# U.S. Environmental Protection Agency

# EPA Region 3

**RESPONSE ACTION CONTRACT**
**Contract No. 68-S7-3002**

# FINAL
# REMEDIAL INVESTIGATION REPORT
## VOLUME 1 of 12

**SHARON STEEL – FARRELL WORKS**
**Superfund Site**
**Mercer County, Pennsylvania**

**JUNE 2005**

**BLACK & VEATCH Special Projects Corp.**

# FINAL
# REMEDIAL INVESTIGATION REPORT
## VOLUME 1 of 12

**Sharon Steel Farrell Works Site**
**Farrell, Mercer County, Pennsylvania**

**Work Assignment No. 036-RICO-03DX**
**Black & Veatch Project No. 047117.0109**

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# Acronyms and Abbreviations

| | |
|---|---|
| AM | Amphibians |
| AVMA | American Veterinary Medical Association |
| AVS | Acid volatile sulfides |
| BAF | Bioaccumulation factor |
| BCF | Bioconcentration factor |
| BERA | Baseline Ecological Risk Assessment |
| BF | Blast furnace |
| Bgs | Below ground surface |
| BOF | Basic oxygen furnace |
| BrB2 | Braceville gravelly loam |
| BTAG | Biological Technical Assistance Group |
| BTF | Biotransfer factors |
| CLP | Contract Laboratory Program |
| $CO_2$ | Carbon dioxide |
| COPC | Contaminants of potential concern |
| COPEC | Contaminants of potential ecological concern |
| CPWC | Consumers Pennsylvania Water Company |
| CR | Crayfish |
| $Cr^{+3}$ | Trivalent chromium |
| $Cr^{+6}$ | Hexavalent chromium |
| DO | Dissolved oxygen |
| DOT | Department of Transportation |
| E&E | Ecology and Environment |
| EF | Electric furnace |
| Eh | Redox potential |
| EPA | United States Environmental Protection Agency |
| ESI | Expanded Site Inspection |
| ESV | Ecological screening value |
| $Fe_2Cl$ | Ferrous chloride |
| GC | Gas chromatography |
| GIS | Geographic Information System |
| Ha | Halsey silt loam |
| HHRA | Human Health Risk Assessment |
| HRS | Hazard Ranking System |
| HWC | Hubbard Water Company |
| IDW | Investigation-derived waste |
| IMS | International Mill Service |
| IPp | Pottsville Group |
| $K_d$ | Soil-water partitioning coefficient |
| $K_H$ | Henry's Law Constant |
| $K_{oc}$ | Organic-carbon partitioning coefficient |
| $K_{ow}$ | Octanol-water partitioning coefficient |
| L/kg | Liters per kilogram |
| LF | Large fish |

## Acronyms and Abbreviations (continued)

| | |
|---|---|
| Mc | Cuyahoga Group |
| MCL | Maximum Contaminant Level |
| Ms | Shenango Formation |
| MW | Monitoring well |
| NPL | National Priorities List |
| Ohio EPA | Ohio State Environmental Protection Agency |
| ORP | Oxidation/reduction potential |
| Pa | Papakating silt loam |
| PADEP | Pennsylvania Department of Environmental Protection |
| PADER | Pennsylvania Department of Environmental Resources |
| PAH | Polycyclic aromatic hydrocarbons |
| PASDA | Pennsylvania Spatial Data Access |
| PCBs | Polychlorinated biphenyls |
| PGC | Pennsylvania Game Commission |
| PPE | Personal protective equipment |
| PVC | Polyvinyl chloride |
| PWS | Public water systems |
| RAC | Remedial Action Contract |
| RCRA | Resource Conservation and Recovery Act |
| Rf | Red Hook silt loam, flooded |
| RFA | RCRA Facility Assessment |
| RI/FS | Remedial Investigation and Feasibility Study |
| RP | Reptiles |
| SAP | Sampling and Analysis Plan |
| SB | Soil boring |
| SD | Sediment |
| SEM | Simultaneously extractable metals |
| SF | Small fish |
| SLERA | Screening Level Ecological Risk Assessment |
| SM | Small mammals |
| SW | Surface water |
| SWMU | Solid Waste Management Unit |
| SOW | Statement of Work |
| SSFW | Sharon Steel Farrell Works |
| SVOC | Semivolatile organic compound |
| SVWC | Shenango Valley Water Company |
| TAL | Target Analyte List |
| TCL | Target Compound List |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TEQ | Toxic Equivalent |
| TOC | Total organic carbon |
| µg/kg | Micrograms per kilogram |
| µg/L | Micrograms per liter |
| Ur | Urban Land |

## Acronyms and Abbreviations (continued)

| | |
|---|---|
| VOC | Volatile organic compound |
| Wa | Wayland silt loam, coarse variant |
| WHO | World Health Organization |

# 1.0 INTRODUCTION

## 1.1 Purpose of Report

The United States Environmental Protection Agency (EPA), using the Remedial Action Contract (RAC) Number 68-S7-3002, authorized Black & Veatch Special Projects Corp. (Black & Veatch) to complete the Remedial Investigation and Feasibility Study (RI/FS) at the Sharon Steel Farrell Works (SSFW) site located in Farrell, Mercer County, Pennsylvania. The RI/FS activities were conducted under Work Assignment Number 036-RICO-03DX in accordance with the Statement of Work (SOW) issued by the EPA to Black & Veatch dated October 4, 2001 (EPA, 2001).

The SSFW site (hereinafter referred to as "the site") was closed in 1992 and was listed on the final National Priorities List (NPL) in July 1998. The basis for the site listing was stressed vegetation, poor surface water quality, and evidence of the discharge of waste acids and oils into ground and surface water. Limited environmental sampling data was also used to support the NPL listing. Chemical analyses of the various waste sources had shown contaminants such as phenol and numerous metals, including arsenic, cadmium, chromium, lead, and nickel. Ground water near the acid-slag area contained elevated levels of metals. Soils adjacent to the acid-slag disposal area were contaminated with metals and polychlorinated biphenyls (PCBs). Aqueous and sediment samples from the wetlands adjacent to the slag piles and the tributary leading from the wetlands to the Shenango River also showed metals contamination.

The remedial investigation (RI) was broken into two phases by EPA to allow the thorough, focused, and efficient placement of field samples and for contractual reasons. Phase 1 included data acquisition and risk screening completed by CDM Federal in 2000 and involved extensive media sampling, screening of human health and ecological risk, identified areas of concern, and in some cases, determined the nature and extent of contamination. The results obtained from the Phase 1 data acquisition were used to focus the data acquisition activities in Phase 2. Phase 2 included additional data acquisition and evaluation of data required to prepare this RI report. Data acquisition activities were conducted by Black & Veatch from August 2002 through May 2003 and involved the collection of data of sufficient content, quality, and quantity to complete the RI.

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– May 2003 and involved the collection of data of sufficient content, quality and quantity to complete:

- Conceptual model – Develop and understanding of the relationships between the source areas of contamination, potential migration pathways for contaminant movement, and potential receptors that may be exposed to these contaminants.
- Off-site Characterization - Evaluate off-site impacts from the site in soil, sediment, surface water and ground water, as they relate to the nature and extent of contamination.
- Risk Assessment - Perform quantitative risk assessment for on-site ecological and human health receptors and for off-site impacts, if any.

To provide the data necessary to accomplish the objectives of the RI/FS, several data gaps were identified from the Phase 1 draft interim RI report prepared by CDM Federal. These data gaps are described in the *Work Plan for the Remedial Investigation/Feasibility Study at the Sharon Steel Farrell Works Site* (Black & Veatch, 2001). The following field activities were conducted during the Phase 2 RI to fill the data gaps and allow for the completion of the RI/FS for the SSFW site:

- Slag/Source Area Assessment – collection of surface and subsurface soil samples.
- Hydrogeological Assessment - installation of permanent monitoring wells in the unconfined surficial aquifer, confined surficial aquifer, and bedrock aquifer to document the horizontal and vertical extent of groundwater contamination; collection of groundwater; and surveying the locations and elevation of monitoring wells.
- Floodplain/Wetland Soil Assessment – collection of surface soil samples.
- Sediment and Surface Water Assessment – collection of sediment and surface water samples.
- Ecological Characterization and Biota Assessment – characterization of ecological habitats and collection of biota samples.

## 1.2 Site Background

The following subsections provide a site description, site history, and a discussion of the various investigations conducted at the SSFW site.

### 1.2.1 Site Description

The site consists of 400 acres of land in Mercer County Pennsylvania, located approximately 400 hundred feet east of the Pennsylvania/Ohio border. The general site location and vicinity is presented in Figure 1-1. The Sharon Steel Corporation-Farrell Works (Sharon Steel) Plant, which is located to the east and northeast of the site, used these 400 acres as a slag and pickle liquor disposal area. The site is characterized by widespread deposits of slag with related waste materials and little to no vegetation. The site layout is presented in Figure 1-2. Waste disposal activities ended in 1992 when operations at the Sharon Steel plant ceased.

There are two businesses (Dunbar Asphalt Company, Inc. and Farrell Slag, Inc. ) currently operating within the boundaries of the site. These businesses are not associated with Sharon Steel plant and do not contribute waste to the site. Dunbar Asphalt Company, Inc. is an asphalt production plant and Farrell Slag is a permitted mining operation. Farrell Slag mines and grades the slag deposits in the portion of the site south of Ohio Street. Dunbar Asphalt Company stockpiles the mined and graded slag material on a portion of the site north of Ohio Street and uses this material in their asphalt formulation. The site is surrounded by commercial/industrial areas and a rural residential area. The former Sharon Steel plant, commercial facilities in the City of Farrell, Pennsylvania and the Borough of Wheatland, Pennsylvania border the site to the east and northeast. These commercial and industrial properties are separated from the site by the Shenango River which runs along the eastern boundary. North and northwest of the site are commercial facilities in the City of Farrell and the City of Masury, Ohio. West and south of the site are rural and residential areas of Hubbard, Ohio and West Middlesex, Pennsylvania.

The site lies in the Shenango River Valley region of Pennsylvania. Slightly upstream of the site, are two major tributaries (Yankee Run and Little Yankee Run) of the Shenango River which flow into the Shenango River from the northwest. The site contains approximately 100 acres of wetlands, the majority of which are located in the southern portion of the site. The site (including the former Sharon Steel manufacturing area) is situated within the 100-year and/or 500-year flood plain of the Shenango River.

### 1.2.2 Site History

The SSFW Plant was founded in 1900 and began to manufacture a variety of steel products including hot and cold carbon steels, alloy sheets, strip and plate sheets, forging quality blooms and ingots, and hot-dipped galvanized steels. Throughout the operating history of the plant, waste and byproducts of the manufacturing process were transported on rail cars across the Shenango River (via bridge) and side cast down embankments or piled into large mounds in several areas on the subject site, which is located west of the facility, across the Shenango River.

From 1949 to 1981, waste liquids (acids and oils) were poured onto the hot slag wastes which were subsequently disposed at the site. This practice continued until 1981, when Sharon Steel was ordered by the Pennsylvania Department of Environmental Protection (PADEP) to cease the practice of disposing the waste liquids in this manner. Although the disposal of waste liquids ceased in 1981, Sharon Steel continued to stockpile slag at the subject site until operations at the plant ceased in 1992. PADEP conducted several inspections of the waste disposal areas in the 1970's and concluded that Sharon Steel was responsible for the depressed biological community along at least 11.5 miles of the Shenango River (CDM, 1987).

In 1987, a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA) was performed at the plant by CDM Federal Programs Corporation on behalf of the EPA. Sharon Steel Corporation also filed for bankruptcy during this time. As part of the RFA, the disposal and storage areas on the western side of the river (which now constitute the subject site) were designated as Solid Waste Management Units (SWMUs) and included the following (CDM, 1987):

- SWMU No. 1 – Acid Slag Disposal Area
- SWMU No. 2 – Basic Oxygen Furnace (BOF) Sludge Disposal Area
- SWMU No. 5 – White Slag Storage Yard
- SWMU No. 6 – BOF/Electric Furnace (EF) Slag Storage Yard, and
- SWMU No. 7 – By-Product Storage Yard

The following provides a description of waste disposal practices and identifies key waste materials found at each of the SWMUs:

- **SWMU No. 1 – Acid Slag Disposal Area.** Acid slag was generated at the Acid Slag Disposal Area when waste pickle liquor was released onto hot alkaline blast furnace (BF) slag where it would vaporize and/or neutralize. This procedure was the disposal method for waste pickle liquor. The waste pickle liquor was primarily composed of hydrochloric acid with approximately 20 percent iron as ferrous chloride ($FeCl_2$) in solution. BF slag is a common byproduct produced during the blast furnace operations or the process of making iron. It is produced from the use of limestone and dolomite as fluxing agents and is alkaline in nature. Because this product is less dense than the iron, it floats to the surface in a molten state and can be separated. The disposal of BF slag and waste pickle liquor was discontinued at the Acid Slag Disposal Area in December 1981.

- **SWMU No. 2 – BOF Sludge Disposal Area.** BOF sludge was produced from the steelmaking method of blowing high purity oxygen into a bath of molten steel. A great deal of dust and gas was produced from this process, referred to as the Basic Oxygen Process. The dust and gas were collected in a water-cooled hood and entrained in a water stream by a venturi-type washer. The entrained dust then settled out in a clarifier unit as a damp dark red to black sludge. This material was subsequently transported and disposed of in a pile at the site.

- **SWMU No. 5 – White Slag Storage Yard.** In December 1981, the disposal activities in the Acid Slag Disposal Area were discontinued, and the BF slag was transported and stored in the White Slag Storage Yard. The molten BF slag from the hot metal making processes was transported in slag pots via the railroad, fom the blast furnace across the Shenango River to the White Slag Storage Yard where it was dumped and left to cool and solidify.

- **SWMU No. 6 – BOF/EF Slag Storage Yard.** BOF/EF slag was formed during the steel and iron-making processes. International Mill Service (IMS) processed the BOF and EF slag material at an onsite facility. This processing facility reclaimed the metals from the slag and sold them back to Sharon Steel as scrap while a portion of the BOF slag was screened to 1-inch-by-4-inch size and also sold back to Sharon Steel as flux slag for blast furnace operations. The remaining slag that remained after these processing activities was transported to the BOF/EF storage area.

- **SWMU No. 7 – By-Product Storage Yard.** The By-Product Storage Yard was used by Dunbar Slag Company Inc. for the recycling of BF slag. Dunbar processed the slag by mechanically crushing, grading, and screening the materials and stockpiling them in the By-Product Storage Yard. The construction grade slag, which was considered a product, was then sold as aggregate to a third party or used by the Dunbar Slag Company in their asphalt operations.

### 1.2.3 CERCLA Regulatory History

The SSFW plant closed in 1992, at which time the waste disposal activities on the subject site ceased.

In August 1993, an Expanded Site Investigation (ESI) was conducted by Ecology & Environment (E&E). Based on the findings of the ESI, the site was recommended for Hazard Ranking System (HRS) scoring in 1995. The HRS package was completed in February of 1998 and the site scored high enough to warrant listing on the NPL.

The site was proposed to the NPL in March 1998 and formally added to the NPL list in July 1998. The basis for this listing was the presence of contaminants detected in ground water (arsenic, lead and chromium) and the potential risk to human health and ecological receptors presented by heavy metals, polycyclic aromatic hydrocarbons (PAHs), PCBs, and the high pH in runoff water from the slag piles and disposal (source) areas, especially in several onsite wetland areas.

### 1.2.4 Phase I Remedial Investigation Activities

In 1999, under the RAC contract with EPA, CDM performed several activities on the site as part of the Phase 1 investigation which included: monitoring well installation, contour mapping of the shallow groundwater aquifer, groundwater sampling, surface water and sediment sampling, slag and sludge characterization, a screening-level air dispersion model, and preliminary human health and ecological risk assessments. Results of the Phase 1 RI identified a preliminary list of the contaminants of potential concern (COPC) to human and ecological health for specific media. A wide variety of EPA Contract Laboratory Program (CLP) Target Compound List (TCL) organics (including volatile organic compounds [VOC], semivolatile organic compounds [SVOC], pesticides, and PCBs) along with an array of Target Analyte List (TAL) inorganics were found to be widespread throughout the site in all media sampled during Phase 1.

### 1.2.5 Phase 2 Remedial Investigation Activities

In 2001, under the RAC contract with EPA, Black & Veatch continued Phase 2 of the remedial investigation. The source area SWMUs (identified in the RFA) were consolidated into three source areas, based on the similarity of contaminants, geographic proximity, origin of waste materials and physical characteristics, likely remedial alternatives, and assumed future usage of areas. These three source areas are presented in Figure 1-3:

- BOF Sludge Disposal Area (includes former SWMU No. 2),
- Northern Slag Pile Area (includes former SWMU Nos. 5 and 7), and
- Southern Slag Pile Area (includes former SWMU Nos. 1 and 6).

Black & Veatch conducted Phase 2 field sampling activities on the site on behalf of the EPA to complete data gaps from Phase 1 and define the extent of contamination and associated risks. Field investigations under Phase 2 were conducted between August 2002 and May 2003. The Phase 2 field sampling included: groundwater sampling, surface and subsurface soil sampling, residential well sampling, surface water and sediment sampling, biota sampling (fish, crayfish, amphibians, mammals, and reptiles), and sampling of slag/sludge disposal areas.

## 1.3 Report Organization

This RI report is organized as follows:

- Section 1.0 presents an introduction and a chronology of activities at the site;
- Section 2.0 presents the physical setting of the site and surrounding area;
- Section 3.0 describes each aspect of the investigation;
- Section 4.0 presents the evaluation of the nature and extent of contamination;
- Section 5.0 is a discussion of potential migration of contaminants;
- Section 6.0 presents findings of the human-health and ecological risk assessments;
- Section 7.0 presents the summary and conclusions of this investigation;
- Section 8.0 presents the report references.

This report includes three volumes and summarizes the RI phase of the RI/FS only. The FS report will be submitted under separate cover. All figures, tables, and appendices follow the body of the report.

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# 2.0 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

## 2.1 Introduction

This section presents a detailed discussion of the physical characteristics of the site-specific and regional study area including geology, hydrogeology, surface hydrology, site ecology, demography and land use.

## 2.2 Geology

The geologic section of this report includes a discussion of information collected from literature review, previous investigations performed on the site and at adjacent facilities, and from drilling activities performed as part of the Phase 2 field investigation conducted by Black & Veatch. The intent of this section is to provide and an overview of the regional geologic settings and a description of site geologic setting.

### 2.2.1 Regional Geology

The SSFW site is located along the western edge of Mercer County, Pennsylvania in the Glaciated Pittsburgh Plateau Section of the Appalachian Plateaus Province. The site is situated between the Ohio-Pennsylvania border and the Shenango River south of the City of Sharon.

The regional geology consists of Quaternary Period sediments underlain by Pennsylvania and Mississippian aged bedrock. The Quaternary Period is divided into the Pleistocene Epoch, which is known for northern and southern-hemisphere continental glaciations, and the Holocene Epoch, which is the current interglacial period of time that started about 10,000 years ago. The region encompassing the site underwent four major glaciations during the Pleistocene. From oldest to youngest, these glaciations were pre-Illinoian (two), Illinoian, and late Wisconsinan (Crowl and Sevon, 1999).

The surficial geology of Mercer County consists of Quaternary Period glacial deposits of the Wisconsinan glaciation. This glacial period occurred about 17,000 to 22,000 years ago as the Eire lobe of Laurentide ice flow moved southeastward terminating at the Kent Moraine. The deposits in the region are typically of the Woodfordian stage and consist of tills, outwash sand and gravel, and ice contact sand and gravel. Thicknesses of the glacial deposits in the area are variable, and are commonly 50 feet or more (Crowl and Sevon, 1999).

The regional geology of the SSFW was summarized in *Geology and Hydrology of the Neshannock Quadrangle, Mercer and Lawrence Counties, Pennsylvania* (Carswell and Bennett, 1963) as follows:

> *"The Shenango River Valley consists of Quaternary Age glacial and alluvial deposits. Upland areas and central parts of the Shenango Valley consist of glacial till (silts and clays), and the valley flanks and smaller valleys contain glacial outwash (sands and gravels). These unconsolidated glacial deposits range from approximately one foot to 200 feet in thickness and are underlain by Mississippian and Pennsylvanian Age bedrock units. The bedrock units consist primarily of alternating units of shale and sandstone, but also contain thin beds of limestone, coal and fireclay. Locally, the morphology of the bedrock surface is highly irregular as result of erosion and deposition associated with each individual ice advance. The prominent jointing direction trends to the northeast and northwest".*

The bedrock in the region dips to the south-southeast at approximately 15 feet per mile and is Pennsylvanian and Mississippian. The Pennsylvanian aged formations are generally cyclic sequences of sandstone, red and gray shale, conglomerate, clay, coal, and limestone, Table 2-1 presents the general geologic sequence details the rock type by formation. The Mississippian aged formations are typically red and gray shale, sandstone or limestone (Berg, 1980).

### 2.2.2 Soils

Based on a review of soil information obtained from the Soil Survey for Mercer County, Pennsylvania, there are six soil types present within the site boundaries including (USDA, 1917):

- Wayland silt loam, coarse variant (Wa)
- Urban Land (Ur)
- Papakating silt loam (Pa)
- Red Hook silt loam, flooded (Rf)
- Halsey silt loam (Ha)
- Braceville gravelly loam, 3 to 8 % slopes, moderately eroded (BrB2)

The Pennsylvania Natural Resource Conservation Service indicates that Wayland, Papakating, and Halsey soils are hydric soils capable of supporting wetlands. Urban and Red Hook soils may be hydric and capable of supporting wetlands in wet spots and depressions.

### 2.2.3 Site Geology

The section of the Shenango River Valley encompassing the site is composed of alluvial and glaciofluvial deposits with thicknesses of up to 200 feet (ESC, 1994). Based on boring logs completed for wells and soil borings, shallow deposits consist of waste deposits (i.e., slag and sludge) and poorly sorted silt, clay, and sand (ESC, 1994). Near the surface, in the top 10 to 30 feet of the natural subsurface profile, silty sand is dominant. Below this shallow deposit is a unit of silt and clayey silt, which appears to average approximately 40 feet in thickness. Sand and gravel are commonly below the silt and clayey silt and extend to bedrock. Most of the sediments deposited above the bedrock may be classified as till with occasional thick lenses and beds of clay and, in places, has a discontinuous high clay content silt or sand. The upper strata of bedrock have been observed to be sandstone, siltstone, and shale. Three geologic cross sections of the site are presented in Figures 2-1 and 2-2. The most significant feature of the bedrock is best recognized in cross-sectional view (cross-section B-B' of Figure 2-2) and appears to be consistent with a low angle fault. The feature, when projected to the surface, strikes to the northeast and dips to the southeast. This alignment is inconsistent with the regional folding, .which has axes trending to the northwest. The feature is oriented along a line near the well cluster of MW-02, MW-04, and RW-6 to the well cluster of MW-01 and AMW-1 (refer to Figure 2-1). The feature alignment and shape was further determined by observation of stratigraphic elevation correlations as determined by boring and well logs on-site. The feature is likely to have minimal effect on the surface water flow; however, it may be related to the observed groundwater mound on-site.

The more shallow units are not uniform across the site and either pinch out or may not be present in the rock column in many boring locations. The bedrock is the only rock that is universally present; however, as mentioned above, the depth to the first identified rock has been observed to vary.

The unconsolidated deposits at the site are 65 to 120 feet thick and underlain by the Mississippian-aged Cuyahoga Group, which consists of medium-gray siltstone and dark-gray shale containing interbedded light-gray flaggy sandstone. The group includes the following, in descending order: Meadville Shale, Sharpsville Sandstone, and Orangeville Shale. Marine fossils are common in this group (Berg, 1980).

## 2.3 Hydrogeology

Four hydrostratigraphic units have been identified at the site as detailed in Table 2-2. The units are based on the regional site geology as presented in Table 2-1. The water table is three to five feet below ground surface (bgs) (ESC, 1994) at normal grade; however, depth to the water table is variable under the waste piles. In addition, information from the Phase 2 field investigation suggests that there may be perched water tables within a portion of the Southern Slag Disposal area. All of the on-site monitoring wells, except four, are installed to monitor groundwater in the shallow unconfined aquifer. Four on-site wells are installed to monitor the groundwater that occurs in the deeper confined aquifer immediately above the bedrock. The four deep wells are nested with four of the shallow wells to create four well pairs. Groundwater flow in the shallow and deeper glacial till aquifers is to the east-southeast. However, since the four deep wells do not monitor zones of similar elevation, the horizontal gradient could not be determined. Vertical gradients at three of the four nested well locations indicate an upward flow gradient, which is expected based on the site's proximity to the Shenango River, a regional discharge zone.

Published information suggests that fluctuations in the pool elevation of the Shenango River can alter the groundwater flow direction proximal to the river (ESC, 1994). Specifically, during times of high river stage and flooding, groundwater flow is from the river toward the site. During normal conditions, groundwater flow in the upper, unconfined aquifer is toward the river.

### 2.3.1 Regional Hydrogeology

Groundwater recharge generally occurs in the upland areas that encompass the majority of the region. Within this region, the zone of saturation can be divided into two separate units: the upper freshwater unit and the lower connate brine unit of the deeper aquifer. The two predominant aquifers in the shallow fresh water zone are within the Pottsville Group, tapping the Homewood Sandstones and Shales and the Connoquenessing Formation Sandstone. In some areas, these formations are used for domestic and municipal water supply. Groundwater flow throughout the freshwater zone is generally controlled by topography, local and regional recharge zones, and the hydraulic properties of the individual stratigraphic layers. Shallow groundwater within the freshwater zone moves laterally to small upland streams and potentially downward to deeper sandstone units before flowing laterally and discharging to the Shenango River and other major streams. Wells at the site, or in the general vicinity of the site, are screened within the shallow, glacial till, gravel zone, and bedrock aquifers.

The following subsections present a general description of the rock in the region of the site as detailed in Engineering Characteristics of the Rocks of Pennsylvania (Geyer and Wilshusen, 1982).

***2.3.1.1 Pottsville Group (Pennsylvanian).*** This group is characterized by light- to dark-gray, fine-grained to coarsely conglomeratic sandstone with subordinate amounts of gray shale, siltstone, limestone, coal, and underclay. This group includes Olean and Sharon conglomerates of northwestern Pennsylvania. Minable coals and commercially valuable high-alumina clay are present locally. The Pottsville Group includes those rocks in western Pennsylvania that are correlative with the Pottsville rocks of the Anthracite region in eastern Pennsylvania.

Joints are moderately well formed; distribution is moderate to high, spacing is wide to moderate in sandstone and close in shale. The sandstone has high to moderate effective porosity; low effective porosities are common in the other rock types and the permeability is low to moderate. The median yield is 50 gallons per minute; sandstone and limestone provide the highest yields, which may exceed 300 gallons per minute (Geyer and Wilshusen, 1982). High concentrations of iron are common in groundwater.

***2.3.1.2 Shenango Formation (Mississippian).*** The upper part of this formation is soft and is characterized by medium- to dark-gray shale, medium-light-gray siltstone, and limy siltstone. The lower part of the formation is fine-grained sandstone (with light-gray to yellowish-gray shale and siltstone), fossiliferous, cross-bedded, and contains some interbedded dark- to medium-gray shale and siltstone.

Joints are well formed in the sandstone and poorly formed in the shale; widely spaced, blocky pattern in sandstone; open and vertical. The joints produce a secondary porosity with a range of magnitude depending on the number and spacing of fractures and rock type. The shale yields little or no water and has a median yield of less than 5 gallons per minute. The sandstone of lower part of formation is a good aquifer, having an estimated optimum yield of 68 gallons per minute (Geyer and Wilshusen, 1982). High iron concentrations exist locally at shallow depths.

***2.3.1.3 Cuyahoga Group (Mississippian).*** Based on the geologic map for the Sharon West Quadrangle (Map 61 – Atlas of Preliminary Geologic Quadrangle Maps of Pennsylvania 1981 PA Geological Survey, Compiled by T.M. Berg, 1976), the bedrock below the site consists of the Cuyahoga Group. There are approximately twenty residential wells producing water near the site, at least eight of which penetrate the Cuyahoga. There is currently not enough detail to determine whether the other wells penetrate the bedrock or if they penetrate other water producing zones. Based on the boring and well logs, the depth from the surface to the top of bedrock on-site ranges from 17 to 123 feet. This group is characterized by medium-gray siltstone and dark-gray shale containing interbedded light-gray sandstone. Marine fossils are common. The Cuyahoga Group includes the following subgroups:

- **Meadville Shale** - This group is characterized by medium- to dark-gray shale, siltstone, lenses of fine-grained sandstone, and local beds of limestone. The Meadville Shale aquifers have estimated optimum yields of 75 gallons per minute (Geyer and Wilshusen, 1982).
- **Sharpsville Sandstone** - This group is characterized by very fine grained, light-gray sandstone and medium- to dark-gray shale and siltstone. Joints are well developed in sandstone, in places abundant, regular, closely spaced, open, and steeply dipping; joints in shale and siltstone are fewer, widely spaced, open and steeply dipping. The jointing provides a low magnitude secondary porosity and the porosity is generally low. Where the Sharpsville Sandstone contains thick beds of fine-grained sandstone and siltstone, it can have a maximum median yield of 50 gallons per minute and an estimated optimum yield of 115 gallons per minute (Geyer and Wilshusen, 1982).
- **Orangeville Shale** - This group is characterized by dark-gray shale, locally containing some siltstone. Orangeville Shale aquifers are poor, having estimated optimum yields of 15 gallons per minute (Geyer and Wilshusen, 1982).

### 2.3.2 Site Hydrogeology

Based on previous investigations as well as the current investigation, the sequence of soils and rock are consistent with the general geologic sequence presented in Table 2-1. The most significant variation in subsurface conditions may be the variable depths of the top of bedrock which ranges from approximately 60 feet to 120 feet below the ground surface. Prior to the Phase 2 investigation, wells had not penetrated bedrock and it had been speculated that the top of bedrock at the site dips to the north as well as to the southeast. The addition of the Phase 2 monitoring wells confirmed that a low angle fault or syncline is present with the fold axis trending (fault striking) northeast-southwest running through the site. If this feature is a fault, the fault zone may either act as a barrier to groundwater or as a groundwater conduit. Due to a lack of data, additional investigation would be required to determine if the fault is a barrier or a conduit.

The depth to groundwater in the upper, unconfined aquifer ranges from 3-5 ft bgs and generally flows to the east-southeast (see Figure 2-3). A non-uniform silt and clay semi-confining layer is prevalent across the site. In some areas it is extensive enough to prevent the downward flow of groundwater. The semi-confining layer is composed mostly of glacial deposits and other sediment. This layer of glacial sediments confines a non-continuous gravel layer below. The gravel layer has not been studied in detail; however, at MW15A (a background well) there was sufficient head to create artesian conditions. In general, the groundwater in the confined gravel bed flows to the northeast. Below the gravel layer is the bedrock aquifer layer. The ground water in this aquifer flows to the east.

Groundwater contour maps are presented in Figure 2-3 for the surficial aquifer, Figure 2-4 for the gravel aquifer, and Figure 2-5 for the bedrock aquifer.

The Phase 2 field investigation identified a perched water table in a portion of the Southern Slag Disposal Area that had a flow direction independent of the natural shallow aquifer (Figure 2-3 and refer to well logs in Appendix C). Flow in this perched aquifer appears to be from the source area directly south into the wetland ponds.

## 2.4 Surface Hydrology

This section presents observations obtained during this RI and information reported in previous investigations to describe the surface water features at the SSFW site.

The SSFW site is located within the glaciated section of the Appalachian Plateaus Physiographic Province which consists of hilly uplands and broad deep valleys cut by the Shenango River. The site is located on the western floodplain of the Shenango River between the Shenango River and the Ohio/Pennsylvania state boundary. The Shenango River originates in far northwestern Pennsylvania and is the largest surface water body in the vicinity of the site. It flows in a general south-southeast direction and joins with the Mahoning River to form the Beaver River approximately 20 miles south of the site. Beaver River continues to flow south for an additional 26 miles before it runs into the Ohio River, approximately 28 miles northwest of Pittsburgh, Pennsylvania. The Shenango River is dammed to form a reservoir (Shenango Reservoir) approximately 7 miles upstream of the site, and flows over a spillway adjacent to the BOF Sludge Disposal Area. Upstream from this spillway, the river forms a broad pool, more than 120 feet across. Downstream from the spillway, the river becomes highly channelized with banks that are up to 3 feet in height. The river width is approximately 100 feet and the water depth is over 3 feet in these areas. It is likely that groundwater from the source areas at the site is released to the surface at exposed contacts of the source areas/ground surface.

A topographic map depicting the surface hydrology and drainage areas is presented in Figure 2-3. Drainage from the site into adjacent surface waters occurs in three main drainage sub-basins. A topographic ridge with elevation ranging between 890 and 945 feet runs north-south in the western section of the site. All drainage from the BOF Sludge Area and the Northern Slag Disposal Area (west of this ridge) flows overland into the Shenango River or collects in topographic depressions within the source area. Drainage from the northern portion of the Southern Slag Disposal Area flows overland in a northward direction into the wetland area bisected by Ohio Street or collects in topographic depressions within the source area. There is no surface direct connection between this wetland area and nearby surface water features – any hydraulic connection to nearby surface waters would be through groundwater. Drainage from the southern portion of the Southern Slag Disposal Area flows overland in a southward direction into the emergent wetland/pond complex or into the unnamed tributary. Both the emergent wetland/pond complex and the unnamed tributary both ultimately flow into the Shenango River.

## 2.5 Site Ecology

Nine general ecological habitats were identified on the SSFW site including:

- Slag piles/industrialized land,
- Forested riverine floodplain (Shenango River and unnamed tributary area floodplain),
- Oak-hickory upland forest,
- Shrub-scrub uplands,
- Shrub-scrub floodplain (southeast area floodplain),
- Palustrine wetlands (open ponds, palustrine shrub/scrub wetland,
- Palustrine emergent wetlands),
- Riverine habitat (Shenango River and the unnamed tributary streams), and
- Open water (slag ponds).

The location of these site habitats are presented in Figure 2-6. Detailed descriptions of these habitats and site ecology are available in the Final Baseline Ecological Risk Assessment (BERA) which was submitted to EPA in June 2005 (Black & Veatch, 2005). Photographs of the ecological habitats at the site are presented in Appendix A.

## 2.6 Demography and Land Use

The site is located on the edge of a highly industrialized area. The site is surrounded by commercial/industrial areas to the north and east and rural residential areas to the west and south. The former Sharon Steel property and commercial areas of the City of Farrell, Pennsylvania and the Borough of Wheatland, Pennsylvania border the site to the east and northeast. These commercial and industrial areas are separated from the site by the Shenango River along the eastern border of the site. Nearby population centers include:

- The city of Farrell, PA (population: 14,000), approximately 1 mile east.
- The city of Sharon, PA (population: 17,500), approximately 3 miles north.
- The city of Masury, OH (population: 3,000), approximately 2 miles northwest.

West and south of the site are rural and residential areas associated with Hubbard, OH and West Middlesex, PA, respectively.

Approximately 40 homes are within 1 mile of the site. Most of these residences receive their drinking water from domestic groundwater wells screened in the confined or bedrock aquifers. These residences are all located upgradient of the site (with respect to topography and groundwater flow) and are primarily located along State Line Road, Chestnut Ridge Road (in Ohio), and Wansack Road (in Pennsylvania) (see Figure 3-6).

The majority of the residences in Mercer County receive their drinking water from treated surface water obtained from the Shenango River system by Aqua America (formerly the Shenango Valley Water Company [SVWC]). Aqua America provides water for these residents from two surface water intakes along the Shenango River. The first is located approximately 3.5 miles upstream of the site and the other is located approximately 18 miles downstream. The water (from the Shenango River) is treated by Aqua America at a processing plant near the Shenango Reservoir.

Along with the Aqua America supply and the domestic wells, the Hubbard Water Company (HWC), also provides potable water for residents outside the Aqua America service area. Until the 1990's the HWC obtained water from a series of wells near the city. The nearest HWC supply well is located 3.1 miles southwest of the site. In late 1994, the HWC discontinued the use of these wells for potable water and began wholesale purchasing of water from the Aqua America. The HWC has a 20-year contract to purchase potable water from the Aqua America. At the present time, the HWC purchases nearly 1,300,000 gallons of water per day.

# 3.0 STUDY AREA INVESTIGATION

The Phase 1 and 2 field activities to support the RI were conducted between August 2000 and May 2003. These investigations included waste area delineation, slag/source area assessment, hydrogeological assessment, floodplain/wetland soil assessment, sediment/surface water assessment, ecological characterization and biota assessment, and off-site assessment.

## 3.1 Waste Area Delineation

The waste areas at the site were delineated by reviewing historical aerial photography for the area and the soil/source area sampling conducted under Phases 1 and 2.

### 3.1.1 Base Mapping Activities

A comprehensive base map of the SSFW study area was developed to facilitate proper mapping of major site features, specifically off-site features for correlation with on-site features. The base map was developed using aerial photography, with a scale of 1 inch equals 457 feet and a contour interval of 5 feet. All pertinent features were mapped, including roads, waterways, wooded areas, major buildings, and utilities. Aerial photographs were obtained in early 2002. Aerial photography and Geographic Information System (GIS) feature data (i.e. floodplains, wetlands, soils, roads) were acquired from the Pennsylvania Spatial Data Access (PASDA) website (http//:www.pasda.psu.edu). The result of the base mapping activities was a geo-referenced base map and a project GIS for the SSFW site which serves as the source for all data evaluation and the figures supporting this report unless otherwise noted.

