on the risks associated with the buried material and the level of protectiveness required. For the sewer sediment in inlets/manholes, a native soil or concrete cap would be appropriate to prevent contact with the sediment remaining in the inlet/manhole. A multilayered cap prevents direct contact and infiltration of surface water and groundwater, controls potential leachate, and prevents subsequent migration to groundwater. The fate and transport analysis did not identify leaching as a contributor of contamination from sewer sediment. Caps are installed using standard earth-moving equipment. Surface water drainage features are typically an important aspect of the cap design because of the surface controls needed to prevent potential infiltration through the buried material; however, surface controls would be a minor feature of capping for the sewer sediment in inlets/manholes because leaching is not a concern and because of the small area extent of the cap.

11.1.4 Removal

Removal of contaminated media (i.e., sewer sediment) from the piping/inlets/manholes at the segment of concern reduces or eliminates the potential for long-term human and environmental exposure to chemicals exceeding concentrations determined to be protective for a given land use. Removal of sewer sediment may be combined with a form of treatment prior to disposal off-site or may be shipped without pre-treatment. Removal of sewer sediment could involve complete excavation of the pipe/inlet/manhole of concern or cleaning techniques (i.e., pressure washing). Removal of sewer sediment in piping/inlet/manhole or the wastewater generated from the pressure washing may be combined with a form of treatment prior to disposal off-site, or sediment and wastewater may be shipped without pre-treatment.

11.1.5 Treatment

Treatment is conducted either in situ or ex situ to reduce contaminant concentrations to acceptable levels. Common types of treatment include biological, chemical, physical, and thermal. However, given the medium (i.e., sewer sediment), COCs (i.e., manganese and lead), and the RAO of preventing direct contact, only processes involving physically binding the contaminants to prevent potential for exposure (e.g., solidification/stabilization) are applicable.

1 Stabilization/solidification of the sewer sediment involves injecting a solidification/solidification
2 agent such as a cement/grout mixture into the pipe/inlet/manhole to bind with the sediment and the
3 contaminants contained within the sediment. The solidified/stabilized material prevents direct contact
4 with the sewer sediment.

5
6 For sewer sediment treated by ex-situ methods, the treatment would stabilize the contaminant (i.e.,
7 lead) in the sediment to prevent leaching prior to off-site disposal.

8 9 **11.1.6 Disposal and Handling**

10
11 Disposal and handling involve the final and permanent placement of waste material in a manner
12 protective of human health and the environment. The impacted media is disposed on-site in an
13 engineered facility or off-site in a permitted or licensed facility, such as a regulated landfill.
14 Similarly, concentrated waste resulting from treatment processes are disposed on-site in a permanent
15 disposal cell or off-site in an approved disposal facility.

16
17 Transportation is accomplished utilizing various methods, including truck, railcar, and/or barge.

18 19 **11.2 INITIAL SCREENING OF TREATMENT TECHNOLOGIES**

20
21 Table 11-1 summarizes the remedial technologies and process options available for the treatment of
22 sewer sediment. The screening focuses on technology types capable of remediating the chemicals
23 present in the sewer sediment and evaluates the implementability of the technology. If treatment
24 technologies are evaluated and retained as potentially viable treatment options for the AOC, the
25 technology will undergo a more detailed evaluation described in the following section.

Table 11-1. Initial Screening of Technologies

General Response Actions	Technology Type	Process Options	Description	Screening Results
No Action	None	None	No action is taken at the AOC. Current LUCs, access restrictions, and monitoring programs will be discontinued. No remedial technologies are implemented to reduce hazards to potential human or ecological receptors.	Retained. Required to be carried through CERCLA analysis.
Institutional Controls	Access Restrictions	LUCs with CERCLA five-year reviews	Implement LUCs at the AOC to restrict access and land use. LUCs will be administered and enforced as part of the Property Management Plan and reviewed in CERCLA five-year reviews. Five-year reviews include review of sampling and monitoring plans, results of monitoring activities, interviews, inspections, and reviews of AOC status.	Not retained. Anticipated remedy will attain Unrestricted Residential Land Use; therefore, LUCs will not be required.
		Fencing	Place fencing around pipes/inlets/manholes (at a minimum) of concern to restrict access and exposure to contamination left in place.	Not retained. Anticipated remedy will attain Unrestricted Residential Land Use; therefore, LUCs will not be required.
		Signs	Signs are placed around pipes/inlets/manholes of concern to inform potential receptors of contaminated sewer sediment in the subsurface.	Not retained. Anticipated remedy will attain Unrestricted Residential Land Use; therefore, LUCs will not be required.
Containment	Capping	Native soil/sediment, clay, concrete, asphalt, synthetic, multilayer.	Uses native soil, clay, concrete, asphalt, synthetic material, or combination of the material to cover contamination in sewer sediment of concern to prevent contact with sediment.	Not retained. Existing overburden over pipe segments prevents direct contact with sewer sediment in pipes. Additional cap would not eliminate direct contact with sewer sediment in pipes. Small areas of inlets/manholes are not conducive to installation of caps.
	Slip Lining	High density polyethylene, fiberglass reinforced, or polyvinyl chloride pipe.	The pipe/inlet/manhole is cleaned and a synthetic material is slipped into the cleaned pipe/inlet/manhole to refurbish its integrity.	Not retained. The pipe/inlet/manholes of concern are no longer functional for intended purposes due to change in land use; therefore, rehabilitation for continued use is not applicable.

Table 11-1. Initial Screening of Technologies (continued)

General Response Actions	Technology Type	Process Options	Description	Screening Results
Treatment	In-situ Techniques	Stabilization/solidification	Contaminants are physically bound or enclosed within a stabilized mass (solidification), or chemical reactions are induced between the stabilizing agent and contaminants to reduce their mobility (stabilization). Grout/cement is pumped into piping/inlet/manhole to stabilize/solidify the material. In addition, solidification of the sewer sediment prevents direct contact with sediment.	Retained.
	Ex-situ Techniques	Stabilization	Chemicals are mixed with the excavated contaminated hazardous sediment to stabilize contaminants in the sediment to prevent leaching above TCLP characteristic prior to shipping for off-site disposal.	Not retained. The sewer sediment is not expected to be characteristically hazardous per disposal requirements.
Removal	Bulk Removal	Excavation and off-site disposal	Contaminated segment of pipe/inlet/manhole is removed and transported to permitted off-site treatment and disposal facilities.	Retained.
		Pressure washing and off-site disposal of wastewater	High pressure directional washing is used to remove sediment accumulated in piping/inlets/manholes. Wastewater is collected/containerized and transported to permitted off-site treatment and disposal facilities.	Not retained. The integrity of pipes/inlets/manholes is suspect. There is a potential distribution (i.e., release) of contaminants in wastewater beyond the current pipe/inlet/manhole.

AOC = Area of Concern

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

LUC = Land Use Control

TCLP = Toxicity Characteristic Leaching Procedure

11.3 DETAILED SCREENING OF TECHNOLOGIES

The remedial action technologies retained from the initial screening process are evaluated against criteria of effectiveness, implementability, and cost (three of the NCP balancing criteria). The rationale for either retaining or eliminating treatment options for the AOC is presented and summarized in Table 11-2. The remedial options retained from the detailed screening process are used to develop the remedial alternatives presented in Section 12.0.

11.3.1 Effectiveness

The effectiveness criterion assesses the ability of a remedial technology to protect human health and the environment by reducing the toxicity, mobility, or volume of contaminants. Each technology is evaluated for the ability to achieve the RAO, potential impacts to human health and the environment during construction and implementation, and overall reliability of the technology.

