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CUMMINGS RITER CONSULTANTS, INC.

June 26, 2000
Project No. 93111.70/02

Mr. Charles Tordella
Pennsylvania Department of Environmental Protection
Northwest Regional Office
230 Chestnut Street
Meadville, PA 16335

RE: TRANSMITTAL – FINAL FEASIBILITY STUDY REPORT – OPERABLE UNIT 2
WESTINGHOUSE ELECTRIC - SHARON PLANT - SHARON, PENNSYLVANIA

Dear Mr. Tordella:

Cummings/Riter Consultants, Inc., on behalf of CBS Corporation, hereby transmits three copies of the Final Feasibility Study (FS) Report for Shenango River sediments, groundwater, and non-aqueous phase liquids at the former Westinghouse facility in Sharon, Pennsylvania. This report has been prepared in accordance with the Remedial Investigation/Feasibility Study Work Plan, Revision 2.0 prepared by Paul C. Rizzo Associates, as approved by the Pennsylvania Department of Environmental Protection and the U.S. Environmental Protection Agency, and is a deliverable under the Consent Order and Agreement dated September 21, 1988 between Westinghouse and PADEP.

This submittal incorporates comments received by CBS on March 3, 2000 with respect to the December 1999 FS Report. CBS' responses to these comments are provided in Appendix E of the enclosed Final FS Report.

Should you have any questions, please feel free to contact either of the undersigned at (412) 373-5240 or Mr. Gordon Taylor of CBS at (412) 642-5851.

Sincerely,
Cummings/Riter Consultants, Inc.

Bryan R. Maurer
Senior Project Engineer

Patrick F. O'Hara, P.E.
President

Copy received
6-26-00
by V. Janosik, RPM

BRM/yrp
Enclosures

pc: Mr. Gordon Taylor - CBS (two copies)
Mr. Vic Janosik - USEPA (three copies)
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CUMMINGS RITER CONSULTANTS, INC.

FEASIBILITY STUDY REPORT – OPERABLE UNIT 2 SEDIMENT, GROUNDWATER, AND NAPLs WESTINGHOUSE ELECTRIC (SHARON PLANT) SHARON, PENNSYLVANIA

Received 6-26-00 by V. Janosik, RPM

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FEASIBILITY STUDY REPORT – OPERABLE UNIT 2
SEDIMENT, GROUNDWATER, AND NAPLs
WESTINGHOUSE ELECTRIC (SHARON PLANT)
SHARON, PENNSYLVANIA

1.0 INTRODUCTION

This Feasibility Study (FS) Report for Operable Unit 2 (OU2) has been prepared on behalf of CBS Corporation (CBS) for the former Sharon Plant in Sharon, Pennsylvania (Figure 1-1) in accordance with the Consent Order and Agreement, dated September 21, 1988, between Westinghouse Electric Corporation (Westinghouse) and the Pennsylvania Department of Environmental Resources (PADER) (currently Pennsylvania Department of Environmental Protection [PADEP]). This document was completed pursuant to the Remedial Investigation/Feasibility Study (RI/FS) Work Plan, Revision 2.0 (Rizzo Associates, 1992), and draws from information presented in the RI Report (Cummings/Riter, 1996) and the Human Health Risk Assessment (HHRA) (ChemRisk, 1998).

In 1998, based on a review of the available data, and after discussion with U.S. Environmental Protection Agency (USEPA) and PADEP, CBS determined that sufficient and/or recent data was not available at that time to assess remedial alternatives for groundwater [including non-aqueous phase liquids (NAPLs)] and sediment. With the concurrence of the agencies, CBS prepared and submitted a FS Report for site soils (Operable Unit 1) while gathering additional data for groundwater, sediment, and NAPLs. The Final FS Report for soils was submitted on November 17, 1998, and was approved by the agencies on December 17, 1998. Accordingly, this FS Report for OU2 evaluates potential remedial alternatives for site groundwater, sediment, and NAPLs.

1.1 SITE BACKGROUND

The Remedial Investigation (RI) Report presented a detailed summary of historical and current site background information. In brief, the nearly 58 acre plant site (Figure 1-2)

has had a long history of industrial use, including iron foundry manufacturing and flour milling dating back to the mid-1800s when a branch of the Erie Canal passed through what is today referred to, on-site, as the Moat. Westinghouse acquired the property from the Savage Arms Corporation in 1922, and operated it over a period of 62 years until it ceased operation in 1984. The Sharon plant produced distribution transformers, power transformers, and related electrical apparatus. During World War II, two-thirds of the facility was used and controlled by the United States government for manufacturing activities in support of the war effort. Specific activities included development and production of underwater ordnance and radio and radar transformers and transformer cores.

1.2 REGULATORY BACKGROUND

In November 1980, the facility qualified for Interim Status under Subtitle C of the Resource Conservation Recovery Act (RCRA) when Westinghouse filed a Notification of Hazardous Waste Activity and Part A of a RCRA Permit Application to treat, store or dispose of hazardous waste. Westinghouse withdrew the Part A Permit Application in July 1983 and converted to generator-only status.

Westinghouse originally submitted a National Pollutant Discharge Elimination System (NPDES) permit application in 1972. Section 1.5.1 of the RI contains a detailed discussion of the NPDES permitted outfalls since 1981.

In April 1985, PADER issued Westinghouse an Administrative Order to undertake a subsurface investigation to determine the horizontal and vertical extent of impacted groundwater and soil (final report submitted by Westinghouse in September 1986), and to submit a Proposed Plan and Schedule for the cleanup of any identified impacted soils and groundwater (submitted by Westinghouse in October 1986).

The site was proposed for inclusion on the National Priorities List (NPL) in June 1988 and was listed on the NPL in August 1990.

In September 1988, Westinghouse entered into a Consent Order and Agreement with PADER to conduct a RI/FS to determine the nature and extent of contamination at the

site. In May 1990, Westinghouse requested permission to extract and dispose of light non-aqueous phase liquids (LNAPL) at the site. As a follow up to this request, in February 1994, the USEPA issued a Unilateral Administrative Order (UAO) for the development and implementation of a Response Action Plan for the removal of LNAPL from groundwater underneath the tank farm in the Middle Sector in order to reduce the threat of off-site migration of LNAPL. A Pilot Study report and addendum letter was approved by the USEPA in August 1995. LNAPL recovery and disposal is an ongoing removal action under the UAO (see Section 1.4).

On March 20, 1996 Westinghouse submitted the final site RI Report (approved by PADEP on May 24, 1996). On June 6, 1997 Westinghouse submitted a final site Screening-Level Ecological Risk Assessment (approved by PADEP on August 7, 1997), and on April 7, 1998 CBS submitted the final site Baseline Human Health Risk Assessment (approved by PADEP on April 22, 1998). Both risk assessments were prepared by ChemRisk® under contract with Westinghouse/CBS.

The Final FS Report for OU1 (soils) was submitted by CBS on November 17, 1998, and was approved by PADEP on December 17, 1998. USEPA issued a Proposed Plan for the remedy of OU1 on June 7, 1999, and the Record of Decision for OU1 is expected to be issued shortly. Based on the Proposed Plan, the selected remedy for site soils may include the excavation and removal of selected soils impacted primarily by polychlorinated biphenyls (PCBs) and lead, the placement of a soil cover over other selected soils impacted primarily by PCBs and lead, and the implementation of deed restrictions to prevent the uncontrolled disturbance of remaining impacted soils.

1.3 PHYSICAL CHARACTERIZATION

The following subsections provide a brief overview of the physical setting of the site, including hydrologic, geologic, and hydrogeologic characteristics in the vicinity of the site. Greater detail on each of these topics can be found in Section 3.0 of the RI Report (Cummings/Riter, 1996).

1.3.1 Surface Water Hydrology

The regional area surface waters drain to the Upper Ohio River Basin. The main tributaries to the Upper Ohio River Basin are the Beaver, Mahoning, and Shenango Rivers. The Shenango River is the dominant surface drainage feature in the immediate site area. The Shenango River flows south from the Shenango River Reservoir, located approximately 3.5 miles to the north, past the site to the confluence with the Mahoning River to form the Beaver River south of New Castle, Pennsylvania.

Uses of the Shenango River in the vicinity of the site include recreation and fishing. Additionally, the Shenango Valley Water Authority draws water from the river approximately 1,600 feet downstream from the Clark Street bridge. The median and mean flow rates of the Shenango River at the Clark Street bridge are 398 and 797 cubic feet per second, respectively, as measured by the U.S. Geological Survey.

Surface water drainage in the areas adjacent to the site and on the site itself is controlled by storm sewers. The site is largely paved or under roof, and thus infiltration of rainwater is limited. The locations of the storm sewers currently receiving drainage from the site are shown on Figure 2-2 of the RI. The Wishart Court sewer receives runoff from the A, B and C Buildings, as well as from the southern half of the F, F-H, H and T Buildings. The Franklin Street sewer receives storm water from the Y Building. The Clark Street sewer receives runoff from the northern half of the F, F-H, H and T Buildings, as well as from all buildings in the North Sector.

1.3.2 Local Geology

The former Sharon Transformer Plant is located in the glaciated section of the Appalachian Plateau physiographic province. The area is a maturely dissected plateau consisting of highlands separated by deep broad valleys. The glaciation of the area masks the preglacial topography without completely hiding it. The effect of glaciation was to smooth and erode hills and partially infill valleys; although many pre-existing features are still evident. Section 3.3 of the RI Report provides a detailed discussion of the regional geologic setting. Following is a description of the local geologic setting, as provided in the RI Report (Cummings/Riter, 1996).

The presence of variable amounts of artificial fill is indicated by site borings. The thickness of the fill across the site ranges from nonexistent to a maximum of approximately 20 feet. Fill was not encountered in borings along much of the eastern portion of the site (Figure 3-5 of the RI). In the North Sector, the fill reaches a maximum thickness of 12 feet in Monitoring Well N-1. The maximum thickness of the fill is 19 feet, achieved in the southwest corner of the Middle Sector (Monitoring Well M-5).

A review of logs for borings encountering fill conducted during the comprehensive subsurface study (Rizzo Associates, 1986) and the RI indicates the fill is primarily comprised of loose to dense, gray, black, and brown cinders and slag with some wood and brick fragments, and trace amounts of sand and silt.

The Shenango River Valley bottom contains Holocene Age alluvial deposits consisting of sand, gravel, silt and clay. Based on the results of site borings, alluvial deposits are present across the site. The alluvial deposits at the site are composed of reworked glacial material. The alluvium thins along the eastern portion of the site (Figure 3-6 of the RI). Based on field observations and data from borings, it is unlikely that the alluvial deposits extend beyond Sharpsville Avenue, except in the southeastern and northeastern limits of the site. Alluvial deposits obtain maximum thickness in the area along the western limits of the Middle Sector and the area east of the former moat in the vicinity of Monitoring Wells S-7 and S-13 (Figure 3-6 of the RI).

Unconsolidated deposits of Pleistocene Age glacial till are present across the former Sharon Transformer Plant Site. The glacial till is present between the alluvial deposits and bedrock. The glacial material encountered at the site is believed to correspond to the Titusville and Mapledale Tills. The glacial till at the site ranges in thickness from less than 10 feet to more than 80 feet thick. The thickness of the glacial till at the site is depicted on Figure 3-7 of the RI.

The surface elevation (feet mean sea level [MSL]) of the glacial till (alluvium/glacial till contact) was determined for each boring and the results contoured (Figure 3-8 of the RI). The surface of the glacial till, as inferred from site borings, generally slopes from east to west across the site. Two depressions are present in the glacial till surface; in the South Sector near Monitoring Well S-7 and also along the western portion of the Middle Sector

building, in the area of Monitoring Wells M-5, M-12 and MW-14B (Figure 3-8 of the RI). These depressions in the surface of the glacial till generally correspond to areas where the overlying alluvial deposits are thickest.

A review of logs for borings encountering glacial till conducted during the comprehensive subsurface study (Rizzo Associates, 1986) and the RI indicates that glacial till is primarily comprised of hard, gray to brown silt and clay with some very dense, fine to coarse sand, gravel and rock fragments.

Bedrock underlying the former Sharon Transformer Plant is blanketed by unconsolidated deposits of Holocene Age (alluvium) and Pleistocene Age (till). The bedrock beneath the site consists of shale, siltstone and sandstone of the Mississippian System. The bedrock units encountered in site borings include the Orangeville Shale and the underlying Berea Sandstone. Bedrock of the Pennsylvanian System subcrops in the area immediately east of the site.

It has been reported that the Sharpsville Sandstone subcrops beneath the unconsolidated deposits along the east side of the former Sharon Transformer Plant (O'Brien and Gere, 1983b). A review of site borings which were advanced to bedrock indicates that the Orangeville Shale subcrops beneath most of the immediate site area. If present, the Sharpsville Sandstone is likely to be slightly east of Sharpsville Avenue. The Berea Sandstone was apparently encountered in two site borings, N-3B and R-1.

The surface of site bedrock was altered during the Pleistocene epoch by the advance and retreat of the glaciers, which scoured the bedrock surface. The approximate existing bedrock surface, as inferred by site borings, is presented on Figure 3-9 of the RI. As shown on that figure, the bedrock surface ranges in elevation from 830 to 780 feet MSL on the former Sharon Transformer Plant Site. The bedrock surface is quite variable, with the highest elevations in the southern portion of the site. The bedrock surface generally slopes north and west from the South Sector. The depth to bedrock ranges from 31 feet (Borings S-2B and S-10) to 108 feet (Boring N-3B) below ground surface.

A review of logs for borings encountering bedrock conducted during the comprehensive subsurface study (Rizzo Associates, 1986) indicates that bedrock encountered was generally comprised of medium to dark gray, soft-to-hard shale and siltstone, with thin gray, medium hard sandstone layers.

According to Carswell and Bennett (1963), Mississippian bedrock units underlying the site area dip south and southwest at the rate of approximately 15 feet per mile.

1.3.3 Groundwater

Bedrock of the region is dissected by major and minor stream valleys. The bedding of the bedrock is relatively flat-lying. Water entering the bedrock system near the top of the ridges tends to move downward and outward toward the stream valleys. The hydraulic head within the ridge areas decreases with depth. Groundwater may emerge as springs and seeps associated with aquitards along the valley walls. Some groundwater emerges as base flow to small streams in the valleys. In addition, some groundwater continues to move downward and emerge in the glacial drift along the axis of the major stream valleys (Schiner and Kimmel, 1976). Groundwater flow in bedrock tends to flow along fractures within the bedrock. Two primary joint sets have been identified by Carswell and Bennett (1963) as trending N40-45°E and N40°W.

Groundwater associated with the unconsolidated deposits occurs primarily in the sand and gravel laid down in the valley as glacial outwash or alluvium in the region. Schiner and Kimmel (1976) report that well yields generally range between approximately 7 to 30 gallons per minute per foot (gpm/ft) of drawdown in the alluvial sand and gravel deposits of the Shenango River in northern Mercer County. A discussion of the alluvium, glacial till and bedrock and how each relates to site hydrogeology is presented in the following subsections.

Alluvium: Grain-size analyses were performed on 15 soil samples of alluvial material from the site borings during the subsurface investigation (Rizzo Associates, 1986). The results of the grain-size analyses indicate the composition of the samples varied widely, with a range of silt and clay-sized particles of 3.4 to 56.7 percent. The lowest percentage of fines was obtained from two samples in a probable zone of glacial outwash gravel (Boring N-3). More typically, the fines averaged about 15 percent with 50 percent or

more of the material grading medium sand or coarser. A typical permeability range for this material would be approximately 10^{-3} to 10^{-4} centimeters per second (cm/sec) with higher values in areas of diminished fines content (Rizzo Associates, 1986).

Groundwater in the alluvium occurs under unconfined conditions across the site. The depth to groundwater in the alluvium generally ranges from 2 to 20 feet below ground surface. Groundwater associated with the alluvium generally flows west-southwest toward the Shenango River.

A groundwater study was conducted by SRW on the property currently owned by AK Steel (formerly ARMCO) just west of the former Sharon Transformer Plant Site (SRW, 1984). A groundwater pumping test was conducted as part of the study to estimate the properties of the alluvium aquifer. The aquifer test findings were reportedly used in design of a groundwater remediation system.

A six-inch diameter groundwater recovery well (PW-1) was reported to be installed to a depth of 55 feet. Two, two-inch diameter observation wells were reportedly installed to a depth of 30 feet.

A 72-hour pumping test was conducted at Well PW-1 by SRW with an average reported flow rate of one gallon per minute (gpm). Transmissivity values ranging from 550 to 1,200 gallons per day per foot (gpd/ft) of drawdown and hydraulic conductivity estimates of 6×10^{-4} to 1×10^{-3} cm/sec were reported (SRW, 1984).

The hydraulic gradient for the alluvial aquifer is variable across the site, but averages approximately 0.015 foot per foot (ft/ft) across the site. The average linear groundwater flow velocity in the alluvial aquifer beneath the site has been estimated using a form of Darcy's Law, $V = (Ki)/n$ (Freeze and Cherry, 1979); where V is the average linear groundwater velocity, K is the hydraulic conductivity (assume 8×10^{-4} cm/sec based on SRW, 1984), i is the hydraulic gradient (assume 0.015 ft/ft; using groundwater elevations recorded in June 1994 for Wells M-18, 878.05 feet MSL and MW-3A, 866.25 feet MSL), and n is the porosity (assume 0.25 for sand and gravel aquifer). The average linear groundwater velocity for the alluvial aquifer, based on the above parameters, is estimated

to average 50 feet per year. Transport of constituents dissolved in the groundwater usually occurs at rates less than the calculated average linear velocity based on variable aquifer conditions and constituent characteristics.

Glacial Till: Glacial till of the Shenango River Valley is described by Shepps, et al. (1959) as being generally impermeable and yields very little water. However, lenses of sand and gravel may be interbedded in the till and the coarse material at the till/bedrock interface (when present) is potentially water bearing.

Grain-size analyses were performed on seven samples of glacial till from the site. Generally, the fines content was 50 percent or greater. Given the high SPT values observed during the drilling, it is expected that the permeability of the glacial till is less than 10^{-6} cm/sec (Rizzo Associates, 1986).

The glacial till is expected to act as an aquitard between the alluvium and bedrock, based on the fine-grained texture, density and thickness of the till. Thin discontinuous sand and/or gravel seams will have minimal effect on vertical groundwater movement. Vertical movement within the glacial till will be controlled by the overall impermeability of the till.

Bedrock: Groundwater flow in site bedrock is believed to be controlled primarily by fractures. Two primary sets of fractures are present in sandstones and shales in the area. One primary fracture set is oriented approximately northwest-southeast and the other primary fracture set is oriented almost 90° from the first set (Schiner and Kimmel, 1976).

Groundwater associated with the uppermost bedrock unit, the Orangeville Shale, occurs under confined conditions. Groundwater associated with the Orangeville Shale Formation generally flows west-southwest toward the Shenango River. The Orangeville Shale exhibits limited primary porosity, and groundwater storage and movement occurs in the secondary fracture openings. Groundwater associated with the Orangeville Shale bedrock unit will generally follow the path that represents the least resistance in the direction of decreasing head potential. Groundwater flow may exhibit localized variances due to anisotropic conditions created by variations in lithology, fracture density, or structural features.

Carswell and Bennett (1963) found that the sandstones have a much higher permeability than the shales in the area. For example, the permeability of the Sharpsville Sandstone can range from 5 to 50 gpd/ft^2 with most wells yielding between 20 and 50 gpm. The Berea Sandstone is reported to have a permeability ranging between 0 and 10 gpd/ft^2 and a well yield of approximately 10 gpm. The Cussewago Sandstone has a permeability ranging from 10 to 40 gpd/ft^2. Carswell and Bennett (1963) report a value of 25 gpd/ft^2 for a well in West Middlesex (a few miles southeast of Sharon) which was screened in the Cussewago Sandstone. Neither the Orangeville Shale nor the Bedford Shale is known to produce significant quantities of water.

Carswell and Bennett (1963) also state that the Shenango River is a natural avenue for the discharge of groundwater. Upland regions intercept most of the precipitation which infiltrates downward into the shallow bedrock (at the surface) and then flows toward the valley and into the unconsolidated section within the valley.

Field permeability testing of the Orangeville Shale was performed using the methodology described in the comprehensive subsurface study (Rizzo Associates, 1986). Reported results obtained from the tests indicate a range from not measurable (impermeable) to greater than 10^{-4} cm/sec. A significant number of the tests resulted in no measurable intake of water by the formation. This is reflective of very low permeability zones in the rock or closure of the water bearing rock fractures by cuttings during coring. The results for zones that took water are very consistent.

The former Sharon Transformer Plant Site is located in an area of limited groundwater usage. Potable water for the immediate Sharon area is provided by the Shenango Valley Water Authority. The Shenango Valley Water Authority obtains water from a surface source located on the Shenango River approximately 1,600 feet downstream from the Clark Street bridge and about 1,600 feet west of the site. Areas outside of the Shenango Valley Water Authority distribution system reportedly rely on groundwater wells for water supplies. Results from the well survey conducted during the RI indicate that no current potable groundwater usage from bedrock wells in the vicinity of the former Sharon Transformer Plant was reported.

1.3.4 Groundwater/Fluid Level Measurements

Water level measurements have been obtained from a total of 80 groundwater monitoring wells installed at and near the site. Groundwater/NAPL level measurements were performed on site monitoring wells on a quarterly basis for approximately three years during Phases IB and II of the RI.

A total of 56 monitoring wells monitor the site alluvium groundwater (at the time of the RI). The results of the historical water levels indicate groundwater in the alluvium flows in a west-southwest direction toward the Shenango River. Based on information provided by site soil borings, there are apparently two areas at the site at which the alluvial material is not saturated. Based on the results of the boring for Monitoring Well M-9, the alluvium is unsaturated in the area along Sharpsville Avenue and the eastern portion of the Middle Sector. Monitoring Well N-4 was installed to communicate with the alluvium. After installation, this well was found to be dry and was subsequently abandoned. The alluvium is very thin (zero to three feet) at former Well N-4.

The average variation in groundwater levels for individual wells screened within the alluvium generally was less than five feet for groundwater elevations recorded from May 1990 through March 1995.

Eleven monitoring wells communicate with site bedrock. Monitoring Wells N-2B, N-3B, N-6B, N-7B, M-4B, M-9, M-11B, S-1B, S-2B and S-8B are designed to communicate with the Orangeville Shale. Monitoring Well R-1 is designed to communicate with the Berea Sandstone. Although Monitoring Well N-3B is finished in the Orangeville Shale it is apparently in communication with the Berea Sandstone. The well screen for N-3B is located within the Orangeville Shale unit; however, the lower section of the boring collapsed. Based on the historic interpreted potentiometric contour maps, groundwater gradients in the Orangeville Shale unit are predominantly to the west-southwest toward the Shenango River.

The average variation in groundwater levels for individual wells screened within the Orangeville Shale formation ranged from 1 to 12 feet during the RI monitoring period (May 1990 to March 1995).

The groundwater elevations reported for alluvium/bedrock nested monitoring wells indicate a downward vertical hydraulic gradient between the alluvium and the bedrock, with the exception of the extreme southern portion of the South Sector (S-1A and S-1B), in which the vertical hydraulic gradient is reversed, with flow potential from the bedrock upward into the alluvium.

Four site monitoring wells were identified during water level measurements to have unexplained declines. Monitoring Wells N-3B, M-4B, S-8B and R-1 exhibited declines in water levels ranging from approximately 5 to 20 feet. The decline in water levels occurred between December 1992 and May 1993. Prior to December 1992, the water level measurements for the wells were found within a consistent range. Since May 1993 the water levels in these wells have exhibited a consistently lower range than pre-December 1992 levels. The cause for the decline in water levels in these wells is currently unexplained, as no bedrock groundwater supply wells are known to exist in the site vicinity.

The results for historical NAPL level measurements were utilized to develop figures depicting areas where LNAPL (Figure 1-3) and dense non-aqueous phase liquids (DNAPL) (Figure 1-4) have historically been observed within site alluvial monitoring wells. LNAPL has been reported at three on-site locations as follows:

- South Sector building at Well S-4;
- Southwest corner of Middle Sector building at Well M-2; and
- The western portion of the Middle Sector building in the vicinity of the former tank farm, extending onto the eastern limits of the AK Steel facility.

The extent of DNAPL levels for alluvial monitoring wells includes the western portion of the former tank farm area (Middle Sector), to the southern limit of the Middle Sector building, and across the former Conrail railroad tracks (currently owned by Pennsylvania Lines, LLC, a subsidiary of Norfolk Southern Corp.) onto the eastern limits of the AK Steel facility.

1.3.5 Residential/Industrial Well Survey

A survey of residential and industrial wells located between the site and the Shenango River was performed during Phase II of the RI. The purpose of the survey was to identify groundwater users and obtain information concerning well use, well construction, and depth. Of the 110 surveys mailed out by Westinghouse, 28 responses were received. No active groundwater supply wells for industrial or domestic use were identified by the survey.

Active groundwater recovery wells exist on the AK Steel facility to the west. The recovery wells are part of a groundwater remediation program at that site (see Section 1.4.2).

1.4 PREVIOUS AND ONGOING REMEDIATION ACTIVITIES

1.4.1 On-Site Remediation Projects

Between 1984 and 1986 (prior to initiation of RI/FS activities), various remedial actions were performed by Westinghouse to address principal threats in the Moat and tank farm areas. These activities resulted in the excavation and off-site disposal of over 7,800 tons of soil impacted with PCBs, including soil from the removal of five underground storage tanks and from the cleanup of a spill of approximately 6,750 gallons of a PCB-impacted mixture of transformer oil and a petroleum distillate in the Moat. Following remediation, the tank excavation area was backfilled and capped with concrete, and the Moat spill area was backfilled. Details on these remediation activities are provided in the RI

In May 1990, Westinghouse requested permission to extract and dispose of LNAPL (which is a mixture of mineral oil and PCBs) from groundwater underneath the tank farm in the Middle Sector at the site, and in February 1994 Westinghouse was issued a UAO for the development and implementation of a Response Action Plan for performing this work. A pilot study was conducted by Groundwater Technology, Inc. in 1995 to evaluate potential LNAPL removal techniques, including skimming, skimming with low-pressure vacuum assistance, and manual removal methods (bailing and absorbent tubes).

Based on observed recovery rates during the pilot study and initial evaluation period using SoakEase™ absorbent tubes and manual bailing, a belt-skimmer system was installed in Monitoring Well GM-4A in June 1996. The belt-skimmer is operated for two

15-minute periods per day. As of October 12, 1999, a total of 455 gallons of LNAPL have been recovered from this well using the various removal methods. The current rate of LNAPL recovery is approximately 0.4 gallons per day from this well.

In addition, SoakEase™ absorbent tubes were placed in several additional monitoring wells where LNAPL has historically been observed. These tubes were initially inspected on a monthly basis and replaced as needed; in October 1997 this frequency was reduced to once per quarter. During these inspections, accumulations of LNAPL in the wells are also bailed manually. A total of 141 gallons of LNAPL have been recovered from these additional wells by means of the absorbent tubes and bailing. The current combined LNAPL recovery rate from these wells is approximately 0.036 gallons per day. The recovered LNAPL and absorbent tubes are contained for subsequent incineration at a permitted off-site facility.

In accordance with the 1994 UAO, implementation of the LNAPL removal will continue until USEPA determines that the removal is no longer necessary. This decision to terminate the removal action may be triggered by the implementation of a Record of Decision (ROD) that addresses impacted groundwater.

1.4.2 Off-Site Remediation Projects

Two previous or ongoing off-site remediation projects in the immediate vicinity of the site are also worth noting. One of these is an ongoing groundwater remediation effort at the AK Steel facility located immediately west and downgradient of the Middle Sector. A groundwater extraction system with treatment by neutralization was installed at the facility in August 1988 in response to the finding of low pH and high inorganics concentrations in groundwater. The source of these conditions are believed to be a leak in a pickling area and former waste acid lagoons located on the western portion of the AK Steel facility (NUS, 1990) (Figure 1-2).

A remediation was also performed at the former Roemer Industries facility immediately west and downgradient of the former Y Building (Figure 1-2). At this site, a soil vapor extraction system was installed and operated from November 1990 until June 1994 to address soil and groundwater contamination, including primarily ethylbenzene, xylene, trichloroethene, and 1,2-dichloroethene. Site media had become impacted by waste

solvents used by Roemer in the manufacturing of metal nameplates. The site owner applied for and received an Act 2 closure from PADEP in May 1996. Data provided in the closure report indicate that trichloroethene and 1,2-dichloroethene, which may be related to activities at the Roemer facility, were still present in alluvial groundwater at the facility (EPM, 1996).

1.5 URBAN RENEWAL AND LAND USE PLAN

The Westinghouse site is an integral part of an industrial re-development and expansion program for the city of Sharon and surrounding communities. These efforts are being undertaken by the Shenango Valley Industrial Development Corporation, Penn Northwest Development Corporation, and the city of Sharon. Since the facility's closure in 1984, Westinghouse has cooperated with state and local public and private interests to identify alternative beneficial uses of the buildings and property. Several buildings formerly owned by Westinghouse are now used by other companies to manufacture and store inventory, including: AK Steel, which owns and occupies the former Westinghouse buildings north of Clark Street along Sharpsville Avenue (the North Sector); Winner Steel Services, Inc., which owns and occupies the former Westinghouse building south of the Middle Sector Buildings on Sharpsville Avenue (the South Sector); and the Shenango Valley Industrial Development Corporation, which owns and occupies the building southwest of the Middle Sector Buildings and west of the Moat (the former Y-Building). Winner Development Corporation also recently purchased the Middle Sector Buildings, which will be redeveloped for industrial uses.

1.6 SUMMARY OF REMEDIAL INVESTIGATION

The RI Report provides an overview of the site history and previous investigations at the former Sharon Transformer Plant Site, details the procedures used in conducting the remedial investigations, presents findings on the physical and chemical characteristics of the site, and provides an overview of the fate and transport processes and the delineation of media of interest for risk assessment. Based on the studies conducted during the RI, the following findings have been established:

- The area east of the site is primarily urban residential, while the area to the west, between the site and the Shenango River, varies from commercial, institutional, recreational and light to heavy industrial.

- Numerous studies, inspections, sampling programs and remediation projects have been completed at and in the vicinity of the former Sharon Transformer Plant Facility.

- The stratigraphic units associated with the former Sharon Transformer Plant Facility consist of varying thicknesses of artificial fill, alluvium, and glacial till overlying bedrock formations corresponding to the Orangeville Shale Formation.

- Groundwater in the alluvium at the site occurs under unconfined conditions. The groundwater flow direction in the alluvium, as determined by groundwater level measurements, is generally in the west-southwesterly direction toward the Shenango River.

- Groundwater in site bedrock occurs under confined conditions. The groundwater flow direction in the bedrock, as determined by groundwater level measurements, is generally in the west-southwesterly direction towards the Shenango River.

- A layer of glacial till is present which ranges from 8 to 80 feet thick across the site. The glacial till acts as an aquitard between the overlying unconfined alluvial aquifer and the underlying confined bedrock aquifer. The glacial till has apparently limited vertical migration of constituents of interest (COI) at the site.

- Comparison of alluvium groundwater levels and bedrock groundwater levels for the shallow and deep nested groundwater wells indicates that a downward vertical hydraulic gradient exists between the alluvium and bedrock over the majority of the site. The exception is at the southern limit of the site, where the vertical hydraulic gradient is reversed, with flow potential from the bedrock to the alluvium. Glacial till deposits were encountered between the alluvium and bedrock at each location investigated during the RI.

- LNAPL (mineral oil with PCBs) was identified at three locations (South and Middle Sectors). A LNAPL recovery pilot study was performed as an initial Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) removal at the on-site

location near the former tank farm area west of the Middle Sector buildings. Based on the results of the pilot study, a LNAPL recovery system has been installed to control potential LNAPL migration in the former tank farm area.

- An area of DNAPL (a mixture of trichlorobenzene and PCBs) has been identified at the bottom of the alluvial aquifer near the western portion of the Middle Sector near the tank farm area. The vertical and horizontal extent of the DNAPL have been defined. DNAPLs are pooled in a depression in the top of the glacial till approximately 35 feet below ground surface.

- Groundwater in the alluvium is impacted by COI (primarily PCBs, chlorinated benzenes, trichloroethene [TCE] and 1,2-dichloroethene [DCE]) both on and off site. Two off-site soil and groundwater remediation programs are currently or were previously conducted adjacent to the site by Roemer Industries and AK Steel.

- Based on the available data at the time of the RI, groundwater in bedrock does not appear to be significantly impacted by the COI of this site. The reported detection of PCBs in one bedrock well (7 micrograms per liter [µg/l]) should be evaluated. (See Section 1.9.2 for more recent data.)

- A residential/industrial well survey was performed in the vicinity of the former Sharon Transformer Plant Facility in 1994. At the time of the survey, no residential or industrial groundwater supply wells were identified within the area surveyed (generally between the site and the Shenango River).

- An ecological assessment of the major vegetative communities was performed in the area surrounding the former Sharon Transformer Plant Facility. None of the plant communities present in the study area were determined to be regionally significant nor do they provide exceptional wildlife habitat value.

- Fish samples collected by PADER have historically indicated the presence of PCBs in fish tissue in the Shenango River adjacent to, upstream of, and downstream of the site.

- Most of the site is paved, and therefore limited surficial soils exist. Surface soils sampled in the North Sector as part of the SRW investigation in 1985 have since been paved with asphalt.

- In the Moat area, PCBs were detected in seven surface soil samples and in 54 of 89 subsurface soil samples. Access to the Moat area is currently restricted by a fence, as required by the RI/FS consent order.

- On-site subsurface soils were found to contain levels of COI that warranted evaluation in the risk assessment to assess controls for future site development. Subsurface soils will be a consideration in future uses of the site.

- Surficial soils on Conrail property immediately west of the North and Middle Sectors contain COIs at levels that warranted evaluation during the risk assessment. The means by which these soils became impacted are not currently known. Access to this area is currently not restricted.

- Subsurface soils on the Conrail property and the ARMCO property west of the site are impacted by DNAPL that underlie the western portion of the Middle Sector of this site at a depth of approximately 35 feet. There is no current direct contact exposure potential.

- Sediments below the Clark Street Sewer outfall into the Shenango River and specific areas downstream therefrom, contain site-specific COI above the levels of the upstream sample. PADER split sediment samples also indicated the presence of several polycyclic aromatic hydrocarbons (PAHs) and metals; however, many of these compounds may be associated with anthropogenic background conditions or off-site sources.

- In final summary, the following media of interest were identified for quantitative evaluation in the baseline risk assessment:
  - On-site surface and subsurface soils,
  - Off-site surface and subsurface soils,
  - Groundwater,
  - Shenango River sediments and biota, and
  - Subsurface soil and groundwater beneath the buildings on site.

An FS Report addressing surface and subsurface soils has previously been prepared and submitted. This FS Report addresses potential remedial alternatives for groundwater (including NAPLs) and Shenango River sediments.

1.7 SUMMARY OF HUMAN HEALTH RISK ASSESSMENT

The following summary is taken from Section 6.0 Summary and Conclusions of the April 7, 1998 HHRA prepared by ChemRisk®. The HHRA evaluated hypothetical upper-bound carcinogenic and non-carcinogenic risks to various potential receptors of constituents of potential concern in impacted media at the Westinghouse site. This summary includes only these issues related to site media being addressed by this FS Report.

Because this assessment has relied upon conservative, and in some cases hypothetical, assumptions and input parameter values throughout, it is believed that the risk estimates presented herein conservatively estimate the reasonable maximum exposures. Thus, the numeric values summarized in Table 5-1 of the HHRA should be considered conservative upper bound estimates of risk.

For carcinogenic risk estimates, the calculated risks to hypothetical receptors, including future adult and child residents as well as industrial workers, from exposure to all three groundwater media evaluated (South Sector alluvium, Middle Sector alluvium, and bedrock) exceeded the National Contingency Plan (NCP) target range. Calculated carcinogenic risks are primarily driven by arsenic, vinyl chloride, dioxin, and PCBs in the south sector alluvium, PCBs, TCE, arsenic, and dioxin in the middle sector alluvium, and arsenic, dioxin, and PCBs in the bedrock. It should be noted that the exposure scenarios evaluated in the HHRA for groundwater do not represent current baseline conditions, as site groundwater is not being used for any purpose. Likewise, the consumption or other direct exposure to site groundwater on a prolonged basis in the future is considered to be extremely unlikely.

The carcinogenic risks to child receptors wading in sediments in the Shenango River were calculated to be within the NCP target range. Risks posed by human consumption of fish impacted by PCBs in sediment could not be quantitatively evaluated as part of the HHRA. A fish consumption advisory is in effect for carp and muskie in the Shenango

River. An additional potential concern is for swimmers at the immediate vicinity of the Clark Street outfall. AK Steel currently maintains absorbent tubes at this outfall to collect floating oil which may be discharged, so swimming at this location is unlikely.

Similarly, excess non-carcinogenic risks emerged for hypothetical future adult and child residents as well as industrial workers from exposure to each of the three groundwater media evaluated. Calculated non-carcinogenic risks are primarily driven by arsenic, iron, PCBs, 1,2-dichloroethene, and manganese in the south sector alluvium, PCBs, 1,2,4-trichlorobenzene, manganese, iron, and trichloroethene in the middle sector alluvium, and PCBs and iron in the bedrock.

As noted in Section 1.3.3, groundwater at the site generally flows in a west-southwest direction toward the Shenango River. A public drinking water intake is located on the Shenango River about 1,600 feet downstream of Clark Street, thus providing an additional potential pathway for exposure to impacted groundwater. Based on available results of sampling surface water in the Shenango River and groundwater between the site and the river, it appears that impacted groundwater from the site is not impacting surface water.

Table 1-1 lists each of the hypothetical exposure scenarios for which the calculated carcinogenic or non-carcinogenic risk exceeds the range of acceptable risks. This table also lists the individual compounds which significantly contribute to the excess risk for each scenario.

1.8 SUMMARY OF SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

The following summary is taken from Section 4.0 Summary and Recommendations of the June 6, 1997 screening-level Ecological Risk Assessment (ERA) prepared by ChemRisk®.

The screening-level ERA report provides a preliminary assessment of the nature, extent, and toxicological significance of chemicals in sediments, surface waters, and biota near the Westinghouse-Sharon Study Area. While the vast majority of chemicals in environmental media do not pose risks, a limited number of chemicals (e.g., PCBs in fish

and PCBs and zinc in sediments) are believed by USEPA to pose potential risks of various levels to benthic invertebrates, fish, minks, and belted kingfishers. The majority of the possible risks associated with sediment exposures are driven by concentrations measured at Station SD-15A, located immediately downstream of the Clark Street Sewer outfall. Concentrations measured elsewhere in the Study Area result in risk estimates that are orders of magnitude lower.

Moderately high ecological risks, as defined by USEPA (1994), are also predicted for aluminum, barium, and manganese in surface water. Although concentrations of these compounds exceed available screening-level ecotoxicity values, it is important to note that they are all common, naturally occurring compounds. Therefore, it is possible that these concentrations reflect natural background levels. In addition, the potential contribution of these and other chemicals from sources other than Westinghouse was not considered in this evaluation.

Potential to moderately high risks (as defined by USEPA, 1994) to fish, minks, and belted kingfishers were associated with whole body PCB concentrations measured in one redbreast sunfish sample collected in 1979.

Terrestrial habitats within the Study Area are primarily limited to a narrow riparian zone located along the Shenango River. Floodplain soil was not characterized as a chemical migration pathway in the approved RI/FS work plan; therefore, soil samples from this area were not collected. In the absence of floodplain soil data, risks to species exposed through this media (e.g., shrews) were not evaluated.

Based on the results of this screening-level assessment, it appears that potential risks to benthic invertebrates, fish, minks, and belted kingfishers exist as the result of the presence of a limited number of chemicals in sediments, surface water, and fish. Risks are predominantly driven by zinc and total PCBs in sediments measured at Station SD-15A. Risks associated with all other sediment sampling stations are significantly lower, although ecological effects quotients (EEQs) associated with certain chemicals exceed one at several of the locations, indicating the potential for risks to ecological receptors.

1.9 SUMMARY OF SUPPLEMENTAL FS SAMPLING ACTIVITIES

Based on a review of the available data in 1998, CBS determined, with the concurrence of PADEP and USEPA, that additional data was needed with respect to the current conditions of groundwater and Shenango River sediment/floodplain soil. CBS subsequently performed various supplemental data collection activities in accordance with the Feasibility Study Supplemental Sampling and Analysis Plan for Groundwater, Sediment, and NAPLs (Cummings/Riter, 1998). The purpose of the supplemental sampling activities was to obtain additional data on sediment and groundwater that would enable completion of a feasibility study of remedial alternatives for this medium. In addition, the performance of bench-scale testing of selected NAPL treatment processes was also to be performed. The findings of these supplemental activities are summarized in the following subsections.

1.9.1 Shenango River Sediment

Additional sampling of sediments in the Shenango River was performed by Cummings/Riter and McLaren/Hart from October 27 to November 3, 1998. This additional sampling focused on specific segments of the river where sampling conducted during the RI indicated the presence of site-related constituents [primarily PCBs above 1.0 milligrams per kilogram (mg/kg)]. The Data Summary Report for Supplemental Sediment Sampling (Cummings/Riter, 1999a) contains a detailed description of the sampling locations, methods, parameters, and results for this sampling event.

Additional sampling of sediments immediately upstream of the dam at the water company was performed on April 18 and 19, 2000. This sampling effort was focused on characterizing the volume and quality of sediment present behind the dam. The Data Summary Report for Area 14 Supplemental Sediment Sampling (Cummings/Riter, 2000) details the locations, methods, and results for this event.

Analytical results for sediment samples collected during the RI are provided in Table 1-2, and results for samples collected during the two supplemental sampling events are provided in Tables 1-3 and 1-4. Sample locations are shown on Figures 1-5 through 1-10. Following is a brief summary of the field observations and analytical data.

- The Shenango River is a relatively rapid-moving water course through much of the study area, particularly below the dam at the Shenango Valley Water Company plant. Because of this, in combination with the presence of the dam, the presence of fine-grained depositional material at Areas 12 and 13 is somewhat limited to isolated pockets. Depositional material is present more frequently at Areas 14 and 15 above the dam, but is still limited to a certain extent by the presence of the dam at the Shenango Reservoir approximately three miles upstream of the site.

- Total PCB concentrations in sediment at Areas 12 and 13 showed no consistent pattern, and were relatively low. Sixteen of the 18 shallow sediment samples and all of the 18 deep sediment samples from these two areas had total PCB concentrations of less than 1.0 mg/kg. Nine riparian samples collected from these areas all had total PCB concentrations of less than 0.6 mg/kg.

- Area 14, in the vicinity of the Shenango Valley Water Company plant, had the highest observed total PCB concentration (52.0 mg/kg along the eastern bank of the river). Nine additional shallow sediment samples and six deep sediment samples collected from this area had total PCB concentrations exceeding 1.0 mg/kg. The total PCB concentrations for three riparian samples collected from this area ranged from 0.76 to 1.23 mg/kg.

- A portion of Area 15 along the eastern bank of the river immediately adjacent to the Clark Street outfall had four shallow and two deep sediment samples with total PCB concentrations exceeding 1.0 mg/kg. The maximum total PCB concentration among sediment samples collected beyond 150 feet downstream of the outfall was 0.24 mg/kg. The total PCB concentrations for three riparian samples collected from the immediate vicinity of the sediment sample with the highest PCB concentration ranged from 9.9 to 39.9 mg/kg.

- Total PCB concentrations for upstream background sediment and riparian samples (Area 17) ranged from not detected to 0.62 mg/kg.

- The locations of sediment samples with relatively high concentrations of metals relative to ecological screening criteria (primarily zinc) were coincident with the locations of samples which exhibited elevated total PCB concentrations, with the exception of one deep sample in Area 12 and one shallow sample in Area 15.

- Additional sediment sampling was performed in April 2000 immediately upstream of the dam at the water company. Based on the findings of this sampling event, there does not appear to be significant volumes of fine-grained sediment adjacent to the dam. Three sediment samples collected from within 60 feet of the dam each contained less than 0.4 mg/kg total PCBs.

1.9.2 Groundwater

Additional sampling of groundwater was performed by Cummings/Riter from July 12 to 16, 1999. The intent of this additional sampling effort was to obtain current conditions of groundwater, particularly in areas away from the main source of groundwater impacts identified in the RI. In addition, the sampling event was used to evaluate the potential for the occurrence of natural attenuation. The Data Summary Report for Supplemental Groundwater Sampling (Cummings/Riter, 1999b) contains a detailed description of the sampling locations, methods, parameters, and results for this sampling event. Analytical results for groundwater samples collected during the RI and supplemental sampling activities are provided in Tables 1-5 through 1-10. Sample locations and concentrations for selected parameters are shown on Figures 1-11 through 1-14. Following is a brief summary of the field observations and analytical data:

- There appear to be three distinct plumes with significant concentrations of organic compounds present in alluvial groundwater. These plumes are described in Section 1.10.2.

- With respect to alluvium groundwater volatile organic compound (VOC) data obtained in 1992 during the RI, the supplemental sampling results for trichloroethene in the OS-1 and OS-2 series wells are 70 to 90 percent lower, while the vinyl chloride concentrations increased by 20 to 115 percent and chlorobenzene concentrations are 3 to 22 times higher. Otherwise, the supplemental VOC data are generally consistent with the RI data.

- The supplemental results for semivolatile organic compounds (SVOCs) in the alluvium groundwater were generally consistent with results obtained in 1992 during the RI.

- PCBs were detected in groundwater samples collected from three alluvial monitoring wells in the vicinity of known or suspected source areas. PCBs were not detected in samples collected from the remaining on-site nor in any of the off-site alluvial monitoring wells sampled during the supplemental sampling event. These results are consistent with (in the case of the off-site wells) or up to three orders of magnitude lower (for the on-site wells) than PCB results obtained in 1992 during the RI.

- Concentrations of dissolved inorganics in the alluvial monitoring wells were generally consistent with previous sampling data.

- No site-related VOCs were detected in any of the 11 site bedrock monitoring wells, with the exception of chlorobenzene in Well M-11B. This is consistent with sampling results obtained in 1992 during the RI.

- Site-related SVOCs and PCBs were detected in bedrock Well M-11B during the supplemental sampling event. However, enhanced purging of the wells followed by subsequent sampling and analysis (conducted approximately three months later) reduced these reported SVOCs and PCBs two orders of magnitude. Well M-11B is located within the area where DNAPLs are known to exist. Our interpretation of these results is that the laboratory analysis of samples from these wells do not represent conditions in the aquifer beyond the immediate proximity of the well boring. These results most likely indicate migration within the well boring itself (the well was installed in 1986). CBS submitted a plan to the agencies on February 3, 2000 to abandon Well M-11B and replace it with two new downgradient bedrock wells located outside of the known DNAPL area. This plan was approved by PADEP on February 11, 2000, and will be implemented in the spring of 2000.

- PCBs were detected in one other bedrock monitoring well (S-1B) during the supplemental sampling event. However, subsequent sampling in October 1999 indicated Well S-1B did not have PCBs above the method detection limit.

- Dissolved inorganic compounds in bedrock groundwater were generally consistent with previous sampling data conducted in 1992 during the RI.

- Based on the results of an initial natural attenuation screening process (USEPA, 1998), there is evidence that natural attenuation is potentially occurring at the site. By comparing the 1992 and 1999 analytical results, several wells are believed to demonstrate that biodegradation processes are at work at the site:
  - Monitoring Wells OS-1A, OS-2A, and OS-2B show a reduction in both trichloroethene and 1,2-dichloroethene concentrations while the vinyl chloride concentrations increase (with the exception of 1,2-dichloroethene in Well OS-1A).
  - Monitoring Well M-2 shows an increase in concentration in dichlorobenzene, chlorobenzene, and benzene, possibly indicating degradation of the trichlorobenzene found in that portion of the site.

1.9.3 NAPL Treatability Studies

As a third part of the supplemental FS activities, CBS and Cummings/Riter reviewed various sources of available information on potential remedial technologies for NAPLs containing PCBs and chlorinated benzenes. Because physical removal methods had been evaluated as part of the ongoing LNAPL removal action, it was decided the supplemental activities would focus on potential in-situ remediation methods. In particular, three treatment methods were identified as being potentially applicable to the site: in-situ oxidation using Fenton's reagent, in-situ biological degradation, and the use of electrical heating or cosolvent flooding to increase NAPL solubility (thereby improving the efficiency of physical removal methods). These methods were subjected to bench-scale treatability testing to determine if the methods were capable of remediating the specific contaminants and concentrations found in site media. The final bench-scale test reports were submitted to the agencies on November 11, 1999, and the findings of each are summarized herein.

In-situ Oxidation: Geo-Cleanse International, Inc. was provided with two samples of DNAPL-saturated subsurface soils in order to conduct lab testing of their Geo-Cleanse® Treatment process, in which organic contaminants are chemically oxidized using a mixture of hydrogen peroxide and ferrous iron (Fenton's reagent). The results of the testing indicated that the Geo-Cleanse® process can effectively oxidize chlorinated benzenes, but the oxidation of PCBs was dependent on the soil grain size, with more efficient oxidation occurring in coarser-grained soils. No hazardous intermediate or final

oxidation byproducts were observed to have been formed during the testing. These findings are generally consistent with published findings from other studies of Fenton's reagent oxidation of these compounds (Geo-Cleanse, 1999). This process would be implemented in the field by injecting the hydrogen peroxide/ferrous iron solution directly into the NAPLs and associated groundwater.

In-situ Bioremediation: Environmental Remediation Consultants, Inc. was provided with approximately two gallons of DNAPL- and LNAPL-impacted groundwater in order to assess the degradative capabilities of their Bio-Integration™ process. After initial difficulties, the test media was eventually homogenized and diluted such that testing using biotic and abiotic co-treatments could proceed. Test results indicated that trichlorobenzene concentrations in the homogenized mixtures were reduced by 66 percent within seven days, and PCB concentrations were reduced by up to 89 percent within 14 days. No hazardous intermediate or final degradation products were observed to have been formed during the testing (ERC, 1999). The desirability and practicality of creating the homogenous mixture of NAPL and groundwater required by a full-scale implementation of this process within the confines of the alluvial aquifer at the site is uncertain.

Solubility Testing and Soil Washing: Applied Hydrology Associates, Inc. was provided with approximately four gallons each of DNAPL and LNAPL in order to evaluate NAPL solubility in various solvents and viscosity at various temperatures. Based on the preliminary findings, additional testing was performed on DNAPL- and LNAPL-impacted soils to evaluate the effects of washing the soil with a solvent (isopropanol) to remove NAPL constituents. The findings of the testing indicate that NAPL viscosity can be substantially reduced through electrical resistivity heating or by injecting isopropanol, thereby improving the efficiency of extraction methods such as pumping. Chemical analysis of impacted soil washed with isopropanol indicated that 51 to 88 percent of the contaminant mass was transferred from the soil to the solvent during washing tests (AHA, 1999). In a field implementation, this solvent/NAPL/water mixture would be pumped to the surface for subsequent treatment, potentially including phase separation and solvent recycling.

1.10 MEDIA OF INTEREST

This FS Report will develop and evaluate a range of remedial options to address potential concerns related to site media identified in the site-specific risk assessments. The risk assessments identified several media and site areas which may pose increased potential risk to future workers, hypothetical residents and trespassers, and environmental receptors. A summary of the site media of interest and constituents of potential concern (COPC) to be addressed in this FS, based on the risk assessments, is provided below. A discussion of the fate and transport of COPCs found in site media is included in Section 5.0 of the RI.

1.10.1 Shenango River Sediment

Based on the findings of the screening level ERA and the supplemental sediment sampling performed in 1998, sediments in portions of the Shenango River pose potential to extreme risk to ecological receptors, as defined in the screening level ERA. Risks to human receptors calculated in the HHRA were within the NCP target range. The highest ecological risks are generally associated with concentrations of zinc and PCBs between the Clark Street bridge and the dam at the Shenango Valley Water Authority. It is noted that elevated concentrations of zinc are generally coincident with elevated concentrations of PCBs in the sediment.

Riparian floodplain soils were not explicitly evaluated in either of the risk assessments, however samples collected during the supplemental sediment sampling program indicate the presence of PCBs in some locations at concentrations which may be of concern to ecological and/or human receptors.

Additionally, sediments contained within storm sewers leading from the site to the river were not explicitly evaluated in either of the risk assessments, as there is no direct human or ecological exposure to these sediments. However, these sediments, where present, could be washed into the river during high flow events. Sediment samples collected from some of these storm sewers during Phase IB of the RI were found to contain concentrations of PCBs and lead which may be of concern to ecological and/or human receptors if washed to the river.

An additional concern related to this medium is the bioaccumulation of PCBs in fish and subsequent consumption by humans. The Pennsylvania Fish and Boat Commission has issued a consumption advisory for carp and muskie in the Shenango River. This potential pathway could not be quantitatively evaluated as part of the HHRA.

Remedial alternatives for riparian soils and storm sewer sediments will be evaluated in this FS concurrently with river sediments.

1.10.2 Alluvial Groundwater

Alluvial groundwater is of potential concern for hypothetical exposures of future residents and industrial workers located on or immediately downgradient of the site. The pathways of concern include ingestion and inhalation/dermal contact while showering. Based on the findings of the RI and supplemental groundwater sampling, three distinct plumes of COPCs have been identified in alluvial groundwater. A chlorinated solvent plume has been identified in off-site groundwater immediately west of the South Sector. A second chlorinated solvent plume has been identified at the northwest portion of the Middle Sector. The source areas for both of these plumes are unknown, and may include off-site sources. A third plume of PCBs and chlorinated benzenes has been identified in the western portion of the Middle Sector extending to the northwest portion of the South Sector and the southeastern portion of the AK Steel property. The probable source area for this plume is the former tank farm west of the Middle Sector buildings. Concentrations of inorganic COPCs such as arsenic and manganese show no apparent pattern. As there were no known uses of many of these compounds at the facility, these concentrations may be representative of background or regional aquifer conditions rather than of a release from the site. Naturally occurring inorganics can also be mobilized by the presence of solvents in groundwater.

It should be noted that the HHRA evaluated two alluvial groundwater media. The South Sector alluvial groundwater exposure scenario in the HHRA included the off-site chlorinated solvent plume west of the South Sector and the southernmost portion of the PCB/chlorinated benzene plume. The Middle Sector alluvial groundwater exposure scenario in the HHRA included the chlorinated solvent plume in the Middle Sector and the remainder of the PCB/chlorinated benzene plume.

1.10.3 Bedrock Groundwater

Bedrock groundwater is of potential concern for hypothetical exposures of future residents and industrial workers located on or immediately downgradient of the site. The pathways of concern include ingestion and dermal contact while showering. These risks are driven primarily by arsenic, PCBs, and iron. Detections of PCBs in bedrock wells have been sporadic, with the highest concentrations being detected in a bedrock well (M-11B) located within an area where NAPLs are present. Concentrations of inorganic COPCs show no apparent pattern, as, for example, the highest arsenic concentration has been found in a bedrock well (M-9) located along the upgradient edge of the site. As there were no known uses of many of these inorganic compounds, such as arsenic and manganese, at the facility, these concentrations may be representative of background or regional aquifer conditions rather than of a release from the site.

2.0 REMEDIAL ACTION OBJECTIVES

In this section, remedial technology screening criteria are discussed, based on the media of interest identified in Section 1.10. Public health and environmental criteria are identified through the listing of potential applicable or relevant and appropriate requirements (ARARs) for the media and COPCs of interest. Then remedial action goals are identified for the environmental media of interest.

2.1 ARARs AND TBCs

The primary requirement to be considered in the development of remedial action alternatives for hazardous waste sites under the CERCLA, or "Superfund," is the protection of public health, welfare and the environment. CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA), also requires that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to make CERCLA response actions consistent with other pertinent federal and state environmental requirements. The USEPA has stated that specific ARARs must be identified for each CERCLA site.

ARARs may include any standard, requirement, criterion, or limitation under federal environmental law. In addition, they may include any promulgated state environmental or facility-siting law, standard, criterion, or limitation that is more stringent than the associated federal requirement, provided that the standard is consistently enforced by the agency responsible for enforcement. An ARAR may be either "applicable" or "relevant and appropriate," but not both.

Applicable requirements are determined on an objective basis: if there is a one-to-one correspondence between the requirement and conditions at the site, then the requirement is applicable. If a given requirement is not applicable, best professional judgment must be exercised to evaluate whether the requirement addresses problems or situations that are generally pertinent (or relevant) to the site conditions, and whether it is well-suited (or appropriate) to the particular site problem.

Relevant and appropriate requirements are those cleanup standards, control standards, and other environmental protective requirements, criteria, or limitations promulgated under federal or state law that, while not directly applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is appropriate at the site. The determination of site-specific relevant and appropriate requirements requires professional judgment.

Additional information which is to be considered in development of remedial action objectives is grouped under the heading of "To Be Considered" (TBC) material. TBCs are advisories or guidance issued by federal or state government (e.g., reference doses) that are not legally binding and do not have the status of potential ARARs, but may be considered during evaluation of potential remedial alternatives.

Section 121(d)(4) of SARA allows the selection of a remedial alternative that will not attain ARARs if any of six conditions for a waiver exist. The six conditions are:

- The remedial action is an interim measure whereby the final remedy will attain the ARAR upon completion;
- Compliance will result in greater risk to human health and the environment than other options;
- Compliance is technically impracticable;
- An alternative remedial action will attain the equivalent of the ARAR;
- For state requirements, the state has not consistently applied the requirement; or
- For Superfund-lead sites, compliance with the ARAR will not provide a balance between protecting human health and the environment at the site with the availability of Superfund money for response at other sites.

ARARs fall into three broad categories, based on the manner in which they are applied at a site. These categories are as follows:

- ***Chemical-Specific ARARs*** govern the acceptable levels of site constituents in environmental media. Such ARARs may be actual concentration-based levels or they may provide the basis for calculating such levels. Examples of chemical-specific ARARs include the Safe Drinking Water Act (SDWA), Maximum Contaminant Levels (MCLs), and the Clean Air Act (CAA).

- ***Location-Specific ARARs*** are considered in view of natural or man-made features. Examples of natural site features which may trigger location-specific ARARs include wetlands, scenic rivers, and flood plains. Man-made features include, for example, the presence of historic districts. ARARs based on aquifer designations are also location-specific ARARs.

- ***Action-Specific ARARs*** pertain to the implementation of a given remedy. Engineering requirements (as in RCRA standards for hazardous waste landfills) are an example of an action-specific ARAR.

In general, chemical-specific ARARs and TBCs are addressed during the assessment of risks to human health and the environment. The action-specific and location-specific ARARs, which affect the implementation and/or operation of the remedial alternatives, are primarily used to assess the feasibility of remedial technologies and alternatives.

2.1.1 Chemical-Specific ARARs and TBCs

This section presents a summary of potential federal and state chemical-specific ARARs and TBCs which provide some guidance on acceptable or permissible concentrations of constituents in soil, water, or air.

The Toxic Substances Control Act (TSCA) PCB regulations (40 CFR 761) specify treatment, storage, and disposal requirements for PCBs based on their form and concentration. TSCA requires that non-liquids containing PCBs at concentrations of 50 parts per million (ppm) or greater be disposed of in a chemical waste landfill, an incinerator or by an alternate method that achieves a level of performance equivalent to incineration. Liquids at concentrations between 50 and 500 ppm, and soils at

concentrations above 50 ppm may also be disposed of in a chemical waste landfill. TSCA requirements do not apply to PCBs at concentrations of less than 50 parts per million; however, PCBs cannot be diluted to escape TSCA requirements. Table 2-1 summarizes disposal options for various PCB materials as set forth by TSCA.

USEPA's "Guidance for Remedial Action for Superfund Sites with PCB Contamination" is a TBC guidance document which describes the recommended approach for evaluating and remediating PCB-impacted sites. This guidance provides preliminary remediation goals, including suggested cleanup concentrations, for various media, including sediment, and identifies other considerations important to ensuring human health and the environment.

Primary MCLs for drinking water (40 CFR 141) were promulgated as a result of SDWA requirements. MCLs are enforceable standards for contaminants in public water supply systems. They consider not only health factors, but also the economic and technical feasibility of removing a contaminant from a water supply system. USEPA has also promulgated Maximum Contaminant Level Goals (MCLGs) for specific substances regulated under the SDWA in drinking water. MCLGs are non-enforceable guidelines that do not consider the technical feasibility of contaminant removal. Groundwater and surface water at a CERCLA site should attain non-zero MCLGs when they are relevant and appropriate. This provision is set forth under CERCLA Section 121(d)(2)(A) and at 40 CFR 300.430(e)(2)(i)(B). When MCLGs are not relevant and appropriate, or are zero, the groundwater or surface water should attain only the corresponding MCLs, provided that the MCLs are relevant and appropriate. Secondary MCLs (40 CFR 143) are non-enforceable guidelines for contaminants that may effect the aesthetic quality of drinking water, such as taste, odor, and appearance, and may deter public acceptance of drinking water provided by public water systems.

Primary MCLs and non-zero MCLGs may be considered relevant and appropriate for remedial actions involving groundwater at the Sharon Plant, because the affected groundwater at and near the site could potentially be used for drinking water and other uses, although a well survey conducted in 1994 as part of the RI indicated that there are currently no known users of groundwater in the vicinity of the site.

USEPA health advisories are TBCs developed by the USEPA Office of Drinking Water for chemicals that may be intermittently encountered in public water supply systems. Health advisories are available for short-term, long-term, and lifetime exposures for a 10 kilogram (kg) child and/or a 70 kg adult. Health advisories may be pertinent for remedial actions involving groundwater, especially for contaminants that are not regulated under the SDWA.

USEPA Ambient Water Quality Criteria (AWQC) are non-enforceable guidelines that were developed for contaminants in surface waters pursuant to Section 304(a)(1) of the Clean Water Act (CWA). Although AWQC are not directly applicable to activities at the site, they have been used by PADEP to develop enforceable water quality standards, and might be considered relevant and appropriate.

The Pennsylvania SDWA of May 1, 1984 (P.C. 206, 35 PS § 721.1 et. seq.) implements a program which includes, but is not limited to, MCLs or treatment technique requirements establishing drinking water quality standards, monitoring, reporting, record keeping, and analytical requirements, requirements for public notification, standards for construction, operation, and modifications to public water systems, emergency procedures, standards for laboratory certification, and compliance and enforcement procedures.

Pennsylvania Water Quality Standards (PA Code, Title 25, Chapter 93) established water quality criteria for toxic substances for waters of the Commonwealth. The standards are based on water uses that are to be protected and are considered by PADEP in its regulation of discharges to surface water. The standards may be applicable for groundwater or sediment remedial actions involving discharges to surface water.

The CAA of 1977, as amended in 1990, considers potential air pollution from sources of air emissions such as remedial actions. National Ambient Air Quality Standards (NAAQS) were promulgated as a result of the CAA requirements (40 CFR 50). NAAQS may be applicable standards and are available for six criteria pollutants, including airborne particulates. The sources of contaminants and the routes of exposure were considered in the formulation of the standards. These standards do not consider the costs of achievement or the feasibility of implementation. The NAAQS allow for a margin of safety to account for unidentified hazards and effects.

Section 112 of the CAA (40 CFR 61) sets forth National Emission Standards for Hazardous Air Pollutants (NESHAP). Significant sources of air pollution listed as hazardous, including asbestos, arsenic, mercury, beryllium, vinyl chloride, and benzene, may be subject to NESHAP. Federal agencies are required to comply with federal and state requirements for control and abatement of air pollution, especially state implementation plans.

New Source Performance Standards (NSPS) are standards for new stationary emissions sources promulgated such that these sources are designed, built, equipped, operated, and maintained based on the best demonstrated technology to minimize emissions (40 CFR 60). Since NSPS are action-specific requirements for operating plants, they may not be applicable to Superfund remedial actions, but may be relevant and appropriate if the pollutant emitted and technology employed during remediation are sufficiently similar to those regulated by NSPS.

Pennsylvania Air Pollution Control Regulations (PA Code, Title 25, Chapters 121 through 143) govern air emissions from remedial actions. The regulations provide for the prevention and control of air pollutants and guidance for the design and operation of air pollution sources. Potential sources of air pollution at the site may include remedial actions that involve volatilization. Pennsylvania has adopted the federal NAAQS and has air quality standards for five additional constituents.

Reference Doses (RfDs) are TBCs defined in the USEPA Integrated Risk Information System as an estimate of a daily exposure to the human population (including sensitive subgroups) that is likely to not constitute an appreciable risk of deleterious effects during a lifetime. RfDs have been incorporated into the risk assessment in the calculation of hazard indices. Cancer Slope Factors (CSFs) are used for estimating the lifetime probability of human receptors contracting cancer as a result of exposure to particular compounds. CSFs have been incorporated into the risk assessment in the calculation of cancer risks associated with compounds at the site.

PADEP's Land Recycling and Environmental Remediation Standards Act of May 19, 1995 (35 PS §§ 6026.101-6026.909) (Act 2), including regulations promulgated

under PA Code, Title 25, Chapter 250, establishes uniform cleanup standards based on health and environmental risks, such that impacted sites may be returned to productive use. Act 2 provides specific remediation standards based on background concentrations, statewide health-based concentrations, and site-specific risk-based concentrations, which are to be applied whenever site remediation is voluntarily conducted or is required by other regulations.

USEPA Region 3 Risk-Based Concentration (RBC) Table (October 1999) is a TBC which provides health-based concentrations of constituents in water, air, fish tissue, and soil which correspond to a hazard index of 1.0 or a cancer risk of 10^{-6} using "standard" exposure scenarios. These concentrations do not consider site-specific parameters or exposure scenarios, multiple constituents, impacts to ecological receptors, or cross-media effects. The RBCs were used to initially screen potential COPC in the human health risk assessment.

2.1.2 Location-Specific ARARs and TBCs

This section presents a summary of potential federal and state location-specific ARARs and TBCs which provide guidance related to specific natural or non-made characteristics of the site.

The Federal Protection of Wetlands and Management of Flood Plains Executive Orders (E.O. 11990 and 11988) provide for consideration of wetlands and flood plains during remedial actions. These Executive Orders are implemented by USEPA's August 6, 1985 policy on flood plains and wetlands assessments for CERCLA actions. The Executive Orders require federal agencies, in carrying out their responsibilities, to take action to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. The Executive Orders emphasize the importance of avoiding new construction in wetlands unless there is no practical alternative to that construction, minimizing the harm to wetlands if such construction is required, and providing early and adequate opportunities for public review of plans involving new construction in wetlands. The only wetlands identified at the site are immediately adjacent to the Shenango River, and may be impacted by potential sediment remediation activities.

Section 311 of the federal CWA, as amended by the Oil Pollution Act of 1990 addresses oil and hazardous substance liability and establishes national programs of the prevention, reduction, and elimination of pollution in navigable waters and groundwater.

The Pennsylvania Flood Plain Management Act and Dam Safety and Encroachment Act (PL 851, No. 155 and PL 1375) regulate construction, earthmoving, filling, and excavation within the 100-year flood plain and within wetlands as well as regulated waters of the Commonwealth. All such encroachments and obstructions must comply with PA Code, Title 25, Chapter 105 requirements.

The Endangered Species Act of 1978 (40 CFR 502) provides for consideration of the impacts on endangered species and their critical habitats. This act requires federal agencies to verify that any action authorized, financed, or carried out by the agency is not likely to jeopardize the continued existence of any endangered or threatened species or adversely affect its habitat. As part of the screening-level ecological risk assessment, no endangered or threatened species were identified as being present at the site.

The Fish and Wildlife Coordination Act (16 USC 61), the Fish and Wildlife Improvement Act of 1978 (16 USC 742a), and the Fish and Wildlife Conservation Act of 1980 (16 USC 2901) provide for consideration of the impacts of remedial actions on wetlands and protected habitats, requiring that federal agencies consult with the appropriate state agencies prior to undertaking action for the modification of any body of water.

2.1.3 Action-Specific ARARs and TBCs

This section presents a summary of potential federal and state action-specific ARARs and TBCs which pertain to the implementation of specific remedies.

Regulations under RCRA Subtitle C (40 CFR 260-266 and 268) regulate the identification, generation, transportation, treatment, storage, and disposal of hazardous waste. For the Sharon Plant, several of the compounds found in groundwater and soil could be characteristic hazardous wastes as defined in 40 CFR 261. Under the requirements of CERCLA, any environmental medium impacted with a characteristic hazardous waste must be managed as a hazardous waste until the medium no longer exhibits the characteristic. Thus, RCRA Subtitle C requirements could be considered

ARARs for any treatment, storage, or disposal activities performed during remediation. Additionally, TSCA sets requirements for the storage, handling, transportation, and disposal of wastes containing PCBs. Significant RCRA Subtitle C requirements that may be ARARs are discussed in the following paragraphs.

RCRA 40 CFR 264 requirements that may be applicable or relevant and appropriate for remedial alternatives involving construction of on-site treatment, storage, or disposal facilities include minimum technology requirements; standards for owners and operators of permitted hazardous waste facilities; preparedness and prevention measures; contingency plans and emergency procedures; record keeping and reporting; and groundwater monitoring. In addition, remedial alternatives must meet closure and post-closure requirements that would be applicable to on-site remedial actions.

If a CERCLA action constitutes treatment, storage, or disposal of hazardous waste, the RCRA "Land Disposal Restrictions" (LDRs) (40 CFR 268) may be applicable. LDRs restrict certain listed or characteristic hazardous wastes from being placed or disposed of on the land without treatment. Land disposal includes placement in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome or salt bed formation, underground mine or cave, or concrete vault or bunker. However, movement within a unit does not constitute disposal or placement. At a CERCLA site, an area of contamination (AOC) can be considered comparable to a unit.

The Pennsylvania Solid Waste Management Act of 1980 and the Pennsylvania Solid Waste Management Rules and Regulations (PA Code, Title 25, Chapter 75) govern the generation, transportation, storage, treatment, and disposal of solid and hazardous wastes. The Pennsylvania hazardous waste regulations are generally equivalent to the federal RCRA regulations, except that Pennsylvania has not enacted regulations equivalent to the RCRA LDRs. In addition, the Pennsylvania regulations contain specific minimum technology requirements and treatment and disposal facility siting requirements. These regulations may be applicable to certain remedial alternatives, such as off-site disposal of impacted media, and relevant and appropriate for other remedial alternatives, such as on-site storage of impacted groundwater.

Included in RCRA are requirements concerning injection wells that are part of remedial actions under CERCLA. If the selected remedial alternative includes the treatment and reinjection of groundwater, then the requirements included in RCRA may be applicable. Regulations concerning underground injection wells have been promulgated under the SDWA, including 40 CFR 144 through 146.

Regulations concerning monitoring well drilling and abandonment have been promulgated under the Water Well Drillers License Act (PA Code, Title 25, Chapter 107), and may be potentially applicable requirements.

Pennsylvania's Act 2 promotes cleanup plans which are based on the actual risk posed by site constituents to human health and the environment, taking into account the current and future uses of the site and the degree to which constituents may spread off site, rather than on cleanup policies which require every site to be returned to "pristine condition." The cleanup plans should have as a goal remedies which treat, destroy, or remove regulated substances whenever technically and economically feasible.

Pennsylvania's Hazardous Sites Cleanup Act 108 (35 PS § 6020.101) of 1988 regulates the development, administration, and enforcement of programs to provide for the investigation, assessment, and cleanup of hazardous sites in the Commonwealth. Such cleanups are required by Act 2 to meet the standards established under Act 2.

Pennsylvania's Hazardous Waste Management Regulations (PA Code, Title 25, Chapters 260 through 270) set forth guidelines for criteria, identification, and listing of hazardous wastes. Exports of hazardous waste, transporters, and waste management facilities are defined and discussed at length in these regulations.

U.S. Department of Transportation (DOT) Rules for Hazardous Materials Transport (49 CFR 107 and 171 through 179) regulate the transportation of hazardous materials, including packaging, shipping, and placarding. These rules are TBCs for hazardous material shipped off site for laboratory analysis, treatment, or disposal.

Pennsylvania's Hazardous Substances Transportation Regulations (PA Code, Titles 13 and 15) govern the transport of flammable liquids and solids, oxidizing materials,

poisons, and corrosive liquids. These regulations are TBCs for impacted media that may be shipped off site for analysis, treatment, or disposal, or for treatment supplies brought on site. These regulations are generally equivalent to federal DOT regulations.

The CWA, as amended, governs point-source discharges to surface waters through NPDES requirements, including the discharge of dredge or fill material and oil and hazardous waste spills to U.S. waters. NPDES requirements, including storm water discharge requirements (40 CFR 122), may be applicable to soil remedial actions which result in direct discharge of water to surface water. Such remedial measures may include changes in grading which result in point-source discharges of storm water runoff or discharge of treated groundwater.

The Pennsylvania NPDES rules (PA Code, Title 25, Chapter 92), which are generally equivalent to the federal standards, govern point-source discharges to Pennsylvania waters. These rules may be applicable to soil remedial actions which result in a discharge to surface water. To the extent that Pennsylvania water quality standards, wastewater treatment requirements, industrial waste quality standards, and special water pollution control regulations pertain to a discharge for which an NPDES permit would be required, the provisions of these chapters may govern if their application provides a more stringent effluent limitation than would be produced by application of federal standards.

The Pennsylvania Waste Water and Industrial Waste Treatment Regulations (PA Code, Title 25, Chapters 95 and 97) provide requirements and standards for treatment of waste water and industrial waste discharges to surface water and groundwater. The regulations include general effluent quality standards based on best practical control technologies, and may be applicable to discharges to surface water.

The Pennsylvania Clean Streams Law (PA Code, Title 35, Chapter 5) provides for the protection of streams and water quality. The objective of the law is to protect streams and other "waters of the Commonwealth," including groundwater.

The Pennsylvania Water Resources Regulations are enacted under the Pennsylvania Clean Streams Law. Requirements under these regulations include applications and

permits, standards for approval, and standards for discharges of industrial waste to publicly owned treatment works (POTW). If the selected remedial alternative includes discharge to a POTW, then this requirement may be applicable.

The Pennsylvania Storm Water Management Act 167 requires measures to control storm water runoff during alterations or development of land. Storm water management systems must be constructed in a manner consistent with the county watershed management plan. The requirements of this act may be applicable to remedial actions that include disturbance of the land, such as grading or excavating.

Pennsylvania Erosion Control Regulations (PA Code, Title 25, Chapter 102) govern erosion and sedimentation control resulting from remedial actions that may involve earthmoving activities. The purpose of the regulations is to control accelerated erosion and the resulting sedimentation in surface waters, and thus to prevent pollution of water from sediment and substances which may be carried by the sediment.

USEPA's Groundwater Protection Strategy, dated July 1991, is a TBC which states the policy of preventing adverse effects to human health and the environment by protecting the nation's groundwater resources. Safe drinking water is the primary goal, along with the protection of interconnected surface water resources and ecosystems. Remediation strategies are to consider the use, value, and vulnerability of the resource as well as social and economic values to set realistic priorities based on actual and expected uses.

USEPA's 1992 "Memorandum on Groundwater Remediation at Superfund Sites" is a TBC which clarifies USEPA's general policy concerning impacted groundwater, especially with regard to NAPLs. This guidance provides recommendations for implementing the selected remedy, and for selecting alternative actions should the selected remedy be unable to achieve cleanup goals.

PADEP's "Groundwater Monitoring Guidance Manual" of February 1996 is a TBC which provides guidance for the implementation of a comprehensive groundwater monitoring program which is consistent with established principles and objectives for protection of Pennsylvania's groundwater resources.

USEPA's guidance document "EPA Use of Monitored Natural Attenuation (MNA) at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites" of April 1999 describes USEPA's policy regarding the use of MNA for the cleanup of soils and groundwater. This document provides specific guidance on evaluating MNA and the prerequisites for implementing MNA as a component of a site remedy.

USEPA's "Contaminated Sediment Management Strategy" of April 1998 describes actions being taken by USEPA to address sediments under existing environmental regulations. This strategy does not set forth sediment quality criteria that are to be used as mandatory cleanup levels, but rather establishes sediment quality criteria to provide focus and continuity to remediation efforts. An important tenet of this strategy is that USEPA will not proceed with active removal of affected sediments if a combination of pollution prevention and source controls will allow the sediments to recover naturally in an acceptable period of time.

2.2 REMEDIAL GOALS FOR SITE MEDIA

This section summarizes the remedial action objectives for sediments and groundwater at the Sharon Plant, formed on the basis of the following:

- Results of sediment and groundwater sampling conducted during the RI;
- Evaluations of potential human health risks presented in the baseline human health risk assessment and ecological risks presented in the screening-level ecological risk assessment;
- An evaluation of potential ARARs; and
- Review of TBC guidance.

Using the results of the baseline human health risk assessment (ChemRisk, 1998), site-specific health-based cleanup levels were calculated for COPC in each groundwater medium of interest (health-based cleanup levels were not calculated for sediment, as this media does not represent an unacceptable risk to human receptors). Cleanup levels were calculated for each COPC which contributed significantly to a hypothetical exposure scenario for which the risk assessment indicated an unacceptable carcinogenic risk level

(greater than 10^{-4}) or hazard index (greater than 1.0). If more than one exposure scenario for a given medium exhibited unacceptable risk levels, the exposure scenario which exhibited the greatest risk level was used to calculate cleanup levels.

For medium-specific cleanup levels based on unacceptable carcinogenic risks, the following equation was used:

$$C_T = \frac{EPC \times R_T}{R_{EPC}}$$

where,

C_T = COPC concentration (mg/kg or µg/l) corresponding to the target carcinogenic risk level (R_T);

EPC = Exposure point concentration (mg/kg or µg/l) used to calculate risk in the baseline risk assessment;

R_T = Target carcinogenic risk level, either 10^{-4}, 10^{-5}or 10^{-6}; and

R_{EPC} = Calculated risk level corresponding to the EPC in the baseline risk assessment.

For medium-specific cleanup levels based on unacceptable non-carcinogenic risks, the following equation was used:

$$C_T = \frac{EPC \times HI_T}{HI_{EPC}}$$

where,

C_T = COPC concentration (mg/kg or µg/l) corresponding to the target non-carcinogenic hazard index (HI_T);

EPC = Exposure point concentration (mg/kg or µg/l) used to calculate risk in baseline risk assessment;

HI_T = Target non-carcinogenic hazard index, which is the inverse of the number of COPC that significantly contribute to the total hazard index for the given exposure scenario; and

HI_{EPC} = Calculated hazard index corresponding to the *EPC* in the baseline risk assessment.

2.2.1 Shenango River Sediment

For sediments in the Shenango River, risks were calculated to be within the acceptable range in the baseline HHRA for the hypothetical receptor (child wader). Based on the screening-level ERA, maximum detected sediment concentrations were compared to USEPA screening level criteria to evaluate the level of potential risk posed to ecological receptors by detected compounds (Tables 2-2 and 2-3). PCBs and zinc were found to pose an "extreme risk" to ecological receptors, as defined in the screening-level ERA. PAHs and several other metals were found to pose a "potential" to "moderately high potential" risk to ecological receptors. Based on the findings of the supplemental sediment sampling, the highest concentrations of COPCs are generally localized in the vicinities of the Shenango Valley Water Company (Area 14) and the Clark Street outfall (Area 15).

Neither riparian floodplain soils nor sediments contained within storm sewers were explicitly evaluated in either of the risk assessments. However, storm sewer sediment samples collected during the RI and riparian soil samples collected during the supplemental sediment sampling program indicate the presence of PCBs in some locations at concentrations which may be of concern to ecological and/or human receptors. Likewise, impacts from the consumption of fish could not be evaluated, however a fish consumption advisory is in place for the Shenango River.

The remedial action objectives for Shenango River sediments are:

- Reduce exposure of ecological receptors to highly impacted sediments,
- Minimize the potential for impacts to human health related to the Shenango Valley Water Company surface water intake,

- Reduce possible exposure of human and ecological receptors due to consumption of impacted fish, and

- Obtain compliance with relevant ARARs.

2.2.2 Alluvial Groundwater

Alluvial groundwater in the vicinity of the South and Middle Sectors were determined in the baseline HHRA to present unacceptable carcinogenic and non-carcinogenic risks to hypothetical receptors, including future residents and workers using the groundwater for bathing and consumption. The carcinogenic risks (total risk level range from 8×10^{-3} to exceeding 1) were driven primarily by arsenic, PCBs, beryllium, trichloroethene, and vinyl chloride. The non-carcinogenic risks (total hazard index range from 370 to 5×10^{6}) were driven primarily by arsenic, PCBs, iron, 1,2-dichloroethene, trichloroethene, and manganese. Other VOCs, SVOCs, dioxins, and inorganics (including lead) also contributed to these risks. A comparison of health-based cleanup levels and ARARs with detected COPC concentrations from the RI and supplemental sampling events for alluvium groundwater in the South and Middle Sectors are provided in Tables 2-4 and2-5, respectively.

Accordingly, the remedial action objectives for alluvial groundwater in the South and Middle Sectors are:

- Abate potential unacceptable future human health effects and/or meet ARARs,

- Where ARARs cannot realistically be obtained using best available technology, establish institutional controls to reduce likelihood of human exposure to impacted groundwater,

- Reduce the potential for further aquifer degradation, and

- Reduce COPC concentrations in groundwater to improve aquifer quality if practicable.

2.2.3 Bedrock Groundwater

Bedrock groundwater throughout the site was determined in the baseline HHRA to present unacceptable carcinogenic and non-carcinogenic risks to hypothetical receptors,

including future residents and workers using the groundwater for bathing and consumption. The carcinogenic risks (total risk level of up to $6x10^{-3}$) were driven primarily by arsenic, PCBs, and beryllium. The non-carcinogenic risks (total hazard index of up to 350) were driven primarily by PCBs, iron, and arsenic. PAHs and dioxins also contributed to these risks. A comparison of health-based cleanup levels and ARARs with detected COPC concentrations from the RI and supplemental sampling events for this medium is provided in Table 2-6.

Based on the findings of the supplemental sampling event, additional characterization of the bedrock aquifer may be appropriate to determine if COPCs are present in the aquifer at concentrations which may pose a risk to hypothetical receptors. Should such additional characterization indicate that these COPCs are present at levels of potential concern, then the remedial action objectives would be:

- Abate potential future human health effects and/or meet ARARs,
- Where ARARs cannot realistically be obtained using best available technology, establish institutional controls to reduce likelihood of human exposure to impacted groundwater,
- Reduce the potential for further aquifer degradation, and
- Reduce COPC concentrations in groundwater to improve aquifer quality, if practicable.

Because of the findings of the supplemental sampling event and the plans for additional characterization of the bedrock aquifer, remedial alternatives for bedrock groundwater cannot be evaluated as part of this FS. Should future characterization of the bedrock aquifer indicate the potential for unacceptable exposures of hypothetical receptors, remedial alternatives will be assessed in an addendum to this FS.

2.2.4 Non-Aqueous Phase Liquids

LNAPL, consisting primarily of mineral oil and PCBs, has been observed at three separate locations in the South and Middle Sectors, and the LNAPL area at the former tank farm is the subject of an on-going CERCLA Removal Action. DNAPL, consisting

primarily of PCBs and chlorinated benzenes, has been observed in a portion of the Middle Sector. The risks associated with LNAPL and DNAPL were not explicitly evaluated as part of the baseline human health risk assessment. However, it is likely that the presence of LNAPL and DNAPL in the subsurface will continue to effect groundwater quality in these areas.

The remedial action objectives for the NAPLs are as follows:

- Abate potential future human health effects,
- Where potential human health effects cannot be abated using best available technology, establish institutional controls to reduce likelihood of human exposure to NAPL,
- Reduce the potential for cross-media effects to groundwater, to the extent practicable, and
- Obtain compliance with relevant ARARs.

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

3.1 GENERAL RESPONSE ACTIONS

In accordance with USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, EPA/540/G-89/004, general response actions were identified for each media of concern at the site. These included the following:

- No action,
- Limited action,
- Containment,
- Removal and disposal, and
- Treatment.

To be more manageable, the evaluation of potential remedy components for the various site media was broken down by type of media. These media of concern include Shenango River sediments and related drainage pathway sediments, alluvial groundwater, and NAPLs.