### 3.1.2 Waste Area/Source Delineation

During the RI planning process, waste area delineation was conducted to focus of the RI field sampling events. The waste area delineation included the determination of the horizontal and vertical extents of contamination based on existing maps and previous investigations. In conjunction with the base mapping, the waste area delineation allowed the field activities to focus on those areas likely to be relevant for defining the nature and extent of off-site contamination and risks to human health and the environment.

The aerial photographic analysis conducted by EPA in 1988 and 1998 was used to confirm the horizontal extent of contamination/waste within the SSFW site area (EPA 1988; EPA, 1998). The physical boundaries of the slag/sludge material (and the source areas) were determined using these photographs. Surface and subsurface soil samples collected during the Phase 1 field investigation confirmed the boundaries of the source areas and provided a focus for the Phase 2 field investigation.

The vertical extent of contamination/waste was determined based on a review of topographic mapping and the waste disposal practices identified for the Sharon Steel plant. Since the wastes were disposed directly on the ground (and not in pits or trenches), the vertical extent of waste in the source areas is expected to be the natural ground surface prior to disposal activities.

***3.1.2.1. BOF Sludge Disposal Area.*** The BOF Sludge Disposal Area encompasses 16.1 acres in the northern portion of the site and includes former SWMU No. 2. This area received sludges produced from the steelmaking method of blowing high purity oxygen into a bath of molten steel. The dust and gas produced from this process were collected and allowed to settle as a damp dark red to black sludge which was dumped in this area. The sludge is distributed in one main pile of variable height, ranging from 20 to 40 feet above the adjacent floodplain. The BOF Sludge Disposal Area is bordered by the Shenango River to the east, a forested floodplain community to the south, and the Northern Slag Pile to the west. Photographs of the BOF Sludge Disposal Area are presented in Appendix A.

***3.1.2.2. Northern Slag Pile Area.*** The Northern Slag Pile Area includes the former White Slag Disposal Area (SWMU No. 5) and the By-Products Storage Yard (SWMU No. 7) in the northern portion of the site. Soil borings from previous investigations indicate that the contaminants in both areas are similar. This area received molten blast furnace slag materials which were transported from the blast furnace across the Shenango River, dumped, and left to cool and solidify. The Northern Slag Pile Area encompasses approximately 70 acres in the northern portion of the site. This area is bordered by the Shenango River to the east and bisected by Ohio Street. Photographs of the Northern Slag Pile Area are presented in Appendix A

***3.1.2.3. Southern Slag Pile Area.*** The Southern Slag Pile Area includes the former BOF/EF Slag Disposal Area (SWMU No.6) and the Acid Slag Disposal Area (SWMU No. 1) in the southern portion of the site (south of Ohio Street). This area was used to dispose of electric arc furnace slag, and basic oxygen furnace slag. The Southern Slag Pile Area encompasses approximately 112 acres in the southern portion of the site. This area is bordered by the Shenango River floodplain to the east, open fields and residential properties along State Line Road to the west, and a large emergent wetland complex to the south.

Currently, blast furnace slag disposed of in the Southern Slag Area is crushed, screened, and sold as aggregate by the Dunbar Slag Company, Inc. This disposal area is within the limits of a PADEP mining permit granted to Buckeye Leasing, Inc. (Buckeye). According to Buckeye representatives, the slag in the Southern Slag Pile Area will be mined during the next 20 to 25 years to a finished grade approximately 5 feet higher than the natural soils elevation (approximately 845 feet). Based on this information, a large portion of the slag in this disposal area will gradually be removed and the remaining lands will be left as a relatively flat slag material 5 feet higher than the original grade. Photographs of the Southern Slag Pile Area are presented in Appendix A.

## 3.2 Slag/Source Area Assessment

Environmental samples of slag/waste material (surface and subsurface soil) from source areas at the SSFW site were obtained from unknown locations in 1980 and 1985, as well as from known locations during both phases of the RI in 2000 and 2002. These samples were collected to aid in the determination of the nature and extent of contamination as well as to aid in the assessment of risks to human health and the environment. Data from surface soil samples was also used to support an air dispersion model used as part of the human health risk assessment.

In 2000, the Phase 1 field activities were conducted by CDM Federal Programs Corp. Phase 1 included the collection of the following samples in the three source areas:

- Surface soil/slag samples - analyzed for the full TCL/TAL analytical suite, grain size, and moisture content.
- Subsurface soil/slag samples - most were analyzed for the full TCL/TAL analytical suite, a smaller subset was analyzed for VOC (only), and four samples analyzed for dioxins/furans.

Black & Veatch selected the slag/source area sample locations for the Phase 2 field investigation in 2002 based on data gaps identified after the Phase 1 field investigation. The following samples were collected in the three source areas:

- Surface soil/slag samples - analyzed for the full TCL/TAL analytical suite, total organic carbon (TOC), and grain size. Two samples were analyzed for dioxin/furans and hexavalent chromium.

- Subsurface soil/slag samples - most were analyzed for the full TCL/TAL analytical suite, TOC, and grain size.
- Surface soil/slag samples for air particulate modeling; analyzed for grain size.
- Ten percent (10%) of all surface soil samples collected in the three slag/source areas were analyzed for dioxin/furans.

Soil samples were also collected during both phases from background/reference locations not likely to have been impacted by the site.

Surface soil (0 to 6-inches), shallow subsurface soils (from 2 to 4 feet bgs), and deep subsurface soils (deeper than 4 feet) were collected in the slag/source areas during Phases 1 and 2. Soil sampling during both phases was conducted using similar sample collection techniques. Surface soil samples were collected using a 4-inch diameter stainless steel soil auger that was turned into the ground by hand. For all soil samples, the VOC portion of the sample was collected first, and then the remaining portion of the sample was homogenized in a stainless steel bowl before filling the rest of the sample containers for the remaining analyses. All sample equipment was decontaminated prior to use at each sample location.

Soil borings were advanced using a hollow stem auger and subsurface soil samples were collected using a split spoon sampler. Phase 1 soil borings ranged in depth from six to 64 feet below grade, continuously sampled the entire length of the boring. During Phase 2, borings were advanced to depths ranging from six to 78 feet below grade and samples were collected at varying intervals and occasionally continuously sampled using a split spoon soil sampler. During each phase, a geologist logged each boring via the samples collected describing the observed soil characteristics. Soil boring logs are presented in Appendix B for all subsurface soil sample locations. Phase 2 subsurface samples chosen for chemical analysis were collected from the slag material within the upper ten feet of the soil boring, attempting to sample the portion of the soil column just above the virgin ground surface.

All surface soil sample identifiers in this RI had a suffix added to avoid confusion of samples. A "-1" suffix attached to the location name to indicate that the sample was collected during Phase 1 and a "-2" suffix to indicate the sample was collected during Phase 2. Subsurface soils were denoted in Phase 1 with a "-"and the corresponding depth interval (e.g. 8-10 indicates 8-to10-feet bgs. For Phase 2, subsurface soils were denoted with a letter extension attached to the location name (e.g. A, B, C, etc.) indicating the depth interval.

The following subsections provide a detailed description of the sampling activities conducted in each source area at the SSFW site and at the background/reference locations.

### 3.2.1 Background/Reference – Surface and Subsurface Soil

Surface soil samples were collected at seven locations in upland areas to represent background/reference locations not likely to have been affected by the site. Deep subsurface soils were collected from two upland locations (RW4-1 and RW6-1). RW4-1 was collected from 10 to 12 feet bgs and RW6-1 was collected from 28 to 30 feet bgs. Background/reference soil sample locations and are presented in Figure 3-1.

### 3.2.2 BOF Sludge Disposal Area

In support of the RI, 28 surface soil samples (including 2 duplicates) were collected from 26 locations in the BOF Sludge Disposal Area. Two shallow subsurface soil samples (no duplicates) were collected from two locations. Twenty-two deep subsurface soil samples (including 2 duplicates) were collected from 12 locations. All soil sample locations for the BOF Sludge Disposal Area are presented in Figure 3-2.

### 3.2.3 Northern Slag Pile Area

A total of 25 surface soil samples (including 1 duplicate) were collected from 24 locations in the Northern Slag Pile Area. No shallow subsurface soil samples were collected. Fourteen deep subsurface soil samples were collected from 9 locations. All soil sample locations for the Northern Slag Pile Area are presented in Figure 3-3.

### 3.2.4 Southern Slag Pile Area

A total of 40 surface soil samples (including 4 duplicates) were collected from 36 locations in the Southern Slag Pile Area. Sixteen shallow subsurface soil samples (including one duplicate) were collected from 15 locations. Seventy-five deep subsurface soil samples (including five duplicates) were collected from 20 locations. All soil sample locations for the Southern Slag Pile Area are presented in Figure 3-4.

## 3.3 Hydrogeological Assessment

The hydrogeological assessment included the installation of monitoring wells, slug testing, geophysical logging, and collection of groundwater samples at or in the vicinity of the site from wells in four groundwater zones (shallow groundwater; glacial till aquifer; gravel zone; and bedrock aquifer) and from residential wells. Groundwater samples were also collected from background/reference locations not likely to have been impacted by the site. This hydrogeological assessment was conducted to:

1. Determine the relationship between groundwater and surface waters,
2. To determine the horizontal and vertical extent of contaminant migration from the source areas, and
3. To determine if nearby residential users of groundwater could be exposed to site-related contamination.

### 3.3.1 Monitoring Well Installation and Development

Installation of monitoring wells (primarily on-site) was conducted from July through August 2000 as part of the Phase 1 investigation. Installation of monitoring wells (primarily off-site) was conducted from September 2002 through May 2003 as part of the Phase 2 investigation

Twenty-three four-inch monitoring wells (RW1 through RW23) were installed in the shallow groundwater aquifer to a depth of at least 20 feet below the natural ground surface during both phases.

Nineteen wells were installed during Phase 2 With the exception of six wells installed during Phase 2, all wells were constructed with 10 feet of two inch diameter, schedule 40 polyvinylchloride (PVC), 0.01-inch slotted screen installed at the deepest interval of the boring. The six other wells were constructed with varying screen lengths depending on the section of the water column of interest.

All wells were "stick-up" wells with the exception of RW-3 and MW-13, which were flush mounted wells. Varying amounts of sand, depending on the length of the screen interval, were used as a filter pack in the annular space from the base of the well screen to two feet above the screen. The filter pack was overlain by a two-foot thick bentonite seal. The annular space above the seal was filled with a grout of Portland cement, bentonite, and water. A concrete pad was placed at the ground surface of each well to protect the well and support the casing. Dedicated bladder pumps were also installed in each of the Phase 1 monitoring wells for sampling purposes; however, the pumps were not used during the Phase 2 groundwater sampling. Peristaltic pumps were used to collect groundwater samples from these well in Phase 2.

Three wells were not completed as designed; MW06 and MW09 were eliminated because of a lack of a confined aquifer in which the wells were to be screened and the bedrock monitoring well MW19 was abandoned due to artesian conditions. These three wells were replaced by three wells MW12A, MW15A, and MW18A which were screened the confined gravel aquifer.

All installed wells were properly developed to ensure that proper hydraulic flow was established between the aquifer and the well and that water turbidity was low enough that it would not affect the quality of samples collected from the wells. The eight existing wells (AMW-1S, -ID, -2S, -2D, -3S, -3D, -4S, and -4D) were re-developed prior to the Phase 1 sampling event. These wells were not re-developed during Phase 2. All wells were developed using a submersible pump and a Horriba® water quality meter which was used to measure temperature, dissolved oxygen (DO), conductivity, salinity, pH, and turbidity. Well development continued until three consecutive sets of water quality parameters were within 10%, at which point the well conditions were considered to have stabilized. A turbidity reading of 10 NTU or less was also required to determine that the well was properly developed. All monitoring well locations are presented in Figure 3-5. A summary of monitoring well information is presented in Table 3-1. Monitoring well installation logs are presented in Appendix C.

### 3.3.2 Slug Testing

During Phase 1, slug tests were performed on 26 shallow aquifer monitoring wells and four monitoring wells screened in the deeper, confined aquifer to determine the hydraulic conductivity of the units in which the wells were screened. Well RW-1 was not tested due to a lack of sufficient water volume to perform the slug test. Slug test calculations are presented in Appendix D.

The conductivities calculated for the shallow aquifer range from 0.00093 ft/min at RW-2 to 0.25 ft/min at RW-3 and the geometric average was calculated to be 0.039 ft/ min. The hydraulic conductivities in the deeper (semi-confined) aquifer ranged from 0.019 ft/min at AMW-3D to 0.068 ft/min at AMW-1D and the geometric average was calculated to be 0.036ft/min. The calculated geometric hydraulic conductivities for both aquifers are consistent with the range expected based on the boring logs.

Slug bars were constructed using 2-inch diameter PVC pipes, a sand filter, and two 2.5-inch caps. A pressure transducer with a data logger was used to record the changes in the water level over time. A rising head test and falling head test were performed on each well until the well recovered to within 10% of the lowest and peak displacement, respectively.

### 3.3.3 Geophysical Logging

Five of the deep wells (MW-01, MW-03, MW-04, MW-07, and MW-10) were geophysically logged by the U.S. Geological Survey (USGS) in April 2003 to determine in-situ physical properties of the fluids. Types of logs included the following (Appendix E):

- Caliper logs (identify fracture locations)
- Natural gamma (lithologic correlation)
- Resistivity (lithologic correlation)
- Fluid Temperature (help identify flow zones).

The geophysical logging of the wells confirmed the observations and logs from those wells during their drilling and construction. The information provided by the natural gamma logging, performed on all five wells showed the identification of lithology and for stratigraphic correlation. The resistivity logging performed on all wells except MW-01 showed a comparison of the resistivity of a formation or formations to depth. The additional data provided by the caliper logs showed the locations of potential fractures and other physical features of the well such as possible slumping of the borehole walls.

MW-01 was logged to 119 feet below ground surface (bgs) using borehole geophysical applications. The caliper log shows no fluctuation in the well walls, indicating that the casing may extend the entire length of the well and that there is no settling of sediments at the terminus of the well. The gamma log ranged from approximately 35 to 80 counts per second, typical of sands or sandstone. The higher counts were detected at depths beyond 100 feet.

MW-03D was logged to 113 feet bgs. Based on the caliper logs, there are 11 feet of fractures from 63 to 74 feet bgs. A few areas of potential well collapse or small factures exist between the 79 feet to 98 feet and at least one foot of sediment has settled at the terminus of the well. The gamma range below 50 feet bgs was from 40 to approximately 180 counts per second. The resistivity below 60 feet ranged from approximately 150 to 400 ohms, the range expected for a sand or sandstone. Based on the caliper, gamma, resistivity, and boring logs, the rock below 60 feet is interbedded sands with high clay content till until approximately 96 feet. From 96 feet until the terminus, the rock generally consists of sandy shale. The temperature log gradually increased from 5° to almost 8° Celsius.

MW-4 was logged to 150 feet bgs. The caliper log shows a large reflection at 108 to 110 feet. This may suggest a fracture and/or well collapse. The gamma log generally increased with depth and ranged from 40 to 160 counts per second,. The resistivity log ranged from 750 to nearly 1,500 ohms. Interbedded sandstone and siltstone are present below a thin bed of sandy gravel at 108 feet bgs. The log does not detail any hydrocarbon content but does mention that water production decreases at approximately 120 feet. Below 130 feet, the siltstone and sandstone are thinly interbedded in beds less than one foot thick. The temperature log had an erratic plot but became constant at 4° to 5° Celsius.

MW-07 was logged to 80 feet bgs. The caliper log shows no significant deflections indicating that there are no significant fractures and that the well walls did not slump. The gamma log ranged from 40 to approximately 180 counts per second. The resistivity log ranged from 120 to 200 ohms, typical of sands or sandstone. The fluctuations in the gamma and resistivity logs indicate interbedded shale and sandstone, which is consistent with the boring logs. The temperature log was irregular at shallow depths and became asymptotic to 9° Celsius with depth.

MW-10D has an estimated total depth of 76 feet bgs and is cased to 46 feet. Based on the caliper log for this well, collapse or fracturing is identified from approximately 46 to 48.5 feet bgs. From 54 feet bgs to the well terminus, the well is slightly narrower than the upper 46 feet by approximately 2 inches. At 46 feet to the terminus, the gamma count ranged from approximately 80 to 160 counts per second, a range that suggests clay. However the resistivity at the same depth was, 400 to 700 ohms, a range more typical of sandy units. The fluctuations in the graphs may suggest interbedded sand and clay layers (sandstone and *shale). The temperature curve showed that the groundwater was at approximately 10°* Celsius. No significant temperature fluctuations were detected.

### 3.3.4 Groundwater Sampling

Groundwater sampling activities were conducted in September 2000 for Phase 1 and between August 2002 and May 2003 for Phase 2. Each phase included the collection of groundwater samples from residential wells, newly installed wells, and existing wells. All monitoring wells were analyzed for the TAL/TCL suite of contaminants. Samples collected during Phase 2 were for analyzed for both total and dissolved TAL metals. A smaller subset of samples was also analyzed for hexavalent chromium. Residential wells were analyzed for the full TAL/TCL suite (and hexavalent chromium) during Phase 1; only TAL metals were analyzed during Phase 2.

During Phase 1, dedicated bladder pumps (installed during well development) were used to collect the groundwater samples using low-flow techniques. Water was purged through dedicated tubing at a rate of 300 to 500 milliliters per minute through a flow-through cell in which water quality parameters (DO, turbidity, conductivity, pH, and temperature) were collected until they stabilized (CDM, 1999).

A submersible pump was used during Phase 2 to collect groundwater samples using the same low-flow techniques and water parameter stabilization as in Phase 1 (Black & Veatch, 2002). All sample equipment was decontaminated prior to use at each sample location.

The groundwater samples were collected from four hydrogeologic zones: shallow groundwater aquifer, glacial till aquifer, gravel zone, and bedrock aquifer. Groundwater sampling locations are presented in Figure 3-5. Residential well locations are presented in Figure 3-6. The following subsections discuss the groundwater samples collected from background/reference locations, each aquifer, and nearby residential wells.

***3.3.4.1 Background/Reference Groundwater.*** Groundwater monitoring wells were installed at 20 locations to represent background/reference locations not likely to have been affected (upgradient) by the site. The following lists the background/reference monitoring wells referenced to each groundwater aquifer:

- Shallow aquifer - MW5, MW8, MW11, MW14, and MW17.
- Glacial till aquifer - RW-2, RW-4, RW-6, MW2, MW12, MW15, and MW18.
- Gravel zone - MW12A, MW15A, and MW18A.
- Bedrock aquifer - MW4, MW7, MW10, MW13, and MW16.

A total of 22 background/reference groundwater samples (including two duplicates) were collected at the site.

***3.3.4.2 Shallow Groundwater Aquifer.*** Eight groundwater samples were collected from shallow monitoring wells located in the Northern Slag Pile Area, the Southern Slag Pile Area, and areas downgradient of these sources in the southeast floodplain.

***3.3.4.3 Glacial Till Aquifer.*** Forty-three groundwater samples (including 4 duplicates) were collected from monitoring wells screened in the glacial till aquifer located in the Northern Slag Pile Area, the Southern Slag Pile Area, the BOF Sludge Disposal Area, and areas downgradient of these sources in the floodplains of the Shenango River, southeast floodplain, and unnamed tributary.

***3.3.4.4 Gravel Zone.*** Nine groundwater samples (including 1 duplicate) were collected during Phases 1 and 2 from monitoring wells screened in the gravel zone aquifer located in the Northern Slag Pile Area, the Southern Slag Pile Area, and areas downgradient of these sources in the southeast floodplain.

***3.3.4.5 Bedrock Aquifer.*** Two groundwater samples (no duplicates) were collected from monitoring wells screened in the bedrock aquifer located in the Northern Slag Pile Area and areas downgradient of these sources in the southeast floodplain.

***3.3.4.6 Residential Wells.*** Thirty-six residential well samples (including one duplicate) were collected during Phase 1 from residences within ¼ mile of the SSFW site. The Phase 1 results indicated that several residences contained arsenic and manganese at levels exceeding their respective maximum contaminant limits (MCL). Therefore, it was decided that these residential wells (and any other residents requesting well samples) would be re-sampled during Phase 2.

During Phase 1, if a residential well owner was available, a well survey was completed to gather information on the history of the use of the well. Residential well surveys are presented in Appendix C. All residential well samples were collected directly from the resident's indoor or outdoor tap, prior to any well water treatment systems. Each tap was run for several minutes to completely purge the well and water quality parameters (DO, turbidity, conductivity, pH, and temperature) were recorded in field logbooks.

## 3.4 Downgradient Soil Assessment

Downgradient soil sampling activities (samples from floodplain/wetland areas lower in elevation than the source areas) were conducted in September 2000 for Phase 1 and between August 2002 and October 2002 for Phase 2. Each phase included the collection of samples from areas adjacent to the source areas which are likely to contain contaminated soils as a result of flooding or surface runoff from the source areas. Downgradient soils were evaluated in four exposure areas at the site including the Shenango River floodplain, southeast floodplain, unnamed tributary floodplain, and the Ohio Street wetlands. Soil samples were also collected from background/reference locations not likely to have been impacted by the site. All downgradient soils were collected from three general depth intervals: surface (0- to 6-inches), shallow subsurface (2- to 4-feet), and deep subsurface (>4 feet).

Downgradient soil samples were collected by hand using a stainless steel spoon for surface soils and a stainless steel hand auger for shallow and deep subsurface samples. The sample was first collected for VOCs, and then the rest was thoroughly homogenized in a bowl and distributed to the appropriate containers for the remaining analyses. All sample equipment was decontaminated prior to use at each sample location. Background/reference area soil sampling locations are presented in Figure 3-1 and downgradient soil sampling locations are presented in Figure 3-7. Samples were analyzed for the full suite of TAL/TCL contaminants. In addition, a smaller subset of samples was analyzed for dioxin, hexavalent chromium, and TOC.

The following subsections discuss the downgradient soil samples collected from background/reference locations and each of the four exposure areas.

### 3.4.1 Floodplain Background/Reference Soils

Samples were collected at four floodplain surface soil locations (SF52, SF53, SS53, and SS54) and two shallow subsurface locations (SF52B and SF53B) to represent a point of comparison for downgradient soils. The purpose of these samples was to represent background/reference constituent concentrations for areas not likely to have been affected by the site. It should be noted that two of these samples (SS53 and SS54) may have been impacted by the presence of a hazardous waste site, the Westinghouse Electric - Sharon Plant (Westinghouse) site, approximately 2.5 miles upstream from the SSFW site on the Shenango River. Many of the contaminants detected in sediments at these background/reference locations (PCBs, PAHs, and metals) are also associated with the Westinghouse site. However, these contaminants are also associated with the SSFW site.

### 3.4.2 Shenango River Floodplain

Twenty surface soil samples (including one duplicate) were collected from 19 locations, five shallow subsurface samples (no duplicates), and four deep subsurface samples (no duplicates) were collected in the Shenango River floodplain.

### 3.4.3 Southeastern Floodplain

Twenty-five surface soil samples (including three duplicates) from 22 locations, 10 shallow subsurface samples (no duplicates), and three deep subsurface soil samples (no duplicates) were collected in the southeastern floodplain.

### 3.4.4 Unnamed Tributary Floodplain

Six soil samples (including one duplicate) were collected from five locations in the unnamed tributary floodplain.

### 3.4.5 Ohio Street Wetlands

Ten soil samples (including one duplicate) were collected from nine locations in the wetlands adjacent to Ohio Street. These locations include three locations originally labeled as sediment; however, since these "sediment" samples were collected in wet soils not inundated by water, they were considered to be surface soil for risk assessment exposure purposes.

## 3.5 Sediment Assessment

Sediment sampling activities were conducted in September 2000 for Phase 1 and between August 2002 and October 2002 for Phase 2. Sediments were collected from four exposure areas downgradient of sources at the site including: the emergent wetlands adjacent to the Southern Slag Pile Area, the wetland/pond complex adjacent to the Southern Slag Pile Area, the Shenango River, and the unnamed tributary south of the Southern Slag Pile Area. Sediment samples were also collected from background/reference locations not likely to have been impacted by the site.

A stainless-steel auger with a T-handle attachment was used to collect sediment samples during Phase 1. A Ponar dredge was used to collect sediment samples during Phase 2. For all samples, the VOC portion of the sample was collected first, and then the remaining portion of the sample was homogenized in a stainless steel bowl before filling the sample containers for the remaining analyses. Sediment samples were also collected in a downgradient to upgradient direction to avoid cross-contamination. All sample equipment was decontaminated prior to use at each sample location. Sediment sample locations are presented in Figure 3-8 for background/reference areas and Figure 3-9 for site habitats. Samples were analyzed for the full suite of TAL/TCL contaminants. In addition, a smaller subset of samples was analyzed for dioxin, hexavalent chromium, TOC, simultaneously extractable metals/acid volatile sulfides (SEM/AVS), and grain size.

The following subsections discuss the sediment samples collected from background/reference locations and each of the exposure areas.

### 3.5.1 Background/Reference Sediment

Sediment samples were collected at 14 locations to represent background/reference locations not likely to have been affected by the site. Six samples (SD11, SD21, SD22, SD54, SD64, and SD65) were collected in the Shenango River, upgradient of the SSFW site to represent background for the Shenango River. Seven samples (SD14, SD15, SD16, SD18, SD19, SD20, and SD27) plus one duplicate were collected from a reference site in an emergent wetland on State Game Lands #294 near Fredonia, Mercer County, Pennsylvania to represent a reference for the on-site wetlands. This reference wetland, which contains a complex of emergent wetlands and ponds similar to those on the SSFW site, was recommended by EPA's Biological & Technical Assistance Group (BTAG). One sample (SD13) plus a duplicate was collected from the unnamed tributary of the Shenango River to represent background for the unnamed tributary.

It should be noted that the Shenango River background/reference sediment samples collected during Phase 1 (SD54, SD64, and SD65) could have been impacted by the Westinghouse site; however, the Phase 2 samples were placed upgradient of the Westinghouse site to avoid this possibility. Many of the contaminants detected in sediments at these background/reference locations (PCBs, PAHs, and metals) are also associated with the Westinghouse site. However, these contaminants are also associated with the SSFW site.

### 3.5.2 Emergent Wetlands

Twenty-eight sediment samples (including one duplicate) were collected from 27 locations in the emergent wetlands.

### 3.5.3 Wetland Ponds

Forty-six sediment samples (including two duplicates) were collected from 44 locations in the wetland ponds.

### 3.5.4 Shenango River

Nineteen sediment samples (including one duplicate) were collected from 18 locations in the Shenango River (adjacent to the site and downstream).

### 3.5.5 Unnamed Tributary

Thirty-one sediment samples (including one duplicate) were collected from 30 locations in the unnamed tributary downgradient from the Southern Slag Pile Area.

## 3.6 Surface Water Assessment

Surface water sampling activities were conducted in September 2000 during Phase 1 and between August 2002 and October 2002 during Phase 2. Surface water sample locations were co-located with the sediment locations and were evaluated in the Shenango River, wetland ponds, and the unnamed tributary. Surface water samples were also collected from background/reference locations not likely to have been impacted by the site.

Surface water samples were collected during both phases by submerging each sample container just below the water surface. All surface water samples were collected prior to the sediment samples and in a downgradient to upgradient order to minimize disturbance. All sample equipment was decontaminated prior to use at each sample location. The following water quality parameters were collected at each surface water sample location: DO, turbidity, conductivity, pH, salinity, oxidation/reduction potential (ORP), and temperature. Surface water sample locations are presented in Figure 3-8 for background/reference areas and Figure 3-9 for site habitats. All surface water samples were analyzed for TCL/TAL contaminants (including total and dissolved metals). Samples collected during Phase 2 also included analysis for alkalinity and hardness.

The following subsections discuss the surface water samples collected from background/reference locations and each of the exposure areas.

### 3.6.1 Background/Reference Surface Water

Surface water samples were collected at 14 locations to represent background/reference locations not likely to have been affected by the site. Six samples (SW11, SW21, SW22, SW54, SW64, and SW65) were collected in the Shenango River, upstream from the SSFW site to represent background for the Shenango River. Seven samples (SW14, SW15, SW16, SW18, SW19, SW20, and SW27) plus one duplicate were collected from the reference wetland near Fredonia, Mercer County, Pennsylvania to represent background for the on-site wetland ponds. One sample (SW13) plus a duplicate was collected from the unnamed tributary of the Shenango River to represent background for the unnamed tributary.

It should be noted that the Shenango River background/reference surface water samples collected during Phase 1 (SW54, SW64, and SW65) could have been impacted by the Westinghouse site; however, the Phase 2 samples were placed upgradient of the Westinghouse site to avoid this possibility.

### 3.6.2 Wetland Ponds

Twenty-two surface water samples (including one duplicate) were collected from 21 locations in the wetland ponds.

### 3.6.3 Shenango River

Seventeen surface water samples (no duplicates) were collected from the Shenango River (adjacent to the site and downstream).

### 3.6.4 Unnamed Tributary

Twelve surface water samples (no duplicates) were collected from the unnamed tributary downgradient form the Southern Slag Pile Area.

## 3.7 Ecological Characterization and Biota Assessment

In Phase 2 of the RI, 58 samples of biota were collected to support the risk assessment activities. This effort included the collection of tissue samples from aquatic and terrestrial environments. Animals collected from aquatic habitats (the Shenango River, unnamed tributary, and the wetland ponds) included large fish, small fish, crayfish, and amphibians. Animal collected from the terrestrial habitats (Shenango River floodplain and the unnamed tributary floodplain) included mammals and reptiles.

Biota sample locations are presented in Figure 3-10 for background/reference areas and Figure 3-11 for site habitats.

The full TAL/TCL suite and lipid content was requested for all biota tissue analyses; however, in some areas it was not possible to collect a sufficient volume of tissue for all analyses. In these instances, the analyses were prioritized in the following orders: metals, SVOCs, PCBs, pesticides, and VOCs. A smaller subset of the large fish samples was also analyzed for dioxin/furan compounds. The following subsections provide a detailed discussion of the biota samples collected at the site.

### 3.7.1 Background/Reference Biota

Biota samples were collected at 16 locations to represent background/reference locations not likely to have been affected by the site. Large fish, small fish, and crayfish were collected at the Shenango River reference locations and crayfish were also collected at the wetland reference location. Reference samples of mammals and reptiles were not collected. The following lists the biota samples according to biota type:

- Large fish (bottom feeders): B02-LF-1-B, B02-LF-2-B, B02-LF-3-B, B32-LF-1-B, B32-LF-2-B, B32-LF-3-B, B33-LF-1-B, B33-LF-2-B, and B33-LF-3-B.
- Large fish (top feeders): B02-LF-1-T, B32-LF-1-T, and B33-LF-1T.
- Small fish: B32-SF, B33-SF, and B02-SF.
- Crayfish: B02-CR and SSFW-B35-CR.

### 3.7.2 Small Mammals

Small mammals were collected at seven stations using Sherman traps and pitfall traps baited with apples, peanut butter and oats. Three Sherman traps were set at each location in a triangular pattern approximately 75 feet apart from each other and away from the reptile traps discussed below. Traps were set in the evening, checked daily, and removed once the sample volume requirements were met. If trapping was unsuccessful, the traps were moved slightly to a new location to prevent animal avoidance. Target species for small mammals included short-tailed shrew, field mice and meadow voles. All small mammals were euthanized using carbon dioxide ($CO_2$) in accordance with procedures outlined by the American Veterinary Medical Association (AVMA) and the Black & Veatch Sampling and Analysis Plan (SAP) (JAVMA 2000; Black & Veatch 2002). For each station, the mammals were composited whole to form a single sample. A summary of the species and contributory weight comprising each sample is provided in Table 3-2. Samples of small mammals included six samples total collected from stations downgradient of source areas site in the southeastern Shenango River floodplain area and one sample was collected from the unnamed tributary floodplain.

### 3.7.3 Reptiles

Reptiles (specifically snakes) were collected at five stations by using plywood boards placed at sampling stations to lure snakes into hiding under the boards. Three plywood boards were set at each location in a triangular pattern approximately 75 feet apart from each other and away from small mammal traps. Each day, snakes were collected by hand or by using snake tongs until sample volume requirements were met. If trapping was unsuccessful, the boards were moved slightly to a new location to prevent animal avoidance. All snakes were euthanized in accordance with procedures outlined by the AVMA and the Black & Veatch SAP (JAVMA, 2000; Black & Veatch, 2002). For each station, the reptiles were composited whole to form a single sample. A breakdown of the species and contributory weight comprising each sample is provided in Table 3-2. Samples from reptiles included five samples total from stations downgradient of source areas in the southeastern Shenango River floodplain area.

### 3.7.4 Crayfish

Crayfish were collected at four stations using hand nets and modified minnow traps baited with cat food until sample volume requirements were met. All crayfish were euthanized in accordance with procedures outlined by the AVMA and the Black & Veatch SAP (JAVMA 2000; Black & Veatch, 2002). For each station, the crayfish were composited whole to form a single sample and composited whole to form a single sample. A breakdown of the species and contributory weight comprising each sample is provided in Table 3-2. Samples from crayfish included four samples total from stations downgradient of source areas in the Shenango River (2 samples), the large wetland pond (1 sample), and the unnamed tributary (1 sample).

### 3.7.5 Amphibians

Amphibians (frogs, toads, and tadpoles) were collected at six stations using hand nets and modified minnow traps at each station until sample volume requirements were met. All amphibians were euthanized in accordance with procedures outlined by the AVMA and the Black & Veatch SAP (JAVMA, 2000; Black & Veatch, 2002). For each station, the amphibians were composited whole to form a single sample. A breakdown of the species and contributory weight comprising each sample is provided in Table 3-2. Samples from amphibians included six samples total from stations downgradient of source areas in the emergent wetland (2 samples), the unnamed tributary (3 samples), and in the pond between the Southern Slag Pile Area and the unnamed tributary (1 sample).

### 3.7.6 Large Fish

Large angler-size fish (meeting PA recreational fishing size requirements) were collected at 13 stations using electroshocking, trot lining, gill netting, or angling techniques. Target species for large fish included angler species that would be consumed by people (for the human health risk assessment) and smaller fish that would be consumed by piscivores (for the ecological risk assessment). The Pennsylvania Game Commission (PGC) provided recommendations of target species for large and small fish for the Shenango River, including several predaceous top feeders (smallmouth bass, walleye, muskellunge) and bottom feeders (channel catfish and common carp) (Black & Veatch, 2002).

Fish were collected, placed on ice, and shipped to the laboratory for analysis in accordance with the Black & Veatch SAP (Black & Veatch, 2002). At the laboratory, the large fish from each sample were filleted and composited to form a single sample. A summary of the species and contributory weight comprising each sample is provided in Table 3-2. Samples from large fish included bottom-feeding fish species from 13 stations total downgradient of source areas in the Shenango River (6 samples), the large wetland pond (4 samples), the unnamed tributary (2 samples), and a small wetland pond (1 sample). Large top-feeding fish could not be obtained near the site.

### 3.7.7 Small Fish

Small fish were collected using electroshocking, netting, and trapping techniques. Target species for small fish included topminnows, darters, shiners, and juveniles of game species such as bass and bluegills that would be consumed by piscivores.

Fish were collected, placed on ice, and shipped to the laboratory for analysis in accordance with the Black & Veatch SAP (Black & Veatch, 2002). At the laboratory, the small fish from each sample were composited to form a single sample. A summary of the species and contributory weight comprising each sample is provided in Table 3-2. Samples of small fish included six samples total from stations downgradient of source areas in the Shenango River (2 samples), the large wetland pond (2 samples), the unnamed tributary (1 sample), and a small wetland pond (1 sample).

## 3.8 Ecotoxicity Assessment

The toxicity assessment was conducted during Phase 2 of the RI and included the collection of soil samples from areas downgradient of source areas in the southeast and unnamed tributary floodplains for toxicity and bioaccumulation tests. Toxicity testing was conducted using the 28-Day Toxicity and Bioaccumulation Test with Earthworms (*Eisenia foetida*) (ATSM, 2004). This test was conducted on six surface soil samples (and one duplicate sample) from the southeast floodplain area and a control sample provided by the analytical laboratory. Ecotoxicity sample locations are presented in Figure 3-12.

To assess biotransfer from soil to earthworms, the concentrations of pesticides, PCBs, and metals in whole-body earthworm tissue from the bioaccumulation tests were measured. The analytical results for earthworm tissue samples were compared to results for surface soils from locations that correspond to the earthworm bioaccumulation test samples (SF31, SF33, SF36, SF37, SF41, and SF43). These results were used to develop soil-to-earthworm biotransfer factors (BTFs) for use in the BERA (Black & Veatch 2004b).

## 3.9 Investigation Derived Wasted Characterization and Disposal

An investigation-derived waste (IDW) minimization approach was used to address the IDW generated during the study. The types of IDW that were generated at the SSFW site included the following:

- Drill cuttings,
- Well development and purge water,
- Personal protective equipment (PPE),
- Decontamination fluids, and
- Uncontaminated wastes.