11.3.2 Implementability

Each process option technology is evaluated for implementability in terms of technical feasibility, administrative feasibility, and availability of the necessary material, equipment, and work force. The assessment considers each technology's short-term and long-term implementability. Short-term implementability considerations include constructability of the remedial technology, near-term reliability, the ability to obtain necessary approvals with other agencies, and the likelihood of obtaining a favorable community response. Long-term implementability evaluates the ease of undertaking additional remedial actions if necessary, monitoring the effectiveness of the remedy, and operation and maintenance (O&M).

11.3.3 Cost

The cost criterion evaluates each remedial process in terms of relative capital and O&M costs. Costs for each technology are rated qualitatively, on the basis of engineering judgment, in terms of cost effectiveness. Therefore, a low cost remedial technology is rated as highly cost effective, while a costly technology is evaluated as being of low cost effectiveness.

Table 11-2. Detailed Screening of Technologies

General Response Actions	Technology Type	Process Options	Effectiveness	Implementability	Cost	Screening Comments
No Action	None	None	Not effective. Exposure to contaminants left in place goes unsupervised and uncontrolled.	Easy to implement. No activities are implemented.	Low cost. No activities driving cost.	Retained. Required by CERCLA.
Treatment	In-situ Techniques	Stabilization/Solidification	Effective. Solidification/stabilization using cement-based grout would be effective in binding contaminants in sewer sediment. Direct contact with sediment would be eliminated. Adding phosphate to grout reduces bioavailability of lead.	Moderately easy to implement. Solidification/stabilization of the sewer sediment uses standard pressure grouting techniques. Grouts for solidification/stabilization are readily available.	Moderate cost.	Retained.
Removal	Bulk Removal	Excavation and Off-Site Disposal	Effective. Once the pipe/inlet/manholes containing contaminated sediment is removed, contaminant exposure to human health and the environment is eliminated for that receptor.	Moderately easy to implement. Technology has been implemented at RVAAP in the past. Pipes/inlets/manholes are less than approximately 7 ft bgs. Pipes under roads and inlets/manholes near roads will disrupt traffic for a short time.	Moderate to high cost.	Retained.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

ft bgs = feet below ground surface

RVAAP = Ravenna Army Ammunition Plant

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12.0 DEVELOPMENT OF REMEDIAL ALTERNATIVES

This section describes the remedial alternatives developed and retained from the initial and detailed technology screening process. The retained remedial alternatives meet GRAs and are composed of implementable technology types and process options that address chemicals requiring remediation in sewer sediment at the Facility-Wide Sewers.

The retained remedial alternatives are:

- Alternative 1: No Action.
- Alternative 2: Attain Unrestricted Residential Land Use ~ In-situ Treatment Using Solidification/Stabilization.
- Alternative 3: Attain Unrestricted Residential Land Use ~ Excavation with Off-site Disposal.

A detailed description of each remedial alternative is provided in the following sections.

12.1 ALTERNATIVE 1: NO ACTION

The No Action alternative is required for evaluation under the NCP. This alternative is the baseline to which other remedial alternatives are compared. This alternative assumes all current actions (e.g., access restrictions and environmental monitoring) are discontinued and assumes no future actions take place to protect human receptors or the environment. Removal or treatment of chemicals at the AOC is not implemented.

12.2 ALTERNATIVE 2: ATTAIN UNRESTRICTED RESIDENTIAL LAND USE ~ IN-SITU TREATMENT USING SOLIDIFICATION/STABILIZATION

Under this alternative, pipes/inlets/manholes would be grouted to solidify/stabilize chemicals requiring remediation. The solidification/stabilization of sewer sediment in pipes/inlets/manholes achieves Unrestricted Residential Land Use by preventing exposure to chemicals the Resident Farmer; this is the objective of Alternative 2.

Alternative 2 consists of pressure grouting the pipes/inlets/manholes with a stabilization/solidification agent to bind the sewer sediment, removing the surface structure (i.e., concrete/metal/tile sides, manhole cover, grate) of inlets and manholes to approximately 2 ft bgs, and restoring the surface around the inlet/manhole to the surrounding conditions (e.g., vegetation, asphalt road surface). Debris from removal of the surface completion of the inlet or manhole would be transported by truck to an off-site licensed disposal facility.

1 This alternative requires four pipes/inlets/manholes to be grouted to stabilize/solidify the chemicals
2 requiring remediation in the sediment. These four pipes/inlets/manholes were identified by sampling
3 activities at the following locations:

- 4
- 5 • TSAsd-002(sn) (7 ft bgs) at the Transportation Storage Area FA;
- 6 • DAAsd-006(sn) (4.3 ft bgs) at the Depot Administration Area FA ,
- 7 • LL2sd-615(st) (3.5 ft bgs) at the Load Line 2 FA; and
- 8 • LL3sd-272(st) (2.2 ft bgs) at the Load Line 3 FA.
- 9

10 The pipes/inlets/manholes requiring stabilization/solidification in these areas are depicted on Figures
11 9-1, 9-2, 9-3, and 9-4. The estimated total length of pipe is 4,191 ft. The inlets are 3 ft wide by 3 ft
12 long, and the manholes are 4 ft in diameter. Pipes in the inlets/manholes are 6-18 inches and are
13 approximately 2.2-7.0 ft bgs. The pipe/inlet/manhole characteristics are presented on Figures 9-1,
14 9-2, 9-3, and 9-4.

15

16 This remedial alternative requires coordination of remediation activities with Ohio EPA, OHARNG,
17 and the U.S. Army. Coordinating with stakeholders during implementation of the grouting minimizes
18 health and safety risks to on-site personnel and potential disruptions of RVAAP/Camp Ravenna
19 activities. The time period to complete this remedial action is relatively short and does not include an
20 O&M period to assess impacts from grouting of sewer sediment, as an unrestricted land use scenario
21 is achieved. Components of this remedial alternative include:

- 22
- 23 • Notifications and approvals;
- 24 • RD sampling;
- 25 • RD;
- 26 • Pre-mobilization activities;
- 27 • Stabilization/solidification of pipes/inlets/manholes;
- 28 • Removal of surface completion of inlet and manhole and disposal; and
- 29 • Restoration.
- 30

31 **12.2.1 Notifications and Approvals**

32

33 Prior to the implementation of this remedial alternative, a review will be conducted to identify
34 required notifications and approvals. This includes (but is not limited to) consultation with the U.S.
35 Fish and Wildlife Service (USFWS) and OHPO.

37 **12.2.2 Remedial Design Sampling**

38

39 The current piping/inlet/manhole segments requiring remediation, presented in Figures 9-1, 9-2, 9-3,
40 and 9-4, were defined by upstream and downstream sample locations below the CUG. Sample points
41 (manholes/inlets) exist between these locations without data. Sediment samples will be collected at
42 inlets/manholes without data to define the pipe segments that require remediation.

1 A delineation sampling plan will be presented to the U.S. Army and Ohio EPA for approval. This
2 plan will present new sample locations to refine the segments that are associated with TSA_{sd}-002(sn),
3 DAA_{sd}-006(sn), LL2_{sd}-615(st), and LL3_{sd}-272(st). The new sample locations will undergo
4 sediment sampling, and the sediment samples will be analyzed for the chemicals associated with that
5 pipe/inlet/manhole (i.e., manganese or lead). Segments of pipes/inlets/manholes below the CUG will
6 be excluded from remediation.