For each of the general response actions, remedial technologies and potential process options were tabulated. Remedial technologies and process options were identified after considering several sources of information. References used for technology screening include the following:

- USEPA, 1989, *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA,* OSWER Washington, D.C., EPA/540/G-89/004.

- DOD Environmental Technology Transfer Committee, 1994, *Remediation Technologies Screening Matrix and Reference Guide, Second Edition, Federal Remediation Technologies Roundtable,* Washington, D.C., EPA/542/B-94/013.

- USEPA, 1993, *USEPA Engineering Issue - Technology Alternatives for the Remediation of PCB-Contaminated Soil and Sediment,* OSWER, Washington, D.C., EPA/540/S-93/506.

- USEPA, undated, *Tech Kit of Information Resources for Brownfield Investigation and Cleanup*.

- USEPA, 1997, *Vendor Information System for Innovative Treatment Technologies (VISITT), Version 6.0,* OSWER, Washington, D.C.

- Alternative Treatment Technology Information Center (ATTIC).

- USEPA, 1990, *Guidance on Remedial Actions for Superfund Sites with PCB Contamination,* OERR, Washington, D.C., EPA/540/G-90/007.

- USEPA, 1998, *In Situ Treatment of Contaminated Sediment, OSWER,* Washington, D.C.

- Groundwater Remediation Technologies Analysis Center (GWRTAC), 1998, *Technologies for DNAPL Source Zone Remediation,* GWRTAC, Pittsburgh, PA, TE-98-02.

- Federal Remediation Technologies Roundtable, 1998, *Remediation Technologies Screening Matrix and Reference Guide*, Version 3.0, http://www.frtr.gov.

- Sutherson, Suthan, 1997, *Remediation Engineering Design Concepts, CRC-Lewis Publishers*, Boca Raton, FL.

Tables 3-1 through 3-3 present a comprehensive listing of potential general response actions, remedial technologies, and process options for sediments, groundwater, and NAPLs, respectively. These tables serve to document the initial technology screening portion of the FS.

3.2 INITIAL SCREENING OF TECHNOLOGIES

Remedial technologies and process options identified for each media were evaluated based on effectiveness, implementability and relative cost given the site-specific conditions at the Former Sharon Transformer Site. In general, the evaluation was based on the references above and professional judgment and consideration of the following:

- ***Effectiveness*** - Whether a technology or process option is applicable to a media or COPC, a demonstrated technology, or able to reduce risk.

- ***Implementability*** - Whether a technology or process option is an established technique and commercially available or whether site-specific conditions prevent or inhibit the implementation of a particular technology or process option.

- ***Cost*** - A qualitative estimate of capital and long-term operation and maintenance costs associated with a particular technology or process option relative to other process options within a given technology.

Upon evaluating these parameters, a determination as to the screening status was made for each of the process options. Each process option was either retained as a potential remedial alternative component or eliminated from further consideration (Tables 3-1 through 3-3; shaded rows indicate process options that were screened out). If multiple process options within the same technology class appear to have similar potential effectiveness and implementability, the options with lower costs were retained. Process options which were retained through the initial screening are evaluated in more detail as part of the secondary screening (Section 3.3).

For all media of interest, the no action and limited action general response actions were retained for further evaluation as a potential component of remedial alternatives. Limited action includes such options as restricting access (institutional controls) and monitoring (site inspections and sampling and analysis). In addition to no action and limited action, the following remedial technologies were retained for further evaluation as potential remedial alternative components:

- ***Shenango River Sediment*** – Additional remedial technologies remaining include capping, excavation or dredging with off-site disposal, and in-situ treatment of impacted soil and sediment.

- ***Groundwater*** – Additional remedial technologies remaining include recovery and disposal options, and in-situ or ex-situ treatment of impacted groundwater.

- ***NAPLs*** – Additional remedial technologies remaining include vertical barriers, recovery and enhanced recovery methods, in-situ treatment, and off-site incineration.

3.3 SECONDARY SCREENING OF REMEDIAL TECHNOLOGIES

Technologies and process options identified for sediments, groundwater, and NAPLs which passed the initial screening (Tables 3-1 through 3-3) were then screened in a more detailed manner for effectiveness, implementability, and cost. At this secondary screening step, these three criteria are applied only to the technologies and general response actions they are intended to satisfy, and not to the site as a whole. This secondary screening will allow for the detailed evaluation of remedial alternatives to more clearly focus on a limited number of effective and implementable alternatives that encompass the range of no action, limited action, containment, treatment, and removal.

Effectiveness focuses on the ability of the technology or process option to handle the estimated volume of media and meet remedial action objectives; the potential impacts to human health and the environment during construction and implementation; and the degree of reliability of the process option with respect to the COPC present and the site conditions. Implementability encompasses both the technical and institutional feasibility of a given process. Because technical implementability was used in the initial screening, the secondary screening places greater emphasis on the institutional and procurement aspects of implementation. The cost rating is based on engineering judgment and is relative to other options in the same technology category. The RI/FS Guidance Document (USEPA, 1988) suggests that at this stage of evaluation, primary emphasis be given to consideration of effectiveness, with lower emphasis placed on implementability and cost.

3.3.1 Shenango River Sediments

The screening level ERA identified sediments in portions of the Shenango River as posing a potential risk to ecological receptors. Subsequent sampling has further defined the extent and quality of sediments, as well as identified impacted riparian soils. Sediments within drainage pathways (storm sewers) may also pose an ecological risk should they be washed into the river. Remedial technologies screened for river sediments and related soils include no action, limited action controls, capping, removal and disposal, and in-situ treatment. Results of this secondary screening phase for sediments are briefly discussed below.

3.3.1.1 No Action

The "no-action" alternative serves as a baseline condition against which other remedial technologies or alternatives are compared. Under this option, no further action would be taken to remediate the sediments and riparian soils in the Shenango River corridor and associated drainage pathways.

Effectiveness: The "no-action" alternative would not meet the remedial action objective of reducing the potential risk of ecological receptors to sediments containing PCBs and other constituents in the short term. Over time, natural resedimentation and/or attenuation of COPCs may reduce the exposure of ecological receptors. This alternative would also not address the potential, but unquantified, risks related to riparian soils and storm sewer sediments.

Implementability: This option is easily implemented, as no action is taken.

Cost: Capital costs would not be incurred. Long-term costs (i.e., five-year reviews) would be low.

Conclusion: "No action" would not meet the remedial action objectives for Shenango River sediments, but is retained for further consideration to serve as a baseline for comparison with other options.

3.3.1.2 Limited Action: Institutional Controls

Institutional controls implemented for the site could include fish consumption advisories or fishing restrictions, as well as other restrictions on activities which may cause the disturbance sediments. No actions would be taken to address COPCs in the sediments.

Effectiveness: Institutional controls would not address the potential ecological risks posed by impacted sediments. If complied with, however, these controls would effectively control the potential risk to humans caused by fish consumption, and would limit the potential for resuspension of impacted sediments into surface water.

Implementability: A fish consumption advisory is currently in place for carp and muskellunge in the Shenango River, and continuing this advisory would be readily achieved. Restrictions on activities which disturb sediments may be more difficult to implement.

Cost: Capital and long-term costs associated with implementing and maintaining these institutional controls would be minimal.

Conclusion: Institutional controls are retained for consideration as an essential component of the selected remedy.

3.3.1.3 Limited Action: Monitoring

Monitoring would consist of routine site inspections for erosion, general maintenance items, and assessment of the permanence and effectiveness of the selected remedial alternative(s). Monitoring may also include sampling and analysis of the affected media to assess current COPC concentrations.

Effectiveness: Monitoring activities alone would not be effective at meeting the remedial action objectives. Continued site monitoring is, however, an essential component of any remedial alternative, in order to assess the performance of the selected remedy.

Implementability: Routine site monitoring is readily implemented for most locations, however portions of the river in the vicinity of the water company are accessible to monitoring by boat only.

Cost: No capital costs would be incurred for monitoring activities. Long-term costs would be low to moderate, depending on the scope of the monitoring activities.

Conclusion: Monitoring is retained for consideration as an essential component of the selected remedy.

3.3.1.4 Limited Action: Natural Attenuation

Natural attenuation is the detoxification of organic COPCs over time by indigenous bacteria under aerobic or anaerobic conditions. Under aerobic conditions, certain microorganisms can reduce organics to water, chloride, and carbon dioxide. Under anaerobic conditions, bacteria which derive energy from chlorine can strip chloride ions from the COPC molecules, generally resulting in less toxic compounds. No specific actions are taken, other than occasional monitoring to verify that natural recovery processes are occurring.

Effectiveness: Numerous studies have been performed indicating that natural attenuation of PCB compounds can and does occur at some locations over time. These studies indicate that attenuation occurs fastest with lesser chlorinated compounds and where initial concentrations are highest. A reduction in chlorine content would render PCBs less toxic and less likely to bioaccumulate. Inorganic COPCs would not be addressed by this approach.

Implementability: The implementation of a natural attenuation remedy is readily achieved.

Cost: Initial and long-term costs for determining if favorable conditions for natural attenuation exist in the Shenango River sediments would be low to moderate.

Conclusion: Natural recovery of sediment quality through natural attenuation is retained for further consideration.

3.3.1.5 Limited Action: Resedimentation

For resedimentation, natural sedimentation processes are allowed to occur over time, gradually capping the existing impacted sediments under a layer of new sediment. No specific actions are taken, other than occasional monitoring to verify that natural sedimentation processes are occurring.

Effectiveness: By allowing resedimentation to occur, the potential risk to ecological receptors would be effectively reduced by eliminating the bioavailability of impacted sediments. As sedimentation patterns shift over time, some areas of impacted sediment may not be effectively covered. Additionally, the dam at the Shenango Reservoir, approximately three miles upstream of the site, tends to limit the quantity of sediment transported by the river to the area of interest. This approach would also not address the potential risks posed by impacted sediments which may be present in the storm water sewers.

Implementability: The implementation of resedimentation is readily achieved.

Cost: Initial and long-term costs for implementing natural resedimentation would be low.

Conclusion: Natural recovery of available sediment quality through resedimentation is retained for further consideration.

3.3.1.6 Containment: Cover

For this technology, impacted Shenango River sediments and riparian soils would be left in place and covered with a geotextile and several inches of a clean cover material, such as riprap or AquaBlok™ (see Appendix D). The cover material would be designed and placed appropriately to minimize the potential for erosion or scouring by the river, which would cause the underlying impacted material to be reexposed.

Effectiveness: A cover, if designed, installed and maintained properly, would effectively reduce the potential risks to ecological receptors associated with Shenango River sediments and riparian soils by eliminating the exposure pathway. Installation of a riprap cover without appropriate sedimentation controls may cause temporary resuspension of some sediment. Changes to the river profile caused by the cover may increase the potential for flooding in nearby low-lying areas. This approach would not address the potential risks posed by impacted sediments which may be present in the storm water sewers.

Implementability: This option is readily implemented along certain portions of the Shenango River corridor, such as near Clark Street, where access to the river by earthmoving equipment can be achieved. This option would be more difficult to implement in other areas such as near the dam, where steep, densely vegetated banks and deep river pools inhibit access by conventional equipment.

Cost: Capital costs for installation of a cover would be moderate, with low to moderate long-term maintenance costs.

Conclusion: The installation of a cover over impacted sediments is retained for further consideration.

3.3.1.7 Containment: Vertical Barriers

A vertical barrier, consisting of either steel sheet piles or cofferdams, would be constructed around the impacted sediments to temporarily divert the river away from the sediments. Such a barrier would minimize the spread of impacted sediments

downstream, as well as provide some protection for the Shenango Valley Water Company surface water intake. The area inside the barrier would be dewatered, allowing earthmoving equipment to remove the impacted sediments or perform other appropriate remedial actions with minimal resuspension of sediment to the main river channel. After completion of the remedial action, the barrier would be removed.

Effectiveness: Installation of a temporary vertical barrier would not by itself address the potential ecological risks associated with impacted sediments, but would reduce potential implementation risks associated with other remedial actions. This approach would also not address the potential risks posed by impacted sediments which may be present in the storm water sewers. Some short-term risk may be posed by the resuspension of sediment during installation of the barrier.

Implementability: The installation of sheet piling is readily implemented along certain portions of the Shenango River corridor, such as near Clark Street, where the channel is shallow and access to the river is available. This option would be slightly more difficult to implement in other areas such as near the dam, where barrier installation would require barge-mounted equipment due to steep, densely vegetated banks and deep river pools.

Cost: Capital costs for installation and subsequent removal of a temporary vertical barrier would be moderate, with no long-term maintenance costs.

Conclusion: The installation of a temporary sheet pile barrier around impacted sediments is retained for further consideration in combination with other remedial alternatives.

3.3.1.8 Containment: Silt Curtains

A temporary silt curtain, similar to silt fences used for erosion control on land, could be placed around impacted sediments subject to subsequent remedial actions. This approach would minimize the potential for sediment resuspended by a remedial action to enter the main river channel. The area inside the silt curtain would not be dewatered. After completion of the remedial action, the barrier would be removed.

Effectiveness: Installation of a temporary silt curtain would not by itself address the potential ecological risks associated with impacted sediments, but would reduce potential

implementation risks associated with other remedial actions. This approach would also not address the potential risks posed by impacted sediments which may be present in the storm water sewers. Some short-term risk may be posed by the resuspension of sediment during installation of the barrier.

Implementability: The installation of a silt curtain is readily implemented along certain portions of the Shenango River corridor, such as near Clark Street, where the channel is shallow and access to the river is available. This option would be slightly more difficult to implement in other areas such as near the dam due to steep, densely vegetated banks and deep river pools.

Cost: Capital costs for installation and subsequent removal of a temporary silt curtain would be low to moderate. No long-term costs would be incurred.

Conclusion: The installation of a temporary silt curtain around impacted sediments is retained for further consideration in combination with other remedial alternatives.

3.3.1.9 Removal and Disposal: Conventional Excavation

Excavation using conventional earthmoving equipment is a viable option for impacted sediments and riparian soils. Dewatering and isolation of the areas to be excavated would be necessary. Sediments and soils containing COPC concentrations exceeding the designated cleanup criteria would be excavated for subsequent treatment and/or disposal, depending on the characteristics of the excavated material. The excavated areas would be backfilled in a manner that would restore the channel to its pre-excavation cross-section.

Effectiveness: With appropriate sedimentation controls in place, excavation and off-site disposal of impacted sediment and soil is an effective means of reducing potential risks to ecological receptors. Post-excavation sampling would verify that impacted sediments were removed. Backfilling the excavations with appropriate material would provide further protection against residual COPCs in the remaining sediments.

Implementability: Excavation using conventional earthmoving equipment is readily implemented along certain portions of the Shenango River corridor, such as near Clark Street, where the channel is shallow and access to the river for such equipment is available. This option would be difficult to implement in other areas such as near the

dam, where steep, densely vegetated banks and deep river pools will restrict the ability to use conventional equipment. A suitable location for staging, dewatering, and loading along the shoreline between the dam and Clark Street may not be available. Additional precautions may be necessary to prevent the introduction of impacted sediment into the Shenango Valley Water Company surface water intake.

Cost: Capital costs for this option would be high relative to other options. Costs for long-term maintenance of the backfilled areas would be low.

Conclusion: Excavation using conventional excavation equipment is retained for further consideration as a remedial alternative in areas accessible by such equipment.

3.3.1.10 Removal and Disposal: Environmental Dredging

Environmental dredging using mechanical dredges (such as clamshells) or hydraulic dredges (such as horizontal augers) is a potentially viable option for impacted sediments. Sediments containing COPC concentrations exceeding the designated cleanup criteria would be removed in a slurry, dewatered with appropriate water treatment and discharge, and taken to an appropriate off-site facility for subsequent treatment and/or disposal, depending on the characteristics of the excavated material. The excavated areas would be backfilled in a manner that would restore the channel to its pre-excavation cross-section.

Effectiveness: With appropriate siltation controls in place, dredging of impacted sediment could be an effective means of reducing potential risks to ecological receptors. However, full-scale environmental dredging projects performed to date in the U.S. have mostly yielded either inconsistent or unverified results (GE, 1997). Post-dredging sampling would verify that impacted sediments were removed. Backfilling the dredged areas with appropriate material would provide further protection against residual COPCs in the remaining sediments.

Implementability: Dredging of impacted sediments would be difficult due to the relative shallowness of the river for barge-mounted equipment, and lack of a suitable shoreline area for land-based dredge access, staging, dewatering, and loading along and between the dam and Clark Street. Additional precautions may be necessary to minimize the introduction of impacted sediment into the Shenango Valley Water Company surface water intake.

Cost: Capital costs for this option would be very high relative to other options. Costs for long-term maintenance of the backfilled areas would be low.

Conclusion: Environmental dredging is retained for further consideration as a remedial alternative.

3.3.1.11 Chemical Treatment: Solvent Extraction

Solvent extraction is typically performed ex situ and involves washing the impacted sediment with a solvent capable of extracting the COPC from the sediment into the solvent, which would then be treated and/or disposed properly. For ex-situ treatments, the cleaned sediment could be used to backfill the excavated areas or disposed at an appropriate off-site facility, depending on the effectiveness of the treatment.

Effectiveness: Solvent extraction has been commercially demonstrated to be an effective method for treating soils and sediments impacted by PCBs. Solvent extraction reduces the volume of the COPC by transfer from solid to liquid media, but does not reduce toxicity. An additional remedy may be necessary for inorganic COPCs, which cannot be treated by this chemical method.

Implementability: The services of a specialized remediation contractor would be required and are readily available. The implementability of the sediment excavation methods would also directly impact the ability to perform this process. Finding a suitable location near the sediment removal areas to perform this treatment process may be difficult.

Cost: Capital costs for solvent extraction, including disposal of the spent solvent, would be high. Costs for long-term maintenance of the excavated areas would be low.

Conclusion: Based on the relatively low volume of impacted sediment and low concentrations of COPCs, solvent extraction would not be cost-effective, and will not be considered further as a potential remedial option.

3.3.1.12 Biological Treatment: Enhanced Biodegradation

Enhanced biodegradation is an in-situ treatment method where COPC-specific microorganisms and, if needed, micronutrients are injected into impacted sediments in order to enhance natural biodegradation of the COPC to less toxic (or non-toxic) compounds.

Effectiveness: Various lab studies indicate that enhanced biodegradation of various organics, including PCBs, is feasible, but few full-scale in-situ treatments for impacted sediments have been performed to date. This method could be effective for reducing potential ecological risks, although achieving a uniform level of treatment in situ can be difficult. The effectiveness of the system depends on the ability to inject (or deliver) the biological organisms to the impacted media. Inorganic COPCs would not be addressed by this approach.

Implementability: Enhanced biodegradation services are commercially available. The limited thickness and general scarcity of fine-grained sediments in the Shenango River would make implementation more difficult.

Cost: Capital costs for enhanced biodegradation would be moderately high relative to other alternatives, while costs for long-term maintenance of the areas would be low.

Conclusion: Due to the lack of demonstrated full-scale success for this method, enhanced biodegradation will not be considered further as a potential remedial alternative.

3.3.2 Alluvial Groundwater

The HHRA identified groundwater in the alluvial aquifer in the South and Middle Sectors of the site as posing unacceptable carcinogenic and non-carcinogenic risks to various potential human receptors, including future residents and workers using groundwater for bathing and consumption. The primary COPC for the alluvial groundwater in the South Sector is VOCs (chlorinated aliphatic hydrocarbons) while the primary COPCs in the Middle Sector include VOCs (both chlorinated aliphatic hydrocarbons and chlorinated aromatic hydrocarbons), dioxin, and PCBs. Inorganic parameters (primarily arsenic)

were also cited in the HHRA as posing an unacceptable risk. However, the detections of the inorganic parameters are somewhat sporadic and may be more representative of background or regional conditions within the aquifer, or of spatial variability.

Remedial technologies screened for alluvial groundwater include no action, limited action controls, recovery and treatment/disposal options, and various physical/chemical and in-situ treatment options. Results of this screening phase for groundwater are briefly discussed below.

3.3.2.1 No Action

The "no-action" alternative serves as a baseline condition against which other remedial technologies or alternatives are compared. Under this option, no further action would be taken to remediate the alluvial groundwater.

Effectiveness: The "no-action" alternative may meet the remedial action objective for current use exposures to impacted alluvial groundwater as well as under reasonably anticipated future land use scenarios. However, potential risks exist for the exposure of hypothetical future residents and/or workers, as determined in the HHRA. In addition, the "no-action" alternative would not meet the remedial action objectives for preventing further aquifer degradation or improving groundwater quality.

Implementability: This option is easily implemented, as no action is taken.

Cost: Capital costs would not be incurred. Long-term costs (i.e., five-year reviews) would be low.

Conclusion: No action would not meet the remedial action objectives for alluvial groundwater, but is retained for further consideration to serve as a baseline for comparison with other options.

3.3.2.2 Limited Action: Deed Restrictions/Municipal Ordinance

Deed restrictions could be implemented to limit future uses of the groundwater at the site through covenants placed on property deeds. Alternatively, a municipal ordinance could be enacted to prohibit the installation and use of groundwater supply wells for specific uses within a certain area. The intent of deed restrictions and/or municipal ordinance

would be to reduce potential unacceptable exposure to human receptors. Such restrictions would have an initial duration of 30 years, after which the current conditions would be re-evaluated to determine the need for continuing the restrictions.

Effectiveness: Deed restrictions and the municipal ordinance as described above would establish institutional measures intended to limit the access to and use of impacted groundwater. Restrictions would prevent water supply wells from being drilled in affected areas for potable, sanitary, or other specified uses. This option would meet the remedial objectives for exposure control, especially in combination with the existing reliable supply of public water available throughout the area, but would not protect the alluvial aquifer from further degradation or reduce COPC concentrations.

Implementability: Deed restrictions could be easily implemented for portions of the site under the administrative control of CBS. For properties downgradient of the site, enactment of a municipal ordinance restricting the use of groundwater may be more readily implemented than individual property deed restrictions. Preliminary discussions with the City of Sharon indicate a general willingness to pursue such an ordinance.

Cost: Capital costs for implementing this option consist primarily of legal and filing fees, and are considered low to moderate. Long-term costs for this option would be low.

Conclusion: Deed restrictions and/or a municipal ordinance may be necessary in order to prevent exposure to impacted groundwater even if an active remedy for groundwater is selected, and is therefore retained as a potential option for groundwater.

3.3.2.3 Limited Action: Monitoring

Monitoring would consist of periodic sampling and analysis of the site groundwater to assess the migration and/or changes in COPC concentrations. In addition to sampling and analysis, routine site inspections may be required to monitor maintenance items and to assess compliance with deed restrictions

Effectiveness: Monitoring activities alone would not be effective at meeting the remedial action objectives. Continued site monitoring is, however, an essential component of any remedial alternative, in order to assess the performance of the selected remedy.

Implementability: Routine site monitoring is readily implemented.

Cost: Some capital costs would be incurred for monitoring activities, consisting primarily of dedicated sampling equipment. Long-term costs would be low to moderate, depending on the scope of the monitoring activities.

Conclusion: Monitoring is retained for consideration as an essential component of the selected remedy.

3.3.2.4 Limited Action: Monitored Natural Attenuation

Monitored natural attenuation (MNA) is defined as *the use of natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remedial objectives within a time frame that is reasonable compared to other methods* (USEPA, 1998). Natural attenuation processes include a variety of physical, chemical, or biological processes that, under favorable conditions, will act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil and groundwater. These processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization or destruction of contaminants (USEPA, 1998).

MNA consists of periodic sampling and analysis of the site groundwater to assess migration, degradation, and changes in COPC concentrations. Groundwater samples may or may not be analyzed for natural attenuation parameters. Although this process is similar to the "Limited Action: Monitoring" process discussed above, it involves a more detailed evaluation of the fate and transport of contaminants and associated degradation of products along the flow path. MNA is typically used in conjunction with (or as a follow-up to) active remedial alternatives such as source control.

Effectiveness: Monitored natural attenuation activities alone would likely not be effective at meeting the remedial action objectives related to groundwater quality within a reasonable time frame. However, MNA in conjunction with temporary use restrictions and/or an active source control process may be an effective remedy for reducing exposure. Groundwater sampling performed at the site in 1999 indicated that natural attenuation processes are potentially occurring at portions of the site.

Implementability: Natural attenuation monitoring is readily implemented.

Cost: Some capital costs would be incurred for monitoring activities, consisting primarily of dedicated sampling equipment. Long-term costs would be low to moderate, depending on the scope of the monitoring activities.

Conclusion: Monitored natural attenuation is retained for consideration as a potential component of the selected remedy. It has application for both the South and Middle Sectors at the site.

3.3.2.5 Recovery and Treatment/Disposal: Groundwater Extraction

For this option, a series of groundwater recovery wells (either vertical or directional) are drilled and installed in the alluvial aquifer. Submersible pumps are then installed into the wells which deliver groundwater to the surface for treatment and/or disposal. The monitoring wells are screened in selected zones containing high concentrations of COPCs. This process may be used to establish hydraulic control within the portions of the alluvial aquifer impacted with COPCs, or as an aggressive aquifer remediation where numerous wells are installed to pump large volumes of impacted groundwater for treatment.

Various types of enhanced groundwater recovery methods may also have application at the Sharon site. These techniques generate enhanced fracture networks which can increase soil permeability to liquids and vapor and therefore, accelerate contaminant removal. Hydraulic fracturing involves injecting water under high pressures into the bottom of a borehole to create a notch. A slurry of water, sand, and a thick gel is then pumped at high pressures into the notch in order to induce fracturing. The gel then biodegrades leaving sand filled fractures. Pneumatic fracturing involves the injection of highly pressurized air into consolidated or semiconsolidated sediments to extend existing fractures and possibly create a secondary fracture network.

Operational procedures can include continuous or pulsed pumping which may optimize groundwater/contaminant recovery. There are various options regarding treatment and/or disposal of the groundwater once it is pumped to the surface. These options will be discussed later in this section.

Effectiveness: This alternative is highly effective in recovering groundwater and establishing hydraulic control at a site, although the effectiveness of groundwater recovery in removing significant quantities of COPCs from the aquifer may be limited. This process option, when combined with an effective treatment/disposal option and temporary use restrictions, could meet the remedial action objectives for exposure control, reduction/mitigation against aquifer degradation, and the eventual reduction of COPC concentrations.

Implementability: Groundwater extraction systems are easily installed using proven methods. A number of drilling contractors can provide these services and are readily available. Off-site well locations would require access agreements. If implemented as a remedial option for both the South and Middle Sectors, one treatment building would be installed with pipelines conveying groundwater from both of the impacted areas.

Cost: Capital costs for this option would be very high relative to other options based on the number of recovery wells required for hydraulic control in each sector. Costs for long-term maintenance of an associated treatment/disposal option would be moderate to high.

Conclusion: The limited effectiveness of groundwater extraction in restoring aquifers in a reasonable time frame, particularly where NAPLs are present, has been well documented. However, because this method is considered to be effective in recovering groundwater and establishing hydraulic control, it is retained to be used in combination with an effective treatment/disposal option. This method option could be utilized in either or both of the South and Middle Sectors at the site.

3.3.2.6 Recovery and Treatment/Disposal: On-Site Disposal to POTW

This option would involve discharging extracted groundwater to a local POTW that has sufficient capacity and is willing to accept the groundwater. The option would involve negotiating an agreement with the local authority and would likely require pretreatment. The groundwater (pretreated or untreated) could either be trucked or conveyed by pipeline to the POTW.

Effectiveness: Assuming acceptance by the local POTW, disposal of groundwater or pretreated effluent by the POTW would be an effective means for disposal of site groundwater.

Implementability: The nearest POTW is the City of Sharon Waste Water Treatment Plant located approximately 1.1 miles from the site. The plant currently does not receive any water from outside disposal facilities and has no plans to do so in the future. The plant is currently rated at 4.5 million gallons per day (gpd) and typically runs at approximately 40 to 70 percent of that capacity (depending primarily on weather conditions). The anticipated flow from a groundwater recovery system (used for hydraulic control) from both the South and Middle Sectors is approximately 180,000 gpd.

Furthermore, the maximum influent concentrations for PCBs that a typical POTW will accept is less than 3 µg/l (in accordance with TSCA), which means that extracted groundwater will likely require an effective pretreatment step prior to discharge to the POTW.

Cost: Capital costs for installation of a tap-in line from the treatment system to the nearest sanitary sewer line would be moderate. Operation and maintenance costs for disposal at the POTW would be high.

Conclusion: Because it is unlikely that the local waste water treatment facility will accept treated or untreated groundwater, and due to the substantial costs involved for this type of disposal, this option of groundwater disposal to the local POTW will not be retained for further consideration.

3.3.2.7 Recovery and Treatment/Disposal: Discharge to the Shenango River

This option would involve discharging extracted groundwater to the Shenango River after completing some form of pretreatment. The treated effluent would require compliance with relevant and appropriate permit conditions specified in an NPDES permit. The pretreated groundwater would likely be conveyed from the treatment facility to the river via a tap-in to an existing storm sewer, such as along Clark Street.

Effectiveness: Disposal of pretreated groundwater into the river would be an effective means of disposal of site groundwater. Assuming an effective groundwater treatment (to health-based and/or ecological-based standards), no adverse effects on human health or the environment are anticipated. This disposal option when used in combination with an adequate groundwater recovery system (for hydraulic control) and groundwater use restrictions would likely meet the remedial action objectives.

Implementability: The Shenango River is located approximately 1,000 feet west of the site. Assuming compliance with the conditions of a discharge permit, the technical implementation of this option is relatively easy. The hydraulic loading rate would be equivalent to the final discharge rate (approximately 200 gpm). The storm sewer at Clark Street is likely the only available storm sewer leading from the site which would have the available capacity to handle this discharge.

Cost: Capital costs would likely be relatively low based on the installation of the storm sewer tap-in and NPDES permitting costs. Operation and maintenance costs related to the discharge would also be low.

Conclusion: This option is retained for potential use in combination with other process options for developing remedial alternatives.

3.3.2.8 Recovery and Treatment/Disposal: Reinjection

This disposal option involves discharging treated groundwater back into the subsurface through a series of injection wells or an infiltration gallery. Surfactants or chemical oxidation agents are sometimes used as additives to assist in DNAPL removal or otherwise flush the aquifer to aid in the removal of COPCs.

Effectiveness: Assuming an effective groundwater collection and treatment (to health-based standards), no adverse effects on human health or the environment are anticipated. This disposal option when used in combination with an adequate groundwater recovery system (for hydraulic control) and groundwater use restrictions would likely meet the remedial action objectives.

Implementability: Based on the site hydrogeology (shallow depths to the water table) and anticipated volume of groundwater to be disposed, it is likely that reinjection would require pressure to be effective. This disposal option would be relatively difficult to implement primarily because the underground piping system would require the disturbance of many site building floors.

Cost: Capital costs would likely be moderate based on the drilling and installation of additional reinjection wells and construction of the piping system. Operation and maintenance costs would also be moderate based on the requirement for reinjection pressure.

Conclusion: Because this option would be difficult to implement (based on the site hydrogeology) and the technical impracticability of pipeline installations, it will not be retained as a disposal option.

3.3.2.9 Physical/Chemical Treatment: Solids Filtration

Filtration is the process of removing solids from the aqueous flow by passing the water through a porous filter medium, typically either sand or a cotton/synthetic fiber cartridge. Sand filters can be backwashed to remove the accumulated solids, while spent cartridges are replaced. Spent cartridges and/or recovered solids are then disposed of as a residual or hazardous waste.

Effectiveness: Filtration is an effective process for removing solids from extracted groundwater, thereby potentially removing inorganic and certain organic compounds which adhere to those solids. Filtration is often a required treatment process prior to other processes such as carbon adsorption in order to prevent clogging of the subsequent treatment processes.

Implementability: Filtration is a readily implemented treatment process. Routine maintenance would be required to backwash the sand beds or change the filter cartridges.

Cost: Capital costs for filtration systems are low to moderate with long-term operation and maintenance costs low.

Conclusion: Due to its potential effectiveness in removing inorganics and common use as pretreatment for other processes, this option is retained for potential use as a groundwater treatment method.

3.3.2.10 Physical/Chemical Treatment: Ion Exchange

Ion exchange is a process is an inorganics treatment method used to remove ions from a liquid stream. A synthetic resin selected specifically for the removal of certain inorganics

exchanges an ion such as sodium for an ion of environmental concern. When the resin is spent, it is washed off with brine, resulting in a concentrated solution of the target inorganics, which would then require further treatment.

Effectiveness: Ion exchange is an effective process for removing inorganics from extracted groundwater, particularly for a high-flow and relatively dilute waste stream such as is anticipated for the Sharon site. The concentrated solution of target inorganics may be a hazardous waste and would require appropriate subsequent treatment at an off-site facility.

Implementability: Ion exchange is a common technology that is readily available from numerous vendors. Further treatment of the concentrated wash solution would be required and is commercially available.

Cost: Capital costs for the ion exchange are high with moderate long-term operation and maintenance costs.

Conclusion: Due to its potential effectiveness in removing inorganics, ion exchange is retained for further consideration in developing remedial alternatives for groundwater treatment.

3.3.2.11 Physical/Chemical Treatment: Air Stripping

Air stripping involves the process of volatilization, or the removal of VOCs from groundwater by passing a stream of air through the water as it flows through a contacting system. This process provides sufficient driving force to promote mass transfer of organic compounds from the liquid to the gas phase. Stripping with steam is sometimes used when steam is available at a site. Several contacting systems can be used, such as mechanical surface aerators, diffused aeration, spray or tray towers, open-channel cascades, and counter-current packed towers. When there is a concern over VOC emissions, the use of packed towers is preferred, as they are more amenable to air pollution controls. Thermal or catalytic oxidation or adsorption can be used to treat off-gases and control vapor-phase hydrocarbons, if needed.

Effectiveness: Air stripping is an effective process for removing chlorinated aliphatic hydrocarbons from groundwater systems. This type of physical treatment transfers certain COPCs from the water phase to the air phase without actually reducing the

mobility, toxicity, or volume of those COPCs. COPCs which are not VOCs (PCBs and chlorinated benzenes) would not be addressed by this method. When this process is used in combination with a hydraulic control (groundwater recovery) system and groundwater use restrictions, it may provide an alternative that will meet the remedial goals at the site. High inorganic concentrations may cause precipitates to form which will require appropriate disposal. The precipitates can also hamper system performance.

Implementability: Air stripping is a commonly used technology that is readily available from numerous vendors. Off-gas treatment may be required as a part of this alternative to comply with provisions of the CAA. Piping will be required from the extraction wells to the treatment system.

Cost: Capital costs for the air stripping option are moderate with long-term operation and maintenance costs moderate to high, depending on the treatment of off-gases and the volume of precipitates that form and require disposal.

Conclusion: Because this option does not address the most significant COPCs at the site, air stripping will not be considered as an ex-situ treatment method.

3.3.2.12 Physical/Chemical Treatment: Aqueous-Phase Carbon Adsorption

Treatment using carbon adsorption consists of pumping groundwater through (an) activated carbon chamber(s). The activated carbon attracts the organic solute molecules, including chlorinated aliphatic hydrocarbons, and other site COPCs. As a result, the organic compounds are transferred from the aqueous to the solid phase. Once the carbon is loaded (saturated with organic molecules), it typically requires treatment prior to disposal or recycling. Maintenance is required to monitor the carbon loading so that a changeout can be completed before contaminant breakthrough occurs.

Effectiveness: Carbon adsorption is an effective process for removing most chlorinated aliphatic hydrocarbons and other organic site COPCs from groundwater, with the exception of vinyl chloride, which is present in low concentrations in a small portion of the aquifer downgradient of the South Sector. The effectiveness of the carbon units (adsorption of organics) is reduced immediately prior to breakthrough. This type of physical treatment transfers the COPC from the water phase to the solid phase without actually reducing the mobility, toxicity, or volume of COPCs. However, when this

process is used in combination with a hydraulic control (groundwater recovery) system, groundwater use restrictions, and appropriate management of spent carbon, it may provide an alternative that will meet the remedial goals at the site.

Implementability: Carbon adsorption is a commonly used technology that is readily available from numerous vendors. Pre- and post-filtering for the reduction of suspended solids will likely be required to optimize the efficiency of the carbon units and meet the effluent discharge requirements due to the hydrophobic nature of PCBs. The activated carbon would either be regenerated for future use or disposed of at a licensed facility in accordance with RCRA and state regulations. Piping will be required from the extraction wells to the treatment system.

Cost: Capital costs for this type of system would be low to moderate relative to other treatment options, while the operation and maintenance costs would be moderate to high, depending on carbon usage.

Conclusions: This option is retained for potential use in combination with other process options for developing remedial alternatives. This remedial option would have application in both the South and Middle Sectors at the site.

3.3.2.13 Physical/Chemical Treatment: Chemical Oxidation with UV Catalyst

This ex-situ process involves the treatment of groundwater by the use of air, or oxidizers, such as ozone, permanganate, or peroxide, to react with the organic chemical species, either by adding oxygen or removing hydrogen (or electrons). The oxidizers break down the carbon molecules in the carbon-hydrogen or carbon-halogen bonds. Ultraviolet (UV) light is used as a catalyst in ozone oxidation or peroxidation processes. The result of the UV light is that complex and often resistant species, such as halogenated hydrocarbons, can either be fully degraded to basic components (carbon dioxide and water) or broken down to simpler molecules which are more easily degraded. The main advantage of the UV oxidation process is that it is a destructive process, as opposed to air stripping or carbon adsorption, for which contaminants are extracted

Effectiveness: This process when used in combination with an effective hydraulic control (groundwater recovery) system and groundwater use restrictions, is effective for

treating the organic COPCs found at the site and may meet the remedial action objectives. However, there is a moderate potential with regard to protectiveness for human health effects because of the handling of chemical oxidants.

Implementability: This type of treatment technology is commercially available in a wide range of sizes. Single lamp bench-top reactors are available which can run in either batch or continuous modes. Handling of oxidizers will require special consideration. Monitoring of the effluent is required to verify adequate quenching of the oxidizer. No residual byproducts that require off-site disposal are generated by this process.

Cost: Capital costs for this option would be high compared to other treatment options. Operation and maintenance costs, including chemicals, would also be high based on the estimated flow rate and contaminant concentrations.

Conclusions: This option is retained for potential use in combination with other process options for developing remedial alternatives. This alternative could be used as a potential remediation for groundwater extracted from both the South and Middle Sectors at the site.

3.3.2.14 In-Situ Treatment: Dual Phase Extraction

This process involves the components of a soil vapor extraction (SVE) system combined with extracting impacted groundwater for aqueous-phase carbon treatment (as described in Section 3.3.2.10). A high vacuum system is applied simultaneously to remove various combinations of hydrocarbon vapors and impacted groundwater from the subsurface. The vacuum causes a negative pressure gradient which prompts the volatilization of VOCs from the soils to the vapor phase. The vapors are treated at the surface using vapor-phase carbon treatment units. Groundwater withdrawal is accomplished through the same extraction wells as the SVE system with a drop tube installed from the wellhead to the screened interval. The groundwater removal lowers the water table allowing more of the unsaturated zone to be exposed for vapor extraction. Treated groundwater is then reinjected back into the aquifer or discharged to a POTW or the Shenango River. Discharge permits may be required for both air and water (off-gas and water treatment processes).

Effectiveness: This process is effective for treating VOCs at the site. However, this process has only limited effectiveness treating PCBs and other SVOCs. The overall effectiveness of this type of system depends upon the efficiency of the vapor and water extraction systems.

Implementability: Dual phase extraction systems are readily available from a number of vendors. Pilot tests would be required to assess the extent of influence of the extraction wells prior to implementing a full-scale system. Appropriate discharge permits and access agreements may need to be obtained.

Costs: Both capital and operation and maintenance costs are expected to be moderate to high compared to other alternatives, due to the need for both vapor-phase and aqueous-phase treatment systems.

Conclusions: Because the effectiveness of this process in treating PCBs and SVOCs is limited, dual-phase extraction will not be retained for further consideration as a remedial option for the Middle Sector. This option may be applicable for the South Sector.

3.3.2.15 In-Situ Treatment: Enhanced Biodegradation

Enhanced biodegradation is an in-situ treatment method where COPC-specific microorganisms and, if needed, micronutrients are applied using one of several methods:

- Direct application of nutrients/microbes onto the ground surface;
- Injection of air/nutrient/microbes into an impacted aquifer (biosparging); and/or
- Injection of air/nutrient/microbes into the vadose zone (bioventing).

These processes are used on impacted groundwater in order to enhance natural biodegradation of the COPCs to less toxic (or non-toxic) compounds. This treatment method could be used as a sole remedy for an entire area or "hot-spot" treatment could be performed in combination with an alternate remedy for untreated areas.

Effectiveness: Enhanced biodegradation is an emerging technology with some commercial success for treating groundwater impacted by various organic compounds. Various types of compounds are used to stimulate biodegradation processes which in

turn, degrade the organic molecules. The degradation process continues until less toxic compounds are produced. The effectiveness of the system depends on the ability to inject (or deliver) the biological organisms to the impacted media. An additional remedy may be necessary for some COPCs, such as inorganics, which may not be treated by biodegradation.

Implementability: The services of a specialized remediation contractor would be required and are readily available. Work performed off-site would require access agreements and related approvals from local landowners.

Cost: Capital costs for biodegradation would be moderate to high relative to other alternatives, while costs for long-term monitoring of the groundwater would be low.

Conclusion: Enhanced biodegradation is a viable alternative for the removal of organic compounds from the site groundwater, either as a sole remedy or for application in selected areas. This process is retained for consideration as a potential component of the selected remedy and would likely have application to both the South and Middle Sectors at the site.

3.3.2.16 In-Situ Treatment: Permeable Reactive Barriers

A permeable reactive barrier (also known as a passive treatment wall) is an innovative treatment technology where a barrier is installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. The contaminants are removed from the water by zero-valent metals (typically iron), chelators (ligands selected for specific metals), sorbents, microbes, or others. The contaminants are either degraded or retained in a concentrated form by the barrier material. Reactive barriers can be designed using several orientations, including a funnel and gate system. The funnel and gate system employs cutoff trenches (i.e., slurry walls or sheet piles) using low permeability material which directs flow through an in-situ reactive zone (treatment gate). Over time the reactive materials may lose their treatment potential and have to be replaced. Furthermore, the permeability of the reactive materials may be reduced over time due to precipitation deposits on the treatment media.

Effectiveness: This process provides an effective treatment for both VOCs and SVOCs in groundwater as it passes through the barrier, but does not treat COPCs which remain at

the source area(s). This innovative treatment has shown to be effective at sites where there is a relatively impermeable aquitard below the impacted zone (which is the case with the glacial till beneath the alluvial aquifer at the site). The process is also somewhat effective in treating inorganics. With proper design of the barrier, a remedy for source control, and groundwater use restrictions upgradient of the barrier, this option could meet the remedial action objectives.

Implementability: Although this method may be effective in treating the site COPCs, it is likely to be difficult to implement because there is no well-defined plume at the site, particularly at the South Sector. Additionally, the design and placement of the barrier wall may be difficult due to substantial infrastructure and industrial development downgradient of the site. Work performed off site would require access agreements and related approvals from local landowners.

Cost: This process would require high to very high capital costs (depending on the length of the wall). Operation and maintenance costs would likely be moderate depending on the frequency that the reactive material needs to be changed.

Conclusions: Because of the difficulty in implementing this process option with regard to location and the lack of a well-defined plume, it will not be retained for further consideration as a remedial alternative.

3.3.2.17 In-Situ Treatment: Recirculating In-Well Air Stripping

This innovative treatment technique is based on the principles of air stripping or sparging and groundwater recirculation. In this method, air is injected into a double screened well, lifting the water in the well and forcing it out the upper screen. Water is drawn in the lower screen simultaneously. The water entering the well will allow for volatilization of the impacted groundwater transferring the contaminants from the liquid to the vapor phase. The volatilized contaminants rise through the water in the well and are extracted and treated by a SVE system. The SVE system also collects vapors from the vadose zone surrounding the well. The partially treated groundwater is never brought to the surface; rather, it is discharged into the unsaturated zone and the process is repeated creating a hydraulic circulation pattern. This continuous cycling of the groundwater allows the contaminant concentrations to gradually be reduced.

Effectiveness: While this process may be effective in treating the VOCs and certain SVOCs at the site, it is not an effective process for treating PCBs. This type of process is primarily used for hot-spot treatment in highly impacted wells and is most effective at sites with well-defined plumes. Fouling of the system can occur by infiltrating precipitates containing oxidized constituents.

Implementability: In-well stripping systems are commercially available although vendors are somewhat limited. These systems would require pilot testing to determine the usefulness at the site. Off-gas treatment may be necessary which would require obtaining the appropriate air discharge permits. Work performed off site would require access agreements and related approvals from local landowners. At impacted portions of the aquifer downgradient of the South Sector, the limited thickness of unsaturated soils (generally less than six feet) makes this option impractical in that area.

Cost: Capital costs would be moderate depending on the number of wells required (or the number of wells where hot-spot treatment is required). Operation and maintenance costs are expected to be moderate to high relative to other alternatives, depending on the need for off-gas treatment.

Conclusions: This option will not be retained for further consideration due to the limited unsaturated zone thickness at the South Sector and presence of non-volatile COPCs in the Middle Sector.

3.3.2.18 In-Situ Treatment: Chemical Oxidation

This treatment method is similar to the ex-situ method described in Section 3.3.2.11, but is performed in situ without a UV catalyst. Because this method is performed in situ, it poses less of an environmental risk, as there is less handling of oxidizing materials and no generation of disposal products. It involves injecting chemical oxidants into impacted groundwater so that the contaminants are either completely oxidized to carbon dioxide or converted into less (or non-) toxic compounds that are commonly found in nature. Typical oxidants include hydrogen peroxide with ferrous iron, potassium permanganate, or ozone.

Effectiveness: This treatment method is effective for a wide variety of organic compounds. The effectiveness of the system depends on the ability to inject (or deliver) the oxidants to the impacted media. Several methods include vertical wells, directional

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wells, jet grouting, and hydraulic fracturing among others. This system could be used in conjunction with other treatment options and/or groundwater use restrictions to provide a protective option that meets the remedial action objectives for the site.

Implementability: Commercially available systems are now available, but would require pilot testing prior to full-scale implementation. The initial injection would be designed to provide a somewhat complete aquifer treatment, while spot polishing in selected areas may be required. Design considerations should include injection point spacing, the radius of influence around the injection wells/points, and a determination of when and/or where re-injections may be required. Work performed off site would require access agreements and related approvals from local landowners.

Cost: Capital costs would be moderate to high based on the amount of chemicals required and the delivery method selected. Operation and maintenance costs would be low to moderate based on the frequency and amount of re-injections required.

Conclusions: This option is retained for potential use in combination with other process options for developing remedial alternatives. When combined with other remedial alternatives, this option could meet the remedial action objectives.

3.3.3 Non-Aqueous Phase Liquids

NAPLs have been detected in the subsurface at various locations in the South and Middle Sectors, with the majority of LNAPLs and DNAPLs being located in the vicinity of the former tank farm at the western edge of the Middle Sector. The HHRA did not explicitly evaluate risk related to exposure to NAPLs, as there are no present or likely future NAPL exposure scenarios. However, the presence of NAPLs in the subsurface would be expected to continue to affect groundwater quality. Remedial technologies screened for NAPLs include no action, limited action controls, vertical barriers, recovery and disposal, and various in-situ treatment options. Results of this secondary screening phase for sediments are briefly discussed below.

3.3.3.1 No Action

The "no-action" alternative serves as a baseline condition against which other remedial technologies or alternatives are compared. Under this option, no further action would be taken to remediate the subsurface NAPLs.

Effectiveness: The "no-action" alternative would not meet the remedial action objectives of reducing the likelihood of human exposure to NAPLs or the potential for impacts to groundwater. Over time, some degradation of NAPL components may occur. Additionally, LNAPLs may migrate laterally and DNAPLs may migrate vertically downward to the bedrock aquifer.

Implementability: This option is easily implemented, as no action is taken.

Cost: Capital costs would not be incurred. Long-term costs (i.e., five-year reviews) would be low.

Conclusion: "No action" would not meet the remedial action objectives for NAPLs, but is retained for further consideration to serve as a baseline for comparison with other options.

3.3.3.2 Limited Action: Use Restrictions

Deed restrictions would serve to control future actions at the site which may disturb the NAPLs. The intent of the deed restrictions would be to reduce potential human exposure, for example, by prohibiting the installation of groundwater supply wells in the areas where NAPLs are present. Such restrictions would have an initial duration of 30 years, after which the current conditions would be reassessed. Because the NAPLs extend onto adjacent properties (Norfolk Southern and AK Steel), similar restrictions would have to be placed on those properties. Alternatively, a municipal ordinance could be enacted prohibiting the installation of groundwater supply wells for potable, sanitary, or other unacceptable uses throughout the site vicinity.

Effectiveness: Restrictions on groundwater supply wells, if complied with, would effectively reduce the potential for human exposure to NAPLs, but would not address potential impacts to groundwater nor reduce COPC concentrations.

Implementability: Deed restrictions are readily implemented on property currently owned by CBS, but may be more difficult to implement on property not under the administrative control of CBS. Discussions with the City of Sharon indicate a possible willingness to pursue municipal restrictions.

Cost: Capital costs consist primarily of legal and filing fees, and would be low relative to other options. Long-term costs would be low.

Conclusion: Pursuing municipal restrictions as well as deed restrictions on CBS property is retained for further consideration.

3.3.3.3 Limited Action: Monitoring

Monitoring would consist of routine site inspections for compliance with restrictions, general maintenance items, and assessment of the permanence and effectiveness of the selected remedial alternative(s). Monitoring may also include sampling and analysis of the affected media to assess current COPC concentrations and/or apparent NAPL thicknesses.

Effectiveness: Monitoring activities alone would not be effective at meeting the remedial action objectives. Continued site monitoring is, however, an essential component of any remedial alternative, in order to assess the performance of the selected remedy.

Implementability: Routine site monitoring is readily implemented for most locations.

Cost: No capital costs would be incurred for monitoring activities. Long-term costs would be low to moderate, depending on the scope of the monitoring activities.

Conclusion: Monitoring is retained for consideration as an essential component of the selected remedy.

3.3.3.4 Containment: Vertical Barriers

A vertical barrier, consisting of either steel sheet piles or a slurry or cement/bentonite wall, would be constructed around the areas of known NAPL presence, in order to inhibit the lateral migration of the NAPLs. The groundwater within the area inside the barrier would typically be extracted in order to maintain a pressure gradient into the barrier interior.

Effectiveness: Installation of a vertical barrier would effectively prevent the lateral migration of LNAPL and NAPL-impacted groundwater, but would not directly prevent the potential exposure of human receptors to NAPLs. The vertical barrier would also not prevent the downward vertical migration of DNAPL to the bedrock aquifer.

Implementability: Equipment and services for vertical barrier installation are available. However, the depth to a confining horizontal barrier (generally 45 feet to the top of the glacial till) and the presence of various industrial buildings and an active railroad line make installation difficult. Work performed off site would require access agreements and related approvals from local landowners.

Cost: Capital costs for installation of a temporary vertical barrier would be moderate, with low to moderate long-term maintenance costs.

Conclusion: Due to existing site development and the lack of vertical control, installation of a vertical barrier wall will not be considered as a potential remedial option.

3.3.3.5 Product Recovery: Horizontal/Vertical Recovery Wells and Pumps

Horizontal and vertical recovery wells could be installed to enable the collection of NAPLs from the subsurface using specialized skimmers, pumps, or other collection devices installed in the completed wells. This could include the low-volume pumping and reinjection of groundwater via a dual-well recovery system to enhance NAPL production at the recovery well. Recovered NAPLs would be contained for treatment and/or disposal at an appropriate off-site facility. Horizontal and vertical wells can also be used as a reagent delivery system for an in-situ treatment process.

Effectiveness: The effectiveness of recovery wells and collection devices is dependent on the viscosity and solubility of the NAPLs, as well as other subsurface and aquifer characteristics which determine the appropriate well spacing. Pumps with float switches designed for NAPL recovery can be an effective means of removing NAPLs from the subsurface when NAPLs accumulate in the wells in sufficient quantities. Vertical recovery wells installed as part of the LNAPL removal action have been moderately effective while using primarily passive recovery techniques. Subsequent treatment and disposal would reduce potential risks to human receptors, and removal from the subsurface would reduce the potential for cross-media effects.

Implementability: Vertical recovery wells and recovery pumps are readily installed. Horizontal wells are more difficult to install, but such services are available. Access agreements for adjacent properties may be required for the installation of additional recovery wells.

Cost: Capital costs for installation of vertical recovery wells and recovery pumps are moderate, with significantly higher installation costs for horizontal wells. Once the wells are installed, long-term maintenance costs for the wells and pumps would be moderate. Pumping equipment typically recovers more water than other product recovery methods, which may increase handling, treatment, and disposal costs substantially.

Conclusion: The installation of additional wells and recovery pumps for product recovery or reagent delivery will be retained for further consideration in developing remedial alternatives.

3.3.3.6 Product Recovery: Skimmers

Belt-type oil skimmers can be placed in vertical recovery wells to continuously extract product from the subsurface. NAPL, but not water, adheres to the belt and is drawn to the surface where the NAPL is scraped off the belt into a container, and the belt returns to the subsurface.

Effectiveness: A belt skimmer installed in Monitoring Well GM-4A during the LNAPL removal action has proven to be moderately effective at withdrawing LNAPL from the subsurface. Approximately 230 gallons of LNAPL have been recovered over a three-year period using this method, with a recovery rate during the third quarter of 1999 of 11.8 gallons per month. The effectiveness has been limited somewhat by the rate by which the LNAPL flows to the recovery well. Skimming of DNAPL has not been performed at the site, but case studies indicate that some DNAPLs, such as coal tars, are amenable to belt skimming.

Implementability: Equipment and services for the installation of belt skimmers are readily available. Access agreements for adjacent properties may be required for the installation of additional recovery wells.

Cost: Capital costs for installation and long-term operation and maintenance of belt skimmers would be low to moderate. Belt skimmers are designed to minimize water recovery, so handling, treatment, and disposal costs would be limited to the recovered NAPLs.

Conclusion: Based on the modest success of the existing belt skimmer at the site, the installation of additional belt skimmers for product recovery will be retained for further consideration in developing remedial alternatives.

3.3.3.7 Product Recovery: Passive Absorbents

This option consists of the placement of tubes filled with absorbent material into vertical recovery wells. NAPLs pass through a hydrophobic screen in the tube and are absorbed by the material. Once the tubes are saturated with oil they must be properly disposed of and replaced.

Effectiveness: Absorbent tubes have been placed in several wells to recover LNAPL as part of the LNAPL removal action. Approximately 97 gallons of LNAPL have been recovered over a three-year period using this method, with a current total recovery rate of one gallon per month. The effectiveness has been limited somewhat by the rate by which the LNAPL flows to the recovery wells. Passive absorption of DNAPL has not been performed at the site to date.

Implementability: Passive absorbent tubes are easily installed. Access agreements for adjacent properties may be required for the installation of additional recovery wells.

Cost: Capital costs for installation of absorbent tubes are low, with moderate long-term costs based on labor and disposal requirements.

Conclusion: Based on the modest success of the absorbent tubes at the site, this option for product recovery will be retained for further consideration in developing remedial alternatives.

3.3.3.8 Product Recovery: Solvent Enhanced Recovery

This option consists of the injection of an appropriate solvent into the NAPL layers. The solvent mixes with the NAPL, reducing the NAPL viscosity and improving flow toward recovery wells. Recovery of the NAPL/solvent mixture for subsequent treatment and disposal is typically performed using pumps or skimmers.

Effectiveness: Bench-scale laboratory tests indicate that isopropanol, a non-toxic solvent, effectively reduces the viscosity of the NAPLs found at the site by 73 to 88 percent.

Reductions in concentrations of NAPL constituents in the tested soils ranged from 50 to 90 percent. It is expected that this option would improve the effectiveness of a selected product recovery option.

Implementability: Equipment and services for implementing this process are readily available. Access agreements for adjacent properties may be required for the installation of injection and additional recovery wells.

Cost: Capital and long-term costs for implementation of solvent enhanced recovery would be moderate to high, depending on if the solvent can be recovered and recycled, rather than disposed of with the recovered NAPLs.

Conclusion: This option for enhanced product recovery will be retained for further consideration in developing remedial alternatives.

3.3.3.9 Product Recovery: Thermally Enhanced Recovery

This option consists of installing single-phase electrodes in borings to electrically heat the subsurface, targeting the depths where NAPLs are present. As the NAPLs are heated, their viscosity and solubility improve, thereby increasing flow toward recovery wells. Recovery of the NAPLs for subsequent treatment and disposal is typically performed using pumps or skimmers.

Effectiveness: Bench-scale laboratory tests indicate that heating the NAPLs found at the site to 100° Fahrenheit reduced NAPL viscosity by 54 to 67 percent. Further heating to 210° Fahrenheit reduced NAPL viscosity by 88 to 92 percent. It is expected that this option would improve the effectiveness of a selected product recovery option.

Implementability: Equipment and services for implementing this process are readily available. Access agreements for adjacent properties may be required for the installation of electrode borings and additional recovery wells.

Cost: Capital and long-term costs for implementation of thermally enhanced recovery would be high, due to electricity costs.

Conclusion: This option for enhanced product recovery will be retained for further consideration in developing remedial alternatives.

3.3.3.10 Product Recovery: Surfactant Flushing

This option is similar to solvent enhanced recovery, and consists of the injection of an appropriate surfactant into the NAPL layers. The surfactant attaches to and solubilizes the NAPL in a microemulsion, improving subsequent recovery via pumping or skimming. The surfactants are commonly injected with a cosolvent such as isopropyl alcohol to further improve NAPL recovery. Subsequent treatment and disposal of the recovered NAPL/surfactant mixture would be required.

Effectiveness: Surfactant flushing was originally developed by the petroleum industry as an oil recovery method, and pilot tests conducted at other sites indicate that this process is a potentially effective method for environmental product recovery as well. It is expected that this option would improve the effectiveness of a selected product recovery option.

Implementability: Equipment and services for implementing this process are readily available. Access agreements for adjacent properties may be required for the installation of injection and additional recovery wells.

Cost: Capital and long-term costs for implementation of surfactant flushing would be moderate to high, depending on if the surfactant can be recovered by microfiltration and recycled, rather than disposed of with the recovered NAPLs.

Conclusion: This option for product recovery will be retained for further consideration in developing remedial alternatives.

3.3.3.11 Product Recovery: Groundwater Depression

This option involves extraction of groundwater to lower the water table, potentially enhancing LNAPL flow towards recovery wells or allowing the more efficient performance of a soil vapor extraction system. Extracted groundwater would require proper treatment and disposal.

Effectiveness: Depressing the groundwater table is a potentially effective means of enhancing recovery of LNAPL, but would not assist in the recovery of DNAPL.

Implementability: Equipment and services for implementing this process, including groundwater treatment services, are readily available. Access agreements for adjacent properties may be required for the installation of additional recovery wells.

Cost: Capital costs for implementation of groundwater depression would be moderate, while long-term operating costs would be moderate to high due to the need for groundwater treatment.

Conclusion: Due to the large quantities of extracted groundwater requiring treatment and because DNAPL would not be addressed, this option for enhanced product recovery will not be retained for further consideration.

3.3.3.12 Disposal: Off-Site Disposal

This option consists of the transportation of recovered NAPLs to an appropriate off-site facility for subsequent treatment and/or disposal. Based on the anticipated characteristics of the recovered NAPLs, it is likely that off-site incineration would be required.

Effectiveness: Proper off-site treatment and disposal of recovered NAPLs at a licensed facility is a highly effective means of disposal.

Implementability: Commercial transportation, treatment, and disposal facilities with sufficient capacity are readily available.

Cost: Long-term costs for off-site disposal of recovered NAPLs would be high.

Conclusion: Off-site disposal of recovered NAPLs will be retained for further consideration in developing remedial alternatives.

3.3.3.13 In-Situ Treatment: Chemical Oxidation

In-situ chemical oxidation involves the injection of a solution which will react with and subsequently destroy the COPCs in the NAPLs within a relatively short time span. Most commonly, this is performed using an oxidizing solution such as hydrogen peroxide with ferrous iron (Fenton's reagent). The ultimate byproducts of this oxidation reaction are carbon dioxide, water, and chloride ions.

Effectiveness: Bench-scale laboratory tests indicate that chemical oxidation can effectively reduce concentrations of chlorinated benzenes in site NAPL/soil mixtures. The effective treatment of PCBs was related to soil grain size: PCBs were more readily oxidized in coarser soils than in finer soils. Besides soil type, the effectiveness of this option would also be dependent on the ability to deliver the reactive solution throughout the areas containing NAPLs. Treatment using this method would effectively reduce the potential for continued impacts to groundwater and human exposure to NAPLs.

Implementability: Equipment and services for implementing this process are available. Access agreements for adjacent properties may be required for the installation of injection wells.

Cost: Capital costs for implementation of in-situ chemical oxidation would be very high. Once treatment is complete, long-term costs would be low.

Conclusion: Based on current estimates of DNAPL mass in the subsurface, costs for implementing chemical oxidation as a primary source destruction technique would be prohibitive, and as such this approach will not be further considered. This technology may be more appropriate in the future after other source removal techniques are performed to reduce DNAPL mass.

3.3.3.14 In-Situ Treatment: Enhanced Biodegradation

In-situ enhanced biodegradation involves the injection of a substrate containing specialized microbes which will degrade the COPCs in the NAPLs in a relatively short period of time. The ultimate byproducts of this degradation are carbon dioxide and water.

Effectiveness: Bench-scale laboratory tests indicate that certain microorganisms can effectively reduce concentrations of chlorinated benzenes in site NAPLs, once the NAPLs are completely homogenized with groundwater in the aquifer. Biodegradation is likely to have little impact on undiluted NAPLs. Successful treatment using this method would effectively reduce the potential for continued impacts to groundwater and human exposure to NAPLs.

Implementability: Equipment and services to perform this process are available. The success of this treatment method is dependent on the ability to recover DNAPLs from the bottom of the aquifer and get them to mix homogenously with groundwater and LNAPL in the aquifer. Access agreements for adjacent properties may be required for the installation of injection and recovery wells.

Cost: Capital costs for implementation of in-situ biodegradation would be very high. As this is a relatively short-duration treatment process, long-term costs would be low.

Conclusion: This option for in-situ treatment will be retained for further consideration in developing remedial alternatives.

3.3.3.15 Ex-Situ Treatment: Incineration

Incineration involves the high temperature ex-situ burning of media containing COPCs, and can be performed at a permitted off-site commercial incinerator or at a temporary incinerator placed on site. Incineration permanently destroys the COPCs.

Effectiveness: Incineration has been demonstrated to be effective and is a TSCA-approved method for treating liquids containing high concentrations of PCBs, which are the primary COPCs in site NAPLs. Removal from the subsurface and subsequent incineration would effectively reduce continuing impacts to groundwater and potential risks to human receptors.

Implementability: Commercial incinerators licensed to handle media such as the NAPLs at the Sharon site are available.

Cost: Capital costs for off-site incineration of recovered NAPLs would be very high. The anticipated volume and rate of NAPL recovery would probably not be sufficient to justify the construction of a temporary on-site incinerator.

Conclusion: For liquids containing PCBs at concentrations exceeding 500 ppm (such as the NAPLs at the Sharon site), incineration is the primary treatment method prescribed by TSCA. Off-site incineration will be retained for further consideration in developing remedial alternatives.

4.0 DEVELOPMENT OF ALTERNATIVES

In this section, remedial alternatives for Shenango River sediments, alluvial groundwater, and NAPLs at the site are formed to address the remedial response objectives. The technologies and process options retained in the screening procedures described in Section 3.0 are developed into medium-specific remedial alternatives. These assembled alternatives are then subjected to further screening in Section 5.0. Consideration of the no-action alternative is required by the NCP.

4.1 SHENANGO RIVER SEDIMENTS

As discussed in Section 3.3.1, the remaining technologies and process options for Shenango River sediments and associated riparian soils include:

GENERAL RESPONSE ACTION	PROCESS OPTION
No Action	No Action
Limited Action	Site Monitoring Institutional Controls
Natural Recovery	Natural Attenuation Resedimentation
Containment	Cover Temporary Vertical Barriers
Removal and Disposal	Conventional Excavation Dredging Off-Site Disposal

Based on the remaining technologies and process options, there are two primary decisions to be made for Shenango River sediments and riparian soils: whether or not to take action; and if action occurs, whether to cover the sediments in place or to excavate for off-site disposal. Secondary decisions must also be made regarding the specific methods to be employed if an active remedy is selected. These choices are considered in

developing the alternatives and are based on the magnitude of COPC concentrations above ecological screening levels, the quantity of affected material, and the potential for impacts to human receptors caused by resuspension of sediments.

In the development of alternatives for sediments and riparian soils in and along the Shenango River, the volume of affected material was estimated based on a review of sediment and soil extent and quality, as well as potentially relevant screening criteria and cleanup levels established in RODs for similar scenarios at other sites.

For the purposes of developing estimates for this FS, a cleanup goal for Shenango River sediments of 1 ppm total PCBs was utilized. This cleanup goal is consistent with sediment cleanup goals established in RODs issued by USEPA for other sites in Region 3, including the Paoli Rail Yard site (ROD ID# R03-92/151) and the Metal Banks site (ROD ID# R-98/012). The lateral extent of sediments to be addressed was determined based on a review of the available sediment extent and quality. Because the 95 percent upper confidence limit (UCL) for shallow sediment samples collected in Areas 12 and 13 was 0.90 and 0.44 mg/kg, respectively, only Areas 14 and 15 are considered in the evaluation of remedial alternatives. It is also noted that, based on grain-size analyses, the majority of the sediments in Areas 12 and 13 contain less than 20 percent fine-grained materials, making these sediments less likely to cause ecological impacts relative to the silt-rich sedimentary deposits found in portions of Area 14.

The successful capping or removal of sediments to this cleanup goal would result in a maximum EEQ of 20 for PCBs in the remaining exposed sediments in Areas 14 and 15 (based on maximum sample results rather than 95 percent UCLs). Based on available sediment quality data, capping or removing these sediments would also reduce the maximum EEQs in the remaining exposed sediments to 13.9 for lead and 13.2 for zinc (single sample results). Maximum EEQs for other COPCs in remaining exposed sediment would be less than ten.

For riparian surface soils which are under water only during periods of high river flow, a cleanup goal of 10 mg/kg total PCBs was assumed. This level is consistent with the non-residential riparian soil cleanup level established in an October 1999 agreement between USEPA and General Electric for the Housatonic River Site in Massachusetts, which was deemed to be protective of human recreational users and biological receptors.

Sediments within the storm sewers leading from the site to the river were assumed to be subject to the same cleanup goals as the Shenango River sediments. The actual presence and current quality of such sediments is uncertain, and the total volume of such sediments requiring removal would be expected to be minimal.

Actual cleanup levels prescribed by the ROD for sediments and related soils at this site may be based on ecological risk-based concentrations; regulations provided under TSCA, Act 2 or other ARARs; or as otherwise determined during the remedy selection process. Other factors which may be considered in developing final cleanup levels include total organic carbon content and grain-size distribution. Actual quantities and extents of affected sediments handled during remedial activities may differ, depending on current conditions and the target cleanup concentrations. Sampling and analysis for specific COPCs during remedial design and/or remedial action may be used to more adequately define quantities and plan remediation.

An extremely important consideration regarding the safety and practicability of any alternative that involves disturbance of existing conditions is the effect on the water supply intake for the Shenango Valley Water Authority. The RI concluded that neither the river water nor the sediments constituted a risk to human health outside of the target range. Sediments are being assessed due to the findings of the screening level ERA, not the HHRA, with additional potential concerns including human consumption of fish and swimmers at the immediate vicinity of the Clark Street outfall. However, it is clear that disturbance of sediments near and upstream from the water intake will increase human health risks on a temporary basis any time the intake is in operation. Additionally, any disturbance of impacted sediment may temporarily result in increased ecological exposure as well.

4.1.1 Shenango River Sediment Alternative 1 – No Action

Under this alternative, no action would be taken to reduce the potential for effects to ecological receptors caused by COPCs in Shenango River sediments, riparian soils, and storm sewer sediments. This alternative is retained for comparison with the other alternatives as required by the NCP.

4.1.2 Shenango River Sediment Alternative 2 – Limited Action/Natural Recovery

This alternative would include maintaining the existing fish consumption advisories for the Shenango River, until such time that it is determined that consumption of fish no longer poses an unacceptable health risk. A second component of this alternative would be the natural resedimentation of the river. Over time, new sediments may be deposited on top of the existing sediments, thereby providing a natural barrier between the impacted sediments and ecological receptors. Additionally, natural attenuation processes may gradually reduce COPC concentrations to levels which pose less risk to ecological receptors.

An essential component of this alternative is routine monitoring of COPC concentrations in both sediment and fish tissue in order to evaluate the effectiveness of the alternative. For the purposes of this FS, it is assumed that biennial (i.e., every two years) sampling of sediment and fish would be appropriate.

4.1.3 Shenango River Sediment Alternative 3 – Cover

For this alternative, portions of the Shenango River where sediments and riparian soils exceed the cleanup goals would be covered by a minimum of 12 inches of clean granular fill or other suitable material, in order to limit the bioavailability of impacted sediments. The cover would be designed appropriately to minimize the potential for erosion and scouring of the riverbed. Routine monitoring would be performed to inspect the cover for signs of erosion. Existing fish consumption advisories would be maintained until it was determined through routine biennial fish tissue sampling that consumption of fish no longer posed an unacceptable health risk.

Additional inspection of the storm sewers leading from the site to the river would also be performed as part of this alternative. If significant quantities of sediment are found in the storm sewers at COPC concentrations which exceed determined cleanup goals, the sediments would be removed and disposed of at an appropriate off-site facility. Monitoring of the surface water intake would be performed during construction, and if determined to be appropriate, withdrawal of water may be limited to non-construction hours as a precautionary measure.

4.1.4 Shenango River Sediment Alternative 4 – Excavate and Treat/Dispose Off Site

Under this alternative, the Shenango River sediments and soils which contain COPCs which exceed the cleanup goals would be excavated and transported to a permitted off-site facility for subsequent treatment and/or disposal. Prior to excavation, temporary barriers such as sheet piling or cofferdams would be installed to isolate the areas being excavated, thereby reducing the potential for impacted sediment to be reintroduced into surface water. The area inside the barriers would be dewatered in order to reduce the water content of excavated material. Additionally, discharge from the Clark Street storm sewer (at least 50 gpm during dry weather) would be temporarily rerouted around the adjacent work area.

Two excavation scenarios have been developed for consideration. Under Alternative 4A, sediments and riparian soils exceeding the established cleanup goals would be excavated to a maximum depth of twelve inches. For Alternative 4B, sediments and riparian soils exceeding the cleanup goals would be excavated to a maximum depth of four feet.

Under both excavation scenarios, the excavated areas would be backfilled with clean fill, as appropriate for erosion and scour control, to reestablish the pre-excavation channel profile such that existing flow and deposition patterns are not changed. Routine monitoring would be performed to inspect the cover for signs of erosion.

At Area 15 (Clark Street), conventional excavating equipment, such as a small track-mounted excavator, would be used to excavate sediments and riparian soils. Some clearing of vegetation adjacent to the Clark Street Bridge would be necessary to allow equipment access to the river. Excavated material would be decanted and stabilized as needed to eliminate free liquids, and then transferred to trucks for hauling to an appropriate disposal facility. Based on available sample data, it is likely that material excavated from Area 15 will be neither a TSCA-regulated waste nor a RCRA hazardous waste. It is estimated that 400 cubic yards of sediment and 100 cubic yards of soil would be excavated from this area under Alternative 4A, and 1200 cubic yards of sediment and 300 cubic yards of soil would be excavated under Alternative 4B.

At Area 14 (adjacent to the water company intake), the depth of the river and steep banks, particularly along the eastern bank of the river, would make it necessary to use a clamshell dredge to remove impacted sediment. Some clearing of vegetation along the

east bank of the river (Sharon Tube Company property) would be necessary to allow equipment access to the river. Excavation areas along the west bank of the river would be accessed from the water company property. Excavated material would be decanted and stabilized as needed to eliminate free liquids, and then transferred to trucks for hauling to an appropriate disposal facility. Based on available sample data, it is likely that except for one small area where sediments contain greater than 50 mg/kg total PCBs, the material excavated from Area 14 will be neither a TSCA-regulated waste nor a RCRA hazardous waste. It is estimated that 725 cubic yards of sediment would be excavated from this area under Alternative 4A, and 2,900 cubic yards under Alternative 4B.

Monitoring of the water company intake would be performed during construction activities, and if determined to be appropriate, withdrawal of water may be limited to non-construction hours as a precautionary measure. Liquids decanted from the excavated material would be subject to treatment prior to discharge to the river.

Additional inspection of the storm sewers leading from the site to the river would also be performed as part of this alternative. If significant quantities of sediment are found in the storm sewers at COPC concentrations which exceed determined cleanup goals, the sediments would be removed and disposed of at an appropriate off-site facility. Existing fish consumption advisories would be maintained until it was determined through routine biennial fish tissue sampling that consumption of fish no longer posed an unacceptable health risk.

4.2 GROUNDWATER AND NAPLS

As discussed in Section 3.3.2, the remaining technologies and process options for alluvial groundwater at the site include:

GENERAL RESPONSE ACTION	PROCESS OPTION
No Action	No Action
Limited Action	Site Monitoring Institutional Controls Monitored Natural Attenuation

GENERAL RESPONSE ACTION	PROCESS OPTION
Recovery and Disposal	Extraction Discharge to River
Ex-Situ Treatment	Carbon Adsorption Chemical Oxidation/UV Catalyst Solids Filtration Ion Exchange
In-Situ Treatment	Enhanced Biodegradation Chemical Oxidation

For site NAPLs (Section 3.3.3), the remaining technologies and process options include:

GENERAL RESPONSE ACTION	PROCESS OPTION
No Action	No Action
Limited Action	Site Monitoring Institutional Controls
Product Recovery	Extraction by Pumping Product Skimmers Passive Absorbents Solvent or Thermally Enhanced Recovery Surfactant Flushing
Ex-Situ Treatment/Disposal	Off-Site Incineration/Disposal
In-Situ Treatment	Enhanced Biodegradation

Because of the intimate relationship between NAPL presence and groundwater quality, potential remedial alternatives for these two media will be evaluated concurrently throughout the remainder of the FS.

Based on the remaining technologies and process options, there are four primary decisions to be made for NAPLs and groundwater at the site: whether or not to take action; if action occurs, whether to pursue limited, passive remedies or active remedies; if active remedies are to be pursued, whether to address NAPLs only or both NAPLs and

groundwater; and whether an active remedy, if selected, will involve in-situ or ex-situ treatment and/or disposal of the NAPLs and groundwater. Secondary decisions must also be made regarding the specific types of limited actions and treatment/disposal methods. Where multiple process options are available within a class of response actions (such as ex-situ treatment) and the options are expected to have similar effectiveness and protectiveness, the more common and/or less costly method was selected for inclusion as part of a remedial alternative. Should such an alternative be selected for the site remedy, site-specific pilot studies may be appropriate to determine the most cost-effective process option. These choices are considered in developing the alternatives and are based on the magnitude of COPC concentrations above human health-based and ARAR-based cleanup levels, the quantity of affected material, and the potential for additional aquifer degradation.

In the development of the alternatives for groundwater, hydraulic responses and well yields estimated from monitoring well installation records and the known extent of COPCs were evaluated to develop estimated configurations and numbers of extraction and/or injection wells that would meet remedial objectives. The accuracy of these estimates is considered to be sufficient for preparation of the FS. However, additional predesign investigation activities, including aquifer testing for example, may be appropriate should an active remediation method be implemented in the future. This process may be iterative with performance monitoring and possible modification in order to achieve the intended performance of such a remedial action.

As discussed in Section 2.2.2, three distinct plumes of COPCs have been detected in the alluvial aquifer, covering two portions of the site. South Sector and Middle Sector groundwater was designated as distinct areas in the HHRA based on the known extent of COPCs in each area. Because the specific COPCs and relative concentrations vary somewhat between the two areas, and because of the presence of NAPLs in the Middle Sector, it is possible that a different remedy may be selected for each area. As such, the evaluation of each potential remedy will consider each area individually, where appropriate, including cost considerations.

Another significant consideration in developing remedial alternatives is the presence of NAPLs in the Middle Sector. Because of the presence of NAPLs in the alluvial aquifer, it is likely that an active remedy which addresses only groundwater without removing or otherwise reducing the impact of NAPLs on groundwater will not result in an

improvement of aquifer quality. In fact, a recent USEPA document (see Appendix A) describes the migration of hazardous wastes in the subsurface, particularly as related to the presence of NAPLs (USEPA, 1999). As failure to recognize and address NAPL issues is a common reason for failure of groundwater remedies, this document suggests a three-phased approach for the remediation of NAPL sites. The first phase consists of direct pumping of significant accumulations of NAPLs, followed by a second phase of enhanced recovery of residual NAPLs. The concluding phase of this suggested approach is the remediation of the remaining aqueous-phase contamination, possibly including in-situ treatment, pump and treat, or monitored natural attenuation. Since over 99 percent of the COPC mass in the alluvial aquifer at the site is contained in the NAPLs, this suggested three-phased approach has been incorporated into the development of remedial alternatives for alluvial groundwater and NAPLs. It is expected that any NAPL remedy will leave some product in the subsurface due to contaminant distribution, geologic heterogeneities, and technological limitations.

It is noted that certain limited action remedies were considered alone as a potential alternative, as well as being retained as a component of other alternatives. In general, deed or groundwater use restrictions and continued groundwater monitoring are included in each alternative that involves NAPL and/or groundwater treatment, even though they are not specifically called out in the name of the alternative.

4.2.1 Alluvial Groundwater/NAPL Alternative 1 – No Action

Under this alternative, no action would be taken to reduce the potential for unacceptable exposures of humans to impacted groundwater or minimize further aquifer degradation. This alternative is retained for comparison with the other alternatives as required by the NCP.

4.2.2 Alluvial Groundwater/NAPL Alternative 2 – Institutional Controls with Monitored Natural Attenuation

Alternative 2 includes deed restrictions for properties under the administrative control of CBS, institution of a municipal groundwater use restriction zone, and continued monitoring of groundwater in support of demonstrating the occurrence of natural attenuation.

For affected properties currently controlled by CBS, restrictions would be incorporated into the property deed which would limit future uses of groundwater on the property. For

properties not controlled by CBS, these restrictions could be implemented in the form of a municipal ordinance which prohibits the installation and use of a groundwater supply well in a designated portion of the community for specific uses. These restrictions would remain in place until monitoring results indicated that groundwater use in the area no longer posed an unacceptable risk to humans and the environment. A copy of a similar ordinance enacted by the Borough of Tamaqua, Pennsylvania on May 19, 1999 is included in Appendix B. Specific conditions of the ordinance would have to be carefully evaluated to ensure the protectiveness of the alternative.

The third component of this alternative is the natural degradation of COPCs in the aquifer by natural biological, chemical, and/or physical processes. Occasional groundwater monitoring would be performed to demonstrate that these natural processes are occurring, and that the selected remedy continues to be protective of human health and the environment. As part of the monitoring program, the installation of additional groundwater monitoring wells may be appropriate. Further assessment of groundwater quality in the bedrock aquifer would also be included in this alternation.

4.2.3 Alluvial Groundwater/NAPL Alternative 3 – NAPL Source Removal with Monitored Natural Attenuation for Groundwater

Alternative 3 includes the limited action components of Alternative 2 (institutional controls and monitored natural attenuation). In addition, one of several options would be employed for eliminating or reducing the extent of subsurface NAPLs, which are the primary source of COPCs in groundwater. NAPLs would either be removed from the subsurface for subsequent treatment and disposal or treated in situ. After source removal methods are completed to the extent practicable, residual COPCs in alluvial groundwater would be allowed to attenuate naturally. Additional assessment of bedrock groundwater quality would also be performed.

The primary focus of the NAPL source removal would be the vicinity of the former tank farm, where both LNAPLs and DNAPLs have been observed in monitoring wells (Figures 1-3 and 1-4).

LNAPL treatment/removal activities would mainly be located within the former tank farm area and immediately west thereof, onto the railroad property and a small portion of the Armco property near the MW-14 well cluster. Additional LNAPL removal activities

may also be performed in two other relatively small areas (at Monitoring Wells S-4 and M-2). Based on available NAPL measurement data, the estimated volume of LNAPL in the subsurface is approximately 60,000 gallons.

DNAPL treatment/removal activities would extend from the northern end of the former tank farm area to approximately the southern limits of the Middle Sector, and would include areas inside the former Westinghouse facility, the railroad property, and the southwest corner of the AK Steel property. Based on available NAPL measurement data, the estimated volume of DNAPL in the subsurface is approximately 600,000 to 1.2 million gallons.

For Alternative 3A (enhanced recovery), NAPLs would be recovered from the subsurface using one or more of several methods, with subsequent containerization and transportation to an appropriate off-site facility for treatment by incineration or other appropriate method. NAPL recovery from existing and newly installed recovery wells would be achieved by using specially designed low-volume product recovery pumps, or where recovery yields in the wells are insufficient for pumping, by using absorbent tubes such as those presently being used for the LNAPL removal action. Pilot tests would be performed initially to estimate well yields and evaluate direct pumping options. One option which may be evaluated would include a dual-well recovery system, where in addition to pumping DNAPL from the bottom of the well, groundwater would also be pumped from the well and reinjected into the aquifer, creating a mild gradient to the well which may enhance NAPL flow toward the well. Alternative 3A1 represents the first phase of a recovery remedy, with no enhancements being performed to improve NAPL recovery rates.

As the recovery rate of NAPLs via direct pumping declines, NAPL recovery may be enhanced by the injection of surfactants, isopropanol, or other appropriate solvent directly into the NAPLs, thereby reducing NAPL viscosity and improving the flow of the NAPLs toward the recovery wells (Alternative 3A2). NAPL recovery may also be enhanced through the use of electrical heating, where electrode borings are advanced to the target zones, and then a current is applied to heat the soil and NAPLs such that NAPL viscosity is reduced. On-site pilot testing would be performed to determine the most appropriate enhancement and recovery methods, as well as to determine the proper spacing for injection/recovery wells and/or electrode borings.

For Alternative 3B (in-situ biodegradation), NAPLs would be destroyed within the confines of the aquifer through the injection of a solution containing specialized microbes and nutrients which degrade the NAPL components, ultimately producing carbon dioxide and water. Because lab treatability testing indicates the microbes are not capable of degrading the undiluted NAPLs as found at the site, it would be necessary to create a homogenous mixture of NAPL and groundwater within the aquifer. This would be accomplished by collecting DNAPL at the bottom of the aquifer and pumping it to the top of the aquifer, allowing the DNAPL to filter back down through and mix with the aquifer, ultimately creating a homogenous mixture into which the microbes would be injected. On-site pilot testing would be performed to determine the most appropriate recovery methods and injection ratios, as well as to determine the proper spacing for collection and injection wells. It should be noted that by virtue of the aquifer mixing being performed, this process may also treat COPCs in groundwater within the NAPL area.

The preliminary objective of the NAPL removal or treatment process would be to reduce the volume of NAPLs which accumulate in the collection and monitoring wells to immeasurable levels. This objective may be refined based on the demonstrated performance of the remedy, the feasibility of achieving the objective, and the current state of technology. It is unlikely that any remedy could remove or destroy all NAPLs in the subsurface. Experience suggests that the maximum amount of NAPL which can be effectively removed from the subsurface, as required by either of these alternatives, is approximately 30 to 50 percent.

4.2.4 Alluvial Groundwater/NAPL Alternative 4 – NAPL Source Removal with Groundwater Extraction, Treatment and Discharge

Alternative 4 includes the (institutional controls, groundwater monitoring, and removal/treatment of subsurface NAPLs, as described for Alternative 3A. Either concurrently with or after the completion of source removal activities, impacted groundwater in non-NAPL portions of the South and/or Middle Sectors would be extracted, treated on site, and discharged to the Shenango River via an existing storm sewer under the requirements of an NPDES permit. Further assessment of the bedrock aquifer would be included in this alternative.