The procedures and safeguards listed below for each types of IDW generated at the site served as the pollution control and mitigation plan for the site. The types of IDW that were produced during the field operations at the site and the procedures and safeguards for processing those wastes are described in the following subsections.

### 3.9.1 Drill Cuttings

These materials were generated during the advancement of boreholes such as drill cutting as and drilling fluids. The procedure for handling the drill cuttings included:

- Containerizing the cuttings separately from each borehole in Department of Transportation (DOT)-approved 55-gallon UN 1A-1 or 1A-2 drums,
- Labeling each drum, and

- Staging the drums at a designated onsite area,

Cuttings generated at offsite locations are assumed to be uncontaminated (they were located upgradient of the source areas) and were dispersed on the ground and leveled at the sampling location.

Drill cuttings (soil) from on-site borings were containerized in DOT-approved 55-gallon UN 1A-1 or 1A-2 drums, labeled to indicate contents, and staged at the predetermined accumulation area on site. In early Spring 2004, two representative samples of soil from these drums were collected and analyzed for TAL metals and Toxicity Characteristic Leaching Procedure (TCLP) for metals. Metals were not detected in soils above their respective detection limits for the TCLP analysis. The analytical validation package for these results is presented in Appendix I. The contents of these drums will be dispersed on the ground and leveled at the staging location.

### 3.9.2 Well Development and Purge Water

These fluids included the groundwater obtained from monitoring well pre-sampling development and purging activities.

During Phase I, well development/purge water was discharged to the ground surface pursuant to the approved site management plan (CDM, 2000) with the exception of development water from RW-3 which was found to contain free product and was containerized for off-site disposal.

During Phase 2, development/purge water from on-site wells was containerized in DOT-approved 55-gallon UN 1A-1 or 1A-2 drums, labeled to indicate contents, and staged at the predetermined accumulation area on site. In early Spring 2004, one representative sample of water from these drums was collected and analyzed for TAL metals. The analytical results for the water sample indicated that all metals are within the MCLs and background/reference levels. The analytical validation package for these results is presented in Appendix I. The contents of these drums will be dispersed on the ground at the staging location.

Fluids derived from offsite well locations are assumed to be uncontaminated (they were located upgradient of the source areas) and were dispersed on the ground at the drilling location.

### 3.9.3 Personal Protective Equipment

This category included the disposable work clothing such as booties, gloves, and coveralls, worn by field personnel during the RI field events. These items were placed in trash bags and disposed of in an onsite dumpster. The contents of the dumpster were disposed of by Waste Management of Midwestern Pennsylvania in accordance with State and Federal regulations and the SAP.

### 3.9.4 Decontamination Fluids

These fluids included wash waters used to decontaminate the sampling equipment and PPE if necessary. The wash waters were containerized in DOT-approved 55-gallon UN 1A-1 or 1A-2 drums, labeled to indicate contents, and were staged near the field office site trailer for off-site disposal.

### 3.9.5 Uncontaminated Wastes

Packaging, trash, flagging, etc., were placed in trash bags and disposed of in an onsite dumpster. The contents of the dumpster were disposed of by Waste Management of Midwestern Pennsylvania in accordance with State and Federal regulations and the SAP.

# 4.0 NATURE AND EXTENT OF CONTAMINATION

The SSFW RI field activities included the collection of samples from several site media to determine the nature and extent of contamination at the site. The following subsections provide a discussion of the analytical results for all sampled media including surface soil (slag/source areas), subsurface soil, groundwater, floodplain soil, sediment, surface water and biota. The analytical data validation packages are presented in Appendix I.

It should be noted that dioxin concentrations discussed in this RI are based on total 2,3,7,8-TCDD toxic equivalents (TEQs). For each sample where dioxins were analyzed, the TEQ was calculated using both USEPA and World Health Organization (WHO) methods and the highest estimated values was used in the RI. Individual dioxin/furan congeners were not considered to be present if not detected; therefore, undetected congeners do not affect the calculated TEQ. The TEQ calculations are presented in Appendix F.

Only non-qualified results were considered to be significant when evaluating nature and extent in the site exposure area; however, several J-, P-, E-, K- and L- qualified results were also mentioned where appropriate. J-qualified data indicate that there is a positive detection of a constituent; however, it was detected at concentrations below the respective detection limit. The result may not be accurate or precise and is considered an estimate. P-qualified data occur in (Phase 1) organic analyses and indicate that the detected concentrations are suspect due to a high percent difference (greater than 25%) in the results of the gas chromatography (GC) analysis. E-qualified data (Phase 1) are non-precise data in which the result is suspect. For example, if the analytical results for dissolved metals analysis are higher than the corresponding value for the total metals, then the results would be E qualified. K- and L-qualified data are positive detections but could be biased high (K) or low (L).

## 4.1 Background/Reference Areas

The following subsections discuss the constituents detected in background/reference areas (presumably uncontaminated) not likely to have been affected by the SSFW site. Upgradient upland soils were used to evaluate the concentrations of contaminants observed in the source areas. Floodplain background soils were used to evaluate the concentrations of contaminants observed in the floodplain areas (areas downgradient of the source areas).

### 4.1.1 Upland Surface Soil

VOCs and SVOCs were detected infrequently in a few samples, but at low levels near or below their respective detection limits. An exception was sample SS55-1 (collected during Phase 1) which contained 17,000 micrograms per kilogram (µg/kg) of benzaldehyde. PCBs were not detected in the upland background/reference surface soil.

PAHs were detected in all upland background/reference surface soil samples except RW4-1, which is located in the wooded area along Ohio Street. It is important to note that all detections of PAHs in upland background/reference soils were estimates (J-qualified) below the respective detection limits for each analyte. PAHs are common contaminants near densely populated areas and it is not uncommon to find low levels of PAHs in surface soil samples from industrial areas outside of cities (ATSDR, 1995).

Pesticides were detected in four upland background/reference surface soil samples. Two samples near the intersection of Stateline and Chestnut Ridge Roads (RW6-1 and SS55-1) showed sporadic hits of pesticides at concentrations below their respective detection limits. 4,4'-DDT was the only pesticide detected in samples SS22-1 (7.3 µg/kg) and SS23-1 (14 µg/kg), which were collected along Stateline Road.

Aluminum, barium, arsenic, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, potassium, vanadium, and zinc were detected in every surface soil sample from the upland background/reference areas at concentrations above their respective detection limits. Sample SS20-1 located in the wooded area west of the Northern Slag Pile Area contained a significantly higher concentration of calcium (80,100 mg/kg) when compared to concentrations of calcium (1,490J – 10,800 mg/kg) in other background samples. Metals are naturally-occurring constituents of soil and would be expected in background/reference soils.

### 4.1.2 Upland Shallow Subsurface Soil

Shallow subsurface soil samples were collected from the upstream areas on the Shenango River floodplain to represent background/reference areas not likely affected by the SSFW site as described in Section 3.2. These subsurface soil samples were collected to evaluate floodplain shallow subsurface soil; however, they were also used for comparison to source area subsurface soils. The analytical results for detected constituents in these samples are presented in Table 4-2. The following major constituent groups were detected:

- VOCs

- SVOC
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except antimony, beryllium, cobalt, mercury, potassium, silver, sodium, thallium, vanadium, and cyanide).

VOCs and SVOCs were detected sporadically in several background/reference shallow subsurface soil samples, but at low levels below their respective detection limits.

PAHs were detected in both background/reference shallow subsurface soil samples at concentrations above their respective detection limits. Location SF52-B contained significantly higher concentrations of PAHs (14,551µg/kg total PAHs) than nearby location SF53-B (4,642 µg/kg total PAHs).

Pesticides were either not detected or were detected at concentrations below their detection limit. The exceptions include endrin aldehyde (43 µg/kg in SF52-B), endrin ketone (12 µg/kg in SF52-B), 4,4'-DDT (76 µg/kg in SF52-B), and methoxychlor (27 µg/kg in SF52-B), which were detected at concentrations above their respective detection limits.

PCBs were not detected in the background/reference shallow subsurface soils with the exception of Aroclor 1260 which was detected at concentrations (1,300 µg/kg in SF52-B and (370 µg/kg in SF53-B) above the detection limit.

Metals and PAHs were the most frequently detected constituents in the background/reference shallow subsurface soils. Metals detected at concentrations above their respective detection limits include aluminum, barium, arsenic, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, selenium, and zinc.

### 4.1.3 Upland Deep Subsurface Soil

Deep subsurface soil samples were collected from upland areas to represent background/reference areas not likely affected by the SSFW site as described in Section 3.2. The analytical results for detected constituents in these samples are presented in Table 4-3. The following major constituent groups were detected:

- VOCs
- SVOC

- Metals (all TAL metals except aluminum, beryllium, cadmium, mercury, silver, sodium, thallium, and cyanide).

Pesticides, PAHs, and PCBs were not detected in the background/reference deep subsurface samples. VOCs and SVOCs were detected sporadically in several background/reference deep subsurface soil samples, but at low levels below their respective detection limits.

Metals were the most frequently detected constituents in the background/reference deep subsurface soils. Those that were detected at concentrations above their respective detection limits include aluminum, barium, arsenic, calcium, chromium, cobalt, copper, iron, lead, manganese, nickel, vanadium, and zinc. It should be noted that all metals concentrations were higher in sample RW4-1 (10-12 feet bgs) than in RW-6 (28-30 feet bgs), suggesting that the concentrations may decrease with increased depth in the background samples.

### 4.1.4 Floodplain Surface Soil

Surface soil samples were collected from upgradient floodplain areas to represent background/reference areas not likely affected by the SSFW site as described in Section 3.4. The analytical results for detected constituents in these samples are presented in Table 4-4. The following major constituent groups were detected:

- VOCs
- SVOC
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except antimony, silver, thallium, and cyanide).

VOCs and SVOCs were detected infrequently in a few samples, but at low levels near or below their respective detection limits. Exceptions included two samples that contained SVOCs at concentrations above their detection limits. Location SS53-2 contained 2-methylnapthalene at 2800 µg/kg and dibenzofuran at 690 µg/kg. Location SS54-1 contained 2-methylnapthalene at 420 µg/kg.

PAHs were detected in all upgradient floodplain surface soil samples; however, most were detected at estimated (J-qualified) concentrations below their respective detection limits. Exceptions included samples SF52-2, SF53-2, and SS54-1 which contained concentrations of some PAHs above their respective detection limits. Total PAHs ranged from 1,727 µg/kg in SF53-2 to 10,985 µg/kg in SF52-2.

Pesticides were detected in all upgradient floodplain surface soil samples; however, most were detected at estimated (J-qualified) or non-precise (P-qualified) concentrations below or near their respective detection limits. Exceptions included methoxychlor (65 µg/kg in SF52-2) and 4,4'-DDT (11 µg/kg in SF53-2 and 4.7 µg/kg in SS54-1) which were detected at concentrations above their respective detection limits.

PCBs were not detected in the upgradient floodplain surface soils with the exception of Aroclor 1260 which was detected at concentrations (3,300 µg/kg in SF52-2 and (79 µg/kg in SF53-2) above the detection limit.

Aluminum, barium, arsenic, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, sodium, vanadium, and zinc were detected at concentrations above their respective detection limits in every surface soil sample from the upgradient floodplain areas. Sample SS53-1 and SS54-1 located in the wooded area west of the Northern Slag Pile Area contained a significantly higher concentration of most metals when compared to concentrations of metals in other background samples. It should be noted that SS53-1 contained non-detected or estimated (J-qualified) concentrations of all other constituents (VOCs, SVOCs, etc.). Metals are naturally-occurring constituents of soil and would be expected in background/reference soils.

### 4.1.5 Downgradient Floodplain Shallow Subsurface Soil

Shallow subsurface soil samples were collected from the upstream areas on the Shenango River floodplain to represent areas not likely affected by the SSFW site as described in Section 3.4. These subsurface soil samples were collected to evaluate downgradient shallow subsurface soil; however, they were also used for comparison to source area subsurface soils. The analytical results for detected constituents in these samples are presented in Table 4-5 and are discussed above in Section 4.1.2.

### 4.1.6 Wetland Area Sediment

Sediment samples were collected from the offsite wetland to represent background/reference locations not likely to have been affected by the site as described in Section 3.5. The analytical results for sediment in the wetland background/reference area are presented in

Table 4-6. The following major constituent groups were detected in sediment in the wetland background area:

- VOC
- SVOC
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except antimony, beryllium, cadmium, cobalt, cyanide, magnesium, nickel, potassium, selenium, silver, thallium, and vanadium).

VOCs were detected sporadically in the wetland background sediment samples at estimated (J-qualified) concentrations below their respective detection limits. An exception was acetone which was detected at 42 µg/kg in sample SD19-2 and 20 µg/kg in SD27-2. It should be noted that acetone was not detected substantially in any other background/reference wetland sediment samples, is considered a common laboratory contaminant and may not be site-related (EPA, 1999).

SVOCs and PAHs were also detected sporadically in the wetland background sediment samples, but all were at estimated (J-qualified) concentrations below their respective detection limits.

Pesticides were detected sporadically in at estimated (J- and P-qualified) below their respective detection limits. An exception included 4, 4'-DDT (19 µg/kg in SD15-2 and 180µg/kg in SD16-2), which were detected at concentrations that were greater than two times the average background/reference concentrations.

One PCB (Aroclor-1254) was detected in one sample (890 µg/kg in SD16-2). PCBs were not detected in any other wetland background sediment samples.

Metals (aluminum, arsenic, barium, calcium, chromium, copper, iron, lead, manganese, mercury, and zinc) were the most frequently detected constituents in the wetland background/reference sediment. Sample SD19-2 contained concentrations of calcium, iron, and manganese that were notably higher than in the other wetland background/reference sediment samples. Concentrations of these metals were also detected at elevated levels in surface water samples collected from the same locations.

### 4.1.7 Shenango River Sediment

Sediment samples were collected upstream from the SSFW site in the Shenango River to represent background/reference locations not likely to have been affected by the site as described in Section 3.5. The analytical results for sediment in the Shenango River background area are presented in Table 4-7. The following major constituent groups were detected in sediment in the Shenango River background/reference area:

- VOC
- SVOC
- PAHs
- Pesticides
- PCBs
- Dioxins/Furans
- Metals (all TAL metals except beryllium, cyanide, sodium, and silver).

VOCs and SVOCs were detected sporadically in the Shenango River background/reference sediment samples at low estimated (J-qualified) concentrations below their detection limits.

PAHs were mostly detected sporadically in the Shenango River background sediment samples at low estimated (J-qualified) concentrations below their detection limits. Exceptions included fluoranthene (SD11-2, SD21-2, SD22-2, and SD64-1); phenanthrene (SD64-1); and pyrene (SD11-2, SD21-2, SD22-2, and SD64-1) which contained detected concentrations of PAHs that were above their respective detection limits. Sample SD64-1 contained notably higher concentrations of these constituents; 4,000 µg/kg, 4,500 µg/kg, and 3,100 µg/kg, of fluoranthene, phenanthrene, and pyrene, respectively.

Pesticides were detected sporadically in the Shenango River background sediment samples at low estimated (J-qualified) or suspect (P-qualified) concentrations below their detection limits. An exception is endrin aldehyde, which was detected in locations SD22-2 and SD65-1 at 9.2 and 69 µg/kg, respectively) at concentrations that were above their respective detection limits

PCBs were mostly not detected in the Shenango River background/reference locations. An exception was Aroclor-1260 which was detected all sediment samples (except SD64) at concentrations ranging from 87 µg/kg (SD11-2) to 1,700 µg/kg (SD65-1).

Dioxins/furans were detected in both samples analyzed for the Shenango River background sediment. Location SD11-2 had a concentration of 6.11 pg/g total 2,3,7,8-TCDD TEQ and location SD22-2 had a concentration of 5.04 pg/g total 2,3,7,8-TCDD TEQ.

Metals (aluminum, arsenic, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, mercury, and zinc) were the most frequently detected constituents in the Shenango River background/reference sediment. Several samples contained elevated concentrations of metals that were notably higher than other samples collected in the Shenango River background/reference sediments including SD54-1 (lead, magnesium, manganese, mercury, and zinc); SD65-1 (copper); SD22-2 (aluminum, arsenic, barium, calcium, and chromium); and SD21-2 (lead).

### 4.1.8 Unnamed Tributary Sediment

One sediment sample (and its duplicate) was collected from the unnamed tributary to represent background/reference locations not likely to have been affected by the site as described in Section 3.5. The analytical results for sediment in the unnamed tributary background area are presented in Table 4-8. The following major constituent groups were detected in sediment in the unnamed tributary background/reference area:

- VOC
- Metals (all TAL metals except antimony, barium, beryllium, cadmium, cobalt, cyanide, magnesium, mercury, nickel, potassium, selenium, silver, thallium, and vanadium).

VOCs and were detected sporadically in the unnamed tributary background/reference sediment samples at low estimated (J-qualified) concentrations below their detection limits.

Metals were the most frequently detected constituents in the unnamed tributary background/reference sediment. Those that were detected in sediment at concentrations above their respective detection limits include aluminum, arsenic, calcium, chromium, copper, iron, lead, manganese, and zinc. It should be noted that calcium was detected in the target sample (SD13-2) at 1,470 mg/kg, but not in the duplicate sample (SD913-2).

### 4.1.9 Wetland Surface Water

Surface water samples were collected from the offsite wetland on State Game Lands #294 near Fredonia, Mercer County, Pennsylvania to represent background/reference locations not likely to have been affected by the site as described in Section 3.6. The analytical results for surface water in the wetland background/reference area are presented in Table 4-9. The following major constituent groups were detected:

- VOC
- SVOC
- Metals (all TAL metals except antimony, beryllium, cadmium, cobalt, and mercury).

VOCs and SVOCs were detected sporadically in very few wetland background surface water samples at low estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations.

Metals were the most frequently detected constituents in the wetland background surface water. Those that were detected in surface water at concentrations above their respective detection limits include aluminum, calcium, copper, iron, magnesium, manganese, potassium, sodium, and zinc. It should be noted the SW15 and SW27 contained significantly higher concentrations of aluminum (5,690 µg/L in SW15), calcium (57,300 µg/L in SW27), copper (77 µg/L in SW27), iron (46,300 µg/L in SW15), magnesium (11,400 µg/L in SW27), manganese (4,010 µg/L in SW15), potassium (23,100 µg/L in SW27), zinc (159 µg/L in SW15) and mercury (0.48 µg/L in SW15) than the other surface water samples collected in the wetland background area.

Antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, nickel, selenium, silver, vanadium, and cyanide were not detected in filtered surface water samples the wetlands.

### 4.1.10 Shenango River Surface Water

Surface water samples were collected upstream from the SSFW site in the Shenango River to represent background/reference locations not likely to have been affected by the site as described in Section 3.6. The analytical results for surface water in the Shenango River background area are presented in Table 4-10. Metals were the only group of constituents that were detected in the surface water in the Shenango River background area.

Metals which were detected in Shenango River background surface water at concentrations above their respective detection limits include aluminum, arsenic, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel potassium, sodium, vanadium, zinc, and mercury. It should be noted the SW64 and SW65 contained significantly higher concentrations of calcium (41,900 µg/L in SW64), iron (3,350 µg/L in SW65), lead (8.2

µg/L in SW65), magnesium (8,680 µg/L in SW64), and manganese (225 µg/L in SW65) than the other surface water samples collected in the Shenango River background area.

Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, lead, nickel, potassium, selenium, silver, thallium, vanadium, and cyanide were not detected in filtered surface water samples the Shenango River.

### 4.1.11 Unnamed Tributary Surface Water

One surface water sample (and its duplicate) was collected from the unnamed tributary to represent background/reference locations not likely to have been affected by the site as described in Section 3.6. The analytical results for surface water in the unnamed tributary background area are presented in Table 4-11. The following major constituent groups were detected:

- VOC
- Metals (all TAL metals except antimony, cadmium, chromium, lead, mercury, selenium, silver, and vanadium).

One VOC was detected in the wetland background surface water sample; however, it was detected at a low estimated (J-qualified) concentration below the detection limit. It should be noted that VOCs were not detected in the duplicate of this sample.

Metals were the most frequently detected constituents in the unnamed tributary background/reference surface water. Those that were detected in surface water at concentrations above their respective detection limits include calcium, magnesium, manganese, sodium, and mercury.

Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, lead, nickel, potassium, selenium, silver, thallium, vanadium, and cyanide were not detected in filtered surface water samples the unnamed tributary. It should be noted that dissolved mercury was detected in the target sample (SW13) at 1.2 µg/L, but not in the duplicate sample. This is problematic because the dissolved metals concentration was higher than the total metals concentration in the same sample.

### 4.1.12 Shallow Groundwater Aquifer

Groundwater samples were collected from the shallow groundwater aquifer to represent background/reference locations not likely to have been affected by the site as described in

Section 3.3. The analytical results for groundwater collected from the background/reference shallow aquifer are presented in Table 4-12. The following major constituent groups were detected:

- SVOC
- Metals (all TAL metals except antimony, selenium, and silver).

One SVOC was detected in the background/reference shallow groundwater; however, it was detected at a low estimated (J-qualified) concentration below the detection limit.

Metals (total and dissolved) were the most frequently detected constituents in groundwater from the background/reference shallow aquifer. Several metals including aluminum, calcium, cobalt, copper, iron, lead, magnesium, manganese, mercury, potassium, and sodium were detected in groundwater at concentrations above their respective detection limits. The remainder of the metals were detected at estimated (J- and K-qualified) concentrations.

Antimony, beryllium, copper, cyanide, lead, mercury, and zinc were not detected in filtered groundwater samples.

### 4.1.13 Glacial Till Groundwater Aquifer

Groundwater samples were collected from the glacial till groundwater aquifer to represent background/reference locations not likely to have been affected by the site as described in Section 3.3. The analytical results for groundwater collected from the background/reference glacial till aquifer are presented in Table 4-13. The following major constituent groups were detected:

- VOC
- SVOC
- Metals (all TAL metals except antimony, cyanide, silver, and zinc).

VOCs were detected sporadically in the background/reference glacial till aquifer; however, most were detected at a low estimated (J-qualified) concentration below their respective detection limits. An exception was acetone which was detected at location RW2-2 (8.8 µg/L). It should be noted that acetone is considered to be a common laboratory contaminant that may not be site-related (EPA, 1999).

One SVOC was detected in the background/reference glacial till aquifer; however, it was detected at a low estimated (J-qualified) concentration below the detection limit.

Metals (total and dissolved) were the most frequently detected constituents in groundwater from the background/reference glacial till aquifer. Several metals including aluminum, calcium, cobalt, iron, lead, magnesium, manganese, mercury, and sodium were detected in groundwater at concentrations above their respective detection limits. The remainder of the detected TAL metals were reported at estimated (J-qualified) concentrations.

Antimony, beryllium, copper, cyanide, lead, mercury, nickel, selenium, silver and zinc were not detected in filtered groundwater samples.

### 4.1.14 Gravel Zone Groundwater Aquifer

Groundwater samples (including two duplicates) were collected from the gravel zone groundwater aquifer to represent background/reference locations not likely to have been affected by the site as described in Section 3.3. The analytical results for groundwater collected from the background/reference gravel zone aquifer are presented in Table 4-14.

Metals (aluminum, calcium, cobalt, iron, lead, magnesium, manganese, mercury, potassium, and sodium) were the only constituents detected in groundwater from the background/reference gravel zone aquifer at concentrations above their respective detection limits. The remainder of the detected TAL metals were reported at estimated (J- and K-qualified) concentrations. Antimony, beryllium, cadmium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc were not detected in filtered groundwater samples.

### 4.1.15 Bedrock Groundwater Aquifer

Groundwater samples were collected from the bedrock groundwater aquifer to represent background/reference locations not likely to have been affected by the site as described in Section 3.3. The analytical results for groundwater collected from the background/reference bedrock aquifer are presented in Table 4-15.

Metals (aluminum, beryllium, calcium, chromium, cobalt, iron, lead, magnesium, manganese, mercury, and sodium) were the only constituents detected in groundwater from the background/reference bedrock aquifer at concentrations above their respective detection limits. The remainder of the detected TAL metals were reported at estimated (J- and K-qualified) concentrations.

Antimony, beryllium, chromium, copper, lead, mercury, selenium, silver, thallium, and zinc were not detected in filtered groundwater samples.

### 4.1.16 Regional Potable Groundwater

Black & Veatch contacted several utility companies and agencies in Ohio and Pennsylvania for information regarding regional concentrations of arsenic and manganese in potable groundwater due to the fact that several residences near the site contained levels of these contaminants above drinking water MCLs.

The Ohio State Environmental Protection Agency (Ohio EPA) provided information gathered from public water systems (PWS), notably the Ambient Monitoring Network databases (Appendix G). Over 11,700 groundwater samples were collected from both the Ambient Monitoring Network and other PWS. Arsenic concentrations in ground water samples from these PWS reveal only limited differences between raw and treated groundwater; thus, the data were combined. The average for these combined data sets is 7.2 micrograms per liter (µg/L). The data are log-normally distributed, with a minimum value of 0.39 µg/L and a maximum value of 90.1 µg/L.

The Trumbull County office of Ohio EPA reported that in Trumbull County, Ohio, the natural arsenic concentrations vary greatly from well to well (Appendix G). Ten water systems in Trumbull County, Ohio showed concentrations of arsenic that exceeded the MCL (10 ug/L) with concentrations ranging from 10.6 ug/L to 119 ug/L. Additionally, ten systems showed exceedances of the MCL for manganese (50 ug/L) and fourteen exceedances of the MCL for iron (300 ug/L). Regional concentrations in Trumbull County, Ohio ranged from 53 ug/L to 485 ug/L for manganese and from 300 ug/L to 7,480 ug/L for iron.

According to the United States Geological Survey (USGS) website (www.usgs.gov) the counties in Ohio that are in close proximity to the SSFW site showed concentrations in groundwater that exceeded 10 µg/L of arsenic in at least 25 percent of samples collected and for counties surrounding Mercer County in Pennsylvania exceeded 50 µg/L of arsenic in at least 25 percent of samples (Ryker, 2001).

### 4.1.17 Large Fish

The analytical results for the background/reference large fish are presented in Table 4-16. The following major constituent groups were detected:

- VOCs
- SVOCs
- PCB's
- Dioxins/furans
- Metals (all TAL metals except arsenic, barium, beryllium, cadmium, chromium, cobalt, nickel, potassium, silver, and vanadium).

VOCs were detected in the all bottom feeding species reference locations except B32-LF-1-B, but were not detected in the three top feeding species reference locations. All VOC detections were either at low levels near their detection limits, were J-qualified, or have been identified as common laboratory contaminants (EPA, 1999).

Bis(2-ethylhexyl)phthalate, an SVOC, was detected in three background/reference large fish samples, although all detections were estimated (J-qualified) at concentrations that were below the respective detection limit. Bis(2-ethylhexyl)phthalate was not detected in either sediment or surface water samples collected from the unnamed tributary and is considered to be a common laboratory contaminant and may not be site-related.

One PCB (Aroclor 1260) was detected in each of the background/reference large fish samples. The highest concentrations of Aroclor 1260 occurred in samples B02-LF-1-B and B02-LF3-B, which had concentrations of 600 and 2,100 µg/kg respectively. Aroclor 1260 was also detected in the background/reference sediment samples collected from the Shenango River. It should be noted that the Shenango River background/reference large fish and sediment samples collected could have been impacted by the Westinghouse site. Many of the constituents associated with contaminated sediments at this site (PCBs, PAHs, and metals) are also associated with the SSFW site.

Dioxins and furans were analyzed for and detected at three background/reference locations (B02-LF-1-B, B02-LF-2-B, and B02-LF-3-B) in large fish samples. The highest detected concentration of 2,3,7,8-TCDD TEQ was 18.18 pg/g which was detected in sample B02-LF-3-B.

Metals were the most frequently detected constituents in the background/reference large fish samples. Metals detected in all large fish samples at concentrations at or above their respective detection limits include aluminum, antimony, calcium, chromium, copper, iron, manganese, mercury, thallium, and zinc.

### 4.1.18 Small Fish

The analytical results for the background/reference small fish are presented in Table 4-17. The following major constituent groups were detected:

- VOCs
- SVOC
- PCBs
- Metals (all TAL metals except arsenic, beryllium, cadmium, chromium, cobalt, copper, mercury, nickel, silver, thallium, and vanadium).

VOCs were detected in the all background/reference locations; however, all were estimated (J-qualified) at low levels near or below their respective detection limits.

Two SVOCs (4-methylphenol and benzaldehyde) were detected in background/reference locations B32-SF and B33-SF, but it should be noted that all detections were estimated (J-qualified) at low levels near or below their respective detection limits.

One PCB (Aroclor 1260) was detected in all background/reference small fish samples. The highest concentration of Aroclor 1260 occurred in sample B02-SF, which had a concentration of 370 µg/kg. The remaining reference samples had concentrations ranging from 43 to 210 µg/kg. Aroclor 1260 was also detected in background/reference sediment samples and large fish background/reference samples collected from the Shenango. It should be noted that the Shenango River background/reference small fish, large fish and sediment samples collected could have been impacted by the Westinghouse site.

Metals were the most frequently detected constituents in the background/reference small fish samples. Metals detected in all small fish samples at concentrations at or above their respective detection limits include aluminum, antimony, barium, calcium, iron, lead, manganese, potassium, selenium, and zinc.

### 4.1.19 Crayfish

The analytical results for the background/reference crayfish are presented in Table 4-18. The following major constituent groups were detected:

- PCBs
- Metals (all TAL metals except beryllium, cadmium, chromium, cobalt, lead, mercury, nickel, silver, thallium, and vanadium).

One PCB (Aroclor 1260) was detected in the Shenango River background/reference crayfish sample at a concentration of 440 µg/kg. As mentioned for the large fish, small fish, and sediment collected from the Shenango background, samples collected could have been impacted by the Westinghouse site. No PCBs were detected in the wetland background/reference location for crayfish.

Metals detected in Shenango River and reference wetland samples with concentrations at or above their respective detection limits include antimony, arsenic, barium, copper, manganese, potassium, selenium, and sodium.

## 4.2 Source Area Soil and Slag/Waste Materials

For clarity in this RI, soil/slag/waste material sampled from the source areas will be referred to herein as soil samples. In the source areas, metals were the most frequently detected constituent in surface soil. PAHs and PCBs (primarily Aroclors 1248, 1254, and 1260) were also detected in a majority of samples. Pesticides, SVOCs, and VOCs were detected sporadically and at estimated (J-qualified) levels at or below the detection limits, in most source/slag surface soil samples. Where analyzed, dioxins and furans were also detected.

In general, the distribution of detected contaminants across the slag/source areas is somewhat consistent at the SSFW site; however, there are some exceptions that are discussed in the following subsections. These subsections discuss the specific nature and extent of contamination in each slag/source area, geospatial trends in the contamination, and provide a comparison to the levels of constituents present in slag/waste materials in the background/reference areas.

### 4.2.1 BOF Sludge Disposal Area

Soil samples were collected in the BOF Sludge Disposal Area from three general depth intervals: surface soil, shallow subsurface soil, and deep subsurface soil.

***4.2.1.1. Surface Soil.*** Surface soil (or waste/slag) samples were collected in the BOF Sludge Disposal Area as described in Section 3.2. The analytical results for detected constituents in these samples are presented in Table 4-19. The following major constituent groups were detected:

- VOCs
- SVOC
- Dioxins/furans

- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals including cyanide).

VOCs were detected sporadically in several surface soil samples at estimated (J-qualified) concentrations near or below their respective detection limits and within background/reference concentrations. 2-Butanone was detected in one sample (SB16-2) at a concentration (42 µg/kg) greater than three times its detection limit.

SVOCs were detected sporadically in several surface soil samples at estimated (J-qualified) concentrations near or below their respective detection limits. 2-Methylnaphthalene was detected in one sample (SB17-2) at a concentration (830 µg/kg) greater than two times the average background/reference concentration. This location also contained elevated levels of PAHs (see below). 2-Methylnapthalene is often found in association with PAH contamination at hazardous waste sites.

Dioxins and furans were analyzed for and detected in two samples (SB13-2 and SB14-2). The average total 2,3,7,8-TCDD TEQ of sample SB13 and its duplicate (SB913) was 31.14 pg/g and the total 2,3,7,8-TCDD TEQ for sample SB14 was 2.26 pg/g.

PAHs were detected at estimated (J-qualified) concentrations below their respective detection limits in most surface soil samples in the BOF Sludge Area. The exceptions were two general areas (presented in Figure 4-1) where the concentrations of PAHs were greater than two times the average background/reference concentrations. The first area includes samples SB01-1, SB02-1 SB12-2, SB20-2, and SB920-2 (duplicate) and is located in the northern end of the BOF Sludge Disposal Area. Total PAHs in these samples ranged from 4,235 µg/kg in SB12-2 to 15,969 µg/kg in SB02-1. SB01-1 and SB02-1 contained notably higher concentrations of PAHs than the other samples collected in the BOF Sludge Disposal Area. The second area includes samples SS15-1 and SS16-1 which are located in an area of low elevation in the southern tip of the BOF Sludge Disposal Area. Total PAHs in these samples were 4,931 µg/kg in SS16-1 to 7,214 µg/kg in SB15-1. This area could potentially become contaminated as a result of flooding along the Shenango River or surface runoff and sedimentation from upgradient portions of the waste pile.

Pesticides were detected in all surface soil samples in the BOF Sludge Disposal Area; however, most were detected at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. Exceptions include samples SB12-2, SB01-1, SB02-1, and SB13-1, which contained concentrations of endrin (4.4 µg/kg in SB01-1), endrin aldehyde (7.5 µg/kg in SB12-2; 5.9 µg/kg in SB020-1; and 9.9 µg/kg in SB01-1), endrin ketone (6.1 µg/kg in SB13-1), and 4,4'-DDT (19 µg/kg in SB01-1) that were greater than two times the average background/reference concentrations. SB01-1 and SB02-1 contained notably higher concentrations of 4,4'-DDT (19 µg/kg and 12 µg/kg, respectively) than the other samples collected in the BOF Sludge Disposal Area. It should also be noted that these same samples contained the highest concentrations of PAHs as stated above.

PCBs were either not detected or detected at estimated (J-qualified) concentrations below their respective detection limits in most of the surface soil samples collected in the BOF Sludge Area. The exception was Aroclor 1260, which was detected at concentrations that were higher than two times the average background/reference concentrations in samples SB11-2 (37 µg/kg) SB12-2 (140 µg/kg), SB16-2 (260 µg/kg)), SB20-2 and its duplicate (1,600 µg/kg), duplicate), SS9-1 (430 µg/kg), SS15-1 (1,100 µg/kg), SS16-1 (920 µg/kg), and SB01-1 150 µg/kg). Three of these samples (SB20-2, SB15-1, and SB16-1) contained notably higher concentrations of Aroclor 1260 than the other surface soil samples collected in the BOF Sludge Disposal Area as well as the other two slag/source areas at the SSFW site. It should be noted that location SB20-2 also contained elevated concentrations of metals and pesticides as stated above. Samples SB15-1 and SB16-1 are in an area of low elevation in the southern tip of the BOF Sludge Disposal Area. This area could potentially become contaminated as a result of flooding along the Shenango River or surface runoff and sedimentation from upgradient portions of the waste pile.

Most metals (with the exception of aluminum which was not detected) were detected at concentrations greater than two times the average background/reference concentrations for most of the surface soil samples collected in the BOF Sludge Disposal Area. Three samples (SB19-2, SB20-2, and SB11-2) in the northern portion of the BOF Sludge Disposal Area contained the highest concentrations of metals, although the presence of metals appears to be widespread. The BOF Sludge Disposal Area contains notably higher concentrations of several metals (cadmium, chromium, copper, lead, mercury, silver, sodium, and zinc) than the other two source/slag areas.

TOC ranged from 6,900 to 86,400 mg/kg (0.69 to 8.6 percent) with an average of 30,250 mg/kg (3 percent) in the BOF Sludge Disposal Area. Samples SB11-2, SB12-2, and SB17-2 contained above average concentrations of TOC, which could partially explain the elevated concentrations of organic constituents (e.g. PAH, pesticides, and/or PCBs) in these same soils.

The grain size of the surface soil in the BOF Sludge Disposal Area was primarily fine to coarse sands; however there were some samples with significant amounts of fines with some fine gravel.

***4.2.1.2. Shallow Subsurface Soil.*** Shallow subsurface soil samples were collected from the BOF Sludge Disposal Area as described in Section 3.2.2. The analytical results for detected constituents in these samples are presented in Table 4-20. It should be noted that one sample (SB01-1) was analyzed for VOCs only. The following major constituent groups were detected:

- VOCs
- SVOC
- Dioxins/furans
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except antimony, cadmium, potassium, silver, thallium, and cyanide).

VOCs were detected in both samples collected in the BOF Sludge Disposal Area at low levels below their respective detection limits and within background/reference concentrations. An exception included xylenes which were detected in both samples (84 µg/kg in RW20-1 and 100 µg/kg in SB01-1) at concentrations greater than two times the average background/reference concentrations.

SVOCs were detected in shallow subsurface soils in the BOF Sludge Disposal Area at low levels below their respective detection limits and within background/reference concentrations. An exception was di-n-octylphthalate which was detected in RW20-1 at a concentration (730 µg/kg) greater than two times the average background/reference concentration.