8 **12.2.3 Remedial Design**

10 An RD plan will be developed prior to the initiation of remedial actions. This plan will outline
11 construction permitting requirements; site preparation activities (e.g., staging and equipment storage
12 areas, truck routes, storm water controls); the extent of the grouting of the pipe/inlet/manhole;
13 sequence of construction activities; decontamination; and segregation, transportation, and disposal of
14 various waste streams. Engineering and administrative controls (e.g., erosion controls, health and
15 safety controls) will be developed during the active construction period to ensure the protection of
16 remediation workers and the environment.

18 **12.2.4 Stabilization/Solidification of Pipes/Inlets/Manholes**

20 Stabilization/solidification of pipe segments will be performed at inlets and/or manholes within the
21 pipe length requiring remediation. The stabilization/solidification material will be a cement-based
22 mixture with phosphate additives (herein referred to as grout). Buffered phosphate (EnviroBlend[®])
23 added at a ratio of 4-10% dry weight to the grout mixture reduces the mobility and the bioavailability
24 of the lead in the sediment. The final grout mixture will be specified in the RD.

26 Pressurized grout pumps will be used to inject the grout into the underground pipe lines beginning
27 from an inlet or manhole located at a non-contaminated segment of the pipe. Non-contaminated
28 upstream and downstream pipes within the manhole where the grouting is originating will be plugged
29 prior to grouting the contaminated pipe segments and completing the grouting of the inlet/manhole.
30 If necessary, obstructions/plugs with pressure release will be installed in the pipes to ensure complete
31 grouting of the pipe within the segment. The inlet/manhole will be grouted to within 1 ft of the
32 ground surface, and the surface will be restored to pre-grouting conditions [i.e., asphalt road,
33 vegetation (mulched and seeded), or rock].

35 Prior to any ground disturbance to implement grouting, erosion control material such as silt fences
36 and straw bales will be installed to minimize sediment runoff. Dust generation is to be minimized by
37 keeping the remediation area misted with water. The health and safety of remediation workers,
38 on-site RVAAP/Camp Ravenna employees, and the general public will be detailed in a site-specific
39 health and safety plan.

41 Pipes that are immediately upstream, downstream, or within the same inlets/manholes will be plugged
42 prior to grouting. The plugs will be left in place until the grout is set. Grout will be pumped through

1 the entire length of the pipe segment of concern and into the inlet or manhole at the end of each
2 segment.

3
4 The removal of the surface structure of the inlet/manhole will be accomplished using conventional
5 construction equipment such as backhoes and front-end loaders. Oversize debris will be crushed or
6 otherwise processed to meet disposal facility requirements.

7
8 The debris resulting from the removal of the surface structure of the inlet/manhole will be set aside.
9 Excavated debris from the removal of the inlet/manhole and any attached soil will be hauled by truck
10 to a licensed and permitted disposal facility. All trucks will be inspected prior to exiting the AOC.
11 Appropriate waste manifests will accompany each waste shipment. Only regulated and licensed
12 transporters and vehicles will be used. All trucks will travel pre-designated routes within RVAAP.

13
14 The debris and soil from the removal of the inlet/manhole will be disposed at an existing off-site
15 facility licensed and permitted to accept the characterized waste stream. The selection of an
16 appropriate facility considers the types of waste, location, transportation options, and cost. Waste
17 streams with different constituents and/or characteristics may be generated. Disposal cost savings are
18 possible by utilizing specific disposal facilities for different waste streams.

19 20 **12.2.5 Restoration**

21
22 Upon completion of surface structure removal of the inlet or manhole and grouting to approximately
23 1 ft bgs, all disturbed areas will be backfilled with appropriate material to restore the AOCs to
24 surrounding conditions. In areas where the surrounding material is ballast (i.e., gravel), the adjacent
25 mounded gravel will be graded to cover the previous location of the manhole or inlet. Manholes and
26 inlets in asphalt roadways will be completed with base material and asphalt. Manholes and inlets in
27 vegetated areas will be filled to surface with clean native soil and graded to meet neighboring
28 contours. The soil backfill will come from a clean source that was previously sampled and approved
29 for use by Ohio EPA. After the area is backfilled and graded, workers will apply a seed mixture (as
30 approved by the OHARNG) and mulch. Restored areas are inspected and monitored as required in
31 the Storm Water Pollution Prevention Plan (SWPPP).

32 33 **12.3 ALTERNATIVE 3: ATTAIN UNRESTRICTED RESIDENTIAL LAND USE ~ EXCAVATION WITH** 34 **OFF-SITE DISPOSAL**

35
36 Under this alternative, pipes/inlets/manholes of concern will be excavated, removed, and disposed at
37 an off-site disposal facility.

38
39 Excavating and removing the contaminated sewer sediment from the pipe/inlet/manhole of concern in
40 the Facility-Wide Sewers obtains Unrestricted Residential Land Use, which is the objective of
41 Alternative 3. This alternative assumes a removal action achieves the CUGs for the Unrestricted
42 Residential Land Use chemicals requiring remediation. Alternative 3 consists of excavating and

removing the pipe/inlet/manhole co-located with the sewer sediment requiring remediation, followed by transportation by truck to an off-site licensed disposal facility.

This alternative requires removal of four pipes/inlets/manholes. These four pipes/inlets/manholes were identified by sampling activities at the following locations:

- TSAsd-002(sn) (7 ft bgs) at the Transportation Storage Area FA;
- DAAsd-006(sn) (4.3 ft bgs) at the Depot Administration Area FA;
- LL2sd-615(st) (3.5 ft bgs) at the Load Line 2 FA; and
- LL3sd-272(st) (2.2 ft bgs) at the Load Line 3 FA.

The extent of the excavation at these pipes/inlets/manholes of concern in these areas is depicted on Figures 9-1, 9-2, 9-3, and 9-4. The depth of the piping segments of piping/inlets/manholes ranges approximately 2.2-7.0 ft bgs. The estimated total disposal volume (i.e., ex situ) is conservatively estimated to be 1,825 yd³. This extent and total disposal volume assumes all piping from these locations to upstream and downstream locations less than CUGs will require excavation. In advance of pipe removal activities, delineation sampling will be performed to refine/confirm the extent of excavation of the pipes/inlets/manholes requiring excavation and disposal.

This remedial alternative requires coordination of remediation activities with Ohio EPA, OHARNG, and the U.S. Army. Coordinating with stakeholders during implementation of the excavation minimizes health and safety risks to on-site personnel and potential disruptions of RVAAP/Camp Ravenna activities. The time period to complete this remedial action is relatively short and does not include an O&M period to assess impacts from excavation of sewer sediment, as an unrestricted land use scenario is achieved. Components of this remedial alternative include:

- Notifications and approvals;
- Delineation and waste characterization sampling;
- RD;
- Pre-mobilization activities;
- Excavation, removal, and disposal; and
- Restoration.

12.3.1 Notifications and Approvals

Prior to the implementation of this remedial alternative, a review will be conducted to identify any required permits, notifications, and approvals. This includes (but is not limited to) consultation with the USFWS and OHPO.

12.3.2 Remedial Design Sampling

Delineation sampling will be conducted to further refine areas containing the chemicals requiring remediation at sample locations TSAAsd-002(sn), DAAAsd-006(sn), LL2sd-615(st), and LL3sd-272(st). A delineation sampling plan will be presented to the U.S. Army and Ohio EPA for approval.

This plan will present new sample locations within segments associated with sample locations DAAAsd-006(sn), TSAAsd-002(sn), LL2sd-615(st), and LL3sd-272(st). The new sample locations within the four segments of concern will undergo sediment sampling, and sediment samples will be analyzed for chemicals requiring remediation (i.e., manganese or lead) in that area. The refined sample areas that exceed the Unrestricted Residential Land Use CUGs will require sediment removal in the pipe/inlet/manhole. Segments of pipes/inlets/manholes below the CUG will be excluded from remediation.