It is assumed for the purposes of this FS that because this alternative involves extraction and subsequent treatment of groundwater, the NAPL treatment/removal option selected would also involve extraction, as described for Alternative 3A. If deemed more appropriate, the NAPLs could be treated in situ, as described in Alternative 3B.

The lateral extent of the areas subject to groundwater extraction and treatment will be dependent on the cleanup goals determined for the aquifer. An additional factor is whether the remedial action would entail a "hot-spot" treatment where only the portions of the aquifer with the highest concentrations are treated and monitored natural attenuation is implemented for the remainder of the impacted aquifer, or if the selected remedy includes all portions of the aquifer where COPC concentrations exceed the applicable cleanup goal. For the purposes of this FS, extraction of groundwater would be limited to the portions of each of the three groundwater plumes with the highest COPC concentrations, with monitored natural attenuation implemented for the remaining impacted portions of the aquifer. The extent of the alluvial aquifer to be subject to extraction and treatment is initially assumed to extend roughly between Monitoring Wells M-17 and 05-1A, an area of approximately seven acres. Groundwater extraction and treatment for full aquifer restoration will not be considered, as this would involve extraction of very large volumes of water with relatively low concentrations of COPCs over a wide-spread area. Thus, the extraction and treatment of this additional groundwater would be extremely inefficient relative to the additional COPC mass treated, particularly in light of the institutional controls which are also part of this remedy.

Groundwater would be extracted from the alluvial aquifer via a series of 26 extraction wells generally placed along the railroad property approximately from the northern end of the former tank farm to the southern end of the former Y-Building. These wells would be located within or immediately downgradient of the portions of the aquifer with the highest COPC concentrations. Fourteen extraction wells would be installed at the South Sector, with average recovery rates of three gpm. Fourteen extraction wells would also be installed at the Middle Sector, with average recovery rates of seven gpm. For the purposes of this FS, it is assumed that groundwater would be pumped from the extraction wells to a single treatment facility located at the former tank farm area or a fenced-in area adjacent to Clark Street. Depending on the required scope of the extraction system,

current aquifer conditions, and other design and administrative concerns, it may be more appropriate and/or cost-effective to install separate extraction and treatment systems for the South and Middle Sectors if pump and treat is the selected remedy for both areas.

The extracted groundwater would be treated by a series of processes to address the COPCs as well as any other constituents which may require treatment to meet the limits of an NPDES permit. For the purposes of this FS, the assumed treatment system would, at a minimum, include oil/water separation, pre- and post-treatment solids filtration, and aqueous-phase carbon adsorption. Additional treatment of inorganics by ion-exchange may also be necessary, depending on influent characteristics and the requirements of the NPDES permit. Alternatively, treatment for organics could be accomplished using chemical oxidation with UV catalyst in place of carbon. For the assumed influent concentrations and flow rates (140 gpm), the carbon adsorption system would include two 10,000 pound carbon vessels (8-foot diameter by 13 feet tall) operating in series. Treatment system effluent would be discharged to the Shenango River via the Clark Street storm sewer under the requirements of an NPDES permit. If feasible and appropriate a portion of the effluent could be reinjected into the subsurface to assist in flushing COPCs from the aquifer. Oil which is separated from the groundwater would be containerized and transported to an off-site facility for subsequent treatment by incineration or other appropriate method.

4.2.5 Alluvial Groundwater/NAPL Alternative 5 – NAPL Source Removal with In-Situ Groundwater Treatment

Alternative 5 includes the institutional controls, groundwater monitoring, and insitu treatment of subsurface NAPLs, as described for Alternative 3B. Either concurrently or after the completion of source removal activities, impacted groundwater in non-NAPL portions of the South and/or Middle Sectors would also be subject to in-situ treatment. Additionally, current groundwater quality in the bedrock aquifer would be further assessed.

The lateral extent of the areas subject to in-situ treatment will be dependent on the cleanup goals determined for the aquifer. For the purposes of this FS, the extent of alluvial groundwater subject to in-situ treatment would be the same as that described in Section 4.2.4 for alternative 4.

It is assumed for purposes of this FS that because this alternative involves in-situ treatment of groundwater, the NAPL treatment/removal option selected would also be an in-situ method, as described for Alternative 3B. If deemed more appropriate, the NAPLs could be removed from the subsurface for subsequent incineration, as described in Alternative 3A.

In-situ groundwater treatment for "hot spot" treatment, as described above, will be evaluated as part of this alternative with monitored natural attenuation for the other impacted portions of the aquifer. In-situ treatment for full aquifer restoration will not be considered, as this would involve treatment over a wide-spread area. The in-situ treatment of these relatively low concentrations of COPCs away from the "hot spot" areas would be extremely inefficient when comparing the effort involved relative to the COPC mass destroyed, particularly in light of the institutional controls which are also part of this remedy.

For Alternative 5, treatment of COPCs in groundwater will be accomplished by in-situ enhanced biodegradation using hydrogen release or oxygen release compounds, which are injected into the subsurface to enhance the natural degradation of the COPCs. This process would be similar to the process used for in-situ biodegradation of NAPLs, as described for Alternative 3B. On-site pilot testing would be performed to determine the most appropriate recovery methods and injection ratios, as well as the proper spacing for injection wells. Alternatively, in-situ chemical oxidation could be used to address residual aqueous-phase COPCs.

No active remediation would be performed for impacted portions of the aquifer beyond the "hot-spot" treatment areas. Monitoring of these areas, in addition to the treated areas, would continue in order to demonstrate the occurrence of natural attenuation to address residual COPC concentrations.

5.0 DETAILED ANALYSIS OF ALTERNATIVES

5.1 CRITERIA USED FOR EVALUATION

In this section, the alternatives developed in Section 4.0 for Shenango River sediments and alluvial groundwater/NAPLs at the site are described and evaluated in detail. The detailed analysis of alternatives provides information to aid in the comparison among alternatives and the selection of the final recommended alternative. This analysis is performed in accordance with the USEPA RI/FS Guidance Document (USEPA, 1988) and the NCP, as revised by 55 Federal Register 8813 (March 8, 1990). In conformance with the NCP, the following nine criteria are used in the final analysis:

- Overall protection of human health and the environment;
- Compliance with ARARs;
- Long-term effectiveness and permanence;
- Reduction of mobility, toxicity, or volume by treatment;
- Short-term effectiveness;
- Implementability;
- Cost;
- State acceptance; and
- Community acceptance.

These criteria are described below, before performing the detailed analysis.

5.1.1 Overall Protection of Human Health and the Environment

The primary requirement that CERCLA remedial actions must meet is protectiveness. A remedy is protective if it adequately eliminates, reduces, or controls current and potential risks posed by each exposure pathway for COPC at the site. For those sites where hazardous substances remain such that unrestricted use and unlimited exposure is not allowable, engineering controls, institutional controls, or some combination of the two must be implemented to control exposure and thereby provide reliable protection over time. In addition, implementation of a remedy cannot result in unacceptable short-term risks to, or cross-media effects on, human health and the environment.

5.1.2 Compliance with ARARs

Evaluation of compliance with ARARs is one of the statutory requirements for remedy selection. Alternatives are developed and refined throughout the CERCLA process to verify that they will either meet their respective ARARs or that there is rationale for waiving an ARAR. During the detailed analysis, information on action-specific ARARs will be assembled along with previously identified chemical-specific and location-specific ARARs. Alternatives will be refined to verify compliance with these requirements or to begin to identify waivers that might be invoked. Tables 5-1 and 5-2 identify potential ARARs for each of the sediment and groundwater/NAPL alternatives, respectively.

5.1.3 Long-Term Effectiveness and Permanence

This criterion reflects CERCLA's emphasis on implementing remedies that will provide protection of human health and the environment in the future, as well as in the near term. In evaluating alternatives for their long-term effectiveness and the degree of permanence they afford, the analysis should focus on the residual risks that will remain at the site after the completion of the remedial action. This analysis should include consideration of the following:

- The degree of threat posed by COPC remaining at the site;
- The adequacy of any controls (e.g., engineering and institutional) used to manage the COPC remaining at the site;
- The reliability of the controls; and
- The potential impacts on human health and the environment should the remedy fail, based on the assumptions included in the reasonable maximum exposure scenario in the risk assessment.

This evaluation criterion incorporates the statutory requirements to take into account the following:

- Uncertainties associated with land disposal;
- Goals, objectives, and requirements of CERCLA and RCRA;

- Persistence, toxicity, mobility, and propensity for bioaccumulation of the COPC and their constituents;
- Long-term potential for adverse human health effects from exposure;
- Potential for future remedial action costs, if the remedy were to fail; and
- Potential threat to human health and the environment associated with redisposal or containment of the COPC.

5.1.4 Reduction of Mobility, Toxicity, or Volume

This evaluation criterion addresses the statutory preference for remedial actions which employ treatment technologies that significantly and permanently reduce the mobility, toxicity, or volume of the hazardous substances (USEPA, 1988). Factors to be considered may include the nature of the treatment and the materials that it can effectively treat; the amount of hazardous substances to be treated; the degree of respective reduction in toxicity, mobility, or volume; the degree of irreversibility; the type and quantity of residuals which will remain after treatment; the degree to which the quantity of residuals remain after treatment; and the degree to which the treatment reduces the hazards posed by principal threats at the site.

For this FS, reduction of mobility, toxicity, and volume refers to the affected medium overall, not merely with respect to the site. For example, if the impacted sediments were removed from the Shenango River and placed elsewhere, this could represent a reduction in volume and toxicity with regard to the river, but would not result in any change in toxicity or volume of the COPC in the medium. Thus, excavation does not in itself constitute a form of treatment.

A reduction in volume would result from treating the affected media such that a portion of the media is no longer above cleanup levels. A reduction in toxicity would result from a treatment which would result in a physical/chemical reaction to a COPC whereby the resultant product(s) of that reaction is less toxic than the original COPC. A reduction in mobility would result from a treatment of engineering control which would result in a physical or chemical change to the COPC to make it less mobile.

5.1.5 Short-Term Effectiveness

This criterion includes the short-term impacts of the alternatives (i.e., impacts of the implementation) on the neighboring community, remedial construction workers, and the surrounding environment. These include potential threats to human health and the environment associated with collection, handling, treatment, and transport of hazardous substances due to implementation of the remedy. The potential cross-media effects of the remedy and the time to achieve protection of human health and the environment are also assessed.

5.1.6 Implementability

Considerations with respect to the ability to implement the remedy include the technical and administrative feasibility of the alternatives, as well as the availability of the goods or services (e.g., treatment, storage, or disposal capacity) on which the viability of the alternative depends. Implementability considerations often affect the timing of various remedial alternatives (e.g., limitations on the season in which the remedy can be implemented, the number and complexity of material handling steps that must be followed, the need to obtain access and permits, and the need to secure technical services).

5.1.7 Cost

Cost encompasses the capital, construction, and operation and maintenance costs, including long-term monitoring costs, incurred over the life of the project (assumed to be 30 years), expressed as the net present value of these costs. A discount rate of 5 percent is used for costs incurred in the future. The feasibility study attempts to evaluate costs to within +50 percent and -30 percent of the actual costs (USEPA, 1988).

Direct capital costs include:

- Cost of materials, labor (including fringe benefits and workers' compensation), and equipment required to install the alternative;
- Short-term costs for treatment, containment, disposal, and/or service equipment necessary to implement the alternative;
- Site development costs; and

- Building and costs such as permanent process and non-process buildings and utility connections.

Indirect capital costs include:

- Costs for administration related to implementation of the alternative, including procurement of contractors;
- Costs for predesign work such as treatability studies and subsurface field investigations;
- Costs for design work and construction monitoring;
- Administrative and technical costs necessary to obtain licenses and permits for installation and operation;
- Startup and shakedown costs for collection, treatment, and disposal processes included in the alternative;
- Construction and engineering overhead and profit, and
- Contingency allowances which attempt to cover costs resulting from unforeseen circumstances such as adverse weather conditions, strikes, and inadequate facility characterization.

Operation and maintenance costs are post-construction costs necessary for the continued effectiveness of an alternative. Operation and maintenance costs can include:

- Operating labor costs (including wages, salaries, training, overhead, and fringe benefits);
- Maintenance materials and labor costs required for routine maintenance of facilities and equipment;
- Costs for auxiliary materials and energy such as chemicals and electricity for treatment plant operation;
- Costs for purchased services such as sampling and analysis;
- Disposal and treatment costs for waste materials generated during operations;

- Costs for administration of alternative operation and maintenance; and
- Contingency costs to cover unanticipated operation and maintenance costs.

5.1.8 State Acceptance

This criterion, which is an ongoing concern throughout the remedial process, reflects the statutory requirement to provide for substantial and meaningful state involvement. However, the state of Pennsylvania is the lead agency monitoring the performance of the RI/FS for this site. State comments are being addressed during the development of the FS, although formal state comments are typically received after the state has reviewed the draft RI/FS report and the draft Proposed Plan prior to the public comment period. The Proposed Plan that is issued for public comment along with the RI/FS report should indicate whether the state has commented on or concurred with the preferred alternative presented in these reports or whether the state's official comments have not yet been received. The ROD should specifically address state concurrence, or the lack thereof, with the response action that is selected, particularly noting state views on compliance or noncompliance with state ARARs. State acceptance will be documented in the ROD following the public comment period.

5.1.9 Community Acceptance

This criterion refers to the community's comments on the remedial alternatives under consideration, where "community" is broadly defined to include interested parties. These comments are taken into account throughout the RI/FS process through communications and public meetings which occur as the community relations plan is implemented. Again, community acceptance can only preliminarily be assessed during the development of the FS, because formal public comment will not be received until after the public comment period of the Proposed Plan and RI/FS is held. The detailed analysis, however, may summarize preliminary comments on components of the alternatives received up to that point. For the purposes of this FS, community acceptance will be evaluated in the ROD following the public comment period.

5.2 FUNCTIONS OF THE NINE EVALUATION CRITERIA

The nine evaluation criteria can be categorized into three groups, each with distinct functions in selecting the remedy. The first group consists of threshold criteria that must

be satisfied so that an alternative is eligible for selection, and includes overall protection of human health and the environment and compliance with ARARs (or invocation of waivers). The second group of evaluation criteria consists of the following primary balancing factors to weigh the tradeoffs between alternative strategies: long-term effectiveness and permanence; reduction of mobility, toxicity, or volume; short-term effectiveness; implementability; and cost. The third group of evaluation criteria, including state and community acceptance, are modifying considerations that are taken into account after public comment is received on the Proposed Plan and RI/FS reports. For the performance of this FS, the first two groups will be evaluated in detail, with the third group being evaluated during development of the ROD.

5.3 DETAILED ANALYSIS OF SHENANGO RIVER SEDIMENT ALTERNATIVES

This section provides the detailed analysis for each Shenango River sediment alternative developed in Section 4.1. Detailed cost estimates were generated for each alternative, and are included in Appendix C. Table 5-3 summarizes the costs associated with each of these remediation alternatives. The cost estimates encompass the capital, construction, and long-term maintenance costs incurred over the life of the remedy (30 years) expressed as the net present value of these costs.

As previously discussed, the HHRA determined that calculated risks for human receptors exposed to sediments in the Shenango River under the assumed exposure scenario (child wader) were within the acceptable range established by the NCP. The screening level ERA indicated that the sediments did pose a potential risk to ecological receptors. Additional potential concerns include consumption of fish and swimming in the immediate vicinity of the Clark Street outfall. The primary COPCs for Shenango River sediments and related soils, based on ecological concerns, are PCBs and zinc, with other inorganic constituents contributing minimally to the total ecological risk. Although PCBs are the only sediment COPCs which are associated with industrial activities at the former Westinghouse facility, it is noted that actions which address sediments with the highest PCB concentrations would also address sediments with the highest concentrations of other COPCs, as described in Section 4.1.

The remedial action objective for Shenango River sediments is to reduce the exposure of ecological receptors to impacted media. In Section 4.1, the following medium-specific remedial alternatives were developed to meet this objective:

- Shenango River Sediment Alternative 1 – No Action;
- Shenango River Sediment Alternative 2 – Limited Action/Natural Recovery;
- Shenango River Sediment Alternative 3 –Cover; and
- Shenango River Sediment Alternative 4 – Excavate and Treat/Dispose Off Site.

Table 5-4 provides a summary of the detailed analysis for each alternative.

5.3.1 Shenango River Sediment Alternative 1 – No Action

The no-action alternative for Shenango River sediment and riparian soils is retained as a baseline for comparison with other alternatives. As part of this alternative, five-year reviews would be conducted as required by SARA Section 121(c), but no remedial action would be performed at the site. Existing sediments and riparian soils would remain in place. Additionally, no action would be taken to address storm sewer sediments. No shut down of the drinking water intake for the Shenango Valley Water Authority would be required.

Overall Protection of Human Health and the Environment: Under the no-action alternative, no remedial action would be taken to address impacted sediments. According to the HHRA, there is no current unacceptable direct threat to human health caused by exposure to these sediments. However, impacted sediments to pose a potential threat to ecological receptors, based on the screening level ERA, allowing the potential bioaccumulation of COPCs which may in turn expose humans to COPCs via fish consumption, although this exposure is somewhat controlled institutionally by a consumption advisory. Consequently, this no-action alternative would not be protective of the environment under existing conditions. In addition, any disturbance of the impacted sediment may cause the resuspension of the sediment, thereby potentially exposing downstream receptors.

Compliance With ARARs: For a very small portion of the river where total PCB concentrations in the sediment exceed 50 mg/kg, this alternative might not comply with TSCA regulations regarding the cleanup and/or disposal of PCBs. No other ARARs have been identified related to the cleanup of impacted river sediments for ecological concerns.

Long-Term Effectiveness and Permanence: The no-action alternative does not directly address remediation of the river sediments, however, natural biological, chemical, and physical processes may gradually reduce concentrations of certain substances. In addition, natural resedimentation processes may gradually provide a cover of clean sediment over the impacted sediments.

Reduction of Mobility, Toxicity, or Volume: The no-action alternative would not reduce the mobility, toxicity, or volume of COPC. However, natural biological, chemical, and physical processes may gradually reduce concentrations of certain substances.

Short-Term Effectiveness: This alternative would not change current site conditions. Ecological risks associated with river sediments would remain, although risks associated with remedy implementation would not be incurred. Shut down of the water intake for the Shenango Valley Water Authority would not be required.

Implementability: An evaluation of the implementability of the no-action alternative is not applicable, as no action is taken.

Cost: The no-action alternative has no capital costs over the 30-year project life, and would incur only costs related to the five-year reviews required by the NCP, estimated to have a net present value of $58,000, as detailed in Appendix C.

5.3.2 Shenango River Sediment Alternative 2 – Limited Action/Natural Recovery

Alternative 2 for Shenango River sediments includes the continuation of the existing fish consumption advisory, along with natural resedimentation and attenuation processes to reduce the potential exposure of ecological receptors. Routine biennial monitoring of sediment quality and fish tissue would be performed to assess the effectiveness of this alternative. Existing sediments and riparian soils would remain in place. Additionally, no action would be taken to address storm sewer sediments.

Overall Protection of Human Health and the Environment: According to the HHRA, there is no current unacceptable direct threat do human health caused by exposure to these sediments. However, impacted sediments to pose a potential threat to ecological receptors, based on the screening level ERA, allowing the potential bioaccumulation of COPCs. Under this alternative, impacted sediments would be covered over time by natural resedimentation processes, and COPC concentrations may reduce over time due to natural attenuation processes. These processes would thus eventually reduce potential exposures of ecological receptors to impacted sediments. Continuation of the fish consumption advisories would control potential risks to human health related to fish consumption. Disturbance of impacted sediment may cause the resuspension of the sediment into the surface water, thereby potentially exposing downstream receptors.

Compliance With ARARs: For a very small portion of the river where total PCB concentrations in the sediment exceed 50 mg/kg, this alternative might not comply with TSCA regulations regarding the cleanup and/or disposal of PCBs. No other potential chemical-specific ARARs have been identified relative to this alternative.

Long-Term Effectiveness and Permanence: This alternative addresses remediation of the river sediments and reduction of potential ecological risks through long-term natural biological, chemical, and physical processes which may gradually reduce concentrations of certain substances or provide a cover over impacted sediments.

Reduction of Mobility, Toxicity, or Volume: This alternative would not directly reduce the mobility, toxicity, or volume of COPC. However, over time resedimentation processes would reduce the mobility of the COPC, and natural biological, chemical, and physical processes may gradually reduce concentrations of certain substances.

Short-Term Effectiveness: In the short term, this alternative would not change current site conditions. Ecological risks associated with river sediments would remain, although risks associated with an excavation or capping remedy would not be incurred. Shut down of the water intake for the Shenango Valley Water Authority would not be required. The fish consumption advisory would be an effective short-term remedy to mitigate potential risks to human health related to fish consumption.

Implementability: The various components of this alternative are readily implementable. Frequency of fish tissue and sediment quality monitoring activities would likely be on a biennial basis.

Cost: This limited action alternative would have minimal capital costs, and the long-term net present value would be approximately $667,000, as detailed in Appendix C.

5.3.3 Shenango River Sediment Alternative 3 – Cover

Under this alternative, portions of the Shenango River where sediments and riparian soils exceed the cleanup goals would be covered by a minimum of 12 inches of granular fill or other appropriate cover material, in order to limit the bioavailability of impacted sediments. Routine monitoring would be performed to inspect the cover for signs of erosion. Additionally, significant accumulations of impacted sediment in the storm sewers leading from the site, if detected, would be removed and properly disposed of off site. No action would be taken to remove impacted sediments and riparian soils from the river corridor. During construction, monitoring of the intake for the Shenango Valley Water Authority will be performed, and if necessary the intake may be shut down during construction hours.

Overall Protection of Human Health and the Environment: As stated previously, there is no current unacceptable direct threat to human health posed by impacted sediments. Installation of a cover over impacted sediments may present a short-term risk to human health due to the possible resuspension of sediment into the surface water, as a public water intake is located in the immediate vicinity of some areas with impacted sediment (Area 14). Proper design, installation, and maintenance of the cover would effectively reduce the potential for ecological exposure to impacted sediments by reducing the bioavailability of COPCs in the sediment. This would in turn reduce concentrations of COPCs in fish over time, reducing the potential risk to humans associated with fish consumption.

Compliance With ARARs: By providing a cover over sediments with total PCB concentrations exceeding 50 mg/kg, this alternative may comply with TSCA regulations. Due to the potential disturbance and resuspension of sediment associated with this alternative, precautions may be necessary to comply with the CWA, SDWA, and Pennsylvania Clean Streams Law.

Long-Term Effectiveness and Permanence: If the cover material is designed appropriately for the prevention of erosion and scouring, this alternative could be an effective long-term remedy for reducing the potential exposure of ecological receptors to impacted sediments.

Reduction of Mobility, Toxicity, or Volume: Installation of a cover is not a treatment method, and toxicity and volume of COPCs would not be reduced. Mobility of the COPCs would be substantially reduced by a properly designed and installed cover system. Natural biological, chemical, and physical processes may gradually reduce concentrations of certain substances in the sediments.

Short-Term Effectiveness: Installation of the cover may result in the temporary resuspension of impacted sediment, which could pose a short-term potential risk to human health due to the water company intake at Area 14, as well as to ecological receptors. Shut down of the Shenango Valley Water Authority intake during construction hours may be necessary.

Implementability: Installation of a cover would be readily implementable at Area 15 and along the western bank at Area 14. Installing a cover along the eastern bank of Area 14 would be more difficult, due to the steepness and dense vegetation along this bank. Regular inspections would be required to verify continued integrity of the riprap cover. Access agreements may be required for work on properties adjacent to the river. On-site construction activities would take one to two months, following four to six months of design and bid solicitation. The feasibility of shutting down the water authority intake during the construction period would also need to be assessed.

Cost: The estimated net present worth of installing a cover at Areas 14 and 15, including long-term maintenance and inspections, is $880,000, as detailed in Appendix C. Note that this does not include costs associated with protecting the public drinking water supply during implementation.

5.3.4 Shenango River Sediment Alternative 4 – Excavate and Treat/Dispose Off Site

Under this alternative, sediments and riparian soils along the Shenango River corridor in Areas 14 and 15 which exceed the respective cleanup goals would be excavated and transported to an appropriate off-site facility for subsequent treatment and/or disposal. Under Alternative 4A, a maximum of twelve inches of impacted sediments and riparian soils would be excavated. For Alternative 4B, up to four feet of impacted sediments and riparian soils would be excavated.

Excavation would be performed by conventional equipment in Area 15 and by dredging in Area 14. This alternative would also include temporary barriers to isolate the areas being excavated, dewatering of the excavation areas, temporary rerouting of the Clark Street storm sewer discharge, and backfilling of the excavated areas with twelve to 48 inches clean fill or other appropriate material to reestablish pre-excavation channel profiles. Additionally, significant accumulations of impacted sediment in the storm sewers leading from the site, if detected, would be removed and properly disposed of off site. The intake for the Shenango Valley Water Authority would be monitored during construction activities and may be shut down during construction hours, if necessary.

Overall Protection of Human Health and the Environment: There is no current unacceptable direct threat to human health posed by impacted sediments. Excavation of impacted sediments and riparian soils may present a short-term unacceptable risk to human health due to the possible resuspension of sediment into the surface water used for public consumption, particularly at Area 14. The use of temporary barriers such as sheet piling may minimize this threat, but even the installation of such barriers could cause resuspension of sediment. Excavation of impacted sediments and replacement with clean fill or riprap would effectively reduce the potential for the unacceptable exposure of ecological receptors. This would in turn reduce concentrations of COPCs in fish over time, thereby reducing the potential risk to humans from fish consumption.

Compliance With ARARs: By removing and properly disposing of sediments with total PCB concentrations exceeding 50 mg/kg, this alternative may comply with TSCA regulations. Due to the disturbance and potential resuspension of sediment, precautions

may be necessary to comply with the CWA, SDWA, and Pennsylvania Clean Streams Law. Disposal of removed sediment at an appropriate off-site facility may be needed to comply with various solid, residual, and/or hazardous waste management regulations.

Long-Term Effectiveness and Permanence: Under Alternative 4B, it is anticipated that a substantial portion of the total site-related COPC mass would be removed from the river, thereby providing a potentially effective and permanent remedy. For Alternative 4A, if the backfill material used to replace the excavated materials is designed appropriately for the prevention of erosion and scouring, this alternative could be an effective long-term remedy for reducing the potential exposure of ecological receptors to impacted sediments. The ability to meet sediment cleanup goals by dredging, as would likely be required at Area 14, has not been demonstrated on a consistent basis at other sites.

Reduction of Mobility, Toxicity, or Volume: Because of the relatively low concentrations of COPCs relative to TSCA and RCRA standards, treatment of excavated materials would likely not be required, and therefore the toxicity and volume of COPCs would not be reduced. Mobility of the COPCs in terms of long-term potential exposure of ecological receptors would be reduced by the removal of the impacted sediments from the river corridor, although mobility may increase in the short term.

Short-Term Effectiveness: As described above, excavation of impacted sediments and/or the installation of temporary siltation controls could result in a substantial increase in risk to human health, due to the presence of a public water supply intake at Area 14. The new intake is located directly across the river (approximately 150 feet wide) from the area where the highest total PCB concentrations have been detected within the subject area. The water intake may need to be shut down during construction hours. This alternative would also pose a temporary increase in potential risk to ecological receptors.

Implementability: Implementation of an excavation alternative would be moderately difficult at Area 15 and along the western bank of Area 14, and would be very difficult along the eastern bank of Area 14. Obstacles to implementation include physical access to the river for equipment, staging and dewatering of excavated materials, and performing the work in a manner which will not result in the introduction of PCBs into the public water supply system. Access agreements may be required for work on properties adjacent

to the river, potentially including the use of a substantial portion of the Sharon Tube Company property. On-site construction activities would take four to six months, following six to nine months of design and bid solicitation. The feasibility of shutting down the Shenango Valley Water Authority intake needs to be addressed.

Cost: The estimated net present worth of excavating impacted sediments at Areas 14 and 15, as described herein, is $1,840,000 for Alternative 4A, and $3,030,000 for Alternative 4B. Detailed cost estimates are provided in Appendix C. Note that this does not include costs associated with protecting the public drinking water supply during implementation.

5.4 DETAILED ANALYSIS OF GROUNDWATER/NAPL ALTERNATIVES

This section provides the detailed analysis for each of the remedial alternatives developed in Section 4.2 for addressing groundwater and NAPLs at the site. Detailed cost estimates are provided in Appendix C and are summarized in Table 5-5.

The remedial action objectives for groundwater and NAPLs at the site are to reduce the likelihood of unacceptable human exposures, reduce the potential for further aquifer degradation, and improve aquifer quality to the extent practicable. In Section 4.2, the following medium-specific remedial alternatives were developed to meet these objectives.

- Alluvial Groundwater/NAPL Alternative 1 – No Action;
- Alluvial Groundwater/NAPL Alternative 2 – Institutional Controls with Monitored Natural Attenuation;
- Alluvial Groundwater/NAPL Alternative 3 – NAPL Source Removal with Monitored Natural Attenuation for Groundwater;
- Alluvial Groundwater/NAPL Alternative 4 – NAPL Source Removal with Groundwater Extraction, Treatment and Discharge; and
- Alluvial Groundwater/NAPL Alternative 5 – NAPL Source Removal with In-Situ Groundwater Treatment.

The institutional controls of Alluvial Groundwater/NAPL Alternative 2 would be included in each of the subsequent alternatives. Table 5-6 provides a summary of the detailed analysis for these alternatives.

5.4.1 Alluvial Groundwater/NAPL Alternative 1 – No Action

As part of this alternative, five-year reviews would be conducted as required by SARA Section 121(c) if any remedial action is performed at the site. No action would be taken to control the migration of COPCs in groundwater, to prevent exposure of humans to impacted groundwater and NAPLs, or to reduce the concentrations of COPCs in the aquifer. There would be no attempt to institute restrictions on the use of groundwater either on site or off site, nor would routine monitoring of groundwater quality be performed.

Overall Protection of Human Health and the Environment: Health risks posed by current and reasonably anticipated future land use in the vicinity of the site are not expected to be significant due to the lack of exposure to the groundwater and the presence of a public water supply system throughout the subject area. However, the HHRA determined that hypothetical future uses of impacted groundwater from both the Middle and South Sectors resulted in an unacceptable risk to human receptors. No institutional controls would be in place to prevent the use of groundwater in such a manner. The no-action alternative would not alleviate potential risks to human health or the environment posed by contact with impacted groundwater and/or NAPLs, nor would it eliminate potential impacts to surface water, although such impacts do not appear to be occurring. Natural processes such as dispersion and degradation may gradually reduce COPC concentrations in the aqueous phase downgradient of the site, as may be indicated by recent groundwater sampling data, however no monitoring would be performed to confirm this reduction. DNAPLs may gradually migrate vertically to the bedrock aquifer.

Compliance With ARARs: The no-action alternative does not comply with chemical-specific ARARs.

Long-Term Effectiveness and Permanence: The no-action alternative does not directly address remediation of alluvial groundwater and NAPLs, however, natural biological, chemical, and physical processes may continue to gradually reduce concentrations of certain substances downgradient of the site.

Reduction of Mobility, Toxicity, or Volume: The no-action alternative would not reduce the mobility, toxicity, or volume of COPCs in the alluvial aquifer. However, natural biological, chemical, and physical processes may continue to gradually reduce concentrations of certain substances.

Short-Term Effectiveness: This alternative would not change current site conditions. Risks associated with the hypothetical direct contact with groundwater would remain, although risks associated with remedy implementation would not be incurred. The availability of a public water supply throughout the effected area reduces likelihood that the hypothetical exposures will take place in the short term.

Implementability: An evaluation of the implementability of the no-action alternative is not applicable, as no action is taken.

Cost: The no-action alternative has no capital costs over the 30-year project life, and would incur only costs related to the five-year reviews required by the NCP.

5.4.2 Alluvial Groundwater/NAPL Alternative 2 – Institutional Controls with Monitored Natural Attenuation

Alternative 2 for alluvial groundwater and NAPLs includes the implementation of deed restrictions for properties under the administrative control of CBS, a municipal ordinance restricting the use of groundwater within a designated area, and monitoring of groundwater conditions in support of demonstrating the occurrence of natural attenuation of COPCs in the aquifer. This alternative does not include the active extraction or treatment of COPCs present in the aquifer.

Overall Protection of Human Health and the Environment: Health risks posed by current and reasonably anticipated future land use in the vicinity of the site are not expected to be significant, however, the HHRA determined that hypothetical future uses of impacted groundwater resulted in an unacceptable risk to human receptors. This alternative would prevent these risks, especially in consideration of the existing public water supply. Individual property and municipal restrictions on the use of groundwater would help provide a level of assurance that human receptors are not being exposed to impacted groundwater. Natural processes such as dispersion and degradation may gradually reduce COPC concentrations in the aqueous phase downgradient of the site. Groundwater sampling performed at the site in 1999 indicated that natural attenuation processes are occurring at portions of the site.

Occasional monitoring of groundwater quality, potentially including analytical parameters associated with natural attenuation processes, would be performed to confirm that groundwater quality downgradient of the source areas is improving. It is not likely that groundwater quality within areas where NAPLs are present (western Middle Sector) will improve significantly under this alternative. DNAPLs may gradually migrate vertically to the bedrock aquifer.

Compliance With ARARs: By providing institutional controls restricting the use of groundwater and thereby eliminating the exposure pathway, compliance with certain ARARs may be achieved. Downgradient of the site, natural attenuation processes may eventually reduce COPC concentrations to levels which meet certain chemical-specific ARARs. In the short-term and in the vicinity of the source areas, this alternative would not comply with ARARs, nor would it comply with the state groundwater quality protection strategy.

Long-Term Effectiveness and Permanence: If complied with, groundwater use restrictions in combination with the existing reliable supply of public water available throughout the area would effectively prevent unacceptable human exposure to impacted groundwater. As the source areas would not be remediated by this alternative, it is likely that the use restrictions would be required to remain in effect for a substantial duration, particularly at and immediately downgradient of the Middle Sector where NAPLs are present.

Reduction of Mobility, Toxicity, or Volume: Implementation of institutional controls would not reduce the mobility, toxicity, or volume of COPC. However, natural biological, chemical, and physical processes may continue to gradually reduce concentrations of certain substances.

Short-Term Effectiveness: The implementation of this alternative would entail minimal risk of human exposure to COPCs in groundwater, with the greatest contribution to this risk resulting from occasional groundwater sampling and the installation of additional monitoring wells as needed.

Implementability: Deed restrictions could be readily implemented for the portions of the site owned by CBS. Preliminary discussions with the City of Sharon indicate the City's general approval of implementing a groundwater use restriction ordinance, however such

a measure must be discussed with the general public (including potentially affected industrial property owners) and approved by the City Council. Groundwater monitoring services, including well installation, are readily available. Frequency of monitoring would likely begin as quarterly and would eventually be reduced to annually or less frequent.

Cost: Capital costs for implementing this alternative would consist primarily of legal, filing fees and associated costs. Long-term costs associated with continued monitoring of groundwater conditions are dependent on the sampling frequency and parameter list. The estimated net present worth is $2,150,000, as detailed in Appendix C.

5.4.3 Alluvial Groundwater/NAPL Alternative 3 – NAPL Source Removal with Monitored Natural Attenuation for Groundwater

This alternative includes the removal of NAPLs from the subsurface using one or more of several options. For Alternative 3A, direct and/or enhanced recovery methods, potentially including dual-well systems, solvent flushing, or electrical heating along with pumping or passive absorption of product, would be implemented to collect NAPLs for appropriate off-site treatment and disposal. For Alternative 3B, an in-situ treatment method such as enhanced biodegradation would be used to destroy the NAPL constituents in the ground. The groundwater use restrictions and continued monitoring of groundwater for natural attenuation of residual COPCs, as described for Alternative 2, would also be included in each of these alternatives.

Overall Protection of Human Health and the Environment: Health risks posed by current and reasonably anticipated future land use in the vicinity of the site are not expected to be significant, however, the HHRA determined that hypothetical future uses of impacted groundwater resulted in an unacceptable risk to human receptors. Groundwater use restrictions would help provide a level of assurance that human receptors are not being exposed to impacted groundwater, and natural processes may gradually reduce COPC concentrations in the aqueous phase downgradient of the site, to be confirmed by occasional monitoring of groundwater quality. By removing or reducing the mass of NAPLs present in the alluvial aquifer, a significant source of PCBs and chlorinated benzenes would be addressed, thereby resulting in an expected improvement of groundwater quality in and immediately downgradient of the Middle Sector in the long term. Reducing or eliminating the mass of DNAPL would also lessen the likelihood that

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the DNAPL would gradually migrate vertically to the bedrock aquifer. Alternative 3B involves thoroughly mixing NAPLs into the aqueous phase, thereby substantially increasing aqueous-phase COPC concentrations, at least in the short term, within the NAPL areas.

Compliance With ARARs: By providing institutional controls restricting the use of groundwater and thereby eliminating the exposure pathway, compliance with certain ARARs may be achieved. Downgradient of the site, natural attenuation processes may eventually reduce COPC concentrations to levels which meet certain chemical-specific ARARs. In the vicinity of the source areas, removal or reduction of NAPL mass may provide ultimate compliance with ARARs over a greater area than if NAPL treatment or removal were not performed. Collected NAPLs (Alternative 3A) would likely require off-site incineration to achieve compliance with TSCA requirements.

Long-Term Effectiveness and Permanence: If complied with, groundwater use restrictions in combination with the existing public water supply would effectively prevent unacceptable human exposure to impacted groundwater. Due to the substantial volume of NAPL mass present in the subsurface, it is unlikely that any enhanced recovery method or in-situ treatment method would effectively remove all COPCs from the subsurface. However, once the NAPLs are removed from the subsurface (Alternative 3A) or destroyed within the aquifer (Alternative 3B), the process is permanent with respect to the NAPLs removed or destroyed. The effectiveness of both of these alternatives is directly related to the ability to draw the NAPLs to the collection points. Bench-scale testing with site NAPLs has indicated that solvent flushing and electrical heating both significantly reduce NAPL viscosity, which could aid in the collection of NAPLs. Incineration is a proven destruction method for the site COPCs. Enhanced biodegradation is an innovative treatment method which has been bench-tested on site NAPLs with modest success. Residual NAPLs may continue to impact groundwater, so it is likely that the use restrictions would be required to remain in effect for a substantial duration, particularly at and immediately downgradient of the Middle Sector.

Reduction of Mobility, Toxicity, or Volume: The nature of the enhanced recovery or treatment methods is to temporarily increase the mobility of the NAPLs, therefore allowing them to be collected and/or treated with greater ease. This is particularly true for Alternative 3B, whereby the NAPLs are thoroughly mixed with groundwater within

the aquifer. Alternative 3A would include incineration of collected NAPLs, and would therefore in the long term reduce the toxicity of the COPC mass associated with the NAPLs. Likewise, Alternative 3B ultimately reduces the toxicity of the COPC mass through degradation of the constituents to water and carbon dioxide. For COPCs in the aqueous phase, natural biological, chemical, and physical processes may continue to gradually reduce concentrations.

Short-Term Effectiveness: Implementation of Alternative 3A would result in moderate short-term risks to human health associated with the installation of injection wells, electrode borings, and/or collection wells, as well as with the handling of collected NAPLs. These risks can be managed using appropriate health and safety provisions. The solvent used for flushing, if selected, would be a non-toxic substance. For Alternative 3B short-term implementation risks would be slightly less, as NAPLs would not be brought to the surface. Minimal additional risks would be incurred during groundwater monitoring activities.

Implementability: Services are readily available to perform either of these alternatives. Access agreements would be required since a portion of the NAPL mass is located outside the CBS property. The presence of a lightly used railroad line and an active pipe manufacturing plant off property may make complete implementation of a NAPL source removal method more difficult. Each of the alternatives would require performance of a six-month pilot test and method evaluation prior to full-scale implementation. For Alternative 3A, it is anticipated that enhanced removal methods would become increasingly less cost effective (in terms of volume of NAPL removed per dollar spent) after the first three to five years. The in-situ treatment method (Alternative 3B) would likewise be completed to a point of diminishing returns within three to five years. Complete NAPL removal or treatment would likely require decades.

Cost: The estimated net present worth of Alternative 3A1 (direct recovery) is $5,970,000, and for Alternative 3A2 (direct and enhanced recovery) is $9,860,000. The estimated net present worth of Alternative 3B (in-situ treatment) is $10,500,000. Detailed cost estimates are provided in Appendix C.

5.4.4 Alluvial Groundwater/NAPL Alternative 4 – NAPL Source Removal with Groundwater Extraction and Treatment

This alternative includes the removal of NAPLs from the subsurface using enhanced recovery methods described in Alternative 3A. In addition, impacted groundwater from non-NAPL areas in the South and/or Middle Sectors would be extracted and pumped to a new on-site facility for treatment by aqueous-phase carbon adsorption and ultimate discharge to the Shenango River. The groundwater use restrictions and continued monitoring of groundwater for natural attenuation of residual COPCs, as described for Alternative 2, would also be included in this alternative.

Overall Protection of Human Health and the Environment: Health risks posed by current and reasonably anticipated future land use in the vicinity of the site are not expected to be significant, however, the HHRA determined that hypothetical future uses of impacted groundwater resulted in an unacceptable risk to human receptors. By removing or reducing the mass of NAPLs present in the alluvial aquifer, a significant source of groundwater COPCs would be addressed, and the likelihood that the DNAPL would gradually migrate vertically to the bedrock aquifer would be lessened. Extraction of impacted groundwater would reduce the volume of COPCs migrating downgradient of the site. Groundwater use restrictions would further help prevent human exposure to impacted groundwater, and natural processes may gradually reduce residual COPC concentrations (and associated risk) in the aqueous phase downgradient of the groundwater extraction areas.

Compliance With ARARs: By providing institutional controls restricting the use of groundwater and thereby eliminating the exposure pathway, compliance with certain ARARs may be achieved. Treatment of extracted groundwater would be expected to meet chemical-specific ARARs. Downgradient of the extraction areas, natural attenuation processes may eventually reduce residual COPC concentrations to levels which meet certain chemical-specific ARARs. In the vicinity of the source areas, removal or reduction of NAPL mass may provide ultimate compliance with ARARs over a greater area than if NAPL removal were not performed. Collected NAPLs would likely require off-site incineration to achieve compliance with TSCA requirements.

Long-Term Effectiveness and Permanence: If complied with, groundwater use restrictions in combination with the existing public water supply would effectively prevent unacceptable human exposure to impacted groundwater. It is unlikely that NAPL recovery and groundwater extraction would effectively remove all COPCs from the subsurface, however the reduction of NAPL mass and extraction/treatment of the most impacted groundwater would effectively reduce COPC concentrations through much of the subject area. Once the NAPLs and impacted groundwater are recovered from the subsurface and treated, the process is permanent with respect to removal of COPC mass from the aquifer. COPCs in the collected NAPL would be destroyed by off-site incineration, while COPCs in extracted groundwater would be captured within the treatment system media, requiring subsequent appropriate management of treatment system residuals. Activated carbon is a proven method for removing site COPCs from extracted groundwater. It is likely that the use restrictions would be required to remain in effect for a substantial duration, particularly at and immediately downgradient of the Middle Sector.

Reduction of Mobility, Toxicity, or Volume: Although the enhanced NAPL recovery methods may temporarily increase the mobility of the NAPLs, the extraction of groundwater within or immediately downgradient of the NAPL areas will minimize the horizontal migration of NAPL constituents. Collected NAPLs would be incinerated, thereby reducing the toxicity of the COPCs in the NAPLs. COPCs in extracted groundwater would be transferred to a different media (filters or activated carbon) which would require subsequent appropriate management. For residual COPCs in the aquifer, natural biological, chemical, and physical processes may continue to gradually reduce concentrations.

Short-Term Effectiveness: Implementation of this alternative would result in moderate short-term risks to human health associated with the installation of injection wells, electrode borings, and/or collection/extraction wells, as well as with the handling of collected NAPLs and groundwater. These risks can be managed using appropriate health and safety provisions. Minimal additional risks would be incurred during groundwater monitoring activities.

Implementability: Services are readily available to perform the activities included in this alternative. Access agreements would be required since a portion of the NAPL mass and impacted groundwater is not located on CBS property. An NPDES permit would have to be obtained for discharge of effluent to the Shenango River. The presence of a lightly used railroad line and active industrial facilities off property may make full-scale implementation of NAPL source removal and groundwater extraction more difficult. The time frame for NAPL removal activities is described in Section 5.4.3. Design and bid solicitation for the groundwater extraction and treatment system would require six to nine months, with system construction, testing, and startup taking an additional three to five months. Complete NAPL removal or treatment and restoration of aquifer quality, particularly in the Middle Sector, would likely require decades.

Cost: The estimated net present worth of Alternative 4 is $17,300,000, including estimated costs associated with NAPL enhanced recovery activities. Detailed cost estimates are provided in Appendix C.

5.4.5 Alluvial Groundwater/NAPL Alternative 5 – NAPL Source Removal with In-Situ Groundwater Treatment

This alternative includes the in-situ treatment of NAPLs within the aquifer as described for Alternative 3B. In addition, impacted groundwater from non-NAPL areas in the South and/or Middle Sectors would also be subject to in-situ treatment via enhanced biodegradation methods. The groundwater use restrictions and continued monitoring of groundwater for natural attenuation of residual COPCs, as described for Alternative 2, would also be included in this alternative.

Overall Protection of Human Health and the Environment: Health risks posed by current and reasonably anticipated future land use in the vicinity of the site are not expected to be significant, however, the HHRA determined that hypothetical future uses of impacted groundwater resulted in an unacceptable risk to human receptors. By treating the mass of NAPLs present in the alluvial aquifer, a significant source of groundwater COPCs would be addressed, and the likelihood that the DNAPL would gradually migrate vertically to the bedrock aquifer would be lessened. Additional in-situ treatment of impacted groundwater would also reduce the volume of COPCs migrating downgradient of the site. Groundwater

use restrictions would further help prevent human exposure to impacted groundwater, and natural processes may gradually reduce residual COPC concentrations (and associated risk) in the aqueous phase downgradient of in-situ treatment areas.

Compliance With ARARs: By providing institutional controls restricting the use of groundwater and thereby eliminating the exposure pathway, compliance with certain ARARs may be achieved. In-situ treatment of impacted groundwater may meet chemical-specific ARARs in some areas, but is unlikely to meet these ARARs in areas where NAPLs are present. Downgradient of the in-situ treatment areas, natural attenuation processes may eventually reduce residual COPC concentrations to levels which meet certain chemical-specific ARARs. In the vicinity of the source areas, reduction of NAPL mass may provide ultimate compliance with ARARs over a greater area than if NAPL treatment were not performed.

Long-Term Effectiveness and Permanence: If complied with, groundwater use restrictions in combination with the existing public water supply would effectively prevent unacceptable human exposure to impacted groundwater. It is unlikely that in-situ treatment of NAPLs and groundwater would effectively remove all COPCs from the subsurface, however the reduction of NAPL mass and treatment of the most impacted groundwater would effectively reduce COPC concentrations through much of the subject area. The in-situ enhanced biodegradation process, an innovative treatment technique with some bench-scale success demonstrated on site NAPLs, is permanent. It is likely that the use restrictions would be required to remain in effect for a substantial duration, particularly at and immediately downgradient of the Middle Sector.

Reduction of Mobility, Toxicity, or Volume: The enhanced biodegradation process for NAPLs may temporarily increase the mobility of COPCs in the NAPLs. COPCs in the treated NAPLs and groundwater would be destroyed, thereby reducing COPC toxicity. For residual COPCs in untreated portions of the aquifer, natural biological, chemical, and physical processes may continue to gradually reduce concentrations.

Short-Term Effectiveness: Implementation of this alternative would result in low to moderate short-term risks to human health associated with the installation of injection wells and/or collection wells, as well as with the handling of biological substrate being injected. These risks can be managed using appropriate health and safety provisions. Minimal additional risks would be incurred during groundwater monitoring activities.

Implementability: Services are available to perform the activities included in this alternative. Access agreements would be required since a portion of the NAPL mass and impacted groundwater is not located on CBS property. The presence of a lightly used railroad line and active industrial facilities off property may make full-scale implementation of NAPL and groundwater treatment more difficult. The time frame for NAPL treatment activities is described in Section 5.4.3. It is anticipated that in-situ treatment of groundwater would require a similar to slightly longer period of time, due to the greater extent of impacted groundwater. Complete NAPL treatment and restoration of aquifer quality would likely require decades.

Cost: The estimated net present worth of Alternative 5 is $12,000,000, including estimated costs associated with in-situ NAPL treatment. Detailed cost estimates are provided in Appendix C.

6.0 SUMMARY OF ALTERNATIVES

This section presents a summary of the three Shenango River sediment and five alluvial groundwater and NAPL remedial alternatives that were subjected to detailed evaluation in Section 5.0. This summary of alternatives is a key step in the remedy decision-making process and in the selection of the most cost-effective alternatives which are fully protective of public health and the environment in accordance with CERCLA and the NCP.

The following summary information on each alternative is to be used as reference for comparison of alternatives with one another. This comparison is made in light of two regulatory considerations. First, the NCP, Section 300.68(i), states that the appropriate remedy shall be determined by the lead agency's selection of a cost-effective remedial alternative that effectively mitigates and minimizes the threat to and provides adequate protection of public health, welfare, and the environment. The NCP defines cost effectiveness as having overall protectiveness proportional to costs incurred, i.e., more costly remedies must have proportionally greater overall protectiveness than less costly remedies. Second, Section 121 of SARA states that:

> "Remedial action in which treatment permanently and significantly reduces the volume, toxicity, or mobility of the hazardous substances, pollutants, and contaminants as a principal element is to be preferred over remedial actions not involving such treatment. The off-site transport and disposal of hazardous substances or contaminated materials without such treatment should be the least favored alternative remedial action where practicable treatment technologies are available."

However, as described in the NCP, (40 CFR 300.430(a)(iii)(A)) USEPA's expectation is to use treatment to address principal threats. USEPA expects to use engineering controls, such as containment, for waste that poses a relatively low long-term threat (40 CFR 300.430(a)(iii)(B)). The NCP also describes USEPA's expectation that groundwater will be returned to beneficial uses where practicable within a reasonable timeframe, or to prevent further migration and exposure if such restoration is not practicable (40 CFR 300.430(a)(iii)(f)).

The information in this summary is based on the present knowledge concerning the known environmental conditions at the site. Technologies described in this and previous sections are based on the current understanding of the nature, degree, and extent of COPC in site media. If this understanding changes during remedial design or between five-year reviews, such that the relative merits of different technologies change, the proposed technologies may be reassessed.

6.1 SHENANGO RIVER SEDIMENTS

The HHRA determined that exposure to impacted sediments does not pose an unacceptable risk to humans, but impacted sediments do pose a potential ecological risk, as described in the Screening Level ERA. Riparian soils, storm sewer sediments, and consumption of impacted fish were not explicitly evaluated in either risk assessment. The primary COPCs in sediments and riparian soils based on ecological concerns are PCBs and zinc. The remedial action objective for river sediments is to reduce the potential exposure of ecological receptors to impacted sediments.

Based on supplemental sediment sampling data obtained in 1998, it is assumed that remedial actions, if taken for sediments, would be focused on Area 14 (adjacent to water company) and Area 15 (Clark Street), as described in Section 4.1. Table 5-4 provides a summary of the detailed analysis for this medium.

6.1.1 Shenango River Sediment Alternative 1 – No Action

The no-action alternative for Shenango River sediment and riparian soils is retained as a baseline for comparison with other alternatives. As part of this alternative, five-year reviews would be conducted as required by SARA Section 121(c), but no remedial action would be performed at the site. Existing sediments and riparian soils would remain in place. Additionally, no action would be taken to address storm sewer sediments.

Under the no-action alternative, no remedial action would be taken to remove or reduce exposure to impacted sediments. Although the risk assessment documents no threat to human health exceeding CERCLA criteria, ecological receptors would be exposed to potential risks related to impacted sediments and humans would be exposed to a potential

risk via fish consumption. Consequently, this alternative may not be protective of the environment under existing conditions. Disturbance of impacted sediments may cause resuspension of sediments, potentially exposing downstream receptors, including the Shenango Valley Water Company surface water intake.

The no-action alternative would not reduce the mobility, toxicity, or volume of COPC. However, natural biological, chemical, and physical processes may gradually reduce concentrations of certain substances, and resedimentation may gradually provide a cover over some impacted sediments. This alternative may not comply with TSCA due to one isolated area with total PCB concentrations in the sediment exceeding 50 mg/kg.

6.1.2 Shenango River Sediment Alternative 2 – Limited Action/Natural Recovery

Alternative 2 for Shenango River sediments includes the continuation of the existing fish consumption advisory, along with natural resedimentation and attenuation processes to reduce the potential exposure of ecological receptors. Existing sediments and riparian soils would remain in place. Routine biennial monitoring of sediment quality and fish tissue would be performed to assess the effectiveness of this alternative.

Under this alternative, impacted sediments would be covered over time by natural resedimentation processes, and COPC concentrations may reduce over time due to natural attenuation processes. These processes would thus eventually reduce potential exposures of ecological receptors to impacted sediments. Continuation of the fish consumption advisories would control potential risks to human health related to fish consumption. Disturbance of impacted sediment may cause the resuspension of the sediment into the surface water, thereby potentially exposing downstream receptors.

This alternative would not directly reduce the mobility, toxicity, or volume of COPC. However, over time resedimentation processes would reduce the mobility of the COPC, and natural biological, chemical, and physical processes may gradually reduce concentrations of certain substances. For a very small portion of the river where total PCB concentrations in the sediment exceed 50 mg/kg, this alternative might not comply with TSCA regulations.

6.1.3 Shenango River Sediment Alternative 3 – Cover

Under this alternative, portions of the Shenango River where sediments and riparian soils exceed the cleanup goals would be covered by 12 inches of granular fill or other appropriate cover material. Additionally, significant accumulations of impacted sediment in the storm sewers leading from the site, if detected, would be removed and properly disposed of off site. No action would be taken to remove impacted sediments and riparian soils from the river corridor.

Proper design, installation, and maintenance of the cover would effectively reduce the long-term potential for ecological exposure to impacted sediments by reducing the bioavailability of COPCs in the sediment. Regular inspections would be required to verify continued integrity of the riprap cover. Installation of a cover may present a short-term potential risk to human health and the environment via resuspension of impacted sediment into the surface water and subsequently into the public water intake located at Area 14. Monitoring of the surface water intake would be performed during construction activities.

Installation of a cover would not reduce the toxicity and volume of COPCs. Mobility of the COPCs would be substantially reduced by a properly designed and installed cover system. Natural biological, chemical, and physical processes may gradually reduce concentrations of certain substances in the sediments. By providing a cover over the small area of sediments with total PCB concentrations exceeding 50 mg/kg, this alternative may comply with TSCA regulations.

Installation of a cover would be readily implementable at Area 15 and along the western bank at Area 14, but would be more difficult along the eastern bank at Area 14, due to the steepness and dense vegetation along this bank. This alternative would increase short-term human health risks, unless the Shenango Valley Water Authority intake was shut down during the construction period.

6.1.4 Shenango River Sediment Alternative 4 – Excavate and Treat/Dispose Off Site

Under this alternative, up to one foot (Alternative 4A) or up to four feet (Alternative 4B) of sediments and riparian soils along the Shenango River corridor in Areas 14 and 15 which exceed the respective cleanup goals would be excavated and transported to an

appropriate off-site facility for subsequent treatment and/or disposal. Excavation would be performed by conventional equipment in Area 15 and by dredging in Area 14. Temporary barriers would be installed to isolate the areas being excavated and allow for dewatering. The excavated areas would be backfilled with clean fill or other appropriate material to reestablish existing flow and deposition patterns. Significant accumulations of impacted sediment in the storm sewers leading from the site, if determined to be present, would be removed and properly disposed of off site.

Excavation of impacted sediments and replacement with appropriately designed clean fill would effectively reduce the potential for the unacceptable exposure of ecological receptors. Excavation of impacted sediments and riparian soils may present a significant short-term risk to the environment and human health due to the possible resuspension of sediment into the surface water used for public consumption, even with the use of temporary barriers. Monitoring of the surface water intake would be performed during construction activities.

Because of the relatively low concentrations of COPCs relative to TSCA and RCRA standards, treatment of excavated materials would likely not be performed prior to disposal, and therefore the toxicity and volume of COPCs would not be reduced. Mobility of the COPCs in terms of long-term potential exposure of ecological receptors would be reduced, although mobility may increase in the short term. By removing and properly disposing of sediments with total PCB concentrations exceeding 50 mg/kg, this alternative may comply with TSCA regulations.

The effectiveness of a sediment removal remedy in meeting cleanup goals has not been demonstrated on a consistent basis. At several sites, including the Alcoa Grasse River site, the General Motors Massena site, and the Sheboygan River site, cleanup goals could not be met despite extensive dredging efforts. At several other sites, including the Waukegan Harbor, Black River, and Lipari Landfill, post-dredging samples were not collected to evaluate remedy performance (General Electric, 1997).

Implementation of an excavation alternative would be moderately difficult at Area 15 and along the western bank of Area 14, and would be very difficult along the eastern bank of

Area 14. Obstacles to implementation include physical access to the river for equipment, staging and dewatering of excavated materials, and performing the work in a manner which will not result in the introduction of PCBs into the public water supply system, possibly including shutting down the intake during the construction period. Access and use of a substantial portion of the Sharon Tube Company property would be required.

6.2 ALLUVIAL GROUNDWATER AND NAPLS

The HHRA identified groundwater in the alluvial aquifer in the South and Middle Sectors of the site as posing an unacceptable carcinogenic and non-carcinogenic risks to various potential human receptors, including future residents and workers using groundwater for bathing and consumption. The primary COPCs for alluvial groundwater in the South Sector are VOCs (chlorinated aliphatic hydrocarbons), while the primary COPCs in the Middle Sector include VOCs (both chlorinated aliphatic hydrocarbons and chlorinated aromatic hydrocarbons), dioxin, and PCBs. The remedial action objectives for alluvial groundwater and NAPLs at the site are to reduce the likelihood of unacceptable human exposures, obtain compliance with ARARs, reduce the potential for further aquifer degradation, and reduce COPC concentrations in groundwater. Table 5-6 provides a summary of the detailed analysis for alluvial groundwater/NAPL alternatives.

It should be noted that upon implementation of a ROD that addresses impacted groundwater, the USEPA may elect to terminate the ongoing LNAPL removal action, as described in the 1994 UAO.

6.2.1 Alluvial Groundwater/NAPL Alternative 1 – No Action

The no-action alternative for alluvial groundwater and NAPLs is retained as a baseline for comparison with other alternatives. As part of this alternative, five-year reviews would be conducted as required by SARA Section 121(c) if any remedial action is performed at the site. No action would be taken to control the migration of COPCs in groundwater, to prevent exposure of humans to impacted groundwater and NAPLs, or to reduce the concentrations of COPCs in the aquifer. There would be no attempt to institute restrictions on the use of groundwater either on site or off site, nor would routine monitoring of groundwater quality be performed.

The no-action alternative would not alleviate potential risks to human health or the environment posed by contact with impacted groundwater and/or NAPLs, nor would it eliminate potential impacts to surface water, although such impacts do not appear to be occurring. While health risks posed by current and reasonably anticipated future land use in the vicinity of the site are not expected to be significant, hypothetical future uses of impacted groundwater from both the Middle and South Sectors for potable or sanitary uses as assumed in the HHRA
resulted in an unacceptable risk to human receptors. Natural processes such as dispersion and degradation may gradually reduce COPC concentrations downgradient of the site. DNAPLs may gradually migrate vertically to the bedrock aquifer.

The no-action alternative would not reduce the mobility, toxicity, or volume of COPCs in the alluvial aquifer. However, natural biological, chemical, and physical processes may continue to gradually reduce concentrations of certain substances. The no-action alternative does not comply with chemical-specific ARARs, nor with Act 2.

6.2.2 Alluvial Groundwater/NAPL Alternative 2 – Institutional Controls with Monitored Natural Attenuation

Alternative 2 for alluvial groundwater and NAPLs includes the implementation of deed restrictions for properties controlled by CBS, a municipal ordinance restricting the use of groundwater within a designated area, and long-term monitoring of groundwater conditions in support of demonstrating the occurrence of natural attenuation of COPCs in the aquifer. No attempt would be made to actively extract and/or otherwise treat impacted alluvial groundwater and NAPLs.

Individual property and municipal restrictions on the use of groundwater would help provide a level of assurance that human receptors are not being exposed to impacted groundwater. Health risks posed by current and reasonably anticipated future land use in the vicinity of the site are not expected to be significant, however, certain hypothetical future uses of impacted groundwater could result in an unacceptable risk to human receptors. Natural processes such as dispersion and degradation may gradually reduce COPC concentrations in the aqueous phase downgradient of the site, based on the findings of sampling performed at the site in 1999. Occasional monitoring of groundwater quality would be performed to confirm that groundwater quality downgradient of the source areas

is improving. It is not likely that groundwater quality within areas where NAPLs are present will improve significantly under this alternative. DNAPLs may gradually migrate vertically to the bedrock aquifer.

Implementation of the institutional controls would not reduce the mobility, toxicity, or volume of COPC. However, natural biological, chemical, and physical processes may continue to gradually reduce concentrations of certain substances. By providing institutional controls restricting the use of groundwater and through natural attenuation processes, compliance with certain ARARs may be achieved. In the short term and in the vicinity of the NAPL areas, this alternative would not comply with chemical-specific ARARs.

6.2.3 Alluvial Groundwater/NAPL Alternative 3 – NAPL Source Removal with Monitored Natural Attenuation for Groundwater

This alternative includes the removal of NAPLs from the subsurface, along with the implementation of groundwater use restrictions and continued monitoring of groundwater for natural attenuation of residual COPCs. No active groundwater extraction or remediation would be performed. For Alternative 3A, direct and/or enhanced recovery methods, potentially including dual-well systems, solvent flushing, or electrical heating along with pumping or passive absorption of product, would be implemented to collect NAPLs for appropriate off-site treatment and disposal. For Alternative 3B, an in-situ treatment method such as enhanced biodegradation would be used to destroy the NAPL constituents in the ground.

By reducing the mass of NAPLs present in the alluvial aquifer, a significant source of COPCs would be addressed, potentially resulting in an improvement of groundwater quality in and immediately downgradient of the Middle Sector in the long term. Reducing the mass of DNAPL would also lessen the likelihood of vertical migration to the bedrock aquifer. Due to the substantial volume of NAPL mass present in the subsurface, it is unlikely that any enhanced recovery method or in-situ treatment method would effectively remove all COPCs from the subsurface within a reasonable time frame. The effectiveness of this alternative is directly related to the ability to draw significant quantities of NAPLs to the collection points.

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Health risks posed by current and reasonably anticipated future land use in the vicinity of the site are not expected to be significant, however, certain hypothetical future uses of impacted groundwater could result in an unacceptable risk to human receptors. Groundwater use restrictions and the availability of a public water supply provide assurance that human receptors are not being exposed to impacted groundwater, and natural processes may gradually reduce COPC concentrations in the aqueous phase downgradient of the site. Short-term risks to human health may be incurred in association with the installation of injection wells, electrode borings, and/or collection wells, as well as with the handling of collected NAPLs, particularly under Alternative 3A. Alternative 3B involves the complete mixing of NAPLs with groundwater in the aquifer, and therefore may not be protective of the environment in the short term.

The nature of the enhanced recovery or treatment methods is to temporarily increase the mobility of the NAPLs, therefore allowing them to be collected and/or treated with greater ease. Alternative 3A would include incineration of collected NAPLs, and would therefore in the long term reduce the toxicity of the COPCs. Likewise, Alternative 3B ultimately reduces the toxicity of the COPC mass through degradation of the constituents to water and carbon dioxide. For COPCs in the aqueous phase, natural biological, chemical, and physical processes may continue to gradually reduce concentrations.

By providing institutional controls, reducing NAPL mass, and through natural attenuation processes, compliance with certain ARARs may be achieved at portions of the site.

6.2.4 Alluvial Groundwater/NAPL Alternative 4 – NAPL Source Removal with Groundwater Extraction and Treatment

This alternative includes the enhanced recovery of NAPLs from the subsurface, along with the implementation of groundwater use restrictions and continued monitoring of groundwater for natural attenuation of residual COPCs. In addition, impacted groundwater in non-NAPL portions of the South and/or Middle Sectors would be extracted and pumped to a new on-site facility for treatment by aqueous-phase carbon adsorption and ultimate discharge to the Shenango River. Groundwater would be extracted from within or immediately downgradient of areas where COPC concentrations are highest.

By reducing the mass of NAPLs present in the alluvial aquifer and by extracting the most significantly impacted groundwater, the potential for vertical and horizontal migration of COPCs in the alluvial aquifer would be substantially reduced. Health risks posed by current and reasonably anticipated future land use in the vicinity of the site are not expected to be significant, however, certain hypothetical future uses of impacted groundwater could result in an unacceptable risk to human receptors. Groundwater use restrictions and the availability of a public water supply provide a level of assurance that human receptors are not being exposed to impacted groundwater, and natural processes may gradually reduce COPC concentrations in the aqueous phase downgradient of the site. Short-term risks to human health may be incurred in association with implementing the components of this alternative, including the handling of collected NAPLs and impacted groundwater.

Although the enhanced NAPL recovery methods may temporarily increase the mobility of the NAPLs, the extraction of groundwater within or immediately downgradient of the NAPL areas will minimize the horizontal migration of NAPL constituents. Collected NAPLs would be incinerated, thereby reducing the toxicity of the COPCs in the NAPLs. COPCs in extracted groundwater would be transferred to a different media which would require subsequent appropriate management. For residual COPCs in groundwater, natural biological, chemical, and physical processes may continue to gradually reduce concentrations.

By providing institutional controls, reducing NAPL mass, extracting impacted groundwater, and through natural attenuation processes, compliance with certain ARARs may be achieved at portions of the site, including Act 2, although compliance with chemical-specific ARARs is unlikely within NAPL areas.

6.2.5 Alluvial Groundwater/NAPL Alternative 5 – NAPL Source Removal with In-Situ Groundwater Treatment

This alternative includes the in-situ treatment of NAPLs and impacted groundwater in non-NAPL areas using enhanced bioremediation techniques, along with the implementation of groundwater use restrictions and continued monitoring of groundwater for natural attenuation of residual COPCs. Groundwater treatment would be performed within or immediately downgradient of areas where COPC concentrations are highest.

By reducing the mass of NAPLs present in the alluvial aquifer and by treating the most significantly impacted groundwater, the potential for vertical and horizontal migration of COPCs in the alluvial aquifer would be substantially reduced. Health risks posed by current and reasonably anticipated future land use in the vicinity of the site are not expected to be significant, however, certain hypothetical future uses of impacted groundwater could result in an unacceptable risk to human receptors. Groundwater use restrictions would help provide a level of assurance that human receptors are not being exposed to impacted groundwater, and natural processes may gradually reduce residual COPC concentrations in groundwater downgradient of the treated areas. Short-term risks to human health may be incurred in association with implementing the components of this alternative, including the handling of biological reagents.

Although the NAPL treatment methods may temporarily increase the mobility of the NAPLs, the extraction of groundwater within or immediately downgradient of the NAPL areas will minimize the horizontal migration of NAPL constituents. COPCs in the treated NAPLs and groundwater would be destroyed, thereby reducing COPC toxicity. For residual COPCs in groundwater, natural biological, chemical, and physical processes may continue to gradually reduce concentrations.

By providing institutional controls, reducing NAPL and COPC mass in the alluvial aquifer, and through natural attenuation processes, compliance with certain ARARs may be achieved at portions of the site, although compliance with chemical-specific ARARs is unlikely within NAPL areas.

6.3 COST EFFECTIVENESS EVALUATION

The NCP requires selected remedial actions to be cost effective, such that its costs are proportional to its overall effectiveness, which considers long-term effectiveness and permanence, reduction of toxicity, mobility or volume by treatment, and short-term effectiveness. This requirement is in addition to satisfying the two threshold criteria of overall protection of human health and the environment and compliance with ARARs (unless a specific ARAR is waived).

6.3.1 Shenango River Sediment Alternatives

Among the remedial alternatives for Shenango River sediments and riparian soils, the excavation alternative (Alternative 4) rates fair for overall protection of human health and the environment but very good for ARAR compliance, while the no action, limited action, and cover alternatives (Alternatives 1, 2, and 3) rate fair or good in the threshold criteria. Likewise, the excavation alternative rates highest in long-term effectiveness, but worst in short-term effectiveness, due to the potential risks of resuspension of impacted sediments. The substantial additional cost of excavation of impacted sediment relative to the other options does not appear to result in a proportional increase in overall effectiveness, in light of the significant potential short-term risks.

6.3.2 Alluvial Groundwater/NAPL Alternatives

The alluvial groundwater and NAPL remedial alternatives which include groundwater use restrictions with monitored natural attenuation (Alternative 2), NAPL source removal with monitored natural attenuation (Alternative 3), NAPL source removal with groundwater extraction and treatment (Alternative 4), and NAPL source removal with in-situ groundwater treatment (Alternative 5) satisfy the threshold criteria. Of these alternatives, the options including in-situ or ex-situ treatment of groundwater in addition to NAPL removal or treatment (Alternatives 4 and 5) would incur substantially higher costs than performing only NAPL removal or treatment (Alternative 3) while providing minimal improvement in overall effectiveness in terms of COPC mass removed from the subsurface relative to Alternative 3. The additional cost of Alternative 3 relative to Alternative 2 does result in increased effectiveness in reducing COPC mass in the aquifer, but does not result in a significant reduction in risk relative to Alternative 2.

6.4 Synergistic and Antagonistic Effects

Synergism refers to the circumstance where one process or technology enhances the effect of another, such that the net effect of the two processes is greater than the net combined effect of the separate processes. Antagonism is the opposite relationship, where one process interferes with or negates the effect of the other such that the net effect is less than the net combined effect of the separate processes. In either synergism or antagonism, the relationship may or may not be mutual.

There do not appear to be any direct synergistic or antagonistic relationships created by the Shenango River sediment alternatives. A remedy selected for this medium would not likely have an impact, either positive or negative, on remedies selected for other site media. However, implementation of either Alternative 3 or Alternative 4 for sediment results in substantial increase in short-term risk over Alternatives 1 and 2, due to the presence of a public drinking water intake at Area 14.

A clear synergistic effect is involved in remedies for groundwater and NAPLs at the site, and was considered in the development of remedial alternatives, as described in Section 4.2. Because of the presence of NAPLs in the alluvial aquifer, it is likely that an active remedy which addresses only groundwater without removing or otherwise reducing the impact of NAPLs on groundwater will not result in a long-term improvement of aquifer quality (USEPA, 1999). On the other hand, a removal or reduction of the NAPL mass may result in a substantial improvement in the quality of the aquifer's aqueous phase by eliminating or reducing the source of COPCs in the aquifer. In fact, a recent USEPA document (Appendix A) suggests a phased approach to addressing NAPL-impacted aquifers in a manner which addresses NAPLs by direct pumping and enhanced recovery *prior to implementing a remedy for COPCs in the aqueous phase* (USEPA, 1999). This approach would likely allow the selected groundwater remedy, whether it be pump and treat, in-situ treatment, or monitored natural attenuation, to occur more effectively.

7.0 CLOSING

This FS Report for Shenango River sediments, groundwater and NAPLs has been prepared in accordance with the Consent Order and Agreement, dated September 21, 1988, between Westinghouse and PADER. This document was completed pursuant to the Remedial Investigation/Feasibility Study (RI/FS) Work Plan, Revision 2.0 (Rizzo Associates, 1992), and draws from information presented in the RI Report (Cummings/Riter, 1996), the HHRA (ChemRisk, 1998), the Screening Level ERA (ChemRisk, 1997), the Supplemental Sediment Sampling Data Summary Report (Cummings/Riter, 1999a), and the Supplemental Groundwater Sampling Data Summary Report (Cummings/Riter, 1999b). This FS Report develops and evaluates a set of remedial alternatives for Shenango River sediments, alluvial groundwater, and NAPLs at the Former Sharon Transformer Plant.

We believe that this FS Report is responsive to the needs of the parties involved, including CBS, the regulatory agencies, and the community of Sharon.

Respectfully submitted,
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Patrick F. O'Hara, P.E.
President

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ACRONYMS

ARAR	Applicable or relevant and appropriate requirement
AWQC	Ambient Water Quality Criteria
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COI	Constituents of interest
COPC	Constituents of potential concern
CSF	Cancer slope factor
CWA	Clean Water Act
DCE	1,2-Dichloroethene
DNAPL	Dense non-aqueous phase liquid
EEQ	Ecological effects quotient
EPC	Exposure point concentration
ERA	Ecological Risk Assessment
HHRA	Human Health Risk Assessment
HI	Hazard index
LDRs	Land Disposal Restrictions
LNAPL	Light non-aqueous phase liquid
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg/kg	Milligrams per kilogram
MSL	Feet mean sea level

ACRONYMS
(CONTINUED)

NAAQS	National Ambient Air Quality Standards
NAPL	Non-aqueous phase liquid
NCP	National Contingency Plan
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSPS	New Source Performance Standard
OU	Operable Unit
PADEP	Pennsylvania Department of Environmental Protection
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
POTW	Publicly-owned treatment works
RBC	Risk-based concentration
RCRA	Resource Conservation Recovery Act
RFD	Reference dose
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SVE	Soil vapor extraction
SVOC	Semi-volatile organic compound

ACRONYMS
(CONTINUED)

TBC	To be considered
TCE	Trichloroethene
TSCA	Toxic Substances Control Act
UAO	Unilateral Administrative Order
USEPA	United States Environmental Protection Agency
VOC	Volatile organic compound

TABLES

TABLES

TABLE 1-1
SUMMARY OF BASELINE HUMAN-HEALTH RISK ASSESSMENT

Medium[a]	Hypothetical Exposure Scenarios[a]	Relevant Exposure Pathway(s)	Significantly Contributing Chemicals[b]	Total Carcinogenic Risk[c]	Total Non-Carc. Hazard Index[c]
Southern Alluvial Groundwater	Adult Resident[d] Child Resident Worker	Ingestion Dermal Contact Inhalation	Aroclor-1254	1.1E-02[e]	1400
			Arsenic	8.7E-03	84
			2,3,7,8-TCDD (teq)	1.3E-03	--
			Vinyl chloride	5.1E-04	--
			1,4-Dichlorobenzene	3.5E-04	1.5
			Trichloroethene	8.1E-05	5.3
			1,1-Dichloroethene	2.3E-05	0.02
			1,3-Dichlorobenzene	--	73
			Iron	--	66
			1,2-Dichloroethene	--	25
			Manganese	--	24
			Chromium	--	15
			Aluminum	--	6.3
			Nickel	--	2.3
			Vanadium	--	1.8
			1,2,4-Trichlorobenzene	--	1.5
			Chlorobenzene	--	1.0
			Mercury	--	1.0
			Barium	--	0.8
			Copper	--	0.6
			Cadmium	--	0.6
			Zinc	--	0.4
			2,4-Dichlorophenol	--	0.4
			Beryllium	--	0.3
			1,2-Dichlorobenzene	--	0.16
			Total of All Chemicals[f]	**2.2E-02**	**1710**
Central Alluvial Groundwater	Adult Resident[d] Child Resident Worker	Ingestion Dermal Contact Inhalation	Aroclor-1254	3.1E+00[g]	5.0E+06
			Aroclor-1248	2.8E+00[g]	--
			Aroclor-1242	4.4E-03	--
			Aroclor-1260	4.4E-03	--
			Trichloroethene	3.2E-03	122
			Arsenic	7.8E-04	7.5
			2,3,7,8-TCDD (teq)	7.3E-04	--
			Benzene	3.2E-04	10
			1,4-Dichlorobenzene	2.8E-04	1.2
			Tetrachloroethene	7.9E-05	0.8
			1,1-Dichloroethene	6.1E-05	0.04
			1,2-Dichloroethane	1.5E-05	0.01
			1,2,4-Trichlorobenzene	--	670
			Manganese	--	160
			Iron	--	100
			1,3-Dichlorobenzene	--	66
			Aluminum	--	10
			Cadmium	--	9.0
			Zinc	--	7.7
			Chromium	--	7.1
			Vanadium	--	3.0

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TABLE 1-1
SUMMARY OF BASELINE HUMAN-HEALTH RISK ASSESSMENT

Medium[a]	Hypothetical Exposure Scenarios[a]	Relevant Exposure Pathway(s)	Significantly Contributing Chemicals[b]	Total Carcinogenic Risk[c]	Total Non-Carc. Hazard Index[c]
Central Alluvial Groundwater (continued)			Copper	--	1.5
			Chlorobenzene	--	1.3
			1,2-Dichlorobenzene	--	1.0
			Barium	--	1.0
			Nickel	--	0.90
			Mercury	--	0.60
			Beryllium	--	0.5
			Silver	--	0.20
			Cyanide	--	0.10
			1,2-Dichloroethene	--	0.07
			Total of All Chemicals[f]	**1.0E+00**	**5.0E+06**
Bedrock Groundwater	Adult Resident[d] Child Resident Worker	Ingestion Dermal Contact	Aroclor-1260	2.8E-03	--
			Aroclor-1254	2.7E-03	340
			2,3,7,8-TCDD (teq)	3.1E-04	--
			Arsenic	2.2E-04	2.0
			Benzo(a)anthracene	1.5E-05	--
			Bis(2-ethylhexyl)phthalate	5.9E-06	0.09
			Aluminum	--	0.5
			Barium	--	0.2
			Cadmium	--	0.2
			Manganese	--	0.4
			Iron	--	3.1
			Total of All Chemicals[f]	**6.1E-03**	**347**

Notes:

a. Only those media and exposure scenarios for which the calculated carcinogenic risk or non-carcinogenic hazard index exceeds the target range (10^{-4} and 1.0, respectively) are shown.

b. Only those chemicals which have a total carcinogenic risk of greater than 10^{-6} or a hazard index of greater than 0.1 are shown.

c. Total risks and hazard indices are the approximate values calculated by USEPA, and include each relevant exposure pathway.

d. Carcinogenic risks are for the combined Adult/Child Resident scenario. Noncarcinogenic risks are for the Child Resident scenario.

e. **Highlighted** values indicate results for which health-based cleanup levels will be calculated, as shown on Tables 2-3 to 2-5.

f. Totals include results for compounds not shown on this table (see note b).

g. Carcinogenic risk cannot exceed 1.0E+00. Value shown is used for calculating cleanup levels.