Dioxins and furans were analyzed for and detected in RW20-1 in the BOF Sludge Disposal Area at a total 2,3,7,8-TCDD TEQ of 6.67 pg/g.

PAHs were detected in shallow subsurface soils at low concentrations near or below their respective detection limits and within background/reference concentrations. None of the PAHs detected in sample RW20-1 were above background/reference concentrations.

Pesticides were detected in shallow subsurface soils at low concentrations below their respective detection limits and within background/reference concentrations. None of the pesticides detected in sample RW20-1 were above background/reference concentrations.

PCBs were detected in shallow subsurface soils in the BOF Sludge Disposal Area at low concentrations near or below their respective detection limits and within background/reference concentrations. None of the PCBs detected in sample RW20-1 were above background/reference concentrations.

Metals were the most frequently detected constituents in the shallow subsurface soils I the BOF Sludge Disposal Area; however, most were detected in sample RW20-1 at concentrations below their respective detection limits and/or less than two times background/reference concentrations. Exceptions included chromium (152 mg/kg), copper (48.8 mg/kg), iron (62,600 mg/kg), and manganese (5,970 mg/kg) which were detected at concentrations greater than two times the average background/reference concentrations.

TOC was not measured in the shallow subsurface soils in the BOF Sludge Disposal Area. However, given the physical similarity of the sludge material, the concentrations of TOC are expected to be similar to those detected in the surface soils in the BOF Sludge Disposal Area (6,900 to 86,400 mg/kg).

***4.2.1.3. Deep Subsurface Soil.*** Deep subsurface soil samples were collected as described in Section 3.2.3. The analytical results for detected constituents in these samples are presented in Table 4-21. The following major constituent groups were detected in the deep subsurface soils:

- VOCs
- SVOCs
- Dioxins/furans
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except thallium).

VOCs and SVOC were either not detected or detected at concentrations below two times the average concentration detected in deep subsurface soils from the background sample samples.

Dioxins and furans were analyzed for, and detected, in two deep subsurface samples in the BOF Sludge Disposal Area, RW21-1 and SB01-1, at a total 2,3,7,8-TCDD TEQ of 0.456 pg/g and 8.55 pg/g, respectively.

PAHs were generally detected at estimated (J-qualified) concentrations below their respective detection limits in most deep subsurface soil samples in the BOF Sludge Disposal Area with the exception of samples RW22-1 (28-30 feet bgs), SB01-1 (10-20 feet bgs), SB11-1 (10-20 feet bgs), SB14-1 (10-20 feet bgs), and SB16-1 (10-20 feet bgs). These sample contained concentrations of most PAHs greater than two times the average background/reference concentrations and total PAHs ranged from 2,735 µg/kg in RW22-1 to 15,969 µg/kg in SB11-1. In particular, two samples (SB11-1 and SB01-1) contained notably higher concentrations of PAHs than the other samples collected in the BOF Sludge Disposal Area. Total PAHs were 9,963 µg/kg at location SB01-1 (10-20 feet bgs) and 15,969 µg/kg at location SB11-1 (10-20 feet bgs).

Pesticides were generally either not detected or detected at concentrations below their detection limit in the deep subsurface soils. Exceptions included samples SB01-1, SB11-1, and SB14. All of these samples were collected at 10-20 feet bgs and contained the following pesticides at concentrations that were greater than two times the average background/reference concentrations: gamma chlordane (15 µg/kg in SB01-1), 4,4'-DDE (14 µg/kg in SB01-1), 4,4'-DDT (28 µg/kg in SB01-1; 5.5 µg/kg in SB11-01), endrin aldehyde (11 µg/kg in SB01-1) and endrin ketone (4 µg/kg in SB14-1). It should be noted that these samples also contained elevated concentrations of PAHs.

PCBs were either not detected, or were detected at low concentrations, below their respective detection limits in deep subsurface soils.

Most TAL metals, if analyzed for, were detected in most deep subsurface soil samples at concentrations greater than two times the average background/reference concentrations. Several samples contained concentrations of total metals that were greater than two times background/reference concentrations. The highest concentrations of metals in these samples included barium (214 mg/kg in SB01-1), calcium (162,000 mg/kg in SB11-1 and SB15-1), chromium (1,750 mg/kg in SB02-1), hexavalent chromium (2.6 mg/kg in SB01-1), copper

(826 mg/kg in SB02-1), iron (211,000 mg/kg in SB11-1), lead (12,700 mg/kg in SB02-1) manganese (41,700 mg/kg in SB11-1), selenium (13.4 mg/kg in SB11-1), vanadium (364 in SB11-1) and zinc (86,900 mg/kg in SB02).

TOC was not measured in the deep subsurface soils in the. However, given the physical similarity of the sludge material, the concentrations of TOC are expected to be similar to those detected in the surface soils in the BOF Sludge Disposal Area (6,900 to 86,400 mg/kg).

***4.2.1.4. Summary of Nature and Extent in BOF Sludge.*** The BOF Sludge Disposal Area is generally the most contaminated source area in terms of number of detected constituents and the concentrations of those constituents, mostly in surface soil and deep subsurface soil. In particular, 2-methylnaphthalaene and several metals (cadmium, chromium, copper, lead, mercury, silver, sodium, and zinc) were detected at higher concentrations than the other two source areas. PAHs were detected at significant concentrations in the northern and southern ends of the BOF Sludge Disposal Area as shown in Figure 4-1. 2-Butanone and di-n-octylphthalate were detected at notable concentrations in isolated samples in this area; however, these are common laboratory contaminants and may not be site-related (EPA, 1999).

### 4.2.2 Northern Slag Pile Area

Surface and subsurface soil samples were collected in the Northern Slag Pile Area. TOC was not analyzed for in these samples.

***4.2.2.1. Surface Soil.*** Surface soil samples were collected in the Northern Slag Pile Area as described in Section 3.2.3. The analytical results for detected constituents in these samples are presented in Table 4-22. The following major constituent groups were detected in the surface soils:

- VOCs
- SVOC
- Dioxins/furans
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except antimony, thallium, and cyanide).

VOCs were sporadically detected in very few surface soil samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. Carbon disulfide was detected at one location (SB02) at a concentration (31 μg/kg) greater than two times the average background/reference concentration.

SVOCs were sporadically detected in a few surface soil samples in the Northern Slag Pile Area; however, all detections were estimated (J-qualified) concentrations below their respective detection limits. There were no SVOCs detected in the Northern Slag Pile Area at concentrations above their detection limit.

Dioxins and furans were analyzed for and detected in one surface soil sample (SB06) in the Northern Slag Pile at a total 2,3,7,8-TCDD TEQ of 1.84 pg/g.

PAHs were detected at concentrations below their respective detection limits in most surface soil samples in the Northern Slag Pile Area. Exceptions included samples SB04-2, SB07-2, SS47-1, and RW16-1 which contained concentrations greater than two times the average background/reference concentrations. Total PAHs in these samples ranged from 4,788 μg/kg in SS47-1 to 13,244 μg/kg in SB04-2. Location SB04-2 contained notably higher concentrations of PAHs than the other surface soil samples collected in the Northern Slag Pile Area. It should be noted that PAHs were not detected above the detection limits in other samples within the general vicinity of SB04-2.

Pesticides were detected in all but one (SB05) surface soil samples in the Northern Slag Pile Area. The majority of the detected pesticides were at estimated (J-qualified) concentrations below their respective detection limits. Exceptions include samples SS47-1, SB07-1, and RW16-1 which contained concentrations of 4,4'-DDT (38 μg/kg in SS47-1, and 28 μg/kg in SB07-1), 4,4'-DDE (13 μg/kg in RW16-1 and 7.4 μg/kg in SB07-1) and dieldrin (29 μg/kg in RW16-1) at concentrations greater than two times the average background/reference concentrations. It should also be noted that these samples are in an area of low elevation along the eastern edge of the Northern Slag pile in an area likely to be frequently flooded by the Shenango River.

PCBs were detected at estimated (J-qualified) concentrations below their respective detection limits in most of the surface soil samples collected in the Northern Slag Pile Area. The exceptions were Aroclors 1248, 1254, and 1260. Their distributions were generally widespread within the Northern Slag Area. Aroclor 1248 was detected at concentrations that were higher than two times the average background/reference concentrations in samples

SB01-2 (190 µg/kg), SB08-2 (56 µg/kg), and SB09-2 (480 µg/kg). Aroclor 1254 was detected at concentrations that were higher than two times the average background/reference concentrations and at notably higher concentrations than other slag/source area samples in samples SB01-2 (110 µg/kg), SB03-2 69 µg/kg), SB06-2 (38 µg/kg), SB07-2 (130 µg/kg), SB08-2 (76 µg/kg), SB09-2 (240 µg/kg), SB10-2 (74 µg/kg), and SB07-1 130 µg/kg). Aroclor 1260 was detected at concentrations greater than two times the average background/reference concentrations in samples SB07-2 (110 µg/kg), SB08-2 (16 µg/kg), SB09-2 (31 µg/kg), SS47-1 (290 µg/kg), and RW1-1 (31 µg/kg).

Most metals were detected at concentrations greater than two times the average background/reference concentrations for the majority of the surface soil samples collected in the Northern Slag Pile Area. Three samples (SS43-1, SS44-1, and SB10-2) in the southeastern corner of the Northern Slag Pile Area (as presented in Figure 4-2) contained the highest concentrations of metals including cadmium (6.6 mg/kg in SS43-1), calcium (330,000 mg/kg in SS44-1), iron (275,000 mg/kg in SS43-1) magnesium (34,000 mg/kg in SB10-2), and potassium (2,320 mg/kg in SB10-2), when compared to other surface soil samples in the Northern Slag Pile Area.

TOC ranged from 1,600 to 15,900 mg/kg (0.16 to 1.6 percent) with an average of 7,321 mg/kg (0.7 percent) in the Northern Slag Pile Area (Phase 2 samples only). Samples SB02-2, SB04-2, SB06-2, SB07-2, and SB-09 contained above average concentrations of TOC, which could partially explain the elevated concentrations of organic constituents (e.g. PAH, pesticides, and/or PCBs) in these same sediments.

The grain size of the surface soil in the Northern Slag Pile Area was primarily sandy silts and gravel/sand mixtures.

***4.2.2.2. Shallow Subsurface Soil.*** Shallow subsurface samples were not collected in the Northern Slag Pile Area.

***4.2.2.3. Deep Subsurface Soil.*** Subsurface soil samples were collected from the Northern Slag Pile Area as described in Section 3.2.4. The analytical results for detected constituents in these samples are presented in Table 4-23. The following major constituent groups were detected in the deep subsurface soils in the Northern Slag Pile Area:

- VOCs
- SVOC
- PAHs

- Pesticides
- PCBs
- Metals (all TAL metals except antimony, mercury, and thallium).

VOCs were generally either not detected or detected sporadically in very few samples at estimated (J-qualified) concentrations in deep subsurface soil in the Northern Slag Pile. Exceptions included a few VOCs (cyclohexane, ethylbenzene, ethyl acetate, methylbenzene, methylcyclohexane, and total xylenes) that were detected in samples RW1-1 (16-18 feet bgs), RW3-1 (12-14 feet bgs), RW17-1 (4-6 feet bgs and 10-13 feet bgs), RW19-1 (22-24 feet bgs), and SB07-1 (6-8 feet bgs) at concentrations that were greater than two times the average background/reference concentrations. Two samples in particular (RW17-1 and SB07-1) contained the highest concentrations of VOCs when compared the other samples collected in the Northern Slag Pile Area. Sample RW17-1 (10 -12 feet bgs) contained elevated concentrations of cyclohexane (98 µg/kg), methylbenzene (19 µg/kg), methylcyclohexane (170 µg/kg), and total xylenes (86 µg/kg). SB07-1 contained a significantly elevated concentration of methylcyclohexane (2,900 µg/kg).

SVOCs were detected sporadically in a few deep subsurface soil samples in the Northern Slag Pile Area; however, all detections were estimated (J-qualified) concentrations below their respective detection limits. Similar to surface soils, there were no SVOCs detected at concentrations above there detection limits in deep subsurface soils the Northern Slag Pile Area.

PAHs were generally either not detected or detected sporadically at concentrations below their respective detection limits in most deep subsurface soil samples in the Northern Slag Pile Area. An exception was phenanthrene which was detected at location SB07-1 (4-14 feet bgs) a concentration (900 µg/kg) that was greater than two times the average background/reference concentrations and significantly higher than other samples collected in the Northern Slag Pile Area.

Pesticides were detected sporadically in a few deep subsurface soil samples in the Northern Slag Pile Area; however, all detections were estimated (J-qualified) concentrations below their respective detection limits.

Only one PCB (Aroclor 1260) was detected in one deep subsurface soil sample in the Northern Slag Pile Area; however, the concentration was below its detection limit and within background/reference concentrations.

Most metals were detected at concentrations below their respective detection limits and within the average background/reference concentrations for the majority of the deep subsurface soil samples collected in the Northern Slag Pile Area. Exceptions included sporadic detections of metals (barium, calcium, chromium, lead and/or manganese) at the following samples: RW1-1 (16-18 feet bgs), RW3-1 (12-14 feet bgs), RW15-1 (8-10 feet bgs), and SB07-1 (4-14 feet bgs). Sample SB07-1 contained a concentration of 430 mg/kg of barium, which was significantly higher than the other deep subsurface sample collected in the Northern Slag Pile Area.

TOC was not measured in deep subsurface soils in the Northern Slag Pile Area. However, given the consistency of the slag/source materials, the concentration of TOC in deep subsurface soil is likely to be similar to the TOC surface soils in the Northern Slag Pile Area which ranged from 1,600 to 15,900 mg/kg (0.16 to 1.6 percent) with an average of 7,321 mg/kg (0.7 percent).

***4.2.2.4. Summary of Nature and Extent in Northern Slag Pile.*** The Northern Slag Pile Area is generally the least contaminated source/slag area in terms of number of detected constituents and the concentrations of those constituents. Metals, PAHs, pesticides, and PCBs were the most frequently detected constituents and were detected in all depth intervals. The southern end of the Northern Slag Pile area contained notably high concentrations of metals as presented in Figure 4-2. It should be noted that cyclohexane and methylcyclohexane was detected at notable concentrations in isolated samples in this area. These are both methylene chloride solvent preservatives used in laboratories (which are common laboratory contaminants) and may not be site-related (EPA, 1999).

### 4.2.3 Southern Slag Pile Area

Surface, subsurface, and deep subsurface soil sample were collected in the Southern Slag Pile Area. TOC was not analyzed for in these samples.

***4.2.3.1. Surface Soil.*** Surface soil samples were collected in the Southern Slag Pile Area as described in Section 3.2. The analytical results for detected constituents in these samples are presented in Table 4-24. The following major constituent groups were detected in the surface soils:

- VOCs
- SVOC

- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals including cyanide).

VOCs were sporadically detected in very few samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. An exception was total xylenes which were detected at location SS31-1 at a concentration (60 µg/kg) higher than two times the average background/reference concentrations.

SVOCs were detected sporadically in several surface soil samples in the Southern Slag Pile Area at estimated (J-qualified) concentrations below their respective detection limits. An exception was benzyl butyl phthalate which was detected in sample RW7-1 at a concentration (370 µg/kg) that was slightly above its respective detection limit and higher than two times the average background/reference concentrations.

PAHs were detected at estimated (J-qualified) concentrations below their respective detection limits in most surface soil samples in the Southern Slag Pile Area with the exception of samples SB26-2, SB30-2, SB101-2, SB102-2, SB105-2, SB106-2, SS28-1, SS22-1, SS32-1, SS33-1, SS34-1, and SS36-1. These samples contained concentrations of most PAHs greater than two times the average background/reference concentrations. Total PAHs in these samples ranged from 3,065 µg/kg in SS36-1 to 29,105 µg/kg in SS34-1. In particular, two samples (SS32-1 and SS34-1) contained notably higher concentrations of PAHs than the other samples collected in the Southern Slag Pile Area.

Pesticides were detected in most surface soil samples in the Southern Slag Pile Area; however, most were detected at estimated (J-qualified) concentrations below their respective detection limits. Exceptions included samples SB25-2, SB26-2, SB27-2, SB28-2, SB17-1, SB19-1, SS32-1, SS33-1, SS34-1, RW7-1, and RW16-1 that contained concentrations of alpha-chlordane (1.9 µg/kg in SB25-2, 10 µg/kg in SB26-2, 3.5 µg/kg in SB27-2, and 8.3 µg/kg in SB28-2), dieldrin (4.4 µg/kg in SB26-2), endrin ketone (10 µg/kg in SB28-2), endrin (8.2 µg/kg in RW7-1), 4,4'-DDE (3.5 µg/kg in SB27-2, 9.6 µg/kg in SB28-2, 4.2 µg/kg in SS34-1, 130 µg/kg in RW7-1, and 8.1 µg/kg in SB17-1), and dieldrin (4.1 µg/kg in RW16-1), and 4,4'-DDT (210 µg/kg in SB28-2,15 µg/kg in SS32-1, 26 µg/kg in SW33-1, 140 µg/kg in RW7-1, and 8.1 µg/kg in SB19-1) at concentrations greater than two times the average background/reference concentrations. Most of these samples were collected in the central portion of the Southern Slag Pile Area as presented in Figure 4-3.

PCBs were either not detected or detected at estimated (J-qualified) concentrations below their respective detection limits in most of the samples collected in the Southern Slag Pile Area. The exceptions were Aroclors 1248, 1254, and 1260 as presented in Figure 4-3. Their distributions were generally widespread within the Southern Slag Pile Area. Aroclor 1248 was detected at concentrations that were higher than two times the average background/reference concentrations in samples SB22-2 (120 µg/kg), SB23-2 (2,800 µg/kg), SB25-2 (97 µg/kg), SB27-2 (67 µg/kg), SB28-2 (400 µg/kg), SB29-2 (87 µg/kg), and RW7-1 (3,500 µg/kg). Aroclor 1254 was detected at location SB26-2 at concentration (270 µg/kg) that was higher than two times the average background/reference concentration and notably higher than concentrations in other slag/source area samples. Aroclor 1260 was detected at concentrations that were higher than two times the average background/reference concentrations in samples SB23-2 (36 µg/kg), SB27-2 (50 µg/kg), SB28-2 (140 µg/kg), SB29-2 (87 µg/kg), SS28-1 (140 µg/kg), and SS29-1 (30 µg/kg). Most of these samples were collected in the central portion of the Southern Slag Pile Area and also contained elevated levels of pesticides as stated above.

All TAL metals were detected in most surface soil samples in the Southern Slag Pile Area at concentrations greater than two times the average background/reference concentrations. Exceptions included samples SS29 and SS31 which contained concentrations of metals in surface soils that were within background/reference concentrations. Samples SB23-2, SB103-2, and SB106-2 contained the highest concentrations of total metals when compared to the other Southern Slag Pile Area samples. These samples area generally located in the in the central portion of the Southern Slag Pile Area as presented in Figure 4-3. Hexavalent chromium was detected at location SB23-2 (and its duplicate SB923-2) at concentrations (16.3 mg/kg and 12.3 mg/kg, respectively) greater than two times the average background/reference concentrations.

The grain size of the surface soil in the Southern Slag Pile Area was primarily medium sandy fine gravel.

***4.2.3.2. Shallow Subsurface Soil.*** Sixteen shallow subsurface soil samples were collected from the Southern Slag Pile Area as described in Section 3-2. The analytical results for these samples are presented in Table 4-25. The following major constituent groups were detected in the shallow subsurface soils of Southern Slag Pile Area:

- VOCs

- SVOC
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except sodium and cyanide).

VOCs were detected infrequently in twelve samples in the Southern Slag Pile Area, but at low levels near or below their respective detection limits and within background/reference concentrations. Exceptions included samples SB101-B and SB106-B which contained concentrations of dichloromethane (91 µg/kg in SB101-B) and carbon disulfide (9 µg/kg in SB106-B) that were greater than two times the average background/reference concentrations.

One SVOC was detected in one shallow subsurface soils sample in the Southern Slag Pile Area at low concentrations below its detection limits; however, the concentration was below the background/reference concentrations.

Pesticides were generally either not detected or detected at concentrations below their detection limit in the shallow subsurface soils in Southern Slag Pile Area. The exception was 4,4'-DDE, which was detected at a concentration (120 µg/kg in SB27-2) greater than two times the average background/reference concentrations. It should be noted that sample SB27-2 in the Southern Slag Pile Area also contained elevated concentrations of 4,4'-DDE in surface soils.

PCBs were detected in shallow subsurface soils in the Southern Slag Pile Area at low concentrations near or below their respective detection limits and within background/reference concentrations. The exception was Aroclor 1248 which was detected at concentrations (5,500 µg/kg in SB27-2; 27 µg/kg in SB28-2; and 410 µg/kg in SB30-2) that were greater than background/reference concentrations. It should be noted that samples SB27-2 and SB28-2 in the Southern Slag Pile Area also contained elevated concentrations of Aroclor 1248 in surface soils.

PAHs were detected in shallow subsurface soils in the Southern Slag Pile Area at low concentrations near or below their respective detection limits and within background/reference concentrations. None of the PAHs detected were above background/reference concentrations.

All TAL metals were detected in most shallow subsurface soil samples in the Southern Slag Pile Area at concentrations greater than two times the average background/reference concentrations. An exception included location SS26-2 which contained concentrations of metals that were within background/reference concentrations. Samples SB102-2, SB106-2, SB27-2, and SB28-2 contained the highest concentrations of total metals when compared to the other shallow subsurface soil samples in the Southern Slag Pile Area. The highest concentrations metals in these samples included calcium (22,700 mg/kg in SB28-2), chromium (2,110 mg/kg in SB27-2), copper (176 mg/kg in SB27-2), iron (214,000 mg/kg in SB106-2), manganese (21,900 mg/kg in SB106-2), and nickel (29.6 mg/kg in SB926-2). These samples are generally located in the vicinity of each other in the central portion of the Southern Slag Pile Area. It should be noted that location SB106-2 also contained elevated concentrations of metals in surface soils.

***4.2.3.3. Deep Subsurface Soil.*** Subsurface soil samples were collected from the Southern Slag Pile Area as described in Section 3.2. The analytical results for detected constituents in these samples are presented in Table 4-26. The following major constituent groups were detected in the deep subsurface soils in the Southern Slag Pile Area:

- VOCs
- SVOC
- Dioxins/furans
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals including cyanide).

VOCs were either not detected or detected sporadically in very few samples at low estimated (J-qualified) concentrations in deep subsurface soil in the Southern Slag Pile. Exceptions included a few VOCs (acetone, carbon disulfide, and total xylenes) which were detected in samples that were greater than two times the average background/reference concentrations. Carbon disulfide was detected in SB106-C (16 μg/kg; 15-21 feet bgs), SB23-C (19 μg/kg; 8-14 feet bgs), and SB23-I (13 μg/kg; 60-70 feet bgs). Total xylenes were detected in SB105-F (21 μg/kg; 60-64 feet bgs), RW7-1 (36 μg/kg; 6-12 feet bgs), and SB10 (25 μg/kg; 4-6 feet bgs).

SVOCs were detected sporadically in a few deep subsurface soil samples in the Southern Slag Pile Area; however, most detections were estimated (J-qualified) concentrations below their respective detection limits. Exceptions included samples RW8-1 (6-8 feet bgs) and

RW9-1 (10-12 feet bgs) which contained significantly high concentrations of benzaldehyde (5,400 μg/kg in RW9-1) and di-n-octylphthalate (1,100 μg/kg in RW8-1) that were greater than two times the average background/reference concentrations.

Dioxins and furans were analyzed for and detected in one deep subsurface soil sample (SB10-1, 8-10 feet bgs) in the Southern Slag Pile Area at a total 2,3,7,8-TCDD TEQ of 0.806 pg/g.

PAHs were either not detected or detected sporadically at concentrations below their respective detection limits in most deep subsurface soil samples in the Southern Slag Pile Area. Exceptions included samples SB105-E (50-60 feet bgs), SB23-I (60-70 feet bgs), SB28-D (18-22 feet bgs), SB28-F (28-34 feet bgs), RW7-1 (6-12 feet and 14-16 feet bgs), RW8-1 (6-8 feet and 16-18 feet bgs), and SB18-1 (30-40 feet bgs) that was greater than two times the average background/reference concentrations and significantly higher than other samples collected in the Southern Slag Pile Area. Location SB28 (depth intervals D and F) contained significantly higher concentrations of PAHs than in the other deep subsurface samples in the Southern Slag Pile Area. Total PAHs were 6,028 μg/kg in depth interval D and 5470 μg/kg in depth interval F.

Pesticides were detected sporadically in a few deep subsurface soil samples in the Southern Slag Pile Area; however, all detections were estimated (J-qualified) concentrations below their respective detection limits. Exceptions included aldrin, alpha-chlordane, heptachlor epoxide, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT which were detected in several samples at concentrations that were greater than two times the average background/reference concentrations. In particular, samples SB23-2, SB27-2, and SB28-2 contained the highest concentrations of these pesticides at several depth intervals when compared to background/reference locations and the other samples collected in the Southern Slag Pile. These samples are located in the general vicinity of each other in the central portion of the Southern Slag Pile Area as presented in Figure 4-3.

PCBs were generally either not detected or detected in deep subsurface soils in the Southern Slag Pile Area at low concentrations near or below their respective detection limits and within background/reference concentrations. The exceptions were Aroclor 1248 and 1260 which were detected in several samples at concentrations that were greater than background/reference concentrations as presented in Figure 4-3. Aroclor 1248 was detected at significantly higher concentrations than other samples in the Southern Slag Pile Area at samples SB23-2 (57,000 μg/kg in SB23-E; 3,800 μg/kg in SB23-F; 14,000 μg/kg in SB23-

G; 1,800 µg/kg in SB23-H; 11,000 µg/kg in SB23-I and SB27; 11,000 µg/kg in SB27-C; 5,100 µg/kg in SB27-D; 8,700 µg/kg in SB27-E; 6,600 µg/kg in SB27-F; 6,000 µg/kg in SB27-G; 2,900 µg/kg in SB27-H; and 3,000 µg/kg in SB27-I). Aroclor 1260 was detected at significantly higher concentrations in samples SB23-2 (84 µg/kg in SB23-F; 270 µg/kg in SB23-G; 39 µg/kg in SB23-H), SB102 (1,300 µg/kg in SB103-C) and SB28-2 (46 µg/kg in SB28-E; 50 µg/kg in SB28-F; 130 µg/kg in SB28-H; and 100 µg/kg in SB28-I). It should be noted that location SB27-2 also contained elevated concentrations of Aroclor 1248 in surface soils and shallow subsurface soils in the Southern Slag Pile Area.

Metals were detected in the majority of the deep subsurface soil samples collected at the Southern Slag Pile Area. Exceptions included twelve samples in which metals were either not detected or did not exceed background/reference concentrations. Several samples (SB103-2, SB23-2, and SB28-2) contained concentrations of metals (barium, calcium, chromium, copper, iron, lead, magnesium, manganese, and vanadium) within several depth intervals that were greater than two times the average background/reference concentrations and the other deep subsurface samples collected in the Southern Slag Pile Area. These samples are located in the general vicinity of each other in the central portion of the Southern Slag Pile Area as presented in Figure 4-3.

TOC was not measured in deep subsurface soils in the Southern Slag Pile Area. However, given the physical similarity of the Southern Slag Pile material to the Northern Slag Pile material, the concentration of TOC is likely to be more similar to the Northern Slag Pile material than to the BOF Sludge material.

***4.2.3.4. Summary of Nature and Extent in Southern Slag Pile.*** In summary, the Southern Slag Pile Area contained some unique contaminants (VOCs and pesticides were detected in this area that were not detected in the other source areas); however, these were detected somewhat infrequently and at low levels. Several of the VOCs and phthalates detected were in isolated samples and are common laboratory contaminants; therefore, these may not be site-related (EPA, 1999).

Metals, PAHs, pesticides, and PCBs were the most frequently detected constituents and were detected in all depth intervals. The Southern Slag Pile Area also contains notably higher concentrations of most PAHs, Aroclor-1248, DDT metabolites, and heptachlor epoxide than the other two source/slag areas, particularly in the central portion of the source area as presented in Figure 4-3.

## 4.3 Downgradient Soil

Soil samples were collected from areas downgradient of the source areas (but not on the source areas) which are located in floodplain or wetland areas. These samples will be referred to hereafter as downgradient soil samples. These samples were collected as described in Section 3.4 from site exposure areas including the Shenango River floodplain, southeast floodplain, unnamed tributary floodplain, and Ohio Street wetlands.

The following subsections discuss the analytical results for the constituents detected in the downgradient soils and provide an evaluation of how the concentrations of these constituents compare to those detected in background/reference locations.

### 4.3.1 Shenango River Floodplain

Downgradient soil samples were collected in the Shenango River floodplain area from three general depth intervals: surface soil, shallow subsurface, and deep subsurface. Most of these samples were collected in areas directly downgradient and adjacent to source areas. Based on the shallow groundwater flow contours, the surface drainage area map, and flooding patterns of the Shenango River, contaminants from the BOF Sludge area and the Northern Slag Pile Area can potentially be in these samples. There are no migration pathways for contaminants from the Southern Slag Pile to this area.

***4.3.1.1 Surface Soil.*** Downgradient surface soil samples were collected in the Shenango River floodplain as described in Section 3.4. The analytical results for detected constituents in these samples are presented in Table 4-27. TOC was not analyzed for in samples from this area. The following major constituent groups were detected in the downgradient surface soils:

- VOCs
- SVOC
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals including cyanide).

VOCs were sporadically detected in a few samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. Exceptions included xylenes (21 µg/kg in SS10-1; 17 µg/kg in SS11-1; and 26 µg/kg in SS48-1; 16 µg/kg in SS49-1; 50 µg/kg in SS50-1; 15 µg/kg in SS51-1; and 20 µg/kg in

SS52-1) and 2-butanone (21 µg/kg in SF45-2; 18 µg/kg in SF46-2; and 30 µg/kg in SF947-2) which were detected concentrations that were greater than two times the average background/reference concentrations. Xylenes were detected in shallow subsurface soils in the BOF Sludge Disposal Area and in deep subsurface soils in the Northern Slag Pile Area suggesting that floodplain areas could potentially become contaminated from the source areas via surface runoff. Samples containing these VOCs also contained elevated levels of SVOCs and PAHs as presented in Figure 4-4.

SVOCs were sporadically detected in a few samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. Exceptions included 2-methylnaphthalene (1,700 µg/kg in SS5-1 and 980 µg/kg in SS10-1) and dibenzofuran (2,800 µg/kg in SS5-1) which were detected at concentrations that were greater than background/reference concentrations. The BOF Sludge Disposal Area also contained elevated concentrations of 2-methylnaphthalene in surface soils, suggesting that floodplain areas could potentially become contaminated from the source areas via surface runoff. Further, 2-methylnapthalene is commonly associated with areas of high PAH concentrations (as observed in surface soils discussed below) at hazardous waste sites. Dibenzofuran was detected at elevated concentrations in one upstream sediment sample in the Shenango River suggesting that floodplain areas could potentially become contaminated during flooding along the Shenango River.

PAHs were detected in downgradient surface soils at concentrations that were greater than two times the average background/reference at samples SS4-1, SS5-1, SS6-1, SS10-1, SS11-1, SS18-1, SS49-1, SS50-1, and SS51-1 (as presented in Figure 4-4). Total PAHs in these samples ranged from 11,530 µg/kg in SS4-1 to 38,990 µg/kg in SS6-1. PAHs were also detected at elevated concentrations in surface soils in the adjacent source areas (BOF Sludge Disposal Area and the Northern Slag Pile Area), suggesting that floodplain areas could potentially become contaminated from the source areas via surface runoff.

Pesticides were detected in all downgradient soil samples in the Shenango River floodplain; however, most were detected at estimated (J-qualified) concentrations below their respective detection limits. Exceptions included sporadic detections of 4,4'-DDT (200 µg/kg in SS49-1 and SS11-1), 4,4'-DDE (40 µg/kg in SS3-1), endrin aldehyde (7.8 ug/kg in SS3-1), dieldrin (15 ug/kg in SS48-1), and heptachlor epoxide (5.3 ug/kg in SS48-1) which were greater than two times that average background/reference concentrations. Pesticides were also detected at elevated concentrations in surface soils in adjacent source areas (BOF

Sludge Disposal Area and the Northern Slag Pile Area), suggesting that floodplain areas could potentially become contaminated from the source areas via surface runoff.

PCBs were either not detected or detected in at estimated (J-qualified) concentrations below their respective detection limits in most downgradient soil samples in the Shenango River floodplain. An exception included location SS3-1 which contained a concentration of Aroclor 1248 (1,200 μg/kg) that was greater than two times the average background/reference concentrations. Aroclor 1260 was detected at elevated concentrations in surface soils in the adjacent BOF Sludge Disposal Area, suggesting that floodplain areas could potentially become contaminated from the source areas via surface runoff.

Most TAL metals were detected in all downgradient soils in the Shenango River floodplain at concentrations greater than two times the average background/reference concentrations. Sample SS52-1 (as presented in Figure 4-4) contained the highest concentrations of metals including aluminum (30,700 mg/kg), barium (321 mg/kg), beryllium (4.1 mg/kg), and magnesium (22,500 mg/kg), when compared to other downgradient soil samples in the Shenango River floodplain. These constituents were all detected in the adjacent source areas (BOF Sludge Disposal Area and the Northern Slag Pile Area) and/or sediment in the Shenango River suggesting that floodplain areas could potentially become contaminated from the source areas via surface runoff or from flooding along the Shenango River.

***4.3.1.2 Shallow Subsurface Soil.*** Downgradient shallow subsurface soil samples were collected in the Shenango River foodplain as described in Section 3.4. The analytical results for detected constituents in these samples are presented in Table 4-28. The following major constituent groups were detected in the downgradient shallow subsurface soils:

- VOCs
- SVOC
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except beryllium, sodium, and cyanide).

VOCs were sporadically detected in several samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations.

SVOCs were sporadically detected in several samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. Exceptions included dibenzofuran (530 µg/kg in SF46-2) which was detected at concentrations that were greater than two times the average background/reference concentrations.

Location RW16-1 in particular contained notably high estimated (J-qualified) concentrations of several SVOCs including 1,1'-biphenyl, 2,4'-dimethylphenol, acetophenone, caprolactam, and di-n-octylphthalate reported at concentrations that were greater than two times the average background/reference concentrations. These estimated concentrations may not be accurate or precise as they are a result of a diluted analysis. However, most of these constituents (except 2,4'-dimethylphenol) were detected in the adjacent source area samples suggesting that floodplain areas could potentially become contaminated from the source areas via surface runoff.

PAHs were mostly detected at estimated (J-qualified) concentrations that were less than two times the average background/reference locations. Exceptions included samples SF44-2 and SF46-2 in which concentrations of PAHs were greater than two times the average background/reference concentrations. Total PAHs in these samples ranged from 13,219 µg/kg in SF44-2 to 53,190 µg/kg in SF46-2. As with SVOCs, location RW16-1 contained notably high estimated (J-qualified) concentrations that were greater than their respective quantitation limit and two times the average background/reference concentrations. These concentrations may not be precise as they are the result of a diluted analysis, which indicates that the concentrations were higher than the laboratory instrument detection limits.

Pesticides were detected in several downgradient soil samples in the Shenango River floodplain at estimated (J-, P-, and/or E-qualified) concentrations below their respective detection limits. Exceptions included endosulfan II (1.2 µg/kg in SF45-2) and 4,4'-DDE (23 µg/kg in RW16-1) which were detected at concentrations that were greater than two times the average background/reference concentrations.

PCBs were not detected in most downgradient shallow subsurface soils. Exceptions included Aroclor 1254 and Aroclor 1260 which were detected at concentrations that were greater than two times the average background/reference concentrations. Aroclor 1254 was detected in SF44-2 (150 µg/kg), SF45-2 (92 µg/kg), SF46-2 (190 µg/kg), and SF47-2 (130 µg/kg). Aroclor 1260 was detected in SF45-2 (1,500 µg/kg), SF46-2 (2,200 µg/kg), and SF47-2 (1,800 µg/kg). In general, Aroclor 1254 and 1260 were detected at elevated concentrations in the same samples. PCBs were also detected in the same samples containing elevated levels of PAHs.

Most TAL metals were detected in all downgradient shallow subsurface soils in the Shenango River floodplain at concentrations greater than two times the average background/reference concentrations. Two samples in particular (SF47-2, and RW16-1) contained the higher concentrations of metals (chromium, copper, iron, magnesium, nickel, thallium, and vanadium) when compared to other downgradient shallow subsurface soil samples in the Shenango River floodplain.

TOC ranged from 7,170 to 19,400 mg/kg with an average of 13,128 mg/kg in the downgradient shallow surface soils in the Shenango River floodplain. Samples SF45-2, SF46-2, and SF47-2 contained above average concentrations of TOC, which could provide a partial explanation for the elevated concentrations of organic constituents (e.g. PAHs and/or PCBs) in these samples.

***4.3.1.3 Deep Subsurface Soil.*** Downgradient deep subsurface soil samples were collected in the Shenango River foodplain as described in Section 3.4. The analytical results for detected constituents in these samples are presented in Table 4-29. TOC was not analyzed for in samples from this area. The following major constituent groups were detected in the downgradient deep subsurface soils:

- VOCs
- SVOC
- Dioxins/furans
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except antimony and cyanide).