12.3.3 Remedial Design

An RD plan will be developed prior to the initiation of remedial actions. This plan will outline construction requirements; site preparation activities (e.g., staging and equipment storage areas, truck routes, storm water controls); the extent of the excavation and pipe/inlet/manhole removal; sequence of construction activities; decontamination; and segregation, transportation, and disposal of various waste streams. Engineering and administrative controls (e.g., erosion controls, health and safety controls) will be developed during the active construction period to ensure protection of remediation workers and the environment.

12.3.4 Excavation, Removal, and Disposal

Prior to any ground disturbance, erosion control material such as silt fences and straw bales will be installed to minimize sediment runoff from the excavation area. Dust generation is to be minimized during excavation activities by keeping equipment movement areas and excavation areas misted with water. The health and safety of remediation workers, on-site RVAAP/Camp Ravenna employees, and the general public will be detailed in a site-specific health and safety plan.

To achieve a scenario in which the AOC is protective for Unrestricted Residential Land Use, sewer sediment requiring remediation will be removed from segments associated with sample locations DAAAsd-006(sn), TSAAsd-002(sn), LL2sd-615(st), and LL3sd-272(st). The depth of the excavation of the pipes/inlets/manholes is approximately 2.2-7.0 ft bgs. It is assumed approximately 0.5 ft of soil will be removed from below the pipe/inlet/manhole in the process of removing the segment of concern. The pipe/inlet/manhole removal will be accomplished using conventional construction equipment such as backhoes, bulldozers, and front-end loaders. Oversize debris will be crushed or otherwise processed to meet disposal facility requirements.

Prior to excavation, a detailed survey will be performed to identify the path and elevation of the pipe to be excavated. Overburden above the pipe will be excavated to approximately 0.5-1.0 ft above the

1 pipe and staged separately from the pipe material and adjacent soil. To prevent sediment from exiting
2 the pipe segment during excavation, piping will be removed in complete sections when possible. The
3 piping at the Transportation Storage Area FA and Depot Administration Area FA is vitrified clay and
4 will be difficult to excavate without breaking. Excavation to approximately 0.5 ft below the piping
5 will ensure any sewer sediment that exits the pipe during excavation is captured. Approximately 1 ft
6 of soil will be excavated around the perimeter of each inlet or manhole requiring excavation. The
7 excavated pipe and debris from inlets/manholes containing sediment and adjacent soil will be staged
8 in rolloff boxes and characterized for full TCLP characterization to determine disposal requirements.
9

10 Once the pipe is removed, composite incremental sampling method (ISM) samples will be collected
11 in the trench and excavated manholes. One composite ISM sample will be collected per piping
12 segment located between manholes and/or inlets. The composite ISM sample will be analyzed for
13 manganese or lead, depending on which chemical was identified as requiring remediation in the
14 respective pipe segment. Once the CUGs are achieved, overburden material will be placed back in
15 the excavation. No chemicals requiring remediation were identified in the material surrounding the
16 pipes/inlets/manholes. The confirmation sampling is to confirm that sediment from piping has not
17 been distributed during excavation of the pipe/inlet/manhole. Upon achievement of the CUGs, the
18 AOC meets requirements for Unrestricted Residential Land Use.
19

20 Excavated piping/inlets/manholes and any co-located soil will be hauled by truck to a licensed and
21 permitted disposal facility. All trucks will be inspected prior to exiting the AOC. Appropriate waste
22 manifests will accompany each waste shipment. Only regulated and licensed transporters and
23 vehicles will be used. All trucks will travel pre-designated routes within RVAAP.
24

25 Excavated piping and inlet/manhole debris and adjacent soil will be disposed at an existing off-site
26 facility licensed and permitted to accept the characterized waste stream. The selection of an
27 appropriate facility considers the types of waste, location, transportation options, and cost. Waste
28 streams with different constituents and/or characteristics may be generated. Disposal cost savings are
29 possible by utilizing specific disposal facilities for different waste streams.
30

31 **12.3.5 Restoration**

32

33 Upon completion of excavation, all disturbed areas will be backfilled with clean soil, graded to meet
34 neighboring contours, and completed to surrounding conditions (e.g., seeded and mulched, asphalt,
35 rock). In areas where surrounding material is ballast (i.e., mounded gravel), the adjacent gravel will
36 be graded to cover the location of the manhole or inlet. Excavation in asphalt roadways will be
37 completed with base material and asphalt. Excavation in vegetated areas will be filled to surface with
38 clean native soil. Backfill will come from a clean source that was previously sampled and approved
39 for use by Ohio EPA. After the area is backfilled and graded, workers will apply a seed mixture (as
40 approved by the OHARNG) and mulch. Restored areas will be inspected and monitored as required
41 in the SWPPP.
42

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13.0 ANALYSIS OF REMEDIAL ALTERNATIVES

13.1 INTRODUCTION

This section presents a detailed analysis of the viable remedial alternatives retained and developed through the technology screening process. The purpose of this detailed analysis is to provide stakeholders ample information to identify and select an appropriate remedy and prepare the PP. Based on this detailed analysis of the retained alternatives, one or more is recommended for media requiring remediation at the Facility-Wide Sewers.

CERCLA guidance suggests the principle element of the selected remedy should reduce volume, toxicity, or mobility. If the selected remedy's principle element does not meet this criterion, an explanation as to why must be presented. In addition, the remedy must meet the following four statutory requirements:

- Be protective of human health and the environment;
- Comply with ARARs (or justification for a waiver);
- Be cost effective; and
- Use permanent solutions and treatment or recovery technologies to the maximum extent practicable.

There are nine established NCP evaluation criteria used to perform a detailed analysis of remedial alternatives to ensure the selected alternative meets the above CERCLA statutory requirements. The nine criteria are grouped into three categories: threshold criteria, balancing criteria, and modifying criteria.

13.2 THRESHOLD CRITERIA

There are two evaluation criteria classified as threshold criteria. This criteria group relates directly to statutory findings. Threshold criteria must be met by the selected remedy. The evaluation criteria in this group are:

1. Overall protection of human health and the environment; and
2. Compliance with ARARs.

Each alternative must be evaluated to determine how it achieves and maintains protection of human health and the environment. An alternative is considered to be protective of human health and the environment if it complies with medium-specific CUGs. Similarly, each remedial alternative must be assessed to determine how it complies with ARARs or, if a waiver is required, an explanation of why a waiver is justified.

13.2.1 Balancing Criteria

There are five evaluation criteria classified as balancing criteria. This group represents the primary criteria upon which the detailed and comparative analysis of each remedial alternative are based. The evaluation criteria in this group are:

1. Long-term effectiveness and permanence;
2. Reduction of toxicity, mobility, or volume through treatment;
3. Short-term effectiveness;
4. Implementability; and
5. Cost.

Long-term effectiveness and permanence is an evaluation of the magnitude of residual risk (risk remaining after implementation of the alternative) and the adequacy and reliability of controls used to manage the remaining waste (untreated waste and treatment residuals) over the long term. Alternatives that provide the highest degree of long-term effectiveness and permanence leave little or no untreated waste at the AOC, make long-term maintenance and monitoring unnecessary, and minimize the need for LUCs.

Reduction of toxicity, mobility, or volume through treatment is an evaluation of the ability of the alternative to reduce the toxicity, mobility, or volume of the waste. The irreversibility of the treatment process and the type and quantity of residuals remaining after treatment are also assessed.

Short-term effectiveness addresses the protection of workers and the community during the remedial action, the environmental effects of implementing the action, and the time required to achieve media-specific preliminary CUGs.