TABLE 1-2

SUMMARY OF RI SHENANGO RIVER SEDIMENT SAMPLES (mg/kg)[a]

	Sample ID:	SD-11A	SD-11B	SD-12A	SD-3A	SD-13A	SD-2A	SD-14A	SD-14AD	SD-4A	SD-15A	SD-1A	SD-16A	SD-17A
	Collection Date:	8/2/94	8/2/94	8/2/94	7/9/92	8/2/94	7/9/92	8/3/94	8/3/94	7/9/92	8/3/94	7/9/92	8/3/94	8/3/94
Compound[b]	Screening Level Criteria (mg/kg)[c]	Below Wishart Ct. Outfall				Below Franklin St. Outfall		Below North Hot Well Outfall			Below Clark St. Outfall		Upstream of Clark St. Outfall	
Zinc	120	410[d]	380	215	NA	400	NA	1,090	1,150	NA	***28,200***	NA	170	155
Total PCBs	0.05	0.34	0.48	***2.81***	0.087	***1.16***	0.22	***3.50***	***3.40***	***0.94***	***7.50***	***8.40***	0.24	0.086
Antimony	2	<3.8	<3.7	<3.7	NA	<3.7	NA	<5.7	<5.7	NA	***22.8***	NA	<4.2	<4.0
Chromium	80	23.1	13.2	10.4	NA	8.3	NA	31.2	31.5	NA	467	NA	10.2	9.7
Lead	35	65.1	46.5	38.9	23	20.6	228	94	76	72.8	203	105	25.4	39.5
Silver	1	<0.6	<0.6	<0.6	NA	<0.6	NA	4.1	1.9	NA	<2.5	NA	<0.7	<0.62
Nickel	30	22	9	8.4	NA	7.4	NA	23.4	19.9	NA	109	NA	10.5	12.7
Total PAHs	4	11.10	9.36	10.20	NA	6.34	NA	10.49	13.15	NA	6.56	NA	5.78	4.46
Mercury	0.15	<0.2	<0.1	<0.2	NA	0.2	NA	0.2	0.4	NA	<0.6	NA	<0.2	<0.16
Cadmium	5	1.1	<0.85	0.87	NA	1.2	NA	10.2	3	NA	<3.8	NA	<1.0	<0.93
Arsenic	33	12.5	8.3	8.3	NA	8.2	NA	22.8	24	NA	36.9	NA	11.5	9.1

a. Concentrations are in milligrams per kilogram (mg/kg).

b. PCB concentrations are from CBS data set; all other concentrations are from PADEP data set.

c. Screening level criteria are for Effects Range - Low (Long and Morgan, 1991).

d. Reported concentrations result in Ecological Effects Quotients in the following ranges (from Screening-Level ERA, ChemRisk, 1997):

EEQ > 100	Extreme risk to ecological receptors
100 > EEQ > 10	Moderately high potential risk to ecological receptors
10 > EEQ > 1	Potential risk to ecological receptors
EEQ < 1	No risk to ecological receptors

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TABLE 1-3
SUPPLEMENTAL SEDIMENT SAMPLE RESULTS

Parameter	Screening Level Criteria[a]	SD-12E1A 11/3/98 0"-4"	SD-12E1B 11/3/98 6"-50"	SD-12W1A 11/3/98 0"-4"	SD-12W1B 11/3/98 6"-50"	SD-12E2A 11/3/98 0"-4"	SD-12E2B 11/3/98 6"-50"	SD-12E3A 11/3/98 0"-4"	SD-12E3B 11/3/98 6"-50"	SD-12E4A 11/3/98 0"-4"	SD-12E4B 11/3/98 6"-50"	SD-12E5A 11/3/98 0"-4"	SD-12E5B 11/3/98 6"-50"
Polychlorinated Biphenyls (ug/kg)[b]													
Aroclor 1016	50	<120[e]	<19	<22	<20	<240	<20	<21	<19	<21	<20	<22	<20
Aroclor 1221	50	<120	<19	<22	<20	<240	<20	<21	<19	<21	<20	<22	<20
Aroclor 1232	50	<120	<19	<22	<20	<240	<20	<21	<19	<21	<20	<22	<20
Aroclor 1242	50	<120	<19	<22	<20	<240	<20	50	<19	50	<20	<22	156
Aroclor 1248	50	<120	<19	<22	<20	<240	<20	<21	<19	<21	<20	<22	<20
Aroclor 1254	50	<120	<19	<22	<20	<240	<20	<21	<19	<21	<20	<22	<20
Aroclor 1260	50	450[f]	237	101	<20	***1,050***	34	144	<19	93	<20	200	129
Total Organic Carbon (mg/kg)[c]		1,710	NA	NA	1,500	NA	NA	NA	760	1,630	NA	NA	1,600
Inorganics (mg/kg)													
Antimony	2	<1.5	<1.2	<1.4	1.8	<1.0	<0.83	<0.88	<0.82	<0.87	<0.86	<0.94	<0.85
Arsenic	33	8.9	16.3	19.0	14.9	11.2	16.5	9.3	13.4	15.9	16.0	14.0	9.9
Beryllium		2.4 B[g]	1.5 B	1.6 B	1.3 B	1.9	0.58	1.2	0.45	1.5	0.67	1.4	1.0
Cadmium	5	1.0	<0.24	<0.28	<0.25	1.1	1.2	1.0	1.1	1.3	2.8	0.99	0.95
Chromium	80	35.0	12.0	9.1	11.9	51.4	10.0	19.0	8.7	24.8	12.2	22.4	11.0
Copper		63.2	14.2	21.2	19.3	17.3	16.6	28.2	10.7	43.3	14.5	16.3	21.0
Lead	35	32.8	24.0	26.4	28.4	163	29.3	68.7	14.7	35.3	47.0	291	52.8
Mercury	0.15	0.093 B	0.026 B	0.088 B	0.12 B	0.14 B	0.16 B	0.24	0.11 B	0.12 B	0.13 B	0.12 B	0.18 B
Nickel	30	47.4	16.5	11.5	15.6	17.3	17.8	15.3	15.7	21.5	16.2	18.0	15.2
Selenium		<1.1	<0.88	<1.0	<0.92	<1.1	<0.90	<0.96	<0.89	<0.94	<0.93	<1.0	<0.92
Silver	1	<0.38	<0.31	<0.35	0.32	<0.34	<0.28	<0.29	<0.27	<0.29	<0.29	<0.31	<0.28
Thallium		<2.5	<2.1	<2.4	<2.2	<2.6	<2.2	<2.3	<2.1	<2.3	<2.3	<2.5	<2.2
Zinc	120	810	131	420	129	371	91.3	301	55.5	326	85.9	208	106
Grain Size Analysis													
Percent Gravel		1.4	NA	NA	33.2	NA	NA	NA	34.5	35.9	NA	NA	31.0
Percent Sand		96.8	NA	NA	45.1	NA	NA	NA	50.6	63.1	NA	NA	55.5
Percent Silt		0.8	NA	NA	13.7	NA	NA	NA	11.9	<1	NA	NA	11.0
Percent Clay		<1	NA	NA	8.0	NA	NA	NA	3.0	<1	NA	NA	2.5
USCS Classification[d]		SP	NA	NA	SM-SC	NA	NA	NA	SM	SP	NA	NA	SM

AR302645

TABLE 1-3
SUPPLEMENTAL SEDIMENT SAMPLE RESULTS

Parameter	Screening Level Criteria[a]	SD-12M5A 11/3/98 0"-4"	SD-12M5B 11/3/98 6"-50"	SD-12E6A 11/3/98 0"-4"	SD-12E6B 11/3/98 6"-50"	SD-12E7A 11/3/98 0"-4"	SD-12E7B 11/3/98 6"-50"	SD-13E0A 11/2/98 0"-4"	SD-13E0B 11/2/98 6"-50"	SD-13E1/2A 11/2/98 0"-4"	SD-13E1/2B 11/2/98 6"-50"	SD-13E1A 11/2/98 0"-4"	SD-13E1B 11/2/98 6"-50"
Polychlorinated Biphenyls (ug/kg)[b]													
Aroclor 1016	50	<20	<19	<22/<21	<19	<1,300	<20	<120	<19	<23	<20	<23	<19
Aroclor 1221	50	<20	<19	<22/<21	<19	<1,300	<20	<120	<19	<23	<20	<23	<19
Aroclor 1232	50	<20	<19	<22/<21	<19	<1,300	<20	<120	<19	<23	<20	<23	<19
Aroclor 1242	50	<20	282	109/53	111	<1,300	<20	<120	<19	83	<20	76	<19
Aroclor 1248	50	<20	<19	<22/<21	<19	<1,300	<20	<120	<19	<23	<20	<23	<19
Aroclor 1254	50	<20	<19	<22/<21	<19	<1,300	<20	<120	<19	<23	<20	<23	<19
Aroclor 1260	50	100	235	222/116	207	***2,000***	184	***810***	28	180	<20	179	27
Total Organic Carbon (mg/kg)[c]		1,070	NA	2,410/NA	NA	NA	NA	NA	NA	NA	1,310	2,360	NA
Inorganics (mg/kg)													
Antimony	2	<0.86	1.9	<0.91/<0.88	<0.82	***20.4***	<0.85	<1.0	1.6	<1.5	2.0	<1.5	3.7
Arsenic	33	8.1	7.6	8.7/9.1	8.1	7.5	8.7	8.5	8.4	10.1	19.0	12.8	27.2
Beryllium		0.89	1.1	1.4/1.9	1.5	0.54	0.60	0.55 B	0.53 B	0.50 B	0.49 B	0.57 B	0.73 B
Cadmium	5	1.1	1.2	1.0/1.0	1.0	0.98	1.2	<0.28	<0.25	7.3	<0.26	<0.30	<0.24
Chromium	80	14.3	13.2	36.6/74.4	16.4	11.2	8.3	10.6	6.8	9.1	6.1	8.4	13.6
Copper		24.9	18.7	19.2/26.4	23.9	15.6	20.8	10.3	6.5	8.4	6.2	8.3	15.1
Lead	35	170	***485***	46.8/38.5	84.5	47.3	61.1	25.1	14.2	25.2	9.7	28.0	52.2
Mercury	0.15	0.11 B	0.14 B	0.11B/0.14B	0.15 B	0.25	0.17 B	0.075 B	0.040 B	0.063	0.027 B	0.059	0.032 B
Nickel	30	15.2	11.3	16.8/19.4	16.0	8.9	11.3	9.0	8.1	8.6	9.1	9.4	14.4
Selenium		<0.94	<0.89	<0.99/<0.95	<0.88	<1.2	<0.92	<1.1	<0.92	<1.1	1.2	<1.1	<0.88
Silver	1	<0.29	0.32	<0.30/<0.29	0.30	<0.37	<0.28	0.40	<0.32	<0.39	<0.33	<0.38	<0.31
Thallium		<2.3	<2.1	<2.4/<2.3	<2.1	<2.9	<2.2	<2.7	<1.9	<2.3	<2.0	<2.3	4.3
Zinc	120	325	143	474/409	193	430	88.6	611	60.2	756	98.8	603	103
Grain Size Analysis													
Percent Gravel		28.7	NA	16.6/NA	NA	NA	NA	NA	NA	NA	31.7	1.3	NA
Percent Sand		70.1	NA	82.1/NA	NA	NA	NA	NA	NA	NA	52.5	95.0	NA
Percent Silt		0.2	NA	0.3/NA	NA	NA	NA	NA	NA	NA	13.8	2.7	NA
Percent Clay		<1	NA	<1.0/NA	NA	NA	NA	NA	NA	NA	2.0	<1.0	NA
USCS Classification[d]		SP	NA	SP/NA	NA	NA	NA	NA	NA	NA	SM	SP	NA

AR302646

TABLE 1-3
SUPPLEMENTAL SEDIMENT SAMPLE RESULTS

Parameter	Screening Level Criteria[a]	SD-13E2A 11/2/98 0"-4"	SD-13E2B 11/2/98 6"-50"	SD-13M3A 11/2/98 0"-4"	SD-13M3B 11/2/98 6"-50"	SD-13E4A 11/2/98 0"-4"	SD-13E4B 11/2/98 6"-50"	SD-13M4A 11/2/98 0"-4"	SD-13M4B 11/2/98 6"-50"	SD-13E5A 11/2/98 0"-4"	SD-13E5B 11/2/98 6"-50"	SD-13M5A 11/2/98 0"-4"	SD-13M5B 11/2/98 6"-50"
Polychlorinated Biphenyls (ug/kg)[b]													
Aroclor 1016	50	<22	<19	<23	<19	<23	<22	<22/<22	<20	<25	<100	<120	<120
Aroclor 1221	50	<22	<19	<23	<19	<23	<22	<22/<22	<20	<25	<100	<120	<120
Aroclor 1232	50	<22	<19	<23	<19	<23	<22	<22/<22	<20	<25	<100	<120	<120
Aroclor 1242	50	<22	<19	<23	<19	97	<22	73/<22	<20	89	<100	<120	<120
Aroclor 1248	50	<22	<19	<23	<19	<23	<22	<22/<22	<20	<25	<100	<120	<120
Aroclor 1254	50	<22	<19	<23	<19	<23	<22	<22/<22	<20	<25	<100	<120	<120
Aroclor 1260	50	141	104	246	45	137	89	115/117	92	308	390	290	***840***
Total Organic Carbon (mg/kg)[c]		2,770	NA	NA	2,000	NA	NA	1,300	NA	NA	1,900	2,600	NA
Inorganics (mg/kg)													
Antimony	2	1.5	1.8	<1.5	2.1	<1.5	1.8	<1.4/<1.4	<1.3	3.5	1.5	<1.6	1.5
Arsenic	33	9.1	15.6	17.1	32.1	10.4	9.9	25.1/15.2	19.7	10.8	11.5	21.7	11.6
Beryllium		0.53 B	1.0 B	1.2 B	1.3 B	1.1 B	1.8 B	1.7B/2.0B	2.2 B	1.1 B	1.0 B	1.9 B	2.0 B
Cadmium	5	<0.28	<0.25	1.0	0.62	<0.3	1.0	0.86/0.85	1.2	1.2	1.0	0.97	1.3
Chromium	80	8.4	11.3	11.6	17.2	8.2	9.5	10.7/14.7	17.6	10.8	8.4	17.4	18.7
Copper		8.9	14.5	15.6	268	38.7	17.5	12/14.3	18.5	13.4	13.5	12.0	18.2
Lead	35	35.4	30.5	32.7	29.8	58.4	49.4	38.1/66.4	37.6	92.7	24.9	27.8	77.9
Mercury	0.15	0.046 B	0.058	0.064 B	0.14 B	0.096 B	0.11 B	0.083B/0.10B	0.087 B	0.10 B	0.11 B	0.11 B	0.11 B
Nickel	30	9.4	13.2	12.8	17.7	9.0	12.0	12.5/14.8	29.2	9.8	12.2	14.8	16.9
Selenium		<1.0	<0.90	<1.1	1.1	<1.1	2.8	<1.0/<1.0	1.4	<1.1	<0.93	<1.1	<1.1
Silver	1	<0.36	<0.31	<0.37	<0.31	<0.38	<0.34	<0.36/<0.36	<0.33	<0.39	<0.33	<0.40	<0.38
Thallium		<2.2	<1.9	<2.5	6.5	<2.6	<2.3	<2.4/2.5	5.3	<2.7	2.6	<2.7	<2.6
Zinc	120	592	154	538	121	595	293	539/465	597	827	164	557	512
Grain Size Analysis													
Percent Gravel		9.9	NA	NA	36.5	NA	NA	6.6	NA	NA	37.4	1.4	NA
Percent Sand		87.3	NA	NA	57.9	NA	NA	92.3	NA	NA	53.7	96.4	NA
Percent Silt		1.3	NA	NA	2.6	NA	NA	<1.1	NA	NA	6.4	1.2	NA
Percent Clay		1.5	NA	NA	3.0	NA	NA	<1.0	NA	NA	2.5	<1.0	NA
USCS Classification[d]		SP	NA	NA	SW-SM-SC	NA	NA	SP	NA	NA	SP-SM	SP	NA

AR302047

TABLE 1-3
SUPPLEMENTAL SEDIMENT SAMPLE RESULTS

Parameter	Screening Level Criteria[a]	SD-14E1A 10/29/98 0"-4"	SD-14E1B 10/29/98 6"-50"	SD-14M1A 10/29/98 0"-4"	SD-14M1B 10/29/98 6"-50"	SD-14E2A 10/29/98 0"-4"	SD-14E2B 10/29/98 6"-50"	SD-14E2[1/2]A 10/29/98 0"-4"	SD-14E2[1/2]B 10/29/98 6"-50"	SD-14W3A 10/29/98 0"-4"	SD-14W3B 10/29/98 6"-50"	SD-14W3[1/2]A 10/29/98 0"-4"
Polychlorinated Biphenyls (ug/kg)[b]												
Aroclor 1016	50	<290	<130	<160	<100	<17,000	<1,400	<1,200	<110	<28	<120	<27
Aroclor 1221	50	<290	<130	<160	<100	<17,000	<1,400	<1,200	<110	<28	<120	<27
Aroclor 1232	50	<290	<130	<160	<100	<17,000	<1,400	<1,200	<110	<28	<120	<27
Aroclor 1242	50	***950***	***440***	***520***	<100	<17,000	<1,400	<1,200	<110	<28	<120	<27
Aroclor 1248	50	<290	<130	<160	<100	<17,000	<1,400	<1,200	<110	<28	<120	<27
Aroclor 1254	50	<290	<130	<160	<100	<17,000	<1,400	<1,200	<110	<28	<120	<27
Aroclor 1260	50	***1,800***	***1,070***	***920***	***687***	***52,000***	***8,300***	***4,800***	***570***	302	***540***	273
Total Organic Carbon (mg/kg)[c]		NA	NA	10,500	NA	NA	NA	3,220	NA	6,500	2,700	5,900
Inorganics (mg/kg)												
Antimony	2	<2.7	<1.2	<1.5	<0.91	2.1	1.5	1.4	<1.0	<1.3	<1.1	<1.3
Arsenic	33	28.1	15.5	23.7	14.6	14.9	10.8	13.3	9.9	14.4	11.2	10.3
Beryllium		<0.23	<0.11	<0.13	0.47 B	<0.14	<0.11	<0.094	1.1 B	<0.11	0.092	<0.11
Cadmium	5	1.1 B	1.2	1.2	1.2	10.7	7.9	2.8	1.7	0.77	0.62	0.70
Chromium	80	21.0	28.4	18.5	18.5	42.9	25.2	19.0	8.8	8.2	9.3	8.9
Copper		28.9	26.9	21.1	21.9	170	135	67.5	26.8	14.2	21.2	15.6
Lead	35	58.0	54.5	51.2	32.3	96.0	70.5	31.5	23.7	38.5	33.7	34.2
Mercury	0.15	0.057	0.056	0.092	0.049	0.48	0.28	0.16	0.061	0.058	0.058	0.078
Nickel	30	19.7	13.5	15.8	11.9	22.3	16.1	33.6	9.8	11.1	12.3	11.0
Selenium		<2.7	<1.2	R	R	<1.6	<1.3	<1.1	<1.0	<1.3	<1.1	<1.3
Silver	1	<0.82	<0.38	<0.45	<0.28	5.7	4.4	1.0	0.40	<0.39	<0.33	<0.39
Thallium		<6.4	<2.9	<3.5	<2.2	<3.8	<3.1	<2.6	<2.4	<3.0	<2.5	<3.0
Zinc	120	***2,540***	1,000	***1,840***	350	732	501	232	159	322	227	344
Grain Size Analysis												
Percent Gravel		NA	NA	6.3	NA	NA	NA	17.1	NA	2.9	2.0	5.0
Percent Sand		NA	NA	72.6	NA	NA	NA	24.0	NA	82.4	85.9	83.8
Percent Silt		NA	NA	16.1	NA	NA	NA	30.9	NA	9.7	9.6	8.7
Percent Clay		NA	NA	5.0	NA	NA	NA	28.0	NA	5.0	2.5	2.5
USCS Classification[d]		NA	NA	SM	NA	NA	NA	CL-ML	NA	SM	SM	SP-SM

AR302648

TABLE 1-3
SUPPLEMENTAL SEDIMENT SAMPLE RESULTS

Parameter	Screening Level Criteria[a]	SD-14W3½B 10/29/98 6"-50"	SD-14W4A 10/29/98 0"-4"	SD-14W4B 10/29/98 6"-50"	SD-14W4½A 10/29/98 0"-4"	SD-14W4½B 10/29/98 6"-50"	SD-14E5A 10/30/98 0"-4"	SD-14E5B 10/30/98 6"-50"	SD-14W5A 10/30/98 0"-4"	SD-14W5B 10/30/98 6"-50"	SD-14W6A 10/30/98 0"-4"	SD-14W6B 10/30/98 6"-50"
Polychlorinated Biphenyls (ug/kg)[b]												
Aroclor 1016	50	<25/<120	<150	<130	<300	<1,300	<260	<240	<180	<180	<130	<110
Aroclor 1221	50	<25/<120	<150	<130	<300	<1,300	<260	<240	<180	<180	<130	<110
Aroclor 1232	50	<25/<120	<150	<130	<300	<1,300	<260	<240	<180	<180	<130	<110
Aroclor 1242	50	<25/<120	<150	<130	<300	<1,300	***2,010***	<240	<180	<180	<130	<110
Aroclor 1248	50	<25/<120	<150	<130	<300	<1,300	<260	<240	***530***	<180	<130	<110
Aroclor 1254	50	<25/<120	<150	<130	<300	<1,300	<260	<240	<180	<180	<130	<110
Aroclor 1260	50	***337/1,310***	***750***	***870***	***4,120***	***6,100***	***3,450***	***2,970***	***1,150***	***820***	***1,450***	450
Total Organic Carbon (mg/kg)[c]		NA/NA	6,000	NA	NA	11,800	NA	5,400	NA	NA	NA	5,100
Inorganics (mg/kg)												
Antimony	2	<1.1/<1.1	<1.3	<1.2	<1.4	<1.2	<1.2	***26.5***	<2.3	<2.3	<1.6	<1.4
Arsenic	33	10.7/11.2	12.4	10.5	14.4	11.9	15.3	12.9	8.7	11.7	6.4	5.2
Beryllium		0.59/0.62	0.56	0.53	0.84	0.74	0.62	1.0	0.76 B	1.1 B	0.76 B	0.62 B
Cadmium	5	1.3/2.7	0.91	0.87	1.4	1.2	1.2	<0.31	<0.47	<0.46	<0.33	<0.28
Chromium	80	11.7/11.8	9.7	10.3	17.4	14.6	18.0	31.0	15.1	28.8	10.3	6.9
Copper		25.1/19.7	25.7	16.6	26.6	22.6	14.7	39.4	19.8	25.0	14.7	16.1
Lead	35	57.4/63.2	47.9	50.4	61.3	51.7	37.5	44.6	75.6	58.1	29.2	15.1
Mercury	0.15	0.10/0.16	0.073	0.082	0.14	0.15	0.035	0.084	0.14	0.14	0.085	0.046
Nickel	30	11.5/11.8	11.8	11.4	21.9	16.3	11.7	12.1	15.8	16.9	12.1	8.5
Selenium		<1.1<1.1	<1.3	R	R	R	R	<1.1	<1.7	2.3	<1.2	<1.0
Silver	1	<0.35/<0.35	0.66	<0.36	0.52	0.42	<0.36	0.57	0.72	1.1	<0.42	<0.35
Thallium		<2.8/<2.7	<3.2	<2.8	<3.3	<3.0	<2.9	<2.3	<3.6	<3.5	<2.5	<2.1
Zinc	120	507/1,280	423	371	279	218	***1,400***	778	178	203	150	83.3
Grain Size Analysis												
Percent Gravel		NA/NA	1.7	NA	NA	8.1	NA	14.9	NA	NA	NA	34.1
Percent Sand		NA/NA	75.6	NA	NA	21.7	NA	75.7	NA	NA	NA	50.5
Percent Silt		NA/NA	19.7	NA	NA	58.7	NA	7.4	NA	NA	NA	12.4
Percent Clay		NA/NA	3.0	NA	NA	11.5	NA	2.0	NA	NA	NA	3.0
USCS Classification[d]		NA/NA	SM	NA	NA	ML	NA	SW-SM	NA	NA	NA	SM

AR302649

TABLE 1-3
SUPPLEMENTAL SEDIMENT SAMPLE RESULTS

Parameter	Screening Level Criteria[a]	SD-14W7A 10/30/98 0"-4"	SD-14W7B 10/30/98 6"-50"	SD-14W8A 10/30/98 0"-4"	SD-14W8B 10/30/98 6"-50"	SD-E23A 4/19/00 0"-48"	SD-E24A 4/19/00 0"-48"	SD-E25A 4/19/00 0"-6"	SD-E25B 4/19/00 6"-48"	SD-W20A 4/19/00 0"-24"	SD-W21A 4/19/00 0"-18"	SD-K20A 4/19/00 0"-24"
Polychlorinated Biphenyls (ug/kg)[b]												
Aroclor 1016	50	<130	<22	<140	<21	< 520	< 670	< 22	< 230	< 51	< 52	< 51
Aroclor 1221	50	<130	<22	<140	<21	< 520	< 670	< 22	< 230	< 51	< 52	< 51
Aroclor 1232	50	<130	<22	<140	<21	< 520	< 670	< 22	< 230	< 51	< 52	< 51
Aroclor 1242	50	<130	<22	<140	<21	< 520	< 670	< 22	< 230	< 51	< 52	< 51
Aroclor 1248	50	<130	<22	<140	<21	< 520	< 670	< 22	< 230	< 51	< 52	98
Aroclor 1254	50	<130	<22	<140	<21	***1,900***	***2,150***	60	***690***	119	64	132
Aroclor 1260	50	***610***	244	***540***	24	***3,650***	***6,000***	167	***1,820***	267	93	165
Total Organic Carbon (mg/kg)[c]		3,700	NA	NA	NA	6,200	9,000	830	7,800	3,000	2,040	3,500
Inorganics (mg/kg)												
Antimony	2	2.0	<1.4	<1.8	<1.4	< 20	< 31	< 26	< 27	< 20	< 20	< 20
Arsenic	33	6.2	13.4	11.5	9.9	16.2	24.4	12.3	18.4	14	19.7	19.3
Beryllium		0.58 B	0.87 B	0.70 B	1.3 B	1.4	0.81	0.87	1.16	0.75	0.78	0.82
Cadmium	5	<0.32	<0.28	<0.35	<0.27	< 2.0	< 3.1	< 2.6	< 2.7	< 2.0	< 2.0	3.1
Chromium	80	7.5	6.3	12.9	6.2	39.8	20.9	19.2	21.7	88.6	23.9	21.5
Copper		14.9	20.9	16.3	42.1	27.6	79	33.8	43.8	22.2	27.9	71.7
Lead	35	29.6	25.5	130	24.5	***669***	47.5	23.6	29.8	147	74.0	59.0
Mercury	0.15	0.072	0.033	0.11	0.042 B	0.102	0.16	0.59	< 0.13	< 0.1	< 0.098	< 0.099
Nickel	30	8.6	7.4	14.2	7.2	14.9	22.6	31	22.8	63.3	19.8	15.7
Selenium		<1.2	<1.0	<1.3	<0.98	< 1.0	< 1.6	< 1.3	< 1.3	< 1.0	< 1.0	< 1.0
Silver	1	<0.41	<0.36	0.66	<0.34	< 2.0	< 3.1	< 2.6	< 2.7	< 2.0	< 2.0	< 2.0
Thallium		<2.5	<2.2	<2.7	<2.1	4.8	< 3.1	3.0	4.1	< 2.0	2.1	< 2.0
Zinc	120	291	148	296	76.7	390	330	113	201	176	183	519
Grain Size Analysis												
Percent Gravel		8.7	NA	NA	NA	NA	NA	27.3	NA	NA	NA	NA
Percent Sand		74.1	NA	NA	NA	NA	NA	19.4	NA	NA	NA	NA
Percent Silt		14.7	NA	NA	NA	NA	NA	21.3	NA	NA	NA	NA
Percent Clay		2.5	NA	NA	NA	NA	NA	32.0	NA	NA	NA	NA
USCS Classification[d]		SM	NA	NA	NA	GP	CH/OH[h]	CH/OH	CH/OH[h]	GP	GP	GP

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TABLE 1-3
SUPPLEMENTAL SEDIMENT SAMPLE RESULTS

Parameter	Screening Level Criteria[a]	SD-15W1A 10/27/98 0"-4"	SD-15W1B 10/27/98 6"-50"	SD-15E2A 10/27/98 0"-4"	SD-15E2B 10/27/98 6"-50"	SD-15W2A 10/27/98 0"-4"	SD-15W2B 10/27/98 6"-50"	SD-15E3A 10/27/98 0"-4"	SD-15E3B 10/27/98 6"-50"	SD-15W3A 10/27/98 0"-4"	SD-15W3B 10/27/98 6"-50"	SD-15E4A 10/27/98 0"-4"	SD-15E4B 10/27/98 6"-50"
Polychlorinated Biphenyls (ug/kg)[b]													
Aroclor 1016	50	<25	<20	<22	<22	<23	<19	<1,100	<210	<25	<19	<1,700	<1,100/<1,200
Aroclor 1221	50	<25	<20	<22	<22	<23	<19	<1,100	<210	<25	<19	<1,700	<1,100/<1,200
Aroclor 1232	50	<25	<20	<22	<22	<23	<19	<1,100	<210	<25	<19	<1,700	<1,100/<1,200
Aroclor 1242	50	<25	<20	<22	<22	<23	<19	<1,100	<210	<25	<19	<1,700	<1,100/<1,200
Aroclor 1248	50	<25	<20	<22	<22	<23	<19	<1,100	<210	<25	<19	<1,700	<1,100/<1,200
Aroclor 1254	50	<25	<20	<22	46	<23	<19	<1,100	<210	<25	<19	***12,300***	<1,100/<1,200
Aroclor 1260	50	192	27	235	33	113	<19	***3,900***	***600***	75	<19	***11,800***	***5,100/8,000***
Total Organic Carbon (mg/kg)[c]		2,460	NA	NA	NA	NA	670	1,560	NA	NA	780	NA	NA/NA
Inorganics (mg/kg)													
Antimony	2	<1.6	2.6	<1.4	<1.4	<1.5	1.4	2.8	1.6	<1.6	<1.2	<5.3	2.7/3.9
Arsenic	33	9.2	25.9	4.4	3.0	7.9	12.8	35.1	18.8	8.2	10.2	33.3	12.3/13.2
Beryllium		0.36 B	0.79 B	0.46 B	<0.049	<0.052	0.73 B	0.24 B	<0.046	0.10 B	0.63 B	1.5	2.7/2.6
Cadmium	5	<0.32	<0.26	1.3	<0.28	<0.30	<0.24	<0.30	<0.27	<0.32	<0.25	<1.1	3.1/1.6
Chromium	80	5.4	8.7	16.5	1.7	5.3	7.1	98.4	13.2	6.7	10.6	86.7	199/269
Copper		8.2	13.7	15.2	3.4	13.4	9.5	44.7	19.9	9.6	10.4	73.9	64.4/145
Lead	35	17.7	129	117	37.7	49.4	13.1	90.8	18.8	20.7	22.1	226	134/96.1
Mercury	0.15	<0.020	<0.017	0.021 B	0.10	0.038 B	<0.017	0.097	0.031 B	<0.023	<0.016	0.13	0.044B/0.24
Nickel	30	7.0	23.7	11.4	3.7	6.3	10	8.9	9.6	7.9	22.0	45.7	25.9/34.4
Selenium		<1.2	2.5	<1.0	<1.0	<1.1	1.7	3.2	1.8	<1.2	1.0	<3.8	2.2/2.7
Silver	1	<0.41	<0.33	<0.36	<0.36	<0.38	<0.31	2.1	<0.34	<0.40	<0.32	<1.3	1.5/2.6
Thallium		<2.8	<2.2	<2.4	<2.5	<2.6	3.3	<2.5	2.7	2.8	<2.1	<9.3	<2.4/<2.6
Zinc	120	214	677	***1,580***	223	185	124	***1,220***	129	224	513	***20,100***	***4,910/4,350***
Grain Size Analysis													
Percent Gravel		4.4	NA	NA	NA	NA	44.1	43.2	NA	NA	39.9	NA	NA/NA
Percent Sand		90.3	NA	NA	NA	NA	49.3	48.5	NA	NA	52.8	NA	NA/NA
Percent Silt		4.3	NA	NA	NA	NA	5.6	5.3	NA	NA	5.8	NA	NA/NA
Percent Clay		1.0	NA	NA	NA	NA	1.0	3.0	NA	NA	1.5	NA	NA/NA
USCS Classification[d]		SP-SM	NA	NA	NA	NA	SP-SM	SW-SM	NA	NA	SW-SM	NA	NA/NA

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TABLE 1-3
SUPPLEMENTAL SEDIMENT SAMPLE RESULTS

Parameter	Screening Level Criteria[a]	SD-15E4½A 10/27/98 0"-4"	SD-15E4½B 10/27/98 6"-50"	SD-15E5A 10/28/98 0"-4"	SD-15E5B 10/28/98 6"-50"	SD-15M5A 10/28/98 0"-4"	SD-15M5B 10/28/98 6"-50"	SD-15E6A 10/28/98 0"-4"	SD-15E6B 10/28/98 6"-50"	SD-15M6A 10/28/98 0"-4"	SD-15M6B 10/28/98 6"-50"
Polychlorinated Biphenyls (ug/kg)[b]											
Aroclor 1016	50	<1,300	<230	<270	<21	<26	<20	<26	<210	<32	<230
Aroclor 1221	50	<1,300	<230	<270	<21	<26	<20	<26	<210	<32	<230
Aroclor 1232	50	<1,300	<230	<270	<21	<26	<20	<26	<210	<32	<230
Aroclor 1242	50	***6,600***	***640***	***3,740***	<21	<26	<20	<26	<210	<32	<230
Aroclor 1248	50	<1,300	<230	<270	<21	<26	<20	<26	<210	<32	<230
Aroclor 1254	50	<1,300	<230	<270	<21	61	75	<26	<210	<32	<230
Aroclor 1260	50	***6,900***	***660***	***3,300***	37	89	149	406	<210	117	***2,630***
Total Organic Carbon (mg/kg)[c]		4,900	NA	5,500	NA	1,890	NA	NA	5,200	6,800	NA
Inorganics (mg/kg)											
Antimony	2	3.5	<1.5	1.8	2.1	2.5	<1.3	3.0	1.1 B	1.4 B	1.0 B
Arsenic	33	14.7	5.1	10.3	8.0	13.8	12.3	14.5	6.3	15.8	9.3
Beryllium		2.5	0.63 B	1.4	1.8	0.48 B	1.1 B	1.3	1.5	0.77 B	0.79 B
Cadmium	5	5.1	4.4	<0.35	17.8	<0.34	<0.26	<0.30	<0.25	<0.37	<0.27
Chromium	80	73.1	113	64.0	67.1	12.2	8.1	16.4	12.9	10.8	10.0
Copper		115	441	23.4	383	8.7	17.9	25.7	48.9	11.2	10.1
Lead	35	144	32.6	60.6	55.5	23.5	17.5	233	21.4	29.5	25.6
Mercury	0.15	0.064	0.12	0.029 B	0.3	<0.020	<0.018	0.15 B	0.043 B	0.10 B	0.045 B
Nickel	30	20.1	7.1	16.7	25.3	10.2	14.6	15.7	14.3	13.0	11.4
Selenium		3.2	1.2	1.6	2.7	<1.2	1.8	<1.2	<1.0	<1.5	<1.1
Silver	1	<0.44	<0.38	<0.44	<0.35	<0.43	<0.33	0.90	0.39	<0.45	<0.33
Thallium		<3.0	<2.6	5.7	<2.4	5.4	<2.2	<2.8	<2.3	<3.5	<2.6
Zinc	120	***5,060***	870	***3,120***	***3,090***	305	1,010	492	99.4	160	105
Grain Size Analysis											
Percent Gravel		54.5	NA	37.2	NA	0.1	NA	NA	36.2	0.1	NA
Percent Sand		39.9	NA	55.2	NA	89.9	NA	NA	57.7	81.4	NA
Percent Silt		<5.6	NA	6.1	NA	7.5	NA	NA	5.1	11.5	NA
Percent Clay		<1.0	NA	1.5	NA	2.5	NA	NA	<1.0	7.0	NA
USCS Classification[d]		GW-GM	NA	SW-SM	NA	SP-SM	NA	NA	SW-SM	SM	NA

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TABLE 1-3
SUPPLEMENTAL SEDIMENT SAMPLE RESULTS

Parameter	Screening Level Criteria[a]	SD-17E1A 10/28/98 0"-4"	SD-17E1B 10/28/98 6"-50"	SD-17E2A 10/28/98 0"-4"	SD-17E2B 10/28/98 6"-50"	SD-17E3A 10/28/98 0"-4"	SD-17E3B 10/28/98 6"-50"	SD-17E4A 10/28/98 0"-4"	SD-17E4B 10/28/98 6"-50"
Polychlorinated Biphenyls (ug/kg)[b]									
Aroclor 1016	50	<25	<21	<25/<25	<20	<24	<19	<130	<20
Aroclor 1221	50	<25	<21	<25/<25	<20	<24	<19	<130	<20
Aroclor 1232	50	<25	<21	<25/<25	<20	<24	<19	<130	<20
Aroclor 1242	50	<25	<21	<25/<25	<20	<24	<19	<130	<20
Aroclor 1248	50	<25	<21	<25/<25	<20	<24	<19	<130	<20
Aroclor 1254	50	<25	<21	<25/<25	<20	<24	<19	<130	<20
Aroclor 1260	50	133	252	150/123	<20	114	<19	***620***	<20
Total Organic Carbon (mg/kg)[c]		NA	2,160	2,500/NA	NA	NA	NA	3,600	NA
Inorganics (mg/kg)									
Antimony	2	<1.0	<0.88	<1.0/<1.0	<0.84	<1.0	<0.80	1.3 B	<0.83
Arsenic	33	7.4	7.1	8.7/8.5	6.2	8.1	7.1	8.2	15.9
Beryllium		0.48 B	1.2	0.50B/0.44B	0.87	0.44 B	1.2	0.39 B	1.1
Cadmium	5	<0.29	<0.24	<0.28/<0.28	<0.23	<0.28	<0.22	<0.29	<0.23
Chromium	80	6.3	6.9	8.8/8.0	7.0	7.6	7.8	6.3	7.2
Copper		4.9	7.2	8.0/7.9	9.2	6.0	4.7	7.8	8.5
Lead	35	15.8	12.2	22.6/19.3	7.7	16.0	8.0	24.9	10.8
Mercury	0.15	0.040 B	0.057 B	0.14B/0.15B	0.041 B	0.048 B	0.031 B	0.058 B	0.064 B
Nickel	30	7.6	9.6	9.9/9.4	9.7	8.6	5.7	7.7	9.3
Selenium		<1.2	<0.97	<1.1/<1.1	<0.93	<1.1	<0.89	<1.2	<0.92
Silver	1	<0.35	<0.29	<0.34/<0.34	<0.28	<0.34	<0.27	<0.35	<0.28
Thallium		<2.7	<2.3	<2.7/<2.7	<2.2	<2.7	<2.1	<2.8	<2.2
Zinc	120	98.3	57.9	162/139	40.9	104	51.4	191	61.9
Grain Size Analysis									
Percent Gravel		NA	36.7	0.0/NA	NA	NA	NA	4.5	NA
Percent Sand		NA	55.5	92.3/NA	NA	NA	NA	84.5	NA
Percent Silt		NA	6.3	5.7/NA	NA	NA	NA	9.0	NA
Percent Clay		NA	1.5	2.0/NA	NA	NA	NA	2.0	NA
USCS Classification[d]		NA	SP-SM	SP-SM/NA	NA	NA	NA	SP-SM	NA

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TABLE 1-3
SUPPLEMENTAL SEDIMENT SAMPLE RESULTS

Notes:

a. Screening level criteria are for Effects Range - Low (Long and Morgan, 1991), as described in the Screening Level Eco-Risk Assessment (ChemRisk, 1997).

b. "ug/kg" is micrograms per kilogram or parts per billion, dry weight.

c. "mg/kg" is milligrams per kilogram or parts per million, dry weight.

d. USCS is United Soil Classification System, as described in Holtz, R.D. and W.D. Kovacs, An Introduction to Geotechnical Engineering, New Jersey, Prentice-Hall, Inc., 1981.

GW=well-graded gravel	SM=silty sand	CL=silty clay
SW=well-graded sand	SC=clayey sand	ML=clayey silt
SP=poorly-graded sand		

e. "<" denotes sample concentration is less than the quantitation limit.

f. Reported concentrations result in Ecological Effects Quotients (EEQs) in the following ranges, as defined in the Screening-Level ERA:

EEQ > 100	Extreme risk to ecological receptors
100 > EEQ > 10	Moderate-high potential risk to eco. receptors
10 > EEQ > 1	Potential risk to ecological receptors
EEQ < 1	No risk to ecological receptors

g. "B" indicates compound was not detected substantially above the level reported in a corresponding laboratory or field blank sample.
"R" indicates the data was rejected as unusable.

h. Samples SD-E24A and SD-E25B were not analyzed for grain-size distribution due to insufficient volume. Based on visual observations, these samples appeared to have a similar composition as SD-E25A (primarily stiff clay with some sand/gravel).

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TABLE 1-4
SUPPLEMENTAL STREAM BANK/RIPARIAN SAMPLE RESULTS

Parameter / Sample ID:	SB-12-1	SB-12-2	SB-12-3	SB-12-4	SB-12-5	SB-13-1	SB-13-2	SB-13-4	SB-13-5
Date:	11/3/98	11/3/98	11/3/98	11/3/98	11/3/98	11/2/98	11/2/98	11/2/98	11/2/98
Sample Depth:	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"
Polychlorinated Biphenyls (ug/kg)[a]									
Aroclor 1016	<200[c]	<200	<97	<110	<19	<22	<20 / <20	<20	<20
Aroclor 1221	<200	<200	<97	<110	<19	<22	<20 / <20	<20	<20
Aroclor 1232	<200	<200	<97	<110	<19	<22	<20 / <20	<20	<20
Aroclor 1242	<200	<200	<97	<110	<19	160	62 / 79	<20	<20
Aroclor 1248	<200	<200	<97	<110	<19	<22	<20 / <20	<20	<20
Aroclor 1254	<200	<200	<97	<110	<19	<22	<20 / <20	<20	<20
Aroclor 1260	360	530	297	380	137	227	137 / 147	173	109
Total Organic Carbon (mg/kg)[b]	NA	1,780	NA	6,400	NA	6,300	NA / NA	6,800	NA
Inorganics (mg/kg)									
Antimony	<0.85	<0.85	<0.82	<0.97	1.0	<1.6	6.1 / 1.6	1.6	3.5
Arsenic	8.3	9.7	18.6	12.3	16.4	10.3	17.2 / 16.7	11.6	44.2
Beryllium	1.5	1.4	0.77	0.90	0.71	1.2 B	1.2B / 1.2B	2.6 B	1.8 B
Cadmium	1.4	1.1	1.2	1.1	1.1	<0.29	<0.26 / <0.26	<0.27	<0.26
Chromium	37.4	16.6	12.5	13.8	11.2	165	7.1 / 11.2	11.2	142
Copper	29.5	18.7	16.2	16.5	16.9	11.1	19.3 / 14.2	73.9	175
Lead	61.1	76.8	29.9	86.2	35.5	33.7	42.6 / 27.6	102	238
Mercury	0.12 B[d]	0.12 B	0.11 B	0.13 B	0.11 B	0.075 B	0.092B / 0.071B	0.2	0.1 B
Nickel	20.5	18.1	15.1	13.1	13.6	9.4	11.9 / 12.5	19.0	69.4
Selenium	<0.92	<0.92	<0.89	<1.0	<0.86	<1.0	<0.93 / <0.94	<0.96	2.6
Silver	<0.28	<0.28	<0.27	<0.32	<0.27	<0.37	<0.33 / <0.33	<0.34	<0.33
Thallium	<2.2	<2.2	<2.2	3.3	<2.1	<2.5	<2.2 / 2.4	2.4	9.3
Zinc	319	225	483	436	396	499	500 / 491	239	424
Grain Size Analysis									
Percent Gravel	NA	24.9	NA	11.9	NA	29.2	NA / NA	35.6	NA
Percent Sand	NA	73.3	NA	82.6	NA	66.5	NA / NA	54.4	NA
Percent Silt	NA	<2	NA	3.5	NA	2.8	NA / NA	6.0	NA
Percent Clay	NA	<1	NA	2.0	NA	1.5	NA / NA	4.0	NA
USCS Classification[e]	NA	SW	NA	SP-SM	NA	SP	NA / NA	SW-SM	NA

AR302655

CUMMINGS RITER

TABLE 1-4
SUPPLEMENTAL STREAM BANK/RIPARIAN SAMPLE RESULTS

Parameter / Sample ID:	SB-12-1	SB-12-2	SB-12-3	SB-12-4	SB-12-5	SB-13-1	SB-13-2	SB-13-4	SB-13-5
Date:	11/3/98	11/3/98	11/3/98	11/3/98	11/3/98	11/2/98	11/2/98	11/2/98	11/2/98
Sample Depth:	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"	0"-6"
Polychlorinated Biphenyls (ug/kg)[a]									
Aroclor 1016	<200[c]	<200	<97	<110	<19	<22	<20 / <20	<20	<20
Aroclor 1221	<200	<200	<97	<110	<19	<22	<20 / <20	<20	<20
Aroclor 1232	<200	<200	<97	<110	<19	<22	<20 / <20	<20	<20
Aroclor 1242	<200	<200	<97	<110	<19	160	62 / 79	<20	<20
Aroclor 1248	<200	<200	<97	<110	<19	<22	<20 / <20	<20	<20
Aroclor 1254	<200	<200	<97	<110	<19	<22	<20 / <20	<20	<20
Aroclor 1260	360	530	297	380	137	227	137 / 147	173	109
Total Organic Carbon (mg/kg)[b]	NA	1,780	NA	6,400	NA	6,300	NA / NA	6,800	NA
Inorganics (mg/kg)									
Antimony	<0.85	<0.85	<0.82	<0.97	1.0	<1.6	6.1 / 1.6	1.6	3.5
Arsenic	8.3	9.7	18.6	12.3	16.4	10.3	17.2 / 16.7	11.6	44.2
Beryllium	1.5	1.4	0.77	0.90	0.71	1.2 B	1.2B / 1.2B	2.6 B	1.8 B
Cadmium	1.4	1.1	1.2	1.1	1.1	<0.29	<0.26 / <0.26	<0.27	<0.26
Chromium	37.4	16.6	12.5	13.8	11.2	165	7.1 / 11.2	11.2	142
Copper	29.5	18.7	16.2	16.5	16.9	11.1	19.3 / 14.2	73.9	175
Lead	61.1	76.8	29.9	86.2	35.5	33.7	42.6 / 27.6	102	238
Mercury	0.12 B[d]	0.12 B	0.11 B	0.13 B	0.11 B	0.075 B	0.092B / 0.071B	0.2	0.1 B
Nickel	20.5	18.1	15.1	13.1	13.6	9.4	11.9 / 12.5	19.0	69.4
Selenium	<0.92	<0.92	<0.89	<1.0	<0.86	<1.0	<0.93 / <0.94	<0.96	2.6
Silver	<0.28	<0.28	<0.27	<0.32	<0.27	<0.37	<0.33 / <0.33	<0.34	<0.33
Thallium	<2.2	<2.2	<2.2	3.3	<2.1	<2.5	<2.2 / 2.4	2.4	9.3
Zinc	319	225	483	436	396	499	500 / 491	239	424
Grain Size Analysis									
Percent Gravel	NA	24.9	NA	11.9	NA	29.2	NA / NA	35.6	NA
Percent Sand	NA	73.3	NA	82.6	NA	66.5	NA / NA	54.4	NA
Percent Silt	NA	<2	NA	3.5	NA	2.8	NA / NA	6.0	NA
Percent Clay	NA	<1	NA	2.0	NA	1.5	NA / NA	4.0	NA
USCS Classification[c]	NA	SW	NA	SP-SM	NA	SP	NA / NA	SW-SM	NA

AR302656

TABLE 1-4
SUPPLEMENTAL STREAM BANK/RIPARIAN SAMPLE RESULTS

Parameter / Sample ID:	SB-14-1	SB-14-2	SB-14-3	SB-15-1	SB-15-2	SB-15-3	SB-17-1	SB-17-2
Date:	10/30/98	10/30/98	10/30/98	10/28/98	10/28/98	10/28/98	10/28/98	10/28/98
Sample Depth:	0"-6"	0"-6"	0"-6"	0"-4"	0"-4"	0"-4"	0"-4"	0"-4"
Polychlorinated Biphenyls (ug/kg)[a]								
Aroclor 1016	<130 / <130	<120	<120	<1,400	<4,000	<13,000 / <13,000	<21	<28
Aroclor 1221	<130 / <130	<120	<120	<1,400	<4,000	<13,000 / <13,000	<21	<28
Aroclor 1232	<130 / <130	<120	<120	<1,400	<4,000	<13,000 / <13,000	<21	<28
Aroclor 1242	<130 / <130	<120	<120	<1,400	26,900	<13,000 / <13,000	<21	<28
Aroclor 1248	<130 / <130	<120	<120	<1,400	<4,000	<13,000 / <13,000	<21	<28
Aroclor 1254	<130 / <130	<120	<120	4,800	<4,000	<13,000 / <13,000	<21	<28
Aroclor 1260	1,230 / 1,140	890	760	5,100	13,000	22,000 / 14,000	95	316
Total Organic Carbon (mg/kg)[b]	NA / NA	NA	11,000	NA	12,800	NA / NA	NA	9,900
Inorganics (mg/kg)								
Antimony	2.5 / <1.7	2.3	<1.5	4.4 B	4.6B	1.7B / 3.3B	<0.86	1.3B
Arsenic	9.1 / 9.9	12.6	8.9	11.7	17.4	15.7 / 16.2	8.4	10.1
Beryllium	0.74B / 0.71B	0.86 B	0.68 B	0.25 B	1.2B	0.99 / 1.1	0.56B	0.54B
Cadmium	<0.34 / <0.33	<0.31	0.34	<0.32	<0.45	<0.3 / <0.30	<0.24	<0.32
Chromium	15.5 / 14.7	21.9	14.3	278	317	91.0 / 150	8.7	10.3
Copper	17.0 / 16.1	19.7	14.3	66.9	331	47.4 / 74.6	12.3	13.3
Lead	49.7 / 49.8	63.2	57.1	48.7	137	111 / 111	37.7	39.3
Mercury	0.13 / 0.14	0.14	0.10	0.14 B	0.18 B	0.11B / 0.14B	0.067B	0.093B
Nickel	20.1 / 19.8	22.9	17.4	48.9	58.8	28.7 / 41.3	12.3	12.5
Selenium	<1.2 / 1.8	<1.1	<1.1	<6.5	4.1	<1.2 / 2.6	<0.96	<1.3
Silver	0.44 / <0.43	0.41	0.41	0.87	1.8	0.37 / 0.38	<0.29	<0.39
Thallium	2.7 / 4.0	<2.4	<2.3	15.6	<4.2	<2.9 / <2.8	<2.3	<3.0
Zinc	550 / 545	675	866	922	16,500	5,560 / 8,440	579	248
Grain Size Analysis								
Percent Gravel	NA / NA	NA	0.3	NA	0.1	NA / NA	NA	0.2
Percent Sand	NA / NA	NA	35.1	NA	20.3	NA / NA	NA	69.2
Percent Silt	NA / NA	NA	54.1	NA	74.6	NA / NA	NA	24.6
Percent Clay	NA / NA	NA	10.5	NA	5.0	NA / NA	NA	6.0
USCS Classification[c]	NA / NA	NA	ML	NA	ML	NA / NA	NA	SM

Notes:

a. "ug/kg" is micrograms per kilogram or parts per billion.

b. "mg/kg" is milligrams per kilogram or parts per million.

c. "<" denotes that sample concentration is less than the

e. USCS is United Soil Classification System, as described in Holtz,R.D. & W.D.Kovacs, An Introduction to Geotechnical Engineering, New Jersey, Prentice-Hall, Inc., 1981.

CUMMINGS RITER

AR302657

TABLE 1-4
SUPPLEMENTAL STREAM BANK/RIPARIAN SAMPLE RESULTS

Parameter / Sample ID:	SB-14-1	SB-14-2	SB-14-3	SB-15-1	SB-15-2	SB-15-3	SB-17-1	SB-17-2
Date:	10/30/98	10/30/98	10/30/98	10/28/98	10/28/98	10/28/98	10/28/98	10/28/98
Sample Depth:	0"-6"	0"-6"	0"-6"	0"-4"	0"-4"	0"-4"	0"-4"	0"-4"
Polychlorinated Biphenyls (ug/kg)[a]								
Aroclor 1016	<130 / <130	<120	<120	<1,400	<4,000	<13,000 / <13,000	<21	<28
Aroclor 1221	<130 / <130	<120	<120	<1,400	<4,000	<13,000 / <13,000	<21	<28
Aroclor 1232	<130 / <130	<120	<120	<1,400	<4,000	<13,000 / <13,000	<21	<28
Aroclor 1242	<130 / <130	<120	<120	<1,400	26,900	<13,000 / <13,000	<21	<28
Aroclor 1248	<130 / <130	<120	<120	<1,400	<4,000	<13,000 / <13,000	<21	<28
Aroclor 1254	<130 / <130	<120	<120	4,800	<4,000	<13,000 / <13,000	<21	<28
Aroclor 1260	1,230 / 1,140	890	760	5,100	13,000	22,000 / 14,000	95	316
Total Organic Carbon (mg/kg)[b]	NA / NA	NA	11,000	NA	12,800	NA / NA	NA	9,900
Inorganics (mg/kg)								
Antimony	2.5 / <1.7	2.3	<1.5	4.4 B	4.6B	1.7B / 3.3B	<0.86	1.3B
Arsenic	9.1 / 9.9	12.6	8.9	11.7	17.4	15.7 / 16.2	8.4	10.1
Beryllium	0.74B / 0.71B	0.86 B	0.68 B	0.25 B	1.2B	0.99 / 1.1	0.56B	0.54B
Cadmium	<0.34 / <0.33	<0.31	0.34	<0.32	<0.45	<0.3 / <0.30	<0.24	<0.32
Chromium	15.5 / 14.7	21.9	14.3	278	317	91.0 / 150	8.7	10.3
Copper	17.0 / 16.1	19.7	14.3	66.9	331	47.4 / 74.6	12.3	13.3
Lead	49.7 / 49.8	63.2	57.1	48.7	137	111 / 111	37.7	39.3
Mercury	0.13 / 0.14	0.14	0.10	0.14 B	0.18 B	0.11B / 0.14B	0.067B	0.093B
Nickel	20.1 / 19.8	22.9	17.4	48.9	58.8	28.7 / 41.3	12.3	12.5
Selenium	<1.2 / 1.8	<1.1	<1.1	<6.5	4.1	<1.2 / 2.6	<0.96	<1.3
Silver	0.44 / <0.43	0.41	0.41	0.87	1.8	0.37 / 0.38	<0.29	<0.39
Thallium	2.7 / 4.0	<2.4	<2.3	15.6	<4.2	<2.9 / <2.8	<2.3	<3.0
Zinc	550 / 545	675	866	922	16,500	5,560 / 8,440	579	248
Grain Size Analysis								
Percent Gravel	NA / NA	NA	0.3	NA	0.1	NA / NA	NA	0.2
Percent Sand	NA / NA	NA	35.1	NA	20.3	NA / NA	NA	69.2
Percent Silt	NA / NA	NA	54.1	NA	74.6	NA / NA	NA	24.6
Percent Clay	NA / NA	NA	10.5	NA	5.0	NA / NA	NA	6.0
USCS Classification[c]	NA / NA	NA	ML	NA	ML	NA / NA	NA	SM

detection limit.

d. "B" indicates compound was not detected substantially above the level reported in a corresponding laboratory or field blank sample.

SM=silty sand SW=well-graded sand
ML=clayey silt SP=poorly-graded sand

CUMMINGS CENTER

AR302658

TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	M-1		M-2		M-4A		M-5	M-6	M-7	M-8	M-10
Collection Date:	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/92	7/92	7/92	7/92
Volatile Organics (ug/l)											
Chloromethane	20 U	10 U	1000 U	500 U	10 U	10 U	10 U	10 U	500 U	10 U	1000 U
Bromomethane	20 U	10 U	1000 U	500 U	10 U	10 U	10 U	10 U	500 U	10 U	1000 U
Vinyl Chloride	20 UJ	10 U	1000 UJ	500 U	10 U	10 U	10 UJ	10 U	500 UJ	10 U	1000 UJ
Chloroethane	20 U	10 U	1000 U	500 U	10 U	10 U	10 U	10 U	500 U	10 U	1000 U
Methylene Chloride	12 JB	16 B	980 J	3,100 B	10 U	14 B	2.8 JB	10 U	460 BJ	6.8 BJ	980 J
Acetone	100 U	10 U	5000 U	590 B	50 U	7 BJ	50 U	50 U	2500 U	50 U	5000 U
Carbon Disulfide	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
1,1-Dichloroethene	10 UJ	10 U	500 UJ	500 U	5.0 U	10 U	5.0 UJ	5.0 U	250 U	5.0 U	500 UJ
1,1-Dichloroethane	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 UJ	250 UJ	5.0 UJ	500 U
1,2-Dichloroethene (total)	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
Chloroform	10 UJ	10 U	500 UJ	500 U	5.0 U	10 U	5.0 UJ	5.0 U	250 UJ	5.0 U	500 UJ
1,2-Dichloroethane	10 UJ	10 U	500 UJ	500 U	5.0 U	10 U	5.0 UJ	5.0 U	250 UJ	5.0 U	500 UJ
2-Butanone	100 U	10 U	5000 U	500 U	50 U	10 U	50 U	50 U	2500 U	50 U	5000 U
1,1,1-Trichloroethane	10 UJ	10 U	500 UJ	500 U	5.0 U	10 U	5.0 UJ	5.0 U	250 U	5.0 U	500 UJ
Carbon Tetrachloride	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
Bromodichloromethane	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
1,2-Dichloropropane	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
cis-1,3-Dichloropropene	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
Trichloroethene	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
Dibromochloromethane	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
1,1,2-Trichloroethane	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
Benzene	20 B	8 J	500 U	200 J	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	340 J
trans-1,3-Dichloropropene	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
Bromoform	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
4-Methyl-2-Pentanone	100 U	10 U	5000 U	500 U	50 U	10 U	50 U	50 U	2500 U	50 U	5000 U
2-Hexanone	100 R	10 U	5000 R	500 U	50 U	10 U	50 R	50 U	2500 R	50 U	5000 R
Tetrachloroethene	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
1,1,2,2-Tetrachloroethane	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
Toluene	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
Chlorobenzene	140	100	1300	5400	5.0 U	10 U	160	5.0 U	1600	5.0 U	2200
Ethylbenzene	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
Styrene	10 U	10 U	500 U	500 U	5.0 U	10 U	5.0 U	5.0 U	250 U	5.0 U	500 U
Xylenes (total)	10 UJ	10 U	500 UJ	500 U	5.0 UJ	10 U	5.0 UJ	5.0 UJ	250 UJ	5.0 UJ	500 UJ

AR302659

TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	M-1		M-2		M-4A		M-5	M-6	M-7	M-8	M-10
Collection Date:	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/92	7/92	7/92	7/92
Semivolatile Organics (ug/l)											
Phenol	2400 UJ	10 U	3200 UJ	10 U	2.6 BJ	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
bis(2-Chloroethyl) ether	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2-Chlorophenol	2400 UJ	10 U	3200 UJ	3 J	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
1,3-Dichlorobenzene	2400 R	78	3200 UJ	3 J	11 U	10 U	72 J	1000 U	1400 J	11 U	150,000 J
1,4-Dichlorobenzene	2400 R	49	3200 UJ	16	11 U	10 U	24 J	1000 U	2500 J	11 U	250,000 J
1,2-Dichlorobenzene	260 J	170 D	3200 UJ	10 U	11 U	10 U	4.9 J	1000 U	2200 UJ	11 U	570,000 UJ
2-Methylphenol	2400 UJ	2 J	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2,2'-oxybis-1-Chloropropane	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
4-Methylphenol	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
N-Nitroso-di-n-propylamine	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Hexachloroethane	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Nitrobenzene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Isophorone	2400 UJ	10 U	3200 UJ	3 J	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2-Nitrophenol	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2,4-Dimethylphenol	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
bis(2-Chloroethoxy) methane	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2,4-Dichlorophenol	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
1,2,4-Trichlorobenzene	8200 J	3700 D	3200 UJ	10 U	11 U	10 U	23 J	1000 U	1100 J	11 U	1,200,000 J
Naphthalene	2400 UJ	10 U	3200 UJ	3 J	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
4-Chloroaniline	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Hexachlorobutadiene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
4-Chloro-3-methylphenol	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2-Methylnaphthalene	2400 UJ	10 U	3200 UJ	6 J	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Hexachlorocyclopentadiene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2,4,6-Trichlorophenol	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2,4,5-Trichlorophenol	2400 UJ	25 U	3200 UJ	25 U	11 U	25 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2-Chloronaphthalene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2-Nitroaniline	5900 UJ	25 U	8000 UJ	25 U	27 U	25 U	31 UJ	2500 U	5400 UJ	27 U	1400000 UJ
Dimethylphthalate	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Acenaphthylene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2,6-Dinitrotoluene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
3-Nitroaniline	5900 UJ	25 U	8000 UJ	25 U	27 U	25 U	31 UJ	2500 U	5400 UJ	27 U	1400000 UJ
Acenaphthene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ

AR302660

TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	M-1		M-2		M-4A		M-5	M-6	M-7	M-8	M-10
Collection Date:	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/92	7/92	7/92	7/92
2,4-Dinitrophenol	5900 UJ	25 U	8000 UJ	25 U	27 U	25 U	31 UJ	2500 U	5400 UJ	27 U	1400000 UJ
4-Nitrophenol	5900 UJ	25 U	8000 UJ	25 U	27 U	25 U	31 UJ	2500 U	5400 UJ	27 U	1400000 UJ
Dibenzofuran	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
2,4-Dinitrotoluene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Diethylphthalate	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
4-Chlorophenyl-phenylether	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Fluorene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
4-Nitroaniline	5900 UJ	25 U	8000 UJ	25 U	27 U	25 U	31 UJ	2500 U	5400 UJ	27 U	1400000 UJ
4,6-Dinitro-2-methylphenol	5900 UJ	25 U	8000 UJ	25 U	27 U	25 U	31 UJ	2500 U	5400 UJ	27 U	1400000 UJ
N-Nitrosodiphenylamine	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
4-Bromophenyl-phenylether	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Hexachlorobenzene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Pentachlorophenol	5900 UJ	25 U	8000 UJ	25 U	27 U	25 U	31 UJ	2500 U	5400 UJ	27 U	1400000 UJ
Phenanthrene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	380 J	11 U	570000 UJ
Anthracene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Carbazole	NA	10 U	NA	10 U	NA	10 U	NA	NA	NA	NA	NA
Di-n-butylphthalate	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Fluoranthene	2400 R	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	250 J	11 U	570000 UJ
Pyrene	2400 R	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	280 J	11 U	570000 UJ
Butylbenzylphthalate	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
3,3'-Dichlorobenzidine	5900 UJ	10 U	8000 UJ	10 U	27 U	10 U	31 UJ	2500 U	5400 UJ	11 U	1400000 UJ
Benzo(a)anthracene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Chrysene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
bis(2-Ethylhexyl) phthalate	2400 R	1 J	3200 UJ	3 J	10 J	10 U	12 UJ	1000 U	2200 UJ	6.0 J	570000 UJ
Di-n-octylphthalate	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Benzo(b)fluoranthene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Benzo(k)fluoranthene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Benzo(a)pyrene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Indeno(1,2,3-cd)pyrene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Dibenzo(a,h)anthracene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ
Benzo(g,h,i)perylene	2400 UJ	10 U	3200 UJ	10 U	11 U	10 U	12 UJ	1000 U	2200 UJ	11 U	570000 UJ

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	M-1		M-2		M-4A		M-5	M-6	M-7	M-8	M-10
Collection Date:	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/92	7/92	7/92	7/92
PCBs (ug/l)											
Aroclor-1016	NA	1 U	NA	100 U	NA	1 U	NA	NA	NA	NA	NA
Aroclor-1221	NA	2 U	NA	200 U	NA	2 U	NA	NA	NA	NA	NA
Aroclor-1232	NA	1 U	NA	100 U	NA	1 U	NA	NA	NA	NA	NA
Aroclor-1242	10,000 U	1.6	10,000 U	100 U	10 U	1 U	10 U	10 U	10,000 U	1.0 U	150,000 U
Aroclor-1248	10,000 U	1U	10,000 U	100 U	10 U	1 U	10 U	10 U	350,000	1.0 U	6,900,000
Aroclor-1254	7800 B	1.9	10,000 U	100 U	10 U	1 U	25 B	10 U	59,000	0.88 J	6,500,000
Aroclor-1260	10,000 U	1 U	68,000	230	10 U	1 U	10 U	10 U	46,000	1.0 U	150,000 U
Dioxins/Furans (ng/l) [2]											
Total TCDD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total TCDF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDF	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Equiv. 2378-TCDD (ng/l)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Miscellaneous (mg/l)											
Total Organic Carbon	NA	19.6	NA	25.1	NA	5.5	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons	1.0 U	NA	1800	NA	2.2	NA	1.0 U	7.7	6200	1.0 U	33,000

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	M-11A	M-12	M-13	M-14	M-15	M-16		M-17		M-18		N-1
Collection Date:	7/92	7/92	7/92	7/92	7/92	7/92	7/99	7/92	7/99	7/92	7/99	7/92
Volatile Organics (ug/l)												
Chloromethane	100U/100U	10 U	10 U	10U/10U	50 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromomethane	100U/100U	10 U	10 U	10U/10U	50 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Vinyl Chloride	100UJ/100UJ	10 UJ	10 UJ	10U/10U	50 UJ	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U
Chloroethane	100U/100U	10 U	10 U	10U/10U	50 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methylene Chloride	120/110	4.7 J	4.2 BJ	10U/10U	51	10 U	12 B	3.7 BJ	13 B	5.9 BJ	15 B	37 B
Acetone	500U/500U	50 U	50 U	50U/50U	250 U	50 U	10 U	50 U	10 U	50 U	9 BJ	6.3 J
Carbon Disulfide	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
1,1-Dichloroethene	50UJ/50UJ	5.0 UJ	5.0 UJ	10.0U/10.0U	25 UJ	5.0 U	10 U	5.0 UJ	10 U	5.0 U	10 U	5.0
1,1-Dichloroethane	50U/50U	5.0 U	5.0 U	5.0UJ/5.0UJ	25 U	5.0 UJ	10 U	5.0 U	10 U	5.0 UJ	10 U	5.0 U
1,2-Dichloroethene (total)	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	9.0	10 U	5.0 U	10 U	5.0 U
Chloroform	50UJ/50UJ	5.0 UJ	5.0 UJ	5.0U/5.0U	25 UJ	5.0 U	10 U	5.0 UJ	10 U	5.0 U	10 U	5.0 U
1,2-Dichloroethane	50UJ/50UJ	5.0 UJ	5.0 UJ	5.0U/5.0U	25 UJ	5.0 U	10 U	5.0 UJ	10 U	5.0 U	10 U	5.0 U
2-Butanone	500U/500U	50 U	50 U	50U/50U	250 U	50 U	10 U	50 U	10 U	50 U	2 B	50 U
1,1,1-Trichloroethane	50UJ/50UJ	5.0 UJ	5.0 UJ	10.0U/10.0U	25 UJ	5.0 U	10 U	5.0 UJ	10 U	5.0 U	10 U	98
Carbon Tetrachloride	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
Bromodichloromethane	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
1,2-Dichloropropane	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
cis-1,3-Dichloropropene	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
Trichloroethene	50U/50U	5.0 U	5.0 U	10.0U/10.0U	25 U	6.6	2 J	250	51 J	5.0 U	10 U	10 U
Dibromochloromethane	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
1,1,2-Trichloroethane	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
Benzene	94/110	5.0 U	5.0 U	10.0U/10.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	10 U
trans-1,3-Dichloropropene	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
Bromoform	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
4-Methyl-2-Pentanone	500U/500U	50 U	50 U	50U/50U	250 U	50 U	10 U	50 U	10 U	50 U	10 U	50 U
2-Hexanone	500R/500R	50 R	50 R	50R/50R	250 R	50 U	10 U	50 R	10 U	50 U	10 U	50 U
Tetrachloroethene	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	25	9 J	5.0 U	10 U	5.0 U
1,1,2,2-Tetrachloroethane	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
Toluene	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
Chlorobenzene	1400/770	33	45	10.0U/10.0U	63	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	10 U
Ethylbenzene	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
Styrene	50U/50U	5.0 U	5.0 U	5.0U/5.0U	25 U	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	5.0 U
Xylenes (total)	50UJ/50UJ	5.0 UJ	5.0 UJ	5.0UJ/5.0UJ	25 UJ	5.0 UJ	10 U	5.0 UJ	10 U	5.0 UJ	10 U	5.0 UJ

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	M-11A	M-12	M-13	M-14	M-15	M-16		M-17		M-18		N-1
Collection Date:	7/92	7/92	7/92	7/92	7/92	7/92	7/99	7/92	7/99	7/92	7/99	7/92
Semivolatile Organics (ug/l)												
Phenol	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
bis(2-Chloroethyl) ether	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
2-Chlorophenol	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
1,3-Dichlorobenzene	910 J/680J	10 J	41 UJ	11U/11U	390 J	11 U	10 U	43 UJ	10 U	10 U	10 U	220 R
1,4-Dichlorobenzene	1100 J/830J	10 J	41 UJ	11U/11U	150 J	11 U	10 U	43 UJ	10 U	10 U	10 U	220 R
1,2-Dichlorobenzene	270 J/130 J	42 UJ	41 UJ	11U/11U	150 J	11 U	10 U	43 UJ	10 U	10 U	10 U	220 R
2-Methylphenol	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
2,2'-oxybis-1-Chloropropane	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
4-Methylphenol	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
N-Nitroso-di-n-propylamine	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Hexachloroethane	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Nitrobenzene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Isophorone	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
2-Nitrophenol	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
2,4-Dimethylphenol	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
bis(2-Chloroethoxy) methane	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
2,4-Dichlorophenol	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
1,2,4-Trichlorobenzene	5200J/1700J	25 J	41 UJ	11U/11U	3600	11 U	10 U	71	10 U	10 U	10 U	220 R
Naphthalene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
4-Chloroaniline	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Hexachlorobutadiene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
4-Chloro-3-methylphenol	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
2-Methylnaphthalene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Hexachlorocyclopentadiene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
2,4,6-Trichlorophenol	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
2,4,5-Trichlorophenol	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	25 U	43 UJ	25 U	10 U	25 U	220 U
2-Chloronaphthalene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
2-Nitroaniline	5300UJ/1300UJ	110 UJ	100 UJ	27U/110U	3200 UJ	28 U	25 U	110 UJ	25 U	25 U	25 U	560 U
Dimethylphthalate	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Acenaphthylene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
2,6-Dinitrotoluene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
3-Nitroaniline	5300UJ/1300UJ	110 UJ	100 UJ	27U/110U	3200 UJ	28 U	25 U	110 UJ	25 U	25 U	25 U	560 U
Acenaphthene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	M-11A	M-12	M-13	M-14	M-15	M-16		M-17		M-18		N-1
Collection Date:	7/92	7/92	7/92	7/92	7/92	7/92	7/99	7/92	7/99	7/92	7/99	7/92
2,4-Dinitrophenol	5300UJ/1300UJ	110 UJ	100 UJ	27U/110U	3200 UJ	28 U	25 U	110 UJ	25 U	25 U	25 U	560 U
4-Nitrophenol	5300UJ/1300UJ	110 UJ	100 UJ	27U/110U	3200 UJ	28 U	25 U	110 UJ	25 U	25 U	25 U	560 U
Dibenzofuran	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
2,4-Dinitrotoluene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Diethylphthalate	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
4-Chlorophenyl-phenylether	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Fluorene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
4-Nitroaniline	5300UJ/1300UJ	110 UJ	100 UJ	27U/110U	3200 UJ	28 U	25 U	110 UJ	25 U	25 U	25 U	560 U
4,6-Dinitro-2-methylphenol	5300UJ/1300UJ	110 UJ	100 UJ	27U/110U	3200 UJ	28 U	25 U	110 UJ	25 U	25 U	25 U	560 U
N-Nitrosodiphenylamine	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
4-Bromophenyl-phenylether	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Hexachlorobenzene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Pentachlorophenol	5300UJ/1300UJ	110 UJ	100 UJ	27U/110U	3200 UJ	28 U	25 U	110 UJ	25 U	25 U	25 U	560 U
Phenanthrene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Anthracene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Carbazole	NA	NA	NA	NA	NA	NA	10 U	NA	10 U	NA	10 U	NA
Di-n-butylphthalate	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Fluoranthene	2100UJ/530UJ	42 UJ	41 UJ	11U/11U	1300 R	11 U	10 U	43 UJ	10 U	10 U	10 U	15 J
Pyrene	2100UJ/530UJ	42 UJ	41 UJ	11U/11U	1300 R	11 U	10 U	43 UJ	10 U	10 U	10 U	13 J
Butylbenzylphthalate	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
3,3'-Dichlorobenzidine	5300UJ/1300UJ	110 UJ	100 UJ	27U/110U	3200 UJ	28 U	10 U	110 UJ	10 U	10 U	10 U	220 U
Benzo(a)anthracene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Chrysene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
bis(2-Ethylhexyl) phthalate	2100UJ/530UJ	42 UJ	41 UJ	11U/11U	1300 R	11 U	10 U	43 UJ	10 U	10 U	10 U	220 R
Di-n-octylphthalate	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Benzo(b)fluoranthene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Benzo(k)fluoranthene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Benzo(a)pyrene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Indeno(1,2,3-cd)pyrene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Dibenzo(a,h)anthracene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U
Benzo(g,h,i)perylene	2100UJ/530UJ	42 UJ	41 UJ	11U/46U	1300 UJ	11 U	10 U	43 UJ	10 U	10 U	10 U	220 U

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	M-11A	M-12	M-13	M-14	M-15	M-16		M-17		M-18		N-1
Collection Date:	7/92	7/92	7/92	7/92	7/92	7/92	7/99	7/92	7/99	7/92	7/99	7/92
PCBs (ug/l)												
Aroclor-1016	NA	NA	NA	NA	NA	NA	1 U	NA	1 U	NA	1 U	NA
Aroclor-1221	NA	NA	NA	NA	NA	NA	2 U	NA	2 U	NA	2 U	NA
Aroclor-1232	NA	NA	NA	NA	NA	NA	1 U	NA	1 U	NA	1 U	NA
Aroclor-1242	10,000U/10,000U	100 U	1.0 R	5.655/11 U	10,000 U	1.1 U	1 U	1000 U	1 U	10 U	1 U	1.0 U
Aroclor-1248	13,000/11,000 J	150	1.0 R	10 U/10 U	10,000 U	1.1 U	1 U	1000 U	1 U	10 U	1 U	1.0 U
Aroclor-1254	14,000/10,000U	130	1.0 R	4.6/11 U	7900 B	0.59 J	1 U	590 B	2.6	10 U	1 U	0.77 J
Aroclor-1260	16,000/13,000	100 U	5.6	10 U/10 U	10,000 U	1.1 U	1 U	1000 U	1 U	10 U	1 U	1.0 U
Dioxins/Furans (ng/l) [2]			8/94									
Total TCDD	NA	NA	0.0070	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDD	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDD	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDD	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDD	NA	NA	0.073B	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total TCDF	NA	NA	0.0200	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDF	NA	NA	0.0450	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDF	NA	NA	0.1000	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDF	NA	NA	0.2700	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDF	NA	NA	0.5600	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Equiv. 2378-TCDD (ng/l)	NA	NA	0.0095	NA	NA	NA	NA	NA	NA	NA	NA	NA
Miscellaneous (mg/l)												
Total Organic Carbon	NA	NA	NA	NA	NA	NA	3.1	NA	3.8	NA	3.0	NA
Total Petroleum Hydrocarbons	20U/5.7	1.0 U	1.0 U	2.7/18	1.0 U	1.0 U	NA	1.0 U	NA	9.8	NA	24

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	N-2A	N-3A/N-3AR		N-5		N-7A/N-7AR				S-1A		S-2A	
Collection Date:	7/92	7/92	7/99	7/92	7/99	7/92	8/94	12/94	7/99	7/92	7/99	7/92	7/99
Volatile Organics (ug/l)													
Chloromethane	10 UJ	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10U / 10U
Bromomethane	10 UJ	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10U / 10U
Vinyl Chloride	10 UJ	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10U / 10U
Chloroethane	10 UJ	10 U	10 U	10 U	10 U	10 U	NA	NA	10 U	10 U	10 U	10 U	10U / 10U
Methylene Chloride	4.0 BJ	14 B	14 B	10 B	28 B	13 B	NA	NA	15 B	10 U	21 B	10 U	7BJ / 5BJ
Acetone	50 UJ	50 U	8 BJ	50 U	9 BJ	50 U	NA	NA	10 B	50 U	13 B	50 U	6BJ / 7BJ
Carbon Disulfide	5.0 UJ	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
1,1-Dichloroethene	5.0 UJ	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
1,1-Dichloroethane	5.0 UJ	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 UJ	10 U	5.0 UJ	10U / 10U
1,2-Dichloroethene (total)	5.0 UJ	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	2J / 1J
Chloroform	5.0 UJ	10	2 J	5.0 U	10 U	5.0 U	NA	NA	40	5.0 U	10 U	5.0 U	10U / 10U
1,2-Dichloroethane	5.0 UJ	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
2-Butanone	50 UJ	50 U	3 B	50 U	10 U	50 U	NA	NA	3 B	50 U	10 U	50 U	10U / 3BJ
1,1,1-Trichloroethane	5.0 UJ	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
Carbon Tetrachloride	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
Bromodichloromethane	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	4 J	5.0 U	10 U	5.0 U	10U / 10U
1,2-Dichloropropane	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
cis-1,3-Dichloropropene	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
Trichloroethene	5.0 U	5.0 U	2 J	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
Dibromochloromethane	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
1,1,2-Trichloroethane	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
Benzene	5.0 U	2.0 J	10 U	5.0 U	10 U	4.0 J	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
trans-1,3-Dichloropropene	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
Bromoform	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
4-Methyl-2-Pentanone	50 U	50 U	10 U	50 U	10 U	50 U	NA	NA	10 U	50 U	10 U	50 U	10U / 10U
2-Hexanone	50 R	50 U	10 U	50 U	10 U	50 U	NA	NA	10 U	50 U	10 U	50 U	10U / 10U
Tetrachloroethene	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
1,1,2,2-Tetrachloroethane	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
Toluene	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
Chlorobenzene	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
Ethylbenzene	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
Styrene	5.0 U	5.0 U	10 U	5.0 U	10 U	5.0 U	NA	NA	10 U	5.0 U	10 U	5.0 U	10U / 10U
Xylenes (total)	5.0 UJ	5.0 UJ	10 U	5.0 UJ	10 U	5.0 UJ	NA	NA	10 U	5.0 UJ	10 U	5.0 UJ	10U / 10U

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	N-2A	N-3A/N-3AR		N-5		N-7A/N-7AR				S-1A		S-2A	
Collection Date:	7/92	7/92	7/99	7/92	7/99	7/92	8/94	12/94	7/99	7/92	7/99	7/92	7/99
Semivolatile Organics (ug/l)													
Phenol	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
bis(2-Chloroethyl) ether	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
2-Chlorophenol	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
1,3-Dichlorobenzene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	2J / 2J
1,4-Dichlorobenzene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
1,2-Dichlorobenzene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
2-Methylphenol	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
2,2'-oxybis-1-Chloropropane	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
4-Methylphenol	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
N-Nitroso-di-n-propylamine	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Hexachloroethane	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Nitrobenzene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Isophorone	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
2-Nitrophenol	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
2,4-Dimethylphenol	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
bis(2-Chloroethoxy) methane	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
2,4-Dichlorophenol	12 UJ	11 U	10 U	10 U	10 U	1.3 J	NA	NA	10 U	12 U	10 U	10 U	3J / 2J
1,2,4-Trichlorobenzene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Naphthalene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
4-Chloroaniline	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Hexachlorobutadiene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
4-Chloro-3-methylphenol	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
2-Methylnaphthalene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Hexachlorocyclopentadiene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
2,4,6-Trichlorophenol	12 UJ	11 U	25 U	10 U	25 U	10 U	NA	NA	25 U	12 U	25 U	10 U	25U / 25U
2,4,5-Trichlorophenol	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
2-Chloronaphthalene	29 UJ	28 U	25 U	26 U	25 U	26 U	NA	NA	25 U	30 U	25 U	25 U	25U / 25U
2-Nitroaniline	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Dimethylphthalate	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Acenaphthylene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
2,6-Dinitrotoluene	29 UJ	28 U	25 U	26 U	25 U	26 U	NA	NA	25 U	30 U	25 U	25 U	25U / 25U
3-Nitroaniline	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Acenaphthene													

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	N-2A	N-3A/N-3AR		N-5		N-7A/N-7AR				S-1A		S-2A	
Collection Date:	7/92	7/92	7/99	7/92	7/99	7/92	8/94	12/94	7/99	7/92	7/99	7/92	7/99
2,4-Dinitrophenol	29 UJ	28 U	25 U	26 U	25 U	26 U	NA	NA	25 U	30 U	25 U	25 U	25U / 25U
4-Nitrophenol	29 UJ	28 U	25 U	26 U	25 U	26 U	NA	NA	25 U	30 U	25 U	25 U	25U / 25U
Dibenzofuran	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
2,4-Dinitrotoluene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Diethylphthalate	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
4-Chlorophenyl-phenylether	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Fluorene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
4-Nitroaniline	29 UJ	28 U	25 U	26 U	25 U	26 U	NA	NA	25 U	30 U	25 U	25 U	25U / 25U
4,6-Dinitro-2-methylphenol	29 UJ	28 U	25 U	26 U	25 U	26 U	NA	NA	25 U	30 U	25 U	25 U	25U / 25U
N-Nitrosodiphenylamine	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
4-Bromophenyl-phenylether	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Hexachlorobenzene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Pentachlorophenol	29 UJ	28 U	25 U	26 U	25 U	26 U	NA	NA	25 U	30 U	25 U	25 U	25U / 25U
Phenanthrene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Anthracene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Carbazole	NA	NA	10 U	NA	10 U	NA	NA	NA	10 U	NA	10 U	NA	10U / 10U
Di-n-butylphthalate	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Fluoranthene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Pyrene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Butylbenzylphthalate	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
3,3'-Dichlorobenzidine	29 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	25 U	10U / 10U
Benzo(a)anthracene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Chrysene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
bis(2-Ethylhexyl) phthalate	12 UJ	11 U	10 U	3.4 J	10 U	10 U	NA	NA	10 U	12 U	5 J	1.4 J	10U / 2BJ
Di-n-octylphthalate	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Benzo(b)fluoranthene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Benzo(k)fluoranthene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Benzo(a)pyrene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Indeno(1,2,3-cd)pyrene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Dibenzo(a,h)anthracene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U
Benzo(g,h,i)perylene	12 UJ	11 U	10 U	10 U	10 U	10 U	NA	NA	10 U	12 U	10 U	10 U	10U / 10U

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	N-2A	N-3A/N-3AR		N-5		N-7A/N-7AR				S-1A		S-2A	
Collection Date:	7/92	7/92	7/99	7/92	7/99	7/92	8/94	12/94	7/99	7/92	7/99	7/92	7/99
PCBs (ug/l)													
Aroclor-1016	NA	NA	1 U	NA	1 U	NA	1.0 UJ	1.0 U	1 U	NA	1 U	NA	1U / 1U
Aroclor-1221	NA	NA	2 U	NA	2 U	NA	2.0 UJ	2.0 U	2 U	NA	2 U	NA	2U / 2U
Aroclor-1232	NA	NA	1 U	NA	1 U	NA	1.0 UJ	1.0 U	1 U	NA	1 U	NA	1U / 1U
Aroclor-1242	1.0 U	1.0 U	1 U	1.0 U	1 U	1.0 U	3.1 J	1.0 U	1 U	1.0 U	1 U	1.1 U	1U / 1U
Aroclor-1248	1.5	1.0 U	1 U	1.0 U	1 U	1.0 U	1.0 UJ	1.0 U	1 U	1.0 U	1 U	1.1 U	1U / 1U
Aroclor-1254	1.8 B	0.58 J	1 U	1.0 U	1 U	94	4.6 J	2.5	1 U	1.0 U	1 U	1.1 U	1U / 1U
Aroclor-1260	1.4	1.0 U	1 U	1.0 U	1 U	1.0 U	1.0 UJ	1.0 U	1 U	1.0 U	1 U	0.79 J	1U / 1U
Dioxins/Furans (ng/l) [2]	8/94	8/94						12/94				12/94	
Total TCDD	ND / ND	ND	NA	NA	NA	NA	NA	0.0087	NA	NA	NA	0.0015	NA
Total PeCDD	ND / ND	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	ND	NA
Total HxCDD	ND / ND	ND	NA	NA	NA	NA	NA	ND	NA	NA	NA	ND	NA
Total HpCDD	ND / ND	0.0240	NA	NA	NA	NA	NA	0.0073	NA	NA	NA	0.0066	NA
OCDD	0.0400B / 0.0290B	0.0920	NA	NA	NA	NA	NA	0.033B	NA	NA	NA	0.022B	NA
Total TCDF	0.0750 / ND	ND	NA	NA	NA	NA	NA	0.012	NA	NA	NA	0.0100	NA
Total PeCDF	ND / ND	ND	NA	NA	NA	NA	NA	0.016	NA	NA	NA	ND	NA
Total HxCDF	0.005 / 0.0028	ND	NA	NA	NA	NA	NA	0.036	NA	NA	NA	0.0100	NA
Total HpCDF	ND / ND	0.0029	NA	NA	NA	NA	NA	0.0059	NA	NA	NA	0.0022	NA
OCDF	0.0120U / 0.0052	0.0054	NA	NA	NA	NA	NA	0.012U	NA	NA	NA	0.0028	NA
Total Equiv. 2378-TCDD (ng/l)	0.0005 / 0.0003	0.0003	NA	NA	NA	NA	NA	0.0023	NA	NA	NA	0.0006	NA
Miscellaneous (mg/l)													
Total Organic Carbon	NA	NA	2.9	NA	2.7	NA	NA	NA	3.2	NA	24.1	NA	5.2 / 5.1
Total Petroleum Hydrocarbons	1.0 U	1.0 U	NA	1.0 U	NA	1.0 U	NA	NA	NA	1.0 U	NA	1.4	NA

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	S-3	S-4	S-5	S-6		S-7	S-8A		S-9	S-10	S-11	S-12R	S-13
Collection Date:	7/92	7/92	7/92	7/92	7/99	7/92	7/92	7/99	7/92	7/92	7/92	7/92	7/92
Volatile Organics (ug/l)													
Chloromethane	10 U/10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	10 U	20 U	NA
Bromomethane	10 U/10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	10 U	20 U	NA
Vinyl Chloride	10 U/10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	10 U	20 U	NA
Chloroethane	10 U/10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	50 U	10 U	20 U	NA
Methylene Chloride	6.8 JB/7.5 JB	10 U	7.3 BJ	6.0 BJ	17 B	7.0 BJ	10 U	43 B	10 U	50 U	21 B	20 U	NA
Acetone	50 U/50 U	12 J	50 U	50 U	10 B	50 U	50 U	22 B	50 U	250 U	50 U	100 U	NA
Carbon Disulfide	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
1,1-Dichloroethene	5.0 U/5.0 U	5.0 UJ	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	50 U	5.0 U	20 U	50 U
1,1-Dichloroethane	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 UJ	10 U	5.0 UJ	25 UJ	5.0 U	10 UJ	50 U
1,2-Dichloroethene (total)	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	3300 E	5.0 U	10 U	NA
Chloroform	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
1,2-Dichloroethane	5.0 U/5.0 U	5.0 UJ	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
2-Butanone	50 U/50 U	50 U	50 U	50 U	2 B	50 U	50 U	4 B	50 U	250 U	50 U	100 U	50 U
1,1,1-Trichloroethane	5.0 U/5.0 U	5.0 UJ	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	20 U	50 U
Carbon Tetrachloride	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
Bromodichloromethane	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
1,2-Dichloropropane	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
cis-1,3-Dichloropropene	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
Trichloroethene	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	50 U	5.0 U	20 U	50 U
Dibromochloromethane	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
1,1,2-Trichloroethane	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
Benzene	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	46 BJ	5.0 U	16 B	13 BJ
trans-1,3-Dichloropropene	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
Bromoform	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
4-Methyl-2-Pentanone	50 U/50 U	50 U	50 U	50 U	10 U	50 U	50 U	10 U	50 U	250 U	50 U	100 U	NA
2-Hexanone	50 U/50 U	50 R	50 U	50 U	10 U	50 U	50 U	10 U	50 U	250 U	50 U	100 U	NA
Tetrachloroethene	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
1,1,2,2-Tetrachloroethane	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
Toluene	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	50 U
Chlorobenzene	5.0 U/5.0 U	5.0 U	17	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	230	5.0 U	130 J	720
Ethylbenzene	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
Styrene	5.0 U/5.0 U	5.0 U	5.0 U	5.0 U	10 U	5.0 U	5.0 U	10 U	5.0 U	25 U	5.0 U	10 U	NA
Xylenes (total)	5.0 UJ/5.0 UJ	5.0 UJ	5.0 UJ	5.0 UJ	10 U	5.0 UJ	5.0 UJ	10 U	5.0 UJ	25 UJ	5.0 UJ	10 UJ	50 U

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	S-3	S-4	S-5	S-6		S-7	S-8A		S-9	S-10	S-11	S-12R	S-13
Collection Date:	7/92	7/92	7/92	7/92	7/99	7/92	7/92	7/99	7/92	7/92	7/92	7/92	7/92
Semivolatile Organics (ug/l)													
Phenol	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	6.5 JB	10 UJ	11 U	2000 U	11 U
bis(2-Chloroethyl) ether	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
2-Chlorophenol	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	22
1,3-Dichlorobenzene	22 U/21 UJ	5300 UJ	170	21 U	10 U	10 U	12 U	10 U	10 U	560	11 U	250	3.0 J
1,4-Dichlorobenzene	22 U/21 UJ	5300 UJ	45	21 U	10 U	10 U	12 U	10 U	10 U	450	11 U	120	20
1,2-Dichlorobenzene	22 U/21 UJ	5300 UJ	3.8 J	21 U	10 U	10 U	12 U	10 U	10 U	152	11 U	320 J	11 U
2-Methylphenol	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
2,2'-oxybis-1-Chloropropane	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
4-Methylphenol	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
N-Nitroso-di-n-propylamine	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Hexachloroethane	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Nitrobenzene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Isophorone	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
2-Nitrophenol	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
2,4-Dimethylphenol	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
bis(2-Chloroethoxy) methane	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	12	11 U	2000 U	1.1 J
2,4-Dichlorophenol	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	75 J	11 U	4900	11 U
1,2,4-Trichlorobenzene	4.7 J/4.7 J	5300 UJ	140	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Naphthalene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
4-Chloroaniline	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Hexachlorobutadiene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
4-Chloro-3-methylphenol	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
2-Methylnaphthalene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Hexachlorocyclopentadiene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
2,4,6-Trichlorophenol	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
2,4,5-Trichlorophenol	22 U/21 UJ	5300 UJ	22 U	21 U	25 U	10 U	12 U	25 U	10 U	10 UJ	11 U	2000 U	11 U
2-Chloronaphthalene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
2-Nitroaniline	56 U/53 UJ	13000 UJ	56 U	53 U	25 U	25 U	30 U	25 U	25 U	26 UJ	29 U	5100 U	27 U
Dimethylphthalate	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Acenaphthylene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
2,6-Dinitrotoluene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
3-Nitroaniline	56 U/53 UJ	13000 UJ	56 U	53 U	25 U	25 U	30 U	25 U	25 U	26 UJ	29 U	5100 U	27 U
Acenaphthene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	S-3	S-4	S-5	S-6		S-7	S-8A		S-9	S-10	S-11	S-12R	S-13
Collection Date:	7/92	7/92	7/92	7/92	7/99	7/92	7/92	7/99	7/92	7/92	7/92	7/92	7/92
2,4-Dinitrophenol	56 U/53 UJ	13000 UJ	56 U	53 U	25 U	25 U	30 U	25 U	25 U	26 UJ	29 U	5100 U	27 U
4-Nitrophenol	56 U/53 UJ	13000 UJ	56 U	53 U	25 U	25 U	30 U	25 U	25 U	26 UJ	29 U	5100 U	27 U
Dibenzofuran	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
2,4-Dinitrotoluene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Diethylphthalate	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
4-Chlorophenyl-phenylether	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Fluorene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
4-Nitroaniline	56 U/53 UJ	13000 UJ	56 U	53 U	25 U	25 U	30 U	25 U	25 U	26 UJ	29 U	5100 U	27 U
4,6-Dinitro-2-methylphenol	56 U/53 UJ	13000 UJ	56 U	53 U	25 U	25 U	30 U	25 U	25 U	26 UJ	29 U	5100 U	27 U
N-Nitrosodiphenylamine	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
4-Bromophenyl-phenylether	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Hexachlorobenzene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Pentachlorophenol	56 U/53 UJ	13000 UJ	56 U	53 U	25 U	25 U	30 U	25 U	25 U	26 UJ	29 U	5100 U	27 U
Phenanthrene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Anthracene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Carbazole	NA/NA	NA	NA	NA	10 U	NA	NA	10 U	NA	NA	NA	NA	NA
Di-n-butylphthalate	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	1 J	10 U	10 UJ	11 U	2000 U	11 U
Fluoranthene	4.3 J/4.2 J	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 R	11 U
Pyrene	4.2 J/4.1 J	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 R	11 U
Butylbenzylphthalate	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
3,3'-Dichlorobenzidine	22 U/21 UJ	13000 UJ	22 U	21 U	10 U	10 U	30 U	10 U	25 U	26 UJ	11 U	5100 U	27 U
Benzo(a)anthracene	2.2 J/2.4 J	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Chrysene	3.3 J/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
bis(2-Ethylhexyl) phthalate	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 R	11 U
Di-n-octylphthalate	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Benzo(b)fluoranthene	4.6 J/4.9 J	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Benzo(k)fluoranthene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Benzo(a)pyrene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Indeno(1,2,3-cd)pyrene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Dibenzo(a,h)anthracene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U
Benzo(g,h,i)perylene	22 U/21 UJ	5300 UJ	22 U	21 U	10 U	10 U	12 U	10 U	10 U	10 UJ	11 U	2000 U	11 U

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TABLE 1-5
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL ON-SITE GROUNDWATER SAMPLES

Sample ID:	S-3	S-4	S-5	S-6		S-7	S-8A		S-9	S-10	S-11	S-12R	S-13
Collection Date:	7/92	7/92	7/92	7/92	7/99	7/92	7/92	7/99	7/92	7/92	7/92	7/92	7/92
PCBs (ug/l)													
Aroclor-1016	NA	NA	NA	NA	1 U	NA	NA	1 U	NA	NA	NA	NA	NA
Aroclor-1221	NA	NA	NA	NA	2 U	NA	NA	2 U	NA	NA	NA	NA	NA
Aroclor-1232	NA	NA	NA	NA	1 U	NA	NA	1 U	NA	NA	NA	NA	NA
Aroclor-1242	10 U/1.0 U	100 U	1.0 U	10 U	1 U	1.0 U	1.0 U	1 U	1.0 U	10 U	1.0 U	1.0 U	1.0 U
Aroclor-1248	10 U/1.0 U	100 U	1.0 U	10 U	1 U	11	1.0 U	1 U	1.0 U	10 U	1.4	1.0 U	1.0 U
Aroclor-1254	10 U/1.0 U	100 U	1.0 U	10 U	1 U	1.0 U	1.4	1 U	1.0 U	14	3.1	150	1.0 U
Aroclor-1260	39/4.7	86 J	8	96	1 U	7	1.0 U	1 U	15	10 U	1.0 U	1.0 U	1.0 U
Dioxins/Furans (ng/l) (2)				8/94			12/94			8/94			
Total TCDD	NA	NA	NA	0.0190	NA	NA	ND	NA	NA	ND	NA	NA	NA
Total PeCDD	NA	NA	NA	ND	NA	NA	ND	NA	NA	ND	NA	NA	NA
Total HxCDD	NA	NA	NA	ND	NA	NA	ND	NA	NA	ND	NA	NA	NA
Total HpCDD	NA	NA	NA	0.0160	NA	NA	ND	NA	NA	0.1500	NA	NA	NA
OCDD	NA	NA	NA	0.043B	NA	NA	0.018B	NA	NA	0.7700	NA	NA	NA
Total TCDF	NA	NA	NA	5.3000	NA	NA	ND	NA	NA	0.1700	NA	NA	NA
Total PeCDF	NA	NA	NA	7.7000	NA	NA	ND	NA	NA	0.2500	NA	NA	NA
Total HxCDF	NA	NA	NA	2.1000	NA	NA	ND	NA	NA	0.1300	NA	NA	NA
Total HpCDF	NA	NA	NA	0.1100	NA	NA	ND	NA	NA	0.1100	NA	NA	NA
OCDF	NA	NA	NA	0.0280	NA	NA	0.0081U	NA	NA	0.0850	NA	NA	NA
Total Equiv. 2378-TCDD (ng/l)	NA	NA	NA	0.1800	NA	NA	0.0000	NA	NA	0.0150	NA	NA	NA
Miscellaneous (mg/l)													
Total Organic Carbon	NA	NA	NA	NA	6.2	NA	NA	6.3	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons	1.0 U/1.0 U	3300	1.0 U	1.2	NA	1.0 U	1.0 U	NA	1.0 U	1.0 U	4.6	1.0 U	1.0 U

Notes:

1. Data qualifiers/symbols are as follows:
   - NA Sample was not analyzed for this compound.
   - B Concentration in sample is less than 5x or 10x the result in an associated blank sample.
   - J Estimated value.
   - U Compound was not detected at the given quantitation limit.
   - E Reported value exceeds calibration range.
   - x/x A duplicate sample was collected at this location.
2. Dioxin/furan results are a summary of the results presented in the RI Report.