VOCs were sporadically detected in several deep subsurface soil samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. An exception was sample RW20-1 (6-8 feet bgs) in which ethylbenzene (16 µg/kg), methylbenzene (15 µg/kg), and xylenes (60 µg/kg) were detected at concentrations that were greater than two times the average background/reference concentrations. It should be noted that these constituents were not detected in the underlying groundwater at RW20-1, a nearby groundwater sample.

SVOCs were either not detected or sporadically detected in a few samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations.

Dioxins and furans were analyzed for and detected in one downgradient deep subsurface soil sample (RW20-1, 6-8 feet bgs) in the Shenango River floodplain at a total 2,3,7,8-TCDD TEQ of 0.057 pg/g.

PAHs were either not detected or detected at estimated (J-qualified) concentrations that were less than two times the average background/reference locations in downgradient deep subsurface soils. One location, RW16-1 (6-8 feet bgs), contained concentrations of PAHs that were detected at notably high estimated (J-qualified) concentrations that were greater than their respective quantitation limit and two times the average background/reference concentrations. It should be noted that this situation also occurred in shallow subsurface soils at the same location and the reported concentrations may not be accurate or precise as they are a result of a diluted analysis, which indicates that the concentrations were higher than the laboratory instrument detection limits. The concentration of total PAHs in RW16-1 was 34,110 µg/kg.

Pesticides were either not detected or detected at estimated (J-qualified) concentrations that were less than two times the average background/reference locations in downgradient deep subsurface soils. One location, RW16-1 (6-8 feet bgs), contained concentrations of pesticides that were detected at notably high estimated (J-qualified) concentrations that were greater than their respective quantitation limit and two times the average background/reference concentrations. This sample also contained PAHs at an elevated level. It should be noted that this situation also occurred in shallow subsurface soils (and for PAH as stated above) at the same location and the reported concentrations may not be accurate or precise.

PCBs were either not detected or detected sporadically in a few samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference locations.

TAL metals were generally detected infrequently in the downgradient deep subsurface soils in the Shenango River floodplain at concentrations greater than two times the average background/reference concentrations. Location RW16-1 contained notably high concentrations of chromium (248 mg/kg), copper (118 mg/kg), nickel (126 mg/kg), thallium (8.3 mg/kg), and vanadium (24.3 mg/kg) when compared to two times the average background and the other downgradient deep subsurface soils collected in the Shenango River floodplain. It should be noted that these constituents were not detected in underlying groundwater at location RW16-1. This sample also contained pesticides and PAHs at elevated concentrations. As seen in RW16-1 for other analytes (pesticides and PAHs), several concentrations of metals were also estimated (J-qualified).

TOC was not analyzed in the deep subsurface soils in the Shenango River floodplain.

***4.3.1.4 Summary of Nature and Extent in Shenango River Floodplain.*** Generally, the same contaminants detected in the adjacent source/slag areas (BOF Sludge Disposal Area and Northern Slag Pile) were also detected in the Shenango River floodplain area. Several VOCs and phthalates were detected in isolated samples and are common laboratory contaminants; therefore, these may not be site-related (EPA, 1999). In particular, PAHs, 2-methylnaphthalene, dibenzofuran, and other SVOCs were detected at similar concentrations (greater than background/reference concentrations) in the northern portion of the BOF Sludge Disposal Area, Shenango River floodplain, and Shenango River sediment. This would suggest that the floodplain areas could potentially become contaminated from the source area via surface runoff or during flooding along the Shenango River. Given the alignment of the Shenango River near the BOF Sludge Disposal Area (which serves as the river bank in some areas) it is possible that the Shenango River erodes or cuts into the source material during periods of high flood flow. As flood waters recede, it is likely that the suspended particles settle onto the floodplain of the Shenango River or in depositional areas as sediment. Areas of interest where there are notable concentrations of site-related contaminants are presented in Figure 4-4.

The most downgradient floodplain sample, SF47-2, contained detections of several metals (chromium, copper, iron, mercury, nickel, thallium, and vanadium) in surface and shallow subsurface soils at concentrations that were greater than two times the average background/reference concentrations. This suggests that the downstream extent of metals contamination in the Shenango River Floodplain has not been fully defined.

### 4.3.2 Southeast Floodplain

Downgradient soil samples were collected in the southeast floodplain area from three general depth intervals: surface soil, shallow subsurface, and deep subsurface. Based on the shallow groundwater flow contours, the surface drainage area map, and flooding patterns of the Shenango River, contaminants from the all source areas can potentially be in these samples.

**4.3.2.1 Surface Soil.** Downgradient surface soil samples were collected in the southeast floodplain as described in Section 3.4. The analytical results for detected constituents in these samples are presented in Table 4-30. The following major constituent groups were detected in the downgradient surface soils:

- VOCs
- SVOC
- Dioxins/furans
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except cyanide).

VOCs were sporadically detected in very few downgradient surface soil samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. Exceptions included 2-butanone (14 µg/kg in SF34-2 26 µg/kg in SF36-2), carbon disulfide (17 µg/kg in SS37-1), and xylenes (10 µg/kg in SS38-1 and µg/kg SS42-1) which were detected at concentrations that were greater than two times the average background/reference concentrations. Xylenes, carbon disulfide, and 2-butanone were detected at elevated concentrations in all adjacent source area soils (BOF Sludge Disposal Area, Northern Slag Pile Area, and Southern Slag Pile Area) suggesting that floodplain areas could potentially become contaminated from the source areas via surface runoff.

SVOCs were either not detected or sporadically detected in very few surface soil samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. Exceptions included two samples that contained concentrations of SVOCs that were greater than two times the average background/reference concentrations. Location RW13-1 contained dibenzofuran at 760 µg/kg and 2-methylnaphthalene at 2,000 µg/kg. This sample also contained notable concentrations of PAHs. Dibenzofuran and 2-methylnaphthalene are often found in association with PAHs on hazardous waste sites. Location SS37-1 contained acetophenone at 1,000 µg/kg and benzaldehyde at 890 µg/kg.

Dioxins and furans were analyzed for and detected in one surface soil sample (SF31-2) in the southeast floodplain at a total 2,3,7,8-TCDD TEQ of 1.84 pg/g.

PAHs were either not detected or detected at estimated (J-qualified) concentrations in most surface soil samples. Exception included samples SF33-2, SF34-2, and RW12-1. Total PAHs in these samples ranged from 10,924 μg/kg in SF34-2 to 13,778 μg/kg in RW12-1. Sample SS33-2 also contained high concentrations of PCBs. PAHs were also detected at elevated concentrations in surface soils in the adjacent source areas (BOF Sludge Disposal Area and the Northern Slag Pile Area), suggesting that floodplain areas could potentially become contaminated from the source areas via surface runoff.

Pesticides were either not detected or detected at estimated (J-qualified) and/or non-precise (P-qualified) concentrations below their respective detection limits in most downgradient surface soil samples. Exceptions included endrin (31 μg/kg in SS38-1), endrin ketone (36 μg/kg in SF33-2), 4,4'-DDT (160 μg/kg in RW12-1) which were detected at concentrations that were greater than two times the average background/reference concentrations. All of these constituents were also detected at elevated concentrations in surface soils in the adjacent source areas (BOF Sludge Disposal Area), suggesting that floodplain areas could potentially become contaminated from the source areas via surface runoff.

PCBs were either not detected or detected sporadically in a few samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference locations. An exception was Aroclor 1254 (460 μg/kg in SF33-2) which was detected at a concentration that were greater than two times the average background/reference concentrations. Sample SS33-2 also contained high concentrations of PAHs.

Most TAL metals were detected in several downgradient soils in the southeast floodplain at concentrations greater than two times the average background/reference concentrations. In general, metals (chromium, copper, iron, mercury, nickel, potassium, and thallium) were detected at similar concentrations with a widespread distribution and no apparent pattern.

TOC in this area ranged from 6,700 to 28,600 mg/kg with an average of 16,100 mg/kg. Several samples including SF32-2, SF33-2, SF36-2, SF37-2 and SF43-2 contained above average concentrations of TOC, which could provide a partial explanation for the elevated concentrations of organic constituents (e.g. PAHs and/or PCBs) in some of these samples.

***4.3.2.2 Shallow Subsurface Soil.*** Downgradient shallow subsurface soil samples were collected in the southeast floodplain as described in Section 3.4. The analytical results for detected constituents in these samples are presented in Table 4-31. The following major constituent groups were detected in the downgradient shallow subsurface soils:

- VOCs
- SVOC
- Dioxins/furans
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except cyanide).

VOCs were sporadically detected in several samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. Exceptions included carbon disulfide (8 μg/kg in SF33-2 and 21 μg/kg in SF40-2) chloromethane (4 μg/kg in SF33-2), dichloromethane (5 μg/kg in SF37-1), methyl acetate (12 μg/kg in SF33-2), acetone (540 μg/kg in SF48-2), and 2-butanone (44 μg/kg in SF34-2) which were detected at concentrations that were greater than two times that average background/reference concentrations. These constituents (with the exception of chloromethane) were also detected at mostly estimated concentrations in the adjacent source areas (BOF Sludge Disposal Area and the Northern Slag Pile Area) which suggests that floodplain areas could potentially become contaminated from the source areas via surface runoff.

SVOCs were sporadically detected in several samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations.

Dioxins and furans were analyzed for and detected in one downgradient shallow subsurface soil sample (SF31-2) in the southeast floodplain at a total 2,3,7,8-TCDD TEQ of 1.88 pg/g which is similar to the concentration detected in the corresponding surface soil sample. Dioxins and furans were not analyzed for in any background/reference samples. Dioxins and furans were also detected at elevated concentrations in surface soils in the adjacent source areas (BOF Sludge Disposal Area and the Northern Slag Pile Area) which suggest that floodplain areas could potentially become contaminated from the source areas via surface runoff.

PAHs were mostly detected at estimated (J-qualified) concentrations that were within background/reference locations. An exception is sample SF34-2 in which concentrations of

PAHs were greater than two times the average background/reference concentrations. Total PAHs in this sample were 17,689 μg/kg slightly higher than the concentration of total PAHs detected in the corresponding surface soil sample.

Pesticides were detected in several downgradient soil samples in the Shenango River floodplain; at estimated (J-, P-, and/or E-qualified) concentrations below their respective detection limits.

PCBs were not detected in most downgradient shallow subsurface soils. Exceptions included Aroclor 1254 (430 μg/kg in SF34-2) and Aroclor 1260 (3,900 μg/kg in SF33-2 and 1,900 μg/kg in SF34-2), which were detected at concentrations that were greater than two times the average background/reference concentrations. PCBs were detected in the same samples containing elevated levels of PAHs. Aroclors were also detected at elevated concentrations in surface soils in all source areas (BOF Sludge Disposal Area, Northern Slag Pile Area, and Southern Slag Pile Area) which suggest that floodplain areas could potentially become contaminated from the source areas via surface runoff.

Most TAL metals were detected in all downgradient shallow subsurface soils in the Shenango River floodplain at concentrations greater than two times the average background/reference concentrations. One location in particular (SS43-2) contained the higher concentrations of metals when compared to other downgradient shallow subsurface soil samples in the southeast floodplain. Metals contamination is generally widespread in the adjacent source areas (BOF Sludge Disposal Area, Northern Slag Pile Area, and Southern Slag Pile Area) which suggest that floodplain areas could potentially become contaminated from the source areas via surface runoff.

TOC ranged from 3,020 to 17,300 mg/kg with an average of 8,904 mg/kg in the downgradient shallow subsurface soils in the southeast floodplain. Samples SF38-2, SF39-2, SF40-1, SF42-2, and SF43-2 contained above average concentrations of TOC, which could provide some reason for the elevated concentrations of organic constituents (e.g. PAHs and/or PCBs) in some of these soils.

***4.3.2.3 Deep Subsurface Soil.*** Downgradient deep subsurface soil samples were collected in the southeast floodplain as described in Section 3.4. TOC was not analyzed in the deep subsurface soils in the southeast floodplain. The analytical results for detected constituents in these samples are presented in Table 4-32. The following major constituent groups were detected in the downgradient deep subsurface soils:

- SVOC

- PAHs
- Pesticides
- Metals (all TAL metals except antimony, beryllium, mercury, silver, sodium, thallium, and cyanide).

One SVOC, di-n-octylphthalate, was detected in one sample (RW12-1) at an estimated (J-qualified) concentration below its respective detection limit but greater than two times the average background/reference concentration. Di-n-octylphthalate was also detected at an estimated concentration in the corresponding surface soil sample for RW12-1.

PAHs were either not detected or detected at estimated (J-qualified) concentrations that were within background/reference concentrations.

Pesticides were either not detected or detected at estimated (J-qualified) concentrations that were less than two times the average background/reference locations. One location, RW12-1 (14-16 feet bgs), contained 4,4'-DDT at a concentration (5.1 μg/kg) that was greater than background/reference concentrations. It should be noted that this location also contained an elevated concentration of 4,4'-DDT in the surface soil.

TAL metals were either not detected or detected at estimated (J-qualified) concentrations within background/reference concentrations. An exception was RW12-1 (12-14 feet bgs) which contained notably high concentrations of aluminum (14,200 mg/kg), chromium (22.7 mg/kg), nickel 37.7 mg/kg), and vanadium (24.4 mg/kg) when compared to two times the average background/reference concentrations and the other downgradient deep subsurface soils collected in the southeast floodplain.

***4.3.2.3 Summary of Nature and Extent in Southeast Floodplain.*** Generally, the same contaminants detected in the adjacent source/slag areas (BOF Sludge Disposal Area, Northern Slag Pile, and Southern Slag Pile Area) were also detected in the southeast floodplain area. Several VOCs and phthalates were detected in isolated samples and are common laboratory contaminants; therefore, these may not be site-related (EPA, 1999). In particular, PAHs, 2-methylnaphthalene, dibenzofuran, and other SVOCs were detected at similar concentrations (greater than background/reference concentrations) in the northern portion of the BOF Sludge Disposal Area, southeast floodplain, and Shenango River sediment. This would suggest that the floodplain areas could potentially become contaminated from the source area via surface runoff or during flooding along the Shenango River. There appears to be a relationship between the higher concentrations of PAHs, PCBs, pesticides, and metals and the presence of an old "oxbow" of the Shenango River in the southeast floodplain. This is a low area where groundwater is near the surface and toward which local runoff is directed as presented in Figure 4-4. Contamination would be expected to accumulate in this area from surface runoff and from periodic flooding of the Shenango River. Contaminants from upgradient source areas along the Shenango River could potentially be carried downstream and deposited on the southeast floodplain.

### 4.3.3 Unnamed Tributary Floodplain

Downgradient surface soil samples were collected in the unnamed tributary floodplain area; deeper samples were not collected. Based on the shallow groundwater flow contours and the surface drainage area map, only contaminants from the Southern Slag Pile Area are likely to be present in these soils.

***4.3.3.1 Surface Soil.*** Downgradient surface soil samples were collected in the unnamed tributary floodplain as described in Section 3.4. The analytical results for detected constituents in these samples are presented in Table 4-33. The following major constituent groups were detected in the downgradient surface soils:

- VOCs
- SVOC
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except antimony, beryllium, cadmium, cobalt, potassium, silver, sodium, thallium, and cyanide).

VOCs were sporadically detected in very few downgradient surface soil samples at estimated (J-qualified) concentrations below their respective detection limits and/or within background/reference concentrations. Exceptions include carbon disulfide (14 µg/kg in SF38-2, 67 µg/kg in SF40-2 and its duplicate) and 2-butanone at concentrations that were greater than background/reference concentrations. Carbon disulfide was also detected in surface soils in the adjacent source areas (Southern Slag Pile Area) which suggests that floodplain areas could potentially become contaminated from the source areas via surface runoff.

SVOCs were either not detected or detected at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. An exception included location SF38-2 in which concentrations of 2-methynaphthalene (2,600 µg/kg) and dibenzofuran (1,300 µg/kg) were detected at concentrations that were greater than two times the average background/reference concentrations. These two samples also contained elevated levels of PAHs. While 2-methynaphthalene and dibenzofuran were not detected at elevated concentration in the unnamed tributary sediments, they were detected at in surface soils in the adjacent source areas (Southern Slag Pile Area) which suggests that floodplain areas could potentially become contaminated from the source areas via surface runoff.

PAHs were either not detected or detected at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. An exception included location SF38-2 in which concentrations of benzo(a)anthracene (570 µg/kg) and phenanthrene (2,100 µg/kg) were detected at concentrations that were greater than two times the average background/reference concentrations. PAHs were also detected at elevated concentrations in surface soils in the adjacent source areas (Southern Slag Pile Area) and in sediment in the unnamed tributary in the vicinity of SF39-2 which suggests that floodplain areas could potentially become contaminated from the source areas via surface runoff or from flooding in the unnamed tributary.

Pesticides were either not detected or detected at estimated (J-qualified) and/or (P-qualified) concentrations below their respective detection limits and within background/reference concentrations.

One PCB (Aroclor 1260) was detected in all downgradient soils in the unnamed tributary floodplain; however, all concentrations were within background/reference concentrations.

Several TAL metals were detected in three downgradient soil samples in the unnamed tributary floodplain at concentrations greater than two times the average background/reference concentrations (as presented in Figure 4-4). One location in particular (SF40-2 and its duplicate) contained the highest concentrations of metals including aluminum (20,000 mg/kg), barium (244 mg/kg), calcium (33,800 mg/kg), copper (60.3 mg/kg), manganese (1,400 mg/kg), mercury (0.54 mg/kg), selenium (4.4 mg/kg), and vanadium (92.5 mg/kg) when compared to other downgradient soil samples in the unnamed tributary floodplain. These metals were also detected at elevated concentrations in surface soils in the adjacent source areas (Southern Slag Pile Area) and in sediment in the unnamed tributary which suggests that floodplain areas could potentially become contaminated from the source areas via surface runoff or from flooding in the unnamed tributary.

TOC in this area ranged from 10,900 to 69,100 mg/kg with an average of 41,317 mg/kg. Samples SF38-2 and SF40-2 (including its duplicate) contained above average concentrations of TOC, which could provide some reason for the elevated concentrations of organic constituents (e.g. PAHs and/or PCBs) in some of these soils.

***4.3.3.2 Summary of Nature and Extent in Unnamed Tributary Floodplain.*** The unnamed tributary floodplain area is immediately downgradient and adjacent to the Southern Slag Area; it is not likely to be impacted by contamination from the other source areas due to its location. Fewer contaminants were detected in this area than in the source areas; however, in general, the same types of contaminants (PAH, PCBs, and metals) were detected, which suggests that the unnamed tributary could potentially become contaminated from the source areas via surface runoff. 2-Butanone was detected in isolated samples (but not in adjacent source areas) and is a common laboratory contaminant; therefore, it may not be site-related (EPA, 1999). The sediments in the unnamed tributary contained notably high concentrations of metals. Given the relatively low topographic elevation in the area of the unnamed tributary, it is probable that contaminants are likely to settle in this area after flooding along the unnamed tributary.

### 4.3.4 Ohio Street Wetlands

Downgradient surface soil samples were collected in the Ohio Street wetlands; deeper samples were not collected. Based on the shallow groundwater flow contours and the surface drainage area map, only contaminants related to surface water runoff from the Southern Slag Pile Area are likely to be present in these soils. Since these samples were collected in non-floodplain areas (they are above the Shenango River floodplain in elevation) they were compared to the upland soil background data set; not the floodplain soil data set.

***4.3.4.1 Surface Soil.*** Surface soil samples were collected in the Ohio Street wetlands as described in Section 3.4. The analytical results for detected constituents in these samples are presented in Table 4-34. The following major constituent groups were detected in the Ohio Street wetland soils:

- VOCs
- SVOC
- PAHs
- Pesticides
- PCBs

- Metals (all TAL metals except antimony, mercury, thallium and cyanide).

VOCs were detected sporadically detected in very few wetland surface soil samples at estimated (J-qualified) concentrations below their respective detection limits and/or within upland background/reference concentrations.

SVOCs were sporadically detected in very few wetland surface soil samples at estimated (J-qualified) concentrations below their respective detection limits and/or within upland background/reference concentrations.

PAHs were either not detected or detected at estimated (J-qualified) concentrations below their respective detection limits and/or within upland background/reference concentrations in most wetland samples. Exceptions included samples SF49-2 and SF51-2 which contained concentrations total PAHs were greater than two times the average upland background/reference concentrations (4,126 µg/kg in SF51-2 and 6,915 µg/kg in SF49-2). PAHs were also detected at elevated concentrations in surface soils in the adjacent source areas (Southern Slag Pile Area) which suggests that the wetland areas could potentially become contaminated from the source areas via surface runoff.

Pesticides were either not detected or detected sporadically at estimated (J-qualified) and/or (P-qualified) concentrations below their respective detection limits and/or within upland background/reference concentrations. Exceptions included endrin aldehyde (5.6 µg/kg in SD32-1) and 4,4'-DDD (5.8 µg/kg in SD32D-1) which were detected at concentrations that were greater than two time the average upland background/reference concentrations. It should be noted that these constituents were each detected in one sample in a duplicate pair, but not the other; therefore, conclusions based on this data should be treated with caution.

PCBs were either not detected or detected sporadically at estimated (J-qualified) or non-precise (P-qualified) concentrations below their respective detection limits and/or within upland background/reference concentrations. Exceptions included Aroclor 1254 (48 µg/kg in SF48-2 and 140 µg/kg in SF49-2) and Aroclor 1260 (20 µg/kg in SF48-2 and 190 µg/kg in SF49-2) which were detected at concentrations hat were greater than two time the average background/reference concentrations. Aroclors were also detected at elevated concentrations in surface soils in the adjacent source areas (Southern Slag Pile Area) which suggests that the wetland areas could potentially become contaminated from the source areas via surface runoff.

Several TAL metals (cadmium, chromium, magnesium, manganese, potassium, silver, vanadium, and zinc) were detected in several samples in the Ohio Street wetlands at concentrations that were greater than two times the average upland background/reference concentrations. These detections were somewhat sporadic and infrequent with no apparent pattern. Metals were also detected at elevated concentrations in surface soils in the adjacent source areas (Southern Slag Pile Area) which suggests that the wetland areas could potentially become contaminated from the source areas via surface runoff.

TOC in this area ranged from 13,800 to 43,000 mg/kg with an average of 25,275 mg/kg. Samples SF48-2 contained above average concentrations of TOC, which could provide some reason for the elevated concentrations of organic constituents (e.g. PAHs and/or PCBs) in some of these soils.

***4.3.4.2 Nature and Extent in Ohio Street Wetlands.*** The wetlands along the south side of Ohio Street are immediately adjacent and downgradient of the Southern Slag Area; this is not likely to be impacted by contamination from the other source areas due to its location. Fewer contaminants were detected in this area than in the source areas; however, in general, the same types of contaminants were detected. In particular, PAH, PCBs, and metals were detected at elevated concentrations in the Ohio Street wetlands as well as in surface soils in the Southern Slag Pile Area, which suggests that the wetland areas could potentially become contaminated from the source areas via surface runoff and deposition of settled materials.

## 4.4 Groundwater

Groundwater samples were collected from the shallow groundwater aquifer, the glacial till aquifer, the gravel zone, and the bedrock aquifer.

### 4.4.1 Shallow Groundwater Aquifer

Groundwater samples were collected from the shallow groundwater aquifer in the Northern Slag Pile Area, Southern Slag Pile Area, and southeast floodplain as described in Section 3.3. The analytical results for groundwater collected from the shallow aquifer are presented in Table 4-35 and Figure 4-9. The following major constituent groups were detected:

- VOCs
- SVOC
- Metals (all TAL metals except beryllium, mercury, and nickel).

VOCs were either not detected or detected sporadically at estimated (J-qualified) concentrations in most shallow groundwater samples. Exceptions included one location in the Northern Slag Pile Area (AMW1S, both phases) and two locations in the southeast floodplain area (AMW2S and AMW3S, both phases) in which several VOCs were detected at concentrations that were greater than two times the average background/reference concentrations. Sample AMW1S contained elevated concentrations of 1,1-dichloroethane (2 μg/L), 1,1-dichloroethylene (1.7 μg/L), benzene (2 μg/L), cis-1,2-dichloroethene (99 μg/L), trans-1,2-dichloroethene (7 μg/L), trichloroethylene (3 μg/L), and vinyl chloride (3 μg/L). Sample AMW2S-2 contained an elevated concentration of acetone (16 μg/L). Sample AMW3S-2 contained trichloroethylene (2.3 μg/L). It should be noted that none of these constituents were detected in overlying soils at, or upgradient of, these monitoring well locations. Additionally, none were detected in downgradient soils or in surface water.

One SVOC [bis(2-ethylhexyl)phthalate] was detected sporadically in shallow groundwater at estimated (J-qualified) concentrations near or below their respective detection limits.

Several TAL metals (except aluminum, antimony, beryllium, cyanide, lead, mercury, nickel, selenium, and silver) were detected in all shallow groundwater samples at concentrations that were above two times the average background/reference concentrations. All of these metals (except chromium, cobalt, and copper), were detected in filtered groundwater samples from this aquifer. The southern end of the Southern Slag Pile Area (sample AMW4S-2 in particular) contained notably higher concentrations of metals (cadmium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, sodium, thallium, and vanadium) when compared to other shallow groundwater samples and background/reference samples as presented in Figure 4-5.

Evaluation of site-specific local hydrogeologic data indicates that the shallow aquifer is discharging into the wetlands, unnamed tributary and the Shenango River. Metals were observed concentration in the surficial aquifer and in sediments and floodplain soils in these probable discharge areas. Several VOCs and phthalates were detected in isolated samples and are common laboratory contaminants; therefore, these may not be site-related (EPA, 1999). Based on these observations, it is apparent that contaminants are migrating from shallow groundwater under the source areas into the wetlands, the unnamed tributary, and the Shenango River.

### 4.4.2 Glacial Till Aquifer

Groundwater samples were collected from the glacial till groundwater aquifer in the Northern Slag Pile Area, Southern Slag Pile Area, BOF Sludge Disposal Area, southeast floodplain, unnamed tributary, and Shenango River floodplain as described in Section 3.3. The analytical results for groundwater collected from the glacial till aquifer are presented in Table 4-36 and Figure 4-10. The following major constituent groups were detected:

- VOCs
- SVOC
- Pesticides
- PAHs
- Metals (all TAL metals except mercury).

VOCs were detected sporadically in the glacial till aquifer at concentrations that were greater than two times the average background/reference concentrations. In the Northern Slag Pile Area, sample RW17-2 contained notably higher concentrations of benzene (3.9 μg/L), ethylbenzene (6.2 μg/L), and xylenes (40 μg/L); however, these constituents were not detected in the surface or subsurface soils of the upgradient source area (the Northern Slag Pile Area). A similar situation occurred in sample RW5-1 in the Southern Slag Pile Area which contained notably higher concentrations of ethylbenzene (7 μg/L), and xylenes (50 μg/L); however, these constituents were not detected in deep subsurface soils in the upgradient source area (the Southern Slag Pile Area). In the Shenango River floodplain, location RW16 contained elevated concentrations of cis-1,2-dichloroethene (33 μg/L), trans-1,2-dichloroethene (2 μg/L), and vinyl chloride (3 μg/L) which were detected in the glacial till aquifer during both phases. None of these constituents were detected in the surface or subsurface soils of the Shenango River floodplain or in surface water; however, they were detected in the overlying shallow aquifer.

SVOCs were either not detected or detected sporadically in the glacial till aquifer at estimated (J-qualified) concentrations near or below their respective detection limits. An exception was 2-methylnaphthalene which was detected in groundwater at samples RW16-1 (3 μg/L) in the Northern Slag Pile Area, RW8-1 (3 μg/L) in the Southern Slag Pile Area and RW17 (6 μg/L in both phases) in the Shenango River floodplain area at concentrations that were greater than two times the average background/reference concentrations. It should be noted that 2-methylnaphthalene was also detected in surface soils in the Northern Slag Pile Area and in deep subsurface soils in the Southern Slag Pile Area in close proximity to these samples.

PAHs were either not detected or detected sporadically in the glacial till aquifer at estimated (J-qualified) concentrations near or below their respective detection limits. Exceptions included sporadic detections of naphthalene (3 µg/L in RW17) and phenanthrene (0.6 µg/L in RW18) in the Northern Slag Pile Area which detected at concentrations that were greater than two times the average background/reference concentrations.

Pesticides and PCBs were either not detected or detected at estimated (J-qualified) concentrations that were below their respective detection limits.

Most TAL metals (except beryllium, cobalt, cyanide, and mercury) were detected in all glacial till groundwater samples at concentrations that were above two times the average background/reference concentrations. All of these same metals (except selenium and silver) were detected in filtered groundwater samples from this aquifer. Overall, the occurrence of elevated metal concentrations in the glacial till aquifer is widespread. Several locations including RW8, RW9, and RW23 in the Southern Slag Pile Area and RW17 in the Northern Slag Pile Area contained notably higher concentrations of metals (aluminum, calcium, copper, iron, manganese, sodium, and vanadium) in the glacial till aquifer than the groundwater samples collected in the other exposure areas. These areas are presented in Figure 4-5.

Evaluation of site-specific local hydrogeologic data indicates that the glacial till aquifer is discharging into the wetlands, unnamed tributary, and the Shenango River. Metals were observed concentration in the surficial aquifer and in sediments and floodplain soils in these probable discharge areas. Several VOCs were detected in isolated samples and are common laboratory contaminants; therefore, these may not be site-related (EPA, 1999). Based on these observations, it is apparent that contaminants are migrating from shallow groundwater under the source areas into the wetlands, the unnamed tributary, and the Shenango River.

### 4.4.3 Gravel Zone

Groundwater samples were collected fom the gravel zone groundwater aquifer (Northern Slag Pile, Southern Slag Pile, and southeast floodplain) as described in Section 3.3. The analytical results for groundwater collected from gravel zone aquifer are presented in Table 4-37 and Figure 4-11. The following major constituent groups were detected:

- VOCs
- SVOC
- Metals (all TAL metals except cobalt, copper, cyanide, mercury, nickel, selenium, silver, vanadium, and zinc).

VOCs were either not detected or detected sporadically at estimated (J-qualified) concentrations below their respective detection limits in most gravel zone groundwater samples. An exception was acetone which was detected at one location in the southeast floodplain (AMW2D-2 and its duplicate), at concentrations (5.5 µg/L and 5.9 µg/L, respectively) that were greater than two times the average background/reference concentrations.

SVOCs were either not detected or detected sporadically in the gravel zone aquifer at estimated (J-qualified) concentrations near or below their respective detection limits. An exception was bis(2-ethylhexyl)phthalate which was detected at samples AMW2D-2 (9.1 µg/L) in the southeast floodplain at concentrations that were greater than two times the average background/reference concentrations.

TAL metals were detected in all gravel zone groundwater samples; however, most were detected at concentrations that were within background/reference concentrations. Exceptions include barium, beryllium (one sample), calcium, magnesium, potassium, and sodium which were detected sporadically at concentrations that were greater than two times the average background/reference concentrations. Barium, calcium, iron, magnesium, manganese, potassium, and sodium were detected in filtered groundwater samples from this aquifer. A sample collected in the southeast floodplain (AMW2D-2 and its duplicate) contained notably higher concentrations of metals (barium, calcium, magnesium, potassium, and sodium) when compared with other exposure areas. Several VOCs and phthalates were detected in isolated samples and are common laboratory contaminants; therefore, these may not be site-related (EPA, 1999).

### 4.4.4 Bedrock Aquifer

Groundwater samples were collected from the bedrock groundwater aquifer (Northern Slag Pile and southeast floodplain) as described in Section 3.3. The analytical results for groundwater collected from bedrock aquifer are presented in Table 4-38.

Barium, selenium, and sodium were the only constituents detected in groundwater from the bedrock aquifer at concentrations that were greater than two times the average background/reference concentrations. However, it should be noted that all of these concentrations were estimated (J-qualified) and below their respective detection limits. Barium was not detected in filtered groundwater samples from this aquifer.

### 4.4.5 Residential Wells

Groundwater samples were collected from the residential wells within a 0.25-mile vicinity of the SSFW site as described in Section 3.3. The analytical results for groundwater collected from residential wells are presented in Table 4-39. The following major constituent groups were detected:

- VOCs
- SVOCs
- Metals (all TAL metals except aluminum, antimony, beryllium, chromium, cobalt, cyanide, mercury, silver, thallium, and vanadium).

VOCs were mostly not detected or detected sporadically at estimated (J-qualified) concentrations below their respective detection limits in residential well samples. An exception was acetone which was detected at 1899 Stateline Road at a concentration (10 µg/L) that was greater than its respective detection limit. This concentration was L-qualified which indicates that the concentration could be biased low. It should be noted that acetone is considered to be a common laboratory contaminant and may not be site-related (EPA, 1999).

SVOCs were either not detected or detected sporadically in the a few residential wells at estimated (J-qualified) concentrations below their respective detection limits.

TAL metals (with the exception of aluminum, antimony, beryllium, chromium, cobalt, cyanide, mercury, selenium, silver, thallium, and vanadium) were detected in all residential well samples at concentrations above their respective detection limits with a widespread distribution. Arsenic and manganese were the only metals detected at levels exceeding drinking water MCLs. Residential wells were not analyzed for dissolved metals. It should be noted that all residential groundwater samples showed concentrations of arsenic and manganese that were within or below the regional concentrations of these constituents as discussed in Section 4.1.16.

## 4.5 Sediment

Sediment sample locations were co-located with the surface water locations and were evaluated in four exposure areas downstream of source areas: the emergent wetlands, the Shenango River, the wetland ponds, and the unnamed tributary. Sediment samples were also collected from background/reference areas not likely to have been impacted by the site. Emergent wetland and wetland pond sediment samples were compared to sediments collected in the reference wetland. Shenango River sediment samples were compared to sediment samples collected from upstream background sites. Unnamed tributary sediment samples were compared to a sediment sample collected from an upstream background site. All sediment samples (including background/reference samples) were analyzed for the full TCL/TAL analytical suite, TOC, grain size, and SEM/AVS. One background/reference sediment sample (SD22) in the Shenango River received dioxin/furans analyses only.

### 4.5.1 Emergent Wetlands

Sediment samples were collected from the emergent wetlands as described in Section 3.5. The analytical results for sediment in the emergent wetlands are presented in Table 4-40. Based on the groundwater contours for the shallow aquifer and the surface soils drainage area map, the Southern Slag Pile Area is only likely source of contamination into this area. The following major constituent groups were detected in sediment in the emergent wetlands:

- VOCs
- SVOC
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except antimony and sodium).

VOCs were detected very infrequently at low concentrations below their respective detection limits and within the wetland area background/reference concentrations. An exception was acetone which was detected in three samples (190 µg/kg in SD01-2, 150 µg/kg in SD04-2, and 81 µg/kg in SD06-2) at concentrations that were greater than two times the average background/reference concentrations. It should be noted that acetone is a common laboratory contaminant and may not be site-related (EPA, 1999).

SVOCs were detected sporadically in the emergent wetland sediment samples at estimated (J-qualified) concentrations below their detection limits and within background/reference concentrations. Exceptions included phenol (2,400 µg/kg in SD79-1) which was detected at non-qualified concentrations that were greater than two times the average background/reference concentrations. Acetophenone was detected at a notably high estimated (J-qualified) concentration of 1,000 µg/kg in SD79-1 and in the adjacent wetland ponds (discussed below).

PAHs, and pesticides were detected sporadically in the emergent wetland sediment samples at estimated (J-qualified) concentrations below their detection limits and within background/reference concentrations.

PCBs were mostly not detected in the emergent wetland sediment samples. An exception was Aroclor-1248 which was detected in SD08-1 at a concentration (130 µg/kg) that was greater than two times that average background/reference concentrations. Aroclor-1248 was not detected at significant levels in surface water or shallow groundwater samples; however, it was detected at elevated concentrations in surface soils in the Southern Slag Pile Area and in sediments in the unnamed tributary, wetland ponds, and Shenango River. This could indicate a possible connection between these areas via surface runoff and flood events.

Metals were the most frequently detected constituents in the emergent wetland sediment. Those that were detected in sediment at concentrations above their respective detection limits include aluminum, arsenic, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, vanadium, and zinc. Overall, metals contamination generally widespread in emergent wetland sediment with the highest concentrations of metals detected in samples (SD08-1, SD09-1, SD79-1, SD89-1, SD90-1, and SD94-1) with no apparent pattern. Metals were detected at elevated concentrations in surficial groundwater, surface soils in the Southern Slag Pile Area, and in sediments in the unnamed tributary, wetland ponds, and Shenango River. This could indicate a possible connection between these areas via groundwater transport, surface runoff, and flood events.

Three sediment samples (SD02-2, SD05-2, and SD06-2) indicating had SEM:AVS ratios greater than 1 that metals in sediment are both bioavailable and potentially toxic.

### 4.5.2 Wetland Ponds

Sediment samples were collected from the wetland ponds immediately adjacent and downgradient of the Southern Slag Pile Area as described in Section 3.5. Based on the groundwater contours for the shallow aquifer and the surface soils drainage are map, the Southern Slag Pile Area is only likely source of contamination into this area. In addition, the wetland ponds are the lowest features in the landscape and would be expected to accumulate contaminants from the adjacent wetlands as well. The analytical results for the wetland ponds are presented in Table 4-41. The following major constituent groups were detected in sediment in the wetland ponds:

- VOCs

- SVOC
- PAHs
- Pesticides
- PCBs
- Dioxins/furans
- Metals (all TAL metals except sodium).