Implementability addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and material required during implementation. Technical feasibility assesses the ability to construct and operate a technology, the reliability of the technology, the ease in undertaking additional remedial actions, and the ability to monitor the effectiveness of the alternative. Administrative feasibility is addressed in terms of the ability to obtain approval from federal, state, and local agencies.

Cost analyses estimate the dollar cost of each alternative. The cost estimates in this report are based on estimating reference manuals, historical costs, vendor quotes, and engineering estimates. Costs are reported in base year 2011 dollars, or present value (future costs are converted to base year 2011 dollars using a 4.125% discount factor). The present value analysis is a method to evaluate expenditures, either capital or O&M, which occur over different time periods. Present value calculations allow for cost comparisons of different remedial alternatives on the basis of a single cost figure. The capital costs have not been discounted due to their relatively short implementation duration. The cost estimates are for guidance in project evaluation and implementation and are believed to be accurate within a range of -30% to +50% in accordance with USEPA guidance

(USEPA 1988a). Actual costs could be higher than estimated due to unexpected conditions or potential delays. Details and assumptions used in developing cost estimates for each of the alternatives are provided in Appendix H.

13.2.2 Modifying Criteria

There are two evaluation criteria categorized as modifying criteria. Modifying criteria are formally evaluated as part of the ROD and after the public has had an opportunity to comment on the PP. This criteria group consists of:

1. State acceptance; and
2. Community acceptance.

State Acceptance considers comments received from agencies of the State of Ohio. Ohio EPA is the primary state agency supporting this investigation. Ohio EPA, as well as other state agencies, will provide comments on the FS and the preferred remedy presented in the PP. This criterion is addressed in the responsiveness summary of the ROD.

Community Acceptance considers comments made by the community, including stakeholders, on the alternatives being considered. Comments will be solicited and accepted from the community on the FS and the preferred remedy presented in the PP. This criterion is addressed in the responsiveness summary of the ROD.

Modifying criteria are future activities. These actions are the same for the retained alternatives. Therefore, the detailed analysis of the remedial alternatives is not included in an evaluation of modifying criteria. The detailed analysis of the retained remedial alternatives for sewer sediment in the Facility-Wide Sewers is presented in the following sections. This analysis is based on seven evaluation criteria (two threshold and five balancing criteria).

13.3 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

A detailed analysis of each alternative against the seven NCP threshold and balancing evaluation criteria is contained in the following sections. The detailed analysis includes further definition of each alternative (if necessary), compares the alternatives against one another, and presents considerations common to the alternatives.

As presented in Section 12.0, the following remedial alternatives were retained for the Facility-Wide Sewers:

- Alternative 1: No Action.
- Alternative 2: Attain Unrestricted Residential Land Use ~ In-situ Treatment Using Solidification/Stabilization.

- Alternative 3: Attain Unrestricted Residential Land Use ~ Excavation with Off-site Disposal.

13.3.1 Alternative 1: No Action

Under this alternative, no remedial actions take place for any media to meet the RAO. Media with concentrations greater than CUGs are left in place. Existing access restrictions (e.g., RVAAP perimeter fence) are not continued. Environmental monitoring is not performed, and no restrictions on land use are implemented.

13.3.1.1 Overall Protection of Human Health and the Environment

Alternative 1 is not protective of human health for the representative receptor (National Guard Trainee), as chemicals requiring remediation in sewer sediment were identified. Additionally, Alternative 1 is not protective of the Unrestricted Residential Land Use, as manganese and lead are identified as chemicals requiring remediation in sewer sediment remain in pipes/inlets/manholes samples for Unrestricted Residential Land Use.

Under Alternative 1, current ecological risk is not reduced and the ecological importance of the AOC remains unchanged. Current and future OHARNG land use allows for sustainability of terrestrial habitat for ecological receptors.

13.3.1.2 Compliance with ARARs

Potential ARARs for remediation of sediment in Facility-Wide Sewers are presented in Section 10.0. These enforceable standards are protective of the representative receptor (National Guard Trainee). There are no chemical-specific, location-specific, or action-specific ARARs identified for Alternative 1.

13.3.1.3 Long-Term Effectiveness and Permanence

Alternative 1 has no long-term management measures to prevent exposures to or the migration of chemicals. Existing security is discontinued, and there is no access control to the sewer sediment that remains in the pipes/inlets/manholes of concern at the Facility-Wide Sewers.

13.3.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 1 does not reduce the toxicity, mobility, or volume of chemicals requiring remediation. This alternative does not remove or treat sewer sediment with concentrations of chemicals above CUGs in the pipes/inlets/manholes.

1 **13.3.1.5 Short-Term Effectiveness**

2
3 Alternative 1 has no additional short-term health risks to the community, remediation workers, or the
4 environment. This remedial alternative offers no short-term benefits or progress to achieve the RAO.
5

6 **13.3.1.6 Implementability**

7
8 This alternative does not require any additional effort to implement, since it does not change the
9 existing condition at the locations with sewer sediment above CUGs at the Facility-Wide Sewers.
10

11 **13.3.1.7 Cost**

12
13 The present value cost to complete Alternative 1 is \$0. No capital costs are associated with this
14 alternative.
15

16 **13.3.2 Alternative 2: Attain Unrestricted Residential Land Use ~ In-situ Treatment Using**
17 **Solidification/Stabilization**

18
19 The implementation of Alternative 2 results in Unrestricted Residential Land Use. Under Alternative
20 2, pipes/inlets/manholes are solidified/stabilized with a cement/phosphate grout mixture to prevent
21 direct contact with sewer sediment containing chemicals requiring remediation above the CUGs.
22

23 **13.3.2.1 Overall Protection of Human Health and the Environment**

24
25 Under Alternative 2, the chemicals in the sewer sediment above CUGs are solidified/stabilized to
26 prevent direct contact with human and ecological receptors. Alternative 2 results in Unrestricted
27 Residential Land Use, as it prevents direct contact with all receptors.
28

29 Alternative 2 beneficially reduces risk from chemicals requiring remediation in sewer sediment to
30 ecological receptors through eliminating potential contact with the sewer sediment in the
31 piping/inlets/manholes.
32

33 **13.3.2.2 Compliance with ARARs**

34
35 There are no identified chemical-specific or location-specific ARARs for Alternative 2. No wetlands
36 are located within the pipe segments of concern. However, there are action-specific ARARs for this
37 alternative.
38

39 Removal of the surface structure of the inlet and the manholes will disturb soil; therefore, Alternative
40 2 will trigger ARARs for the control of fugitive dust emissions and erosion control measures.
41 Action-specific ARARs only apply if the action is taken.
42

13.3.2.3 Long-Term Effectiveness and Permanence

Solidification/stabilization provides long-term effectiveness and permanence. The chemicals requiring remediation in the sewer sediment are bound in cement/phosphate grout used for stabilization/solidification. Direct contact with the chemicals requiring remediation is eliminated. The mobility of sewer sediment and chemicals requiring remediation in sewer sediment is reduced. Bioavailability of lead is reduced in the phosphate-stabilized sediment. No CERCLA five-year reviews or O&M sampling is required.

13.3.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 2 eliminates the direct contact exposure pathway, reduces the toxicity of lead by reducing its bioavailability, and reduces the mobility of the inorganic chemicals (i.e., manganese and lead) in sewer sediment remaining in the pipes/inlets/manholes. Alternative 2 does not reduce the volume of the contaminated sewer sediment.

13.3.2.5 Short-Term Effectiveness

There are potential short-term worker and community exposures associated with Alternative 2. Workers may potentially have direct contact with sediment during the grouting of the pipes/inlets/manholes. A health and safety plan that identifies appropriate PPE for workers will minimize and/or eliminate direct contact with waste-in-place.