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TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	OS-1A		*OS-1B*		OS-2A		*OS-2B*		OS-3A		*OS-3B*	
Sample Date:	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99
Volatile Organics (ug/l)												
1,1,1-Trichloroethane	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane	20 UJ	10 U	10 UJ	10 U	50 U	20 U	10 U	20 U	10 UJ	10 U	10 UJ	10 U
1,1-Dichloroethene	20 UJ	10 U	10 UJ	10 U	50 U	20 U	2 J	20 U	10 UJ	10 U	10 U	10 U
1,2-Dichloroethane	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene (total)	100	180	10 U	10 U	500	190	560	120	10 U	10 U	10 U	10 U
1,2-Dichloropropane	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
2-Butanone	20 U	10 U	10 U	4 J	50 U	6 J	10 U	20 U	10 U	4 J	10 U	4 J
2-Hexanone	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 UJ	10 U
4-Methyl-2-Pentanone	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 UJ	10 U
Acetone	20 U	11 B	10 U	17 B	50 U	45 B	10 U	20 U	9 BJ	15 B	10 U	13 B
Benzene	20 U	2 J	10 U	10 U	50 U	5 J	3 BJ	20 U	2 J	2 J	5 BJ	4 J
Bromodichloromethane	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Bromoform	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Bromomethane	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Carbon Disulfide	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Carbon Tetrachloride	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Chlorobenzene	6 J	130	10 U	10 U	45 J	280	65	190	45	41	150	120
Chloroethane	20 U	2 J	10 U	10 U	50 U	9 J	8 J	20 U	10 U	10 U	10 U	10 U
Chloroform	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Chloromethane	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
cis-1,3-Dichloropropene	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Dibromochloromethane	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Ethylbenzene	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Methylene Chloride	5 BJ	18 B	10 U	42 B	13 BJ	110 B	10 U	10 BJ	10 U	40 B	10 U	34 B
Styrene	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Tetrachloroethene	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Toluene	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
trans-1,3-Dichloropropene	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U
Trichloroethene	170	10 U	10 U	10 U	56	5 J	68	20 U	10 U	10 U	10 U	10 U
Vinyl Chloride	20 U	43	10 U	10 U	50 U	61	15	18 J	10 U	10 U	10 U	10 U
Xylenes (total)	20 U	10 U	10 U	10 U	50 U	20 U	10 U	20 U	10 U	10 U	10 U	10 U

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TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	OS-1A		*OS-1B*		OS-2A		*OS-2B*		OS-3A		*OS-3B*	
Sample Date:	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99
Semivolatile Organics (ug/l)												
1,2,4-Trichlorobenzene	10 U	10 U	4 J	10 U	46	540 D	110	510 D	1000	770 D	3600	2800 D
1,2-Dichlorobenzene	10 U	13	10 U	10 U	31	61	42	58	55 J	48	240	160 DJ
1,3-Dichlorobenzene	10 U	71	10 U	10 U	180	510 D	240	470 D	36 J	38	260	140 DJ
1,4-Dichlorobenzene	10 U	21	10 U	10 U	27	140 D	50	140 D	22 J	22	150	60
2,2'-oxybis-1-Chloropropane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
2,4,5-Trichlorophenol	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	500 U	25 U	130 U	25 U
2,4,6-Trichlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
2,4-Dichlorophenol	10 U	10 U	10 UJ	10 U	10 U	2 J	10 U	2 J	200 U	10 U	50 U	10 U
2,4-Dimethylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
2,4-Dinitrophenol	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	500 U	25 U	130 U	25 U
2,4-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
2,6-Dinitrotoluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
2-Chloronaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
2-Chlorophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
2-Methylnaphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
2-Methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1 J	200 U	10 U	50 U	2 J
2-Nitroaniline	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	500 U	25 U	130 U	25 U
2-Nitrophenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
3,3'-Dichlorobenzidine	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
3-Nitroaniline	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	500 U	25 U	130 U	25 U
4,6-Dinitro-2-methylphenol	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	500 U	25 U	130 U	25 U
4-Bromophenyl-phenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
4-Chloro-3-methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
4-Chloroaniline	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
4-Chlorophenyl-phenylether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
4-Methylphenol	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
4-Nitroaniline	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	500 U	25 U	130 U	25 U
4-Nitrophenol	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	500 U	25 U	130 U	25 U
Acenaphthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Acenaphthylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U

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TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	OS-1A		*OS-1B*		OS-2A		*OS-2B*		OS-3A		*OS-3B*	
Sample Date:	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99
Benzo(a)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Benzo(a)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Benzo(b)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Benzo(g,h,i)perylene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Benzo(k)fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
bis(2-Chloroethoxy) methane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
bis(2-Chloroethyl) ether	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
bis(2-Ethylhexyl) phthalate	10 U	2 J	10 U	3 J	10 U	1 J	10 U	4 J	200 U	10 U	50 U	1 J
Butylbenzylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Carbazole	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Chrysene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Dibenz(a,h)anthracene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Dibenzofuran	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Diethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Dimethylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Di-n-butylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Di-n-octylphthalate	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Fluoranthene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Fluorene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Hexachlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Hexachlorobutadiene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Hexachlorocyclopentadiene	10 UJ	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Hexachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Indeno(1,2,3-cd)pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Isophorone	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Naphthalene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Nitrobenzene	10 U	10 U	10 UJ	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
N-Nitroso-di-n-propylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
N-Nitrosodiphenylamine	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Pentachlorophenol	25 U	25 U	25 U	25 U	25 U	25 U	25 U	25 U	500 U	25 U	130 U	25 U
Phenanthrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U
Phenol	10 U	10 U	10 U	10 U	10 U	10 U	3 J	10 U	200 U	10 U	50 U	10 U
Pyrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U	200 U	10 U	50 U	10 U

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TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	OS-1A		*OS-1B*		OS-2A		*OS-2B*		OS-3A		*OS-3B*	
Sample Date:	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99	7/92	7/99
Pesticides/PCBs (ug/l)												
Aroclor-1016	1.0 U	1 U	1.0 U	R	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U
Aroclor-1221	2.0 U	2 U	2.0 U	R	2.0 U	2 U	2.0 U	2 U	2.0 U	2 U	2.0 U	2 U
Aroclor-1232	1.0 U	1 U	1.0 U	R	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U
Aroclor-1242	1.0 U	1 U	1.0 U	R	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U
Aroclor-1248	1.0 U	1 U	1.0 U	R	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U
Aroclor-1254	1.0 U	1 U	1.0 U	R	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U
Aroclor-1260	1.0 U	1 U	1.0 U	R	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U
Dioxins/Furans (ng/l) [3]					12/94						8/94	
Total TCDD	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Total PeCDD	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Total HxCDD	NA	NA	NA	NA	0.018	NA	NA	NA	NA	NA	ND	NA
Total HpCDD	NA	NA	NA	NA	0.35	NA	NA	NA	NA	NA	ND	NA
OCDD	NA	NA	NA	NA	1.7	NA	NA	NA	NA	NA	0.016B	NA
Total TCDF	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Total PeCDF	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	ND	NA
Total HxCDF	NA	NA	NA	NA	0.025	NA	NA	NA	NA	NA	ND	NA
Total HpCDF	NA	NA	NA	NA	0.1	NA	NA	NA	NA	NA	ND	NA
OCDF	NA	NA	NA	NA	0.07	NA	NA	NA	NA	NA	0.0065U	NA
Total Equiv. 2378-TCDD (ng/l)	NA	NA	NA	NA	0.0044	NA	NA	NA	NA	NA	0.0000	NA
Miscellaneous (mg/l)												
Total Organic Carbon	NA	6.7	NA	3.9	NA	7.5	NA	8.0	NA	6.0	NA	14.1
Total Petroleum Hydrocarbons	1.0 U	NA	1.0 U	NA	3.4 U	NA	1.0 U	NA	1.0 U	NA	1.0 U	NA

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TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	OS-4A		*OS-4B*		OS-5A	*OS-5B*	*OS-6A*	*OS-6B*	*OS-7A*	*OS-7B*	MW-3A/MW-3AR		*MW-3B*	
Sample Date:	7/92	7/99	7/92	7/99	7/92	7/92	8/99	8/99	7/99	7/99	7/92	7/99	7/92	7/99
Volatile Organics (ug/l)														
1,1,1-Trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
1,1,2,2-Tetrachloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
1,1,2-Trichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
1,1-Dichloroethane	10 UJ	10 U	10 UJ	10 U	10 UJ	10 UJ	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 UJ	10 U
1,1-Dichloroethene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 UJ	10 U
1,2-Dichloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
1,2-Dichloroethene (total)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	5 J	8 J	10 UJ	1 J	250 U	10 U
1,2-Dichloropropane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
2-Butanone	10 U	2 BJ	10 U	10 U	10 U	10 U	10 U	7J / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
2-Hexanone	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
4-Methyl-2-Pentanone	10 UJ	10 U	10 U	10 U	10 U	10 UJ	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Acetone	10 U	10 U	10 U	6 BJ	10 U	10 UJ	10 U	60 / 33	7 BJ	4 BJ	10 U	14 B	250 UJ	12 B
Benzene	4 BJ	10 U	10 U	10 U	3 BJ	5 BJ	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Bromodichloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Bromoform	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Bromomethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Carbon Disulfide	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Carbon Tetrachloride	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Chlorobenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Chloroethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Chloroform	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Chloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
cis-1,3-Dichloropropene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Dibromochloromethane	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Ethylbenzene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Methylene Chloride	4 BJ	5 BJ	10 U	6 BJ	3 BJ	4 BJ	7 BJ	9BJ / 8BJ	6 BJ	5 BJ	10 U	31 B	250 U	20 B
Styrene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Tetrachloroethene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	9 J
Toluene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	1J / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
trans-1,3-Dichloropropene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Trichloroethene	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10	25	10 UJ	10 U	5400 E	830 D
Vinyl Chloride	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U
Xylenes (total)	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10U / 10U	10 U	10 U	10 UJ	10 U	250 U	10 U

TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	OS-4A		*OS-4B*		OS-5A	*OS-5B*	*OS-6A*	*OS-6B*	*OS-7A*	*OS-7B*	MW-3A/MW-3AR		*MW-3B*	
Sample Date:	7/92	7/99	7/92	7/99	7/92	7/92	8/99	8/99	7/99	7/99	7/92	7/99	7/92	7/99
Semivolatile Organics (ug/l)														
1,2,4-Trichlorobenzene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
1,2-Dichlorobenzene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
1,3-Dichlorobenzene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
1,4-Dichlorobenzene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
2,2'-oxybis-1-Chloropropane	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
2,4,5-Trichlorophenol	25 U	50 U	25 U	25 U	25 U	25 U	50 U	25U / 25U	25 U	25 U	28 U	25 U	25 U	25 U
2,4,6-Trichlorophenol	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
2,4-Dichlorophenol	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 UJ	10 U
2,4-Dimethylphenol	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
2,4-Dinitrophenol	25 U	50 U	25 U	25 U	25 U	25 U	50 U	25U / 25U	25 U	25 U	28 U	25 U	25 U	25 U
2,4-Dinitrotoluene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
2,6-Dinitrotoluene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
2-Chloronaphthalene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
2-Chlorophenol	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
2-Methylnaphthalene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
2-Methylphenol	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
2-Nitroaniline	25 U	50 U	25 U	25 U	25 U	25 U	50 U	25U / 25U	25 U	25 U	28 U	25 U	25 U	25 U
2-Nitrophenol	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 UJ	10 U	10 UJ	10 U
3-Nitroaniline	25 U	50 U	25 U	25 U	25 U	25 U	50 U	25U / 25U	25 U	25 U	28 U	25 U	25 U	25 U
4,6-Dinitro-2-methylphenol	25 U	50 U	25 U	25 U	25 U	25 U	50 U	25U / 25U	25 U	25 U	28 U	25 U	25 U	25 U
4-Bromophenyl-phenylether	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
4-Chloroaniline	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
4-Chlorophenyl-phenylether	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
4-Methylphenol	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
4-Nitroaniline	25 U	50 U	25 U	25 U	25 U	25 U	50 U	25U / 25U	25 U	25 U	28 U	25 U	25 U	25 U
4-Nitrophenol	25 U	50 U	25 U	25 U	25 U	25 U	50 U	25U / 25U	25 U	25 U	28 U	25 U	25 U	25 U
Acenaphthene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Acenaphthylene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Anthracene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U

TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	OS-4A		*OS-4B*		OS-5A	*OS-5B*	*OS-6A*	*OS-6B*	*OS-7A*	*OS-7B*	MW-3A/MW-3AR		*MW-3B*	
Sample Date:	7/92	7/99	7/92	7/99	7/92	7/92	8/99	8/99	7/99	7/99	7/92	7/99	7/92	7/99
Benzo(a)anthracene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Benzo(a)pyrene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	R
Benzo(b)fluoranthene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	R
Benzo(g,h,i)perylene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	R
Benzo(k)fluoranthene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 UJ	R
bis(2-Chloroethoxy) methane	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
bis(2-Chloroethyl) ether	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
bis(2-Ethylhexyl) phthalate	10 U	3 BJ	10 U	10 U	10 U	10 U	20 U	1J / 10U	1 BJ	10 U	11 U	10 U	10 U	10 U
Butylbenzylphthalate	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Carbazole	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Chrysene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Dibenz(a,h)anthracene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	R
Dibenzofuran	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Diethylphthalate	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Dimethylphthalate	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Di-n-butylphthalate	10 U	20 U	10 U	10 U	10 U	10 U	20 U	1J / 10U	1 J	10 U	11 U	10 U	10 U	10 U
Di-n-octylphthalate	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 UJ	10 U	10 U	R
Fluoranthene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Fluorene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Hexachlorobenzene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Hexachlorobutadiene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 UJ	10 U
Hexachloroethane	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	R
Isophorone	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Naphthalene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Nitrobenzene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 UJ	10 U	10 UJ	10 U
N-Nitroso-di-n-propylamine	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
N-Nitrosodiphenylamine	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Pentachlorophenol	25 U	50 U	25 U	25 U	25 U	25 U	50 U	25U / 25U	25 U	25 U	28 UJ	25 U	25 U	25 U
Phenanthrene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Phenol	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U
Pyrene	10 U	20 U	10 U	10 U	10 U	10 U	20 U	10U / 10U	10 U	10 U	11 U	10 U	10 U	10 U

TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	OS-4A		*OS-4B*		OS-5A	*OS-5B*	*OS-6A*	*OS-6B*	*OS-7A*	*OS-7B*	MW-3A/MW-3AR		*MW-3B*	
Sample Date:	7/92	7/99	7/92	7/99	7/92	7/92	8/99	8/99	7/99	7/99	7/92	7/99	7/92	7/99
Pesticides/PCBs (ug/l)														
Aroclor-1016	1.0 U	2 U	1.0 U	1 U	1.0 U	1.0 U	2 U	1U / 1U	1 U	1 U	1.0 U	1 U	1.0 U	1 U
Aroclor-1221	2.0 U	4 U	2.0 U	2 U	2.0 U	2.0 U	4 U	2U / 2U	2 U	2 U	2.0 U	2 U	2.0 U	2 U
Aroclor-1232	1.0 U	2 U	1.0 U	1 U	1.0 U	1.0 U	2 U	1U / 1U	1 U	1 U	1.0 U	1 U	1.0 U	1 U
Aroclor-1242	1.0 U	2 U	1.0 U	1 U	1.0 U	1.0 U	2 U	1U / 1U	1 U	1 U	1.0 U	1 U	1.0 U	1 U
Aroclor-1248	1.0 U	2 U	1.0 U	1 U	1.0 U	1.0 U	2 U	1U / 1U	1 U	1 U	1.0 U	1 U	1.0 U	1 U
Aroclor-1254	1.0 U	2 U	1.0 U	1 U	0.38 J	1.0 U	2 U	1U / 1U	1 U	1 U	0.75 BJ	1 U	0.75	1 U
Aroclor-1260	1.0 U	2 U	1.0 U	1 U	1.0 U	1.0 U	2 U	1U / 1U	1 U	1 U	1.0 U	1 U	1.0 U	1 U
Dioxins/Furans (ng/l) [3]	8/94													
Total TCDD	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDD	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDD	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDD	0.0093	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDD	0.042B	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total TCDF	0.002	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PeCDF	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HxCDF	0.0026	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total HpCDF	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCDF	0.0089U	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Equiv. 2378-TCDD (ng/l)	0.0003	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Miscellaneous (mg/l)														
Total Organic Carbon	NA	3.9	NA	6.3	NA	NA	6.4	6.6 / 6.3	3.8	2.9	NA	2.9	NA	3.0
Total Petroleum Hydrocarbons	1.0 U	NA	1.0 U	NA	3.3 U	1.0 U	NA	NA	NA	NA	1.0 U	NA	1.0 U	NA

TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	MW-7		MW-14A	*MW-14B*	MW-15A	*MW-15B*	MW-16A	*MW-16B*	MW-17AR	PW-1
Sample Date:	7/92	12/94	7/92	7/92	7/92	7/92	7/92	7/92	12/94	7/92
Volatile Organics (ug/l)										
1,1,1-Trichloroethane	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
1,1,2,2-Tetrachloroethane	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
1,1,2-Trichloroethane	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
1,1-Dichloroethane	10 U	NA	10 UJ	10 UJ	10 UJ	20 UJ	10 UJ	20 UJ	10 U	10 UJ
1,1-Dichloroethene	10 U	NA	10 UJ	10 UJ	10 UJ	20 UJ	10 UJ	20 UJ	10 U	10 UJ
1,2-Dichloroethane	10 U	NA	10 UJ	10 U	10 U	6 J	10 UJ	4 R	2 J	10 UJ
1,2-Dichloroethene (total)	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
1,2-Dichloropropane	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
2-Butanone	10 U	NA	19 J	10 U	10 U	20 U	10 UJ	20 UJ	10 U	9 J
2-Hexanone	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 R
4-Methyl-2-Pentanone	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Acetone	10 U	NA	48 BJ	10 U	10 U	11 B	10 U	20 U	10 U	57 BJ
Benzene	10 U	NA	10 UJ	5 J	10 U	290	10 U	230	10 U	2 BJ
Bromodichloromethane	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Bromoform	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Bromomethane	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Carbon Disulfide	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Carbon Tetrachloride	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Chlorobenzene	10 U	NA	11 J	44	10 U	310	10 UJ	200 J	10 U	10 UJ
Chloroethane	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Chloroform	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Chloromethane	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
cis-1,3-Dichloropropene	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Dibromochloromethane	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Ethylbenzene	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	5 J
Methylene Chloride	10 U	NA	3 BJ	10 U	10 U	20 U	9 BJ	31 BJ	0.8 J	7 BJ
Styrene	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Tetrachloroethene	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	12	3 J
Toluene	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	5 BJ
trans-1,3-Dichloropropene	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Trichloroethene	2 J	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	2 J	5 J
Vinyl Chloride	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	10 UJ
Xylenes (total)	10 U	NA	10 UJ	10 U	10 U	20 U	10 UJ	20 UJ	10 U	6 J

AR302683

TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	MW-7		MW-14A	*MW-14B*	MW-15A	*MW-15B*	MW-16A	*MW-16B*	MW-17AR	PW-1
Sample Date:	7/92	12/94	7/92	7/92	7/92	7/92	7/92	7/92	12/94	7/92
Semivolatile Organics (ug/l)										
1,2,4-Trichlorobenzene	200 U	NA	210 J	680	24	48,000	10 U	36,000	10 U	3 J
1,2-Dichlorobenzene	200 U	NA	2000 U	63 J	10 U	910	10 U	10,000 U	10 U	10 U
1,3-Dichlorobenzene	200 U	NA	2000 U	260	10 U	510	10 U	10,000 U	10 U	10 U
1,4-Dichlorobenzene	200 U	NA	2000 U	89 J	10 U	360	10 U	10,000 U	10 U	10 U
2,2'-oxybis-1-Chloropropane	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
2,4,5-Trichlorophenol	500 U	NA	5000 U	500 U	25 U	500 U	25 U	25,000 U	25 U	25 U
2,4,6-Trichlorophenol	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
2,4-Dichlorophenol	200 U	NA	2000 U	200 U	10 UJ	200 U	10 U	10,000 U	10 U	10 U
2,4-Dimethylphenol	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
2,4-Dinitrophenol	500 U	NA	5000 U	500 U	25 U	500 U	25 U	25,000 U	25 U	25 U
2,4-Dinitrotoluene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
2,6-Dinitrotoluene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
2-Chloronaphthalene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
2-Chlorophenol	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
2-Methylnaphthalene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	2 J
2-Methylphenol	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
2-Nitroaniline	500 U	NA	5000 U	500 U	25 U	500 U	25 U	25,000 U	25 U	25 U
2-Nitrophenol	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
3,3'-Dichlorobenzidine	200 U	NA	2000 U	200 UJ	10 UJ	200 UJ	10 U	10,000 U	10 U	10 U
3-Nitroaniline	500 U	NA	5000 U	500 U	25 U	500 U	25 U	25,000 U	25 U	25 U
4,6-Dinitro-2-methylphenol	500 U	NA	5000 U	500 U	25 U	500 U	25 U	25,000 U	25 U	25 U
4-Bromophenyl-phenylether	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
4-Chloro-3-methylphenol	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
4-Chloroaniline	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
4-Chlorophenyl-phenylether	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
4-Methylphenol	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	3 J
4-Nitroaniline	500 U	NA	5000 U	500 U	25 U	500 U	25 U	25,000 U	25 U	25 U
4-Nitrophenol	500 U	NA	5000 U	500 U	25 U	500 U	25 U	25,000 U	25 U	25 U
Acenaphthene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Acenaphthylene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Anthracene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U

AR302684

TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	MW-7		MW-14A	*MW-14B*	MW-15A	*MW-15B*	MW-16A	*MW-16B*	MW-17AR	PW-1
Sample Date:	7/92	12/94	7/92	7/92	7/92	7/92	7/92	7/92	12/94	7/92
Benzo(a)anthracene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Benzo(a)pyrene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Benzo(b)fluoranthene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Benzo(g,h,i)perylene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Benzo(k)fluoranthene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
bis(2-Chloroethoxy) methane	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
bis(2-Chloroethyl) ether	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
bis(2-Ethylhexyl) phthalate	200 U	NA	2000 U	200 U	10 U	200 U	3 J	10,000 U	10 U	16
Butylbenzylphthalate	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	0.2 J	10 U
Carbazole	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Chrysene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Dibenz(a,h)anthracene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Dibenzofuran	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Diethylphthalate	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	0.3 J	10 U
Dimethylphthalate	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Di-n-butylphthalate	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	0.4 J	10 U
Di-n-octylphthalate	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Fluoranthene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Fluorene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Hexachlorobenzene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Hexachlorobutadiene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Hexachlorocyclopentadiene	200 U	NA	2000 U	200 UJ	10 UJ	200 UJ	10 U	10,000 U	10 U	10 U
Hexachloroethane	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Isophorone	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Naphthalene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	5 J
Nitrobenzene	200 U	NA	2000 U	200 U	10 UJ	200 U	10 U	10,000 U	10 U	10 U
N-Nitroso-di-n-propylamine	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
N-Nitrosodiphenylamine	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Pentachlorophenol	500 U	NA	5000 U	500 U	25 U	500 U	25 U	25,000 U	25 U	25 U
Phenanthrene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U
Phenol	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	3 J
Pyrene	200 U	NA	2000 U	200 U	10 U	200 U	10 U	10,000 U	10 U	10 U

AR302685

TABLE 1-6
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN ALLUVIAL OFF-SITE GROUNDWATER SAMPLES

Sample ID:	MW-7		MW-14A	*MW-14B*	MW-15A	*MW-15B*	MW-16A	*MW-16B*	MW-17AR	PW-1
Sample Date:	7/92	12/94	7/92	7/92	7/92	7/92	7/92	7/92	12/94	7/92
Pesticides/PCBs (ug/l)										
Aroclor-1016	1.0 U	1.0 U	10,000 U	1.0 U	1.0 U	10,000 U	1.0 U	10,000 U	1.0 U	1.0 U
Aroclor-1221	2.0 U	2.0 U	20,000 U	2.0 U	2.0 U	20,000 U	2.0 U	20,000 U	2.0 U	2.0 U
Aroclor-1232	1.0 U	1.0 U	10,000 U	1.0 U	1.0 U	10,000 U	1.0 U	10,000 U	1.0 U	1.0 U
Aroclor-1242	1.0 U	1.0 U	10,000 U	1.0 U	1.0 U	10,000 U	R	10,000 U	1.0 U	1.0 U
Aroclor-1248	1.0 U	1.0 U	7900 J	59 P	1.0 U	30,000	R	10,000 U	1.0 U	1.0 U
Aroclor-1254	0.74 BJ	1.0 U	10,000 U	1.0 U	4.3	47,000	R	44,000 B	1.0 U	4.7 B
Aroclor-1260	1.0 U	1.0 U	3600 J	55 P	1.0 U	10,000 U	R	10,000 U	1.0 U	1.0 U
Dioxins/Furans (ng/l) (3)		12/94		8/94						
Total TCDD	NA	ND	NA	0.038	NA	NA	NA	NA	ND	NA
Total PeCDD	NA	ND	NA	ND	NA	NA	NA	NA	ND	NA
Total HxCDD	NA	ND	NA	ND	NA	NA	NA	NA	ND	NA
Total HpCDD	NA	ND	NA	ND	NA	NA	NA	NA	0.0052	NA
OCDD	NA	0.026U	NA	0.026B	NA	NA	NA	NA	0.022B	NA
Total TCDF	NA	ND	NA	0.11	NA	NA	NA	NA	ND	NA
Total PeCDF	NA	ND	NA	0.087	NA	NA	NA	NA	ND	NA
Total HxCDF	NA	0.0094B	NA	0.23	NA	NA	NA	NA	0.021	NA
Total HpCDF	NA	ND	NA	0.11	NA	NA	NA	NA	0.013	NA
OCDF	NA	0.036U	NA	0.094	NA	NA	NA	NA	0.021U	NA
Total Equiv. 2378-TCDD (ng/l)	NA	0.0009	NA	0.04	NA	NA	NA	NA	0.0013	NA
Miscellaneous (mg/l)										
Total Organic Carbon	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons	23	NA	1600	1.0 U	1.0 UJ	1.0 U	1.0 U	1.0 U	NA	1.0 U

Notes:

1. Monitoring well IDs which are italicized indicate wells screened across the alluvium/till interface.
2. Data qualifiers/symbols are as follows:
   - B Parameter detected in associated blank sample.
   - D Reported value determined from a diluted analysis.
   - E Reported value exceeds calibration range.
   - J Estimated value.
   - U Compound was not detected at the given quantitation limit.
   - P Reported value may be of poor precision.
   - R Result is rejected.
3. Dioxin/furan results are a summary of the results presented in the RI Report.

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CUMMINGS CENTER

TABLE 1-7
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN BEDROCK GROUNDWATER SAMPLES

Sample ID:	M-4B		M-9		M-11B			N-2B		N-3B		N-6B/N-6BR	
Collection Date:	7/92	7/99	7/92	7/99	7/92	7/99	10/99	7/92	7/99	7/92	7/99	7/92	7/99
Volatile Organics (ug/l)													
1,1,1-Trichloroethane	5.0 UJ	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
1,1,2,2-Tetrachloroethane	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
1,1,2-Trichloroethane	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
1,1-Dichloroethane	5.0 U	10 U	5.0 UJ	10 U	5.0 UJ	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 UJ	10 U
1,1-Dichloroethene	5.0 UJ	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
1,2-Dichloroethane	5.0 UJ	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
1,2-Dichloroethene (total)	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
1,2-Dichloropropane	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
2-Butanone	50 U	2 B	50 U	10 U	50 U	10 U	NA	50 U	3 BJ	50 U	10 U	50 U	10 U
2-Hexanone	50	10 U	50 U	10 U	50 U	10 U	NA	50 U	10 U	50 U	10 U	50 U	10 U
4-Methyl-2-Pentanone	50 U	10 U	50 U	10 U	50 U	10 U	NA	50 U	10 U	50 U	10 U	50 U	10 U
Acetone	50 U	12 B	50 U	7 BJ	50 U	7 BJ	NA	50 U	7 BJ	50 U	9 BJ	50 U	7 BJ
Benzene	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Bromodichloromethane	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Bromoform	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Bromomethane	10 U	10 U	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U
Carbon Disulfide	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Carbon Tetrachloride	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Chlorobenzene	5.0 U	10 U	5.0 U	10 U	5.0 U	9 J	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Chloroethane	10 U	10 U	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	5.0 UJ	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Chloromethane	10 U	10 U	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,3-Dichloropropene	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Dibromochloromethane	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Ethylbenzene	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Methylene Chloride	2.5 JB	15 B	10 U	31 B	10 U	5 BJ	NA	30 B	6 BJ	12 B	17 B	10 U	11 B
Styrene	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Tetrachloroethene	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Toluene	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
trans-1,3-Dichloropropene	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Trichloroethene	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U	NA	5.0 U	10 U	5.0 U	10 U	5.0 U	10 U
Vinyl Chloride	10 UJ	10 U	10 U	10 U	10 U	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U
Xylenes (total)	5.0 UJ	10 U	5.0 UJ	10 U	5.0 UJ	10 U	NA	5.0 UJ	10 U	5.0 UJ	10 U	5.0 UJ	10 U

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TABLE 1-7
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN BEDROCK GROUNDWATER SAMPLES

Sample ID:	M-4B		M-9		M-11B			N-2B		N-3B		N-6B/N-6BR	
Collection Date:	7/92	7/99	7/92	7/99	7/92	7/99	10/99	7/92	7/99	7/92	7/99	7/92	7/99
Semivolatile Organics (ug/l)													
1,2,4-Trichlorobenzene	11 UJ	10 U	12 U	10 U	10 U	540 D	18	11 U	10 U	11 U	10 U	11 U	10 U
1,2-Dichlorobenzene	11 UJ	10 U	12 U	10 U	10 U	14	10 U	11 U	10 U	11 U	10 U	11 U	10 U
1,3-Dichlorobenzene	11 UJ	10 U	12 U	10 U	10 U	40	10 U	11 U	10 U	11 U	10 U	11 U	10 U
1,4-Dichlorobenzene	11 UJ	10 U	12 U	10 U	10 U	29	10 U	11 U	10 U	11 U	10 U	11 U	10 U
2,2'-oxybis-1-Chloropropane	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
2,4,5-Trichlorophenol	11 UJ	25 U	12 U	25 U	10 U	25 U	25 U	11 U	25 U	11 U	25 U	11 U	25 U
2,4,6-Trichlorophenol	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
2,4-Dichlorophenol	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
2,4-Dimethylphenol	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
2,4-Dinitrophenol	26 UJ	25 U	29 U	25 U	26 U	25 U	25 U	27 U	25 U	27 U	25 U	26 U	25 U
2,4-Dinitrotoluene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
2,6-Dinitrotoluene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
2-Chloronaphthalene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
2-Chlorophenol	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
2-Methylnaphthalene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
2-Methylphenol	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
2-Nitroaniline	26 UJ	25 U	29 U	25 U	26 U	25 U	25 U	27 U	25 U	27 U	25 U	26 U	25 U
2-Nitrophenol	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
3,3'-Dichlorobenzidine	26 UJ	10 U	29 U	10 U	26 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
3-Nitroaniline	26 UJ	25 U	29 U	25 U	26 U	25 U	25 U	27 U	25 U	27 U	25 U	26 U	25 U
4,6-Dinitro-2-methylphenol	26 UJ	25 U	29 U	25 U	26 U	25 U	25 U	27 U	25 U	27 U	25 U	26 U	25 U
4-Bromophenyl-phenylether	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
4-Chloro-3-methylphenol	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
4-Chloroaniline	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
4-Chlorophenyl-phenylether	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
4-Methylphenol	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
4-Nitroaniline	26 UJ	25 U	29 U	25 U	26 U	25 U	25 U	27 U	25 U	27 U	25 U	26 U	25 U
4-Nitrophenol	26 UJ	25 U	29 U	25 U	26 U	25 U	25 U	27 U	25 U	27 U	25 U	26 U	25 U
Acenaphthene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Acenaphthylene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Anthracene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U

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TABLE 1-7
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN BEDROCK GROUNDWATER SAMPLES

Sample ID:	M-4B		M-9		M-11B			N-2B		N-3B		N-6B/N-6BR	
Collection Date:	7/92	7/99	7/92	7/99	7/92	7/99	10/99	7/92	7/99	7/92	7/99	7/92	7/99
Benzo(a)anthracene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	1.4 J	10 U	11 U	10 U	11 U	10 U
Benzo(a)pyrene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Benzo(b)fluoranthene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Benzo(g,h,i)perylene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Benzo(k)fluoranthene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
bis(2-Chloroethoxy) methane	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
bis(2-Chloroethyl) ether	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
bis(2-Ethylhexyl) phthalate	11 UJ	10 U	12 U	10 U	10 U	2 BJ	10 U	3.6 J	10 U	11 U	10 U	11 U	10 U
Butylbenzylphthalate	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Carbazole	NA	10 U	NA	10 U	NA	10 U	10 U	NA	10 U	NA	10 U	NA	10 U
Chrysene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	1.7 J	10 U	11 U	10 U	11 U	10 U
Dibenzo(a,h)anthracene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Dibenzofuran	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Diethylphthalate	11 UJ	10 U	12 U	10 U	10 U	5 J	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Dimethylphthalate	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Di-n-butylphthalate	11 UJ	10 U	12 U	10 U	10 U	6 J	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Di-n-octylphthalate	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Fluoranthene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	4.9 J	10 U	11 U	10 U	11 U	10 U
Fluorene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Hexachlorobenzene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Hexachlorobutadiene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Hexachlorocyclopentadiene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Hexachloroethane	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Indeno(1,2,3-cd)pyrene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Isophorone	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Naphthalene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Nitrobenzene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
N-Nitroso-di-n-propylamine	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
N-Nitrosodiphenylamine	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Pentachlorophenol	26 UJ	25 U	29 U	25 U	26 U	25 U	25 U	27 U	25 U	27 U	25 U	26 U	25 U
Phenanthrene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	1.9 J	10 U	11 U	10 U	11 U	10 U
Phenol	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	11 U	10 U	11 U	10 U	11 U	10 U
Pyrene	11 UJ	10 U	12 U	10 U	10 U	10 U	10 U	3.3 J	10 U	11 U	10 U	11 U	10 U

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TABLE 1-7
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN BEDROCK GROUNDWATER SAMPLES

Sample ID:	M-4B		M-9		M-11B			N-2B		N-3B		N-6B/N-6BR	
Collection Date:	7/92	7/99	7/92	7/99	7/92	7/99	10/99	7/92	7/99	7/92	7/99	7/92	7/99
PCBs (ug/l)													
Aroclor-1016	NA	1 U	NA	1 U	NA	230	5.92	NA	1 U	NA	1 U	NA	1 U
Aroclor-1221	NA	2 U	NA	2 U	NA	200 U	0.47 U	NA	2 U	NA	2 U	NA	2 U
Aroclor-1232	NA	1 U	NA	1 U	NA	100 U	0.47 U	NA	1 U	NA	1 U	NA	1 U
Aroclor-1242	1.0 U	1 U	1.0 U	1 U	10 U	100 U	0.47 U	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U
Aroclor-1248	1.0 U	1 U	1.0 U	1 U	10 U	100 U	0.47 U	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U
Aroclor-1254	1.0 U	1 U	1.0 U	1 U	10 U	100 U	0.47 U	2.0	1 U	0.52 J	1 U	0.36 J	1 U
Aroclor-1260	6.8	1 U	1.0 U	1 U	10 U	290	2.47	1.0 U	1 U	1.0 U	1 U	1.0 U	1 U
Dioxins/Furans (ng/l) [2]	8/94		12/94		8/94			12/94					
Total TCDD	ND		0.0024		ND		NA	0.0025		NA	NA	NA	NA
Total PeCDD	ND		ND		ND		NA	ND		NA	NA	NA	NA
Total HxCDD	ND		ND		ND		NA	ND		NA	NA	NA	NA
Total HpCDD	ND		ND		ND		NA	0.001		NA	NA	NA	NA
OCDD	0.0160 B		0.0072 B		0.0610 U		NA	0.0093 B		NA	NA	NA	NA
Total TCDF	ND		0.0300		ND		NA	ND		NA	NA	NA	NA
Total PeCDF	ND		0.0026		ND		NA	ND		NA	NA	NA	NA
Total HxCDF	ND		0.0050		ND		NA	0.0043		NA	NA	NA	NA
Total HpCDF	ND		ND		ND		NA	ND		NA	NA	NA	NA
OCDF	0.0078 U		0.0039 U		0.1000		NA	0.0024 U		NA	NA	NA	NA
Total Equiv. 2378-TCDD (ng/l)	0.0000		0.0017		0.0001		NA	0.00045		NA	NA	NA	NA
Miscellaneous (mg/l)													
Total Organic Carbon	NA	2.5	NA	2.4	NA	3.2	NA	NA	1.9	NA	3.1	NA	1.6
Total Petroleum Hydrocarbons	1.0 U	NA	1.0 U	NA	17	NA	NA	1.2	NA	1.0 U	NA	1.0 U	NA

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TABLE 1-7
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN BEDROCK GROUNDWATER SAMPLES

Sample ID:	N-7B			S-1B				S-2B		S-8B		R-1	
Collection Date:	7/92	8/94	7/99	7/92	8/94	7/99	10/99	7/92	7/99	7/92	7/99	7/92	7/99
Volatile Organics (ug/l)													
1,1,1-Trichloroethane	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
1,1,2-Trichloroethane	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
1,1-Dichloroethane	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 UJ	10 U	5.0 UJ	10 U	10 U	10 U
1,1-Dichloroethene	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
1,2-Dichloroethane	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
1,2-Dichloroethene (total)	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
1,2-Dichloropropane	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
2-Butanone	50 U	NA	2B / 10U	50 U	NA	10 U	NA	50 U	10 U	50 U	4 J	10 U	10 U
2-Hexanone	50 U	NA	10U / 10U	50 U	NA	10 U	NA	50 U	10 U	50 U	10 U	10 U	10 U
4-Methyl-2-Pentanone	50 U	NA	10U / 10U	50 U	NA	10 U	NA	50 U	10 U	50 U	10 U	10 U	10 U
Acetone	50 U	NA	10B / 10B	50 U	NA	12 B	NA	50 U	5 BJ	50 U	22 B	10 U	5 BJ
Benzene	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	4 BJ	10 U
Bromodichloromethane	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Bromoform	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Bromomethane	10 U	NA	10U / 10U	10 U	NA	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U
Carbon Disulfide	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Carbon Tetrachloride	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Chlorobenzene	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Chloroethane	10 U	NA	10U / 10U	10 U	NA	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Chloromethane	10 U	NA	10U / 10U	10 U	NA	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,3-Dichloropropene	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Dibromochloromethane	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Ethylbenzene	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Methylene Chloride	24 B	NA	15B / 15B	22 B	NA	19 B	NA	10 U	7 BJ	10 U	32 B	4 BJ	6 BJ
Styrene	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Tetrachloroethene	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Toluene	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
trans-1,3-Dichloropropene	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Trichloroethene	5.0 U	NA	10U / 10U	5.0 U	NA	10 U	NA	5.0 U	10 U	5.0 U	10 U	10 U	10 U
Vinyl Chloride	10 U	NA	10U / 10U	10 U	NA	10 U	NA	10 U	10 U	10 U	10 U	10 U	10 U
Xylenes (total)	5.0 UJ	NA	10U / 10U	5.0 UJ	NA	10 U	NA	5.0 UJ	10 U	5.0 UJ	10 U	10 U	10 U

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TABLE 1-7
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN BEDROCK GROUNDWATER SAMPLES

Sample ID:	N-7B			S-1B				S-2B		S-8B		R-1	
Collection Date:	7/92	8/94	7/99	7/92	8/94	7/99	10/99	7/92	7/99	7/92	7/99	7/92	7/99
Semivolatile Organics (ug/l)													
1,2,4-Trichlorobenzene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
2,2'-oxybis-1-Chloropropane	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol	11 U	NA	25U / 25U	10 U	NA	25 U	NA	11 U	25 U	10 U	25 U	25 U	25 U
2,4,6-Trichlorophenol	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
2,4-Dinitrophenol	27 U	NA	25U / 25U	25 U	NA	25 U	NA	28 U	25 U	26 U	25 U	25 U	25 U
2,4-Dinitrotoluene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
2,6-Dinitrotoluene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
2-Chloronaphthalene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
2-Methylnaphthalene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
2-Methylphenol	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
2-Nitroaniline	27 U	NA	25U / 25U	25 U	NA	25 U	NA	28 U	25 U	26 U	25 U	25 U	25 U
2-Nitrophenol	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
3,3'-Dichlorobenzidine	11 U	NA	10U / 10U	10 U	NA	10 U	NA	28 U	10 U	26 U	10 U	10 U	10 U
3-Nitroaniline	27 U	NA	25U / 25U	25 U	NA	25 U	NA	28 U	25 U	26 U	25 U	25 U	25 U
4,6-Dinitro-2-methylphenol	27 U	NA	25U / 25U	25 U	NA	25 U	NA	28 U	25 U	26 U	25 U	25 U	25 U
4-Bromophenyl-phenylether	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
4-Chloroaniline	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
4-Chlorophenyl-phenylether	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
4-Methylphenol	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
4-Nitroaniline	27 U	NA	25U / 25U	25 U	NA	25 U	NA	28 U	25 U	26 U	25 U	25 U	25 U
4-Nitrophenol	27 U	NA	25U / 25U	25 U	NA	25 U	NA	28 U	25 U	26 U	25 U	25 U	25 U
Acenaphthene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Acenaphthylene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Anthracene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U

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TABLE 1-7
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN BEDROCK GROUNDWATER SAMPLES

Sample ID:	N-7B			S-1B				S-2B		S-8B		R-1	
Collection Date:	7/92	8/94	7/99	7/92	8/94	7/99	10/99	7/92	7/99	7/92	7/99	7/92	7/99
Benzo(a)anthracene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Benzo(a)pyrene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Benzo(g,h,i)perylene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Benzo(k)fluoranthene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroethoxy) methane	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroethyl) ether	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
bis(2-Ethylhexyl) phthalate	11 U	NA	2J / 10U	10	NA	2 J	NA	1.8 J	1 BJ	10 U	10 U	10 U	10 B
Butylbenzylphthalate	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Carbazole	NA	NA	10U / 10U	NA	NA	10 U	NA	NA	10 U	NA	10 U	10 U	10 U
Chrysene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Dibenzo(a,h)anthracene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Dibenzofuran	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Dimethylphthalate	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Di-n-octylphthalate	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Fluorene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobenzene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobutadiene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Hexachloroethane	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Isophorone	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Nitrobenzene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
N-Nitroso-di-n-propylamine	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
N-Nitrosodiphenylamine	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Pentachlorophenol	27 U	NA	25U / 25U	25 U	NA	25 U	NA	28 U	25 U	26 U	25 U	25 U	25 U
Phenanthrene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Phenol	11 U	NA	10U / 10U	3.5 J	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U
Pyrene	11 U	NA	10U / 10U	10 U	NA	10 U	NA	11 U	10 U	10 U	10 U	10 U	10 U

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TABLE 1-7
SUMMARY OF HISTORICAL GROUNDWATER SAMPLE ANALYTICAL RESULTS
ORGANICS IN BEDROCK GROUNDWATER SAMPLES

Sample ID:	N-7B			S-1B				S-2B		S-8B		R-1	
Collection Date:	7/92	8/94	7/99	7/92	8/94	7/99	10/99	7/92	7/99	7/92	7/99	7/92	7/99
PCBs (ug/l)													
Aroclor-1016	NA	1.0 U	1U / 1U	NA	1.0U / 1.0 U	1 U	0.48 U	NA	1 U	NA	1 U	1.0 U	2 U
Aroclor-1221	NA	2.0 U	2U / 2U	NA	2.0U / 2.0 U	2 U	0.48 U	NA	2 U	NA	2 U	2.0 U	4 U
Aroclor-1232	NA	1.0 U	1U / 1U	NA	1.0U / 1.0 U	1 U	0.48 U	NA	1 U	NA	1 U	1.0 U	2 U
Aroclor-1242	10 U	1.0 U	1U / 1U	1.0 U	1.0U / 1.0 U	1 U	0.48 U	1.0 U	1 U	1.0 U	1 U	1.0 U	2 U
Aroclor-1248	10 U	1.0 U	1U / 1U	1.0 U	1.0U / 1.0 U	1 U	0.48 U	1.0 U	1 U	1.0 U	1 U	1.0 U	2 U
Aroclor-1254	6.7 J	1.0 U	1U / 1U	1.0 U	1.0U / 1.0 U	2.0	0.48 U	1.0 U	1 U	1.0 U	1 U	1.0 U	2 U
Aroclor-1260	10 U	1.0 U	1U / 1U	2.5	1.0U / 1.0 U	1.6	0.48 U	1.0 U	1 U	0.23 J	1 U	1.0 U	2 U
Dioxins/Furans (ng/l) [2]		12/94			12/94					8/94		12/94	
Total TCDD	NA	ND		NA	ND		NA	NA	NA	ND		ND	
Total PeCDD	NA	ND		NA	ND		NA	NA	NA	ND		ND	
Total HxCDD	NA	ND		NA	ND		NA	NA	NA	ND		ND	
Total HpCDD	NA	ND		NA	ND		NA	NA	NA	0.0074		ND	
OCDD	NA	0.0062 B		NA	0.034 B		NA	NA	NA	0.0530 B		0.0059 B	
Total TCDF	NA	0.001		NA	0.0086		NA	NA	NA	ND		ND	
Total PeCDF	NA	ND		NA	0.0074		NA	NA	NA	0.0092		ND	
Total HxCDF	NA	0.0036		NA	0.0071		NA	NA	NA	ND		ND	
Total HpCDF	NA	ND		NA	ND		NA	NA	NA	ND		0.0018	
OCDF	NA	0.0041 U		NA	0.0034		NA	NA	NA	0.0120 U		0.0016 U	
Total Equiv. 2378-TCDD (ng/l)	NA	0.00047		NA	0.00023		NA	NA	NA	0.0006		0.0000	
Miscellaneous (mg/l)													
Total Organic Carbon	NA	NA	2.7 / 2.9	NA	NA	6.1	NA	NA	3.1	NA	2.5	NA	2.0
Total Petroleum Hydrocarbons	1.0 U	NA	NA	1.0 U	NA	NA	NA	1.0 U	NA	1.0 U	NA	1.0 U	NA

Notes:

1. Data qualifiers/symbols are as follows:
   - NA Sample was not analyzed for this compound.
   - B Concentration in sample is less than 5x or 10x the result in an associated blank sample.
   - J Estimated value.
   - U Compound was not detected at the given quantitation limit.
   - E Reported value exceeds calibration range.
   - x/x A duplicate sample was collected at this location.
2. Dioxin/furan results are a summary of the results presented in the RI Report.

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TABLE 2-1
REMEDIATION OPTIONS FOR PCB WASTE UNDER TSCA[a]

PCB Waste Category	PCB Conc. (ppm)	Incinerator	Chemical Waste Landfill	High-Efficiency Boiler	Equivalent Alternative Method	Method Approved By Region
Liquids	≥ 500	X			X	
Liquids w/ flashpoint > 60°C	50 - 500	X	X	X	X	
Liquids w/ flashpoint < 60°C	50 - 500	X		X	X	
Other liquids that are also hazardous wastes	≥ 500	X			X	
	50 - 500	X		X	X	
Non-liquids (soil, rags, debris)	≥ 50	X	X		X	
Dredged materials and municipal sewage sludge	≥ 50	X	X		X	X

a. Adapted from Table 2-1 of USEPA's "Guidance on Remedial Actions for Superfund Sites with PCB Contamination," August 1990.

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TABLE 2-2
SUMMARY OF SHALLOW SEDIMENT SAMPLE RESULTS[a]
RELATIVE TO SCREENING LEVEL CRITERIA

Parameter	Screening Level Criteria[b]	Area 12 Conc. (mg/kg)[c] (Wishart Ct. Outfall)			Area 13 Conc. (mg/kg) (Franklin St. Outfall)			Area 14 Conc. (mg/kg) (North Hot Well Outfall)			Area 15 Conc. (mg/kg) (Clark St. Outfall)			Area 17 Conc. (Background)	
		Mean	Max.	95% UCL	Mean	Max.	95% UCL	Mean	Max.	95% UCL	Mean	Max.	95% UCL	Mean	Max.
Total PCBs	0.05	***0.51***	***2.0***	***0.9***	0.31	***0.81***	0.44	***4.8***	***52***	***10.0***	***4.5***	***24.1***	***8.9***	0.25	***0.62***
Antimony	2	2.7	***20.4***	7.0	1.1	3.5	1.7	1.1	2.1	1.4	1.8	3.5	2.4	< 1.0[d]	< 1.0
Arsenic	33	All results < criteria			All results < criteria			All results < criteria			15.2	35.1	21.1	8.1	8.7
Cadmium	5	All results < criteria			1.3	7.3	2.8	1.6	10.7	2.7	0.75	5.1	1.6	< 0.28	< 0.28
Chromium	80	All results < criteria			All results < criteria			22.3	88.6	30.7	36	98.4	57.6	7.3	8.8
Lead	35	97.9	291	157	40.4	92.7	54.9	91.6	***669***	156	92	233	139	19.8	24.9
Mercury	0.15	0.098	0.25	0.15	All results < criteria			0.14	0.59	0.21	All results < criteria			< 0.05	< 0.05
Nickel	30	19.1	47.4	26.4	All results < criteria			19.8	63.3	25.4	14.8	45.7	21.4	8.5	9.9
Silver	1	All results < criteria			All results < criteria			0.93	5.7	1.5	0.48	2.1	0.83	< 0.35	< 0.35
Zinc	120	407	810	519	624	827	689	565	***2,540***	858	***2,969***	***20,100***	***6,449***	139	191

a. Only sediment samples collected from 0 to 6 inches below streambed in 1998 and 2000 are shown.
b. Screening level criteria are for Effects Range - Low (Long and Morgan, 1991), as described in the Screening Level Eco-Risk Assessment (ChemRisk, 1997).
c. "mg/kg" is milligrams per kilogram or parts per million.
d. "<" denotes sample concentration is less than the quantitation limit.
e. Reported concentrations result in Ecological Effects Quotients (EEQs) in the following ranges, as defined in the Screening-Level ERA:

EEQ > 100	Extreme risk to ecological receptors
100 > EEQ > 10	Moderate-high potential risk to eco. receptors
10 > EEQ > 1	Potential risk to ecological receptors
EEQ < 1	No risk to ecological receptors

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TABLE 2-3
SUMMARY OF DEEP SEDIMENT SAMPLE RESULTS[a]
RELATIVE TO SCREENING LEVEL CRITERIA

Parameter	Screening Level Criteria[b]	Area 12 Conc. (mg/kg)[c] (Wishart Ct. Outfall) Mean	Max.	95% UCL	Area 13 Conc. (mg/kg) (Franklin St. Outfall) Mean	Max.	95% UCL	Area 14 Conc. (mg/kg) (North Hot Well Outfall) Mean	Max.	95% UCL	Area 15 Conc. (mg/kg) (Clark St. Outfall) Mean	Max.	95% UCL	Area 17 Conc. (Background) Mean	Max.
Total PCBs	0.05	0.18	***0.52***	0.29	0.18	***0.84***	0.36	***2.1***	***8.3***	***3.2***	***1.5***	***8.0***	***3.0***	0.07	0.25
Antimony	2	All results < criteria			1.9	3.7	2.4	2.5	26.5	6.0	1.5	3.9	2.1	<0.8[d]	<0.8
Arsenic	33	All results < criteria			All results < criteria			All results < criteria			All results < criteria			9.1	15.9
Cadmium	5	All results < criteria			All results < criteria			1.4	7.9	2.2	2.3	17.8	5.2	<0.22	<0.22
Chromium	80	All results < criteria			All results < criteria			21.7	88.6	29.6	60.0	269	110	7.2	7.8
Lead	35	91.9	***485***	189	36.2	77.9	50.0	81.6	***669***	141.8	50.3	134	75.3	9.7	12.2
Mercury	0.15	All results < criteria			All results < criteria			0.09	0.28	0.12	0.07	0.3	0.13	<0.04	<0.04
Nickel	30	All results < criteria			All results < criteria			16.3	63.3	21.4	16.8	34.4	22.1	8.6	9.7
Silver	1	All results < criteria			All results < criteria			0.77	4.4	1.2	0.50	2.6	0.93	<0.27	<0.27
Zinc	120	114	193	140	234	597	361	385	***1,280***	519	***1,342***	***4,910***	***2,330***	53.0	61.9

a. Only sediment samples collected from 6 to 50 inches below streambed are shown.
b. Screening level criteria are for Effects Range - Low (Long and Morgan, 1991), as described in the Screening Level Eco-Risk Assessment (ChemRisk, 1997).
c. "mg/kg" is milligrams per kilogram or parts per million.
d. "<" denotes sample concentration is less than the quantitation limit.
e. Reported concentrations result in Ecological Effects Quotients (EEQs) in the following ranges, as defined in the Screening-Level ERA:

EEQ > 100	Extreme risk to ecological receptors
100 > EEQ > 10	Moderate-high potential risk to eco. receptors
10 > EEQ > 1	Potential risk to ecological receptors
EEQ < 1	No risk to ecological receptors

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TABLE 2-4
COMPARISON OF HEALTH-BASED AND ARAR-BASED CLEANUP LEVELS WITH DETECTED LEVELS IN SOUTH SECTOR ALLUVIAL GROUNDWATER

Constituent of Potential Concern	Human Health Risk Assessment Calculations			Site-Specific Health-Based Cleanup Levels (ug/l)					USEPA MCL or PADEP Act 2 Non-Res. Used Aquifer (ug/l)	Maximum Detected Concentration (ug/l)	
	EPC (ug/l)	Carcin. Risk	Non-Carc. HI	Carc. 10^{-4}[a]	Carc. 10^{-5}	Carc. 10^{-6}	Indiv. NC HI=1[b]	Cumul. NC HI=1[c]		'92/'94 RI Samples	'99 Suppl. Samples[d]
Aroclor-1254	14	1.1E-02	1400	0.13	0.01	0.001	0.01	0.0005	0.5 (MCL)	150 (S-12R)	ND
Arsenic[e]	390	8.7E-03	84	4.5	0.45	0.04	4.6	0.21	50 (MCL)	394 (OS-1A) *51* (OS-1B)	*76* (OS-1A)
2,3,7,8-TCDD (teq)	1.42E-05	1.3E-03	NA	1E-06	1E-07	1E-08	NA	NA	3.0E-5 (MCL)	1.8E-4 (S-6)	NA
Vinyl chloride	15	5.1E-04	NA	2.9	0.29	0.03	NA	NA	2 (MCL)	15 (OS-2B)	61 (OS-2A)
1,4-Dichlorobenzene	450	3.5E-04	1.5	129	13	1.3	300	14	75 (MCL)	450 (S-10)	140 (OS-2A/2B)
Trichloroethene	170	8.1E-05	5.30	210	21	2.1	32	1.5	5 (MCL)	170 (OS-1A)	25 (OS-7B)
1,1-Dichloroethene	2	2.3E-05	0.02	8.7	0.87	0.09	125	NA	7 (MCL)	2 (OS-2B)	ND
1,3-Dichlorobenzene	560	NA	73	NA	NA	NA	7.7	0.35	600 (Act 2)	560 (S-10)	510 (OS-2A)
Iron[e]	308,000	NA	66.0	NA	NA	NA	4,667	212	300 (SMCL)	459,000 (S-12R) *10,500* (OS-1A)	*13,000* (OS-1A)
1,2-Dichloroethene	3,300	NA	25.0	NA	NA	NA	132	6.0	70 (cis-) (MCL)	3,300 (S-10)	190 (OS-2A)
Manganese[e]	7,500	NA	24	NA	NA	NA	313	14	50 (SMCL)	24,600 (S-12R) *9,050* (S-12R)	*12,500* (S-2A)
Chromium[e]	480	NA	15	NA	NA	NA	32	1.5	100 (MCL)	482 (OS-1B) *ND*	*5.8* (OS-7A)
Aluminum[e]	98,000	NA	6.3	NA	NA	NA	15,556	707	200 (SMCL)	129,000 (S-12R) *ND*	*ND*
Nickel[e]	720	NA	2.3	NA	NA	NA	313	14	100 (Act 2)	717 (OS-1B) *120* (OS-1B)	*ND*
Vanadium[e]	180	NA	1.8	NA	NA	NA	100	4.5	6 (Act 2)	232 (S-12R) *12.2* (S-10)	*9.7* (S-1A)
1,2,4-Trichlorobenzene	110	NA	1.5	NA	NA	NA	73	3.3	70 (MCL)	4,900 (S-12R)	540 (OS-2A)
Chlorobenzene	230	NA	1.0	NA	NA	NA	230	10	100 (Act 2)	720 (S-13)	280 (OS-2A)
Mercury[e]	1.5	NA	1.0	NA	NA	NA	1.5	0.07	2 (MCL)	1.5 (S-10) *ND*	*0.13* (S-2A)
Barium[e]	900	NA	0.8	NA	NA	NA	1125	51	2,000 (MCL)	1,420 (S-12R) *275* (S-10)	*474* (OS-7B)
Cadmium[e]	4.6	NA	0.6	NA	NA	NA	7.7	0.35	5 (MCL)	5.4 (S-12R) *ND*	*ND*

TABLE 2-4
COMPARISON OF HEALTH-BASED AND ARAR-BASED CLEANUP LEVELS WITH DETECTED LEVELS IN SOUTH SECTOR ALLUVIAL GROUNDWATER

Constituent of Potential Concern	Human Health Risk Assessment Calculations			Site-Specific Health-Based Cleanup Levels (ug/l)					USEPA MCL or PADEP Act 2 Non-Res. Used Aquifer (ug/l)	Maximum Detected Concentration (ug/l)	
	EPC (ug/l)	Carcin. Risk	Non-Carc. HI	Carc. 10^{-4}[a]	Carc. 10^{-5}	Carc. 10^{-6}	Indiv. NC HI=1[b]	Cumul. NC HI=1[c]		'92/'94 RI Samples	'99 Suppl. Samples[d]
Copper[e]	390	NA	0.6	NA	NA	NA	650	30	1,000 (SMCL)	**551** (S-12R) *ND*	*4.4* (S-8A)
2,4-Dichlorophenol	11	NA	0.4	NA	NA	NA	28	1.3	20 (Act 2)	12 (S-10)	2 (OS-2A/2B)
Zinc[e]	1,800	NA	0.4	NA	NA	NA	4500	205	5,000 (SMCL)	**1,790** (S-10) *25.5* (S-5)	*170* (S-2A)
Beryllium[e]	7	NA	0.30	NA	NA	NA	23	1.1	4 (MCL)	**6.9** (OS-1B) *ND*	*ND*
1,2-Dichlorobenzene	152	NA	0.16	NA	NA	NA	950	43	600 (MCL)	320 (S-12R)	61 (OS-2A)
Lead[e]	250	NA	NA	NA	NA	NA	NA	NA	5 (Act 2)	**246** (OS-2B) *ND*	*ND*

a. Selecting all cleanup levels from this column will result in a remaining total cancer risk of greater than 10^{-4}.
b. Non-carcinogenic cleanup level calculated using a target HI of 1.0 for the individual compound.
c. Non-carcinogenic cleanup level calculated using a target total HI of 1.0 for 22 contributing compounds.
d. Not all site monitoring wells were sampled during the 1999 supplemental sampling event.
e. EPCs and risks for inorganic compounds were calculated using total (unfiltered) analyses. Maximum detected concentrations are shown for both **total (bold)** and *dissolved* (*italicized*) samples where available.

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TABLE 2-5
COMPARISON OF HEALTH-BASED AND ARAR-BASED CLEANUP LEVELS WITH DETECTED LEVELS IN MIDDLE SECTOR ALLUVIAL GROUNDWATER

Constituent of Potential Concern	Human Health Risk Assessment Calculations			Site-Specific Health-Based Cleanup Levels (ug/l)					USEPA MCL or PADEP Act 2	Maximum Detected Concentration (ug/l)	
	EPC (ug/l)	Carcin. Risk	Non-Carc. HI	Carc. 10^{-4}[a]	Carc. 10^{-5}	Carc. 10^{-6}	Indiv. NC HI=1[b]	Cumul. NC HI=1[c]	Non-Res. Used Aquifer (ug/l)	'92/'94 RI Samples	'99 Suppl. Samples[d]
Aroclor-1254	47,000	3.1E+00	5.0E+06	1.5	0.15	0.02	0.009	0.0004	0.5 (MCL)	6.5E6 (M-10)	2.6 (M-17)
Aroclor-1248	30,000	2.8E+00	NA	1.1	0.11	0.01	NA	NA	0.5 (MCL)	6.9E6 (M-10)	ND
Aroclor-1242	5.7	4.4E-03	NA	0.13	0.01	0.001	NA	NA	0.5 (MCL)	5.7 (M-14)	1.6 (M-1)
Aroclor-1260	6	4.4E-03	NA	0.13	0.01	0.001	NA	NA	0.5 (MCL)	68,000 (M-2)	230 (M-2)
Trichloroethene	4,000	3.2E-03	122	125	13	1.3	32.8	1.3	5 (MCL)	5,400 (MW-3B)	830 (MW-3B)
Arsenic[e]	35	7.8E-04	7.5	4.5	0.45	0.04	4.7	0.19	50 (MCL)	**78.7** (OS-4A) *16.4* (M-10)	*12* (M-18)
2,3,7,8-TCDD (teq)	8.3E-06	7.3E-04	NA	1E-06	1E-07	1E-08	NA	NA	3.0E-5 (MCL)	9.5E-6 (M-13)	NA
Benzene	290	3.2E-04	10	91	9.1	0.9	29	1.2	5 (MCL)	340 (M-10)	200 (M-2)
1,4-Dichlorobenzene	360	2.8E-04	1.2	129	13	1.3	300	12	75 (MCL)	250,000 (M-10)	60 (OS-3B)
Tetrachloroethene	25	7.9E-05	0.8	32	3.2	0.3	31	1.3	5 (MCL)	25 (M-17)	9 (M-17/MW-3B)
1,1-Dichloroethene	5	6.1E-05	0.04	8.2	0.82	0.08	130	NA	7 (MCL)	5 (N-1)	ND
1,2-Dichloroethane	6	1.5E-05	0.01	40	4.0	0.40	460	NA	5 (MCL)	6 (MW-15B)	ND
1,2,4-Trichlorobenzene	48,000	NA	670	NA	NA	NA	72	2.9	70 (MCL)	1.2E6 (M-10)	3,700 (M-1)
Manganese[e]	50,000	NA	160	NA	NA	NA	313	13	50 (SMCL)	**124,000** (MW-16B) *12,200* (MW-7)	*7,750* (M-1)
Iron[e]	477,000	NA	100	NA	NA	NA	4,770	191	300 (SMCL)	**477,000** (MW-16B) *15,700* (M-5)	*12,700* (M-2)
1,3-Dichlorobenzene	510	NA	66	NA	NA	NA	8	0.3	600 (Act 2)	150,000 (M-10)	140 (OS-3B)
Aluminum[e]	162,000	NA	10	NA	NA	NA	16,200	648	200 (SMCL)	**175,000** (OS-4A) *3,990* (MW-17AR)	*61* (M-2)
Cadmium[e]	67	NA	9.0	NA	NA	NA	7.4	0.30	5 (MCL)	**67** (M-17) *29* (M-12)	*3* (M-17)
Zinc[e]	36,000	NA	7.7	NA	NA	NA	4,675	187	5,000 (SMCL)	**3,460** (MW-7) *384* (MW-17AR)	*190* (OS-4A)
Chromium[e]	230	NA	7.1	NA	NA	NA	32	1.3	100 (MCL)	**346** (M-10) *ND*	*5.5* (MW-3AR)
Vanadium[e]	280	NA	3.0	NA	NA	NA	93	3.7	6 (Act 2)	**284** (MW-16A) *11.2* (MW-14A/B)	*6.9* (MW-3B)
Copper[e]	950	NA	1.5	NA	NA	NA	633	25	1,000 (SMCL)	**950** (M-17) *11.2* (MW-17AR)	*133* (OS-3B)

TABLE 2-5
COMPARISON OF HEALTH-BASED AND ARAR-BASED CLEANUP LEVELS WITH DETECTED LEVELS IN MIDDLE SECTOR ALLUVIAL GROUNDWATER

Constituent of Potential Concern	Human Health Risk Assessment Calculations			Site-Specific Health-Based Cleanup Levels (ug/l)					USEPA MCL or PADEP Act 2 Non-Res. Used Aquifer (ug/l)	Maximum Detected Concentration (ug/l)	
	EPC (ug/l)	Carcin. Risk	Non-Carc. HI	Carc. 10^{-4}[a]	Carc. 10^{-5}	Carc. 10^{-6}	Indiv. NC HI=1[b]	Cumul. NC HI=1[c]		'92/'94 RI Samples	'99 Suppl. Samples[d]
Chlorobenzene	310	NA	1.3	NA	NA	NA	238	9.5	100 (Act 2)	2,200 (M-10)	5,400 (M-2)
1,2-Dichlorobenzene	910	NA	1.0	NA	NA	NA	910	36	600 (MCL)	910 (MW-15B)	170 (M-1)
Barium[e]	1,110	NA	1.0	NA	NA	NA	1110	44	2,000 (MCL)	**1,040** (MW-16A) *233* (M-5)	*581* (N-5)
Nickel[e]	290	NA	0.9	NA	NA	NA	322	13	100 (Act 2)	**314** (OS-4A) *23.5* (MW-14A)	*ND*
Mercury[e]	0.96	NA	0.6	NA	NA	NA	1.6	0.1	2 (MCL)	**2.1** (M-10) *ND*	*0.11* (OS-4B)
Beryllium[e]	12	NA	0.5	NA	NA	NA	24	1.0	4 (MCL)	**11.5** (MW-16B) *ND*	*ND*
Silver[e]	16	NA	0.2	NA	NA	NA	80	3.2	100 (SMCL)	**61** (M-17) *ND*	*4.5* (M-4A)
Cyanide	38	NA	0.1	NA	NA	NA	380	15	200 (MCL)	205 (M-17)	NA
1,2-Dichloroethene	9	NA	0.07	NA	NA	NA	129	5.1	70 (cis-) (MCL)	9 (M-17)	1 (MW-3AR)
Lead[e]	690	NA	NA	NA	NA	NA	NA	NA	5 (Act 2)	**336** (OS-5A) *ND*	*ND*

a. Selecting all cleanup levels from this column will result in a remaining total cancer risk of greater than 10^{-4}.
b. Non-carcinogenic cleanup level calculated using a target HI of 1.0 for the individual compound.
c. Non-carcinogenic cleanup level calculated using a target total HI of 1.0 for 25 contributing compounds.
d. Not all site monitoring wells were sampled during the 1999 supplemental sampling event.
e. EPCs and risks for inorganic compounds were calculated using total (unfiltered) analyses. Maximum detected concentrations are shown for both **total (bold)** and *dissolved (italicized)* samples where available.

AR302701

TABLE 2-6
COMPARISON OF HEALTH-BASED AND ARAR-BASED CLEANUP LEVELS WITH DETECTED LEVELS IN BEDROCK GROUNDWATER

Constituent of Potential Concern	Human Health Risk Assessment Calculations			Site-Specific Health-Based Cleanup Levels (ug/l)					USEPA MCL or PADEP Act 2 Non-Res. Used Aquifer (ug/l)	Maximum Detected Concentration (ug/l)	
	EPC (ug/l)	Carcin. Risk	Non-Carc. HI	Carc. 10^{-4}[a]	Carc. 10^{-5}	Carc. 10^{-6}	Indiv. NC HI=1[b]	Cumul. NC HI=1[c]		'92/'94 RI Samples	'99 Suppl. Samples
Aroclor-1260	3.8	2.8E-03	NA	0.14	0.01	0.001	NA	NA	0.5 (MCL)	6.8 (M-4B)	290/2.5 (M-11B)
Aroclor-1254	3.3	2.7E-03	340	0.12	0.01	0.001	0.01	0.001	0.5 (MCL)	6.7 (N-7B)	2.0/ND (S-1B)
2,3,7,8-TCDD (teq)	3.6E-06	3.1E-04	NA	1E-06	1E-07	1E-08	NA	NA	3.0E-5 (MCL)	1.7E-6 (M-9)	NA
Arsenic[d]	9.7	2.2E-04	2.0	4.4	0.44	0.04	4.9	0.69	50 (MCL)	*9.7* (M-9)	*15.2* (M-9)
Benzo(a)anthracene	1.4	1.5E-05	NA	9.3	0.93	0.09	NA	NA	4 (Act 2)	1.4 (N-2B)	ND
Bis(2-ethylhexyl)phthalate	7.1	5.9E-06	NA	120	12	1.2	NA	NA	6 (MCL)	10 (S-1B)	2 (S-1B/N-7B)
Iron[d]	14,000	NA	3.1	NA	NA	NA	4,516	645	300 (SMCL)	*14,300* (M-11B)	*1,110* (M-11B)
Aluminum[d]	7,700	NA	0.5	NA	NA	NA	15,400	2,200	200 (SMCL)	*7,690* (M-11B)	*561* (M-11B)
Manganese[d]	133	NA	0.4	NA	NA	NA	333	48	50 (SMCL)	*133* (M-11B)	*92.5* (M-9)
Barium[d]	270	NA	0.2	NA	NA	NA	1,350	193	2,000 (MCL)	*300* (S-8B)	*2,090* (S-8B)
Cadmium[d]	2.5	NA	0.2	NA	NA	NA	13	1.8	5 (MCL)	*2.5* (M-11B)	*ND*

a. Selecting all cleanup levels from this column will result in a remaining total cancer risk of greater than 10^{-4}.
b. Non-carcinogenic cleanup level calculated using a target HI of 1.0 for the individual compound.
c. Non-carcinogenic cleanup level calculated using a target total HI of 1.0 for 25 contributing compounds.
d. EPCs and risks for inorganic compounds were calculated using dissolved (filtered) analyses. No total (unfiltered) inorganic samples have been collected from the bedrock aquifer.

AR302702

TABLE 3-1
INITIAL TECHNOLOGY SCREENING MATRIX
SHENANGO RIVER SEDIMENT

General Response Actions	Remedial Technology	Process Options and Descriptions	Effectiveness	Implementability	Cost	Screening Status
No Action	None	None	Not effective in reducing ecological risk.	Easily implemented	No cost	Retain as required by NCP
Limited Action	Restrict Access	Institutional Controls - Implement restrictions to limit future sediment disturbance, fishing restrictions.	Not effective in reducing ecological risk, but does address potential human exposure.	Fish consumption warnings in place. Other restrictions not readily implementable.	Very low capital cost	Retain for secondary screening analysis.
	Monitoring	Site Inspections - Routine inspections for erosion/ resedimentation and other maintenance items.	Essential long-term component of some remedial alternatives.	Easily implemented	Low capital cost, moderate long-term cost	Retain for secondary screening analysis.
		Sampling and Analysis - Routinely assess concentrations of COPCs.	Essential long-term component of some remedial alternatives.	Easily implemented	Low capital cost, moderate long-term cost	Retain for secondary screening analysis.
	Natural Recovery	Natural Attenuation - Natural detoxification of organic compounds by native microbes.	Effectiveness dependent on site-specific conditions.	Easily implemented if shown to be occurring	Low to moderate capital cost, moderate long-term cost	Retain for secondary screening analysis.
		Resedimentation - Natural deposition of clean sediments over impacted sediments.	Effective over time in isolating impacted sediments in certain portions of channel.	Easily implemented	Low capital cost, low long-term cost	Retain for secondary screening analysis.
Containment	Capping	Soil Cover - Cap impacted sediments with several inches of clean backfill.	Soil cover may be scoured away by river at some locations.	Implementable using established technology	Moderate capital cost, moderate long-term cost	No further consideration
		Riprap Cover - Cap impacted sediments with several inches of erosion- and scour-resistant rock.	Effective in isolating impacted sediments.	Implementable using established technology	Moderate capital cost, moderate long-term cost	Retain for secondary screening analysis.

Shaded cells indicate technologies that are screened out.

TABLE 3-1
INITIAL TECHNOLOGY SCREENING MATRIX
SHENANGO RIVER SEDIMENT

General Response Actions	Remedial Technology	Process Options and Descriptions	Effectiveness	Implementability	Cost	Screening Status
Containment (continued)	Vertical Barriers	Sheet Piling, Cofferdams - Provide temporary physical barrier to isolate impacted sediments from river.	Effective in isolating impacted sediments. Minimizes migration during removal.	Implementable using established technology, possible disruption of floodplain	Moderate capital cost	Retain for secondary screening analysis.
	Sediment Control Structures	Silt Curtain - Temporary containment structure used to capture sediments from water passing through the structure.	Moderately effective in mitigating downstream contamination due to resuspension during removal.	Implementable using well established technology	Low to moderate capital cost	Retain for secondary screening analysis.
Removal and Disposal	Excavation	Sediment removal using conventional excavation equipment after dewatering area.	Effective in removing sediment. May cause resuspension of sediment.	Implementable using well established and available equipment	Moderate capital cost	Retain for secondary screening analysis.
	Dredging	Hydraulic or Mechanical Dredge - Sediment removal via suspension in slurry. Water content in slurry depends on dredge type and sediment characteristics.	Varied effectiveness demonstrated at other sites.	Implementable using established technology	High capital cost due to water handling/ treatment costs	Retain for secondary screening analysis.
	Disposal	Off-site Disposal - Transportation and disposal at permitted facility.	Effective in reducing ecological risk.	Easily implemented	Moderately high capital cost	Retain for secondary screening analysis.
		On-site Disposal - Dispose removed material meeting appropriate human health standards on site.	Effective in reducing ecological risk.	Appropriate on-site location will not be available.	Not evaluated	No further consideration

Shaded cells indicate technologies that are screened out.
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CUMMINGS CENTER

TABLE 3-1
INITIAL TECHNOLOGY SCREENING MATRIX
SHENANGO RIVER SEDIMENT

General Response Actions	Remedial Technology	Process Options and Descriptions	Effectiveness	Implementability	Cost	Screening Status
Treatment	Physical Treatment (Ex situ)	Solidification/Stabilization - Immobilization of COPC.	Inconclusive results in technology demonstration projects for PCBs.	Implementable using well established technology	Moderately high capital cost	No further consideration
		Soil Washing - Separate COPC from sediment with water by (1) dissolution or suspension, or (2) concentration through size separation.	Very limited application to PCBs in sediment.	Implementable using well established technology	High capital cost	No further consideration
	Chemical Treatment (Ex situ)	Solvent Extraction - Separate COPC from sediment using solvent as opposed to water	Effective in reducing the volume of COPCs to be disposed of.	Implementable using established technology	High capital cost	Retain for secondary screening analysis.
		Chemical Reduction/Oxidation - Chemically convert hazardous COPC to nonhazardous or nontoxic compounds via redox reactions.	Innovative technology with some demonstrated success for organics.	Implementable using established technology	High capital cost	No further consideration
	Biological Treatment	In-situ Treatment				
		Enhanced Biodegradation - Stimulating organic-destroying microbes to increase rate of dechlorination and degradation.	Innovative technology with some success, dependent on site-specific conditions.	Implementable using tested technology	Moderate capital cost, moderate long-term cost	Retain for secondary screening analysis.