VOCs were detected very infrequently at low concentrations below their respective detection limits and within the wetland area background/reference concentrations.

SVOCs were detected sporadically in very few wetland pond sediment samples at low estimated (J-qualified) concentrations below their detection limits and within background/reference concentrations. Exceptions included several samples (SD48-1, SD49-1, SD50-1, and SD51-1) in the small wetland pond and (SD45-1, SD46-1, and SD47-1) in the other small ponds also contained estimated (J-qualified) concentrations of SVOCs (acetophenone and benzaldehyde) that were greater than background/reference concentrations as presented in Figure 4-6.

PAHs were detected sporadically in very few wetland pond sediment samples at low estimated (J-qualified) concentrations below their detection limits and within background/reference concentrations. Exceptions included several samples (SD48-1, SD49-1, SD50-1, and SD51-1) in the small wetland pond and (SD45-1, SD46-1, and SD47-1) in the other small ponds also contained estimated (J-qualified) concentrations of most PAHs that were greater than background/reference concentrations. These areas, which also showed elevated concentrations of SVOCs are presented in Figure 4-6. PAHs were detected at high estimated (J-qualified) concentrations shallow groundwater, in surface soils in the Southern Slag Pile Area, and in sediments in the unnamed tributary and Shenango River. This could indicate a possible connection between these areas via groundwater transport, surface runoff, and flood events.

Pesticides were detected sporadically in very few wetland pond sediment samples at low estimated (J-qualified) concentrations below their detection limits and within background/reference concentrations. An exception was heptachlor epoxide which was detected in sample SD75-1 at a concentration (26 µg/kg) that was greater than two times the average background/reference concentrations. Heptachlor epoxide was not detected in surface water; however, it was detected at low estimated (J-qualified) concentrations in surface soils and shallow groundwater in the Southern Slag Pile Area which suggests that the wetland ponds could potentially become contaminated from the source areas via surface runoff or groundwater recharge.

PCBs were detected sporadically in very few wetland pond sediment samples at low estimated (J-qualified) concentrations below their detection limits and within background/reference concentrations. Exceptions included Aroclor-1248 (170 µg/kg in the large wetland pond sample SD07-2) and Aroclor-1260 (100 µg/kg in the other wetland pond sample SD18-1). In addition, several samples (SD48-1, SD49-1, SD50-1, SD51-1, and SD75-1) in the small wetland pond contained estimated (J-qualified) concentrations of most Aroclors that were greater than background/reference concentrations. These areas, which also showed elevated concentrations of SVOCs and PAH are presented in Figure 4-6. Aroclors were not detected in surface water locations or shallow groundwater; however, they were detected at elevated concentrations in soils from the Southern Slag Pile Area, and in sediments in the unnamed tributary and Shenango River. This could indicate a possible connection between these areas via surface runoff and flood events.

Dioxin/furans were detected in the small wetland pond sample SD24-2 and its duplicate SD924-2 with an average total 2,3,7,8-TCDD TEQ of 0.85 pg/g.

Metals were the most frequently detected constituents in the wetland pond sediment. Several metals were detected at concentrations that were greater than two times the average background/reference concentrations including aluminum, arsenic, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, selenium, silver, thallium, vanadium, and zinc. The metals contamination in the wetland ponds is generally widespread. The large wetland pond contained the highest concentrations of arsenic, copper lead, magnesium, and silver whereas the small wetland pond contained the highest concentrations of barium, calcium, manganese, vanadium, and zinc as presented in Figure 4-6. The small wetland pond contained a notable concentration of calcium (402,000 mg/kg) which could be major factor in the elevated pHs observed in both groundwater and surface water in the area. Calcium carbonate was observed leaching form nearby slag piles and is a likely contributing factor to the elevated pH levels. The other wetland pond contained the highest concentrations of aluminum, chromium, iron, nickel, selenium, and thallium. Metals were detected at elevated concentrations in surficial groundwater, surface soils in the Southern Slag Pile Area, and in sediments in the unnamed tributary, emergent wetlands, and Shenango River. This could indicate a possible connection between these areas via groundwater transport, surface runoff, and flood events.

One sediment sample (SD24-2 and its duplicate) from the largest of the small wetland ponds had SEM:AVS ratios greater than 1 (they were greater than 45) indicating that metals in sediment are both bioavailable and potentially toxic. Other sediment samples all had SEM:AVS ratios of less than 1.

### 4.5.3 Shenango River

Sediment samples were collected from the Shenango River as described in Section 3.5. The analytical results for the Shenango River are presented in Table 4-42. Based on the groundwater contours for the shallow aquifer and the surface soils drainage are map, the BOF Sludge Pile and the Northern Slag Pile are the likely sources of contamination into this area. It is important to note that the Shenango River watershed is heavily industrialized upgradient of the site and that there are numerous additional potential contaminant sources. Additionally, another Superfund site (Westinghouse), a known source of PCB contamination, is located upgradient of the site. Below the discharge point of the unnamed tributary, contaminants from the Southern Slag Pile Area may enter the system. The following major constituent groups were detected in sediment in the Shenango River:

- VOCs
- SVOC
- PAHs
- Pesticides
- PCBs
- Dioxins/furans
- Metals (all TAL metals except antimony and sodium).

VOCs were detected sporadically in the Shenango River sediment samples at low estimated (J-qualified) concentrations below their respective detection limits and within background/reference. An exception was sample SD59-1 in which 1,2-dichlorobenzene (29 µg/kg); 1,2,4-trichlorobenzene (55 µg/kg); 1,4-dichlorobenzene (250 µg/kg); chlorobenzene (120 µg/kg); and mdichlorobenzene (1,200 µg/kg) were detected at concentrations that were greater than two times the average background/reference concentrations. These VOCs were not detected in surface water, source area surface soils, or in soil samples downgradient of the site, suggesting that they are not site-related.

SVOCs were detected sporadically in the Shenango River sediment samples at low estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. An exception was dibenzofuran which was detected

(140,000 µg/kg in sample SD63-1) at a concentration that was greater than two times that average background/reference concentrations. In addition, 2-methylnaphthalene and carbazole were detected in samples SD61-1 and SD-63 at estimated (J-qualified) concentrations that were greater than background/reference concentrations. This area of elevated SVOC concentrations is presented in Figure 4-7. Dibenzofurans and 2-methylnapthalene are often found in association with PAHs (discussed below) at hazardous wastes sites. Further, these constituents were also detected at elevated levels in the underlying groundwater (glacial aquifer) in the source areas, in surface soils in the source areas, and in downgradient floodplain soils along the Shenango River. This suggests that there is a possible connection between these areas via groundwater transport, surface runoff, and flood events.

PAHs were mostly detected in the Shenango River sediment samples at estimated (J-qualified) concentrations below their respective detection limits and within background/reference concentrations. Exceptions included samples SD09-2, SD31-1, SD52-1, SD61-1, and SD63-1 which all contained concentrations of PAHs that were greater than two times the average background/reference concentrations. These locations are presented in as presented in Figure 4-7. Location SD63 contained a notably high concentration of total PAHs (2,629,000 µg/kg). PAHs were not detected in surface water and were detected sporadically at low estimated (J-qualified) concentrations in surficial groundwater (glacial till aquifer only). However, PAHs were detected at elevated concentrations in downgradient floodplain soils of the Shenango River samples (SS4-1, SS5-1, and SS6-1) which are in the vicinity of SD63-1. This suggests that surface runoff from the Shenango River floodplain could contribute to the elevated sediment concentrations.

Pesticides were mostly detected in the Shenango River sediment samples at estimated (J- and L-qualified) or non-precise (P-qualified) concentrations below their respective detection limits and within background/reference concentrations. Exceptions included 4'4'-DDE (1,100 µg/kg in SD55-1 and 47 µg/kg in SD56-1); heptachlor epoxide (120 µg/kg in SD56-1); heptachlor (2.9 µg/kg in SD63-1 and 4.4 µg/kg in SD09-2); endrin (11 µg/kg in SD09-2); gamma-chlordane (21 µg/kg in SD09-2). These constituents were also detected at elevated levels in the underlying groundwater (glacial aquifer) in the source areas, in surface soils in the source areas, and in downgradient floodplain soils along the Shenango River. This suggests that there is a possible connection between these areas via groundwater transport, surface runoff, and flood events.

PCBs were detected in the Shenango River sediment at SD08-2, SD09-2, SD10-2, SD25-2, and SD26-2, which contained elevated concentrations of Aroclor 1260 ranging from 92 μg/kg (SD25-2) to 450 μg/kg (SD09-2). Aroclors were also detected at elevated levels in surface soils in the source areas and in downgradient floodplain soils along the Shenango River. This suggests that there is a connection between these areas via surface runoff and flood events.

Dioxins/furans were detected in sample SD25-2 at 0.37 pg/g, which within the background/reference concentration for total 2,3,7,8-TCDD TEQ of 11.15 pg/g.

Metals were the most frequently detected constituents in the Shenango River sediment samples. Arsenic, cadmium, cobalt, copper, lead, manganese, selenium, silver, and zinc were detected at concentrations above their respective detection limits and two times average site background/reference concentrations. Sample location SD60-1, which is located downstream of the source areas, contained higher concentrations of lead (1,400 mg/kg) and zinc (10,100 mg/kg) than in the other Shenango River sediment samples or background/reference sediment. Generally, elevated concentrations of metals occur in the samples located in the Shenango River south of Ohio Street as presented in Figure 4-7. Given the drainage patterns at the site and the fact that the same constituents were also detected at elevated levels in surface soils in the source areas and in downgradient floodplain soils along the Shenango River, contaminated sediments are likely migrate to the river via surface runoff and to and from the river during flood events.

Two sediment samples (SD08-2 and SD10-2) had SEM:AVS ratios greater than 1 indicating that metals in sediment are both bioavailable and potentially toxic.

It should be noted that the farthest downstream samples, SD09-2 and SD10-2, contained selenium (4.7 μg/kg in SD09-2) and zinc (1,500 μg/kg in SD09-2 and 902 μg/kg in SD10-2) at concentrations that were greater than two times the average background/reference concentrations. These two metals are known to be present in the source areas and their presence in these furthest downstream samples may indicate that the nature and extent of contamination has not been determined in downstream sediments.

### 4.5.4 Unnamed Tributary

Sediment samples were collected from the unnamed tributary as described in Section 3.5. The analytical results for the unnamed tributary are presented in Table 4-43. Based on the groundwater contours for the shallow aquifer and the surface soils drainage are map, the

Southern Slag Pile Area is only likely source of contamination into this area. In addition, all drainage from the wetland ponds and the adjacent wetlands would ultimately flow through this area as well. The following major constituent groups were detected in sediment in the unnamed tributary:

- VOCs
- SVOCs
- PAHs
- Pesticides
- PCBs
- Metals (all TAL metals except sodium).

VOCs were detected sporadically in the unnamed tributary sediment samples at low estimated (J-qualified) concentrations below their respective detection limits and within background/reference. An exception was 2-butanone which was detected in sample SD106-1 (47 µg/kg) and SD107-1 (33 µg/kg) at concentrations that were greater than the average background/reference concentrations. 2-Butanone is a common laboratory contaminant and may not be site-related (EPA, 1999).

SVOCs were detected sporadically in very few unnamed tributary sediment samples at low estimated (J-qualified) concentrations below their detection limits.

PAHs were detected sporadically in the majority of unnamed tributary sediment samples at low estimated (J-qualified) concentrations below their detection limits and within background/reference concentrations. Exceptions include sample SD02-1, SD12-1, and SD81-1, in which PAHs were detected at concentrations that were greater than two times average background/reference concentrations. Total PAH concentrations ranged from 9,405 µg/kg in SD12-1 to 21,430 µg/kg in SD81-1. These areas are presented in Figure 4-8. PAHs were also detected at elevated levels in the underlying groundwater (glacial aquifer) in the Southern Slag Pile Area, in surface soils in the source areas, and in downgradient southeast floodplain soils. This suggests that there is a possible connection between these areas via groundwater transport, surface runoff, and flood events.

Pesticides were detected sporadically in very few unnamed tributary sediment samples at low estimated (J-qualified) concentrations below their detection limits.

Aroclor-1260 was detected in SD12-2, SD02-1, SD03-1, SD07-1, SD11-1, SD12-1, SD13-1, SD14-1, SD15-1, SD16-1, SD17-1, SD82-1, SD83-1 at concentrations that were greater than two times the average background/reference concentrations. This area is presented in Figure 4-7. The concentration of Aroclor-1260 in these samples ranged from 150 µg/kg (SD12-2) to 1,900 µg/kg (SD02-1). Aroclors were also detected at elevated levels in soils from the Southern Slag Pile Area, in downgradient floodplain soils along the Shenango River, and in the southeast floodplain (one sample). This suggests that there is a possible connection between these areas via surface runoff and flood events.

Several TAL metals (aluminum, arsenic, calcium, chromium, copper, iron, and zinc) were detected the majority of the sediment samples in the unnamed tributary at concentrations that were greater than two times the average background/reference concentrations. The area with the highest concentrations of metals is presented in Figure 4-8. Metals were detected at elevated concentrations in surficial groundwater, surface soils in the Southern Slag Pile Area, and in sediments in the unnamed tributary, emergent wetlands, and Shenango River. This could indicate a possible connection between these areas via groundwater transport, surface runoff, and flood events.

Only one sample was analyzed for SEM:AVS; however, it did not indicate a ratio greater than 1.

## 4.6 Surface Water

Surface water sample locations were co-located with the sediment locations and were evaluated in the Shenango River, the wetland ponds, and the unnamed tributary as discussed in Section 3.6. Surface water samples were also collected from background/reference locations not likely to have been impacted by the site.

Water quality parameters (DO, turbidity, conductivity, pH, and temperature) recorded at surface water sample locations are presented in Table 4-44.

### 4.6.1 Wetland Ponds

Surface water samples were collected from the Wetland Ponds (large, small, and other) immediately adjacent and downgradient of the Southern Slag Pile Area as described in Section 3.6. The analytical results for the Wetland Ponds are presented in Table 4-45. The following major constituent groups were detected in surface water in the Wetland Ponds:

- VOCs
- SVOC
- Pesticides

- Metals (all TAL metals except antimony, beryllium, cobalt, and mercury).

VOCs, SVOCs, and pesticides were detected very infrequently at low concentrations below their respective detection limits and within the wetland area background/reference concentrations.

Metals were detected in all surface water samples in the wetland ponds (small, large, and other); however, most concentrations were estimated (J-qualified) values below their detection limit. Exceptions included twelve samples in which metals were greater than wetland two times the average background/reference concentrations. One location in the large wetland pond (SW96) contained a concentration of potassium (62200 μg/L) that was higher than two times the average wetland background/reference concentration and significantly higher than the concentrations of potassium in the other samples collected in the large wetland pond. All but one sample (SW66) in the small wetland pond contained concentrations of potassium that were greater than two times the average wetland background/reference concentrations. Samples SW68 and SW70 contained significantly higher concentrations of potassium than in the other samples collected in the small wetland pond. Sodium was also detected at concentrations that were greater than two times the average wetland background/reference concentrations in three samples (SW68, SW69, and SW70) in the small wetland pond. The other wetland ponds contained sporadic detections of calcium, copper, iron, magnesium, potassium, and sodium that were greater than two times the average background/reference concentrations. The other wetland ponds also contained concentrations of most metals that were greater than the concentrations detected in the large and small ponds.

In the larger ponds (those immediately adjacent to the slag pile) hardness and alkalinity were generally consistent. Hardness (measured as calcium carbonate) ranged from 91 to 159 mg/L. Alkalinity ranged from 39.8 to 54.8 mg/L. In a smaller wetland pond, hardness was measured at 422 mg/L and alkalinity was 15 mg/L. The DO was lowest in the smaller ponds, ranging from 4.84 to 5.34 mg/L; in the larger ponds, DO ranged from 13.31 to 13.79 mg/L. Acidity (measured as pH standard units) ranged from 6.35 to 6.38 in the wetland ponds; however, the pH was significantly higher in the small wetland pond (9.67 units). The small pond was completely void of all visible signs of aquatic life (e.g. vegetation, fish and other aquatic organisms). Turbidity was variable in the wetland ponds ranging from 12.5 to 275 NTU.

### 4.6.2 Shenango River

Surface water samples were collected from the Shenango River as describe in Section 3.6. The analytical results for the Shenango River are presented in Table 4-46. The Shenango River is downgradient of all source areas and immediately adjacent to the BOF Sludge and Northern Slag Areas. The following major constituent groups were detected in surface water in the Shenango River:

- VOCs
- Metals (all TAL metals except antimony, beryllium, cadmium, cobalt, mercury, selenium, thallium, and cyanide).

One VOC was detected at a low concentration in one sample; however, this VOC (CFC-12) was not detected in any source/slag area samples.

Metals were detected in all samples collected in the Shenango River; however all but one sample contained concentrations that were estimated (J-qualified) at low concentrations below the detection limit. An exception was copper in one sample (SW08-2) that was detected at a concentration (39.2 µg/L) that was slightly higher than two times the average background/reference concentration (24 µg/L).

Hardness and alkalinity concentrations measured in the river were generally consistent. Hardness (measured as calcium carbonate) ranged from 105 to 116 mg/L. Alkalinity ranged from 55 to 76.3 mg/L. The DO in the Shenango River ranged from 8.4 to 12.09 mg/L. Acidity (measured as pH units) ranged from 4.71 to 6.77. Turbidity ranged from 1.4 to 8.3 NTU.

### 4.6.3 Unnamed Tributary

Surface water samples were collected from the unnamed tributary as described in Section 3.6. The analytical results for the unnamed tributary are presented in Table 4-47. The following major constituent groups were detected in surface water in the unnamed tributary:

- SVOC
- Metals (all TAL metals except antimony, cadmium, chromium, copper, lead, mercury, selenium, silver, thallium, and vanadium).

One SVOC was detected in one surface water sample in the unnamed tributary; however, it was detected at a low estimated (J-qualified) concentration below the detection limit.

Metals were detected in all surface water samples in the unnamed tributary; however, most concentrations were estimated (J-qualified) and below their detection limit. Exceptions included twelve samples in which concentrations of calcium, iron, magnesium, manganese, sodium, and zinc were greater than the unnamed tributary background/reference concentrations. All samples contained elevated concentrations of iron and manganese. In particular, samples SW11-1, SW16-1, and SW107-1 contained significantly higher concentrations of these metals than the other surface water samples.

Hardness (measured as calcium carbonate) was measured at 197 mg/L and alkalinity was 80 mg/l. Dissolved oxygen (DO) in the unnamed tributary was 8.8 mg/L. Acidity (measured as pH units) was 6.67. Turbidity was measured at 0 NTU.

## 4.7 Biota

Metals were the most frequently detected constituent in all biota samples collected. VOCs and SVOCs were detected sporadically and at estimated levels below the detection limits, in most biota samples. PCBs (specifically Aroclor 1260) were detected in a majority of the large and small fish samples, as well as crayfish; while pesticides were only detected sporadically in large fish, reptiles, and amphibian samples. Where analyzed (in large fish only), dioxins and furans were also detected.

The following subsections discuss the specific nature and extent of contamination in each collection area and provide a comparison to the levels of constituents present in the sampled biota to the background areas.

### 4.7.1 Large Fish

Large angler-size fish were collected at stations adjacent to, or downgradient of, the site in the Shenango River, the large wetland pond, the unnamed tributary, and a small wetland pond. The analytical results for large fish are presented in Table 4-48. The following major constituent groups were detected:

- VOCs
- SVOC
- Pesticides
- PCBs
- Dioxins/furans
- Metals (all TAL metals except arsenic, beryllium, cadmium, chromium, cobalt, lead, nickel, silver, and vanadium).

VOCs were detected at estimated (J-qualified) concentrations below their respective detection limits in most of large fish samples in the Shenango River and large wetland pond Area. The majority of these detections were also below two times the average background locations. The exception was location B26-LF-1-B in the large wetland pond. At this location, 1,1-dichloroethene (99 µg/kg) and trichlorofluoromethane (21 µg/kg) exceeded both the detection limit and two times the average background concentration. Neither of these analytes were detected in sediment or surface water samples taken from the large wetland pond, which would be the main means of uptake by bottom feeding large fish. Additionally, these contaminants were not detected in source are samples. Also, neither VOC was detected in the shallow unconfined aquifer groundwater samples taken from the Southern Slag area near the large wetland pond.

Bis(2-ethylhexyl)phthalate, an SVOC, was detected in one large fish sample collected from the large wetland pond area. The detected concentration was estimated (J-qualified) and within background/reference concentrations for the large wetland pond.

One pesticide (gamma-BHC) was detected in one large fish sample collected from the Shenango River. The detected concentration (0.81 µg/kg) was K-qualified (analyte present, but biased high) and within reference/background concentration for the Shenango River.

One PCB (Aroclor 1260) was detected in six large fish samples collected from the Shenango River, in one tributary sample, and in the small wetland pond sample. Only one sample (B03-LF-3-B), which is located in the Shenango River, had a concentration of Aroclor 1260 (710 µg/kg) that was greater than two times average site background (504 µg/kg). The concentrations in the unnamed tributary and small wetland pond were 15 µg/kg and 27 µg/kg, respectively. Several sediment samples collected from the Shenango River, unnamed tributary and the small wetland pond showed Aroclor 1260 concentrations above their detection limits. Direct exposure to sediment as well as food-chain biotransfer is believed to be the main uptake for PCB contamination in the bottom feeding species, and thus may be the possible source of Aroclor 1260 in sample B03-LF-3-B.

Dioxin/furans were detected in all of the Shenango River large fish samples and in one large wetland pond sample. All concentrations of total 2,3,7,8-TCDD TEQ in both samples were below two times the average background concentration (22 pg/g) with the highest concentration of total 2,3,7,8-TCDD TEQ detected in sample B03-LF-3-B (20.2 pg/g).

Only two metals (calcium and mercury) were detected at concentrations greater than two times average background for the large fish samples. Calcium was detected in large wetland pond sample B23-LF-2-B at a concentration of 2,700 mg/kg and mercury was detected in Shenango River sample B01-LF-3-B at a concentration of 0.31 mg/kg. Significantly high levels of calcium were detected in both the sediment and surface water samples collected from the large wetland pond which may explain high concentration in the large fish from the pond. Mercury was detected in Shenango River sediment. Metals are a common contaminant associated with the source areas. Direct exposure to sediment as well as food-chain biotransfer is believed to be the main uptake for mercury contamination in the bottom feeding species, and thus may be the possible source of mercury in sample B01-LF-3-B. Mercury was not detected in Shenango River surface water samples.

### 4.7.2 Small Fish

Small fish samples were collected from stations adjacent to, or downgradient of, the site in the Shenango River, the large wetland pond, the unnamed tributary, and a small wetland pond. The analytical results for small fish are presented in Table 4-49. The following major constituent groups were detected:

- VOCs
- SVOC
- PCBs
- Metals (all TAL metals except arsenic, beryllium, cadmium, chromium, cobalt, mercury, nickel, silver, thallium, and vanadium).

VOCs were detected at estimated (J-qualified) concentrations below their respective detection limits in all of small fish samples in the Shenango River, the large wetland pond, the unnamed tributary, and the small wetland pond areas. The majority of these detections were also below two times the average background locations for small fish.

SVOCs were detected at estimated (J-qualified) concentrations below their respective detection limits in all of the small fish samples in the Shenango River, the large wetland pond, the unnamed tributary areas. No SVOCs were detected in the small wetland pond area. The majority of these detections were also below two times the average background locations for small fish.

One PCB (Aroclor 1260) was detected in all the Shenango River and small wetland pond samples. B01-SF (located in the Shenango River) contained Aroclor 1260 at a concentration (640 μg/kg) significantly exceeding both its detection limit and two times the average background value. Several sediment samples, near B01-SF, collected from the Shenango River showed Aroclor 1260 concentrations above their detection limits. Direct exposure to sediment as well as food-chain biotransfer is believed to be the main uptake for PCB contamination in the bottom feeding species, and thus may be the possible source of Aroclor 1260 in sample B01-SF. PCBs were not detected in surface water samples collected from the Shenango River.

Only two metals (aluminum and iron) were detected at concentrations greater than two times average background for the small fish samples. Aluminum was detected in fish from a large wetland pond sample (B28-SF) at a concentration of 29.1 mg/kg and iron was detected in both the Shenango River (sample B01-SF) and unnamed tributary (sample B31-SF) at concentrations of 139 and 301 mg/kg, respectively. Significantly high levels of aluminum were detected in both the sediment and surface water samples collected from the large wetland. Iron was detected in both the Shenango River and unnamed tributary sediment and surface water samples. Metals are a common contaminant associated with the source areas. Sediment and surface water in all three samples could be a contributor to the levels of these metals observed in the small fish from these areas.

### 4.7.3 Crayfish

VOCs were detected at estimated (J-qualified) concentrations below their respective detection limits in most of crayfish samples in the Shenango River and the unnamed tributary. The exception was at SSFW-B29-CR (unnamed tributary) where carbon disulfide (97 μg/kg) and methylene chloride (190 μg/kg) exceeded their respective detection limits and were not J-qualified. Methylene chloride was not detected substantially in any other crayfish sample, and is a common laboratory contaminant and may not be site-related (EPA, 1999). Carbon disulfide was not detected in sediment or surface water samples collected from the unnamed tributary nor in groundwater samples collected from the shallow aquifer near the Shenango River.

PCBs (Aroclor 1260) was detected in crayfish from both the Shenango River and the unnamed tributary at concentrations ranging from 60 to 240 μg/kg. All detected concentrations were below two times average background for crayfish (880 μg/kg) which was collected from the Shenango reference area. No background crayfish were collected from the unnamed tributary.

Only four TAL metals (aluminum, barium, calcium and iron) were detected at concentrations greater than two times average background for the crayfish samples collected in the Shenango River and unnamed tributary. Aluminum was detected in Shenango River sample B01-CR at a concentration of 93.6 mg/kg but was J-qualified. Barium was detected in both Shenango River sample B01-CR at 10.7 mg/kg and in unnamed tributary sample B29-CR at 13.3 µg/kg. Calcium was detected in both Shenango River sample B01-CR at 10,000 mg/kg and in unnamed tributary sample B29-CR at 14,000 mg/kg, although sample B01-CR was J-qualified. Iron exceeded two times average background in sample B29-CR (565 mg/kg) but was K-qualified, stating the concentration may be biased high. Aluminum, barium, and calcium were all detected in sediment samples collected from the Shenango River, while barium, calcium, and iron were all detected in unnamed tributary sediment samples. Metals are a common contaminant associated with the source areas. Sediment in both samples could be a contributor to the levels of these metals observed in the crayfish in these areas.

### 4.7.4 Small Mammals

Small mammals were collected at locations adjacent to, or downgradient of, the site in the southeast floodplain area and one sample was collected from the unnamed tributary floodplain. The analytical results for small mammals are presented in Table 4-51.
The following major constituent groups were detected:

- VOCs
- SVOC
- Metals (all TAL metals except arsenic, beryllium, chromium, cobalt, mercury, nickel, silver, thallium, and vanadium).

All VOCs were detected at estimated (J-qualified) concentrations below their respective detection limits, in each of the small mammal samples collected in the Shenango River and unnamed tributary floodplains.

All SVOCs were detected at estimated (J-qualified) concentrations below their respective detection limits in all small mammal samples in the Shenango River and unnamed tributary floodplains.

The majority of metals (except arsenic, barium, beryllium, chromium, cobalt, mercury, nickel, silver, thallium and vanadium) were detected in all small mammal samples in both the Shenango River and unnamed tributary floodplains. Several metals (aluminum, iron, magnesium, and zinc) were J or K-qualified in all samples. The following metals all had their highest concentrations in the Shenango River floodplain [antimony (0.62 mg/kg), barium (2.8 mg/kg), cadmium (0.29 mg/kg), calcium (8,800 mg/kg), cooper (4.5 mg/kg), lead (0.48 mg/kg), manganese (10.3 mg/kg), potassium (3,100 mg/kg), selenium (1.2 mg/kg), and sodium (1,200 mg/kg)]. Metal contamination in small mammals is generally widespread; however, higher metal concentrations were detected in the Shenango River floodplain samples. This is possibly due to correspondingly higher surface soil concentrations in the Shenango River floodplain to which the small mammals may be exposed. Metals are a common contaminant associated with the source areas.

### 4.7.5 Reptiles

Reptiles (specifically snakes) were collected adjacent to, or downgradient of, the site in the southeastern Shenango River floodplain area. The analytical results for reptiles are presented in Table 4-52. The following major constituent groups were detected:

- VOCs
- SVOC
- Pesticides
- Metals (all TAL metals except beryllium, cobalt, nickel, silver, thallium, and vanadium).

All VOCs were detected at estimated (J-qualified) concentrations below their respective detection limits, in all reptile samples collected in the Shenango River floodplain

SVOCs [specifically benzaldehyde, bis(2-ethylhexyl)phthalate, and phenol] were detected in three reptile samples in the Shenango River floodplain; however, all detections were estimated (J-qualified) concentrations below their respective detection limits.

Pesticides were detected in only one of the reptile samples (B04-RP) collected from the Shenango River floodplain. Heptachlor epoxide was detected at an estimated (J-qualified) concentration of 3.4 µg/kg and dieldrin was detected at a concentration of 2.3 µg/kg Both heptachlor epoxide and dieldrin were detected in nearby Shenango River floodplain surface soil samples. Surface soil in these locations could be a contributor to the levels of these pesticides observed in the reptiles in this area.

The majority of TAL metals (except beryllium, cobalt, nickel, silver, thallium and vanadium) were detected in all reptile samples in the Shenango River Floodplain. Several metals (aluminum, iron, magnesium, and zinc) were J or K-qualified in all samples collected from the Shenango River Floodplain. Antimony, arsenic, barium, cadmium, calcium, chromium, copper, iron, lead, manganese, mercury, potassium, selenium, and sodium are generally detected at consistent concentrations with no apparent pattern throughout samples the Shenango River floodplain. Metals are a common contaminant associated with the source areas.

### 4.7.6 Amphibians

Amphibians (frogs, toads, and tadpoles) were collected adjacent to or downgradient of, the site in the emergent wetland, the unnamed tributary, and in the pond between the Southern Slag Pile Area and the unnamed tributary. The analytical results for amphibians are presented in Table 4-53. The following major constituent groups were detected:

- VOCs
- SVOC
- Metals (all TAL metals except beryllium, cobalt, mercury, and silver).

VOCs were detected at estimated (J-qualified) concentrations below their respective detection limits in each of the amphibian samples collected from the three sample areas. The exception was in emergent wetland location B19-AM. At this location, methyl acetate (28 μg/kg) exceeded its respective detection limits and was not J-qualified. Methyl acetate was not detected in either sediment, surface water, or shallow aquifer groundwater samples collected from the wetland areas.

SVOCs [specifically 4-methylphenol, benzaldehyde, and bis(2-ethylhexyl)phthalate] were detected in four of the six amphibian samples; however, all detections were estimated concentrations below their respective detection limits.

The majority of TAL metals (except beryllium, cobalt, mercury, nickel, and silver) were detected in all amphibian samples collected from the three sample areas. Several metals (aluminum, copper, iron, magnesium, sodium, and zinc) were J or K-qualified in all samples collected. While many of these results were detected at significant concentrations, the results are estimated and could possibly be near or below their respective detection limits. Antimony, arsenic, barium, cadmium, calcium, chromium, lead, manganese, potassium, selenium, thallium and vanadium were detected in the amphibian samples are generally widespread and at consistent concentrations with no apparent pattern throughout the Shenango River floodplain. Metals are a common contaminant associated with the source areas.

# 5.0 CONTAMINANT FATE AND TRANSPORT

## 5.1 Potential Routes of Migration

The primary sources of contamination at the SSFW site are the slag and sludge disposal areas. These areas are described in greater detail in Section 1.2.6 of this RI Report. The principal contaminants associated with the SSFW site include, metals, PAHs, pesticides, and PCBs. These contaminants have been detected in samples collected from source/waste area surface and subsurface soils and groundwater. They were also detected in downgradient surface and subsurface soils, groundwater, surface water, sediment, and biota.

The source areas are uncapped exposed piles with some sparse vegetative cover. The BOF Sludge Area is partially covered with herbaceous vegetation, shrubs, and isolated stands of trees. The Northern and Southern Slag Areas are generally barren. Each of these source areas consists of slag or sludge that was dumped from rail cars down the upland slopes adjacent to the original Shenango River floodplain. Over time, with the continuation of the dumping, these areas grew into piles that were close to the elevations of the original hillsides.

Based on the nature of the contamination at the SSFW site and the physical characteristics of the site, potential routes of contaminant migration likely include the following:

- *Soil-to-Air Migration*
- Soil-to-Surface Water/Sediment Migration
- Soil-to-Groundwater Migration
- Groundwater-to-Surface Water Migration
- Biological/Food Chain Migration

The following subsections present a discussion of each potential route of contaminant migration for the SSFW site.

### 5.1.1 Soil-to-Air Migration

Fine-grained materials from source areas may be transported by the wind and released to the atmosphere. Constituents bound to surface soils may be transported as suspended particulates or dust to downwind locations. Factors influencing the potential for dust entrainment into the atmosphere include surface roughness, surface soil moisture, soil particle sizes, type and amount of vegetative cover, amount of soil surface exposed to the eroding wind force, physical and chemical properties of the soil, wind velocity, and other meteorological conditions (USEPA, 1983). While some areas of the site are covered with vegetation, there are large areas on the sources with little or no cover which are expected to be dusty. Dust formation may be significant during extended periods of dry weather. As a result, contaminants in the soil would be expected to be present in the air as dusts at certain times of the year.

Volatile organics present in surface soils may be released to air through volatilization. However, the surface soils at the SSFW have been exposed to natural weathering over a long period of time and are likely to have lost the bulk of volatile constituents as a result of volatilization, leaching to groundwater, and/or runoff to surface water. Therefore, air transport of volatile organics is not likely to be a significant migration process at the site.

Air monitoring samples were to measure dusts generated from the site source areas were not collected as part of the RI. However, air dispersion modeling was conducted to support the RI and the human health risk assessment (MACTEC, 2004). The results of the air modeling analysis are presented in Air Dispersion Modeling Analysis and Identification of Chemicals of Potential Concern for Inhalation Exposure (Phase 1 and Phase 2; MACTEC, 2004) (see Appendix H. In the Phase 1 modeling effort, a preliminary set of COPCs (for both acute and chronic exposures) were identified for the site based on conservative assumptions regarding the potential for dust emissions, wind dispersion, as well as measured constituent concentrations in soil and risk based screening concentrations for air. In the Phase 2 modeling effort, atmospheric concentrations of the preliminary COPCs identified in Phase 1 were predicted for seven on site locations and four offsite locations at the Sharon Steel Farrell Works Site. Air concentrations were predicted using EPA's Industrial Source Complex Short Term Model (ISCST3) and refined site specific assumptions regarding emissions (e.g., particle threshold friction velocity and erosion potential). Seven on-site exposure areas were identified including the Northern Slag Pile, the BOF Sludge Area, the Southern Slag Area, the Shenango River Floodplain, the Unnamed Tributary Floodplain, the Southeast Floodplain, and the Ohio Street Wetlands. Four off-site exposure areas were also identified including the State Line Residential Area, the Wansack Residential Area, the Ohio Street Industrial Area, and the Farrell Residential Area. A fifth off-site exposure area was also identified for areas not encompassed by any of the other exposure zones.

Both maximum and average 1-hour and 5-year concentrations were predicted for each preliminary COPC identified in Phase 1 (see Appendix H). The maximum and average 1-hour concentrations represent potential acute exposure levels, and the maximum and average 5-year concentrations represent chronic exposure levels. For purposes of illustration, Figure 5-1 presents the predicted one hour maximum (acute) results for aluminum. This distribution pattern is typical for the other contaminant of concern from the source areas. Details of the constituents and predicted air concentrations are presented in the Phase 2 report (see Appendix H). Dust-borne contaminants of concern include PAHs, pesticides, PCBs, total 2,3,7,8-TCDD TEQ and inorganics. The locations of the highest concentrations varied among the constituents; however, the model estimated that the highest dust-borne contaminant concentrations would be located within the boundaries of the three source areas and would decrease rapidly with distance from the sources.

This air modeling indicated that there is a potential for dust-borne contamination from the source areas to move from the site to adjacent areas, primarily toward the east-northeast. However, the distribution of dust-borne contaminants at levels of concern is general limited to areas within 500 feet of the site (Appendix H).

### 5.1.2 Soil-to-Surface Water/Sediment Migration

Contaminants from source areas may be transported by the wind or surface water runoff and deposited in downgradient floodplains, surface waters and/or settle in surface water bodies as sediment. Site drainage patterns are presented in Figure 2-6. Soils from the BOF Sludge Area and the Northern Slag Pile Area can travel downslope into the Shenango River floodplain and ultimately into the Shenango River (Drainage Area 1). Soils from the Southern Slag Pile Area can travel downslope into the Ohio Street wetland area (Drainage Area 2). Soils from the Southern Slag Pile Area can also travel downslope into the wetland complex south of the pile, into the wetland ponds, into the unnamed tributary and ultimately into the Shenango River (Drainage Area 3). Soils fom the Southern Slag Pile Area can travel downslope and into the southeastern Shenango River floodplain and then into the Shenango River (Drainage Area 4).