The community near the AOC and along the route to the disposal facility can be exposed during removal and transportation activities. Mitigation measures during removal of the surface completions of the inlets/manholes, such as erosion and dust control, minimize/eliminate potential short-term impacts. The community will be protected during debris/soil/solid waste transport by inspecting vehicles before and after use, decontaminating as needed, covering the transported waste, observing safety protocols, following pre-designated routes, and limiting the distance to the disposal facility. Transportation risks associated with material leaks increase with distance and volume of material. Transportation of soil to an off-site disposal facility will comply with all applicable state and federal regulations. Pre-designated travel routes will be established and an emergency response program will be developed to facilitate any potential accident response.

The grouting of the pipes/inlets/manholes is estimated to be complete in 6 weeks.

13.3.2.6 Implementability

Alternative 2 is easy to implement after the development of an RD and all appropriate permitting/coordination with local, state, and federal agencies is completed. Grouting of pipes/inlets/manholes, removal/excavation of surface structure of manholes/inlets, and waste handling are conventional, straightforward construction techniques and methods. Multiple off-site disposal

facilities are available to accept generated waste. Resources (e.g., equipment, material, trained personnel) to implement this alternative are readily available.

The implementability of grouting may be challenging in localized areas, as access to some of the underground pipes may be restricted. Video surveying at Load Lines 2 and 3 indicated lines have collapsed in some locations, and grouting may be difficult in these instances. In addition, the inlets at Load Lines 2 and 3 contain ballast which will require removal prior to grouting.

The small amount of excavation required to remove the inlets/manholes will be coordinated with RVAAP and OHARNG to minimize alterations and/or impacts to OHARNG. The RD will identify access routes to the AOC for heavy equipment and steps to minimize potential hazards to on-site personnel. The development of the RD and coordination with local, state, and federal permitting organizations increases the implementation difficulty of Alternative 2.

13.3.2.7 Cost

The present value cost to complete Alternative 2 is approximately \$366,906 (in base year 2011 dollars with a 4.125% discount factor). The development of a RD, grouting of the pipes/inlets/manholes, and restoration of the surrounding surfaces around the inlets/manholes is included in this cost. A detailed description of Alternative 2 costs is contained in Appendix H.

13.3.3 Alternative 3: Attain Unrestricted Residential Land Use ~ Excavation with Off-site Disposal

The implementation of Alternative 3 results in achieving CUGs for Unrestricted Residential Land Use. To achieve Unrestricted Residential Land Use, Alternative 3 implements excavation and off-site disposal of sediment with chemicals above the CUGs in pipe segments proximate to locations DAAsd-006(sn), TSAsd-002(sn), LL2sd-615(st), and LL3sd-272(st). An estimated 2,120 yd³ (ex situ) of piping, concrete, overburden soil, and sediment will be excavated, with approximately 720 yd³ of this material being transported (via truck) to an off-site permitted disposal facility. Other technologies required include monitoring, short-term containment, and waste handling via trucks.

13.3.3.1 Overall Protection of Human Health and the Environment

Under this alternative, piping/inlets/manholes containing sewer sediment above CUGs are excavated and removed, as recommended in the HHRA. These segments are located around sample locations TSAsd-002(sn), DAAsd-006(sn), LL2sd-615(st), and LL3sd-272(st). Removal of contaminated sediment in these pipe segments, as described in the remedial alternative, results in the AOC being protective of human health for Unrestricted Residential Land Use.

Alternative 3 beneficially reduces existing chemical risks to ecological receptors through removal of sediment. Implementation of Alternative 3 results in minimal temporary vegetation loss and alteration of soil adjacent to excavation areas. Excavation of the four piping segments of concern

disrupts approximately 53,520 ft² (1.2 acres), primarily in already disturbed land. The clearing area should recover from excavation activities in one year.

13.3.3.2 Compliance with ARARs

There are no identified chemical-specific or location-specific ARARs for Alternative 3. However, there are action-specific ARARs for this alternative. Those requirements identified as ARARs deal primarily with the characterization, management, and disposal of contaminated sediment and debris generated from excavation of pipes/inlets/manholes. Disturbance of the soil to remove the pipes/inlets/manholes will trigger ARARs for the control of fugitive dust emissions and erosion control measures. Action-specific ARARs only apply if the action is taken. Potential ARARs for soil excavation are presented in Section 10.0.

13.3.3.3 Long-Term Effectiveness and Permanence

Alternative 3 effectively reduces and controls chemicals requiring remediation in the sewer sediment over the long-term. Pipes/inlets/manholes with sewer sediment requiring remediation are excavated and transported to an off-site disposal facility to result in Unrestricted Residential Land Use, thereby mitigating risks to human health and the environment. Accordingly, LUCs are not required at the completion of the removal activities. No CERCLA five-year reviews or O&M sampling is required.

13.3.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative 3 does not achieve a reduction in the toxicity or volume of contaminated media. The mobility of chemicals requiring remediation in the sewer sediment is reduced at the off-site disposal facility through engineering controls (e.g., clay liners, geomembranes).

13.3.3.5 Short-Term Effectiveness

There are potential short-term worker and community exposures associated with Alternative 3. Workers are exposed during excavation activities. A health and safety plan that identifies appropriate PPE for workers will minimize and/or eliminate exposures.

The community near the excavation area and along the route to the disposal facility can be exposed during removal and transportation activities. Mitigation measures during excavation, such as erosion and dust control, minimize/eliminate potential short-term impacts. The community will be protected during soil transport by inspecting vehicles before and after use, decontaminating as needed, covering the transported waste, observing safety protocols, following pre-designated routes, and limiting the distance to the disposal facility. Transportation risks associated with material leaks increase with distance and volume of material. Transportation of soil to an off-site disposal facility will comply with all applicable state and federal regulations. Pre-designated travel routes will be established, and an emergency response program will be developed to facilitate any potential accident response.

The excavation of the pipes/inlets/manholes containing sewer sediment requiring remediation and restoration of the AOC is estimated to be complete in 2 months. Storm water controls will be monitored weekly for 6 months or until vegetation is 70% established. Upon completion of excavation activities, the Facility-Wide Sewers can be released for Unrestricted Residential Land Use.

13.3.3.6 Implementability

Alternative 3 is easily implemented after the development of an RD and all appropriate permitting/coordination with local, state, and federal agencies is complete. Excavation of piping/inlets/manholes, adjacent soil, and waste handling are conventional, straightforward construction techniques and methods. Multiple off-site disposal facilities are available to accept generated waste. Resources (e.g., equipment, material, trained personnel) to implement this alternative are readily available.

Excavation activities are coordinated with RVAAP and OHARNG to minimize alterations and/or impacts to OHARNG. The RD identifies access routes to the AOC for heavy equipment and steps to minimize potential hazards to on-site personnel. The development of the RD and coordination with local, state, and federal permitting organizations increases the implementation difficulty of Alternative 3.

13.3.3.7 Cost

The present value cost to complete Alternative 3 is approximately \$411,954 (in base year 2011 dollars with a 4.125% discount factor). This alternative does not include an O&M period subsequent to the sediment removal, as unrestricted land use is achieved. See Appendix H for a detailed description of Alternative 3 costs.

13.4 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES USING NCP CRITERIA

This section includes a comparative analysis of the alternatives conducted to identify relative advantages and disadvantages of each, based on the detailed analysis above. The comparative analysis provides a means by which remedial alternatives can be directly compared to one another with respect to common criteria. Overall protection and compliance with ARARs are threshold criteria that must be met by any alternative to be eligible for selection. The other criteria, consisting of short- and long-term effectiveness; reduction of contaminant toxicity, mobility, or volume through treatment; ease of implementation; and cost are the primary balancing criteria used to select a preferred remedy among alternatives that satisfy the threshold criteria. A summary of the comparative analysis is provided in Table 13-1.