AR302705

Shaded cells indicate technologies that are screened out.
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CUMMINGS RITER

TABLE 3-1
INITIAL TECHNOLOGY SCREENING MATRIX
SHENANGO RIVER SEDIMENT

General Response Actions	Remedial Technology	Process Options and Descriptions	Effectiveness	Implementability	Cost	Screening Status
Treatment (continued)	Biological Treatment (continued)	Exsitu Treatment				
		Composting - Stimulating bidegradation of COPC through periodic aeration of soils.	Innovative technology with some success.	Implementable using tested technology.	Moderately high capital cost	No further consideration
	Thermal Treatment (Ex situ)	Incineration - High temperature destruction of COPC.	Effective in destroying COPCs.	Commercial facilities available	Very high capital cost	No further consideration due to low COPC concentrations.
		Thermal Desorption - Separation of organics from sediment through volatilization at low to medium temperatures.	Effective in reducing direct contact risk and treating PCBs.	Implementable using well established technology	High capital cost	Not cost effective due to low COPC concentrations and volume
		Vitrification - Destruction of COPC by high temperature by melting soil into glass- or rock-like mass.	Effective in reducing direct contact risk and treating PCBs.	Not implementable due to high moisture content.	Very high capital cost	No further consideration

AR302706

Shaded cells indicate technologies that are screened out.
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CUMMINGS CENTER

TABLE 3-2
INITIAL TECHNOLOGY SCREENING MATRIX
GROUNDWATER

General Response Actions	Remedial Technology	Process Options and Descriptions	Effectiveness	Implementability	Cost	Screening Status
No Action	None	None	Not effective in reducing direct contact risk.	Easily implemented	No cost	Retain as required by NCP
Limited Action	Restrict Access	Institutional Controls - Deed restrictions or a municipal ordinance to limit future groundwater use.	Effective in reducing direct contact risk by minimizing potential exposure.	Easily implemented	Very low capital cost	Retain for secondary screening analysis.
	Monitoring	Site Inspections - Routine inspections for maintenance items and assess deed restriction compliance.	Essential component of remedial alternatives.	Easily implemented	Low capital cost, moderate long-term cost	Retain for secondary screening analysis.
		Sampling and Analysis - Routinely assess concentrations of COI.	Essential component of groundwater remedial alternatives.	Easily implemented	Low capital cost, moderate long-term cost	Retain for secondary screening analysis.
	Natural Recovery	Monitored Natural Attenuation	Effective plume management under correct conditions	Implementable using established technology	Low capital cost, moderate long-term cost	Retain for secondary screening analysis.
Containment	Capping	Soil Cover, Asphalt Cap, or Low permeability Cap - Provide physical barrier to prevent leaching of COI from affected soils.	Not Appicable to groundwater	No Evaluation	No Evaluation	No further consideration

AR302707

Shaded cells indicate technologies that are screened out.
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CUMMINGS RITER

TABLE 3-2
INITIAL TECHNOLOGY SCREENING MATRIX
GROUNDWATER

General Response Actions	Remedial Technology	Process Options and Descriptions	Effectiveness	Implementability	Cost	Screening Status
Containment *(continued)*	Vertical Barriers	Slurry Wall, C/B Wall, or Sheet Piling - Provide physical barrier to contain affected groundwater.	Effective in reducing migration.	Very difficult to implement due to existing structures	Moderate capital cost	No further consideration
	Horizontal Barriers	Liners, Grout Injection - Provide physical barrier to reduce leaching to groundwater.	Not Appicable to groundwater	No Evaluation	No Evaluation	No further consideration
Removal and *Disposal*	Groundwater Extraction	Groundwater Removal using horizontal or vertical recovery wells.	Effective in recovering groundwater and establishing hydraulic control.	Potentially difficult to implement due to existing structures	Moderately high capital cost and high O&M costs	Retain for secondary screening analysis.
	Disposal	Offsite Disposal - Transportation and disposal at permitted facility.	Effective disposal of groundwater	Easily implemented	Very high long-term costs	No further consideration
		Onsite Disposal to POTW.	Effective disposal of groundwater or treated effluent	Pretreatment likely to be necessary	Low capital cost moderate long-term usage costs	Retain for secondary screening analysis.
		Discharge to River	Effective in disposal of treated effluent	Technically easy, possible permit issues	Low capital cost	Retain for secondary screening analysis.
		Reinjection	Effective in disposal of treated effluent	Implementable using well established technology	Low capital cost, moderate long-term cost	Retain for secondary screening analysis.

AR302708

Shaded [illegible] ndicate technologies that are screened out.
brm\[illegible] .echscm-r1.xls-Groundwater
revised [illegible] 00

CUMMINGS [illegible]ER

TABLE 3-2
INITIAL TECHNOLOGY SCREENING MATRIX
GROUNDWATER

General Response Actions	Remedial Technology	Process Options and Descriptions	Effectiveness	Implementability	Cost	Screening Status
Treatment	Physical/Chemical Treatment	Precipitation - Alter COI solubility through pH adjustment.	Effective metals treatment, not effective for organics	Implementable using well established technology	High capital cost, moderate long-term cost	No further consideration
		Filtration - Physical separation of solids using a porous medium, typically sand or cotton fibers.	Effective for particulate removal.	Implementable using well established technology	Low capital cost, low long-term cost	Retain for secondary screening analysis.
		Air Stripping - Transfer VOCs from water to air.	Effective VOC treatment	Implementable using well established technology	Moderate capital cost, low long-term cost	Retain for secondary screening analysis.
		Dual-Phase Extraction - Combined vacuum extraction and air spaging, bioventing, or bioremediation.	Effective treatment for smear zone organics contributing to groundwater impacts.	Implementable using well established technology	Moderate capital cost, low long-term cost	Retain for secondary screening analysis.
		Carbon Adsorption - Removal of COI by adsorption onto activated carbon.	Effective organic treatment	Implementable using well established technology	Moderate capital cost, low long-term cost	Retain for secondary screening analysis.
		Reverse Osmosis - High pressure membrane filtration.	Effective metals treatment when high concentrations present	Implementable using established technology, difficult to control	Very high cost to operate	No further consideration

AR302709

Shaded cells indicate technologies that are screened out.
brm\111\gwfs-techscrn-r1.xls-Groundwater
revised 3/29/00

CUMMINGS RITER

TABLE 3-2
INITIAL TECHNOLOGY SCREENING MATRIX
GROUNDWATER

General Response Actions	Remedial Technology	Process Options and Descriptions	Effectiveness	Implementability	Cost	Screening Status
Treatment (continued)	Physical/Chemical Treatment (continued)	Ion Exchange - COI removal through ion exchange when passed through resin bed.	Effective metals treatment, not effective for organics	Implementable using well established technology	High capital cost, moderate long-term cost	Retain for secondary screening analysis.
		Chemical Oxidation - Chemically convert hazardous COI to nonhazardous or nontoxic compounds via oxidation reactions.	Effective organic treatment, ancillary inorganic treatment.	Implementable using established technology	High capital cost, high long-term cost	Retain for secondary screening analysis.
	Biological Treatment	Biological Reactor - Treat COI with micro-organisms under controlled aerobic or anaerobic conditions	Effective organic treatment	Implementable using established technology, difficult to control	High capital cost, high long-term cost	No further consideration
	Insitu Treatment	Enhanced Biodegradation - Stimulating microbes to degrade COI through nutrient addition.	Innovative technology, effective organics treatment	Implementable using recently developed established technology	Low capital cost, moderate long-term cost	Retain for secondary screening analysis.
		Permeable Reactive Barriers - Passive treatment via trenches filled with reactive or adsorptive media.	Innovative technology, effective organics or metals treatment	Implementable using well established construction technology with recently developed treatment media	High capital cost, low long-term cost	Retain for secondary screening analysis.

AR302710

Shaded cells indicate technologies that are screened out.

CUMMINGS CENTER

TABLE 3-2
INITIAL TECHNOLOGY SCREENING MATRIX
GROUNDWATER

General Response Actions	Remedial Technology	Process Options and Descriptions	Effectiveness	Implementability	Cost	Screening Status
Treatment (continued)	Insitu Treatment (continued)	In-well Stripping - Insitu air stripping	Innovative technology, effective organics treatment.	Commercially available technology.	Moderate capital cost, low long-term cost	Retain for secondary screening analysis.
		Insitu Chemical Oxidation - Chemically convert hazardous COI to nonhazardous or nontoxic compounds via oxidation reactions.	Innovative technology, effective organics treatment.	Commercially available technology.	Low to high capital cost, low long-term cost	Retain for secondary screening analysis.

AR302711

Shaded cells indicate technologies that are screened out.
brm\111\gwfs-techscm-r1.xls-Groundwater
revised 3/29/00

CUMMINGS RITER

TABLE 5-1
SUMMARY OF POTENTIAL ARARs
SHENANGO RIVER SEDIMENT ALTERNATIVES

Potential ARAR	Alternative 1 No Action	Alternative 2 Natural Recovery	Alternative 3 Cover	Alternative 4 Excavation/Disposal
Chemical-Specific				
TSCA	X	X	X	X
MCLs/MCLGs			X	X
PA Safe Drinking Water Act			X	X
PA Water Quality Standards			X	X
PA Act 2	X	X	X	X
Location-Specific				
Wetlands Protection and Floodplain Management EOs			X	X
Clean Water Act			X	X
PA Floodplain/Dam Safety Acts			X	X
Endangered Species Act	X	X	X	X
Fish and Wildlife Acts	X	X	X	X
Action-Specific				
RCRA Subtitle C/LDRs			X	X
PA Solid Waste Management			X	X
PA HSCA/Haz. Waste Mgmt.		X	X	X
Clean Water Act/NPDES				X
PA Waste Water Treatment				X
PA Clean Streams Law			X	X
PA Storm Water Mgmt/Erosion Ctrl.			X	X

Note: See Sections 2.1.1 through 2.1.3 of the FS for descriptions of these potential ARARs.

AR302712

CUMMINGS RITER

TABLE 5-2
SUMMARY OF POTENTIAL ARARs
ALLUVIAL GROUNDWATER/NAPLs ALTERNATIVES

Potential ARAR	Alternative 1 No Action	Alternative 2 Instit.Controls Mon.Nat.Att.	Alternative 3A NAPL Recovery/ Mon.Nat.Att.	Alternative 3B In-Situ NAPL Trtmnt. and Mon.Nat.Att.	Alternative 4 NAPL Recovery/ GW Pump & Treat	Alternative 5 In-Situ NAPL and GW Treatment
Chemical-Specific						
TSCA	X	X	X	X	X	X
MCLs/MCLGs	X	X	X	X	X	X
PA Safe Drinking Water Act					X	
PA Water Quality Standards					X	
Clean Air Act/NAAQS/NESHAP			X		X	
New Source Performance Standards					X	
PA Air Pollution Control Regs.					X	
PA Act 2	X	X	X	X	X	X
Location-Specific						
Clean Water Act	X	X	X	X	X	X
Action-Specific						
RCRA Subtitle C/LDRs			X		X	
PA Solid Waste Management			X		X	
SDWA (Underground Injection)				X		X
PA Water Well Drillers License Act		X	X	X	X	X
PA HSCA/Haz. Waste Mgmt.		X	X	X	X	X
Clean Water Act/NPDES			X		X	
PA Waste Water Treatment			X		X	
PA Clean Streams Law		X	X	X	X	X
PA Storm Water Mgmt/Erosion Ctrl.			X		X	

Note: See Sections 2.1.1 through 2.1.3 of the FS for descriptions of these potential ARARs.

TABLE 5-3
SUMMARY OF ESTIMATED REMEDIAL COSTS
SHENANGO RIVER SEDIMENTS

Alternative	Description	Capital Cost	Total 30-Yr. Present Worth
1	No Action	$0	$58,000
2	Limited Action/Natural Recovery	$129,000	$667,000
3	Cover[2]	$436,000	$880,000
4A	1-Foot Excavation/Disposal/Reestablish Profiles[2]	$1,400,000	$1,840,000
4B	4-Foot Excavation/Disposal/Reestablish Profiles[2]	$2,590,000	$3,030,000

1. See Appendix C for detailed cost estimates.
2. Does not include costs associated with provisions for protecting the public drinking water supply, such as shutting off the surface water intake, obtaining water from another local authority, or adding new treatment facilities or storage to the existing plant.

AR302714

TABLE 5-4A
COMPARISON OF REMEDIAL ALTERNATIVES
SHENANGO RIVER SEDIMENT - AREA 14 (NEAR WATER COMPANY)

Remedial Alternative	Description	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduces Mobility, Toxicity, or Volume by Treatment	Short-Term Effectiveness	Implementability	Cost
1	No Action	◎	◎	⊗	⊗	○	●	●
2	Limited Action/Natural Recovery	○	○	◎	⊗ *	○	●	○
3	Cover	○	○	○	⊗ *	◎	◎	○
4A	1-Foot Excavation/Disposal/Cover	◎	●	◎	⊗ *	⊗	⊗	◎
4B	4-Foot Excavation/Disposal/ Reestablish Profiles	◎	●	◎	⊗ *	⊗	⊗	⊗

Key:
- ● = Very Good
- ○ = Good
- ◎ = Fair
- ⊗ = Poor

* - Alternatives 2 through 4 are not treatment methods, but would otherwise be rated fair (2) or good (3 and 4) for reduction of mobility.

AR302715

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revised 3/29/00

TABLE 5-4B
COMPARISON OF REMEDIAL ALTERNATIVES
SHENANGO RIVER SEDIMENT - AREA 15 (CLARK STREET)

Remedial Alternative	Description	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduces Mobility, Toxicity, or Volume by Treatment	Short-Term Effectiveness	Implementability	Cost
1	No Action	◎	◎	⊗	⊗	○	●	●
2	Limited Action/Natural Recovery	○	○	◎	⊗ *	○	●	○
3	Cover	○	○	○	⊗ *	◎	○	○
4A	1-Foot Excavation/Disposal/Cover	◎	●	○	⊗ *	◎	◎	◎
4B	4-Foot Excavation/Disposal/ Reestablish Profiles	○	●	●	⊗ *	◎	◎	⊗

Key:
- ● = Very Good
- ○ = Good
- ◎ = Fair
- ⊗ = Poor

* - Alternatives 2 through 4 are not treatment methods, but would otherwise be rated fair (2) or good (3 and 4) for reduction of mobility.

AR302716

brm\111\gwfs-comp-table-r1 xls-sediment-15
revised 3/29/00

TABLE 5-5
SUMMARY OF ESTIMATED REMEDIAL COSTS
ALLUVIAL GROUNDWATER AND NAPLS

Alternative	Description	Capital Cost	Total 30-Yr. Present Worth
1	No Action	$0	$0
2	Institutional Controls with Monitored Natural Attenuation	$205,000	$2,150,000
3A1	Direct NAPL Recovery with Monitored Natural Attenuation	$2,110,000	$5,970,000
3A2	Direct/Enhanced NAPL Recovery with Monitored Natural Attenuation	$4,290,000	$9,860,000
3B	NAPL In-Situ Treatment with Monitored Natural Attenuation	$5,320,000	$10,500,000
4	NAPL Enhanced Recovery with Groundwater Extraction/Treatment	$6,000,000	$17,300,000
5	NAPL In-Situ Treatment with In-Situ Groundwater Treatment	$6,320,000	$12,000,000

1. See Appendix C for detailed cost estimates.

AR302717

TABLE 5-6
COMPARISON OF REMEDIAL ALTERNATIVES
ALLUVIAL GROUNDWATER AND NAPLS

Remedial Alternative	Description	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduces Mobility, Toxicity, or Volume by Treatment	Short-Term Effectiveness	Implementability	Cost
1	No Action	◎	⊗	⊗	⊗	◎	●	●
2	Institutional Controls with Monitored Natural Attenuation	◎ to ○	◎	◎	⊗	○	●	○
3A1	NAPL Direct Recovery with Monitored Natural Attenuation	○	○	○	○	◎	○	○
3A2	NAPL Direct/Enhanced Recovery with Monitored Natural Attenuation	○	○	○	○	◎	○	◎
3B	NAPL In-Situ Treatment with Monitored Natural Attenuation	○	○	○	◎	○	◎	◎
4	NAPL Enhanced Recovery with Groundwater Extraction/Treatment	○	○	○	●	◎	◎	⊗
5	NAPL In-Situ Treatment with In-Situ Groundwater Treatment	○	○	○	○	○	◎	⊗

Key:
- ● = Very Good
- ○ = Good
- ◎ = Fair
- ⊗ = Poor

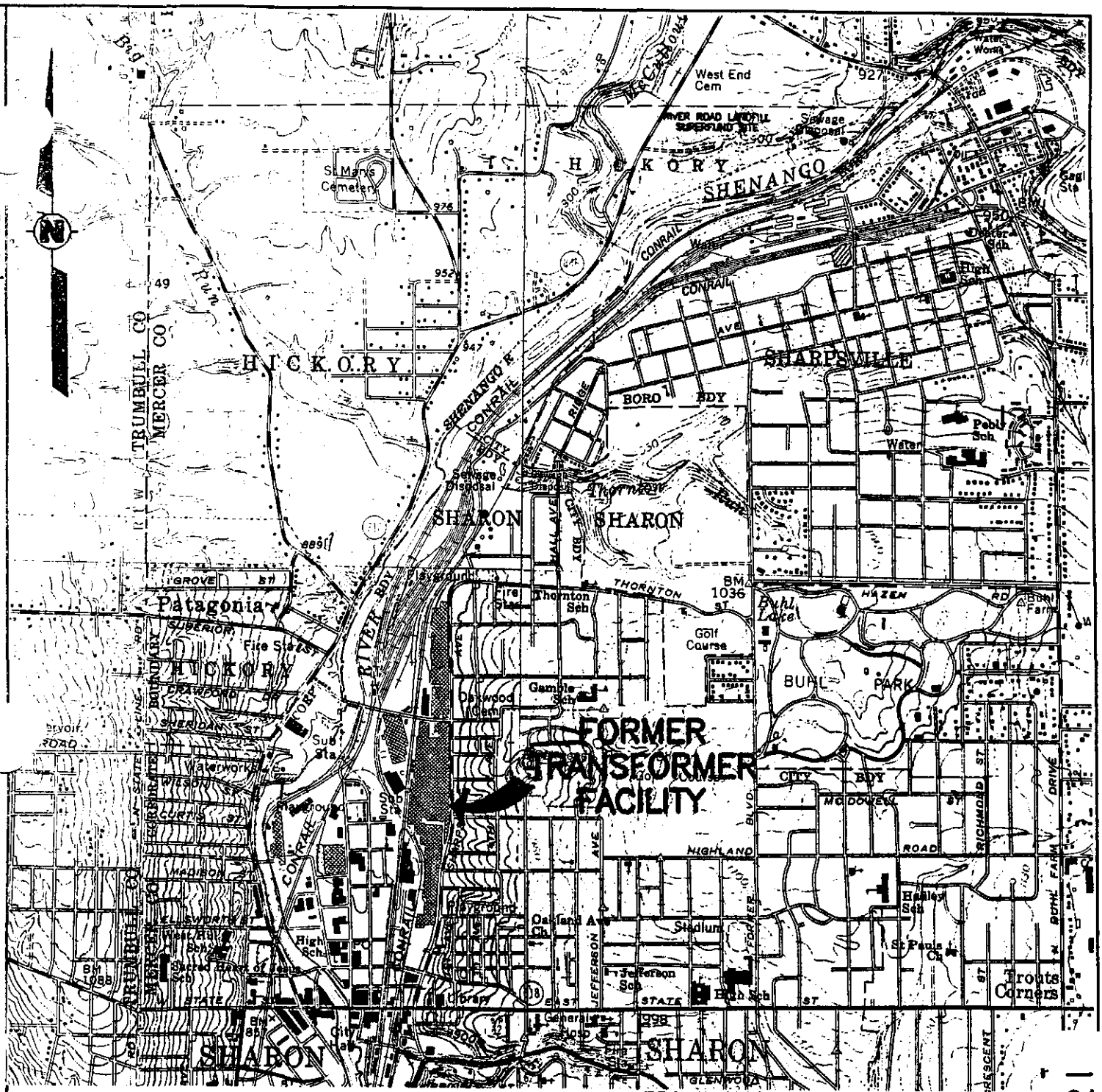
AR302718

brm\111\gwfs-comp-table-r1.xls-gw-napl
revised 3/29/00

FIGURES

FIGURES

DRAWING NUMBER 93111A3



REFERENCE:
7.5-MIN. TOPOGRAPHIC QUADRANGLE; ORANGEVILLE, OH-PA, 1961 PHOTOREVISED 1979; SHARON EAST, PA, 1958 PHOTOREVISED 1981; SHARON WEST, OH-PA, 1962 PHOTOREVISED 1979; AND SHARPSVILLE, PA, 1958 PHOTOREVISED 1981, SCALE 1:24000.

SCALE
0 2000 4000 FT.

FIGURE 1-1
SITE LOCATION MAP
FORMER TRANSFORMER FACILITY SHARON, PENNSYLVANIA

PREPARED FOR
CBS CORPORATION
PITTSBURGH, PENNSYLVANIA

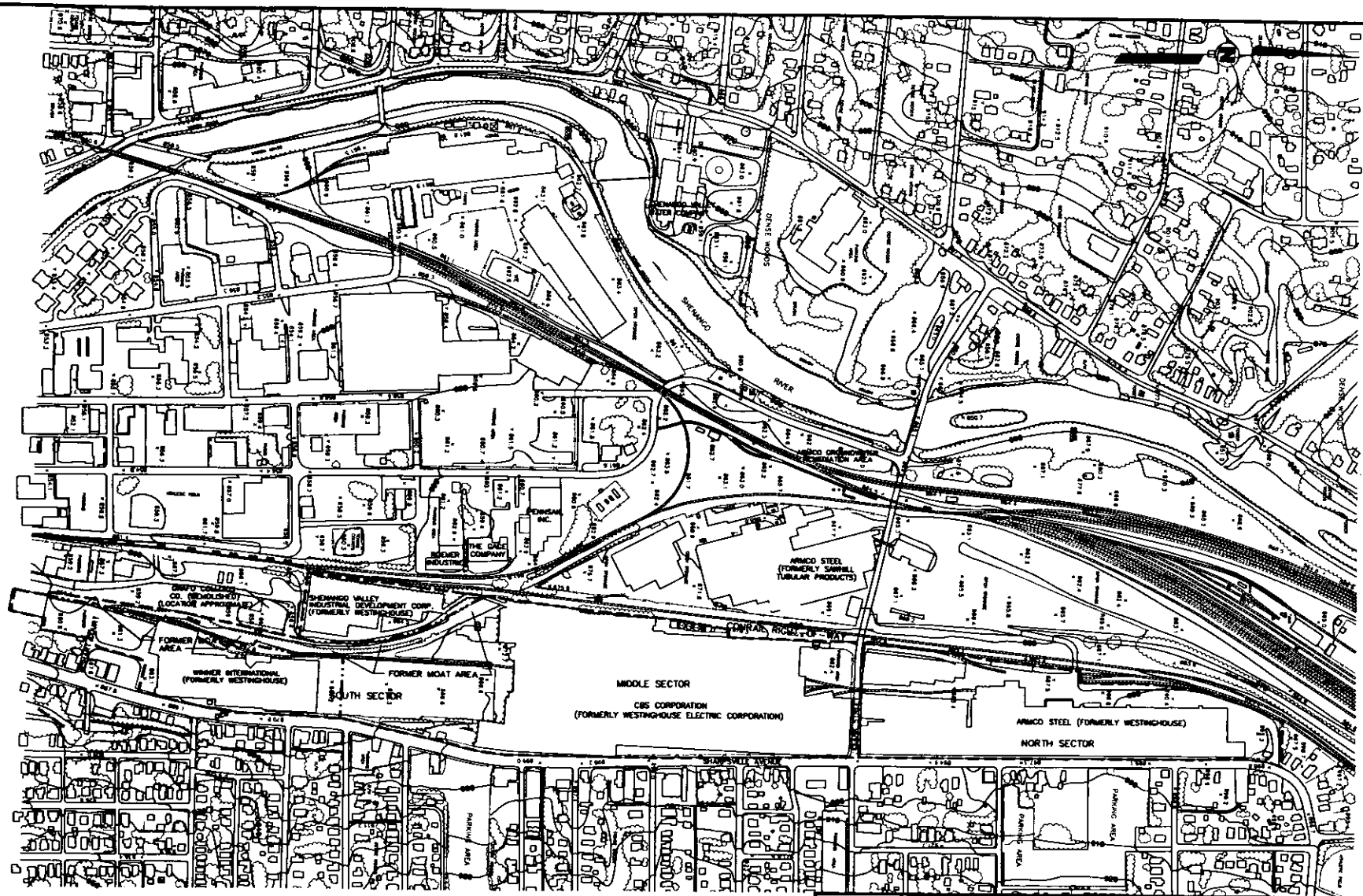
CUMMINGS RITER CONSULTANTS, INC.

DRAWING NUMBER 93111A3

REVISION	DATE	DESCRIPTION

DRAWN BY:	B. MAURER	DATE:	3-14-94
CHECKED BY	W. BAUGHMAN	DATE:	3-14-94
APPROVED BY:	P. O'HARA	DATE:	3-14-94

AR302721



REFERENCE:
THE MAP WAS GENERATED BY WITCH MAPPING, INC., 1991.

NOTES:
1. TOPOGRAPHIC CONTOURS PROVIDED ARE TWO-FOOT INTERVALS IN FEET ABOVE MEAN SEA LEVEL.

2' CONTOUR INTERVAL

SCALE
200 0 200 400 FEET

LEGEND:

- APPROXIMATE BOUNDARY OF SITE
- APPROXIMATE CURRENT ON-SITE PROPERTY LINE
- APPROXIMATE BOUNDARY BETWEEN SOUTH AND MIDDLE SECTORS

AR302722

CUMMINGS RITER CONSULTANTS, INC.
3100 William Pitt Way
Pittsburgh, PA 15238
(412) 826-3005
Fax: (412) 826-3007

REVISIONS

REV.	DESCRIPTION	DATE	APPROVED
1	GENERAL REVISION	11/17/98	

DRAWN BY:	T.E. McKee	DATE: 7-11-98
CHECKED BY:	B.R. Maurer	DATE: 7-24-98
APPROVED BY:	P.F. O'Hara	DATE: 7-24-98

FIGURE 1-2
TOPOGRAPHIC VICINITY MAP
FORMER TRANSFORMER FACILITY
SHARON, PENNSYLVANIA

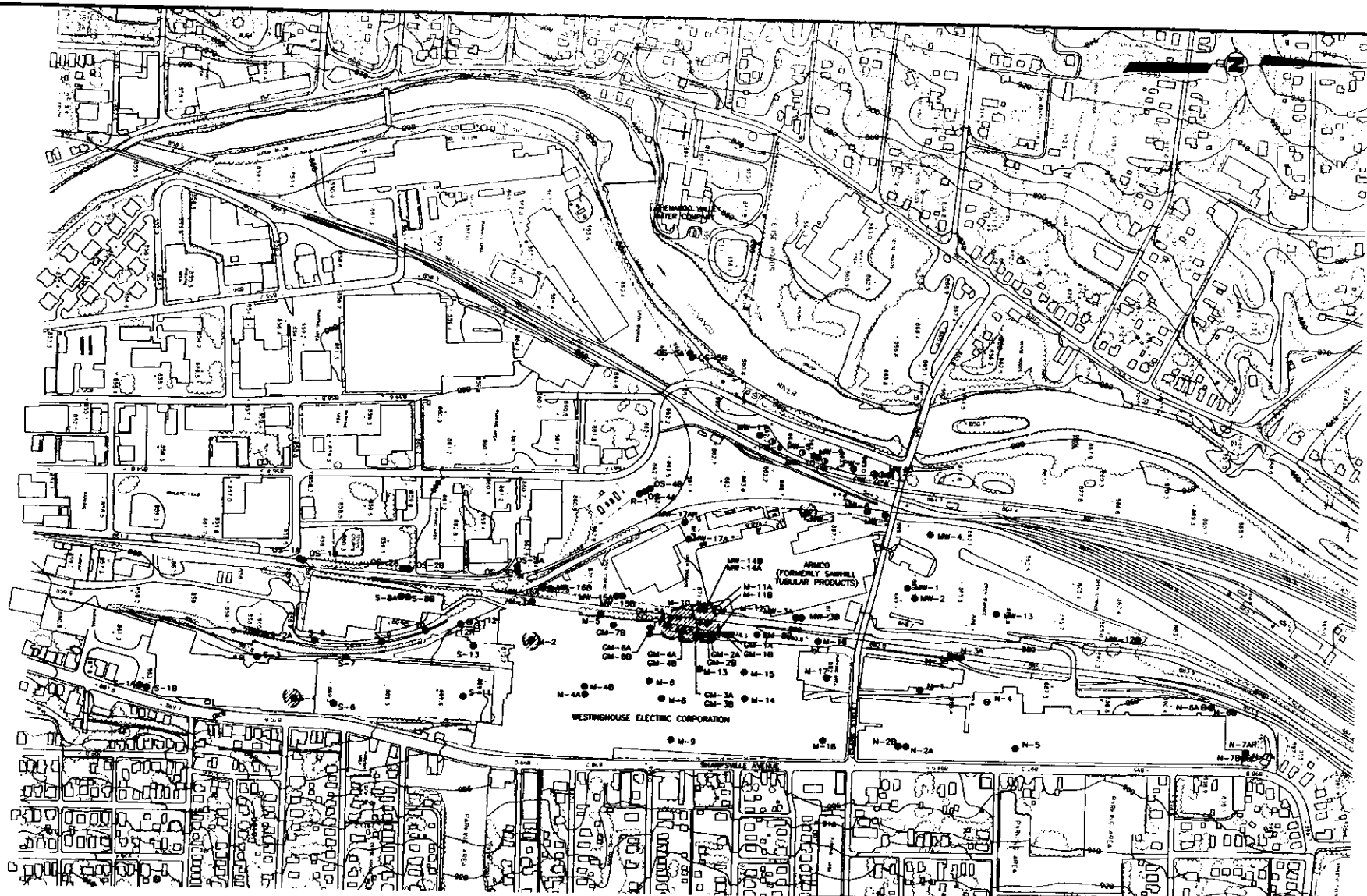
PREPARED FOR
CBS CORPORATION
PITTSBURGH, PENNSYLVANIA

SIZE	DRAWING NUMBER	REV.
E	93111E59	1

SCALE: 1" = 200'
SHEET 1 OF 1

DRAWING NUMBER 9" "E59

PLOT SCALE 1=20C



REFERENCE:
1. MAP WAS GENERATED BY ERM MAPPING, INC., 1991.

NOTES:
1. TOPOGRAPHIC CONTOURS PROVIDED ARE TWO-FOOT INTERVALS IN FEET ABOVE MEAN SEA LEVEL.

LEGEND:

- M-9 EXISTING RI/FS MONITORING WELL
- MW-1 SAWHILL MONITORING WELL
- PW-1 SAWHILL PUMPING WELL
- GM-7B INTERIM MEASURE WELLS
- N-4 ABANDONED MONITORING WELL
- AREAS WHERE LIGHT NON-AQUEOUS PHASE LIQUIDS WERE DETECTED IN THE ALLUVIAL AQUIFER

2' CONTOUR INTERVAL

SCALE

200 0 200 400 FEET

AR302723

CUMMINGS RITER CONSULTANTS, INC.
3100 William Pitt Way
Pittsburgh, PA 15238
(412) 826-3300
Fax: (412) 826-3307

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED

DRAWN BY:	T. GROSSO	DATE: 3-10-95
CHECKED BY:	B. MAURER	DATE: 3-17-95
APPROVED BY:	W. BAUCHMAN	DATE: 3-30-95

FIGURE 1-3
AREAS OF HISTORICAL OCCURENCES OF LNAPL
FORMER TRANSFORMER FACILITY
SHARON, PENNSYLVANIA

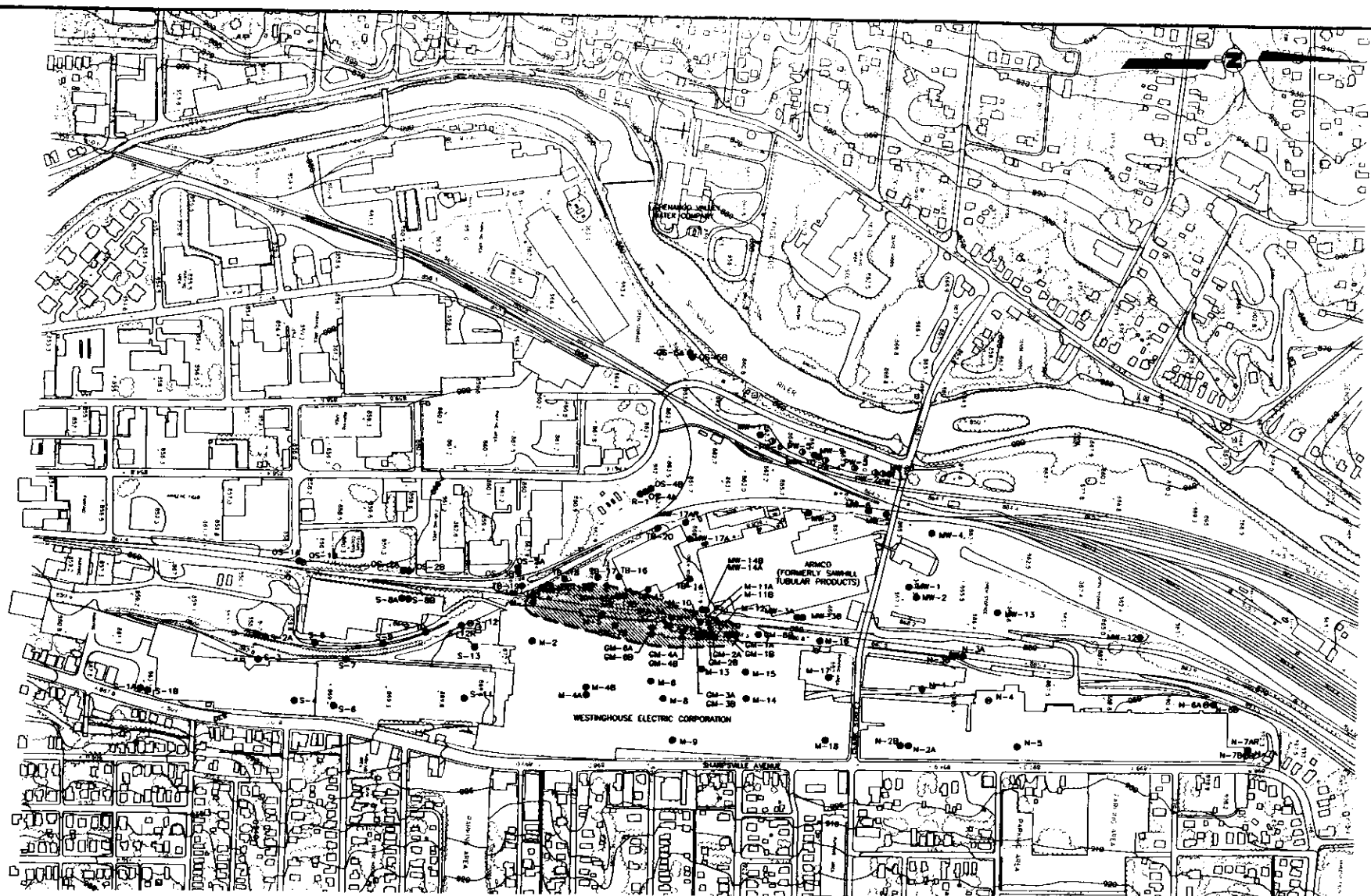
PREPARED FOR
WESTINGHOUSE ELECTRIC CORPORATION
PITTSBURGH, PENNSYLVANIA

SIZE: E | DRAWING NUMBER: 93111E36 | REV.

SCALE: 1"=200' | SHEET 1 OF 1

DRAWING NUMBER 93111E36

PLOT SCALE: 1=200



2" CONTOUR INTERVAL

SCALE

200 0 200 400 FEET

NOTES:

1. MAP WAS GENERATED BY FERM MAPPING, INC., 1991.

NOTES:

1. TOPOGRAPHIC CONTOURS PROVIDED ARE TWO-FOOT INTERVALS IN FEET ABOVE MEAN SEA LEVEL.

LEGEND:

- M-9 — EXISTING RI/FS MONITORING WELL
- MW-1 — SAWHILL MONITORING WELL
- PW-1 — SAWHILL PUMPING WELL
- GM-7B — INTERIM MEASURE WELLS
- N-4 — ABANDONED MONITORING WELL
- AREA WHERE DENSE NON-AQUEOUS PHASE LIQUIDS WERE DETECTED IN THE ALLUVIAL AQUIFER

AR302724

CUMMINGS RITER CONSULTANTS, INC.
2880 William Pitt Way
Pittsburgh, PA 15238
(412) 826-3300
Fax: (412) 826-3307

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED

DRAWN BY:	T. GROSSO	DATE: 3-10-95	
CHECKED BY:	B. MAURER	DATE: 3-17-95	
APPROVED BY:	W. BAUGHMAN	DATE: 3-30-95	

FIGURE 1-4
AREA OF HISTORICAL OCCURENCES OF DNAPL FORMER TRANSFORMER FACILITY SHARON, PENNSYLVANIA

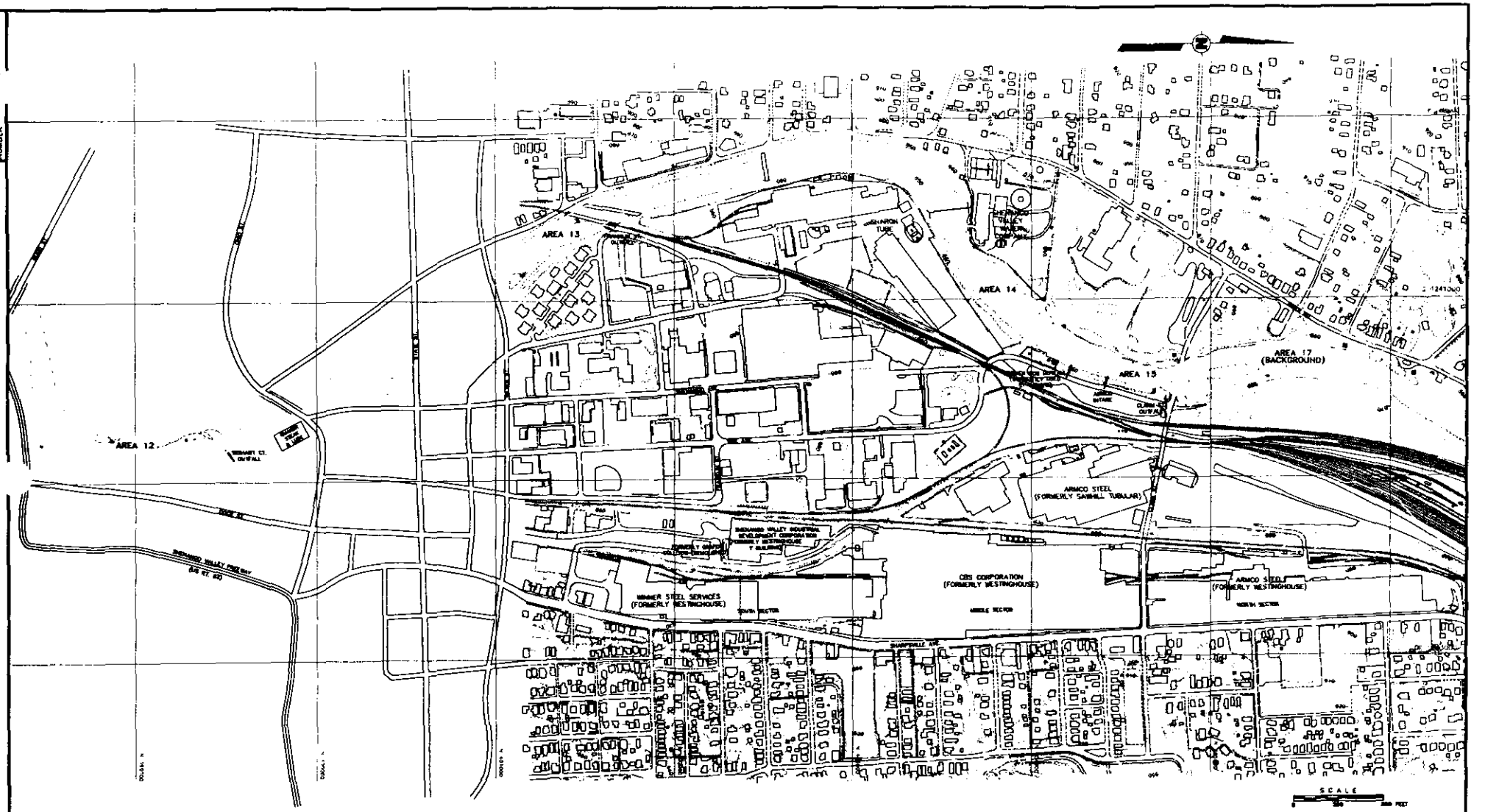
PREPARED FOR
WESTINGHOUSE ELECTRIC CORPORATION
PITTSBURGH, PENNSYLVANIA

SIZE	DRAWING NUMBER	REV.
E	93111E37	

SCALE: 1"=200'

DRAWING NUMBER 93111E37

PLOT SCALE: 1=200



REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED

CUMMINGS RITER CONSULTANTS, INC.
3026 Beaver Road
Pittsburgh Mall, Suite 201
Moon Township, Pa. 15108
(412) 262-5000
Fax: (412) 262-5040

DRAWN BY: B. MAURER DATE: 11/30/98
CHECKED BY: B. MAURER DATE: 5/21/99

FIGURE 1-5
SEDIMENT SAMPLING LOCATIONS
SUPPLEMENTAL SAMPLING PROGRAM
FORMER SHARON TRANSFORMER PLANT
SHARON, PENNSYLVANIA

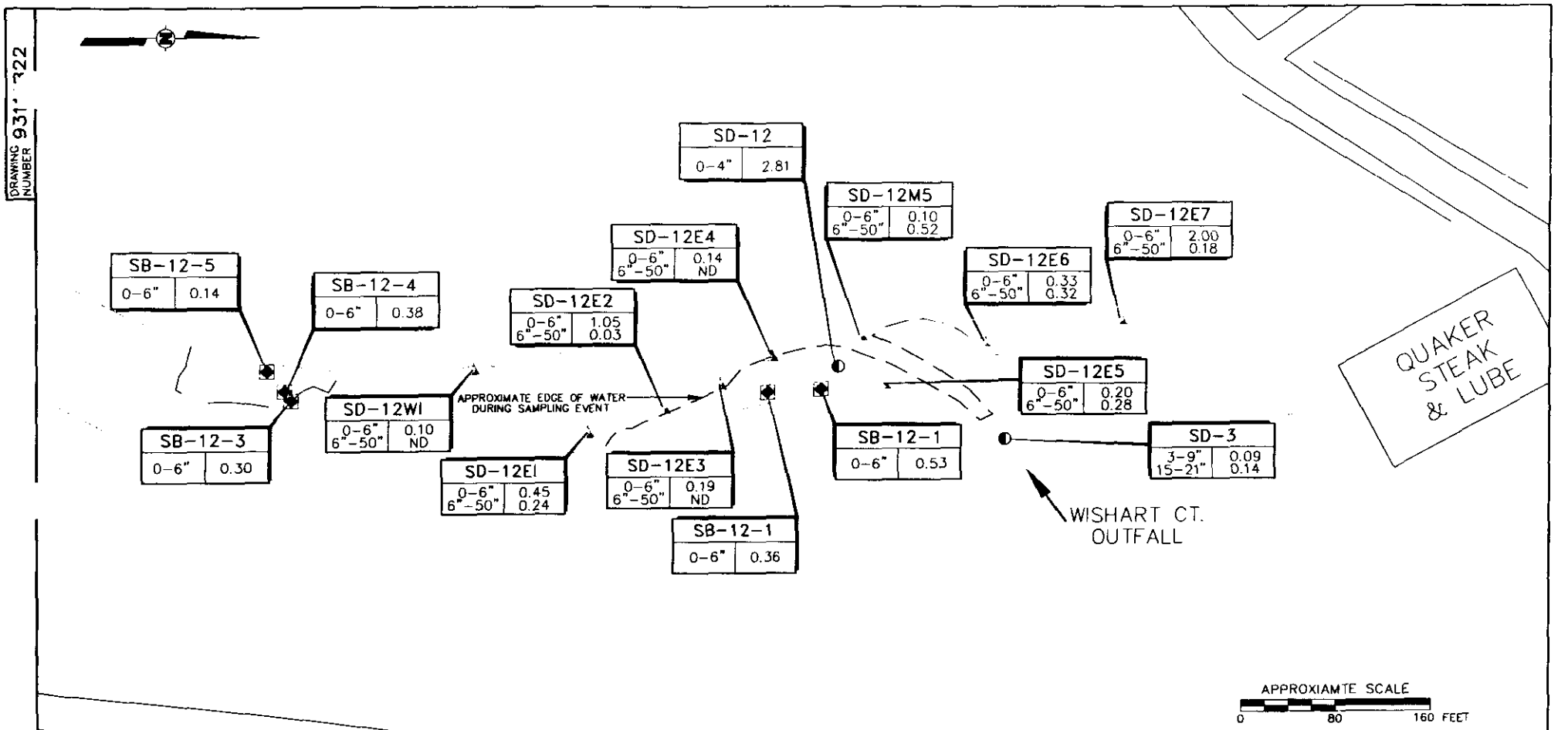
PREPARED FOR
CBS CORPORATION
PITTSBURGH, PENNSYLVANIA

SIZE: E DRAWING NUMBER: 93111E66 REV.

DRAWING NUMBER 93111E66

PLOT SCALE 1=1

AR302725



LEGEND:

- SUPPLEMENTAL SEDIMENT SAMPLE LOCATION (1998)
- SUPPLEMENTAL RIPARIAN SAMPLE LOCATION (1998)
- APPROXIMATE RI SEDIMENT SAMPLE LOCATION (1992/1994)
- APPROXIMATE EXTENT OF FINE-GRAINED SEDIMENT (1998)

FIGURE 1-6

TOTAL PCB CONCENTRATIONS (mg/kg)
AREA 12 SEDIMENT SAMPLES
FORMER SHARON TRANSFORMER PLANT
SHARON, PENNSYLVANIA

PREPARED FOR
CBS CORPORATION
PITTSBURGH, PENNSYLVANIA

CUMMINGS RITER CONSULTANTS, INC.

DRAWING NUMBER 93111B22

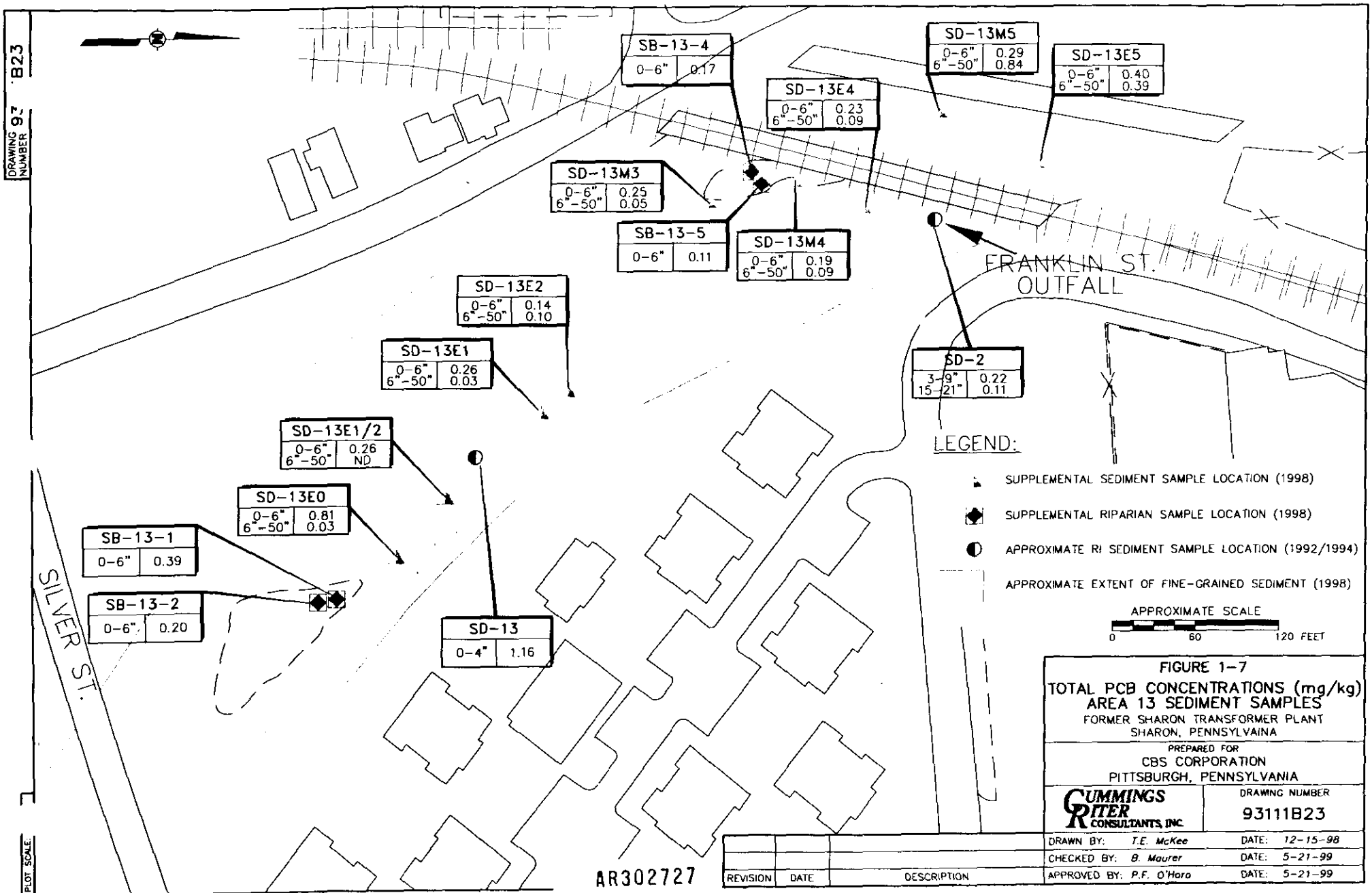
DRAWN BY: T.E. McKee DATE: 12-8-98
CHECKED BY: B. Maurer DATE: 5-21-99
APPROVED BY: P.F. O'Hara DATE: 5-21-99

REVISION	DATE	DESCRIPTION

AR302726

DRAWING NUMBER 931 322

PLOT SCALE: 1"


SB-13-4
0-6" 0.17
SD-13M5
0-6" 0.29
6"-50" 0.84
SD-13E5
0-6" 0.40
6"-50" 0.39
SD-13E4
0-6" 0.23
6"-50" 0.09
SD-13M3
0-6" 0.25
6"-50" 0.05
SB-13-5
0-6" 0.11
SD-13M4
0-6" 0.19
6"-50" 0.09
FRANKLIN ST.
OUTFALL
SD-13E2
0-6" 0.14
6"-50" 0.10
SD-13E1
0-6" 0.26
6"-50" 0.03
SD-2
3-9" 0.22
15-21" 0.11
SD-13E1/2
0-6" 0.26
6"-50" ND
SD-13E0
0-6" 0.81
6"-50" 0.03
SB-13-1
0-6" 0.39
SB-13-2
0-6" 0.20
SD-13
0-4" 1.16
SILVER ST.
LEGEND:
SUPPLEMENTAL SEDIMENT SAMPLE LOCATION (1998)
SUPPLEMENTAL RIPARIAN SAMPLE LOCATION (1998)
APPROXIMATE RI SEDIMENT SAMPLE LOCATION (1992/1994)
APPROXIMATE EXTENT OF FINE-GRAINED SEDIMENT (1998)
APPROXIMATE SCALE
0 60 120 FEET
FIGURE 1-7
TOTAL PCB CONCENTRATIONS (mg/kg)
AREA 13 SEDIMENT SAMPLES
FORMER SHARON TRANSFORMER PLANT
SHARON, PENNSYLVAINA
PREPARED FOR
CBS CORPORATION
PITTSBURGH, PENNSYLVANIA
CUMMINGS RITER CONSULTANTS, INC.
DRAWING NUMBER
93111B23
DRAWN BY: T.E. McKee DATE: 12-15-98
CHECKED BY: B. Maurer DATE: 5-21-99
APPROVED BY: P.F. O'Hara DATE: 5-21-99
REVISION DATE DESCRIPTION
AR302727
DRAWING NUMBER 93 B23
PLOT SCALE
93111b23.dwg 11-19-99 1:58:59 pm EST

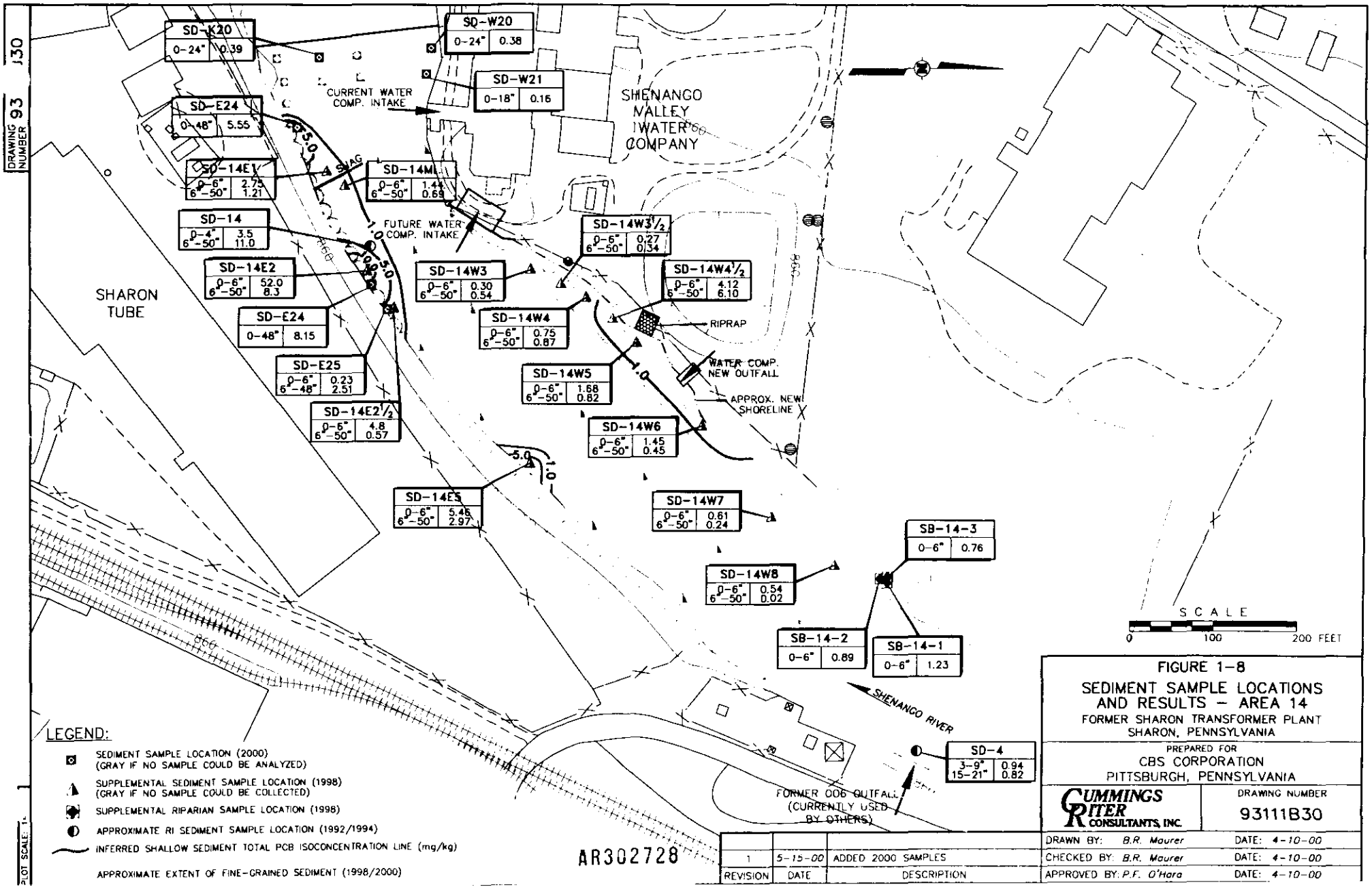


FIGURE 1-8

SEDIMENT SAMPLE LOCATIONS AND RESULTS – AREA 14

FORMER SHARON TRANSFORMER PLANT
SHARON, PENNSYLVANIA

PREPARED FOR
CBS CORPORATION
PITTSBURGH, PENNSYLVANIA

CUMMINGS RITER CONSULTANTS, INC.

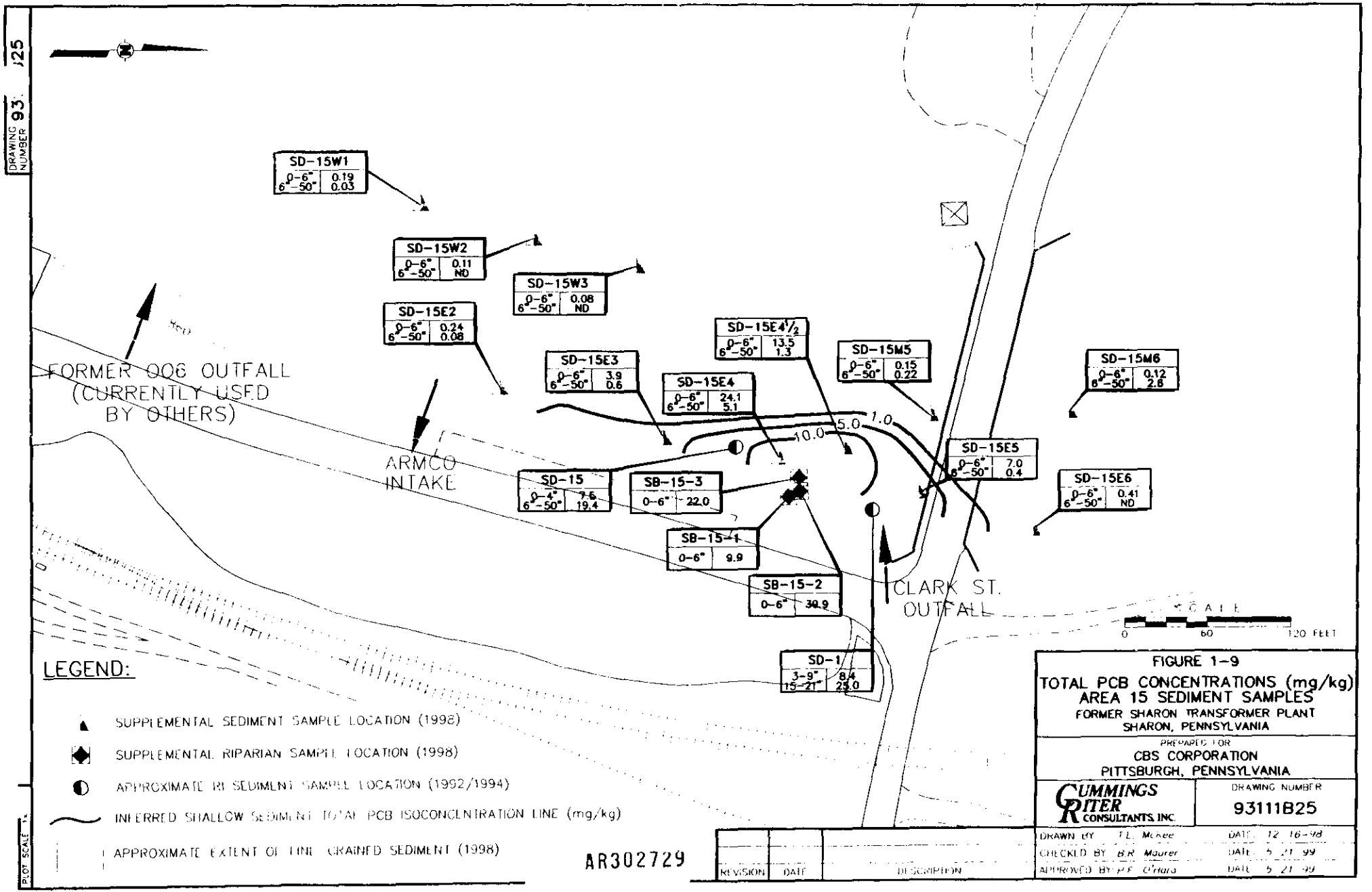
DRAWING NUMBER 93111B30

REVISION	DATE	DESCRIPTION
1	5-15-00	ADDED 2000 SAMPLES

DRAWN BY: B.R. Maurer DATE: 4-10-00
CHECKED BY: B.R. Maurer DATE: 4-10-00
APPROVED BY: P.F. O'Hara DATE: 4-10-00

DRAWING NUMBER 93 J30

PLOT SCALE: 1:1


SD-15W1
0-6" 0.19
6"-50" 0.03
SD-15W2
0-6" 0.11
6"-50" ND
SD-15W3
0-6" 0.08
6"-50" ND
SD-15E2
0-6" 0.24
6"-50" 0.08
SD-15E3
0-6" 3.9
6"-50" 0.6
SD-15E4
0-6" 24.1
6"-50" 5.1
SD-15E4 1/2
0-6" 13.5
6"-50" 1.3
SD-15M5
0-6" 0.15
6"-50" 0.22
SD-15M6
0-6" 0.12
6"-50" 2.8
SD-15E5
0-6" 7.0
6"-50" 0.4
SD-15E6
0-6" 0.41
6"-50" ND
SD-15
0-4" 7.6
6"-50" 19.4
SB-15-3
0-6" 22.0
SB-15-1
0-6" 9.9
SB-15-2
0-6" 39.9
SD-1
3-9" 8.4
15-21" 25.0
1.0
5.0
10.0
FORMER OQG OUTFALL
(CURRENTLY USED
BY OTHERS)
ARMCO
INTAKE
CLARK ST.
OUTFALL
SCALE
0
60
120 FEET
LEGEND:
SUPPLEMENTAL SEDIMENT SAMPLE LOCATION (1998)
SUPPLEMENTAL RIPARIAN SAMPLE LOCATION (1998)
APPROXIMATE RI SEDIMENT SAMPLE LOCATION (1992/1994)
INFERRED SHALLOW SEDIMENT TOTAL PCB ISOCONCENTRATION LINE (mg/kg)
APPROXIMATE EXTENT OF FINE GRAINED SEDIMENT (1998)
AR302729
REVISION
DATE
DESCRIPTION
DRAWN BY T.L. McKee
DATE 12-16-98
CHECKED BY B.R. Maurer
DATE 5-21-99
APPROVED BY P.F. O'Hara
DATE 5-21-99
FIGURE 1-9
TOTAL PCB CONCENTRATIONS (mg/kg)
AREA 15 SEDIMENT SAMPLES
FORMER SHARON TRANSFORMER PLANT
SHARON, PENNSYLVANIA
PREPARED FOR
CBS CORPORATION
PITTSBURGH, PENNSYLVANIA
CUMMINGS RITER CONSULTANTS, INC.
DRAWING NUMBER
93111B25
DRAWING NUMBER 93 125
PLOT SCALE 1:

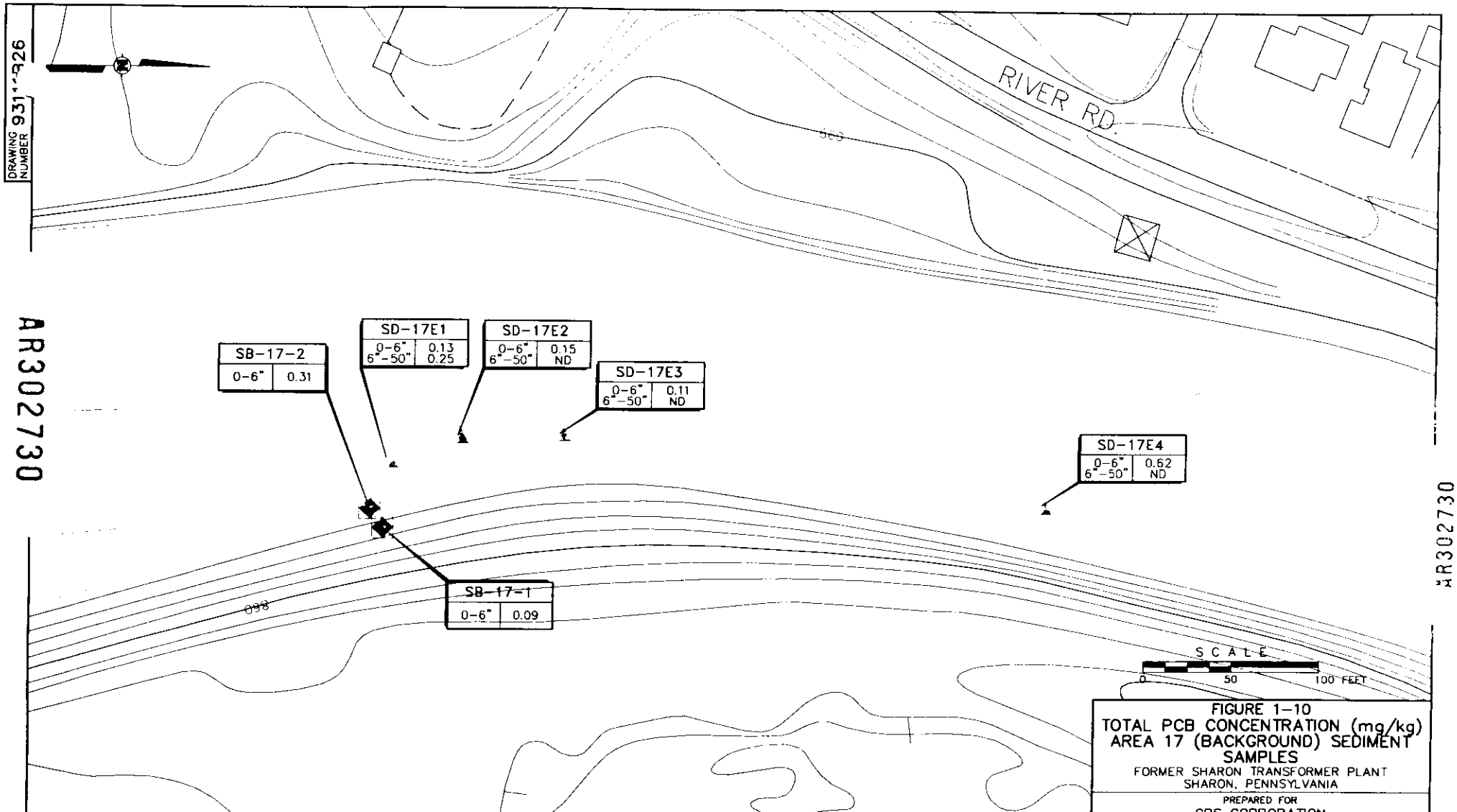


FIGURE 1-10
TOTAL PCB CONCENTRATION (mg/kg)
AREA 17 (BACKGROUND) SEDIMENT SAMPLES
FORMER SHARON TRANSFORMER PLANT
SHARON, PENNSYLVANIA

PREPARED FOR
CBS CORPORATION
PITTSBURGH, PENNSYLVANIA

CUMMINGS RITER CONSULTANTS, INC.

DRAWING NUMBER 93111B26

DRAWN BY: T.E. McKee	DATE: 12-16-98	
CHECKED BY: B.R. Maurer	DATE: 5-21-99	
APPROVED BY: P.C. O'Hara	DATE: 5-21-99	

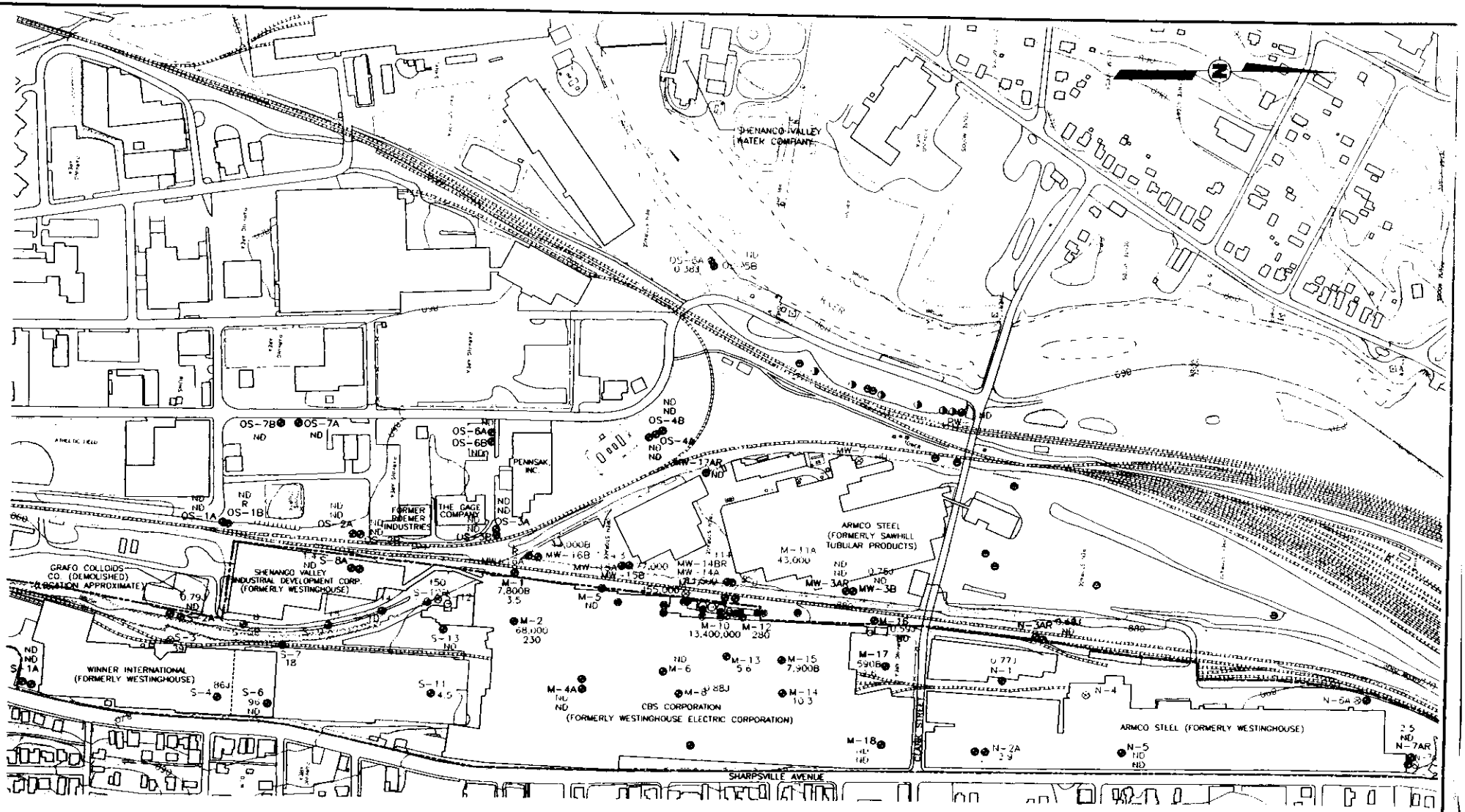
REVISION	DATE	DESCRIPTION

DRAWING NUMBER 93111B26

PLOT SCALE: 1"

AR302730

AR302730



NOTES:

1. TOPOGRAPHIC CONTOURS PROVIDED ARE TWO-FOOT INTERVALS IN FEET ABOVE MEAN SEA LEVEL.

DATA ABBREVIATIONS:
J - PCBs ALSO DETECTED IN ASSOCIATED BLANK SAMPLE
ND - NOT DETECTED
J - ESTIMATED VALUE
R - DATA REJECTED DURING VALIDATION

REFERENCE:
BASE MAP WAS GENERATED BY EASTERN MAPPING, INC., 1989.

LEGEND:

- M-9 EXISTING RI/FS MONITORING WELL
- MW-1 SAWHILL MONITORING WELL
- PW-1 SAWHILL PUMPING WELL
- GM-7B INTERIM MEASURE WELLS
- N-4 ABANDONED MONITORING WELL
- APPROXIMATE SITE BOUNDARY
- 65,000 TOTAL PCB CONCENTRATION FROM RI (ug/l) (IF MULTIPLE SAMPLES, MOST RECENT IS SHOWN)
- 250 TOTAL PCB CONCENTRATION FROM 1999 SUPPLEMENTAL SAMPLING EVENT (ug/l)

2' CONTOUR INTERVAL

SCALE
150 0 150 300 FEET

AR302731

CUMMINGS RITEK CONSULTANTS, INC.
308 Haymaker Road
Parkway Bldg., Suite 201
Monroeville, PA 15146
(412) 373-5840
Fax: (412) 373-5242

REV.	DESCRIPTION	DATE	APPROVED
1	GENERAL	11-8-99	BRM

DRAWN BY:	B. MAURER	DATE: 10-21-99
CHECKED BY:	M. VALENTINE	DATE: 10-29-99
APPROVED BY:	M. VALENTINE	DATE: 10-29-99

FIGURE 1-11
PCB CONCENTRATIONS
ALLUVIAL AQUIFER
FORMER TRANSFORMER PLANT
SHARON, PENNSYLVANIA

PREPARED FOR
CBS CORPORATION
PITTSBURGH, PENNSYLVANIA

SIZE E | DRAWING NUMBER 93111B28 | REV.
SCALE: AS SHOWN | SHEET 1 OF 1

DRAWING NUMBER 93111B28

PLOT SCALE 1=30'

EPA REGION III
SUPERFUND DOCUMENT MANAGEMENT SYSTEM

DOC ID 320490

PAGE #

IMAGERY COVER SHEET
UNSCANNABLE ITEM

SITE NAME Westinghouse Electric (Sharon Plant) OU2

OPERABLE UNIT

ADMINISTRATIVE RECORDS- SECTION VOLUME III E

REPORT OR DOCUMENT TITLE Feasibility Study Report (cover Letter Attached)

DATE OF DOCUMENT June 26, 00

DESCRIPTON OF IMAGERY Alluvial Aquifer

NUMBER AND TYPE OF IMAGERY ITEM(S) 3 oversized maps

APPENDIX A

APPENDIX A

HOW HAZARDOUS WASTES MIGRATE IN THE SUBSURFACE

How Hazardous Wastes Migrate in the Subsurface

Importance of an Accurate Concept of Hazardous Waste Migration
for Cost-Efficient Site Investigations
and Selection of Functional Remedial Responses

by
Mark Mercer, P.E.
U.S. EPA HQ Corrective Action Programs Branch

Introduction

It has been 18 years since the terms of art "Non-Aqueous Phase Liquid" (NAPL) and "Aqueous Phase Liquid" (APL) were first coined and later gained wide-spread usage, however, in spite of that, the true environmental significance of hazardous waste migration in the NAPL phase has not been completely understood. This paper presents a brief history of the state of knowledge concerning hazardous waste releases to the environment and subsequent migration in ground water. Beyond that, this paper points out certain areas where current general knowledge is still inconsistent with actual hazardous waste behavior and proposes improved hazardous waste migration theories that address this shortfall. In fact, the unrecognized influence of NAPLs as the principal migration mechanism is probably the single-most important root cause of remedial failures, and especially the failures of many ground water pump-and-treat (GWP&T) remedial efforts.

The state of the art of hazardous waste migration modeling can be synopsized into three general stages. These three stages are here referred to as (1) the Past Paradigm (i.e., the recognition of aqueous phase contamination only and the belief that hazardous waste migrated only as an APL plume); (2) the Present Paradigm (i.e., an improved but imperfect understanding of hazardous waste migration that recognizes that NAPLs exist and may even be mobile for the short-term, but which assumes that the primary migration mechanism of hazardous constituents is as a plume of aqueous phase contaminants dissolved from the NAPL "source"); and (3) the proposed New Paradigm (i.e., an understanding that the principal transport mechanism for hazardous waste is as a NAPL plume rather than as an aqueous phase contaminant plume).

In support of the New Paradigm, this paper describes the principal mechanism by which the author believes hazardous waste moves in the subsurface and also proposes several predictive tools for use in identifying the presence of NAPLs that have previously gone unrecognized, as well as possible remedial approaches for cleaning up contaminated sites cost effectively and within realistic time-frames. Certainly an accurate understanding the mechanisms by which hazardous wastes are released to the environment and migrate is the key to a successful remediation. Without an accurate understanding of the reason behind the failures, remedial alternatives to GWP&T may be selected without realizing that they also suffer from the same limitation and are themselves doomed to failure, or in the other extreme, GWP&T will not be chosen for fear of failure even in those cases where it is an appropriate remedial measure and would be successful.

Topics to be Discussed:

- How Hazardous Wastes Migrate
- History of the Common Hazardous Waste Migration Perception
- Which Plume is Faster, NAPL or APL?
- Which Plume Constitutes the Principal Migration Mechanism?
- How Long Does a NAPL Plume Continue to Migrate?
- Neutrally Buoyant Non-Aqueous Phase Liquids (NNAPL)
- The Single Cause for the Failures of Ground Water Pump & Treat

- Simple Test to Determine if a Site has NAPL
- When it is OK to use GWP&T
- Triple-Train Remedial Approach
- Proper implementation of Triple-Train Unit Operations
- Remedial Alternatives to GWP&T that are Equally Flawed
- Containment Realities

Discussion

How Hazardous Wastes Migrate

The principal point made by this paper is that when organic fluids are placed in a permitted hazardous waste disposal facility, and the facility fails to contain the material, the released organic fluids will be released at a rate that exceeds the ground water's ability to dissolve and carry away the hydrophobic constituents. Hence, the bulk of the organic fluids will flow away from the disposal facility as neat organic fluids. As these fluids flow through the porous media, they will leave a trail of residual saturated media behind. At some point, the entire mass of highly saturated organic fluid will be dissipated in the tail of residual saturated media. These fluids will flow as long as there exists a volume of media that has saturation above residual saturation and as long as a pressure gradient exists within the NAPL Plume. This time can be estimated and discussed. This concept has the principal contaminant mass migrating as a NAPL plume (99%+) ( ). Dissolution into surrounding ground water occurs as the primary NAPL plume moves through the water saturated media and forms the secondary (cloud) APL plume. This is a Class 2 site.

The perception and modeling of dilute solute contamination originating at the disposal location and moving to the sampling point as a retarded dilute solute would not be correct at this type of site. Although for sites where there only is a dilute solute plume (no NAPL plume), the 800+ dilute solute computer models are appropriate. These sites are Class 1 sites.

Click for further discussion on What are APLs and NAPLs?

History of the Common Hazardous Waste Migration Perception

Hazardous waste professionals are aware of NAPLs, however not all share the same degree of understanding of its behavior or significance. There are in all probability as many theories of NAPL behavior as there are theorists. Some of these theories have evolved over time. Others have remained fairly constant. Unfortunately, certain aspects of NAPL behavior on a large scale, such as would be expected in association with a hazardous waste disposal operation rather than an isolated small-scale spill, have not yet been thoroughly investigated. In the author's opinion, the commonly held perception of NAPL behavior continues to overlook a few critical areas of hazardous waste mobility and its significance to ground water and surface water resources. Before exploring the finer points of hazardous waste migration theory, we will quickly review the history of the general level of understanding over the past two decades.

Past Migration Paradigm

In the eighties, the predominant perception of hazardous waste migration was one of dilute solute contamination moving with the flow of ground water. The presence of NAPLs was for the most part yet unrecognized. According to the general understanding of the time, all sites were then the equivalent of what we would today call a CLASS 1 site; that is, all contaminants leaving the site did so as dilute solutes in ground water. The belief was that dissolved contaminants would sorb onto the aquifer materials, thereby retarding the movement of the contaminant plume relative to the velocity of the ground water. At any one time, part of the mass of the contaminants would be sorbed onto the aquifer materials at levels in equilibrium with the ground water concentrations and part would be dissolved in the ground water. Ground water pump-and-treat (GWP&T) systems were designed to remove the combined mass of the contaminants dissolved in ground water and the mass sorbed onto the aquifer materials. In

those cases that truly were Class 1 sites (e.g., where this mass happened to represent the entire contaminant mass requiring removal) the GWP&T systems performed as intended and was successful. In those cases where this mass was insignificant in comparison to the actual mass present in an unrecognized NAPL plume (what today we would call a Class 2 site), the GWP&T contaminant mass extraction rate was inadequate to remediate the site and the GWP&T system failed. In both cases, though, the GWP&T extraction system would produce the mass removal rate intended.

The failures then were not in the performance of the GWP&T systems to remove the contaminant mass they were designed for. Rather the failures were in not recognizing how hazardous wastes migrate from CLASS 2 sites and that a significantly larger volume of contaminants could be present in the form of a concentrated NAPL plume. However, because NAPL masses were not anticipated, they were not investigated and the cause of the failures remained a mystery. One contributing factor to the GWP&T failures was the failure to compare the mass of contaminants actually placed at the site to the amount of contaminant mass calculated as migrating away from the site (Mercer, 1991b). Even though it may not have been possible to make this comparison with precision, a gross order of magnitude comparison would have been sufficient to determine if the contaminant mass in solution and sorbed onto the aquifer materials was sufficiently large to represent the principal release pathway. Failure to balance the mass of waste released with the mass of waste characterized in the subsurface prolonged the problem by preventing many from recognizing the presence of NAPLs.

Present Migration Paradigm

In the nineties, the terms NAPL and APL were widely used and recognized as terms of art. The most commonly held paradigm was that of a stationary NAPL source area at or near the release point and a migrating APL plume that was capable of traveling a much greater distance from the original release point than the NAPL. Just the fact of recognizing the presence of NAPL in the subsurface was a dramatic improvement over the eighties perception that anticipated only an APL plume with dissolved contaminant mass sorbed and in solution. The new understanding in the nineties recognized the possibility of contaminant mass existing as residual NAPL saturation and stationary NAPL pools near the release point. Sites with non-migrating NAPL contamination are called CLASS 2 S sites. They are a subset of Class 2 sites. The key defining characteristic of a Class 2 S site is that the NAPL is stationary; that is, it is no longer migrating.

Sites that had a small amount of NAPL released, or sites that had the NAPL released over a short period of time, will form stationary source areas of residual NAPL saturation. DNAPL sites without an aquitard to induce horizontal flow, or one with a closed depression in an aquitard that induces pooling can form a Class 2 S site. Small and medium size NNAPL sites can also form Class 2 S sites as can LNAPL sites with a fluctuating water table.

Migration Paradigm Proposed in this Paper

There is another type of site however, that has not yet been fully recognized by either the eighties of the nineties paradigms. These areCLASS 2 M sites where the NAPL plume is continuing to migrate, often for very long periods of time and potentially for very long distances. Class 2 M sites are commonly associated with hazardous waste disposal sites or any location where large volumes of NAPLs were released over long periods of time. For these sites the principal migration mechanism must be consistent with the magnitude or volume of wastes placed in the facility and the duration of the release. It may be useful to think of the NAPL plume at a Class 2 M site as the primary transport mechanism and the observed dilute solute concentration as a secondary cloud of contamination arising from the NAPL as it moves through the aquifer. Because of the difficulty of dissolving large amounts of organic fluid compounds into the ground water, most of the contaminant mass in this case will be in the migrating NAPL plume rather than as an APL. Also, because of the retardation factor for dissolved contaminants in ground water, the NAPL plume has the potential to migrate much faster than any associated APL plume that might form from the NAPL. Of course residual saturation levels, viscosity of the NAPL, slope of any aquitards and the hydraulic head within the plume will all factor into the speed and duration of NAPL mobility, but as long as it is mobile the leading edge of the contamination will potentially be formed by the migrating NAPL plume. Eventually, after the NAPL plume has naturally demobilized, subsequent migration of contaminants will be as an APL plume. But because the contaminants have migrated a large

distance as a NAPL plume, the size and location of the APL plume will differ from what would be expected had it originated only at the initial site location.