Chemicals with high organic-carbon partitioning coefficient ($K_{oc}$) are likely to have a strong affinity for organic carbon. These chemicals generally include SVOCs, PCBs, PAHs and pesticides. Surface soils and sediments are often rich in organic carbon content; therefore, contaminants in these media with high $K_{oc}$ may rapidly become strongly adsorbed onto these organic carbon particles. Once adsorbed, the availability for these contaminants to move independently of the adsorbed particle or exert toxic effects is limited.

In addition, the physical properties of the soil or sediment material itself may also be a factor that affects fate and transport of contaminants, especially metals. Properties such as grain size, TOC, and acidity can drastically affect the availability of inorganic and organic compounds.

Migration potential generally increases with grain size. The larger the particles (e.g. more space between particles), the less the potential for surface binding area of smaller particles. Grain size was measured in the Southern Slag Pile only.

It is important to note that the TOC of source materials varies greatly between the slag areas and the BOF sludge area. The BOF Sludge Disposal Area has the highest TOC concentrations measured at the site and the slap pile areas have the lowest. This could suggest that contaminants in materials from the Northern and Southern Slag Pile areas may be more bioavailable than those from the BOF Sludge Area.

The Northern Slag Pile contained more gravel particles than the other source areas which suggests that the migration potential is higher in this area.

The analytical data generated in the RI showed a relationship between the nature of contaminants observed in the source areas and the distribution of these same contaminants in downgradient areas. In general, areas of floodplain soil in areas downgradient associated with topographic depressions contained source-related contaminants at significant levels. Sediment depositional areas in downgradient surface waters also contained source-related contaminants at significant levels. These observations indicate a high likelihood that contaminants from the source areas are moving downgradient into adjacent floodplains, wetlands, and surface waters.

### 5.1.3 Soil-to-Groundwater Migration

Based on the evaluation of site characteristics and monitoring data, groundwater is a major mode of transport for contaminants at the SSFW site. During the field investigation, the sampling crew observed that water levels in the ponds south of the Southern Slag Pile Area would rise approximately 2 to 3 days after a steady rain. During periods of rainfall, water infiltrates the source areas containing contaminants and carries with it dissolved organic and inorganic constituents. A portion of the dissolved constituents are adsorbed by the soils underneath the affected surface soil zone. The remaining portion of the constituents, which is desorbed from the soil particles, continues to leach downward with infiltrating precipitation until it reaches the groundwater.

The potential for contaminants to move into groundwater from source material is dependent on several physical and chemical properties of the particular contaminants. As stated previously, the ability for a contaminant to move from soil into water is affected by the $K_{oc}$ for contaminants in the soil/slag. Contaminants with high $K_{oc}$ are likely to strongly absorb to soil particles and will resist leaching into groundwater. These chemicals generally include SVOCs, PCBs, PAHs and pesticides. Metals (or their related salts) may readily become soluble with infiltrating precipitation and are likely to contaminate groundwater.

Contaminant migration is also expected to be slower than groundwater flow due to retardation as a result of adsorption to soil particles. Retardation may be negligible for the highly mobile constituents (such as the metals) and significant for the relatively immobile compounds (such as the organics). Constituents also disperse laterally as they are transported downgradient, diluting as affected groundwater mixes with laterally adjacent, unaffected groundwater.

Solubility, which is related to the affinity of a chemical to water, is another property that affects migration of contamination in water. Chemicals with a high solubility have the potential to rapidly dissolve into water (surface water or groundwater) and will therefore move with the water in which it is dissolved. Chemicals with a low solubility do not readily dissolve in water and will either float (if they have a low density) or sink (if they have a high density).

Chemicals with a high specific gravity or density, as compared to water, may readily migrate and sink into groundwater until they encounter an impervious zone. These chemicals, known as dense non-aqueous phase liquids (DNAPLs), have the combination of low $K_{OC}$, high viscosity, and density that make them highly likely to move from contaminated areas into groundwater and move with the groundwater along an impervious layer (e.g. bedrock or clay lenses). DNAPLs generally refer to chlorinated solvents and can include select VOCs and SVOCs. In addition, the presence of these DNAPLs in mixtures with other organic contaminants (e.g. PCBs and pesticides) can reduce the capability for these other contaminants to be adsorbed onto soils particles and can increase their migration potential in groundwater. There were no significant detections of DNAPL at the site; therefore, this is not expected to be a migration process of concern.

The groundwater data for the unconfined aquifers under the source areas (the surficial and glacial till aquifers) indicated significantly high levels of the same metals detected in these sources. In some areas, there were also PAHs detected in source area soils and in underlying groundwater. In addition, the grain size and TOC data provides an additional line of evidence that migration from soil-to-groundwater is likely to be occurring and may be rapid. These observations indicate a high likelihood that contaminants from the source areas are leaching into groundwater in the unconfined aquifer.

### 5.1.4 Groundwater-to-Surface Water Migration

Based on the hydrogeologic assessment conducted in Section 2.3, groundwater in the unconfined aquifers at the SSFW site (the surficial and the glacial till) generally flows to the east and southeast and discharges into adjacent surface waters as presented in Figure 2-3. At the BOF Sludge and the Northern Slag Disposal Source Areas, groundwater flow in these surface aquifers discharges into the Shenango River. At the Southern Slag Reclamation Source Area, groundwater flow in the surficial aquifers discharges into the wetland/pond complex, the unnamed tributary, and the Shenango River. Therefore, all groundwater from the three source areas eventually discharges into the Shenango River.

The concentrations of site-related constituents in the groundwater is significant at the source areas; however, as groundwater migrates toward distant surface discharge points, the concentrations of both inorganic and organic contaminants generally decrease due to retardation, adsorption, and dilution. Groundwater is thought to flow downward from the surficial aquifer into the glacial till as evidenced by the consistent concentrations of site-related metals in both the surficial and the glacial till aquifers.

Glacial sediments on-site are extensive enough to produce a confining bed above the gravel zone and underlying bedrock and create artesian conditions in the vicinity (refer to well logs in Appendix C). However, concentrations of site-related constituents in the gravel and bedrock aquifers, below and downgradient of the source areas, are generally consistent with regional background levels. In addition, these contaminant concentrations decrease with depth. These observations suggest that there is insignificant downward flow into the deeper confined aquifers. This observation is supported by the observation of artesian conditions in the portions of the confined aquifer which would indicate upward flow from the deeper aquifers into the shallow aquifers and the Shenango River (refer to well logs in Appendix C).

### 5.1.5 Biological Migration

Biological migration may occur through uptake, bioaccumulation, and food-chain transfer. EPA Region 3 typically considers the list of contaminants presented in Table 4-2 of

*Bioaccumulative Testing and Interpretation for the Purposes of Sediment Quality Assessment, Status and Needs* (EPA, 2000) as those of concern for biological transport. Bioaccumulative contaminants from this list detected in media at the SSFW site include: arsenic, cadmium, chromium (as hexavalent chromium), copper, lead, mercury (as methyl mercury), nickel, silver, zinc, PAHs, pesticides, PCBs (Aroclors), and dioxin/furans.

## 5.2 Contaminant Fate and Transport Properties

Contaminants present at the SSFW may migrate offsite and remain persistent in site media. Some contaminants, such as the VOCs, are expected to be relatively mobile and may be quickly degraded in exposed media. Other contaminants such as some SVOCs and inorganics are expected to be less mobile and may remain in the source areas for much longer periods of time. The following subsections briefly summarize the fate and transport properties of the contaminants detected at the SSFW site. Table 5-1 provides a listing of the contaminants detected in the source areas at the site and their key fate and transport factor values as discussed in the flowing sections.

### 5.2.1 Volatile Organic Compounds

Volatile organic compounds possess a wide range of physicochemical properties, but generally have high vapor pressures [greater than 1.0 millimeters of mercury (mm Hg)] and low $K_{oc}$ values.

The $K_{oc}$ for VOCs generally range from 20 to 400 liters per kilogram (L/kg) which suggests that these constituents would not be strongly adsorbed by organic materials. The octanol-water partition coefficients (log $K_{ow}$) range from 1.5 to 3.2 and indicate that these constituents would not be overwhelmingly distributed to the octanol phase. Thus, none of the VOCs would be expected to accumulate in media or tissues whose physicochemical properties resemble that of octanol, especially in biological systems where removal systems are operative. In soils with a low organic material content, VOCs can quickly degrade or leach readily into groundwater where it may migrate both vertically and horizontally.

Henry's Law is a measure of air-to-water partitioning, or how a chemical distributes itself between water and air phases. The Henry's Law contant ($K_H$) is determined by dividing the vapor pressure of a chemical by it's solubility. VOCs that have $K_H$ greater than $10^{-3}$ atmosphere-cubic meters per mole (atm-m$^3$/mole) are exepected to volatilize readily (Fetter, 1988).

Because the detected VOCs in site media are water soluble, they are expected to be present in solution and mobile in the aquatic environment. Biodegradation and volatilization are important fate processes that may affect their transport. However, the extent of the control of these processes is likely to be limited because these processes are expected to be slow compared to the rate of groundwater movement.

### 5.2.2 Semi-Volatile Organic Compounds

Semi-volatile organic compounds possess a wide range of physicochemical properties, but generally have low vapor pressures and water solubilities and high $K_{oc}$ values. In general, contaminants with a high $K_{oc}$ value (greater than 100), such as PAHs, organochlorine pesticides, and several other SVOCs tend to adsorb to the organic components in soils and sediment will resist movement from soil/sediment into groundwater and surface water (Howard, 1990). In addition to adsorption, photolysis is considered the most significant fate process affecting these constituents in the aquatic environment. Volatilization and biodegradation rates are expected to be low for several PAHs due to the high molecular weights of these constituents.

### 5.2.3 Pesticides, PCBs, and Dioxins

Most organic pesticides have low solubility, low vapor pressure and high $K_{oc}$ values. Consequently, these constituents are expected to be relatively immobile. Adsorption onto suspended solids and particulate matter, and complexation with natural organic substances, are probably the most important environmental transport processes for these pesticides. The available information suggests that these constituents are strongly adsorbed to soils and sediments, and that migration to groundwater by leaching from soil is a very slow process. While biodegradation is probably the most important fate process, degradation is expected to be a slow mechanism because of these constituents' high molecular weights.

PCBs are mixtures of different congeners of chlorobiphenyl and the relative importance of the environmental fate mechanisms generally depends on the degree of chlorination. In general, the persistence of PCB congeners increases with an increase in the degree of chlorination. Experimentally determined $K_{oc}$ values for these PCBs suggest that they should be tightly adsorbed in soil and should not leach to groundwater. Although biodegradation is expected to occur very slowly, no other degradation mechanisms have been shown to be important in soil systems; therefore, biodegradation may be the primary degradation process in soil. In water, adsorption to sediments and organic matter is a major fate process for these PCBs.

Because of their high lipophilicity (high log $K_{ow}$) and low water solubility, total 2,3,7,8-TCDD TEQs are primarily associated with particulate and organic matter in soil, sediment and the water column. The available evidence indicates that total 2,3,7,8-TCDD TEQs (chlorinated dioxins/furans) are extremely stable compounds under most environmental conditions. The only environmentally significant transformation processes are atmospheric photo oxidation and photolysis of non-sorbed species in the gaseous phase or at the soil or water-air interface. Burial in-place or erosion of soil to water bodies appears to be the predominant fate of total 2,3,7,8-TCDD TEQs sorbed to soil. Once in the water column, total 2,3,7,8-TCDD TEQs primarily undergo sedimentation with some uptake by aquatic biota.

### 5.2.4 Inorganic Compounds

Many metals have a high potential to adsorb to fine-grained soil/sediments, such as clays and silts, due to the increase in available surface area in these small particles. However, the potential for metals to adhere to soil/sediment particles is also limited by other physical chemical factors such as pH, hardness, and reactions with other chemicals. As such, the adsorption/adherence potential of metals in soil/sediment is highly complex and cannot be reasonably estimated in a general evaluation.

While the pure metallic forms of metals are insoluble in water, many of the salts are soluble in varying degrees. The primary fate process for these inorganics in relation to groundwater is adsorption. These constituents may be released into solution depending on pH, the particular chemical state present, and the presence of aerobic or anaerobic conditions at the site. Values of the soil-water partition coefficient ($K_d$) have been reported to range from 6.5 (cadmium) to as high as 1500 L/kg (aluminum and thallium) for these inorganic constituents and suggest that they are likely to be primarily distributed to the soil phase. The important fate and transport characteristics of some of the more toxic inorganic constituents are discussed below (EPA, 1985).

Aluminum partitions between solid and liquid phases by reacting and complexing with water molecules and anions such as chloride, fluoride, sulfate, nitrate, phosphate, and negatively charged functional groups on humic materials and clay. The mobilization of aluminum is primarily controlled by pH (decreasing pH results in an increase in mobility).

Sorption to clays and minerals is normally the most important mechanism resulting in the removal of antimony from solutions, although antimony may be reactive with other heavy metals to form insoluble compounds. However, antimony in natural water is typically soluble and quite mobile.

Arsenic is generally quite mobile and may be leached from soil depending on the specific oxidation state.

Barium is generally present in solution in surface water or groundwater only in trace amounts. Barium is not soluble at more than a few parts per million (in water that contains sulfate); however, barium sulfate may become considerably more soluble in the presence of chloride and other ions.

Cadmium is relatively mobile in the aquatic environment, but is expected to move slowly through soil. Cadmium is removed from aqueous media by complexing with organic materials and subsequent adsorption to the sediment.

Chromium may exist in either the trivalent ($Cr^{+3}$) or hexavalent ($Cr^{+6}$) state. $Cr^{+6}$ is quite soluble and mobile in groundwater and aquatic systems. $Cr^{+6}$ is quickly reduced to $Cr^{+3}$ in poorly drained soils. $Cr^{+3}$ is strongly adsorbed to clays and soils high in organic matter.

Very little cobalt appears to occur in soluble form in natural aquatic systems. The most important control on the mobility of cobalt is probably adsorption to clay minerals and hydrous oxides of iron, manganese, and aluminum. Adsorption and desorption processes are typically controlled by pH, redox potential (Eh), and the concentrations of cobalt and competing compounds.

Copper is among the more mobile inorganics in the environment. The amount of various copper compounds and complexes that actually exist in solution depend on the pH, temperature, alkalinity, and concentrations of other chemical species present. Many copper compounds are readily soluble and, as a result, copper is mobile in the soil system and in groundwater. Adsorption to organic matter and clays is the primary process that limits the environmental mobility of copper.

Soluble metal cyanides exhibit variable sorption properties, with the extent of sorption increasing with decreasing pH and increasing iron oxide, clay, and organic material contents of sediment and suspended solids. However, sorption is much less significant compared to volatilization and biodegradation. Oxidation, hydrolysis, and photolysis are the three predominant chemical processes that may cause loss of simple cyanides in aquatic media.

Elemental iron and many iron compounds, including iron hydroxide and the iron oxides, are insoluble in water. Iron also tends to chelate with organic and inorganic matter. Consequently, much of the iron present in aquatic systems tends to partition to the bottom sediments. In addition, iron has relatively low mobility in soil.

Lead may exist in either organic or inorganic forms. Organic lead is generally unstable and undergoes rapid conversion to inorganic lead compounds. Inorganic lead is relatively insoluble and not very mobile. Sorption processes exert a dominant effect on the distribution of lead in the environment.

In freshwater systems, manganese can occur as a soluble ion, in complex organic ions, or in colloidal suspensions. In soil, the solubility of manganese is increased at low pH and under reducing conditions. The presence of high concentrations of chlorides, nitrites, or sulfates may also increase solubility

Mercury in soil is generally complexed to organic compounds. In the aquatic environment, the most important process determining the fate of mercury is adsorption onto suspended and bed sediments. Sorption of mercury is strongest into organic materials. Elemental mercury can be oxidized in sediment to divalent mercury, and both aerobic and anaerobic bacteria have been found capable of methylating divalent mercury in sediments. The methylated form is more water soluble and more biologically active than the inorganic form.

Nickel is a highly mobile metal in aquatic systems because many nickel compounds are highly soluble in water. However, insoluble nickel sulfide is rapidly formed under reducing conditions that exhibits some control over nickel mobility. Sorption and co-precipitation processes are also moderately effective in limiting the mobility of nickel.

Selenium is strongly adsorbed by hydrous metal oxides while clays and organic materials have a lesser affinity. Most selenium in aquatic systems is probably transported as the dissolved species. Experimental studies indicate that selenium is quite mobile in clays, especially under alkaline conditions.

Silver is strongly sorbed by manganese dioxide, ferrous hydroxide, and clay minerals. In general, silver is expected to be present in sediments at higher concentrations than overlying surface water.

Thallium is highly associated with potassium and rubidium as well as several other cations, and is usually found incorporated into various minerals, mainly sulfides. During natural weathering, thallium is readily mobilized and transported together with alkaline metals. An important environmental fate process is sorption onto clay minerals and hydrous metal oxides.

The extent to which vanadium is mobile in the environment is largely determined by the chemical species present and by environmental factors determining its solubility and ability to bind to organic materials.

The relative mobility of zinc in soil and water is determined by pH, salinity, the concentration of complexing liquids, and the concentration of zinc. Zinc normally partitions to soil (sediment) to a greater degree than to it does to solution.

## 5.3 Factors that Affect Contaminant Migration

Several factors could affect contaminant migration at the SSFW site including physical properties of the site, chemical properties of site media, degradation mechanisms, and chemical reactions. The following subsections provide a discussion of each of these factors as they relate to the SSFW site.

### 5.3.1 Physical Properties of the Site

As stated previously, the primary sources of contamination at the SSFW site are the slag and sludge disposal areas. The principal contaminants associated with the SSFW site include, metals, PAHs, pesticides, and PCBs. These contaminants have been detected in samples collected from surface soil, subsurface soil, waste, groundwater, surface water, sediment, and biota. These contaminants are likely to be associated with materials disposed of at the site. Based on the physical setting of the SSFW site, the probable affected areas include the source areas themselves, the receiving waterways (Shenango River, wetlands, ponds, and the unnamed tributary), and areas within the 100-year floodplain of the Shenango River to the downgradient extent of detectable contamination.

Several physical properties of the subsurface such as soil type, hydraulic conductivity, porosity, presence of geologic fractures would be expected to affect contaminant migration in groundwater.

Because of the historical depositional environments of the site a wide variety of soil types are present. The site had been in a glacial depositional environment which dominates much of the subsurface sediments at the site. The till deposited was logged during the drilling of borings and monitoring wells and some of the samples submitted for laboratory analysis had a sediment type breakdown analysis. As typical with tills, the deposits ranged from poorly sorted to well-sorted combinations or uniform clays, silts, clays, and gravel. The near surface deposits consist of mainly silt, sand, and gravel.

The hydraulic conductivities calculated for the shallow aquifer range from 0.00093 ft/min at RW-2 to 0.25 ft/min at RW-3 and the geometric average was calculated to be 0.039 ft/ min. The hydraulic conductivities in the deeper (semi-confined) aquifer ranged from 0.019 ft/min at AMW-3D to 0.068 ft/min at AMW-1D and the geometric average was calculated to be 0.036ft/min. The calculated geometric hydraulic conductivities for both aquifers are within the expected range, based on the boring logs (presented in Appendix B).

No site specific information exists regarding the porosity of any materials on-site; however, expected porosities on-site would range from 10-20% in the unconfined aquifer and 25-50% in the confined aquifer (Meinzer, 1923; Davis, 1969; Cohen, 1965; MacCary and Lambert, 1962). Secondary porosity is frequently a significant conduit of contamination migration; however no presence of fractures were observed in boreholes that extended into the bedrock.

Factors influencing the potential for dust entrainment into the atmosphere and/or surface runoff include, soil moisture, soil particle sizes, type and amount of vegetative cover, and amount of soil surface exposed to the eroding forces (e.g. wind and/or water).

Soil moisture can be a limiting factor on the mobility of the contaminant. Should the soil moisture content be too low, especially at the surface and very near surface soils, the contaminant and/or daughter compounds may be exposed to the air and inhaled by surface organisms or may be transported on soil particles when the upper soils are disturbed by the weather or animal or human activities. If the soil moisture is too high, as with a saturated sample, the contaminant may become mobilized and move within groundwater or in the direction of groundwater during percolation. Soils with moderated moisture contents can retain the contaminant due to the polarities of the compounds and/or surface tension of the particles. The soils on-site ranged greatly in the moisture content, from one percent to greater than 100%. The range is as expected for the site as higher moisture contents would be found near a radius of influence of a surface water body (such as the Shenango floodplain areas) or with depth as the soil in the vadose zone approaches the water table and the capillary fringe.

The source areas are generally not covered with any type of clean cover. The BOF Sludge Area is partially covered with herbaceous vegetation, shrubs, and isolated stands of trees which could limit the potential for dust entrainment and surface water runoff. The Northern and Southern Slag Areas are exposed barren areas with little resistance to wind and water-driven erosion. The surface soils in the source areas consist primarily of silts, sands, and gravels. During dry periods, the silts and sands, which are the smaller particles, would be susceptible to wind erosion. These particles would also erode during periods of heavy precipitation.

### 5.3.2 Chemical Properties of Media

The fate and transport of many contaminants (mostly metals) are affected by the chemical properties of the media in which they are found. In soils and sediment, the availability of aluminum and iron (and to a lesser degree, a few other metals) are known to be inversely proportional to soil/sediment pH. High pH levels appear to interfere with the binding capability of these metals to soil particles and leave them available for movement (usually into groundwater) independent of the media. It should be noted that pH was not measured in surface soils or sediment at the SSFW site.

In surface water, pH levels affect availability of aluminum and iron (and some other metals) and tends to affect the adherence of these metals onto suspended particulates. The pH of surface waters at the site are slightly acidic and were measured at 4.71 to 6.77. The exception to this was water in the small wetland pond which had a strongly basic pH of 9.67. This would indicate that the metals may be less bioavailable in the small wetland pond compared to other surface waters at the site.

In surface water, hardness (measured as calcium carbonate) is another factor that limits the availability of metals. The bioavailability of several metals is known to be inversely proportional to hardness levels (e.g. bioavailability decreases as hardness increases). Hardness dependant metals include: cadmium, copper, lead, nickel, silver, and zinc. Hardness values were generally between 100 and 200 mg/l in surface waters associated with the site, except it was very high (422 mg/l) in one of the smaller wetland ponds.

### 5.3.3 Degradation Mechanisms and Chemical Reactions

Most organic contaminants are broken down into other products by a variety of degradation processes including biological degradation/transformation, photo-degradation, and other processes. Of greatest importance, in the development of a risk assessment, are the potential for the creation of daughter or breakdown products that may be more toxic or bioavailable than the parent compounds.

While there are organic contaminants of some concern at the site, these organic contaminants (PAHs, PCBs, pesticides) are generally stable compounds that degrade slowly.

Inorganic contaminants are elements that do not naturally break down or transform to other chemicals. However, some inorganics often form associations with organic contaminants to form significantly more toxic compounds. Chromium and mercury are two examples of metals that may form associations which are more toxic (hexavalent chromium and methyl mercury).

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# 6.0 BASELINE RISK ASSESSMENT

The Baseline Risk Assessment for the SSFW site includes a Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA). The Final HHRA (Black & Veatch, 2005a) and Final ERA (Black & Veatch, 2005b) were completed as separate documents along with this RI Report. The information presented in the sections below is an executive summary of those two risk assessment reports.

## 6.1 Human Health Risk Assessment

This section summarizes the key information presented in the Baseline Human Health Risk Assessment for the SSFW site, highlighting the COPCs selected, the approaches used for estimating exposure, the toxicological assumptions, and the total potential carcinogenic and noncarcinogenic risks to each receptor group. The methods used in conducting the HHRA are those presented in the U.S. Environmental Protection Agency (EPA) Risk Assessment Guidance for Superfund (RAGS) – Volume I Human Health Evaluation Manual, Part A (EPA, 1989) and Part D, Standardized Planning, Reporting and Review of Superfund Risk Assessments (EPA, 2001). Other guidance documents used in the preparation of the HHRA include Human Health Evaluation Manual, Supplemental Guidance "Standard Default Exposure Factors" (EPA, 1991); Region 3 Technical Guidance Manual Updated Dermal Exposure Assessment Guidance (EPA, 2003); Exposure Factors Handbook (EPA, 1997); and Risk Assessment Guidance for Superfund Volume I (Human Health Evaluation Manual) Part E Supplemental Guidance for Dermal Risk Assessment (EPA, 2001).

### 6.1.1 Chemicals of Potential Concern

Constituents at the various source areas at the SSFW site were identified from samples of soil/slag and on-site groundwater. Over 100 constituents (including VOCs, SVOCs, PAHs, pesticides, PCBs, dioxin and inorganics) were detected in these media. A screening of constituents was conducted, during which constituents detected in blanks were eliminated and maximum detected concentrations were compared to risk-based screening levels (EPA Region 3 Risk Based Concentrations). Through this process, a large number of constituents were selected as chemicals of potential concern (COPCs) for the SSFW site. These COPCs are presented in Table 6-1.

Not every COPC was detected or selected at every source area or in every environmental media sampled at the SSFW site. Consequently, potential health risks and hazards are characterized based on the selected COPCs for each relevant medium at each identified source area.

### 6.1.2 Exposure Assessment

The exposure assessment included a characterization of the local climate, geology, soils, groundwater, surface water conditions, and population demographics, as well as an identification of exposure pathways and the quantification of exposure intakes for each receptor group at the SSFW site. Local population statistics and land/water uses were also presented.

A fate and transport analysis of the COPCs in conjunction with the source area characteristics identified the potential constituent migration and exposure pathways at the SSFW site. An exposure pathway screening was then conducted to identify those pathways to be included in the detailed quantitative analysis. The selected exposure pathways considered most applicable to the SSFW site include:

- Current Ingestion of COPCs in Drinking Water from Residential Wells
- Current Dermal Absorption of COPCs in Water from Residential Wells
- Current Inhalation of Vapors Associated with Use of Residential Well for Showering
- Current/Future Ingestion of COPCs in Soil
- Current/Future Dermal Absorption of COPCs in Soil
- Current/Future Inhalation of COPCs in Dust (includes both chronic and acute exposure)
- Current/Future Ingestion of COPCs in Surface Water
- Current/Future Dermal Absorption of COPCs in Surface Water
- Current/Future Ingestion of COPCs in Sediment
- Current/Future Dermal Absorption of COPCs in Sediment
- Future Ingestion of COPCs in Drinking Water from Groundwater
- Future Dermal Absorption of COPCs in Groundwater
- Future Inhalation of Vapors Associated with Use of Groundwater for Showering
- Current/Future Ingestion of COPCs in Fish Tissue
- Current/Future Ingestion of COPCs in Duck Tissue

Exposure was quantified based on an analysis of the COPC exposure point concentrations for each media in each exposure unit. Intake was estimated for receptors for each media in each exposure unit.

### 6.1.3 Toxicity Assessment

The toxicity assessment presented the available human health toxicological health effects criteria for each COPC and for each exposure route identified for the SSFW site. For carcinogenic effects, the available oral and inhalation cancer slope factors and unit risk factors were identified and presented for each constituent classified as a carcinogen by the USEPA. In addition, dermal cancer slope factors were calculated by dividing the oral cancer slope factor by an oral-to-dermal adjustment factor. For chronic noncarcinogenic effects, the available oral and inhalation reference doses and reference concentrations were identified and presented for each constituent. In addition, dermal reference doses were calculated by multiplying the oral reference dose by an oral-to-dermal adjustment factor.

For acute noncarcinogenic effects, the available acute inhalation health effects criteria were reviewed for each COPC selected for the dust inhalation pathway. Since acute inhalation reference concentrations were not available, to provide a conservative evaluation and in consultation with the EPA Region 3 toxicologist, the lowest available acute toxicity value for each constituent was selected as the toxicity value for purposes of evaluating the potential for acute health effects associated with inhalation of dusts at the SSFW site.

The toxicity values used for COPC in each media in each exposure unit as presented in RAGS D Tables 5 and 6 (Tables 5.1 through 5.3 and Tables 6.1 through 6.2, Black & Veatch, 2004a).

### 6.1.4 Risk Characterization

A summary of the human health risk characterization is presented in Table 6-2. The following is a summary of the potential cancer risks and noncancer hazards associated with exposures at each of the investigated areas at the SSFW site. Contaminants that may present an unacceptable risk, but which are at or near background levels have been omitted from this summary; however, these contaminants are discussed more thoroughly in the HHRA.

***6.1.4.1 Residential Wells.*** Current potential cancer risks associated with exposures to residential wells exceed the acceptable risk range. The potential cancer risks are due to arsenic. Current potential noncancer hazards are a concern due to concentrations of arsenic and thallium. The residential wells in which arsenic and thallium were detected are located up gradient of the site. The up gradient locations of arsenic and thallium in residential wells indicates a weak correlation between these constituents and groundwater contamination at the Sharon Steel Farrell Works Site.

***6.1.4.2 Northern Slag Pile Area.*** Current and future potential cancer risks associated with exposures to COPCs in soil at the Northern Slag Pile are within the acceptable risk range. Current and future potential noncancer hazards are a concern due to concentrations of aluminum, iron, manganese and vanadium detected in soil. In addition, there is a potential concern for acute effects due to inhalation of dusts containing arsenic, barium, nickel and vanadium. None of these constituents can be attributed to background.

***6.1.4.3 BOF Sludge Area.*** Current and future potential cancer risks associated with exposures to soil at the BOF Sludge Area exceed the acceptable risk range due to concentrations of chromium detected in soil. Current and future potential noncancer hazards are a concern due to aluminum, cadmium, chromium, iron, lead, manganese, thallium, vanadium and zinc. In addition, there is a potential concern for acute effects due to inhalation of dusts containing arsenic, barium, nickel and vanadium. However, concentrations of aluminum detected in surface soil at the BOF Sludge Area can be attributed to background.

***6.1.4.4 Southern Slag Pile Area.*** Current and future potential cancer risks associated with exposures to soil at the Southern Slag Pile are within the acceptable risk range. Current and future potential noncancer hazards are a concern due to aluminum, chromium, iron, manganese, thallium, and vanadium. In addition, there is a potential concern for acute effects due to inhalation of dusts containing arsenic, barium, nickel and vanadium. However, concentrations of aluminum and arsenic detected in surface soil/slag at the Southern Slag Pile can be attributed to background.

***6.1.4.5 Shenango River Floodplain.*** Current and future potential cancer risks associated with exposures to soil at the Shenango River Floodplain exceed the acceptable risk range due to concentrations of benzo(a)pyrene detected in soil. Current and future potential noncancer hazards are a concern due to aluminum, chromium, iron, manganese and vanadium. In addition, there is a potential concern for acute effects due to inhalation of dusts containing arsenic, barium, nickel and vanadium. However, concentrations of aluminum, arsenic, and barium detected in surface soil at the Shenango River Floodplain can be attributed to background.

***6.1.4.6 Unnamed Tributary Floodplain.*** Current and future potential cancer risks associated with exposures to soil at the Unnamed Tributary Floodplain exceed the acceptable risk range due to concentrations of chromium detected in soil. Current and future potential noncancer hazards are a concern due to aluminum, chromium, manganese and vanadium. In addition, there is a potential concern for acute effects due to inhalation of dusts containing barium, nickel and vanadium. However, concentrations of aluminum, barium, chromium, and manganese detected in surface soil at the Unnamed Tributary Floodplain can be attributed to background.

***6.1.4.7 Southeast Floodplain.*** Current and future potential cancer risks associated with exposures to soil at the Southeast Floodplain are within the acceptable risk range. Current and future potential noncancer hazards are a concern due to aluminum, iron and manganese. In addition, there is a potential concern for acute effects due to inhalation of dusts containing arsenic, barium, nickel and vanadium. However, concentrations of aluminum, arsenic, barium, manganese, and vanadium detected in surface soil at the Southeast Floodplain can be attributed to background.

***6.1.4.8 Ohio Street Wetlands.*** Current and future potential cancer risks associated with exposures to soil at the Ohio Street Wetlands exceed the acceptable risk range due to concentrations of chromium detected in soil. Current and future potential noncancer hazards are a concern due to aluminum, chromium, and manganese. In addition, there is a potential concern for acute effects due to inhalation of dusts containing arsenic, barium, nickel and vanadium. However, concentrations of aluminum, arsenic, barium, manganese and nickel detected in surface soil at the Ohio Street Wetlands can be attributed to background.

***6.1.4.9 Shallow Groundwater.*** Future potential cancer risks associated with exposure to shallow groundwater exceed the acceptable risk range due to concentrations of arsenic and vinyl chloride. Future potential noncancer hazards are a concern due to antimony, arsenic, cadmium, chromium, iron, manganese, thallium, vanadium, and vinyl chloride. However, concentrations of vanadium detected in shallow groundwater can be attributed to background.

***6.1.4.10 Glacial Till Groundwater.*** Future potential cancer risks associated with exposure to glacial till groundwater exceed the acceptable risk range due to concentrations of arsenic and vinyl chloride. Future potential noncancer hazards are a concern due to antimony, aluminum, arsenic, cadmium, cyanide, iron, manganese, thallium, vanadium and vinyl chloride. None of these constituents can be attributed to background glacial till groundwater.

***6.1.4.11 Gravel Zone Groundwater.*** Future potential cancer risks associated with exposure to gravel zone groundwater are within the acceptable risk range. Future potential noncancer hazards are a concern due to barium and thallium. Neither of these two constituents can be attributed to background gravel zone groundwater.

***6.1.4.12 Bedrock Groundwater.*** Future potential cancer risks associated with exposure to bedrock groundwater exceed the acceptable risk range due to concentrations of arsenic. In addition, future potential noncancer hazards are a concern due to arsenic. However, concentrations of arsenic detected in bedrock groundwater can be attributed to background.

***6.1.4.13 Shenango River.*** Current and future potential cancer risks associated with exposure to the Shenango River exceed the acceptable risk range due to concentrations of benzo(a)pyrene and dibenzo(a,h)anthracene in sediment as well as Aroclor 1260 and total 2,3,7,8-TCDD TEQs in fish tissue. Future potential noncancer hazards are a concern due to mercury and thallium in fish tissue. None of the constituents of concern in sediment can be attributed to background; however, Aroclor 1260, total 2,3,7,8-TCDD TEQs and thallium detected in fish tissue can be attributed to background.

***6.1.4.14 Large Wetland Pond.*** Current and future potential cancer risks associated with exposure to the Large Wetland Pond are within the acceptable risk range. Future potential noncancer hazards are a concern due to thallium in fish and duck tissues. However, the concentrations of thallium detected in fish tissue and estimated in duck tissue can be attributed to background.

***6.1.4.15 Small Wetland Pond.*** Current and future potential cancer risks associated with exposure to the Small Wetland Pond are within the acceptable risk range. In addition, future potential noncancer hazards are not a concern at the Small Wetland Pond.

***6.1.4.16 Other Wetland Ponds.*** Current and future potential cancer risks associated with exposure to the Other Wetland Ponds are within the acceptable risk range. In addition, future potential noncancer hazards are not a concern at the Other Wetland Ponds.

***6.1.4.17 Unnamed Tributary.*** Current and future potential cancer risks associated with exposure to the Unnamed Tributary are within the acceptable risk range. Future potential noncancer hazards are a concern due to thallium in fish tissue. However, the concentrations of thallium detected in fish tissue can be attributed to background.

***6.1.4.18 Emergent Wetland.*** Current and future potential cancer risks associated with exposure to the emergent wetland are within the acceptable risk range. In addition, future potential noncancer hazards are not a concern at the emergent wetland.

***6.1.4.19 Slag Pond.*** Current and future potential cancer risks associated with exposure to the Slag Pond are within the acceptable risk range. Future potential noncancer hazards are a concern due to thallium in fish tissue. The concentrations of thallium detected in fish tissue at the Slag Pond can not be attributed to background.

***6.1.4.20 Stateline Residential Area.*** Current and future potential cancer risks associated with exposure to dust at the Stateline Residential Area are within the acceptable risk management range for all receptor scenarios. Future potential noncancer hazards are a concern for residents due to concentrations of manganese predicted in dust. In addition, there is a potential concern for acute effects due to inhalation of dusts containing nickel and vanadium. Information on concentrations of these constituents of concern in background dust is not available; consequently none of these constituents can be attributed to background.

***6.1.4.21 Wansack Residential Area.*** Current and future potential cancer risks associated with exposure to dust at the Wansack Residential Area are within the acceptable risk management range for all receptor scenarios. Future potential noncancer hazards are a concern for residents due to concentrations of manganese predicted in dust. In addition, there is a potential concern for acute effects due to inhalation of dusts containing nickel and vanadium. Information on concentrations of these constituents of concern in background dust is not available; consequently none of these constituents can be attributed to background.

***6.1.4.22 Ohio Street Industrial Area.*** Current and future potential cancer risks associated with worker and residential exposure to the Ohio Street Industrial Area exceed the acceptable risk range due to concentrations of chromium predicted in dust. Future potential noncancer hazards are a concern for all receptors due to concentrations of chromium and manganese predicted in dust. In addition, there is a potential concern for acute effects due to inhalation of dusts containing arsenic, barium, nickel and vanadium. Information on concentrations of these constituents of concern in background dust is not available; consequently none of these constituents can be attributed to background.