The following remedial alternatives were retained and analyzed in detail:

- Alternative 1: No Action.

1
2 • Alternative 2: Attain Unrestricted Residential Land Use ~ In-situ Treatment Using
3 Solidification/Stabilization

4
5 • Alternative 3: Attain Unrestricted Residential Land Use ~ Excavation with Off-site Disposal
6

7 The relative advantage and disadvantages of these alternatives are described below.
8

9 **13.4.1 Overall Protection of Human Health and the Environment**

10
11 Alternative 1 does not provide overall protection of human health because no provisions are
12 implemented to prevent direct contact to the chemicals requiring remediation in sewer sediment.
13 Manganese and lead were identified as human health COCs and will remain in sewer sediment.
14

15 Alternative 2 provides protection of human health by eliminating the exposure pathway (i.e., direct
16 contact) to receptors by treating the chemicals requiring remediation in sewer sediment using
17 solidification/stabilization. The mobility of the chemicals requiring remediation in sewer sediment is
18 reduced. The bioavailability of the lead is reduced. Alternative 2 achieves Unrestricted Residential
19 Land Use. Alternative 2 beneficially reduces exposure and risk to ecological receptors to chemicals
20 requiring remediation in sewer sediment. The physical risk during implementation and disruption of
21 terrestrial habitat is mainly confined to areas near the inlets/manholes.
22

23 Alternative 3 provides protection of human health through removal of contamination and does not
24 require additional protectiveness after contaminant removal, as the alternative achieves Unrestricted
25 Residential Land Use. Alternative 3 is beneficial to ecological receptors, as it reduces exposure to
26 chemicals requiring remediation, but the temporary disruption of some terrestrial habitat is greater
27 than Alternative 2 because of the slightly larger area of excavation (i.e., pipe segments between
28 manholes) and the additional staging areas required under Alternative 3.
29

30 **13.4.2 Compliance with ARARs**

31
32 All alternatives are considered to be in compliance with ARARs. There are no chemical-specific or
33 location-specific ARARs for any of the alternatives. Action-specific alternatives are applicable to
34 Alternatives 2 and 3.
35

36 **13.4.3 Long-Term Effectiveness and Permanence**

37
38 Alternative 1 is rated low in terms of long-term effectiveness in preventing exposures or the spread of
39 existing contamination. Alternative 1 does not involve any remedial action or LUCs for potential
40 future exposure.
41

42 The long-term effectiveness and permanence of Alternative 2 is considered medium. This alternative
43 achieves Unrestricted Residential Land Use. The exposure pathway for the receptors is eliminated

and is expected to be a permanent solution and remedy, including as a long-term solution for reducing mobility of chemicals and bioavailability of lead. Relative to Alternative 3, this alternative is considered to potentially have lower long-term effectiveness since contamination will be left in place, even though exposure and mobility will be reduced.

The long-term effectiveness and permanence of Alternative 3 is considered high. This alternative is highly permanent and effective since it involves the removal of pipes/inlets/manholes containing chemicals requiring remediation to achieve Unrestricted Residential Land Use.

13.4.4 Reduction in Contaminant Volume, Toxicity, and Mobility through Treatment

The ability of Alternative 1 to reduce the volume, toxicity, and mobility of chemicals requiring remediation is low since this alternative does not involve treatment.

Alternative 2 is rated high because it reduces the toxicity of lead by reducing the bioavailability of the lead and reduces the mobility of the manganese and lead in sediment remaining in the pipes/inlets/manholes through treatment using solidification/stabilization.

The mobility of chemicals is reduced for Alternative 3 given the excavated sewer sediment is disposed of at an off-site facility equipped with engineering controls. Alternative 3 is rated medium.

13.4.5 Short-Term Effectiveness

There are no additional short-term risks posed to the community, remedial workers, or the environment with Alternative 1. Therefore the short-term effectiveness of this remedial alternative is rated high.

Alternative 2 presents short-term risks to workers, the community, and the environment during grouting of pipes/inlets/manholes, excavation of surface completions of inlets/manholes, and transportation of inlet/manhole construction debris/soil. Mitigation measures (e.g., dust control, storm water controls, housekeeping activities, covering and cleaning haul trucks) during excavation activities minimize and/or eliminate all potential risks. The RAO is achieved within 6 weeks of implementation. Excavation results in a temporary loss of vegetated habitat. Short-term environmental impacts are minimized through construction mitigation techniques. Alternative 2 is rated medium for short-term effectiveness.

Alternative 3 presents similar but slightly greater short-term risk to workers, the community, and the environment during excavation of the piping/inlets/manholes as Alternative 2 because of the slightly larger area of excavation (i.e., pipe segments between inlets/manholes), the additional staging areas for excavated overburden and waste, and confirmation (trench) and waste sampling. Alternative 3 beneficially reduces exposure and risk to ecological receptors to chemicals requiring remediation, but the physical risk and temporary disruption of some terrestrial habitat is greater than Alternative 2 (i.e., larger area of excavation and additional staging areas). Alternative 3 is rated low.

13.4.6 Implementability

All alternatives are considered implementable on a technical and availability-of-services basis; however, the implementability of the alternatives decreases relative to each other as the level of physical activity to implement the corrective action increases. Alternative 1, as a “No Action” alternative, is rated high. Alternative 2 requires RD sampling, solidification/stabilization (i.e., grouting) of pipes/inlets/manholes of concern, removal of surface completions of inlets and manholes, and restoration of the small area of the inlets and manholes. Alternative 2 is rated low because of the uncertainty associated with grouting some pipes and inlets in Load Lines 2 and 3. Alternative 3 is rated medium given that excavation and off-site disposal has been implemented at other AOCs at RVAAP, the relatively shallow depth (< 8 ft bgs), the relatively low quantity of material to be excavated, and the current land use surrounding the areas to be excavated.

13.4.7 Cost

Costs were estimated for comparison purposes only and are believed accurate within a range of -30% to +50%. The estimated present value cost (in base year 2011 dollars with a 4.125% discount factor) to complete each of the alternatives is as follows:

Alternative 1:	\$	0
Alternative 2:	\$	366,906
Alternative 3:	\$	411,954

Table 13-1. Summary of Comparative Analysis of Remedial Alternatives

NCP Evaluation Criteria	Alternative 1: No Action		Alternative 2: Attain Unrestricted Residential Land Use ~ In-situ Treatment Using Solidification/Stabilization		Alternative 3: Attain Unrestricted Residential Land Use ~ Excavation with Off-site Disposal	
	Ranking	Score	Ranking	Score	Ranking	Score
Threshold Criteria	Result		Result		Result	
1. Overall Protectiveness of Human Health and the Environment	Not protective		Protective		Protective	
2. Compliance with ARARs	Compliant		Compliant		Compliant	
Balancing Criteria	Ranking	Score	Ranking	Score	Ranking	Score
3. Long-Term Effectiveness and Permanence	Low	1	Medium	2	High	3
4. Reduction of Toxicity, Mobility, or Volume through Treatment	Low	1	High	3	Medium	2
5. Short-Term Effectiveness	High	3	Medium	2	Low	1
6. Implementability	High	3	Low	1	Medium	2
7. Cost	High	3	Low	1	Low	1
Balancing Criteria Score		11		9		9

“High” = highly favorable

“Medium” = moderately favorable “Low” = not favorable

Scoring for the Balancing Criteria is as follows: High = 3, Medium = 2, Low = 1

ARAR = Applicable or Relevant and Appropriate Requirements

NCP = National Contingency Plan

14.0 AGENCY COORDINATION AND PUBLIC INVOLVEMENT

The U.S. Army is the lead agency responsible for executing the CERCLA process and ultimately completing an approved ROD for the Facility-Wide Sewers. This section reviews actions that have been conducted and presents activities that are planned to ensure the regulatory agencies and members of the public have been provided with appropriate opportunities to stay informed of the progress of the Facility-Wide Sewers environmental investigation, restoration efforts, and final selection of a remedy.