Supporting Discussion

Relative Velocity

The principal problem with the nineties perception (i.e., that of an APL plume having a vastly greater areal extent than the NAPL source area) is the relative velocities of the two types of plumes. Hydrophobic contaminants in an APL plume will flow with a retarded velocity. Because of the time spent sorbed onto aquifer materials the average speed of the dissolved contaminants in an APL plume will be reduced from the velocity of the ground water flow. A NAPL plume does not suffer from this retardation mechanism. Rather, the hydraulic gradient as determined by the slope of the aquitard (or water table in the case of an unconfined LNAPL) will generally be the determining factor in NAPL migration velocity. In cases where both the APL and NAPL plumes are migrating horizontally the NAPL will typically be faster. For hydrophobic compounds it is quite frequently faster; for hydrophilic compounds it is less frequently faster. As a result, when both plumes are moving horizontally, the NAPL plume will in most cases be the leading edge of the contamination. Dilute solute contamination discovered away from the release point will be the result of the NAPL migrating through uncontaminated ground water and having the contaminant compounds dissolved from it rather than the APL plume migrating at a retarded velocity all the way from the release point as a migrating APL plume. In this case the APL plume is the secondary manifestation of the principal migration as a NAPL plume. At Class 2 M sites, models based on the assumption that hazardous waste constituents dissolved in ground water had migrated from the source to distant sampling locations as an APL plume will not be accurate. The expected dispersion of a dilute solute plume migrating with the ground water from a distant source to the sampling point will not be observed in the case of a NAPL plume that typically leaves only a narrow trail of dilute solute contamination that has diffused laterally from its flanks.

Retardation of dilute solute compounds that are hydrophobic is a real phenomenon (USEPA, 1988). Octanol/water partition studies are often performed to determine the relative propensity for a molecule to partition between a polar solvent and a non-polar solvent, or to spend time at the interface of a solid and the polar solvent, however, the mechanism of retardation is not widely understood. If the non-polar solvent is stationary and the polar solvent is flowing, the average migration velocity of the contaminant will be the time weighted average of the velocity while flowing and the time the molecules spend moving at this velocity and the time they spend at zero velocity while sorbed.

Depending on the Octanol/water partition coefficient (table 1,2,3,4), the equilibrium ratio of the number of molecules that are stationary to mobile molecules will vary. It may be 10:1; 100:1; 1,000:1; or more. The greater the ratio, the slower the average velocity of the contaminant. It is important to remember that APL plumes with more than one contaminant will show different velocities for each contaminant. It may be useful to visualize each contaminant forming a separate, but overlapping plume, with the relative velocity of each contaminant determining the length for each plume.

The retardation of dilute solutes is most frequently modeled as a function of the fraction of organic carbon in the aquifer porous media. Table 1,2,3,4, 0.1% Hazardous Waste Migration Animation, and 1.0% Hazardous Waste Migration Animation, are all based on various fraction of organic carbon (Foc) in the aquifer porous media. Foc's of 0.0002, 0.001, 0.002, and 0.01 are presented. The literature varies as to when the Foc retardation mechanism dominates and when other retardation mechanisms dominate. Some modelers model based on actual Foc for high values of Foc and use a minimum value of Foc when the actual is below the minimum value. The OSWER Technical Directive 9285.5 (SEAM, 1988), Olsen, Davis, (1990), Scwharzenbach (1983) suggests using Foc minimum of 0.001. McCarty (1981) has developed an equation that relates the retardation due to Foc and surface area as a function of Kow of the contaminant. For contaminants with Kow of 1-3 the inflection point is consistent. For contaminants with Kow 4 and above the inflection point moves to lower Foc's. Karickhoff (1984) developed threshold values at which the surface area contributes significantly to retardation. Four Foc's are provided so that the reader may evaluate the issue based on their own understanding and preference.

Partitioning of dilute solutes from solution to the interface between the solid surface and the polar solvent also occurs due to the reduction in Gibbs free energy. This retardation mechanism occurs but will not be presented in this paper. Cation exchange also causes retardation of dilute solutes, but will not be discussed in this paper. Specific chemical interaction between the dilute solutes and aquifer solids also can cause retardation. It is very compound specific and thus is far beyond the scope of this paper. All these additional mechanisms will cause more retardation than presented based on Foc.

We have prepared animations of two Foc's to help convey the relative velocity of the APL plume compared to the NAPL plume (0.1% Hazardous Waste Migration Animation, and 1.0% Hazardous Waste Migration Animation). The 0.1% Hazardous Waste Migration Animation is based on the 0.001 Foc minimum Foc interpretation. The 1.0% Hazardous Waste Migration Animation represents an order of magnitude higher Foc. Typical aquifer media Foc's may range from 0 to 0.0075 (Pankow, Cherry, 1996). Sites where the granular porous media was formed from parent rock that was sedimentary in origin may have much higher Foc. Peat, and Lignite deposits may exceed Foc of 0.5 .

The Blue tint represents the dilute solute migration, each specific compound having a slightly different frequency. The Red tints represent the highly saturated and residually saturated NAPL plumes. The Animations are based on the assumed condition that the ground water and NAPL plume are moving at the same horizontal velocity. Since the relative velocity of the ground water and the NAPL plume can be dissimilar; there can be conditions where the low Kow contaminants can move more quickly than the NAPL plume. For higher Kow's the APL plume will be slower than the NAPL plume. The break even point will change with the relative velocity of the ground water with respect to the NAPL plume, the Foc, and the Kow for the contaminant.

(Click for detailed discussion)

Relative Proportion of NAPL Area to APL Area

Until it has dissipated itself by leaving its entire mass as a trail of residual saturation (and dammed pools), a NAPL plume will generally migrate faster than an APL plume that is moving at a retarded velocity. Once the NAPL plume has used up its mass it will cease to move and the APL plume will be the only remaining mode of contaminant transport. By then, however, the greater mass of the contamination will have been spread far beyond the limits of the plume representing the movement of contaminants from the release point in the dissolved phase alone. Due to the difference in speed while both plumes are mobile, it will take some time for the APL plume that originated at the release point to catch up with the leading edge of the NAPL. In the meantime, the NAPL will continue to be a source for contaminants to dissolve into the ground water and form a secondary cloud of APL contamination.

A major problem with the eighties and nineties paradigms is the relative horizontal extent of the NAPL and APL plumes. According to these paradigms, the APL contamination should form the larger plume with the NAPL (if present at all) acting as a source area restricted to a relatively small region near the original site. However, the maximum time available for the contamination to have migrated from the release point to the sampling points where it has been observed is frequently insufficient for it to have traveled such distances entirely as an APL plume moving at a retarded velocity due to sorbing. Observed APL contaminants in these situations must have been transported in the subsurface as part of a fast-moving NAPL plume and were subsequently dissolved into the ground water near the distant location where they were sampled. This would explain the presence of APL contaminants found at sampling locations beyond the point that could have been reached by APL transport alone within the time allowed. Contrary to the old paradigms, we believe that for a significant length of time (tens to fifty years) the NAPL plume is much greater in extent than the APL plume.

(Click for detailed discussion)

Charging Time to NAPL Mobility Time Comparison

The length of time that a NAPL is mobile is a function of the duration of the charging time, and the initial and residual saturation levels. The ratio of the charging time to the time required for the NAPL plume to cease migrating because it has been entirely dissipated as a trail of residual saturation can be estimated (Mercer 1991a,b). As discussed in the Relative Velocity section above, hydrophobic

contaminants migrate with a retarded velocity in APL plumes but are not retarded when migrating in NAPL Plumes. Hence, the first stage of Hazardous Waste horizontal migration from a Class 2 M site will usually involve the NAPL plume leading the APL plume. In fact, a secondary APL plume will be dissolving from the migrating NAPL mass while it is moving away from the original source as well as from the residual NAPL left behind. After the NAPL plume has naturally demobilized, subsequent migration will be as an APL plume moving at a retarded velocity. This eventual change in the primary transport mechanism from NAPL to APL ultimately changes the site from a Class 2 M to a Class 2 S site. In order to design appropriate remedial measures, it is useful to understand the length of time required for the principal contaminant migration mechanism to shift from NAPL plume dominated to APL plume dominated migration.

For simple cases the time can be estimated (click for Detailed Discussion). Estimates are based on the ratio of the volume of media containing 100% of the released NAPL at an initial saturation level to the volume of media that would be necessary to contain this same mass of NAPL but at its residual saturation level. Based on the assumption that the NAPL plume will maintain a constant cross sectional area sufficient to sustain mass flux, the variation in volume between the initial saturation and residual saturation will be a entirely a function of length. With the additional assumption of constant hydraulic conductivity and pressure gradient, the variation in length can be inferred to be proportional to the time required for migration through the length. Typical hazardous waste disposal scenarios allow for the further assumption of a continuous release over the charging time. This suggests that a fully saturated NAPL plume volume generated during the charging time has a length equal to the horizontal velocity times the charging time. After cessation of the release to the subsurface the volume of the NAPL-contaminated media will increase due to the migration of the highly saturated front leaving a trail of residual saturation behind. The NAPL plume will not stop moving until the highly saturated NAPL mass at the leading edge has been completely diminished and left behind in the residual trail. The increased volume of the NAPL-contaminated media at this point will contain, at a reduced saturation level, the entire contaminant mass that was present in the initial highly saturated volume immediately after cessation of the NAPL release. The ratio of residual saturation length to initial saturation length suggests the ratio of the NAPL plume mobility time to the charging time.

The Importance of Recognizing NNAPLs

LNAPL plumes are expected to only contaminate the ground water near the water table and DNAPL plumes are expected to contaminate the ground water at the bottom of the aquifer. After a great passage of time, dilute concentrations can be disbursed over large vertical distances from the NAPL source mass by lateral mixing and dispersion, but the process of vertical dispersion is much slower than the horizontal movement of these same contaminants by advection with the ground water flow. Therefore, the detection of dilute solute contaminant concentrations at large distances from a site and at middle depths consistent with that anticipated for an APL plume has contributed to the misconception of rapid APL plume migration. Such occurrences have been interpreted as arriving at the sampling location through APL migration from the site. By circular reasoning, it may have been concluded that because the APL contamination is found at middle depths at distant sampling points it must have migrated there as an APL plume from the release site and therefore there is no need to model the APL plume migration. However, contaminant velocity modeling may reveal that hydrophobic contaminants have been detected at distances that turn out to be further from the release point than can be explained by retarded APL migration alone. Because of their discovery at intermediate depths, neither LNAPL nor DNAPL migration satisfactorily explains of their presence. Understanding how hazardous wastes migrate can explain the presence of these dilute solute concentrations at intermediate depths and at distances from the site which are further than could be achieved through retarded APL plume migration.

The key to understanding how contaminants are transported from the release point to the sampling point is in understanding how hazardous wastes migrate. The actual trajectory of a migrating NAPL plume can be very complex. Clearly there are cases where crisp LNAPL and DNAPL plumes occur. For example (discounting variations in permeability, inclined high conductivity lenses, and cascading migration over discontinuous aquitards that can affect vertical migration), a leaking underground storage tank that contained gasoline will produce a crisp floating LNAPL plume; a dry-cleaning facility that disposed of dry-cleaning fluid to an underground injection well or disposal pit will, after an initial vertical descent through the aquifer, produce a crisp basal DNAPL plume. The main difference between an LNAPL plume and a DNAPL plume is in the source of the NAPL and whether it

contained unsubstituted or substituted organic fluids. But the assumption that all NAPLs migrate as either a crisp LNAPL or crisp DNAPL plume does not take into account the very nature of many large hazardous waste disposal sites.

We are not aware of any hazardous waste disposal operations that bothered to place all the unsubstituted organic fluids in one pit and the substituted organic fluids into another pit. If they had, the density of the fluids would then determine the NAPL migration trajectory that the released fluids would take - the lighter unsubstituted fluids would form a floating LNAPL plume; the heavier substituted organic fluids would form a basal DNAPL plume. Typically, however, all organic fluids arriving at the facility for disposal were placed into the same operating pit. This practice led to the mixing of the various fractions within the pit. The density of the fluids released from the pit would then be a function of the types of fluids placed in the pit. If repeated truckloads of unsubstituted organic fluids were place into the pit, then an LNAPL plume would be expected. If a long string of trucks unloaded substituted organic fluids, such as TCE, then a DNAPL plume could be expected. More typically, a variable mixture of substituted and unsubstituted compounds would be in the pit at any particular point in time. Although mixing is severely constrained once the NAPLs are flowing through a porous media, the mixing beforehand in the pit can be significant, and depending on the densities of the individual wastes, would be quite capable of creating a hazardous waste mixture with a specific gravity near to that of water. These near-neutrally buoyant fluids, or NNAPLS, may flow in large plumes in the undissolved state within the ground water for long distances before finally sinking to the bottom. The speed of the contaminant mass transport in an NNAPL plume would be equal to that of the ground water, not the much slower retarded velocity of those same contaminants traveling as dilute solutes in an APL plume. (click for detailed discussion)

Remedial Measures

Understanding how hazardous wastes migrate through the subsurface is essential to selecting an appropriate remedial measure that will achieve success within a reasonable time frame. Failure to understand how hazardous wastes migrate has resulted in failures to remediate because inappropriate remedial measures were selected. A continued lack of understanding will cause continued failures because the reasons for the remedial failures will not be corrected and alternate remedies will be chosen that are equally flawed. The tendency then may be to declare the problem uncorrectable, when in actuality it is only necessary to design a remedial measure that is based on the true field conditions.

The primary difference between the eighties perception of appropriate hazardous waste remediation and that proposed in this paper is in the profound difference in the mass of contaminants requiring removal and, hence, the mass-removal rate required of a remedial measure (, 1991,b). Although the nineties perception of hazardous waste subsurface migration is a dramatic improvement over the eighties, it still causes remedial measures to be chosen that will fail. To be successful, the mass removal rate needs to be commensurate with the mass placement rate. Ground Water Pump and Treat (GWP&T) systems typically remove 1 to 2 barrels of contaminants per year (table 5,6). This rate may be sufficient for a CLASS 1 site. For a CLASS 2 M or a CLASS 2 S site that was a hazardous waste disposal facility that received 2 to 20 truckloads (each containing 80 barrels of waste) per day for roughly ten years, the mass released to the subsurface vastly exceeds the removal rate of GWP&T. In this example, a waste mass of 580 thousand to 5.8 million barrels will require 100,000 years to 3 million years to be cleaned up by using GWP&T. Even by factoring in the average fraction of liquids to solids in the waste will only reduce the time by 10 to 20%; still much too long a time period for remediation by this method (Skinner 1984). This is truly a hopeless miss-match. This miss-match is by far more serious than the other 19 minor impediments to GWP&T that are discussed in the literature as potential explanations for the failures of GWP&T. This paper proposes it as the sole explanation for the failures of GWP&T when applied to Hazardous Waste disposal facilities

Literature's Twenty Impediments vs. The Problem

Since the author's explanation of the relationship between NAPLs and failures of GWP&T was not successfully disseminated (as judged by the pursuit of remedial alternatives that have the same limitation), this paper seeks to respectfully reiterate the author's explanation for the failures of GWP&T.

In the literature, potential challenges to remediations are discussed with over 20 potential problems. This paper suggests we need to focus on the single impediment that caused the failures of GWP&T in the eighties. Without open discussion of this single major cause of the failures of GWP&T, we will continue to use remedial measures with the same limitation, and we will be afraid to use GWP&T in some of the cases where it is perfectly suitable. Misunderstanding how hazardous wastes migrate is the cause for the failures of GWP&T. A more viable understanding of how hazardous waste migrate is essential for effective site characterization and selection of remedial measures that will not fail in the same way as GWP&T has. This is not to suggest that the other 19 challenges are not challenges, they are. Site remediators in the eighties were aware of them, so they did not cause the failures. Rather, the one problem that they were not aware of was the cause of the failures.

The 19 minor factors suggested as explanation for the failures of GWP&T were present at the sites where GWP&T was working and the sites where it was failing. They are clearly factors that are true and they are difficulties; however, they were not the cause of the failure of GWP&T for any of the sites in the study (Mercer 1991b).

Class 1 sites can be easily cleaned up by using GWP&T because its mass removal rate is similar to the mass placement rate. GWP&T will also work in Class 2 S sites to contain the APL plume area, or to remove it once the residual NAPL portion of the site has been addressed by other means. However, GWP&T will not remove contaminant mass at a sufficient rate to address a Class 2 M site or the NAPL area of a Class 2 S site because the mass removal rate of GWP&T is grossly inadequate when compared to the mass placement rate (, 1991,b).

Knowing whether a site is a Class 2 M site or a Class 2 S site is important in order to grasp whether a Class 1 type remedial measure will work on a region of the contamination. GWP&T can be used to clean up areas solely contaminated with APLs, if they exist. If the dilute solute contamination in a region represents the secondary cloud of APL contamination surrounding a NAPL plume, GWP&T will fail in that region (i.e., all of a Class 2 M site and the NAPL area of a Class 2 S site) because the NAPL will continue to feed dissolved contaminants into the ground water. As previously discussed, once a mobile NAPL plume has dissipated itself by leaving all its mass in a trail of residual saturation (Class 2 S), all subsequent contaminant migration will be as an APL plume. With a relatively small release and sufficient time, the area of APL contamination may be large enough to treat separately from the residual NAPL contaminated area. For a spill or other short-term release, this may occur in within a reasonable period of time. For large releases, such as from hazardous waste disposal facilities, the amount of time required before the APL plume can be successfully treated independently of the NAPL contamination is much too large (potentially on the order of tens of thousands of years or more) for GWP&T to be an effective remedy.

Triple Train Technique

Successful response to NAPL contamination at a Class 2 site requires a mass extraction or destruction rate that is similar to the mass-placement rate (1991b). Because the contaminants exist in three forms (mobile NAPL plume, residual NAPL saturation, and APL contamination), remediation requires three discrete unit operations applied in sequence (the Triple Train Technique). Each unit operation addresses a single form of contaminant in the migration cycle of a site from Class 2 M through Class 2 S to Class 1.

1st Unit Operation (for Class 2 M sites)

The first stage in triple train remediation must achieve a high mass removal rate in order to remove large volumes of NAPL that is capable of contaminating many thousands of times its mass of ground water. This mass is the highly mobile concentrated threat to the surrounding currently uncontaminated ground water. An area highly saturated with mobile NAPL is best remediated with **direct pumping of the NAPL** by means of one or more wells placed into the NAPL plume. NAPL plumes may vary from a few inches to 20 feet or more in thickness. It is very important to fully understand the geology of a site i order to accurately identify where the NAPLs have, or are likely to have, migrated. A thick NAPL plume is more efficiently addressed with direct pumping than a thin meandering plume. Residual NAPL and APL cannot be addressed through direct pumping because the residual NAPL (as a non-mobile source)

will not flow into the extraction well and APL contamination does not contain NAPL. If there is no mobile NAPL plume, or if the mobile NAPL plume is small and/or hard to find, there may be no choice but to skip this first step and move on to the second, recognizing, of course, that success in the second step might take longer to achieve because of the lesser mass removal rate efficiency.

2nd Unit Operation (for Class 2 S sites)

Because residual NAPL does not flow on its own, it cannot be addressed by direct pumping and, hence, requires a secondary recovery technique. A common theme for the second stage of triple train is the need to **mobilize the residual NAPL** so that it can be removed (or destroyed) at a high mass removal rate and not act as a continuing source for contaminants over the course of several centuries. Some of these techniques are adapted from the petroleum industry. They are:

- Surfactant flushing for mobilization of residual NAPL fluids
- Solvent flushing for mobilization of residual NAPL fluids
- Water flooding, and
- Thermal mobilization of residual NAPL fluids.

Some useful techniques that are not adapted from the petroleum industry include:

- Soil vapor extraction
- In situ oxidation of the NAPL fluids, and
- Thermal volatilization.

3rd Unit Operation (for Class 1 sites)

After the mobile and residual NAPL has been removed through the first two stages of triple train, the remaining contamination will be dilute solute contamination that can readily be addressed by **GWP&T or other measures that work on the dilute solute contamination**. These techniques have a mass removal/destruction rate that is commensurate with the contamination levels associated with Class 1 sites. Some of the measures that can be effective for APL contamination are:

- Ground water pump and treat (GWP&T)
- Bioremediation
- Natural attenuation
- Surfactant flushing focused on dissolution of NAPL mass
- Solvent flushing focused on dissolution of NAPL mass
- In situ oxidation of aqueous contamination
- Fentons
- Hydrogen peroxide
- Metal permanganate
- Dissolved oxygen
- Air sparging
- Bio air sparging, and
- Ground water gradient control to stop migration of an APL plume.

(_____)

Remedial Alternatives that Do Not Address the Problem with GWP&T

It is not only important to understand how hazardous wastes migrate in the subsurface, but also to determine the approximate total mass placed at the site and whether it is likely to be present in NAPL or APL form. It should be pointed out that none of the Class 1-type remedial measures (3rd unit operation of triple train listed above) are effective when NAPLs are present, and though they may be somewhat

interchangeable as alternatives for APL remediation, they cannot be utilized effectively for NAPLs. As discussed below, caution must be exercised so that these techniques are not mistakenly advocated as possible alternatives for GWP&T in those cases where the presence of NAPLs (either recognized or unrecognized) was the root cause of failure, otherwise the supposed alternative approach will also fail.

Class 1 sites can be addressed effectively with Class 1 remedial measures. Although Class 1 remedial measures cannot be efficiently used as the sole remedial measure at Class 2 sites, they can play an ancillary role in the remediation of these sites when multiple techniques are used. Unfortunately, some Class 1-type remedial measures have been attempted at Class 2 sites as suggested alternatives to GWP&T. The expectation seems to be that these alternatives will perform better than GWP&T. If the total mass of the contaminant is limited (as in an APL plume), the alternative might work; however, the typically much higher mass in place at a Class 2 site suggests that these alternative remedial measures will produce the same disappointing results as the GWP&T remedy that was so readily employed in the eighties at sites where it was not appropriate due to the presence of NAPL. Although they have similar mass removal rates, many of these alternatives remedial measures are more technically complex than GWP&T and may involve the introduction of large volumes of adulterants to the environment. In those instances where NAPLs are present, the use of more technically complex remedial alternatives (but with equally slow mass removal rates) will not necessarily achieve better or faster cleanup results.

Bioremediation

Bioremediation is often suggested as a remedial alternative to GWP&T. It, however has similar mass removal/destruction rates. Because of this, it does not increase the mass removal rate sufficiently to equal the rate necessary to remediate the contaminant mass present as NAPL in a Class 2 site. Bioremediation may be appropriate for a Class 1 site, but then, so might GWP&T be appropriate for a Class 1 site. In making the determination whether to utilize GWP&T or Bioremediation, one has to be assured that the biodestruction will progress all the way to mineralization (e.g., carbon dioxide) and not just change the molecular identity of the original compound into another form of contaminant left in solution. In order to get the microorganisms to thrive, it is frequently suggested that additional nutrients be added in order to be co-metabolized with the contaminant. The volume of additional nutrients that must be added is often much greater than the mass of the original contaminant. The volume of added nutrients becomes prohibitively massive if the contaminant is present in concentrated NAPL form. Furthermore, Bioremediation can only address the dilute solute contamination. The microorganisms that are utilized for Bioremediation physically cannot survive in NAPL; the osmotic pressure causes their cell walls to burst. Therefore the microorganisms can only thrive and survive in the dilute solute in APL form once it has been dissolved out of the NAPL phase - a process that will take just as long as GWP&T of the APL.
(click for detailed discussion)

Natural Attenuation

Natural attenuation has also been proposed as a possible solution to the failures of GWP&T. In this approach, monitoring is conducted to confirm that contaminant levels indeed drop over time and to warn of any potential problems of a critical nature in time to be remedied. Natural attenuation usually involves less active human participation than does Bioremediation, and because it is basically a passive approach, one can expect slower rates of contaminant mass destruction than with Bioremediation. For Class 1 sites, natural attenuation may or may not be effective in achieving desired goals, however the monitoring required by the approach will guard against possible problems. At Class 2 sites, on the other hand, the very fact that NAPLs are present to serve as a continuing source of slowly dissolved contaminants in the ground water dictates that any natural attenuation of the APL phase that may take place will be on a geologic time scale rather than a human scale. (click for detailed discussion)

Surfactant/Solvent Flushing to Achieve Dissolution of NAPL Mass

Surfactant/solvent flushing of NAPL entrapped as residual saturation in the subsurface can be implemented with two distinct results-oriented goals. One is to mobilize residual NAPL to make it move in NAPL form; the other is to increase the dissolution of a stationary NAPL mass so that it dissolves faster into the ground water as an APL. The first is a common secondary recovery technique employed by the petroleum industry to enhance crude oil recovery in depleted formations. The second approach,

while it might superficially seem similar to secondary crude oil recovery techniques, is not used as a secondary recovery technique because the quantities of water that would need to be produced in order to market a barrel of recovered crude oil would be astronomically expensive.

For the curious reason that the desired result of mobilizing the NAPL is often mistakenly seen as a potential handicap for remediations, the first approach to surfactant/solvent flushing is often avoided. Even more curious is the apparent popularity of surfactant/solvent flushing with the stated goal of increasing the dissolution of the NAPL mass as an alternative to conventional GWP&T. Solubilization efforts have been shown to increase the solubility of a NAPL 5 to 50 fold. In theory, the NAPL is dissolved faster into the ground water because of the surfactant/solvent flushing and therefore made available for removal through GWP&T. Though this may seem a significant increase in efficiency, that fact remains that it falls far short of what is necessary if the NAPL is to be extracted through dissolution and subsequent treatment of the APL. For example, a site with 250,000 barrels of NAPL that manages to extract 1 barrel per year through GWP&T will take 250,000 years to remediate; whereas the same site with a 5 to 50 fold increase in solubility will still take 5,000 to 50,000 years using surfactant/solvent flushing for dissolution. Realistically, we must achieve cleanup in less time than this.

Surfactant/solvent flushing for the mobilization of NAPL, rather than its dissolution, can reduce this time to a number of years instead of millennia. Mobilization is the stated goal of secondary crude oil recovery and should not be avoided in remediations. While mobilization of residual NAPL is necessary in order to remove it, there is the potential for the mobilized NAPL to move in unwanted directions. Clearly the catching wells need to be in place before any mobilization activities are begun and the capture strategy should be well thought out before hand. Other safeguards should be considered as well. Contracts, for example, could be written so that catching activities could be run to completion even if administrative functions such as funding are disrupted, or at a minimum, mobilization activities should be shut off at the first sign of a disruption and any mobilized NAPL should be captured before terminating site activities. With proper design and safeguards, a NAPL mobilization project could form the basis for the second step in a Triple Train remedial approach to NAPL contamination.

In Situ Chemical Oxidation of Aqueous Contamination

In order to chemically oxidize dissolved organic contaminants in situ, chemical adulterants must be introduced into the ground water in order to react with the dilute solutes. In situ chemical oxidation of aqueous contamination has been explored as an alternative to GWP&T. However, in instances where GWP&T has failed due to the presence of NAPLs, chemical oxidation of the dilute solute contamination will do nothing to address the basic mass removal/destruction rate problem that plagues GWP&T. It simply takes too long, at ambient temperatures, to wait for the contaminants to dissolve out of the NAPL so that they can then be removed or destroyed. When used in conjunction with thermal mobilization, however, in situ oxidation can be useful to destroy mass at a rate that will supplement the secondary recovery technique.

For the amount of contaminant mass present as an APL at a typical Class 1 site, the stoichiometry of 2.3 to 5.6 pounds of adulterant per pound of contaminant may not be a significant problem. However, for an average Class 2 site, the mass of adulterant that must be introduced at a ratio measured in some multiple of the contaminant mass present in NAPL form will be costly and present difficult logistical challenges. For reagents such as oxygen and hydrogen peroxide, the reaction products left after oxidation are not problematic, but for adulterants such as potassium permanganate, the potassium and manganese reaction products left after the oxidation must then be addressed. In the case of a Class 2 site with thousands of barrels of NAPL present, many times this amount of potassium permanganate will be required, and the potassium and manganese reaction products (in proportion to the mass of adulterant added) will themselves require flushing and extraction. (click for detailed discussion)

Ground Water Gradient Control to Stop Migration of APL Plume

Ground water gradient control has been practiced at many sites to stop migration of APL plumes. This approach has worked well at Class 1 sites (i.e., where there is only an APL plume). When properly designed and perpetually operated, it can be effective at Class 2 S sites as well as some Class 2 M LNAPL sites where the LANPL will drain into the cones of depression around the recovery wells.

However, it is not an effective approach at Class 2 M DNAPL and NNAPL sites because the NAPL in these cases can flow underneath or otherwise bypass the gradient control wells. In this case the gradient control wells may stop that portion of the APL plume that is up-gradient from the well field, but the faster and much more concentrated NAPL plume will continue to migrate. As the NAPL moves down gradient it will form additional dilute solute contamination beyond the gradient control well field.

Conclusion

A NAPL plume is a million times more concentrated than a 1 ppm APL plume dissolved in ground water. The NAPL may flow through an aquifer 100 times faster than an APL plume that has a log Octanol/water partition coefficient of 5 (i.e., lindane). It is therefore appropriate to think of the NAPL plume as the primary hazardous waste transport mechanism at Class 2 sites and the dilute solute contamination is a secondary effect of the NAPL contamination. An example is the Hyde Park site (Conestoga-Rovers 1989a,b) where 99.97% of the released hazardous waste mass was present as NAPL and only 0.03% as APL.

The failure of GWP&T to remediate some sites in the past was not due to failures in the design. Pump and treat wells produced the gallonage that they were designed for and extracted the contaminants at rates commensurate with the concentrations in the ground water near the well screens. They did not fail to produce the contaminant mass at the expected rate; rather the failure was in not extracting all the contaminants from the ground water. It is our belief that the failure to extract all of the contamination was due to a lack of understanding of how hazardous wastes migrate, thus leading to a failure to characterize how much contaminant mass was actually present. Calculations performed on defined APL plumes at hazardous waste sites have never shown more than the equivalent of one truckload of hazardous waste dissolved in the ground water even though many hundreds of truckloads of hazardous wastes may have entered the sites. Conservation of mass needs to be considered in order to plausibly explain the migration pathways of released hazardous waste.

Because of the failures, some have suggested the summary abandonment of GWP&T as a remedial measure (Travis 1990). This is unwarranted. Though ineffective for NAPLs, it continues to be appropriate for dilute solute contamination. However, use of remedial measures that extract contaminant mass at a GWP&T rate will not be successful if mobile NAPL or its residual saturation extends into the region that is incorrectly believed to contain only dilute solute contamination. In order to make the appropriate decisions, quantitative modeling of the relative velocities of the APL and NAPL plumes needs to be performed as well as quantitative determinations as to whether the mobile NAPL plume has yet become naturally demobilized.

Triple Train is the appropriate containment/remediation technique to use at Class 2 sites. Remedial measures need to extract or destroy the contaminant mass at a rate that is similar to the placement rate if we are to remediate successfully in a reasonable time frame. Remedial techniques that are effective only for APL, even those that seek to increase the effectiveness by 5 to 50 fold, do not provide the mass extraction rate necessary to remediate most NAPL contamination. Techniques such as bioremediation and solvent flushing for dissolution of the NAPL do not address the mass removal rate problem because these techniques are still limited by the extremely slow rate of NAPL dissolution and the time it would take to totally convert all the NAPL mass into the dissolved phase.

We all share the goal of protecting our environment, but in order to be effective our remedial efforts need to be based on sound science and an accurate characterization of site conditions. If correct, the issues presented in this paper reflect an improvement over the ideas of the past, however these issues have not been widely disseminated or accepted to date. Your thoughts, constructive criticism and input are welcomed. Please post your comments and discussions so that all may benefit.

Click for References

AR302748

APPENDIX B

APPENDIX B

EXAMPLE GROUNDWATER USE RESTRICTION ORDINANCE

Research - GW Ordinance

ORDINANCE NO. 519

AN ORDINANCE REQUIRING ALL OWNERS OF IMPROVED PROPERTY LOCATED WITHIN THE BOROUGH OF TAMAQUA AND ACCESSIBLE TO THE PUBLIC WATER SYSTEM OWNED BY THE TAMAQUA AREA WATER AUTHORITY TO CONNECT THEREWITH; RESTRICTING THE USE OF PRIVATE SOURCES; SETTING FORTH RELATED MATTERS; AND PRESCRIBING PENALTIES FOR VIOLATION.

DEC 0 1999

BE IT ORDAINED by the Council of the Borough of Tamaqua, and it is hereby ordained by the authority of the same as follows:

ARTICLE I

DEFINITIONS

SECTION 1. DEFINITIONS. Unless the context specifically and clearly indicates otherwise, the meaning of the terms and phrases used in this Ordinance shall be as follows:

A. "Authority" shall mean the Tamaqua Area Water Authority, a Pennsylvania municipality authority.

B. "Improved Property" shall mean any property located within this Borough upon which there is erected a structure intended for continuous or periodic habitation, occupancy or use by human beings or animals to which structure shall be connected to the Public Water System.

C. "Owner" shall mean the person, custodian, guardian, trustee, caretaker, executor, administrator in whose name the deed for a property is designated.

D. "Person" shall mean an individual, partnership, company, corporation, association, corporate political body, joint ownership or any other entity capable of functioning in the context used herein.

E. "Premises" shall mean the property, building, or other site to which water service is furnished, including:

1. a building under one roof, owned or leased by one person, occupied as one residence or business;
2. each combination of buildings owned or leased by one person, served by one service line, and occupied by one family or business;
3. each side of a double unit or each housing unit;
4. each apartment, condominium, manufactured housing, mobile home, office, or suite of offices located in a building having several such apartments, offices, or suites of offices and using in common one or more means of entrance; or
5. such other situations as the Authority shall deem proper and advisable.

F. "Borough" shall mean the Borough of Tamaqua, Schuylkill County, Pennsylvania, a political subdivision, acting by and through its Borough Council or, in appropriate cases, by and through its authorized representatives.

G. "Water Service" shall mean the provision by the Authority of water as a commodity, of readiness to provide water for any purposes, and of any services related thereto.

H. "Water System" shall mean the Authority's water supply and distribution facilities taken as a whole or any portion thereof, situate in or adjacent to this Borough and owned, maintained and operated by the Authority.

AR302751

ARTICLE II

USE OF PUBLIC WATER SYSTEM REQUIRED

SECTION 2. USE OF PUBLIC WATER SYSTEM REQUIRED.

SECTION 2.01. The Owner of any Improved Property which is located within the corporate limits of the Borough of Tamaqua, except any Improved Property which constitutes an industrial establishment which has its own supply of water for use other than human and/or agricultural use or consumption, and excepting any Improved Property which as of the effective date of this Ordinance is being served by a private water source, and whose principal building or structure is within one hundred fifty (150') feet of the public Water System shall connect such Improved Property with and shall use such public Water System in such manner as the Borough and/or Authority may require, within sixty (60) days after notice to such Owner from the Borough to make such connection; subject to such limitations and restrictions as may be established herein or otherwise shall be established by the Borough and/or Authority. If the Borough and/or the Authority determines that it cannot reasonably make the connection to such Improved Property and/or cannot provide adequate water pressure, the Borough and/or the Authority shall exempt such property from the requirement to use the public Water System.

SECTION 2.02. It shall be unlawful for any owner, lessee, or occupier of any Improved Property in the Borough to employ any means of cross-connecting any other water source to the public Water System, including service lines and house plumbing served by these services. Private water sources, including wells, may be continued to be used by the Owner of Improved Property so long as the private water source is not used for domestic purposes (including use for drinking water), agricultural purposes, or interconnected to the public Water System. This provision limiting the use of private water sources shall not apply to owners of Improved Property whose principal building and/or structure is not within one hundred fifty (150') feet of the public Water System or whose Improved Property is exempted from the requirement to use the public Water System pursuant to the provision of Section 2.01.

SECTION 2.03. The Owner or Owners of the aforementioned Improved Property identified in Section 2.01 hereof shall permit the Borough and/or Authority's designated inspector full and complete access to all Water System facilities in each building and in and about all parts of the property for the purposes of inspecting said facilities.

SECTION 2.04. The notice by this Borough to each Owner of Improved Property to make connection to the public Water System referred to in Section 2.01, shall consist of a copy of this Ordinance, including any amendments at the time in effect, and a written or printed document requiring such connection in accordance with the provision of this Ordinance and specifying that such connection shall be made within sixty (60) days from the date such notice is given. Such notice may be given at any time after the public Water System is in place which will provide potable water to the particular Improved Property in accordance with Section 2.01. Such notice shall be served upon the Owner of such Improved Property either by personal service or by registered mail, return receipt requested.

SECTION 2.05. All service connections shall be made by each Owner of Improved Property pursuant to the rules and regulations of the Authority.

ARTICLE III

ENFORCEMENT

SECTION 3.01. Any person, firm or corporation who shall violate any provision of this Ordinance shall, upon conviction thereof, be subject to pay a fine of not more than Five Hundred ($500.00) Dollars, together with the costs of prosecution in each case. Each day that a violation of this Ordinance continues shall constitute a separate offense.

ARTICLE IV

REPEALER

SECTION 4.01. All ordinances or parts of ordinances which are inconsistent herewith are hereby repealed.

ARTICLE V

SEVERABILITY

SECTION 5.01. If any sentence, clause, section or part of this Ordinance is, for any reason, found to be unconstitutional, illegal or invalid, such unconstitutionality, illegality or invalidity shall not affect or impair any of the remaining provisions, sentences, clauses, sections or parts of this Ordinance. It is hereby declared as the intent of the Borough of Tamaqua that this Ordinance would have been adopted had such unconstitutional, illegal or invalid sentence, clause, section or part thereof, not have been included herein.

ARTICLE VI

EFFECTIVE DATE

SECTION 6.01. This Ordinance shall become effective immediately.

ARTICLE VII

DECLARATION OF PURPOSE

SECTION 7.01. It is hereby declared that the enactment of this Ordinance is necessary for the protection, benefit, and preservation of the health, safety, and welfare of the inhabitants of the Borough of Tamaqua.

ORDAINED AND ENACTED this 19th day of May, 1999, by the Council of the Borough of Tamaqua, in lawful session duly assembled.

BOROUGH OF TAMAQUA

By: Pat Freeb-Stefanek
President

Attest: Kevin A. Steigerwalt
Secretary

APPROVED by me this 19th day of May, 1999

Richard M. Hadasty Sr.
Mayor

I, Kevin A. Steigerwalt, Secretary of the Borough of Tamaqua, do hereby certify that the above is a true and correct copy of an ordinance duly passed by Council, signed by officers and approved by the Mayor of said Borough on said date indicated therein; that the same has been duly recorded in the Borough Ordinance Book; and the same was duly published in the Times News, a newspaper of general circulation in the Borough, May 4, 1999.

Kevin A. Steigerwalt
Kevin A. Steigerwalt, Secretary

APPENDIX C

APPENDIX C

COST ESTIMATES

APPENDIX C
DETAILED COST ESTIMATES

This appendix presents a breakdown of estimated costs for each of the remedial alternatives evaluated in this FS. In accordance with USEPA guidance, these estimated costs are intended to have an accuracy of –30 to +50 percent. A number of assumptions were made based on the site conditions as currently known. Actual costs incurred during remediation may vary due to differences in site conditions relative to assumed conditions, economic considerations, and selected cleanup levels or other variations included in the final remedy(ies).

Material quantities (areas and volumes) were measured from the site figures, which were prepared based on available data. Unit costs and mark-up percentages were determined based on published estimating references (R.S. Means 2000 Site Work and Landscape Cost Data), discussions with equipment technology providers, experience and quotations for similar work performed at other sites in Western Pennsylvania, and professional judgment.

TABLE C-1A
PRELIMINARY COST ESTIMATE
SHENANGO RIVER SEDIMENT ALTERNATIVE 1
NO ACTION

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Subtotal - Direct Costs				$0	
Indirect Costs					
Remedial Design				$0	
Mobilization/Misc. Site Prep	(5% of Direct Costs)			$0	
Site Administration	(1% of Direct Costs)			$0	
Permitting/Legal Costs	(2% of Direct Costs)			$0	
Construction Management/Oversight	(10% of Direct Costs)			$0	
Subtotal - Indirect Costs				$0	
Contingency - 25% of Direct and Indirect Costs				$0	
Total Capital Costs				**$0**	
Operation and Maintenance Costs					
Site Inspections/Maintenance					$0
Five-Year Reviews (annualized cost)					$3,000
Subtotal - O&M Costs					$3,000
Contingency Reserve - 25% of O&M Costs					$750
Total Annual O&M Costs					**$3,750**
Net Present Worth of Annual O&M Costs				**$57,647**	
Total Net Present Worth of Alternative				**$58,000**	

TABLE C-1B
PRELIMINARY COST ESTIMATE
SHENANGO RIVER SEDIMENT ALTERNATIVE 2
LIMITED ACTION/NATURAL RECOVERY

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Resedimentation/Attenuation Assessment				$75,000	
Subtotal - Direct Costs				$75,000	
Indirect Costs					
Remedial Design				$15,000	
Mobilization/Misc. Site Prep	(5% of Direct Costs)			$3,750	
Site Administration	(1% of Direct Costs)			$750	
Permitting/Legal Costs	(2% of Direct Costs)			$1,500	
Construction Management/Oversight	(10% of Direct Costs)			$7,500	
Subtotal - Indirect Costs				$28,500	
Contingency - 25% of Direct and Indirect Costs				$25,875	
Total Capital Costs				**$129,375**	
Operation and Maintenance Costs					
Site Inspections/Maintenance					$5,000
Biennial Fish/Sediment Sampling/Analysis (annualized cost)					$20,000
Five-Year Reviews (annualized cost)					$3,000
Subtotal - O&M Costs					$28,000
Contingency Reserve - 25% of O&M Costs					$7,000
Total Annual O&M Costs					**$35,000**
Net Present Worth of Annual O&M Costs				**$538,036**	
Total Net Present Worth of Alternative				**$667,000**	

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revised 5/10/00

CUMMINGS RITER

TABLE C-1C
PRELIMINARY COST ESTIMATE
SHENANGO RIVER SEDIMENT ALTERNATIVE 3
COVER

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Access Agreements				$20,000	
Clearing					
Area 14	1	Ac	$9,925	$9,925	
Area 15	0.5	Ac	$9,925	$4,963	
AquaBlok/Rock Placement (6" each)					
Area 14	25,000	SF	$4.85	$121,250	
Area 15	20,000	SF	$4.85	$97,000	
Storm Sewer Video Inspection	7,500	Ft	$2.30	$17,250	
Subtotal - Direct Costs				$270,388	
Indirect Costs					
Remedial Design				$30,000	
Mobilization/Misc. Site Prep	(5% of Direct Costs)			$13,519	
Site Administration	(1% of Direct Costs)			$2,704	
Permitting/Legal Costs	(2% of Direct Costs)			$5,408	
Construction Management/Oversight	(10% of Direct Costs)			$27,039	
Subtotal - Indirect Costs				$78,670	
Contingency - 25% of Direct and Indirect Costs				$87,264	
Total Capital Costs				**$436,322**	
Operation and Maintenance Costs					
Site Inspections/Maintenance					$10,000
Biennial Fish Sampling/Analysis (annualized cost)					$10,000
Five-Year Reviews (annualized cost)					$3,000
Subtotal - O&M Costs					$23,000
Contingency Reserve - 25% of O&M Costs					$5,750
Total Annual O&M Costs					**$28,750**
Net Present Worth of Annual O&M Costs				**$441,958**	
Total Net Present Worth of Alternative				**$880,000**	

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TABLE C-1D
PRELIMINARY COST ESTIMATE
SHENANGO RIVER SEDIMENT ALTERNATIVE 4A
LIMITED EXCAVATION AND COVER

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Access Agreements				$35,000	
Area 14 Costs					
Delineation Sampling (PCBs)	100	Ea	$100	$10,000	
Clearing	1	Ac	$9,925	$9,925	
Temporary Sheet Piles (install/remove)	10,000	SF	$22	$220,000	
Dewater Excavation Area	30	Day	$468	$14,040	
Dredge Mobilization				$30,000	
Excavation of Sediments	725	CY	$50	$36,250	
Decant/Treat Water from Sediments				$40,000	
Sediment Transportation/Disposal					
Non-Hazardous Landfill	1350	Ton	$50	$67,500	
TSCA Landfill	100	Ton	$160	$16,000	
Backfill (Geotextile/AquaBlok/6" Rock)	25,000	SF	$4.85	$121,250	
Area 15 Costs					
Delineation Sampling (PCBs)	100	Ea	$100	$10,000	
Clearing	0.75	Ac	$9,925	$7,444	
Reroute Storm Sewer Dicharge	10	Day	$3,440	$34,400	
Temporary Sheet Piles (install/remove)	3,200	SF	$18	$57,600	
Dewater Excavation Area	15	Day	$468	$7,020	
Excavation of Soil/Sediments	500	CY	$15	$7,500	
Decant/Treat Water from Sediments				$10,000	
Soil/Sediment Transportation/Disposal					
Non-Hazardous Landfill	1000	Ton	$50	$50,000	
Backfill (Geotextile/AquaBlok/6" Rock)	20,000	SF	$4.85	$97,000	
Storm Sewer Video Inspection	7,500	Ft	$2.30	$17,250	
Subtotal - Direct Costs				$898,179	
Indirect Costs					
Remedial Design				$60,000	
Mobilization/Misc. Site Prep	(5% of Direct Costs)			$44,909	
Site Administration	(1% of Direct Costs)			$8,982	
Permitting/Legal Costs	(2% of Direct Costs)			$17,964	
Construction Management/Oversight	(10% of Direct Costs)			$89,818	
Subtotal - Indirect Costs				$221,672	
Contingency - 25% of Direct and Indirect Costs				$279,963	
Total Capital Costs				**$1,399,814**	
Operation and Maintenance Costs					
Site Inspections/Maintenance					$10,000
Biennial Fish Sampling/Analysis (annualized cost)					$10,000
Five-Year Reviews (annualized cost)					$3,000
Subtotal - O&M Costs					$23,000
Contingency Reserve - 25% of O&M Costs					$5,750
Total Annual O&M Costs					**$28,750**
Net Present Worth of Annual O&M Costs				**$441,958**	
Total Net Present Worth of Alternative				**$1,840,000**	

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TABLE C-1E
PRELIMINARY COST ESTIMATE
SHENANGO RIVER SEDIMENT ALTERNATIVE 4B
EXCAVATION TO 4 FEET AND COVER

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Access Agreements				$35,000	
Area 14 Costs					
Delineation Sampling (PCBs)	200	Ea	$100	$20,000	
Clearing	1	Ac	$9,925	$9,925	
Temporary Sheet Piles (install/remove)	10,000	SF	$22	$220,000	
Dewater Excavation Area	40	Day	$468	$18,720	
Dredge Mobilization				$30,000	
Excavation of Sediments	2900	CY	$50	$145,000	
Decant/Treat Water from Sediments				$40,000	
Sediment Transportation/Disposal					
Non-Hazardous Landfill	5700	Ton	$50	$285,000	
TSCA Landfill	100	Ton	$160	$16,000	
Backfill (Geotextile/AquaBlok/Rock)	25,000	SF	$12.55	$313,750	
Area 15 Costs					
Delineation Sampling (PCBs)	100	Ea	$100	$10,000	
Clearing	0.75	Ac	$9,925	$7,444	
Reroute Storm Sewer Dicharge	10	Day	$3,440	$34,400	
Temporary Sheet Piles (install/remove)	3,200	SF	$18	$57,600	
Dewater Excavation Area	20	Day	$468	$9,360	
Excavation of Soil/Sediments	1500	CY	$15	$22,500	
Decant/Treat Water from Sediments				$10,000	
Soil/Sediment Transportation/Disposal					
Non-Hazardous Landfill	3000	Ton	$50	$150,000	
Backfill (Geotextile/AquaBlok/Rock)	20,000	SF	$12.55	$251,000	
Storm Sewer Video Inspection	7,500	Ft	$2.30	$17,250	
			Subtotal - Direct Costs	$1,702,949	
Indirect Costs					
Remedial Design				$60,000	
Mobilization/Misc. Site Prep			(5% of Direct Costs)	$85,147	
Site Administration			(1% of Direct Costs)	$17,029	
Permitting/Legal Costs			(2% of Direct Costs)	$34,059	
Construction Management/Oversight			(10% of Direct Costs)	$170,295	
			Subtotal - Indirect Costs	$366,531	
			Contingency - 25% of Direct and Indirect Costs	$517,370	
			Total Capital Costs	**$2,586,849**	
Operation and Maintenance Costs					
Site Inspections/Maintenance					$10,000
Biennial Fish Sampling/Analysis (annualized cost)					$10,000
Five-Year Reviews (annualized cost)					$3,000
			Subtotal - O&M Costs		$23,000
			Contingency Reserve - 25% of O&M Costs		$5,750
			Total Annual O&M Costs		**$28,750**
			Net Present Worth of Annual O&M Costs	**$441,958**	
Total Net Present Worth of Alternative				**$3,030,000**	

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TABLE C-2A
PRELIMINARY COST ESTIMATE
ALLUVIAL GROUNDWATER AND NAPL ALTERNATIVE 1
NO ACTION

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Subtotal - Direct Costs				$0	
Indirect Costs					
Remedial Design				$0	
Mobilization/Misc. Site Prep	(5% of Direct Costs)			$0	
Site Administration	(1% of Direct Costs)			$0	
Permitting/Legal Costs	(2% of Direct Costs)			$0	
Construction Management/Oversight	(10% of Direct Costs)			$0	
Subtotal - Indirect Costs				$0	
Contingency - 25% of Direct and Indirect Costs				$0	
Total Capital Costs				**$0**	
Operation and Maintenance Costs					
Site Inspections/Maintenance					$0
Five-Year Reviews - Cost included in Sediment alternatives					$0
Subtotal - O&M Costs					$0
Contingency Reserve - 25% of O&M Costs					$0
Total Annual O&M Costs					**$0**
Net Present Worth of Annual O&M Costs				**$0**	
Total Net Present Worth of Alternative				**$0**	

TABLE C-2B
PRELIMINARY COST ESTIMATE
ALLUVIAL GROUNDWATER AND NAPL ALTERNATIVE 2
INSTITUTIONAL CONTROLS WITH
MONITORED NATURAL ATTENUATION

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Deed Restrictions				$20,000	
Municipal Ordinance				$10,000	
Additional Monitoring Well Installation				$68,000	
Install Dedicated Sampling Pumps	34	Ea	$870	$29,580	
Subtotal - Direct Costs				$127,580	
Indirect Costs					
Remedial Design				$20,000	
Mobilization/Misc. Site Prep	(5% of Direct Costs)			$0	
Site Administration	(1% of Direct Costs)			$1,276	
Permitting/Legal Costs	(2% of Direct Costs)			$2,552	
Construction Management/Oversight	(10% of Direct Costs)			$12,758	
Subtotal - Indirect Costs				$36,585	
Contingency - 25% of Direct and Indirect Costs				$41,041	
Total Capital Costs				**$205,207**	
Operation and Maintenance Costs					
Long-Term Monitoring Program Costs				Net Present Worth	Annual Cost
Years 1 and 2 (Quarterly--Impacted and Delineation Wells)					
Labor/Equipment/Reporting/Expenses				$251,020	$135,000
Laboratory Analytical Costs				$316,100	$170,000
Purge Water Disposal				$3,719	$2,000
Years 3 to 5 (Semi-Annually--Impacted and Delineation Wells)					
Labor/Equipment/Reporting/Expenses				$160,554	$65,000
Laboratory Analytical Costs				$185,255	$75,000
Purge Water Disposal				$3,705	$1,500
Years 6 to 30 (Annually--Impacted Wells)					
Labor/Equipment/Reporting/Expenses				$162,174	$15,000
Laboratory Analytical Costs				$237,855	$22,000
Purge Water Disposal				$8,109	$750
Long-Term Site Management				$230,587	$15,000
Five-Year Reviews - Cost included in Sediment alternatives					$0
Subtotal - O&M Net Present Worth				$1,559,078	
Contingency Reserve - 25% of O&M Costs				$389,769	
Net Present Worth of Annual O&M Costs				**$1,948,847**	
Total Net Present Worth of Alternative				**$2,150,000**	

TABLE C-2C
PRELIMINARY COST ESTIMATE
ALLUVIAL GROUNDWATER AND NAPL ALTERNATIVE 3A1
DIRECT NAPL RECOVERY WITH
MONITORED NATURAL ATTENUATION

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Deed Restrictions				$20,000	
Municipal Ordinance				$10,000	
Phase I Direct NAPL Recovery					
Pilot Studies				$150,000	
Dual Well Systems	10	Ea	$85,000	$850,000	
Miscellaneous Piping/Equipment				$250,000	
Additional Monitoring Well Installation				$68,000	
Install Dedicated Sampling Pumps	34	Ea	$870	$29,580	
Subtotal - Direct Costs				$1,377,580	
Indirect Costs					
Remedial Design				$65,000	
Mobilization/Misc. Site Prep	(5% of Direct Costs)			$68,879	
Site Administration	(1% of Direct Costs)			$13,776	
Permitting/Legal Costs	(2% of Direct Costs)			$27,552	
Construction Management/Oversight	(10% of Direct Costs)			$137,758	
Subtotal - Indirect Costs				$312,964	
Contingency - 25% of Direct and Indirect Costs				$422,636	
Total Capital Costs				**$2,113,181**	
Operation and Maintenance Costs					
				Net Present Worth	Annual Cost
Direct Recovery System Operation - 3 Years					
Energy Requirements				$32,679	$12,000
Miscellaneous O&M				$680,812	$250,000
Disposal of Recovered NAPL					
Year 1 - average 250 gpd				$464,286	$487,500
Year 2 - average 150 gpd				$265,306	$292,500
Year 3 - average 50 gpd				$84,224	$97,500
Long-Term Groundwater Monitoring Program					
See Alternative 2 for cost breakdown				$1,328,491	
Long-Term Site Management				$230,587	$15,000
Five-Year Reviews - Cost included in Sediment alternatives					$0
Subtotal - O&M Net Present Worth				$3,086,385	
Contingency Reserve - 25% of O&M Costs				$771,596	
Net Present Worth of Annual O&M Costs				**$3,857,981**	
Total Net Present Worth of Alternative				**$5,970,000**	

TABLE C-2D
PRELIMINARY COST ESTIMATE
ALLUVIAL GROUNDWATER AND NAPL ALTERNATIVE 3A2
DIRECT/ENHANCED NAPL RECOVERY WITH
MONITORED NATURAL ATTENUATION

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Deed Restrictions				$20,000	
Municipal Ordinance				$10,000	
Phase I Direct NAPL Recovery					
See Alternative 3A1 for Breakdown				$1,250,000	
Phase II Enhanced Recovery (starts EOY 2)					
Pilot Studies				$226,757	
Electricity Distribution Equipment				$526,077	
Electrode Installation	380	Ea	$1,500	$517,007	
IPA Injection Well Installation	44	Ea	$1,000	$39,909	
Miscellaneous Equipment/Materials				$150,000	
Additional Monitoring Well Installation				$68,000	
Install Dedicated Sampling Pumps	34	Ea	$870	$29,580	
Subtotal - Direct Costs				$2,837,331	
Indirect Costs					
Remedial Design				$85,000	
Mobilization/Misc. Site Prep	(5% of Direct Costs)			$141,867	
Site Administration	(1% of Direct Costs)			$28,373	
Permitting/Legal Costs	(2% of Direct Costs)			$56,747	
Construction Management/Oversight	(10% of Direct Costs)			$283,733	
Subtotal - Indirect Costs				$595,720	
Contingency - 25% of Direct and Indirect Costs				$858,263	
Total Capital Costs				**$4,291,313**	
Operation and Maintenance Costs					
				Net Present Worth	Annual Cost
Recovery System Operation					
Energy/Misc. O&M (Years 1 and 2)				$487,166	$262,000
Energy Requirements (Years 3 to 5)				$182,785	$74,000
Chemicals (Years 3 to 5)				$142,276	$57,600
Miscellaneous O&M (Years 3 to 5)				$617,517	$250,000
Disposal of Recovered NAPL					
Year 1 - average 250 gpd				$464,286	$487,500
Year 2 - average 150 gpd				$265,306	$292,500
Year 3 - average 250 gpd				$421,121	$487,500
Year 4 - average 150 gpd				$240,640	$292,500
Year 5 - average 50 gpd				$76,394	$97,500
Long-Term Groundwater Monitoring Program					
See Alternative 2 for cost breakdown				$1,328,491	
Long-Term Site Management				$230,587	$15,000
Five-Year Reviews - Cost included in Sediment alternatives					$0
Subtotal - O&M Net Present Worth				$4,456,568	
Contingency Reserve - 25% of O&M Costs				$1,114,142	
Net Present Worth of Annual O&M Costs				**$5,570,710**	
Total Net Present Worth of Alternative				**$9,860,000**	

TABLE C-2E
PRELIMINARY COST ESTIMATE
ALLUVIAL GROUNDWATER AND NAPL ALTERNATIVE 3B
IN-SITU NAPL TREATMENT WITH
MONITORED NATURAL ATTENUATION

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Deed Restrictions				$20,000	
Municipal Ordinance				$10,000	
In-Situ NAPL Bioremediation					
Pilot Study				$175,000	
Collection Wells/Pumps	30	Ea	$25,000	$750,000	
Distribution/Injection Piping				$990,000	
Bio-Reactor Materials/Installation				$1,280,000	
Miscellaneous Controls/Equipment				$215,000	
Additional Monitoring Well Installation				$68,000	
Install Dedicated Sampling Pumps	34	Ea	$870	$29,580	
			Subtotal - Direct Costs	$3,537,580	
Indirect Costs					
Remedial Design				$85,000	
Mobilization/Misc. Site Prep			(5% of Direct Costs)	$176,879	
Site Administration			(1% of Direct Costs)	$35,376	
Permitting/Legal Costs			(2% of Direct Costs)	$70,752	
Construction Management/Oversight			(10% of Direct Costs)	$353,758	
			Subtotal - Indirect Costs	$721,764	
			Contingency - 25% of Direct and Indirect Costs	$1,064,836	
			Total Capital Costs	**$5,324,181**	
Operation and Maintenance Costs				Net Present Worth	Annual Cost
In-Situ Bioremediation System Operation - 3 Years					
Bacteria and Amendments				$953,137	$350,000
Energy Requirements				$367,638	$135,000
Miscellaneous O&M				$1,007,602	$370,000
System Decommissioning after Year 3				$95,022	$110,000
Performance Sampling				$122,546	$45,000
Long-Term Groundwater Monitoring Program					
See Alternative 2 for cost breakdown				$1,328,491	
Long-Term Site Management				$230,587	$15,000
Five-Year Reviews - Cost included in Sediment alternatives					$0
			Subtotal - O&M Net Present Worth	$4,105,023	
			Contingency Reserve - 25% of O&M Costs	$1,026,256	
			Net Present Worth of Annual O&M Costs	**$5,131,279**	
Total Net Present Worth of Alternative				**$10,500,000**	

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TABLE C-2F
PRELIMINARY COST ESTIMATE
ALLUVIAL GROUNDWATER AND NAPL ALTERNATIVE 4
ENHANCED NAPL RECOVERY WITH
GROUNDWATER PUMP AND TREAT

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Deed Restrictions				$20,000	
Municipal Ordinance				$10,000	
Direct/Enhanced NAPL Recovery					
See Alternative 3A2 for Breakdown				$2,709,751	
Groundwater Extraction/Treatment					
Recovery Wells/Pumps	28	Ea	$6,600	$184,800	
Trenching/Conveyance Pipes/Wiring	22,200	Ft	$30	$666,000	
Treatment System (carbon/ion exch)				$150,000	
Treatment Building				$35,000	
Miscellaneous Construction Costs				$75,000	
NPDES Discharge Permit Application				$12,000	
Additional Monitoring Well Installation				$68,000	
Install Dedicated Sampling Pumps	34	Ea	$870	$29,580	
			Subtotal - Direct Costs	$3,960,131	
Indirect Costs					
Remedial Design				$125,000	
Mobilization/Misc. Site Prep	(5% of Direct Costs)			$198,007	
Site Administration	(1% of Direct Costs)			$39,601	
Permitting/Legal Costs	(2% of Direct Costs)			$79,203	
Construction Management/Oversight	(10% of Direct Costs)			$396,013	
			Subtotal - Indirect Costs	$837,824	
			Contingency - 25% of Direct and Indirect Costs	$1,199,489	
			Total Capital Costs	**$5,997,443**	
Operation and Maintenance Costs					
				Net Present Worth	Annual Cost
Enhanced Recovery System Operation - 5 Years					
See Alternative 3A2 for cost breakdown				$1,429,743	
Disposal of Recovered NAPL - see Alternative 3A2 for breakdown				$1,467,747	
Groundwater Pump and Treat System Operation - 30 years					
Energy Requirements				$215,214	$14,000
Spent Carbon Regeneration/Disposal				$1,460,383	$95,000
Miscellaneous O&M				$2,305,868	$150,000
NPDES Sampling/Analysis/Reporting (twice monthly)				$332,045	$21,600
Long-Term Groundwater Monitoring Program					
See Alternative 2 for cost breakdown				$1,328,491	
Long-Term Site Management				$538,036	$35,000
Five-Year Reviews - Cost included in Sediment alternatives					$0
			Subtotal - O&M Net Present Worth	$9,077,526	
			Contingency Reserve - 25% of O&M Costs	$2,269,382	
			Net Present Worth of Annual O&M Costs	**$11,346,908**	
Total Net Present Worth of Alternative				**$17,300,000**	

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TABLE C-2G
PRELIMINARY COST ESTIMATE
ALLUVIAL GROUNDWATER AND NAPL ALTERNATIVE 5
IN-SITU NAPL TREATMENT WITH
IN-SITU GROUNDWATER TREATMENT

Component	Estimated Quantity	Unit	Estimated Unit Cost	Estimated Capital Cost	Estimated Annual O&M Cost
Capital Costs					
Direct Implementation Costs					
Deed Restrictions				$20,000	
Municipal Ordinance				$10,000	
In-Situ NAPL Bioremediation					
See Alternative 3B for breakdown				$3,410,000	
In-Situ Groundwater Remediation					
Pilot Testing				$85,000	
Delivery Point Installation	325	Ea	$500	$162,500	
Initial Chemical Treatment	35,000	Lb	$7.00	$245,000	
Miscellaneous Labor/Equipment				$150,000	
Additional Monitoring Well Installation				$68,000	
Install Dedicated Sampling Pumps	34	Ea	$870	$29,580	
Subtotal - Direct Costs				$4,180,080	
Indirect Costs					
Remedial Design				$120,000	
Mobilization/Misc. Site Prep	(5% of Direct Costs)			$209,004	
Site Administration	(1% of Direct Costs)			$41,801	
Permitting/Legal Costs	(2% of Direct Costs)			$83,602	
Construction Management/Oversight	(10% of Direct Costs)			$418,008	
Subtotal - Indirect Costs				$872,414	
Contingency - 25% of Direct and Indirect Costs				$1,263,124	
Total Capital Costs				**$6,315,618**	
Operation and Maintenance Costs					
				Net Present Worth	Annual Cost
In-Situ NAPL Bioremediation System Operation - 3 Years					
See Alternative 3B for cost breakdown				$2,545,945	
In-Situ Groundwater Remediation - Second Application (Year 2)					
Chemicals				$222,222	$245,000
Miscellaneous Labor/Equipment				$136,054	$150,000
Long-Term Groundwater Monitoring Program					
See Alternative 2 for cost breakdown				$1,328,491	
Long-Term Site Management				$307,449	$20,000
Five-Year Reviews - Cost included in Sediment alternatives					$0
Subtotal - O&M Net Present Worth				$4,540,162	
Contingency Reserve - 25% of O&M Costs				$1,135,041	
Net Present Worth of Annual O&M Costs				**$5,675,203**	
Total Net Present Worth of Alternative				**$12,000,000**	

APPENDIX D

APPENDIX D

AQUABLOK™ INFORMATION

Manuscript presented at WEVA Midwest chapter mtg in Chicago, IL, Jan, 2000

SEDIMENT CAPPING DEMONSTRATION PROJECT ON THE OTTAWA RIVER: AN IMPACTED LAKE ERIE TRIBUTARY

J.H. Hull, P.E., D.E.E., P.B. Hotz, and J.M. Jersak, Ph.D., CPSS[1]

ABSTRACT: The City of Toledo is conducting a sediment capping demonstration project on the Ottawa River, a Lake Erie tributary located in Northwestern Ohio. The Project, for which cap construction phases were completed in September 1999, involves installation and field-scale testing of different in-situ, sediment-cap designs along an approximately 2.5-acre section of the river known to have elevated levels of PCBs in the sediments. AquaBlok™, an innovative, clay mineral-based capping technology, is a principal component of each cap design. Once applied through the water column, this capping material hydrates and forms a cohesive, low-permeability and erosion-resistant barrier between contaminated sediments and the overlying aquatic ecosystem. Three different test cap designs were constructed: AquaBlok™ exclusively; a basal geogrid component overlain by AquaBlok™; and geogrid plus AquaBlok™, plus a surficial stone layer. A variety of installation techniques were also demonstrated as part of the Project, including the use of a conveyor (telebelt), helicopter, and dragline. The primary, long-term goal of the Project is to assess the relative effectiveness of AquaBlok™-based sediment caps to physically stabilize and isolate impacted sediments occurring in a riverine environment representative of many Great Lakes tributaries. An additional Project goal is to characterize development of invertebrate benthic communities within encapsulated areas over time and as a function of cap design. The Project is funded, in large part, by a Lake Erie Protection Fund grant from the Ohio Lake Erie Commission.

Results of field observations made during cap construction as well as results of initial post-construction survey and core-sampling activities are presented. Collectively, the data indicate that the construction techniques employed were viable methods for installation of the AquaBlok™-based sediment caps. Also presented are generalized unit costs associated with AquaBlok™ cap construction using each technique.

INTRODUCTION

The City of Toledo, Ohio is conducting a demonstration capping project within an approximately 2.5-acre portion of the Ottawa River, located in Northwestern Ohio. The Project, for which cap-construction phases were completed in September 1999, generally involves the construction and field-scale testing of different in-situ sediment-barrier (cap) designs along a particular section of the river known to have elevated levels of polychlorinated biphenyls (PCBs) and other contaminants in the sediments. The Project is not a mandated remedial activity, however, initiation of cap-construction phases required pre-approval from the U.S. Army Corps or Engineers and other regulatory agencies. It is being funded, in large part, by a Lake Erie Protection Fund grant provided to the City by the Ohio Lake Erie Commission.

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Prior to construction of the sediment caps, extensive site and sediment characterization activities were conducted, as well as laboratory scale cap-development and flume (erosion) studies. Pre-capping field activities also included working with the Ohio EPA to characterize invertebrate benthic communities occurring within targeted capping areas prior to capping; pre-capping results will be compared to subsequently collected, post-capping invertebrate data in order to assess benthic colonization of encapsulated areas over time and as a function of cap design.

A principal component of each of the cap designs being tested in the Ottawa River is AquaBlok™, a remedial technology developed by New Waste Concepts, Inc. (NWC) and marketed by AquaBlok, Ltd. Hull & Associates, Inc. provides technical assistance to NWC and AquaBlok, Ltd. and also acts as the City's primary engineering/environmental consultant for the Project.

AquaBlok™ is a patented, composite-aggregate product – resembling small stones – that is comprised of a solid, dense core surrounded by a clay mineral-based (bentonite-rich) coating fixed to the core with polymers. When applied through a water column and across the surface of contaminated sediments, AquaBlok™ acts as a low-permeability and erosion-resistant, cohesive barrier between the sediments and overlying deepwater or wetland ecosystems. In other pilot-scale field studies conducted elsewhere, AquaBlok™ has been proven effective in reducing organism exposure to contaminated sediments and offering a viable substrate for re-establishment of indigenous flora and fauna.

This project demonstrates field-scale implementation of the AquaBlok™ capping technology in a flowing-river environment. Principal goals for the Project include assessing the relative effectiveness of AquaBlok™-based sediment caps in physically stabilizing and isolating contaminated sediments occurring in a riverine environment representative of many Great Lakes tributaries as well as characterizing invertebrate colonization of encapsulated areas over time. It was also anticipated that significant knowledge would be gained pertaining to the utilization of different application techniques to accomplish product deployment, the adequacy of each technique in constructing targeted sediment-cap designs, and generalized unit costs associated with cap construction using each technique.

SITE DESCRIPTION

The Ottawa River flows into the Maumee Bay, which is located at the far west end of Lake Erie. The Project area comprises an approximately 0.2 mile-long stretch of the river and is typically

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100 to 120-feet wide in this portion of the river. Although highly variable, depending on Lake Erie levels, water depths typically range from one to eight feet. Water-borne sediments across the Project area are typically silt and clay rich and occur at thicknesses ranging from less than 0.5 feet to 3 feet plus.

The Ottawa River, like other tributaries to Lake Erie's western basin, has a drowned mouth that creates estuarine conditions within its lower portions, including the Project area. These conditions are characterized by rapid and sometimes significant changes in river water levels and flow directions, both of which result from climatically induced changes in Lake Erie water levels.

Beginning in the early twentieth century, a variety of industrial operations occurring along the Ottawa River have negatively impacted the river's water and sediment quality, including related deepwater and wetland habitats. According to analytical data from the Ohio EPA, elevated concentrations of PCBs as well as polynuclear aromatic hydrocarbons (PAHs) and various heavy metals occur in lower-river sediments, including within the Project area.

DEMONSTRATION CAP DESIGNS

For demonstration purposes, the sediment caps constructed within the Project area comprise three contiguous capping sections (Sections A, B, and C) which differ somewhat in terms of components and design. Specifically, the Section A cap was constructed of AquaBlok™ exclusively; a portion of the Section B cap was constructed of AquaBlok™ plus a basal geogrid (Tensar™); and the Section C cap was constructed of AquaBlok™ plus geogrid, plus a surficial layer of protective stone. Typical targeted thicknesses for Section A and B caps were approximately five to six inches while the Section C cap was approximately five to eight inches.

CAP CONSTRUCTION

Three different techniques were used to construct the AquaBlok™-based sediment caps in September 1999: (1) an articulated, telescoping conveyor (or telebelt), operated from both barge and on-shore positions; (2) a helicopter, equipped with specially designed drop bags for applying AquaBlok™ or protective stone; and (3) a dragline, which was operated from the shore. The ability to access remediation areas, the sizes of possible project areas, and other factors will vary significantly. It was assumed that the three technologies are representative of the possible range of typical application techniques. Other techniques no doubt could be developed.

Installation of the basal geogrid component across Sections B and C, prior to AquaBlok™ deployment, generally involved first tying the geogrid together, lowering it to the river-bottom

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surface from work boats, and finally systematically placing AquaBlok™-filled bags across the surface of the geogrid to keep it in place. Geogrid was not placed across one portion of Section B as originally intended as a significant topographical depression was encountered in this area of the river bottom; the cap in this area is comprised exclusively of AquaBlok™.

After geogrid installation was completed in Sections B and C, a total of approximately 472 tons of AquaBlok™ was installed across the Project area using the techniques described above. An additional, approximately 206 tons of ODOT #4 stone was then applied across the AquaBlok™ component in Section C. Quantities of capping materials installed using the different techniques as well as approximate areas covered and average product application rates are summarized in Tables 1 and 2. AquaBlok™ quantities included in Table 1 do not include masses of bagged AquaBlok™ used to stabilize the geogrid component (which comprised an estimated total of approximately 11 tons, or less than three percent of the total 472 tons of AquaBlok™ applied).

Table 1 - Summary of AquaBlok™ Applications: Methods, Quantities, Application Rates

Application Method	Approximate Quantity of AquaBlok™ Applied (tons)	Approximate Area Covered (acres)	Average AquaBlok™ Application Rate (lbs/ft^2)[1]
Conveyor (Telebelt)	364[2]	1.92	8.7
Helicopter	82	0.46	8.2
Dragline	15	0.087	7.9

[1] The target application rate for AquaBlok™, to achieve a typical hydrated thickness ranging from approximately five to six inches, was approximately 8.4 lbs/ft^2.

[2] This total includes approximately five tons of AquaBlok™ that was, for demonstration purposes, subsequently placed across a conveyor-application area in one portion of the site using the dragline technique.

Table 2 - Summary of Stone Applications: Methods, Quantities, Application Rates

Application Technique	Approximate Quantity of Stone Applied (tons)	Approximate Area Covered (acres)	Average Stone Application Rate (lbs/ft^2)[1]
Conveyor (Telebelt)	113	0.46	11.3
Helicopter	93	0.35	12.2
Dragline	0	0	not applicable

[1] The target application rate for ODOT #4 stone, to achieve a surficial layer thickness of approximately two inches, was approximately 13.3 lbs/ft^2.

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Applications of AquaBlok™ and stone using conveyor techniques involved placement of materials across the targeted river-bottom surface in piecemeal fashion. Specifically, targeted areas for AquaBlok™ or stone coverage were first delineated and marked with multi-colored floats, with the dimensions of a given area corresponding to the targeted material application rate and the capacity of a given rock-box load of product provided to the barge-based conveyor. During product applications from the shore-based conveyor, which occurred in a near-bank portion of Section B, AquaBlok™ or stone was brought to the conveyor hopper by land and load sizes estimated based on the degree of hopper filling. Shore-based dragline applications of AquaBlok™, which occurred in small portions of Sections A and B, were conducted in a similar fashion.

Applications of AquaBlok™ and stone using the helicopter, which occurred in Section C, were accomplished by first establishing linear-shaped, "swimming lane"-like targets parallel to river flow. Drop-bag loads of capping material were then placed along these targets in series, with the area covered by each individual application dictated by the size of a given bag load as well as the targeted material application rate. A number of "practice runs" using the helicopter technique were conducted at a local borrow area prior to river applications in order to establish typical dimensions of product coverage as a function of load size, flight speed, and elevation of the drop bag above the water surface.

During AquaBlok™ and stone applications using the different deployment techniques, field personnel observed – from above the water surface - the apparent uniformity of coverage across each targeted application area, assisting or guiding operators during the application process to insure adequate spatial coverage when required. Based on the field observations made, an adequate degree of product coverage into targeted areas was achieved using each of the application techniques. The adequacy of capping-material applications (i.e. cap construction) relative to design specifications was also determined following cap construction, as summarized in the following section.

INITIAL POST-CAPPING EVALUATIONS

Following cap construction, river-bottom elevations were determined at a total of 297 points along 13 cross-river transects (at approximately five-foot intervals) situated across and at the borders of all three capping sections. Elevational surveys were conducted using a footed probe and standard station-survey methods. Post-cap survey data were then quantitatively compared to river-bottom elevations determined within the same locations just prior to cap construction in order to determine net elevation increases within each surveyed location, thus providing an indication of hydrated cap thickness. To establish the degree of vertical error that could be associated with such a comparison

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of survey measurements, pre- and post-cap surveys were also conducted at a total of 17 points along a "control" transect located just outside of the capping area. Survey results for transects across capping sections A and B and across capping Section C are provided in Table 3.

Table 3 - Results of Post-Application Cap Surveys

Parameter	Sections A and B *Transects AA to BC Inclusive*	Section C *Transects BC to CC Inclusive*
Total Number of Survey Points	159[1]	110
Mean Elevation Increase (Cap Thickness)	4.9 inches	5.7 inches
Standard Deviation	2.9 inches	2.8 inches
99% Confidence Interval About Mean	4.3 to 5.5 inches	5.0 to 6.4 inches
Targeted Cap Thickness (Typical)	5 to 6 inches	5 to 8 inches

[1] A total of 187 transect points were surveyed across Sections A and B, with a total of 159 points indicating a net positive elevation change and 28 points indicating a net negative change. The negative values were not included in these calculations in that a majority of the values are likely related to the barge dragging the bottom in localized, shallower areas, prior to capping-material application.

Survey results indicate that cap thicknesses across the Project area (based on net positive changes in river-bottom elevations) fall within respective, targeted cap thicknesses for Section A and B cap designs as well as for the Section C cap design. Some degree of downward AquaBlok™ hydration likely occurred into the capped sediment surface in all sections, which could explain average elevational increases occurring towards the low ends of targeted cap-thickness ranges. The surficial stone-layer component of the Section C cap may also have experienced some degree of settling into the underlying AquaBlok™ component (thus affecting elevation changes), although the average cap thickness across Section C is still greater than that for Sections A and B, as expected. Finally, some degree of vertical error (perhaps up to 0.1ft) is also likely associated with pre- versus post-capping survey comparisons based on surveys conducted along the control transect; such error could also slightly affect calculated elevational changes.

As a final note regarding survey work, 28 out of the total 187 survey points across Sections A and B indicated a net negative change in river-bottom elevation, ranging from –1.34 feet to –0.01 feet (average of –0.33 feet); no such negative changes were observed at any of the 110 survey points across Section C. Although some of these negative values could reflect typical vertical error, most more highly negative values are likely due to the barge dragging the bottom in localized, shallower areas of Sections A and B during set-up stages of the Project (prior to cap construction). The barge

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did not transverse Section C. The water surface elevation of the Ottawa River during application was at a significant low relative to that during inception of the Project.

To corroborate survey results, probing of the capped river bottom with conduit was also conducted within each surveyed location to qualitatively establish the presence of AquaBlok™ and/or stone capping material. Qualitative probing across Sections A and B indicated that AquaBlok™ was confirmed as being present within all but 17 of the 187 survey locations (including the majority of the river-bottom areas presumably impacted by the barge), whereas stone and/or AquaBlok™ were present within all but two of the 110 survey locations across Section C.

As an additional component to post-capping evaluations, and to assist in interpretation of survey data, river-bottom core samples were collected from across Sections A and B in November 1999; geogrid presence across Section C and portions of Section B precluded core collection in these areas. In addition to facilitating interpretation of survey data (through direct measurement of cap thicknesses in core samples), coring activities also enable assessment of physical mixing occurring along the cap/sediment interface (i.e. sediment incorporation into capping material).

A total of 48 core samples were collected from nine different transect locations, with faculty from the University of Toledo engineering department (UT) assisting with sampling activities. Statistical evaluation of core-sample and related cap-thickness data is ongoing, with UT also assisting in this phase of study. Visual inspection of core samples indicate the consistent occurrence of sharp – rather than diffuse and mixed – boundaries along the cap/sediment interface in the samples collected. Minimal mixing of AquaBlok™ with sediments along this interface translates into maximal *effective* cap thickness (i.e. capping material free of sediment-borne contaminants), and thus, maximal sediment isolation and minimal exposure to potential receptor organisms.

GENERAL UNIT COSTS FOR AQUABLOK™ CAPPING

Based on results of this demonstration capping project, generalized unit costs for AquaBlok™ cap construction using each of the demonstrated techniques - including material costs - are as follows:

- Helicopter – approximately $1.20 per square foot
- Shore-based conveyor – approximately $0.85 per square foot
- Barge-based conveyor – approximately $1.00 per square foot
- Shore-based dragline – approximately $0.90 per square foot

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For simplicity, these generalized costs were developed assuming construction of a targeted six-inch hydrated AquaBlok™ cap without the geogrid or stone-layer components present; such additional components would add additional costs, depending on the specific materials used and the final cap design. General costs were also developed assuming deployment of the standard AquaBlok™ formulation, applied at a rate of approximately 8.5 pounds per square foot and at a bulk, delivered cost of approximately $150 per ton. Additionally, the general costs provided do not include costs associated with other major project components such as project planning and management; preliminary laboratory studies; cap design; permitting; QC monitoring during cap construction as well as long-term performance monitoring; and cap maintenance. It is also important to note that unit costs for cap construction will vary significantly as a function of overall project goals (which will dictate final cap design) as well as site-specific conditions such as existing infrastructure and site access; sediment type and characteristics; size and ecology of the project area; and surface water salinity levels, which may dictate the particular AquaBlok™ formulation required.

SUMMARY

Results of field observations made during construction of the AquaBlok™-based demonstration caps as well as results of survey and core-sampling work conducted just after cap construction collectively indicate that all three deployment or construction techniques – the conveyor, the helicopter, and the dragline – are viable techniques for construction of all three demonstration capping designs being tested. Other existing techniques for product deployment could also be used effectively at other sites, such as pumping, slinging, and/or dry application methods.

Development of general costs for the Project also indicate that construction of AquaBlok™-based sediment caps using any one or more of these techniques can be accomplished cost effectively.

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Introduction

AquaBlok™

Barrier Between Contaminated Substrates and Adjacent Water Resources

AquaBlok™ composite particles are a proprietary blend of clay minerals, polymers, and other special additives surrounding a dense aggregate nucleus (Figure 1). The mineral coating typically contains extremely small, negatively charged clay sized particles having very large surface-area-to-mass ratios. Upon wetting, these reactive particles hydrate and physically expand around the dense particle nucleus.

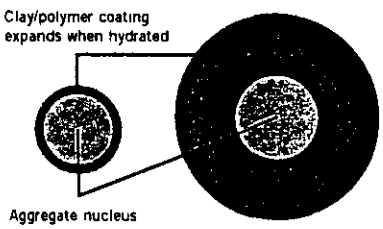


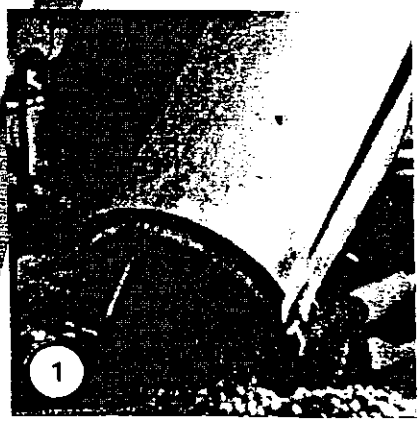
Figure 1. Cross section of typical AquaBlok™ particle.

Once deployed through water, AquaBlok™'s heavy nucleus carries the clay bearing particles to the bottom where the product collectively grows into a continuous and cohesive, erosion-resistant layer of very low permeability. When applied to environmentally impacted deepwater or wetland ecosystems, AquaBlok™ acts as a physical, hydraulic, and chemical barrier between contaminated sediments (or subtrates) and the overlying water column, protecting flora and fauna and also minimizing contaminant movement into the food chain.

Similarly, if ground water protection is a project goal, AquaBlok™'s low permeability also minimizes downward movement of surface waters through the cap, which could carry contaminants into underlying substrate. AquaBlok™ can also be used as a component of landfill liners and covers, or can be used to limit infiltration losses of clean water from reservoirs.

Easy Handling

AquaBlok™ composite particles are engineered to hydrate slowly so they can be delivered to the target area easily.



AquaBlok™ is easy to handle.

The hard, smooth, marble-like particles flow easily from a bucket, chute, or pipeline and sink quickly to the bottom before forming a physically uniform and continuous layer of clean substrate over contaminated subtrates (Photograph 1).

Versatile

Using water-, shoreline-, or air-based equipment, AquaBlok™ can be delivered into a variety of hydrologic environments, ranging from flowing rivers or estuaries to deep lakes or reservoirs. Depending on surface-water hydrology and climatic conditions, AquaBlok™ can also be applied to seasonally exposed, wetland ecosystems.

Local Manufacture

AquaBlok™ can be custom formulated on site, incorporating locally obtained materials whenever possible. Local manufacture – as opposed to shipment of AquaBlok™ into the site – is cost effective, particularly when applying the technology at distant and geographically isolated locations.

Environmentally Friendly

As opposed to more invasive remedial technologies like dredging, AquaBlok™ offers a low-impact approach to addressing contaminated subtrates in deepwater and wetland ecosystems. AquaBlok™ also offers a viable and clean substrate for re-establishment of plant and benthic communities.

Weather Resistant

AquaBlok™ remains stable and resilient in the harshest of weather conditions, including erosional stresses related to seasonal flooding as well as freeze/thaw or desiccation stresses related to periodic subaerial exposure of the capping material.

Product Specification

AquaBlok™ formulations can be customized during manufacture to meet site- or project-specific needs through modifying the quantities or types of particle components. Cap designs may be comprised of AquaBlok™ alone, or AquaBlok™ in concert with other capping components (like geotextiles or stone armor layers), again depending on site-specific conditions and project needs.