***6.1.4.23 Farrell Residential Area.*** Current and future potential cancer risks associated with exposure to dust at the Farrell Residential Area are within the acceptable risk management range for all receptors. Future potential noncancer hazards are a concern for construction workers and residents due to concentrations of manganese predicted in dust. In addition, there is a potential concern for acute effects due to inhalation of dusts containing nickel and vanadium. Information on concentrations of these constituents of concern in background dust is not available; consequently none of these constituents can be attributed to background.

## 6.2 Ecological Risk Assessment

This section summarizes the key information presented in the Baseline Ecological Risk Assessment for the SSFW site, highlighting the Screening-level Ecological Risk Assessment (SLERA), ecological risk assessment problem formulation, and ecological risk characterization. The methodology used in the BERA is based on, and complies with, the latest guidance from the U.S. Environmental Protection Agency (EPA) as described in the Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (EPA 1997); also known as the "ERAGS".

The ERA evaluated the following habitats of concern (Figure 2-7) at the SSFW site:

- Shrub-scrub upland habitat
- Forested riverine floodplain habitat – Shenango River
- Shrub-sapling floodplain habitat
- Forested riverine floodplain habitat – unnamed tributary
- Shrub-sapling palustrine wetland habitat
- Palustrine emergent wetland habitat
- Open water/pond habitat
- Shenango River habitat
- Unnamed tributary habitat

### 6.2.1 Screening-level Ecological Risk Assessment

Steps 1 and 2 of the ERAGS were conducted to assess the need, and if necessary, the level of effort required, to conduct a BERA at the SSFW site. The SLERA screen included a comparison of the maximum concentrations of contaminants detected in surface soil, surface water (freshwater), sediment, and groundwater to the respective EPA Region III ecological screening values (ESV). Those contaminants that exceeded these ESVs were identified as preliminary contaminants of potential ecological concern (COPEC) and were retained for further evaluation in subsequent steps of the ERA process. In this SLERA, only those contaminants that were detected in a media for each exposure unit were considered as potential contaminants of ecological concern.

***6.2.2.1 Soil.*** PAHs, PCBs, and inorganic compounds were identified as preliminary contaminants of potential ecological concern (COPEC) in all of the exposure areas. DDT metabolites were also identified as preliminary COPECs in the Southern Slag Pile and the Shenango floodplain areas. In addition, the Shenango floodplain also identified two methyphenols as preliminary COPEC that were not identified in on-site samples. All seven exposure areas identified several VOCs, SVOCs, pesticides, and hexavalent chromium as preliminary COPEC because there were no acceptable ESVs available for these contaminants.

***6.2.2.2 Sediment*** PAHs, PCBs, and inorganic compounds were identified as preliminary COPECs in all of the exposure areas. The Shenango River sediments also contained a number of different VOCs and SVOCs than other site samples at levels of concern. The wetland area also contained diethylphthalate and phenol (which were not detected in other site samples). Most exposure areas identified several VOCs, SVOCs, pesticides, and inorganics as preliminary COPECs because there were no acceptable ESVs available for these contaminants.

***6.2.2.3 Surface Water.*** Surface water samples were evaluated at the palustrine open water habitats (the large pond, the small pond, and other ponds), and riverine open water habitats (the Shenango River and the unnamed tributary). In general, inorganic compounds were identified as preliminary COPECs in all of the exposure areas. The small pond and unnamed tributary also identified di-n-butyl phthalate as a preliminary COPEC.

***6.2.2.4 Groundwater.*** Based on geological investigations conducted as part of the RI, it was suspected that the top two aquifers in the vicinity of the site (the unconfined surficial and the glacial till aquifers), discharge into adjacent surface waters and wetlands (Shenango River, the unnamed tributary, and the various ponds). Analytical data for groundwater samples collected in each of these aquifers was compared to surface water ESVs. Inorganic compounds were identified as preliminary COPECs in all of the exposure areas. In addition, three pesticides and one PAH compound were identified as preliminary COPECs. Several organic compounds were identified as preliminary COPEC because there were no acceptable ESVs available for these contaminants.

### 6.2.2 Baseline Ecological Risk Assessment

Based on the conclusions of the SLERA, it was determined that there were potential ecological risks at the site; therefore, the subsequent steps (Steps 3 through 7) of the ERA were completed. The BERA established the assessment endpoints - the specific ecological values to be protected. A conceptual model of the site was developed that includes questions about the assessment endpoints and the relationship between exposure and effects.

Preliminary site-specific AEs for the SSFW site were developed based on the information collected in the Phase 1 RI. The problem formulation step (Step 3) of the ERA process was initiated to develop a thorough understanding of the results of the SLERA, refine the list of preliminary COPEC to focus additional investigations, develop a conceptual site model and risk questions, and finalize the site-specific AEs that would be evaluated in the BERA. After the SLERA and additional consultation with the EPA Region III BTAG, these AEs were refined to include:

- AE No. 1 - Protection of terrestrial plant communities from the toxic effects (on survival and reproduction) of site-related chemicals present in surface soils.
- AE No. 2 - Protection of terrestrial soil invertebrate communities from the toxic effects (on survival and reproduction) of site-related chemicals present in surface soils.
- AE No. 3 - Protection of terrestrial herbivore communities from the toxic effects (on survival and reproduction) of site-related chemicals present in terrestrial plant tissue.
- AE No. 4 - Protection of terrestrial vermivore communities from the toxic effects (on survival and reproduction) of site-related chemicals present in terrestrial invertebrate tissue.
- AE No. 5 - Protection of terrestrial carnivore communities from the toxic effects (on survival and reproduction) of site-related chemicals present in terrestrial wildlife prey tissue.
- AE No. 6 - Protection of small mammal communities from the toxic effects (on survival and reproduction) of site-related chemicals present in body tissue.

- AE No. 7 - Protection of reptile communities from the toxic effects (on survival and reproduction) of site-related chemicals present in body tissue.

- AE No. 8 - Protection of wetland plant communities from the toxic effects (on survival and reproduction) of site-related chemicals present in sediment via direct exposure.

- AE No. 9 - Protection of aquatic communities from the toxic effects (on survival and reproduction) of site-related chemicals present in surface water.

- AE No. 10 - Protection of benthic invertebrate communities from the toxic effects (on survival and reproduction) of site-related chemicals present in sediment.

- AE No. 11 - Protection of aquatic herbivore communities from the toxic effects (on survival and reproduction) of site-related chemicals present in aquatic plant tissue.

- AE No. 12 - Protection of benthivore communities from the toxic effects (on survival and reproduction) of site-related chemicals present in benthic invertebrate tissue.

- AE No. 13 - Protection of carnivore communities from the toxic effects (on survival and reproduction) of site-related chemicals present in amphibian tissue.

- AE No. 14 - Protection of piscivore communities from the toxic effects (on survival and reproduction) of site-related chemicals present in prey (fish and crustacean) tissue.

- AE No. 15 - Protection of amphibian communities from the toxic effects (on survival and reproduction) of site-related chemicals present in animal tissue.

The conceptual site model (CSM), presented in Figure 6-1, and establishes the complete exposure pathways that were evaluated in the BERA. Risk questions (about the relationships among AEs and their predicted responses when exposed to contaminants) were posed to develop AEs measurement endpoints (MEs) for each AE. The CSM, risk questions, and MEs for each AE evaluated in the BERA are presented in Table 6-3. Based on this evaluation, a work plan was developed (Step 4) to collect additional data needed to completely assess ecological risks at the site. This data was collected as part of the Phase 2 field investigation.

### 6.2.3 Risk Characterization

The risk characterization step integrated the information and data presented in Steps 1 through 6 into a comprehensive assessment of potential risk to assess the endpoints agreed to by risk managers and stakeholders during the ERA process. The characterization answered the associated risk questions and integrated the answers into a risk statement using a weight-of-evidence approach. These statements of potential risk to the assessment endpoints are followed by a discussion of uncertainties and limitations in the statement of risks.

The evaluation of the endpoints for each of the habitats of concern at the SSFW indicated that all habitats contained contaminated media that present a risk to ecological communities with the exception of the Northern and Southern Slag Piles, which do not support usable ecological habitat. These risks are summarized in the following sections.

***6.2.3.1 Shrub-Scrub Upland Habitat.*** In the shrub-scrub upland habitat, which is also the BOF Sludge Area (a source area), the plant community is likely adversely impacted by direct exposure to metals, PAHs, and dioxins. In site investigation, conducted in this area, there were no overt visible signs of plant toxicity. Plants species which had recolonized this area are likely to be resistant to the contaminants in the surface soil; therefore, direct toxicity to plant communities is probably not a driving risk in this habitat. The soil invertebrate population is likely adversely impacted by metals in surface soils. Finally, the vermivore community is likely impacted by food-chain exposure to metals from surface soils. Metals appear to be the key risk drivers in the shrub-scrub upland habitat.

***6.2.3.2 Forested Riverine Floodplain Habitat – Shenango River.*** In the forested riverine floodplain habitat, the plant community does not appear to be adversely impacted by physical or chemical stressors. Metals, PAHs, and pesticides are present in surface soils from all areas of this habitat at levels that present a direct exposure risk to soil invertebrates and food chain exposure risk to vermivore communities. Metals appear to be the key risk drivers in the forested riverine floodplain habitat.

***6.2.3.3 Shrub-Sapling Floodplain Habitat.*** In the shrub-sapling floodplain habitat (located southeast of the Southern Slag Pile) metals, PAHs, and endrin metabolites in surface soil present an ecological risk. Plant communities are at risk from direct exposure to metals and endrin metabolites in soil. Soil invertebrate communities are at risk from total PAHs in surface soil. Vermivore communities are at risk from food chain transfer of arsenic, mercury, selenium, and PAHs in surface soil. Metals and PAHs appear to be the key risk drivers in the shrub-sapling floodplain habitat.

***6.2.3.4 Forested Riverine Floodplain Habitat – Unnamed Tributary.*** Based on the evaluation of the assessment and measurement endpoints considered for the forested riverine floodplain habitat associated with the unnamed tributary, metals and PAHs in surface soil may result in unacceptable ecological risk. Plant communities are at risk from metals in surface soil through direct exposure. Vermivore communities are at risk from food chain transfer of metals and PAHs from surface soil. Metals and PAHs appear to be the key risk drivers in the forested riverine floodplain habitat.

***6.2.3.5 Shrub-Sapling Palustrine Wetland Habitat.*** Based on the evaluation of the assessment and measurement endpoints considered for the shrub-sapling palustrine wetland habitat, PAHs in surface soil may result in unacceptable ecological risk to avian vermivores.

***6.2.3.6 Palustrine Emergent Wetland Habitat.*** Contaminants in sediment of the palustrine emergent wetlands contain metals at levels that present a direct exposure risk to benthic invertebrate communities. In addition, metals in the sediments also present a risk to benthivore communities in the palustrine emergent wetland habitat. These risks are primarily driven by levels of arsenic and zinc in sediments from this habitat. Samples containing arsenic and zinc at levels of concern also contain the other COPEC.

***6.2.3.7 Open Water/Pond Habitat.*** The open water/ponds were evaluated separately with concern to ecological risks. In general, iron in surface water is only a contaminant of concern in some of the smaller slag ponds throughout the site. Contaminants in sediment of the open water/pond habitat include metals, PAHs, and total 2,3,7,8-TCDD TEQs at levels that present a direct exposure risk to benthic invertebrate and food-chain exposure risk to benthivore communities. Most samples containing zinc at levels of concern contain the other COC as well; therefore, zinc appears to be the principle driver for risks in this habitat. It should be noted that no wildlife were observed in the small open water pond area during any of the previous site investigations.

***6.2.3.8 Shenango River Habitat.*** Copper presents a risk to aquatic communities in surface water at two disparate locations. One location (SW26) is located adjacent to the site. The second location (SW08) is located approximately 1 km downstream of the site. Copper as detected at levels of concern in groundwater and could be discharged from the site with groundwater into the Shenango River. However, it is not a widespread contaminant.

Contaminants in sediment from the Shenango River contain metals, PAHs, and pesticides at levels that present a direct exposure risk to benthic invertebrates. In addition, these same contaminants also present a food-chain exposure risk to benthivore communities. The principal COCs are PAHs and zinc. The most significant PAH locations (with respect to upstream concentrations) are located on the upstream edge of the BOF Sludge Area and at the confluence of the unnamed tributary with the Shenango River. Based on the river morphology, the locations near the BOF Sludge Area are likely to be locations where erosion associated with stormwater flow in the Shenango River has cut into the bank formed by deposited sludge materials.

***6.2.3.9 Unnamed Tributary Habitat.*** Aluminum is a COC in surface water at two disparate locations and is not likely to be a widespread contaminant in surface water. Iron was detected at significant levels in every surface water sample from the unnamed tributary; therefore, it is likely to present a risk to aquatic communities. Iron was detected in groundwater samples from monitoring wells in the surficial groundwater and was also detected in the soils/wastes of the Southern Slag Pile Are, the nearest source.

Sediment contained acetone, SVOCs, Aroclor 1260, barium, beryllium, and thallium at levels that present a direct exposure risk to benthic invertebrate communities in the tributary. Arsenic, chromium, lead, selenium, and PAHs were present in sediment at levels that present a risk through direct and food chain exposure to benthic invertebrate communities and benthivores. Zinc was detected at levels in sediment that presents a risk through food chain exposure.

# 7.0 SUMMARY AND CONCLUSIONS

## 7.1 Nature and Extent of Contamination

The following sections present a summary of the major conclusions of the nature and extent of contamination at the SSFW site.

### 7.1.1 Nature and Extent in Source Areas

In general the three source areas at the SSFW site (BOF Sludge Disposal Area, Northern Slag Pile Area, and Southern Slag Pile Area) contain similar types of contaminants in soils including metals, PAHs, PCBs, and pesticides. Some SVOCs (2-methylnapthalene, dibenzofuran, and others) which are typically associated with PAH contamination were also detected at elevated concentrations in the source areas.

The BOF Sludge Disposal Area is generally the most contaminated source area in terms of number of detected constituents and the concentrations of those constituents, mostly in surface soil and deep subsurface soil. In particular, 2-methylnaphthalaene and several metals (cadmium, chromium, copper, lead, mercury, silver, sodium, and zinc) were detected at higher concentrations than the other two source areas and were greater than background/reference concentrations. PAHs were detected at significant concentrations in the northern and southern ends of the BOF Sludge Disposal Area. Most of the contaminants detected in the BOF Sludge Disposal Area were also detected in downgradient Shenango River floodplain soils and in sediment in the Shenango River. This could indicate that contamination migrates from the BOF Sludge Disposal Area to these low-lying areas via surface runoff and flooding.

The Northern Slag Pile Area is generally the least contaminated source area in terms of number of detected constituents and the concentrations of those constituents. Metals, PAHs, pesticides, and PCBs were the most frequently detected constituents and were detected in all depth intervals; thus defining the vertical extent of contamination. The southern end of the Northern Slag Pile area contained notably high concentrations of metals. Most of the contaminants detected in the Northern Slag Pile Area were also detected in downgradient Shenango River floodplain soils, southeast floodplain soils, and in sediment in the Shenango River. This could indicate that contamination migrates from the Northern Slag Pile Area to these low-lying areas via surface runoff and flooding.

Metals, PAHs, pesticides, and PCBs were the most frequently detected constituents in all depth intervals in the Southern Slag Pile Area. This area also contained some unique contaminants (VOCs and pesticides that were detected in this area but not detected in the other source areas); however, these were detected somewhat infrequently and at low levels. The Southern Slag Pile Area also contains notably higher concentrations of most PAHs, Aroclor-1248, DDT metabolites, and heptachlor epoxide than the other two source areas, particularly in the central portion of the area. Most of the contaminants detected in the Southern Slag Pile Area were also detected in downgradient southeast floodplain soils, unnamed tributary floodplain soils and sediment, wetland ponds, and the Ohio Street wetlands. This suggests that contamination likely migrates from the Southern Slag Pile Area to these low-lying areas via surface runoff and flooding.

### 7.1.2 Nature and Extent in Groundwater

Groundwater was collected from four general zones: shallow aquifer (between 10-30 ft.), glacial till aquifer (between 30-70 ft.), gravel zone (between 70-120 ft.), and bedrock aquifer (deeper than 120 ft.). Residential well samples were also collected from homes in the vicinity of the SSFW site.

The surficial aquifers (shallow and glacial till) contained the highest levels of contamination (mostly metals and PAH) in groundwater when compared to the gravel zone and bedrock aquifers (refer to Figures 4-9, 4-10, and 4-11). Contaminant concentrations in the underlying confined aquifers (gravel zone and bedrock) are significantly lower and are near background levels. In addition, some portions of these confined aquifers are artesian, indicating an upward gradient of groundwater flow.

Data collected as part of this RI indicates that groundwater in the unconfined surface aquifers effectively transports contamination toward the east and southeast. At the BOF Sludge and the Northern Slag Disposal Areas, groundwater flow in these surface aquifers discharges into the Shenango River. At the Southern Slag Disposal Area, groundwater flow in the surficial aquifers discharges into the wetland/pond complex, the unnamed tributary, and the Shenango River. This observation is supported by the observation of artesian conditions in the portions of the confined aquifer which would indicate upward flow from the deeper aquifers into the shallow aquifers and the Shenango River.

The base of the glacial till and the upward flow gradient from the underlying confined aquifers appears to be a somewhat effective barrier to contamination of the confined aquifers. Hydrogeologic data indicates that groundwater in the confined aquifers generally flows to the north and partially discharges into the Shenango River.

Drinking water wells for some of the residents along Stateline and Wansack Roads (west and southwest of the site, respectively) contained levels of arsenic and manganese exceeding drinking water MCLs. Based on the well surveys, these wells are screened in the gravel zone or bedrock aquifers. These levels of arsenic and manganese were within or below regional concentrations based on a survey of nearby groundwater supplies and water utilities conducted as part of this RI. Data evaluated in the RI also indicates that groundwater flow in the aquifers which supply these local residents is toward the north or northeast. This flow direction would transport site-related contamination away from these residents. Based on this information, contaminated groundwater from the site is not likely to be impacting these residential well users.

### 7.1.3 Nature and Extent in Downgradient Areas

Samples of media associated with areas downgradient of the sources (floodplain soil, sediment, and surface water were collected in the RI. These media contained many of the same contaminants found in soils and groundwater at the source areas including metals, PAHs, SVOCs (2-methylnapthalene, dibenzofuran, and others which are typically associated with PAH contamination at hazardous wastes sites), and PCBs. However, it is important to note that there is another Superfund site (Westinghouse) located several miles upstream which has documented releases of PCBs into the Shenango River. This is a confounding factor in attribution of PCBs in the Shenango River and associated floodplains since PCBs were also detected in source area material at significant levels.

The furthest downstream floodplain samples from the Shenango River contained elevated (greater than background/reference) concentrations of several metals in surface and shallow subsurface soils. These floodplain soil samples were collected approximately 1,500 feet downstream of the site. The furthest downstream sediment from the Shenango River also contained elevated (greater than background/reference) concentrations of zinc, a site-related contaminant. This sediment sample was collected approximately 3,000 feet downstream of the site. This data indicates that that the downstream extent of metals contamination in the Shenango River and its floodplain has not been fully delineated.

Along the Shenango River there are clustered areas of contamination. Along the north end of the BOF Sludge Area, floodplain soils and sediments contain significant concentrations of metals and PAHs. Given the alignment of the Shenango River near the BOF Sludge

Disposal Area (which serves as the river bank in some areas) it is possible that the Shenango River erodes or cuts into the source material during periods of high flood flow. As flood waters recede, it is likely that the suspended particles settle onto the floodplain of the Shenango River or in depositional areas as sediment. In general, most of the Shenango River floodplain and sediments contain elevated levels of metals along the west bank of the Shenango River.

Downgradient of the Southern Slag Disposal Area, contamination also appears to cluster in two general areas. One of these areas is an old "oxbow" of the Shenango River, which now is a surface depression draining toward the unnamed tributary. Groundwater seeps have been observed in this area and surface drainage from source areas also flows into the area. Soils in this "oxbow" areas as well as sediments sampled in the adjacent areas of the unnamed tributary contained elevated levels of metals, PAHs, and PCBs. The other area of contaminant accumulation appears to be at the end of the tributary at its confluence with the Shenango. Sediments in this area contained significant concentrations of metals, PAHs, and PCBs.

The most significant areas of contamination in these wetlands and ponds are along an axis from the small wetland pond moving southward through another small pond toward the unnamed tributary. However, in general, contaminant concentrations in the emergent wetlands and the wetland pond are much lower that in the areas described previously.

In general, from the point at which source areas are no longer in direct contact with source materials (soil or contaminated groundwater), concentrations of contaminants in, and along, the Shenango River decreases with distance. This point appears to be the confluence of the Shenango River and the unnamed tributary.

### 7.1.4 Nature and Extent in Biota

Metals were the most frequently detected constituent in all biota samples including large fish, small fish, crayfish, amphibians, small mammals, and reptiles. Site-related metals were also present at elevated concentrations in all the areas where biota samples were collected. It is important to note that metals are essential components of biota and whole-body samples of biota would be expected to contain metals. Metal concentrations in the aquatic biota appear to be elevated compared to those from reference sites; however, no such comparison could be made to terrestrial biota. PCBs (specifically Aroclor 1260) were detected in a majority of the large and small fish and crayfish from the Shenango River. It is important to note that the Westinghouse site located several miles upstream, which has documented releases of PCBs into the Shenango River, could also be a contributor in the PCBs found in Shenango River biota. This is a confounding factor in attribution of PCBs since they were also detected in source area material at significant levels.

## 7.2 Risk Assessment

The following subsections provide a summary of the BERA and HHRA conducted based on the samples collected under this RI (Black & Veatch 2004a; Black & Veatch 2004b).

### 7.2.1 Risks at Source Areas

The soils and groundwater sampled at the three source areas contain levels of contaminants that present risks to both human health and ecological receptors.

***7.2.1.1. BOF Sludge Area.*** There are current and future potential cancer human health risks associated with exposures to soil at the BOF Sludge Area under exposure scenarios for workers and residents due to inhalation of dusts containing chromium. There are current and future potential noncancer hazards associated with exposure scenarios for workers, trespasser/visitors and residents due to ingestion, inhalation of dusts and dermal contact of cadmium, chromium, iron, lead, manganese, thallium, vanadium and zinc. In addition, there is a potential concern for acute effects due to inhalation of dusts containing arsenic, barium, nickel and vanadium for all receptors under all exposure scenarios. Metals, PAHs, and dioxins present an ecological risk at the BOF Sludge Area and are likely to adversely impact soil invertebrate communities though direct exposure. Vermivores may also be impacted though food-chain exposure to these same contaminants.

***7.2.1.2. Southern Slag Disposal Area.*** At the Southern Slag Disposal Area, current and future cancer risks associated with exposures to soil are within the acceptable range. However, there are current and future potential noncancer hazards associated with exposure scenarios for workers, trespasser/visitors and residents due to ingestion, inhalation of dusts and dermal contact with soil containing chromium, iron, manganese, thallium, and vanadium. In addition, there is a potential concern for acute effects due to inhalation of dusts containing barium, nickel and vanadium for all receptors. There are no ecological risks associated with the Southern Slag Pile area since it is currently a barren area which provides little usable habitat.

***7.2.1.3. Northern Slag Disposal Area.*** Current and future cancer risks associated with exposures to soil at the Northern Slag Disposal Area are within the acceptable range.. There are noncancer risks associated with current and future workers as well as future residents due to ingestion, inhalation of dusts and dermal contact with soil containing aluminum, iron, manganese and vanadium. In addition, there is a potential concern for acute effects due to inhalation of dusts containing arsenic, barium, nickel and vanadium for all receptors. There are no ecological risks associated with this source area since it is currently a barren area which provides little usable habitat.

***7.2.1.4. Source Area Groundwater.*** At the all of the source areas, there are future potential human health cancer risks associated with worker and residential exposures to unconfined groundwater aquifers related to the ingestion of arsenic and vinyl chloride. Future potential noncancer hazards are also a concern for workers and residents primarily due to ingestion and dermal contact of antimony, aluminum, arsenic, cadmium, chromium, iron, manganese, thallium, vanadium, cyanide, and vinyl chloride.

The risk assessment concluded that there are no current or future human health cancer risks associated with any of the exposure scenarios evaluated for the deeper confined aquifers (gravel zone and bedrock) at the source areas. There is a potential noncancer risk associated with a future residential ingestion exposure to barium and thallium in groundwater from the gravel zone at the source areas.

### 7.2.2 Risks at Off-site Areas

The soils, sediment, and surface waters sampled at areas downgradient of the source areas contain levels of contaminants that present risks to both human health and ecological receptors. In addition, modeled air concentrations of contaminants in dust were also present at levels that present a human health risk to nearby residents and industrial workers. However, residents west and south of the site who use groundwater as a source of potable water are not at risk from site-related contamination.

***7.2.2.1 Shenango River Floodplain.*** There are current and future potential human health cancer risks associated with residential exposures to Shenango River floodplain soils due to ingestion and dermal contact with benzo(a)pyrene detected in soil. There are also current and future potential noncancer hazards associated with exposure scenarios for workers and residents due to ingestion, inhalation of dust (from the source areas), and dermal contact of chromium, iron, manganese, and vanadium. In addition, there is a potential concern for acute effects due to inhalation of dusts containing nickel and vanadium for all receptors. Metals in surface soil may present an ecological risk along the Shenango River floodplain. Metals are likely to cause adverse effects to plant communities and soil invertebrate communities through direct exposure and to vermivore communities through food-chain exposure risks. PAHs and pesticides are also likely to cause adverse effects to soil invertebrates though direct exposure and through the food-chain to vermivores.

***7.2.2.2 Shenango River.*** There are current and future potential human health cancer risks associated with worker and residential exposure to sediment in the Shenango River due to ingestion of, and dermal contact with benzo(a)pyrene and dibenzo(a,h)anthracene. There are also current and future potential human health cancer risks associated with ingestion of fish containing Aroclor 1260 and total 2,3,7,8-TCDD TEQs (dioxins/furans). There is also a potential noncancer hazard related to the ingestion of fish containing mercury. It should be noted that PCBs and dioxins/furans were also detected at similar concentrations in fish tissue samples from upgradient background areas and PCBs may also be associated with the Westinghouse site. Copper was detected in surface water at two locations that may present an ecological risk to aquatic communities in the Shenango River. One location (SW26) is located adjacent to the site. The second location (SW08) is located approximately 1 kilometer downstream of the site. Contaminants in sediment from the Shenango River contain metals, PAHs, and pesticides at levels that may present a direct exposure risk to benthic invertebrates and a food-chain exposure risk to benthivore communities. Samples of crayfish and fish tissue from the Shenango River did not contain contaminants at levels that present an ecological risk to piscivorous communities.

***7.2.2.3. Southeast Floodplain Area.*** Current and future human health cancer risks associated with exposures to soil at the southeast floodplain are within the acceptable range. However, there is a current and future potential noncancer hazard associated with residents (child only) due to ingestion and dermal contact with soil containing iron. There is also a potential concern for acute effects for all receptors in this area due to inhalation of dusts (from the source areas) containing nickel In the southeast floodplain, metals, PAHs, and endrin metabolites in surface soil may present an ecological risk. Plant communities may be impacted by direct exposure to metals and endrin metabolites in soil. Soil invertebrate communities may be impacted by total PAHs in surface soil. Vermivore communities may be impacted by food chain transfer of arsenic, mercury, selenium and PAHs in surface soil. Samples of mammal and reptile tissue from the southeast floodplain habitats did not contain contaminants at levels that present an ecological risk to carnivorous communities.

***7.2.2.4. Unnamed Tributary Floodplain.*** Potential human health cancer risks associated with exposures to soil at the unnamed tributary floodplain are acceptable. Current and future potential noncancer hazards are a concern for residents associated with ingestion, inhalation of dust (from source areas), and dermal contact with vanadium. In addition, there is a potential concern for acute effects for all receptors in this area due to inhalation of dusts (from source areas) containing nickel and vanadium. Metals in surface soil may present an ecological risk to plant communities through direct exposure and vermivore communities are at risk from food-chain transfer of bioaccumulative metals and PAHs.

***7.2.2.5. Wetland Ponds.*** Current or future potential human health cancer risks associated with exposure to surface water, sediment, fish, or ducks in the wetland ponds are within the acceptable range for all of the exposure scenarios. Future potential noncancer hazards are a concern in the large wetland pond based on recreational ingestion of fish and duck tissue containing thallium, however thallium can be attributed to background.. There are no human health noncancer risks associated with exposure to surface water and sediment in any of the other wetland ponds for any of the exposure scenarios. Iron was detected in surface water (in some of the smaller slag ponds throughout the site) that may present an ecological risk to aquatic communities in the wetland ponds. It should be noted that no wildlife were observed in the small open water pond area during any of the previous site investigations; however, this lack of wildlife in this habitat may be related to the physical/chemical conditions of the pond itself (high pH, fine grain size, low DO). Samples of crayfish and fish tissue from the wetland ponds did not contain contaminants at levels that present an ecological risk to piscivorous communities.

***7.2.2.6. Emergent Wetlands.*** There are no current or future potential human health risks associated with exposure to sediment in the emergent wetland for any of the exposure scenarios. Metals (primarily zinc) and total 2,3,7,8-TCDD TEQs in sediment may present an ecological risk through direct exposure to benthic invertebrate and food-chain exposure to benthivore communities. Samples of amphibian from the emergent wetland did not contain contaminants at levels that present an ecological risk to carnivorous communities.

***7.2.2.7. Unnamed Tributary.*** Current and future potential human health cancer risks associated with exposure to surface water, sediment and fish in the unnamed tributary are acceptable for all exposure scenarios. Future potential noncancer hazards are a concern in the unnamed tributary based on recreational ingestion of fish containing thallium, however thallium can be attributed to background.. Aluminum was detected in surface water at levels that may present an ecological risk to aquatic communities in the unnamed tributary. Iron was also detected at significant levels in every surface water sample from the unnamed tributary; therefore, it is likely to present a risk to aquatic communities. Sediment collected in the unnamed tributary contained acetone, SVOCs, Aroclor 1260, barium, beryllium, and thallium at levels that may present a direct exposure risk to benthic invertebrate communities. Arsenic, chromium, lead, selenium, and PAHs were present in sediment at levels that also present a risk through direct exposure to benthic invertebrate communities and through food-chain exposure to benthivores. Zinc was detected at levels in sediment that presents a risk to benthivores through food-chain exposure.

***7.2.2.8 Ohio Street Wetlands.*** There are potential human health cancer risks associated with exposures to chromium in soil due to inhalation of dust for workers and residents at the Ohio Street wetlands. Current and future potential noncancer hazards are a concern for workers and residents associated with inhalation of chromium in dust (from source areas). In addition, there is a potential concern for acute effects for all receptors in this area due to inhalation of dusts (from source areas) containing vanadium. Concentrations of contaminants in soils from this wetland were below levels of ecological concern.

***7.2.2.9. Nearby Residential Areas.*** Current and future potential cancer risk associated with exposure to dust from source areas for all of the receptor exposure scenarios considered were acceptable in all of the nearby residential areas. Current and future potential noncancer hazards are a concern for residents and construction workers due to concentrations of manganese predicted in dust from the source areas. In addition, there is a potential concern for acute effects due to inhalation of dusts from the source areas containing nickel and vanadium. There are no ecological risks associated with these areas, which provide limited ecological habitat.

***7.2.2.10. Nearby Industrial Areas.*** Concentrations of chromium predicted in dust from the source areas presents an unacceptable current and future potential human health cancer risk for workers and residents. Future potential noncancer hazards are a concern for all receptors due to concentrations of chromium and manganese predicted in dust from the source areas. In addition, there is a potential concern for acute effects due to inhalation of dusts containing arsenic, barium, nickel and vanadium. There are no ecological risks associated with these areas, which provide limited ecological habitat.

## 7.3 Data Limitations

The following is a summary of the data limitations encountered during this investigation.

- All of the analytical data evaluated for this investigation was generated through the CLP and validated by EPA's validation contractors. All site media contained positive detections of constituents that were J-qualified at concentrations below their detection limit. These data are estimated and may not be accurate or precise. Additional information regarding laboratory qualifiers is available in the data validation packages provided in Appendix I.
- The BERA evaluated risks based on the best available toxicity data found in the scientific literature. There were no site-specific toxicity tests conducted for contaminated soils, surface waters, or sediments. Conclusions describing direct exposure risks for benthic communities related to contaminated sediment in the Shenango River, the emergent wetland, and the unnamed tributary may be overstated. Site-specific toxicity testing of these sediments could be helpful in determining if there are actual risks to the benthic communities in these areas. Conclusions describing direct exposure risks for soil invertebrate communities related to contaminated soils in the Shenango River floodplain, the southeast floodplain, and the floodplain of the unnamed tributary may be overstated. Additional site-specific toxicity testing of these soils could be helpful in determining if there are actual risks to the soil invertebrate communities in these areas. Earthworm toxicity tests were performed during the RI at did not indicate any toxicity; however, the soils sampled as part of this toxicity study did not capture the highest areas of contamination in soils. Therefore, the ability of these toxicity tests to definitively assess invertebrate toxicity at the site is questionable.
- The furthest downstream samples of floodplain soil and sediment, ¼ mile and ¾ mile downstream, respectively, contained significant levels of some site-related contaminants. Based on this data, the downstream extent of contamination was not determined in this study.
- The Westinghouse Superfund Site, located approximately 5 miles upstream on the Shenango River, is a known source of PCBs. This is a confounding factor in attribution of PCBs since they were also detected in source area material at significant levels.

## 7.4 Recommendations for Additional Work

As stated previously, the downstream extent of sediment contamination (metals) has not been fully determined. The RI would benefit from additional downstream investigation in the Shenango River to fully define the extent of metals contamination in floodplain soils and sediment.

Conclusions describing direct exposure risks for benthic communities related to contaminated sediment in the Shenango River, the emergent wetland, and the unnamed tributary may be overstated (as described previously) and could drive remediation of areas that may not required these measures. Site-specific toxicity testing of these sediments could be helpful in determining if there are actual risks to the benthic communities in these areas.

Conclusions describing direct exposure risks for soil invertebrate communities related to contaminated soils in the Shenango River floodplain, the southeast floodplain, and the floodplain of the unnamed tributary may be overstated. Additional site-specific toxicity testing of these soils could be helpful in determining if there are actual risks to the soil invertebrate communities in these areas.

## 7.5 Recommended Remedial Objectives

Based on the results of this investigation, the following remedial objectives are recommended for the SSFW site:

1. Reduce human health risks at the Northern and Southern Slag Pile Areas by reducing current and long-term human exposure to contaminated soils or reducing the contaminant concentrations in the source material. In addition, these two source areas generate dusts which present chronic and acute inhalation exposure risks to receptors in nearby residential and industrial areas. It is important to consider that reclamation mining of the slag piles at the Southern Slag Pile Area is expected to continue for several years under the current PADEP permit. Selected remedial objectives must consider measures to reduce dust generation and restrict human exposure to these areas where mining activities will continue. An objective should also be to eliminate surface runoff from the source areas which can continue to contaminate downgradient areas.
2. Reduce human health and ecological risks at the BOF Sludge Disposal Area by reducing current and long-term human and wildlife exposure to contaminated soils or reducing the contaminant concentrations in the source material. In addition, this source area generates dusts which present chronic and acute inhalation exposure risks to receptors in nearby residential areas. Food chain risks to vermivores can be reduced to acceptable levels by lowering the average concentrations of COCs to acceptable levels, reducing bioavailability of COCs, or by eliminating the exposure pathway. Remedial objectives should also consider further evaluation and elimination of the erosion from northern portion of the BOF Sludge Disposal Area

(if occurring) which releases contamination to the Shenango River and downgradient areas. An objective should also be to eliminate surface runoff from the source areas which can continue to contaminate downgradient areas.

3. Unconfined groundwater aquifers at the source areas contain COC contaminants at levels that present human health risks. Remedial objectives to address this groundwater should seek to limit the use of this water for potable or production purposes to levels that do not result in an unacceptable risk. In addition, remedial options for the source areas themselves should include preventing infiltration of precipitation which drives the movement of site-related contaminants from the sources, into groundwater, and ultimately, into the downstream habitats. This may be a challenge at the Southern Slag Pile Area due to the mining operations that will be ongoing.
4. Reduce or eliminate exposure to contaminants in downgradient habitats and media to levels that do not present direct or food-chain exposure risks. It should be noted that these downstream habitats appear to be functioning well and do support diverse wildlife communities. Decision made to remediate soils and sediments in these areas should consider the adverse impacts of remedial activities in these areas versus the short- and long-term benefits of these actions. Considerations should also be made to the impact of source remediation activities on these downstream areas. For example, remedial activities that eliminate the source of contaminants to these areas (runoff and groundwater discharge from the source areas) may allow these systems to recover through natural attenuation, dilution, and dispersion. Long-term monitoring may be a feasible remedial alternative to consider in these areas.

Screening and evaluation of specific remedial alternatives to meet these objectives will be addressed in detail in the Feasibility Study (FS) Report.

# 8.0 REFERENCES

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