As described in Section 13.0, two of the nine NCP evaluation criteria are known as “modifying criteria” – state acceptance and community acceptance. These criteria provide a framework for obtaining the necessary agency coordination and public involvement in the remedy selection process.

14.1 STATE ACCEPTANCE

State acceptance considers comments received from agencies of the State of Ohio on the proposed remedial alternatives. Ohio EPA is the lead regulatory agency for supporting remedy of sewer sediment at Facility-Wide Sewers. This RI/FS report has been prepared in consultation with the Ohio EPA.

Ohio EPA has provided input during the ongoing investigation and report development to ensure the remedy ultimately selected for Facility-Wide Sewers is protective of human health and the environment and fulfills the requirements of the DFFO (Ohio EPA 2004). Ohio EPA provided comments on this RI/FS Report and will provide comments on the subsequent PP and ROD. The U.S. Army will obtain Ohio EPA concurrence prior to the final selection of the remedy for sewer sediment at the Facility-Wide Sewers.

14.2 COMMUNITY ACCEPTANCE

Community acceptance considers comments provided by community members for each proposed remedial alternative. CERCLA 42 U.S.C. 9617(a) emphasizes early, constant, and responsive community relations. The U.S. Army has prepared a *Community Relations Plan* (USACE 2003b) to facilitate communication between RVAAP and the community surrounding Ravenna, Ohio during environmental investigations and potential remedial action. The plan was developed to ensure the public has convenient access to information regarding project progress. The community relations program interacts with the public through news releases, public meetings, public workshops, and Restoration Advisory Board (RAB) meetings with local officials, interest groups, and the general public.

CERCLA 42 U.S.C. 9617(a) requires an Administrative Record be established “at or near the facility at issue.” Relevant documents regarding RVAAP have been made available to the public for review and comment. The Administrative Record for this project is available at the following location:

1 **Ravenna Army Ammunition Plant**
2 Building 1037
3 8451 State Route 5
4 Ravenna, Ohio 44266-9297

5
6 Access to RVAAP is restricted, but can be obtained by contacting facility management at (330)
7 358-7311. In addition, an Information Repository of current information and final documents is
8 available to any interested reader at the following libraries:

9
10 **Reed Memorial Library**
11 167 East Main Street
12 Ravenna, Ohio 44266

13
14 **Newton Falls Public Library**
15 204 South Canal Street
16 Newton Falls, Ohio 44444-1694

17
18 Additionally, RVAAP has an online resource for restoration news and information. This website is
19 available at: www.rvaap.org.

20
21 Comments will be received from the community upon issuance of the FS and the PP. As required by
22 the CERCLA regulatory process and the RVAAP *Community Relations Plan*, the U.S. Army will
23 hold a public meeting and request public comments on the PP for Facility-Wide Sewers. These
24 comments will be considered prior to the final selection of a remedy. Responses to these comments
25 will be addressed in the responsiveness summary of the ROD.

15.0 CONCLUSIONS AND RECOMMENDED ALTERNATIVE

15.1 CONCLUSIONS

The primary purposes of this RI/FS report are to review of the history of Facility-Wide Sewers, summarize RI activities, evaluate results of the RI, develop the RAO and remedial alternatives, and present a recommended alternative to address contaminated media at the AOC.

The RAO for Facility-Wide Sewers is to prevent: (1) National Guard Trainee exposure to chemicals requiring remediation in sewer sediment above CUGs; (2) adverse ecological effects from previous AOC activities; and (3) negative groundwater impacts from contaminant migration from source media (e.g., sewer sediment). An assessment of data collected at Facility-Wide Sewers concluded that remediation was not necessary for outfall water, outfall sediment, and pipe bedding material for any receptor. However, the assessment identified chemicals in sewer sediment in specific pipe segments, inlets, and manholes as requiring remediation. Fate and transport modeling indicates remediation to protect groundwater is not warranted. Anticipated remedial activities to protect the human receptor will benefit ecological resources and reduce the potential for contaminant migration to groundwater.

The HHRA identified manganese as a C OC at the Transportation Storage Area FA and Depot Administration Area FA, and lead was identified as a potential localized source that can impact downstream receptors at the Load Line 2 FA and Load Line 3 FA. After the identification of chemicals requiring remediation and the establishment of CUGs, remedial technologies were screened and the following viable remedial alternatives developed:

- Alternative 1: No Action.
- Alternative 2: Attain Unrestricted Residential Land Use ~ In-situ Treatment Using Solidification/Stabilization
- Alternative 3: Attain Unrestricted Residential Land Use ~ Excavation with Off-site Disposal

These alternatives are applicable and are compared against one another to provide information of sufficient quality and quantity to justify the selection of a remedy. The following section provides the recommended alternative for sewer sediment requiring remediation at the Facility-Wide Sewers.

15.2 RECOMMENDED ALTERNATIVE

The recommended alternative for Facility-Wide Sewers is Alternative 3: Attain Unrestricted Residential Land Use ~ Excavation with Off-site Disposal. The comparative analysis of the three alternatives indicated Alternative 1 was not protective for human health and the environment; therefore, Alternative 1 was eliminated as a potential alternative. Alternatives 2 and 3 were protective of human health and the environment and are compliant with ARARs. These two alternatives also

1 scored the same with respect to the balancing criteria. Alternative 3 was chosen as the recommended
2 alternative due to the fact that implementability for Alternative 3 is greater than Alternative 2.

3
4 Alternative 3 involves the removal of segments of pipes, inlets, and manholes that contain
5 contaminated sewer sediment above the CUGs surrounding the following four discrete sample
6 locations: TSAsd-002(sn) at the Transportation Storage Area FA, DAAsd-006(sn) at the Depot
7 Administration Area FA, LL2sd-615(st) at the Load Line 2 FA, and LL3sd-272(st) the Load Line 3
8 FA. The discrete sample locations at the Depot Administration Area FA and the Transportation
9 Storage Area FA exceed the CUGs for manganese for the National Guard Trainee, which is also
10 protective of the Resident Farmer. The discrete sample locations at Load Line 2 and Load Line 3 do
11 not exceed the CUGs for lead for either the National Guard Trainee or Resident Farmer; however,
12 these elevated lead concentrations were upstream of impacted surface water locations. Therefore,
13 these locations were classified as localized source to be removed.

14
15 Alternative 3 assumes sewer sediment removal to achieve unrestricted land use; therefore, LUCs and
16 five-year reviews will not be required following the remedy. The cost for Alternative 3 is estimated
17 to be \$411,954.

18
19 The next step in the CERCLA process is to prepare a PP to solicit public input on the remedial
20 alternatives. The PP will present these alternatives with the preferred alternative for Facility-Wide
21 Sewers. Comments on the PP provided by state and federal agencies and the public will be presented
22 in the Responsive Summary Section of the Facility-Wide Sewers ROD. The ROD will provide a
23 brief summary of the history, characteristics, and risks associated with the Facility-Wide Sewers and
24 will document its selected remedy.

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