If you think that the AquaBlok™ composite particle system could be of use in your remediation projects, call us. We'll be happy to discuss your project with you, and help determine how the AquaBlok™ technology could be successfully applied at your sites.

For more information, including test reports and case histories, call AquaBlok, Ltd. at **(419) 385-2018** or fax us at **(419) 385-2990**. You can also e-mail us at: services@aquablokinfo.com

Supporting test reports on the AquaBlok™ capping technology include: physical characteristics of different AquaBlok™ formulations; settling characteristics; product permeability; pilot-scale column tests; erosion resistance; contaminant attenuation; and freeze/thaw effects.

AquaBlok™
Composite Particle System

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AquaBlok™ is a trademark of New Waste Concepts, Inc
AquaBlok™ composite particles are patented
Other patents pending

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Physical Characteristics

AquaBlok™

TEST REPORT #1: Physical Characteristics of Standard and Modified AquaBlok™ Formulations

Background and Purpose of Testing

The AquaBlok™ composite particle system is a combination of dry clay minerals, polymers, and an aggregate core. As shown in Figure 1, each AquaBlok™ particle typically consists of a clay mineral-based (often bentonite-rich) outer shell that is fixed with polymers to a nucleus (aggregate core) comprised of gravel or other hard material such as glass cullets.

AquaBlok™'s configuration facilitates efficient delivery of reactive clay components, like bentonite, through water to form a cohesive barrier between contaminated sediments and the overlying deepwater or wetland ecosystem (see TEST REPORT #6). AquaBlok™ can be modified in terms of its physical or clay mineral characteristics to accommodate site-specific conditions or to meet overall project objectives; a "standard" AquaBlok™ formulation is manufactured using approximately equal bulk-weight percentages of gravel (as the aggregate core) and clay coating.

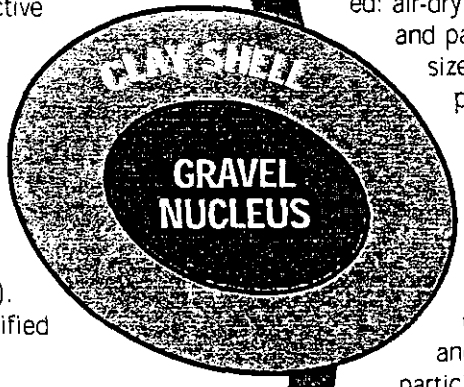

Figure 1. Configuration of Typical AquaBlok™ Particle.

The purpose of this set of laboratory tests was to demonstrate general physical characteristics of standard and modified formulations of AquaBlok™, both in terms of bulk (mixed) characteristics as well as characteristics associated with discrete particle size classes.

Methods

Large bulk samples of AquaBlok™ were prepared using poorly graded gravel plus a proprietary polymer and varying quantities (weight percentages) of bentonite clay material. The formulations prepared ranged from a bentonite-rich product (70% bentonite plus 30% gravel, referred to as "70BE") to a much leaner formulation (20% bentonite plus 80% gravel, referred to as "20BE"). Five different formulations were prepared for testing: 70BE, 50BE, 40BE, 30BE, and 20BE. Selected physical characteristics of AquaBlok™ were demonstrated using representative, air-dry samples of these formulations. The physical characteristics determined included: air-dry bulk density and particle size distribution per formulation as well as composition (relative bentonite percent), moisture content, and density per particle size class. Results of previous laboratory characterization studies conducted using another bulk sample of AquaBlok™ of standard formulation are also presented for comparison.

Bulk densities for selected AquaBlok™ formulations were determined by weighing masses of AquaBlok™ of known (typically five-gallon) volumes. Particle size distributions were determined in general conformance with ASTM Method No. D 421. This involved passing representative spit-and-quartered bulk samples of each AquaBlok™ formulation through a series of five metal sieves and measuring total particle mass retained on each sieve, as well as the material passing through the smallest (#10) sieve.

Moisture content per particle size class was determined on representative subsamples in general conformance with ASTM Method No. 2216. Following moisture content determination, proportions of clay and gravel comprising oven-dried particle size classes were determined through physically removing clay coatings from gravel cores and weighing respective clay and gravel components. Finally, average densities of discrete particles were determined by weighing a separate subsample of air-dry particles then determining the volume of water displaced by this mass of particles (to obtain total sample volume).

Results

Testing results are summarized in the following table and graphs. Results derived through testing a previous standard AquaBlok™ formulation are included in the graphs as the "50BE B" formulation. *(continued on back)*

AquaBlok™ Composite Particle System

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Table 1.
Typical Air-Dry Bulk Densities for Selected AquaBlok™ Formulations.

AquaBlok™ Formulation	Typical Air-Dry Bulk Density (lbs/ft³)
70BE	78.3
40BE and 50BE	76.0
20BE	85.8

Observations & Conclusions

Air-dry bulk densities range from between 76.0 and 85.8 pounds per cubic foot (Table 1). Values tend to be higher when greater percentages of the AquaBlok™ formulation are comprised of gravel, as illustrated with the 20BE sample. Bulk density values also likely change with moisture content, which may vary during the manufacturing process.

Bentonite-rich AquaBlok™ formulations tend to be comprised of larger-diameter particles than are leaner product formulations, as illustrated by differences in the proportion of 1.00 - 0.75 inch-sized particles for the 70BE and 20BE formulations (Figure 2). This is a characteristic of the AquaBlok™ manufacturing process.

Smaller AquaBlok™ particles tend to carry higher percentages of clay than larger particles, particularly for bentonite-rich formulations (Figure 3); this is also a characteristic of the AquaBlok™ manufacturing process. Differences in clay content amongst smaller fractions of the two standard formulations (the 50BE A and B mixes) could be due to several factors including slight differences in clay content of the bulk mixture and particle integrity during the sieving process.

Smaller AquaBlok™ particles tend to contain higher moisture content than larger particles (Figure 4). This is because moisture is associated with the clay (rather than the gravel) component and because smaller particle size fractions have higher clay percentages than larger fractions.

For any formulation, smaller AquaBlok™ particles tend to be less dense than larger particles (Figure 5); this is because of the presence of higher proportions of less-dense clay. This relationship between particle size and density is generally accentuated in bentonite-rich formulations in which relatively greater percentages of each particle size are comprised of clay rather than gravel.

Figure 2. AquaBlok Particle Size Distribution as a Function of Formulation

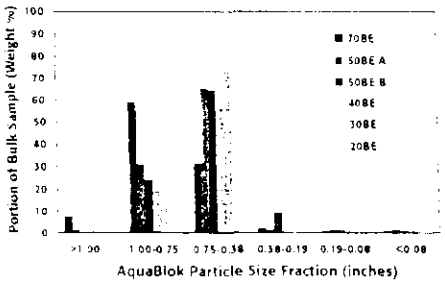


Figure 3. Bentonite Content as a Function of Particle Size and Formulation

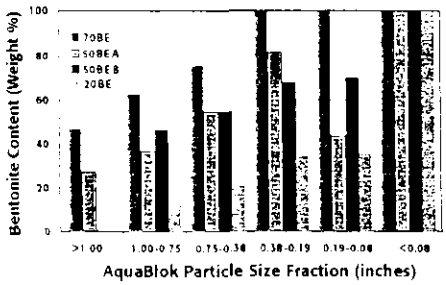


Figure 4. Moisture Content as a Function of Particle Size and Formulation

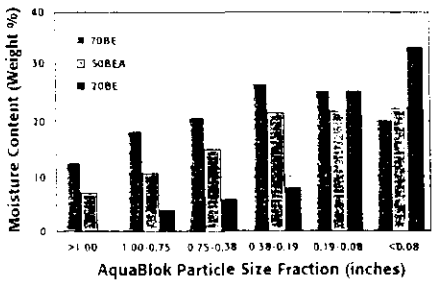
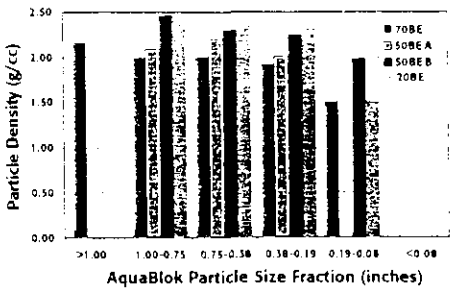


Figure 5. AquaBlok Particle Density as a Function of Particle Size and Formulation



AquaBlok™
Composite Particle System

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AquaBlok™ is a trademark of New Waste Concepts, Inc.
AquaBlok™ composite particles are patented.
Other patents pending.

Testing conducted by Hull & Associates, Inc. for AquaBlok, Ltd.
Data for 50BE B formulation from Abeltech, Inc. Report originally prepared by Abeltech, Inc. and revised by AquaBlok, Ltd.

LAST REVISED 4/5/99

AR302781

Settling Characteristics

AquaBlok™

TEST REPORT #2: Settling Characteristics of Individual AquaBlok™ Particles and Bulk AquaBlok™ Masses Through Water

Background and Purpose of Testing

Variable quantities or types of clay minerals can be used to manufacture different AquaBlok™ formulations to accommodate site-specific needs and overall project objectives. The physical characteristics of dry, bulk (mixed) AquaBlok™ masses as well as discrete particle size classes vary as a function of product formulation (see TEST REPORT #1). Nevertheless, despite differences in physical parameters like bulk density or percent clay content between formulations, bulk samples of AquaBlok™ consistently display a broad range of particle sizes as well as predictably variable particle densities amongst the size fractions (TEST REPORT #1).

The settling velocity of any single particle through a standing (non-flowing) water column depends on a particle's size, density, and shape, and water density and viscosity. In general, the settling velocity of a larger particle is higher than that of a smaller particle of the same density and shape; quantitatively, Stoke's law states that, under such conditions, a particle's settling velocity is proportional to the square of its radius (Day, 1965). Unpublished laboratory research conducted in the University of Toledo's Civil Engineering Department (UT) also indicates that constant (terminal) settling velocities for individual AquaBlok particles of different sizes typically occur within one foot of vertical descent through a standing water column.

In contrast to the relatively predictable settling behavior of individual particles, the settling behavior of bulk (mixed) material masses through water is typically much more complex. Bulk material tends to settle as a single entity rather than as individual particles (Dortch, 1990). As a mass settles, shear stresses and drag forces develop at the mass/water interface, resulting in the formation of turbulent eddies within and around the settling mass. According to Dortch (1990), a settling mass tends to reach terminal velocity after falling only a short distance; quantification of terminal settling velocities for bulk AquaBlok™ masses is currently being addressed at UT.

The purpose of this laboratory testing was two-fold: (1) to quantitatively demonstrate average settling velocities of individual AquaBlok™ particles of different sizes through small, standing water columns, and (2) to qualitatively demonstrate settling characteristics of different bulk AquaBlok™ masses through field-scale water columns. Data related to the settling characteristics of individual AquaBlok™ particles provide a useful theoretical basis for characterizing the settling behavior of bulk AquaBlok™ masses through standing water columns, which is more relevant to field applications.

In turn, laboratory observations of settling characteristics of bulk AquaBlok™ masses through non-flowing water columns provides baseline information that can be used when modeling AquaBlok™ applications to lotic (flowing-water) environments.

Methods

Settling Velocity of Individual Particles

Ten representative AquaBlok™ particles were chosen from selected particle-size fractions of a sieved, air-dry sample of AquaBlok™ of standard formulation. Each particle was dropped through a 31 inch-tall standing column of municipal tap water at room temperature (~70° F) from just above the water surface and the fall time for each particle was measured with a stop watch to the nearest 0.01 second.

Settling Characteristics of Bulk AquaBlok™ Masses

The general settling characteristics of bulk masses of standard AquaBlok™ were observed as part of several large-scale settling-column studies which are discussed in greater detail in TEST REPORT #6. The studies were conducted using a large (23-inch x 23-inch x 12 foot-tall), steel-reinforced Plexiglas settling column. Each AquaBlok™ mass was applied from just above the water surface by "pouring" the material from a bucket. Relative settling velocities of different-sized particles comprising the bulk mass were qualitatively observed, as was the general nature of dispersion and movement of the mass during descent. *(continued on back)*

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To more closely mimic AquaBlok™ applications as they occur in the field (e.g. applied gradually from barged stockpiles or shore-based conveyors), the application of AquaBlok™ masses to standing water columns was continuous and rapid, but not instantaneous. Product application on a less-than-instantaneous basis – although more representative of field practice – precludes precise quantification of settling velocities for bulk settling AquaBlok™ masses, or detailed evaluation of how variable mass or water-column thickness may quantitatively affect settling behavior. As stated previously, these deployment-related issues are currently the subject of ongoing laboratory research.

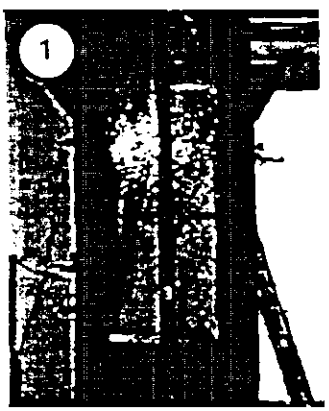
Results

Table 1 summarizes results of average settling velocities of individual AquaBlok particles through the small standing water column while Photograph 1 qualitatively illustrates typical particle-settling and dispersive behavior of bulk AquaBlok™ masses during descent through large water columns (in this case, 31 pounds of dry AquaBlok™ descending through a 8.8 foot water column).

Table 1.
Settling Behavior of Individual Particles (Standard Formulation).

AquaBlok™ Particle Size Fraction (inches)	Average Setting Velocity (ft/sec)
1.00 - 0.75	1.94
0.75 - 0.38	1.55
0.38 - 0.19	1.03
0.19 - 0.08	0.72

Typical behavior of a settling AquaBlok™ mass.



Observations and Conclusions

Individual AquaBlok™ particles

Small AquaBlok™ particles settle slower than larger particles (Table 1). This is because smaller particles have lower densities and higher surface-area-to-mass ratios than larger particles. Differences in average settling velocities as a function of particle size probably also occur for other AquaBlok™ formulations, although actual values may differ.

Based on results of research at UT, average settling velocities reported above should approximate terminal settling velocities for individual AquaBlok™ particles of standard formulation.

AquaBlok™ Masses

Visual observations of typical settling masses (Photograph 1) indicate that, as expected, little to no difference in settling velocities appear to occur as a function of particle size when the product is applied as a bulk mass. Instead, the mass tends to behave more-or-less as a single, turbulent and complex entity as it descends through the water column.

When applied as a bulk mass, AquaBlok™ tends to disperse during descent (Photograph 1). Results of several different column studies indicate that a greater degree of lateral dispersion tends to occur with greater water-column thickness, and that such dispersion may be constrained somewhat (during laboratory testing) when applying large masses of AquaBlok™ through large water columns. Empirical observations also indicate that a greater degree of lateral dispersion of the AquaBlok™ mass typically results in a more spatially uniform distribution of AquaBlok™ across the targeted sediment surface.

Due to the virtual lack of vertical segregation of AquaBlok particle sizes during bulk-mass descent through a field-scale water column, product segregation is not observed within the applied AquaBlok™ layer as it occurs across the targeted sediment area.

References

Day, P.R. 1965. Particle fractionation and particle-size analysis, pp. 545-567 in "Methods of Soil Analysis", Vol. 1, by C.A. Black (Ed.), American Society of Agronomy.

Dortch, M.S., tech. Ed. 1990. "Methods of Determining the Long-Term Fate of Dredged Material for Aquatic Disposal Sites," Technical Report D-90-1, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Miss.

AquaBlok™

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Other patents pending.

Testing conducted by Hull & Associates, Inc. for AquaBlok, Ltd. Jointly distributed overall from Abeltech, Inc. Jointly originally prepared by Abeltech, Inc. and revised by AquaBlok, Ltd.

LAST REVISED 4/5/99

Bench-Scale Permeability

AquaBlok™

TEST REPORT #3: Bench-Scale Hydraulic Conductivity (Permeability) of AquaBlok™

Background and Purpose of Testing

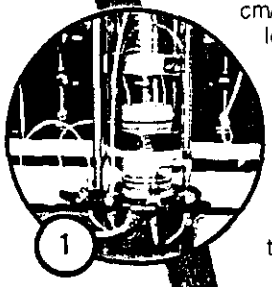
According to guidance developed by the U.S. Army Corps of Engineers for the U.S. EPA (Palermo et. al., 1998), one principal function of an in-situ remedial sediment cap should be to reduce the flux of dissolved contaminants from sediments into the overlying water column. Contaminants can move from sediments into water – including underlying ground water resources - through advective as well as diffusive processes. Advection refers to the movement of bulk porewaters, the ultimate rate and extent of which is largely a function of a substrate's hydraulic conductivity (or permeability); advective movement of contaminants involves contaminant movement by "mechanical" or non-chemical means. In contrast, diffusion – or diffusive contaminant movement – is the process whereby contaminants dissolved in water are transported by random molecular motion from areas of high concentration to areas of low concentration (Palermo et. al., 1998). The rate and extent of contaminant movement by diffusion is primarily controlled by concentration gradients, however, contaminant attenuation by – or sorption to – reactive substrates like AquaBlok™ can greatly reduce diffusion. AquaBlok™'s chemical-attenuating abilities is the subject of TEST REPORT #7 whereas AquaBlok™ permeability under saturated conditions is the focus of the current test report.

The purpose of this testing was to characterize the hydraulic conductivity (permeability) of different AquaBlok™ formulations under controlled laboratory conditions and using standard testing procedures.

Methods

Representative samples of three different AquaBlok™ formulations – 50BE, 40BE, and 20BE – were used to determine saturated hydraulic conductivity in general conformance with ASTM Method No. D 5084; typical physical and compositional characteristics for this range of AquaBlok™ formulations are provided in TEST REPORT #1. One subsample for each of the 50BE and 40BE formulations was tested whereas four subsamples of the much leaner 20BE formulation were tested to more accurately determine analytical variability for this method.

Laboratory procedures involved placing masses of dry AquaBlok™ into flexible-wall permeameters and thoroughly hydrating the samples with de-aired municipal tap water under pressure to assure that samples were completely saturated prior to testing. The pre-saturation process typically took from one to two weeks, until samples stopped taking in water from both ends. After sample saturation, the hydraulic conductivity test was run under constant hydraulic gradients ranging from approximately 17 to 19 cm/cm for 20BE samples and from 26 to 28 cm/cm for 40BE and 50BE samples; according to ASTM D 5084, hydraulic conductivity values are presumably unaffected by variable hydraulic gradients – testing values of which were below the recommended maximum (30 cm/cm) for testing low-permeability (less than 10^{-7} cm/sec) materials. Photograph 1 shows a typical AquaBlok™ sample during permeability testing.



Permeability testing of AquaBlok™ samples.

Results

Testing results are summarized in Table 1, with the typical appearance of AquaBlok™ samples after testing shown in Photograph 2.

Observations and Conclusions

Saturated AquaBlok™ is highly impervious to advective flow and is quantitatively on the order of what would typically be expected for hydrated bentonite.

Table 1.
Hydraulic Conductivity of Different AquaBlok™ Formulations.

AquaBlok™ Formulation	Hydraulic Conductivity Values (cm/sec)
50BE	5.93×10^{-9}
40BE	3.94×10^{-9}
20BE	Arithmetic Mean = 4.59×10^{-9}
	Geometric Mean = 4.52×10^{-9}

Typical AquaBlok™ Sample after permeability testing.

Similarly, low hydraulic conductivity values observed for the more lean 20BE AquaBlok™ formulation and the relatively bentonite-enriched 40BE and 50BE formulations implies that the presence of significant quantities of gravel within the hydrated AquaBlok™ matrix has an insignificant effect on AquaBlok™ performance as an effective hydraulic barrier.

Consistently low permeability values for AquaBlok™ can be achieved through controlled laboratory testing, which is testament to both the reproducibility of the testing procedure as well as the inherently impervious nature of AquaBlok™'s clay component.

References

Palermo, M., S. Maynord, J. Miller, and D. Reible. 1998. "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments," EPA 905-B96-004, Great Lakes National Program Office,

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Other patents pending.

Testing conducted by Hull & Associates, Inc. for AquaBlok, Ltd.
Permeability data for 50BE formulation from Abeltech, Inc.
Report originally prepared by Abeltech, Inc. and revised by AquaBlok, Ltd.

LAST REVISED 3/26/99

Field-Scale Permeability

AquaBlok™

TEST REPORT #4: Field-Scale Hydraulic Conductivity (Permeability) of AquaBlok™

Background and Purpose of Testing

Results of bench-scale AquaBlok™ testing indicate that, under controlled laboratory conditions and using standard testing procedures, saturated AquaBlok™ displays very low hydraulic conductivity values (TEST REPORT #3). The highly impervious nature of saturated AquaBlok™ contributes to its ability to minimize flux of sediment-borne contaminants into adjacent surface- or ground-water bodies through minimizing advective pore-water flow. As also discussed in TEST REPORT #3, contaminant flux reduction is considered to be an important function of in-situ remedial caps.

The purpose of this test was to determine the permeability (hydraulic conductivity) of hydrated AquaBlok™ on a large (field-equivalent) scale using a recognized and accepted procedure developed for evaluating the efficiency of clay based landfill caps and liners.

Test Method Background and Procedures

The field-scale permeability of hydrated AquaBlok™ was determined using the Two-Stage Borehole Field Permeability Test developed by Soil Testing Engineers, Inc. – a procedure also commonly known as the *Boutwell Permeability Test*. The Boutwell Test is a standardized field procedure used for quantitatively evaluating the permeability of rainfall through clay based landfill caps, or leachate through constructed liner systems. The Boutwell Test is widely recognized and accepted by U.S. EPA, U.S. Army Corps of Engineers, and many state regulatory agencies.

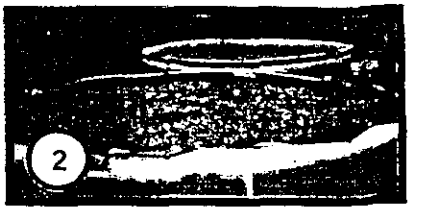
In theory, the Boutwell Test is based on the concept that when the three-dimensional geometry of a substrate's wetted zone is varied systematically, the vertical and horizontal permeabilities also vary in a calculable manner. That is, during "Stage I" of this permeability test, the bottom of a test hole augered into a substrate is positioned flush with the bottom of the cased (and water-filled) hole, allowing for primarily vertical flow from the casing into the substrate. In contrast, "Stage II" of the test involves advancing the test hole several inches beyond the bottom of the water-filled casing, thus allowing for significant *horizontal* flow through the substrate.

The Boutwell Test has associated with it a number of boundary condition requirements that must be met in order for the test to be considered valid. As described in detail by Boutwell (1992), such requirements range from a minimal thickness of material below the bottom of the test hole during Stage II (8 inches) to a minimum horizontal distance between test holes (20 inches). Personal communication with Dr. Gordon Boutwell confirmed that these and other requisite assumptions and conditions (Boutwell, 1992) were met through conducting our particular permeability test using AquaBlok™.

The Boutwell Test was performed out-of-doors in two large, (1000-gallon capacity) plastic testing vessels, each equipped with valving and drainage along perimeter sides and bases to allow for gravity drainage from each vessel (in order to meet boundary condition requirements).

Quantities of AquaBlok™, similar in composition to the 40BE formulation (see TEST REPORT #1), were added and hydrated incrementally in 4- to 6- inch lifts (Photograph 1), with approximately one-day hydration time between lifts. The final, cumulative hydrated AquaBlok™ thickness in each vessel was approximately 3.5 feet (Photograph 2). At this point, the AquaBlok™-filled vessels were ready for installation of the testing devices.

Addition of bulk AquaBlok™ to testing vessels.



Hydrated AquaBlok™ prior to instrument installation.

A total of seven permeameters and one TEG (temperature effect gauge) unit were installed in the hydrated AquaBlok™, to total depths of about twenty inches below the material's surface (Photograph 3). A hand auger was used to drill the 4.5-inch diameter holes to the required depth, into which each test device was installed.

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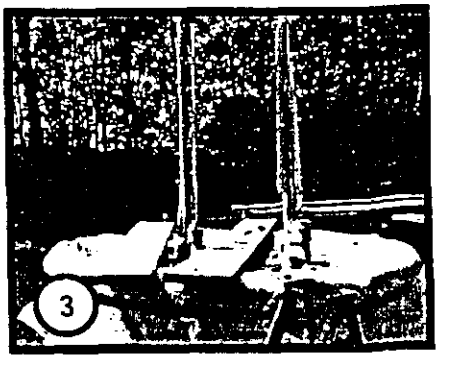

Instrumented Boutwell testing vessels.

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Permeability testing involved collecting data in two different stages, as described above: Stage I of the test, during which vertical permeability has the greatest affect, was conducted over a period of sixteen days. Once the permeability values for Stage I had apparently stabilized (which took approximately two weeks), Stage II was conducted over a period of ten days. Visual and manual inspection of hydrated (but pre-tested) AquaBlok™ removed from augered test holes indicated that the bentonite-rich material may not have been fully hydrated during the initial portion of Stage I monitoring.

Table 1. Calculated vertical and horizontal permeability through hydrated AquaBlok™ (n = 7 samples).

Calculated Vertical Permeability [1]			Calculated Horizontal Permeability [1]		
All values in units of cm/sec					
Value Range	Arithmetic Mean	Geometric Mean	Value Range	Arithmetic Mean	Geometric Mean
5.70×10^{-9} to 1.12×10^{-8}	8.65×10^{-9}	8.41×10^{-9}	2.84×10^{-8} to 3.96×10^{-8}	3.26×10^{-8}	3.23×10^{-8}

1 Variability (standard deviation) amongst replicates for the respective calculated values was small, less than 18 percent.

Results and Observations

Results of large-scale AquaBlok™ permeability testing using the Boutwell test method are summarized in Table 1. For comparison, see Table 1 of TEST REPORT #3 for AquaBlok™ permeability values determined on a bench scale in the laboratory.

As can be seen in Table 1, calculated mean permeability values for vertical and horizontal flow through hydrated AquaBlok™ on a field scale are quite low, on the order of 10^{-8} to 10^{-9} cm/sec; if, in fact, the AquaBlok™ had been fully hydrated during Stage I, the actual vertical component would likely have been lower. Furthermore, AquaBlok™ permeability on a field scale is comparable to values determined under controlled conditions in the laboratory, which ranged from 3.51×10^{-9} to 5.93×10^{-9} cm/sec for different product formulations (see TEST REPORT #3).

Conclusions

Results of this large-scale field permeability test indicate that AquaBlok™ - once in place and hydrated in the field – can form not only an effective physical barrier between contaminated substrate and the adjacent environment, but also an effective hydraulic barrier between such ecosystem components. Whether considering a landfill, deepwater, or wetland application scenario, such characteristically low permeabilities would help protect against the downward migration of dissolved contaminants into underlying ground water resources, as well as upward migration of contaminated pore waters into an overlying water column.

References

Boutwell, G.P., 1992. The STEI Two-Stage Borehole Field Permeability Test. Presented to "Containment Liner Technology and Subtitle D" seminar sponsored by Geotechnical Committee, Houston Branch, ASCE, Houston, Texas – March 12, 1992.

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Other patents pending.

Testing conducted by H.J. & Associates, Inc. for AquaBlok, Ltd. Report prepared by AquaBlok, Ltd.

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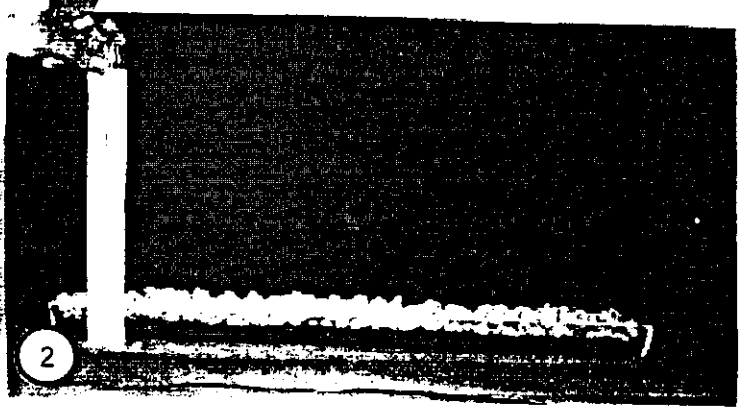
Erosion Resistance

AquaBlok™

TEST REPORT #5: Response of AquaBlok™ and Non-Cohesive Substrates to Erosive Forces

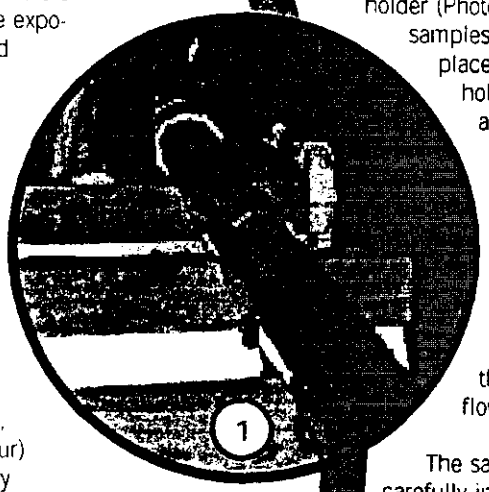


Side view of AquaBlok™-over-sand sample prior to testing.

Background and Purpose of Testing

According to the U.S. Army Corps of Engineers (Palermo et. al., 1998), one principal function of an in-situ remedial sediment cap – in addition to reducing contaminant flux, as discussed in TEST REPORT #3 – should be to stabilize contaminated sediments, preventing their re-suspension and subsequent transport to other (e.g. downstream) locations. Installation and maintenance-in-place of remedial caps that withstand significant erosional forces related to hydrologically dynamic systems (like rivers or estuaries) will minimize exposure, redistribution, and dispersion of the sediments being capped.

The purpose of this set of laboratory tests was to demonstrate the relative physical resistance of hydrated AquaBlok™ of standard formulation and other, less cohesive materials to significant, fluvial-like erosive (scour) forces of known velocity and duration.



Large-scale circulating flume system.

Methods

For several different projects, the physical resistance of a variety of saturated AquaBlok™, fine-grained sediment, and sand samples have been characterized in the laboratory using a circulating flume system. This flume system (Photograph 1) is comprised of a 7.5-foot long x 4 inch-internal-diameter, clear PVC sample chamber, a pump, and a holding tank that supplies and receives flow to and from the sample chamber. The sample chamber is connected to the rest of the flume system through flexible hosing and threaded unions.

Depending on project needs, specific parameters and procedures for flume testing can vary with respect to induced flow velocities, flow duration, sample size or configuration, pre-test hydration periods, etc. Nevertheless, the general procedure typically used during testing is as follows: a pre-weighed sample is placed into the clear, semi-circular, two-foot-long x 1.5-inch high acrylic sample holder (Photograph 2); samples are typically placed into the holder to result in a surface that is 0.4 to 0.8 inches above the top edge of the holder, thus placing a portion of the sample directly into the water's flow path.

The sample is then carefully inserted into the sample chamber. Flat and sloped spacer sections are placed into the flume chamber - both "upstream" and "downstream" - to establish more uniform flow over the test sample.

Once the flume chamber is closed and secured, water is pumped across the sample surface at controllable flow velocities (as manipulated through the use of in-line valves). The system configuration allows for establishing and periodically checking flow velocities by diverting flume-chamber discharge from the holding tank into a volume-calibrated drum and measuring the time required to pass a specific water volume across the test sample. Flow velocities over a given sample - in units of feet per second - can then be calculated using bulk-flow measurements together with estimates of the cross-sectional surface area over the top of a sample. Flow velocities are referred to in terms of approximate ranges because cross-sectional areas can vary along sample length (due to variable surface topography) and also over time (due to continued clay hydration and/or erosional losses).

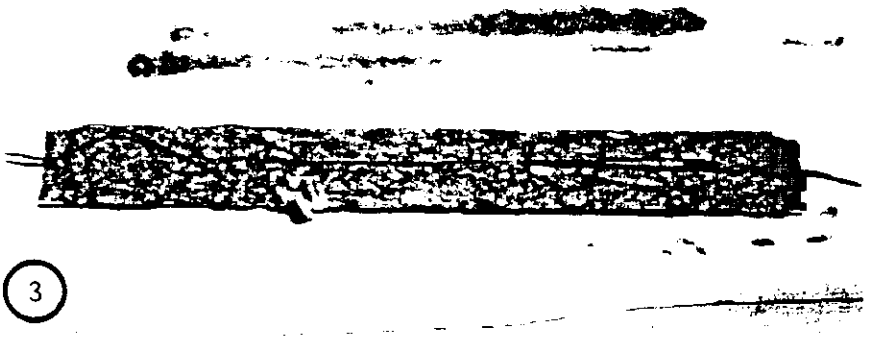
After testing, a sample can then be removed from the chamber and re-weighed to determine mass loss through erosion. The physical response of samples during and after testing can be evaluated in various ways, including: visual observation and video documentation, pre-/post-test weight comparisons, or estimating clay mass loss based on typical, pre-test AquaBlok™ compositions (Hull et al., 1998). *(continued on back)*

AquaBlok™ Composite Particle System

AR302787

Results and Observations

Results of multiple flume tests indicate that insignificant AquaBlok™ erosion occurs at flow velocities as high as 5 to 6 ft/sec, and for continuous flow durations of as long as 5 days. Photograph 3 illustrates typical AquaBlok™ sample response to flume testing.



3

Typical plan-view appearance of AquaBlok™ sample after testing (red ribbons are flow indicators).

In contrast to AquaBlok™'s resistance under high-flow conditions, erodability is typically high for sand and unconsolidated, fine-grained sediments at flow velocities of ~2 ft/sec or less, and for flow periods of as short as 10 to 20 minutes; such unconsolidated saturated materials can display 90 percent-plus mass loss under these relatively passive flow conditions.

Conclusions

Laboratory study of erosion resistance of AquaBlok™ under various testing conditions indicates that saturated AquaBlok™ is relatively resistant to significant - and sustained - fluvial like erosive forces. As a result, sediments occurring in lotic (flowing-water) environments and overlain by AquaBlok™ or AquaBlok™-based capping systems should remain in place and physically stabilized during high-flow events. In contrast, other materials such as less-cohesive sediments and sands prove much less resistant to erosive forces. Depending on a site's hydrologic/hydraulic conditions, capping of sediments with less scour-resistant materials like sand may not offer the same degree of sediment stabilization as would AquaBlok™ capping, or would require excessive thicknesses of sand that could interfere with waterway navigation.

References

Hull, J.H., J.M. Jersak, and B.J. McDonald, 1998. Examination of a new remedial technology for capping contaminated sediments: large-scale laboratory evaluation of sediment mixing and cap resistance to erosive forces. Remediation, Summer 1998 issue: pp 37-58.

Palermo, M., S. Maynord, J. Miller, and D. Reible. 1998. "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments," EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

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Other patents pending.

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Pilot-Scale Column Studies

AquaBlok™

TEST REPORT #6: Development and Function of AquaBlok™ Caps

Background and Purpose of Testing

Two principal functions of in-situ remedial sediment caps, according to the U.S. Army Corps of Engineers (Palermo et. al., 1998), should be to reduce the flux of dissolved sediment-borne contaminants into the overlying water column and to physically stabilize contaminated sediments, preventing their re-suspension and transport to other sites. AquaBlok™'s ability to reduce the advective or "mechanical" flux of contaminant-bearing pore waters into adjacent water resources is discussed in TEST REPORTS #3 and #4 whereas AquaBlok™'s ability to attenuate dissolved contaminants is the subject of TEST REPORT #7. The physical resistance of hydrated AquaBlok™ to substantial hydrologic erosive forces – resulting in stabilization of underlying, capped sediments – is the subject of TEST REPORT #5.

A third recommended function of remedial sediment caps – the physical isolation of contaminated sediments from the benthic (macroinvertebrate) environment – can also be fulfilled by AquaBlok™ and AquaBlok™-based caps, although this would need to be evaluated on a site-by-site basis. Most mud-dwelling fauna in river environments typically occur within the upper several inches of substrate (Hynes, 1970) which is within the vertical dimension of most AquaBlok™ capping designs. AquaBlok™ can also offer a physically similar – and clean – substrate for the re-colonization of burrowing invertebrates, over and above simply isolating the organisms from contaminated sediments. The potential for natural deposition of clean sediments over AquaBlok™ caps over time would also isolate organisms from contaminated sediments to an even greater degree.

AquaBlok™'s unique attributes as a physical, hydraulic and chemical barrier between contaminated sediments and the overlying water column (or underlying ground water) appear evident. Nevertheless, in order for the AquaBlok™ technology to effectively meet such functional objectives within a large-scale laboratory or real-field setting, development of a laterally continuous, hydrated AquaBlok™ cap above the sediment/water-column interface is essential.

This test report addresses typical sediment responses to AquaBlok™ applications as well as the subsequent development of hydrated AquaBlok™ caps.

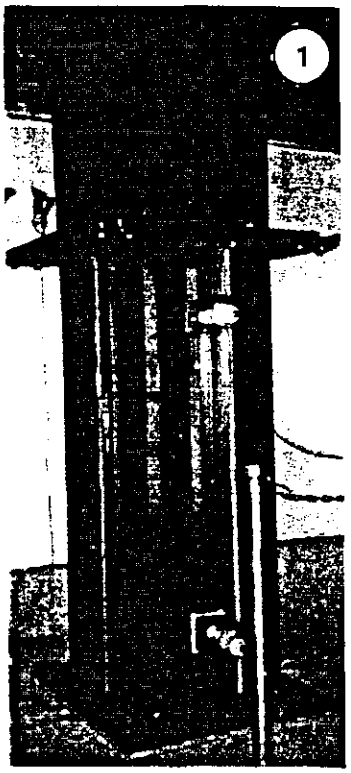
The specific purpose of this laboratory test was four-fold: (1) to demonstrate AquaBlok™ cap development and properties as a function of product formulation, on a relatively small scale and without sediment present; (2) to demonstrate typical sediment responses to bulk AquaBlok™ applications on a large scale; (3) to demonstrate the nature of AquaBlok™ cap development over the top of sediments over time; and (4) to demonstrate the degree of physical as well as hydraulic isolation of sediments achieved by AquaBlok™ applications on a large scale.

Methods

For different projects, numerous laboratory studies characterizing water and sediment responses to AquaBlok™ applications and subsequent cap development have been conducted at different column scales and using different AquaBlok™ formulations, sediment types, water-column thicknesses, and rates of AquaBlok™ application.

Some AquaBlok™ cap-development studies have involved the use of small acrylic columns; small-column studies have been conducted with and without sediment components present beneath the AquaBlok™ cap. More recent column studies have involved the use of a much larger (23-inch x 23-inch x 12 foot-tall), steel-reinforced Plexiglas settling column (Photograph 1). This field-scale settling column is equipped with a gravity drainage system that allows for monitoring vertical water flow through the column. Using this apparatus, the behavior of water-column, sediment, and capping components – including their hydraulic behavior – can be observed at vertical dimensions comparable to those of the deepwater or wetland ecosystems being modeled. Clear column sides also facilitate visual observation and quantification of water, cap, and sediment dynamics.

Procedures for column setup, prior to AquaBlok™ additions, typically include the following: placement of the desired sediment type and thickness (up to three feet) into the column; addition of the desired thickness (and type) of water over the top of the sediments, up to 8 or 9 feet; allowing for water clarification and sediment stabilization through self-consolidation beneath the water column; and determination of pre-cap flow through the sediment, with or without manipulations to the water height.



Large-scale settling column.

Procedures for column operation and data collection during and after AquaBlok™ addition typically include observation of the following: descent of the bulk AquaBlok™ mass and dispersion through the water column; the degree of sediment-surface coverage, sediment penetration and sediment re-suspension upon particle impact with and settlement into the sediment; the rate and extent of AquaBlok™ hydration and thickness increase over time; and ultimately, the degree of sediment isolation, including post-cap flow measurements to determine hydraulic isolation. *(continued on back)*

AquaBlok™ Composite Particle System

AR302789

Results and Observations

Cap Development and Properties as a Function of AquaBlok™ Formulation

The rate and net vertical extent of cap expansion (thickness) will vary depending on a number of factors including: the type of sediment being capped, product application rate, product formulation, and salinity level. An example of the effect of AquaBlok™ formulation on cap thickness and other physical cap properties, as determined under controlled laboratory conditions, is illustrated in Table 1.

Physical and Hydrologic Isolation of Sediment by AquaBlok™ Caps

Physical isolation of contaminated sediments from the overlying water column is effectively achieved through the formation of a laterally continuous and cohesive AquaBlok™ layer atop the sediments (Photograph 2). As illustrated by Table 1, hydrated cap thicknesses will depend on a variety of factors, including the particular AquaBlok™ formulation used.

As shown in Figure 1, post-capping water flow through a three foot-thick sediment column is significantly reduced relative to pre-capping flow – thus indicating relative hydraulic isolation of sediments. Further evidence of hydraulic isolation during one particular study was the formation of air-filled voids below the cap/sediment interface (Photograph 3), in the presence of a four foot water column atop the cap.

Table 1. Physical properties of Hydrated AquaBlok™ Caps of Different Formulations.

AquaBlok™ Formulation	Hydrated Cap Thickness Range (inches)	Net Vertical Expansion (% initial)	Average Wet Bulk Density(g/cc)	Average Moisture Content (% Dry Weight)
70BE (70% clay)	4.0 – 5.3	233 – 354	1.23	175.3
50BE (50% clay)	3.7 – 5.2	219 – 340	1.32	170.7
20BE (20% clay)	2.5 – 3.6	135 - 213	1.53	88.9

Descriptions and physical characteristics of the above AquaBlok™ formulations are included in TEST REPORT #1. The tabled data were derived through using replicate four-inch, fresh-water-filled acrylic columns and a bulk AquaBlok™ application rate (4 - 10.0 pounds square foot to each column, n = 4 for each formulation). To simulate field conditions as closely as possible, column design allowed for product hydration from below as well as above the capping layer, over time periods of from 25 to 27 days.

Sediment Response to AquaBlok™ Applications

Varying degrees of sediment re-suspension can occur during AquaBlok™ particle impact with the sediment surface, depending primarily on sediment texture and product application rates. Suspended sediments re-deposited onto the hydrating AquaBlok™ mass are effectively encased within the fully hydrated cap. If needed, re-suspension can be greatly reduced during deployment by first placing a thin sand layer atop the targeted sediment prior to AquaBlok™ application.

Minimal sediment penetration and settlement typically occurs during and after bulk AquaBlok™ application through four to nine foot thick water columns, even when applying to relatively soft and fine grained (penetration-sensitive) sediments. Minimal particle intrusion into the sediment insures that the cap will develop effectively over the top of the targeted sediment instead of within the sediment mass.

Development of AquaBlok™ Cap

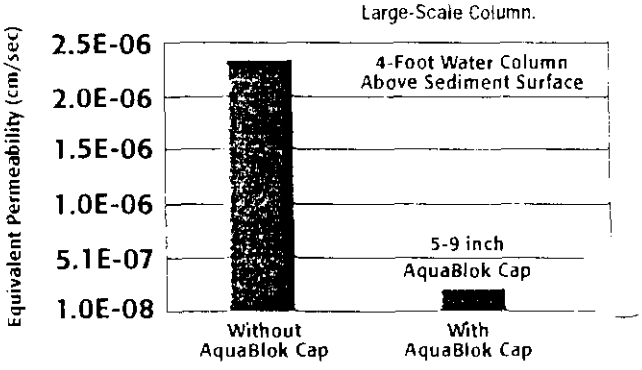
Within seven to ten days of product application, the layer of initially discrete AquaBlok™ particles hydrates and expands both laterally and vertically, coalescing into a continuous and cohesive cap over the top of sediments (Photograph 2).

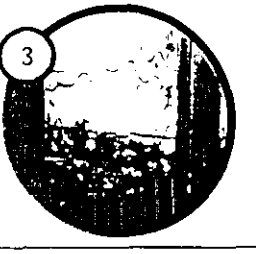
Hydrated AquaBlok™ cap formed over the top of sediments.

Conclusions

AquaBlok™ can form a continuous and cohesive physical, hydraulic, and chemical barrier over the top of contaminated sediments, thereby protecting overlying deepwater or wetland ecosystems and their inhabitants. AquaBlok™ cap designs – as well as the AquaBlok™ formulation itself – can also be customized to meet site-or project-specific needs.

Figure 1.
Vertical Flow through Large-Scale Column.





Air-filled voids beneath the AquaBlok™/sediment interface.

References

Hynes, H.B. 1970. The Ecology of Running Waters. University of Toronto Press, 555 pages.

Palermo, M., S. Maynord, J. Miller, and D. Reible. 1998. "Guidance for In-Situ Subaqueous Capping of Contaminated Sediments", EPA 905-B96-004, Great Lakes National Program Office, Chicago, IL.

AquaBlok™
Composite Particle System

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AquaBlok™ is a trademark of New Waste Concepts, Inc.
AquaBlok™ composite particles are patented.
Other patents pending.

Testing conducted by Hull & Associates, Inc. for AquaBlok Ltd. Report prepared by AquaBlok Ltd.

LAST REVISED 4/5/99

AR302790

Chemical Attenuation

AquaBlok™

TEST REPORT #7: Contaminant Attenuation by AquaBlok™

Clay minerals are natural and essentially inert with physical and chemical properties that are well understood. They have long been used in the environmental industry to contain or isolate various hazardous substances, primarily because of their relatively low permeability to aqueous solutions. In particular, bentonite, which is a geologic deposit rich in smectite clays, has been used extensively as an integral component of drilling fluids, in landfill liner and capping systems, and in slurry walls for diverting ground water flow. Bentonite is a principle component of typical formulations of AquaBlok™ (TEST REPORT #1) and not only has substantial merit as a hydraulic barrier (TEST REPORT #3), but also as a chemical barrier as well.

Because of its mineralogical and surface-charge configuration, montmorillonite – typically the major component of bentonite - has an inherently large surface area compared to other commonly occurring "plate-like" clay minerals (Table 1). This high surface area, in combination with water's affinity for montmorillonite's negatively charged surfaces, results in significant physical expansion of the clay upon its hydration (TEST REPORT # 6). The high surface area and negatively charged surfaces also account for the clay's ability to sorb or exchange relatively large quantities of dissolved cations (Table 1).

Table 1. Physical and Chemical Properties of Montmorillonite and Other Selected Phyllosilicate Minerals (from Bohn et. al., 1979).

Clay	Surface Area (m^2/g)	Expands Upon Hydration?	Cation Exchange Capacity (meq/100g)
Montmorillonite	600 - 800	Yes	80 - 120
Mica	20 - 40	No	70 - 120
Kaolinite	10 - 20	No	1 - 10

Published research indicates that naturally occurring montmorillonite and bentonite can not only sorb innocuous base-metal cations like calcium, magnesium, and sodium, but can also sorb – or *attenuate* – potentially toxic heavy metal cations onto clay surfaces, effectively keeping such metals out of the bulk solution phase of pore and surface waters. Batch-shaking and flow-through column studies typically indicate significant removal of heavy metal cations like dissolved lead, copper, zinc, cadmium, and nickel from solution onto montmorillonite and bentonite (Table 2).

Table 2. Heavy Metal Sorption from Solution onto Montmorillonite and Bentonite (from Bereket et. al., 1997[1] and Lothenbach et. al., 1997[2]).

Heavy Metal	Montmorillonite [1] (initial solution pH = 5)	Bentonite [2] (pH between ~ 4 and 7)
	-------- Percent of Metal Removed from Solution --------	
Lead	82	20 - 100
Copper	56	20 - 100
Zinc	34	20 - 40
Cadmium	71	15 - 20
Nickel	No data available	15 - 20

The degree of metal attenuation by montmorillonite and bentonite differs between charged metal species and also with system variables including: pH, competition between metals for exchange or sorption sites, total salt concentrations in solution, oxidation-reduction potential, presence of dissolved organic substances, and speciation of metal ions in solution. For example, lead and copper typically sorb more strongly to most clay mineral surfaces, including montmorillonite, than do zinc and cadmium, and metal sorption is usually greater overall in higher-pH systems. Published research also generally indicates that, despite such systematic factors affecting ion sorption, heavy metal cations are held more strongly to montmorillonite and bentonite than mono- and divalent base-metal cations. Additionally, a greater degree of metal sorption occurs to montmorillonite than to other lower surface-area clays like kaolinite. In many situations, oxides of iron, manganese, or aluminum can accentuate heavy metal sorption to clay rich substrates. *(continued on back)*

AquaBlok™ Composite Particle System

Given demonstrated abilities for metal sorption/attenuation under controlled laboratory conditions, montmorillonite and bentonite have both been used in different capacities in the environmental industry to: immobilize heavy metals in contaminated soils and sediments, remove metals from landfill leachates, and remove metals from waters and wastewaters. Due to its low permeability and radionuclide-sorbing capabilities, bentonite is also commonly considered for use as an environmental buffer during disposal of radioactive wastes. Such remedial uses of these clay and clay rich materials will likely increase as should development and use of chemically modified versions of montmorillonite and bentonite clays for selective attenuation of organic pollutants.

Specially engineered cation-like compounds, generally referred to as quaternary ammonium ions, can be used to physically displace base cations, like sodium, from exchange sites of montmorillonite clays; the use of tetramethylammonium (TMA+) ions is one example.

Reactive surfaces of these "organoclays" or organobentonites are more organophilic in nature (compared to non-modified clays) and, as a result, have a great affinity for charged and non-charged organic pollutants. Published research indicates that organoclays can selectively remove a variety of organic pollutants including non-polar, nonionic BTEX compounds, phenols and chlorinated hydrocarbons, and pesticides. As with metal-clay interactions, the degree of attenuation by organoclays is dependent on factors like pH and competition for clay sorption sites. Organoclays have been used commercially in water and wastewater treatment systems for the removal of organic pollutants from contaminated ground waters and industrial waste streams (including oils and greases). Organoclays have also been tested for use in the solidification/stabilization of phenolic-contaminated soils.

The bentonite component of basic AquaBlok™ formulations, either in bentonite's natural or modified form, can effectively remove heavy metals and organic pollutants from the bulk solution phase. However, other types of clay minerals and/or hydrous oxides can also be used in conjunction with bentonite to develop special AquaBlok™ formulations designed to address site-specific needs, including sediment isolation in saline environments.

In summary, AquaBlok™ can keep toxic, harmful compounds from moving into ground water, or from interacting with floral or faunal communities inhabiting overlying deepwater or wetland ecosystems. AquaBlok™'s inherently low permeability accentuates its ability to isolate pollutants from such environments. Therefore, AquaBlok™ not only acts as an erosion-resistant, physical and hydraulic barrier between contaminated sediments and water resources, but can also be mineralogically and compositionally tailored to maximize chemical attenuation of specific metal or organic pollutants, depending on site-specific conditions and needs.

References

Bereket, G., A. Aroguz, and M. Ozel, 1997. Removal of Pb(II), Cd (II), and Zn (II) from aqueous solutions by adsorption on bentonite. Jour. Colloid Interface Sci, vol. 187, pp. 338-343.

Bohn, H., B. McNeal, and G. O'Connor, 1979. Soil Chemistry. John Wiley & Sons., 239p.

Cadena, F., 1989. Use of tailored bentonite for selective removal of organic pollutants. Jour. Environ. Eng. Vol.115, pp.756-767.

Lothenbach, B., G. Furrer, and R. Schulin, 1997. Immobilization of heavy metals by polynuclear aluminum and montmorillonite compounds. Envir. Sci. Technol, vol. 31, pp.1452-1462.

AquaBlok™

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Other patents pending

Report prepared by AquaBlok, Ltd.

AR302792

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Freeze/Thaw Effects

AquaBlok™

TEST REPORT #8: Freeze/Thaw Effects on AquaBlok™

Background and Purpose of Testing

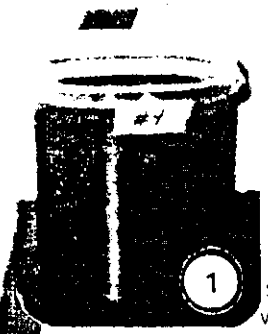
For some ecosystems, including seasonally exposed wetlands occurring in northern regions, the potential exists for periodic exposure of substrates to climatically induced, freeze/thaw effects. The effects of cyclic freeze/thaw on the physical structure and conductive properties of different clay mineral-based landfill capping and lining materials have been investigated both in the laboratory and field. Results of these studies generally indicate that while the physical structure and hydraulic conductivity of many compacted clay materials can be adversely affected by freeze/thaw (e.g. Bowders and McClelland, 1994; Benson and Othman, 1993), that of geosynthetic clay liners, or GCLs, is typically not (U.S. EPA, 1996). The marked resilience, or "healing" abilities, of GCLs is largely attributable to the bentonite component in GCLs; bentonite is a principle component of typical AquaBlok™ formulations.

The purpose of this testing was to qualitatively demonstrate effects of cyclic freeze/thaw on the physical appearance of hydrated samples of AquaBlok™.

Methods

Five samples of hydrated AquaBlok™ (standard formulation) were prepared in four-inch square, clear-plastic containers. The containers were selected to allow for observation of freeze/thaw effects, and to minimize confining pressure on the samples.

500 mls of municipal tap water and a 2-inch thick layer of dry AquaBlok™ particles were added to each container. The particles were then hydrated by periodically adding water to achieve complete saturation. The volume of each sample approximately doubled through hydration and expansion, with total hydrated AquaBlok™ volumes ranging from about 1,100 to 1,200 mls (Photograph 1).

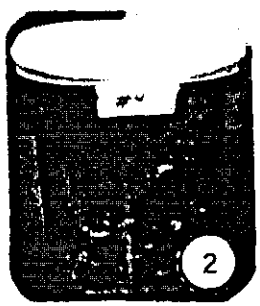


Hydrated test sample prior to freezing.

Each sample was then subjected to a total of five freeze/thaw cycles and the physical condition of the samples after each cycle were observed and recorded.

Results and Observations

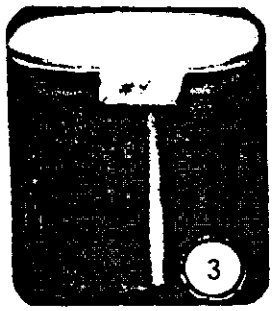
Each freezing event produced discrete, open fractures (less than 1/4-inch in width) which contained free water that probably migrated from water on top of the sample; none of the observed fractures penetrated entire sample thicknesses. The positions and orientations of these freezing fractures were noted by tracing them with a marker on the clear plastic containers (Photograph 2).



Representative test sample after third freezing event – note fractures.

All fractures completely closed, or "healed", upon thawing of the samples. Subsequent freezing events produced new fractures of different position and orientation, implying that planes of weakness do not form in the hydrated product.

Again, these newly formed fractures healed upon thawing of the samples. No fractures persisted from one freeze/thaw cycle to the next (Photograph 3).



Representative test sample after third thawing event – note healing of fractures.

Conclusions

Freezing of hydrated AquaBlok™ samples produces discrete, open fractures, however, the fractures do not penetrate the total sample thickness.

Freeze-induced fractures heal, and the mass of hydrated AquaBlok™ returns to its original, physically homogeneous state upon thawing. Such an AquaBlok™ response to cyclic freeze/thaw was generally expected, based on published literature.

References

Benson, C. and M. Othman.1993. Hydraulic conductivity of compacted clay frozen and thawed in situ. Journal of Geotechnical Engineering, 119: 276-294.

Bowders J. and S. McClelland.1994. The effects of freeze/thaw cycles on the permeability of three compacted soils, pp. 461-481, in D.E. Daniel and S.J. Trautwein (eds.) "Hydraulic Conductivity and Waste Contaminant Transport in Soil," ASTM STP 1142. American Society for Testing and Materials, Philadelphia, PA.

U.S. Environmental Protection Agency (U.S. EPA). 1996. Workshop on geosynthetic clay liners. U.S. EPA Document No. EPA/600/R-96/149.

AquaBlok™ Composite Particle System

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AquaBlok™ composite particles are patented
Other patents pending

Testing conducted by Abeltech, Inc. Report originally prepared by Abeltech, Inc. and revised by AquaBlok, Ltd

LAST REVISED 4/5/99

APPENDIX E

APPENDIX E

COMMENT/RESPONSE DOCUMENT
FEASIBILITY STUDY - OPERABLE UNIT 2

APPENDIX E
COMMENT/RESPONSE DOCUMENT
FEASIBILITY STUDY - OPERABLE UNIT 2
FORMER SHARON, PENNSYLVANIA FACILITY

GENERAL COMMENTS

COMMENT NO. 1: The FS Report should contain a listing of acronyms that are used in the document since there are numerous acronyms and a reader who is reading just one section, and who has not necessarily read the full written explanation for any given acronym in the text, would have difficulty finding an explanation of that acronym.

RESPONSE: A list of acronyms will be added to the report.

COMMENT NO. 2: For all alternatives that would involve disturbance of soil or sediments, there should be provisions included to protect the water intake for the Shenango Valley Water Authority. These could consist of monitoring, filtration, temporary upstream intakes, or other methods to ensure that Site-related chemicals are not migrating to and entering that intake at unacceptable levels.

RESPONSE: We concur that during such remedial actions, a minimum additional activity should include monitoring of the intake. The remedial alternative descriptions in Sections 4.1.2 and 4.1.3 and subsequent sections will be expanded to describe potential provisions for protecting the intake. CBS will be contacting the water authority with respect to the administrative and technical feasibility of such provisions, such that their issues and/or concerns can be addressed in the development of the Proposed Plan.

COMMENT NO. 3: In Section 4, the ground water alternatives, in all cases, include only 3 options which are essentially no action or limited action for non-NAPL areas. All of the alternatives assume that no treatment other than monitored natural attenuation would be used for COPCs outside of the NAPL areas. Alternatives other than monitored natural attenuation should also be evaluated for the non-NAPL areas.

RESPONSE: As described in Sections 4.2.4 and 4.2.5, groundwater Alternatives 4 and 5 both address a broader area of groundwater through in-situ or ex-situ treatment, in addition to NAPL source removal. The preliminary extent of the treatment area for these alternatives are described as those areas where current contaminant concentrations above the USEPA MCL or PADEP Act 2 standard, an area which extends roughly from Well M-17 to Well OS-1A. The actual area included in these alternatives would be based on the performance standards to be

determined in the Record of Decision, as well as additional pre-design sampling, if needed. The text will be modified to more clearly define these alternatives.

COMMENT NO. 4: References to (former) ARMCO properties should now be "former(ly) ARMCO..." or "AK Steel." References to (former) Conrail properties should now be "former(ly) Conrail" or "Pennsylvania Lines, LLC." [Pennsylvania Lines, LLC is apparently now the owner of record and it is my understanding that it is a subsidiary of Norfolk Southern Corporation].

RESPONSE: These references will be modified appropriately.

COMMENT NO. 5: Sediment alternatives for the 6"-50" sediment depth should be developed. The proposal to remove only the top 6" and add backfill fails to account for contamination below 6", as well as the potential for redistribution of added material to expose underlying contaminated sediments. Several samples from the 6"-50" depth in zones 14 and 15 contained PCB concentrations >1ppm. The top 6" is the biologically active zone for invertebrates, but hibernating species such as snapping turtles may be exposed to sediments further below the surface. Secondly, findings at other contaminated sites and sedimentation patterns indicate that sediments adjacent to dams hold significant PCB mass.

RESPONSE: RESPONSE: CBS understands the agencies concerns regarding deeper impacted sediments which may remain after a remedial action is performed. However, capping of underlying sediments with uncontaminated materials is a remedial alternative often proposed by EPA

We believe that the remediation goals for sediment must be carefully developed in order to establish a realistic endpoint which is protective (in both the short and long term) of human health and the environment, with the performance standard being demonstrably achievable in order for the remedy to be consistent with the NCP.

As noted in Section 6.1.4 (formerly 6.1.3) of the FS, environmental dredging operations in other riverine systems with the goal of removing impacted sediments to low residual levels (such as 1 mg/kg PCBs or lower) have commonly failed to demonstrate achievement of this goal, apparently due to the inevitable resuspension and redistribution of impacted sediments during dredging operations.

In an attempt to directly address agency concerns, considering lessons learned from other sediment remediation efforts, CBS has modified the FS to include two sediment remediation scenarios. One is a "limited" excavation alternative (maximum 12 inches) followed by placement of a clean, erosion-resistant cover material such as AquaBlok™ and/or appropriately sized rock. The second

excavation alternative includes removal of impacted sediments to a maximum depth of 4 feet, followed by placement of a clean, erosion resistant cover material. (See also Comment No. 45.)

With respect to the dam sediments, the results of the sampling performed in April 2000 indicate that the presence of fine-grained sediments adjacent to the dam appears to be somewhat limited, and total PCB concentrations of sampleable material within 60 feet of the dam were below 0.4 mg/kg.

COMMENT NO. 6: A table of potential ARARs pertaining to the various alternatives should be included in the "Tables" portion of the document.

RESPONSE: The requested table(s) will be included.

SPECIFIC COMMENTS

COMMENT NO. 7: Page 1-15; top paragraph: The last sentence is misleading. Please delete it.

RESPONSE: The referenced sentence is an objective statement based on a review of the data contained in the Roemer facility closure report. The text will, however, be modified.

COMMENT NO. 8: Section 1.7, 3rd paragraph; page 2-8, last paragraph; Section 5.4.1, Overall Protection; page 6-6, 1st paragraph: Ground water flows toward the river, and the municipal water intake is 1600' downstream on the river. Therefore, the relationship of the Site-related ground water contamination to the public water supply should be expressed.

RESPONSE: CBS acknowledges that alluvial groundwater generally flows west-southwest toward the Shenango River. Based on the Site's distance from the river (800 to 2000 feet), the relatively slow rate of groundwater linear velocity (50 feet per year), and the results of sampling surface water in the Shenango River and groundwater between the Site and the river, it appears that impacted groundwater from the site is not impacting surface water. The referenced sections will be modified.

COMMENT NO. 9: Page 1-19; 3rd paragraph, 2nd sentence: The south sector and middle sector risk drivers include dioxin.

RESPONSE: The text will be modified appropriately.

COMMENT NO. 10: Section 1.7, page 4-3, last paragraph; page 5-7, last paragraph; page 5-8, next-to-last paragraph; page 5-10, 1st paragraph; page 5-11, last

paragraph; page 6-2, 2nd paragraph; page 6-2, last paragraph: The sediment was also identified qualitatively as a potential concern for human health via fish consumption. For the river surface water, EPA found a potential concern for swimmers at one location.

RESPONSE: The text will be revised to include these potential concerns.

COMMENT NO. 11: **Section 1.8; second paragraph: Studies published in 1995, 1996, and 1998, since the Screening-Level Ecological Risk Assessment have resulted in revised NOAELs for PCB toxicity in birds (Summer et al. 1996) and mammals (Heaton et al. 1995, Restum et al. 1998). In particular, these studies examined effects of exposure to metabolized, bioaccumulated PCBs present in fish tissue in multiple generations of mink and chickens. Using these NOAELs, the EEQs for heron, kingfisher, and mink increase 57-, 57-, and 25-fold, respectively. Therefore, the 1997 ERA underestimates ecological risk and is neither "very conservative" nor representative of "a worst case scenario". Please revise the text accordingly.**

RESPONSE: The sentence characterizing the nature of the ERA will be deleted.

COMMENT NO. 12: **Section 1.9.1; page 1-22, second sentence: In accordance with the Supplemental Sampling and Analysis Plan, areas for the additional sediment sampling were chosen based on previous RI sediment samples exceeding 1.0 ppm for PCBs.**

RESPONSE: The text will be modified appropriately.

COMMENT NO. 13: **Table 1-1: The total residential cancer risk, not just the adult cancer risk, should be shown. Noncarcinogens with HIs less than 1 should be shown if they can contribute to an HI of 1 in combination with other noncarcinogens. Changes due to updated toxicity criteria should also be incorporated (the RI does not have to be redone, but the FS should include updated numbers).**

RESPONSE: The table will be modified to incorporate the updated risk numbers.

COMMENT NO. 14: **Section 1.9.2; page 1-23, 1st bullet: The three plumes should be briefly identified, or reference made to section 1.10.2 where these plumes are identified.**

RESPONSE: The text will be modified accordingly.

COMMENT NO. 15: **Section 1.9.2; page 1-24, 1st and 3rd bullet: "Significantly," "slightly," and "substantially" should be briefly defined. Note that detection limits should also be considered when looking at trends. For example, results of "<200**

µg/l" in the first round and "45 µg/l" in the second round cannot be specifically identified as increasing, decreasing, or staying the same.

RESPONSE: The text will be modified to describe observed trends in terms of orders of magnitude or percent changes where the data is available to support such statements.

COMMENT NO. 16: **Section 1.9.2; page 1-24, 5th bullet: Chlorobenzene was detected in M-11B in July 1999. Also, please update this section to reflect the approved work plan for the additional bedrock wells and well M-11B abandonment.**

RESPONSE: The text will be revised appropriately, and will include as much information as is currently available with respect to the ongoing bedrock assessment activities.

COMMENT NO. 17: **Section 1.10.1; page 1-27, 1st paragraph: It should be noted that the Department and EPA expressed concern about the potential for bioconcentration of PCBs in fish tissue and ultimate human consumption, a pathway that could not be quantitated during the RI.**

RESPONSE: The text will be modified appropriately.

COMMENT NO. 18: **Section 1.10.2; 1st paragraph: Metals may also be mobilized by solvents in the groundwater.**

RESPONSE: The paragraph will be modified to include this consideration.

COMMENT NO. 19: **Section 1.10.3; last sentence: Several example substances should be listed to replace the term "these compounds."**

RESPONSE: The text will be modified appropriately.

COMMENT NO. 20: **The tables corresponding to Section 1 do not display groundwater dioxin results. These should be included.**

RESPONSE: The dioxin results will be added to the tables.

COMMENT NO. 21: **Section 2.1.1; page 2-4, 3rd paragraph: In the sentence that begins with "The SDWA states that ...," those four words should be deleted from the sentence.**

RESPONSE: The text will be revised accordingly.

COMMENT NO. 22: Section 2.1.1; page 2-6, 1st paragraph: The sentence beginning with "These standards..." should be deleted. In the last sentence of the paragraph, the reference to local requirements should be deleted.

RESPONSE: The text will be revised accordingly.

COMMENT NO. 23: Section 2.1.1; page 2-6, 3rd paragraph: The term "thermal treatment" should be deleted from the third sentence.

RESPONSE: The text will be revised accordingly.

COMMENT NO. 24: Section 2.1.2: At the beginning of this section, there should be a sentence such as, "This Section presents a summary of potential location-specific ARARs and TBCs."

RESPONSE: The text will be revised accordingly.

COMMENT NO. 25: Section 2.1.2 should list the federal Clean Water Act, Section 311 as a potential ARAR.

RESPONSE: The text will be revised accordingly.

COMMENT NO. 26: Page 2-8: The last three paragraphs on this page are unnecessary and should be deleted.

RESPONSE: The text will be revised accordingly.

COMMENT NO. 27: Section 2.1.3: At the beginning of this section, there should be a sentence such as, "This Section presents a summary of potential action-specific ARARs and TBCs."

RESPONSE: The text will be revised accordingly.

COMMENT NO. 28: Page 2-13; 4th paragraph: This paragraph should be deleted. NEPA is not an ARAR for Superfund remedial actions.

RESPONSE: The text will be revised accordingly.

COMMENT NO. 29: Section 2.2.1; Page 2-16: An additional remedial action objective would be to reduce the exposure of human and ecological receptors to consumption of contaminated fish.

RESPONSE: The text will be revised accordingly.

COMMENT NO. 30: Section 2.2.2: Alluvial HIs range from 370 to 5E6. The paragraph should be adjusted to reflect this. Also, the discussions and displays of alluvial groundwater risks should also include lead (Pb).

RESPONSE: The text and tables will be revised appropriately.

COMMENT NO. 31: Section 2.2.3: Bedrock cancer risks range up to 6E-3; HIs range up to 350. The first paragraph of the section should be adjusted to reflect this.

RESPONSE: The text will be revised accordingly.

COMMENT NO. 32: Table 2-3: The table should be adjusted in accordance with Table 1-1. Therefore, the PRG at 1E-6 cancer risk and the PRG at HI of 1 each would be as indicated (other risks can be determined by multiplication or division, as appropriate; separation by target organ is also possible).

ADDITIONAL COMMENTS ON TABLE 2-3

COMMENT NO. 33A: Table 2-3 should also be footnoted to show that choosing all the numbers in the 1E-4 column would result in a total cancer risk greater than 1E-4.

COMMENT NO. 33B: Lead (Pb) should be added.

COMMENT NO. 33C: The MCL/Act 2 column numbers should be amended as follows: Aroclor 1254, 0.5 µg/l; nickel, MCL remanded; identify source of vanadium and 1,3-DCB numbers. Add values for cadmium, copper, 2,4-DCP, 1,2-DCB, zinc, and lead.

COMMENT NO. 33D: The maximum concentrations based on the RI risk assessment should be: arsenic, 394 µg/l; Aroclor 1254, 14 µg/l; beryllium, 6.9 µg/l; 1,4-DCB, 610 µg/l; 2,3,7,8-TCDD, 1.46E-5 µg/l; iron, 308000 µg/l; chlorobenzene, 230 µg/l; manganese, 7450 µg/l; aluminum, 97900 µg/l; chromium, 482 µg/l; 1,2,4-TCB, 110 µg/l; nickel, 717 µg/l; vanadium, 175 µg/l; 1,3-DCB, 620 µg/l; mercury, 1.5 µg/l; barium, 899 µg/l; cadmium, 5.2 µg/l; copper, 385 µg/l; 2,4-DCP, 12 µg/l; 1,2-DCB, 270 µg/l; zinc, 1790 µg/l; lead, 246 µg/l.

COMMENT NO. 33E: The maximum concentrations from 1999 data should be: manganese, 12500 µg/l (duplicate of 12300 µg/l); cadmium, ND; copper, 4.4 µg/l; 2,4-DCP, 2 µg/l; 1,2-DCB, 61 µg/l; zinc, 170 µg/l; lead, ND.

RESPONSE: Table 2-3 will be modified in response to these comments. Note that for inorganics, the maximum detected concentrations were shown for dissolved (filtered) metals, as indicated in footnote (d). The table will be revised to include maximum total metals results where available. Also, please note that maximum

RI concentrations listed in the tables include all samples collected during the RI, and is not limited to just those results used in quantifying risk in the HHRA.

COMMENT NO. 34: **Table 2-4: The table should be adjusted in accordance with Table 1-1. Therefore, the PRG at 1E-6 cancer risk and the PRG at HI of 1 each would be as indicated (other risks can be determined by multiplication or division, as appropriate; separation by target organ is also possible).**

ADDITIONAL COMMENTS ON TABLE 2-4:
COMMENT NO. 35A: **Table 2-4 should also be footnoted or otherwise designated to show that choosing all the numbers in the 1E-4 column would result in a total cancer risk greater than 1E-4.**

COMMENT NO. 35B: **Lead (Pb) should be added.**

COMMENT NO. 35C: **The MCL/Act 2 column numbers should be amended as follows: Aroclors, 0.5 µg/l; nickel, MCL remanded; identify source of zinc, vanadium and 1,3-DCB numbers. Copper has an Action Level of 1300 µg/l. Add values for 1,2-DCE, silver, barium, cyanide, mercury, and lead.**

COMMENT NO. 35D: **EPCs should be: 1,2-DCE, 9 µg/l; aluminum, 162000 µg/l; cadmium, 67 µg/l; zinc, 36000 µg/l; chromium, 230 µg/l; vanadium, 280 µg/l; 1,1,1-TCA, 63 µg/l; copper, 950 µg/l; silver, 16 µg/l; barium, 1110 µg/l; cyanide, 38 µg/l; mercury, 0.96 µg/l.**

COMMENT NO. 35E: **The maximum concentrations based on the RI risk assessment should be: 1,2-DCE, 9 µg/l; Aroclor 1254, 47000 µg/l; Aroclor 1248, 30000 µg/l; arsenic, 34.9 µg/l; beryllium, 11.5 µg/l; Aroclor 1260, 5.6 µg/l; benzene, 290 µg/l; 1,4-DCB, 360 µg/l; 2,3,7,8-TCDD, 8.4E-6 µg/l; 1,2,4-TCB, 48000 µg/l; chlorobenzene, 310 µg/l; manganese, 124000 µg/l; iron, 477000 µg/l; aluminum, 162000 µg/l; cadmium, 67.4 µg/l; zinc, 38700 µg/l; chromium, 250 µg/l; vanadium, 284 µg/l; 1,3-DCB, 510 µg/l; copper, 948 µg/l; nickel, 290 µg/l; silver, 60.9 µg/l; barium, 1420 µg/l; cyanide, 205 µg/l; mercury, 0.96 µg/l; lead, 692 µg/l.**

COMMENT NO. 35F: **The maximum concentrations from 1999 data should be: 1,2-DCE, 1 µg/l; aluminum, 75.5 µg/l; silver, 4.6 µg/l; barium, 581 µg/l; cyanide, NA; mercury, 0.47 µg/l; lead, ND. For chromium, the value should be 5.5 µg/l (5.8 µg/l in OS7A is for the south sector, not the middle sector).**

RESPONSE: Table 2-4 will be modified in response to these comments. Note that for inorganics, the maximum detected concentrations were shown for dissolved (filtered) metals, as indicated in footnote (d). The table will be revised to include maximum total metals results where available. Also, please note that maximum

RI concentrations listed in the tables include all samples collected during the RI, and is not limited to just those results used in quantifying risk in the HHRA.

COMMENT NO. 36: Table 2-5: The table should be adjusted in accordance with Table 1-1. Therefore, the PRG at 1E-6 cancer risk and the PRG at HI of 1 each would be as indicated (other risks can be determined by multiplication or division, as appropriate; separation by target organ is also possible):

ADDITIONAL COMMENTS ON TABLE 2-5:
COMMENT NO. 37A: Table 2-5 should also be footnoted to show that choosing all the numbers in the 1E-4 column would result in a total cancer risk greater than 1E-4.

COMMENT NO. 37B: The MCL/Act 2 column numbers should be amended as follows: Aroclors, 0.5 µg/l; identify source of benz[a]anthracene number. Add values for aluminum, barium, cadmium and manganese.

COMMENT NO. 37C: The maximum concentrations based on the RI risk assessment should be: 2,3,7,8-TCDD, 3.55E-6 µg/l; aluminum, 7690 µg/l; barium, 300 µg/l; cadmium, 2.5 µg/l; manganese, 133 µg/l.

COMMENT NO. 37D: The maximum concentrations from 1999 data should be: aluminum, 561 µg/l; barium, 2090 µg/l; cadmium, ND; manganese, 92.5 µg/l.

RESPONSE: Table 2-5 will be modified in response to these comments. Note that for inorganics, the maximum detected concentrations were shown for dissolved (filtered) metals, as indicated in footnote (c). The table will be revised to include maximum total metals results where available.

COMMENT NO. 38: The text in Section 3.3 pertaining to the retention of remedial technologies after secondary screening does not correlate with the associated tables. Please review and revise accordingly. The following discrepancies were noted:

Section 3.3.1.10 vs. Table 3-1; enhanced biodegradation
Section 3.3.2.6 vs. Table 3-2; onsite POTW disposal
Section 3.3.2.8 vs. Table 3-2; groundwater reinjection
Section 3.3.2.9 vs. Table 3-2; air stripping
Section 3.3.2.14 vs. Table 3-2; permeable reactive barriers
Section 3.3.2.15 vs. Table 3-2; in-well stripping
Section 3.3.3.4 vs. Table 3-3; vertical barriers
Section 3.3.3.10 vs. Table 3-3; chemical oxidation

RESPONSE: These items will be reviewed and revised as appropriate. Please note that Tables 3-1 through 3-3 represent an initial screening phase, with qualitative comparisons being made relative to other process options within the same

technology class. The discussions in Section 3.3 represent the secondary screening phase, with a more detailed review of the screening criteria.

COMMENT NO. 39: Table 3-1: It is not clear why the treatment methods were screened out when only the cost appears unfavorable. Explanations of this should be provided in the text.

RESPONSE: The text and table will be reviewed and modified as appropriate.

COMMENT NO. 40: Section 3.3.2: Dioxins are also risk drivers in groundwater and should be noted as such.

RESPONSE: The text will be revised accordingly.

COMMENT NO. 41: Section 3.3.2; page 3-13: Rather than omitting methods for inorganics, the FS should have assumed metals treatment would be necessary unless and until the RD shows otherwise. This approach has been taken in other Region 3 RODs where the metals could not be eliminated as site-related during the RI (e.g., 1990 ROD for Keystone Sanitation Landfill).

RESPONSE: The text will be revised to include consideration of groundwater treatment for inorganics. Note that in the case of a pump and treat system with discharge to the river, treatment of inorganics would likely be as needed to meet the requirements of a discharge permit. These requirements may or may not be the same as the cleanup goals for the aquifer.

COMMENT NO. 42: Section 3.3.3: Please explain why surfactant flushing was not included as a potential product recovery technique.

RESPONSE: CBS concurs that surfactant flushing should be included as a potential product recovery technique. The text will be revised accordingly.

COMMENT NO. 43: Section 3.3.3 did not discuss groundwater depression or offsite disposal, both of which appear on Table 3-3.

RESPONSE: The text will be revised appropriately.

COMMENT NO. 44: Table 3-3: It is not clear why the permeable reactive barrier was screened out, since the table shows it as potentially effective and readily implementable, with a moderate to low cost.

RESPONSE: The effectiveness of a permeable reactive barrier is largely dependent on the flow of the impacted media (in this case, NAPL) through the barrier. Based on aquifer monitoring activities over the last 10-15 years, it

appears that the NAPLs at the site, and in particular the DNAPLs, are relatively immobile. As such, a permeable reactive barrier would likely be an ineffective means of reducing COPC mass in site NAPLs.

COMMENT NO. 45: Section 4.1; page 4-1: Please explain why no alternatives were developed for Limited Action (Site Monitoring) and Natural Recovery (Natural Attenuation/Resedimentation). Also, monitoring (including monitoring of levels of site-related contaminants in fish tissue) and institutional controls (such as consumption advisories currently in place or needed in the future) should be components of all alternatives.

RESPONSE: CBS concurs that a "Limited Action/Natural Recovery" alternative should be included among the sediment alternatives. The report will be revised accordingly.

COMMENT NO. 46: Section 4.1; page 4-3; First Paragraph: Please explain whether there is any regulatory basis (such as other RODs) for utilizing the 10 ppm level, or any other level, for PCB cleanup of riparian areas.

RESPONSE: CBS could not locate a regulatory precedent for the specific clean up of riparian soils within USEPA Region III. The majority of RODs issued by USEPA to date have provided clean up levels for sediment as well as for other site soils, with no specific consideration of riparian soils.

The October 7, 1999 cleanup agreement between USEPA and General Electric for the Housatonic River Site in Pittsfield, Massachusetts calls for the removal of non-residential floodplain and bank soils with greater than 10 ppm PCBs in the top 12 inches, and greater than 15 ppm PCBs in the 12 to 36 inch interval, for "protection of human recreational users and biological receptors."

COMMENT NO. 47: Section 4.2; page4-6: Table 3-3 indicates that in-situ chemical oxidation (ISCO) is a potential process option for NAPLs. The bench-scale studies exhibited good destruction of NAPLs. Please explain why it was not included under Section 4.2. Other modifications to this section in response to Comment No. 38 above should also be included.

RESPONSE: Discussions with technology vendors for this process option indicated that based on the current estimates of contaminant mass in the subsurface, using ISCO as a primary treatment method would be extremely cost prohibitive (in excess of $130 million), and is more appropriate as a secondary or tertiary "polishing" process after more direct NAPL removal techniques are employed.

COMMENT NO. 48A: Section 4.2.5: The institutional controls have been treated as primarily temporary (i.e., 30 years with reevaluation). For institutional controls to contribute to the protectiveness and permanence of a remedy, they should be assumed to extend beyond 30 years.

> **RESPONSE:** CBS concurs that the duration of institutional controls should be until the threats the controls are intended to mitigate have been reduced to acceptable risk levels, as described in Section 4.2.2.

COMMENT NO. 48B: Section 4.2.5; Page 4-14: This alternative is virtually the same as Alternative 3B, which, calls for NAPL recovery and requires homogenizing of NAPLs through the aqueous phase in order for biodegradation to occur. Please revise accordingly.

> **RESPONSE:** Alternative 5 includes the components of Alternative 3B, but in addition includes the in-situ treatment of impacted groundwater in a much larger portion of the aquifer than the NAPL areas. See response to Comment No.3.

COMMENT NO. 49: Page 5-10, 2nd paragraph and page 5-12, 1st paragraph: The ARARs statement(s) for the sediment cleanup alternatives should be revisited. Land Disposal Restrictions under RCRA might be potential ARARs for sediment cleanup. Also, the CWA, SDWA, and Pennsylvania's Clean Streams Law, Solid Waste Management Act and residual waste regulations are potential ARARs.

> **RESPONSE:** These potential ARARs will be considered in reviewing and if appropriate revising the text. Note that based on existing sediment quality data, CBS does not anticipate that the RCRA LDR concentrations will be exceeded.

COMMENT NO. 50: Section 5.3.3; Page 5-11; Second Paragraph: There is a risk posed to human health through consumption of fish that potentially adsorb the site-related contaminants from the sediments. Currently, this is somewhat controlled institutionally by a consumption advisory.

> **RESPONSE:** A discussion of this potential risk will be incorporated in the text.

TABLE 5-2
COMMENT NO. 51A: It is not clear why No Action is fair, rather than poor, for overall protectiveness.

> **RESPONSE:** The No Action alternative for sediment was rated fair for overall protectiveness on the basis that there is currently no unacceptable risk to human health, but there is a potential risk to the environment.

COMMENT NO. 51B: It is not clear why Alternatives 2 and 3 would be fair, rather than good, for reduction of mobility.

RESPONSE: We concur that these alternatives would be good for reduction of mobility, although there would be a short-term increase in mobility associated with implementation.

COMMENT NO. 51C: Although it may present some minor short-term risk to human health that can be minimized, it is not clear why Alternative 3 would be poor, rather than good, for overall protection of human health and the environment. Please revise the table and text accordingly.

RESPONSE: These sediments do not currently pose an unacceptable risk to human health. While CBS concurs that steps can be taken to reduce the potential human health risks associated with this alternative, CBS does not consider the short-term risk to human health associated with the excavation of sediments, particularly in the immediate vicinity of the water company intake, to be "minor." Included in the definition of overall protectiveness is that implementation of a remedy cannot result in unacceptable short-term risks to, or cross-media effects on, human health and the environment.

TABLE 5-4:
COMMENT NO. 52A: It is not clear why No Action is fair, rather than poor, for overall protectiveness.

RESPONSE: This alternative was rated fair for overall protectiveness on the basis that under current and reasonably anticipated future land and groundwater use, there is no unacceptable risk to human health due to impacted groundwater and NAPLs.

COMMENT NO. 52B: It is not clear why Alternative 2 is rated equally as good as Alternatives 3 through 5 for overall protectiveness (especially since they differ with respect to long- and short-term effectiveness and ARARs compliance).

RESPONSE: CBS concurs with this comment, and the text and table will be revised accordingly.

COMMENT NO. 53: Section 6.0: This introductory section should also acknowledge the expectation of restoration to beneficial use that is noted in the NCP.

RESPONSE: The text will be revised to acknowledge this expectation where such restoration is deemed to be practicable.

COMMENT NO. 54: Section 6.1.1, 2nd paragraph: The second sentence contains the phrase "in exceedance of" which, is often used as engineering jargon, is not a legitimate word and should be replaced with a word such as exceeding.

RESPONSE: The text will be revised appropriately.

COMMENT NO. 55: Section 6.2: Dioxins are also risk drivers.

RESPONSE: The text will be revised appropriately.

COMMENT NO. 56: Section 6.3.2 describes NAPL removal as producing only "minimal improvement" in terms of COPC mass removal. This seems to contradict the earlier descriptions of these remedies and the last paragraph of Section 6.4. It also contradicts the assumption throughout the report that NAPL removal would be the most significant reduction of contamination, since only natural attenuation is proposed as an active remedy for non-NAPL constituents.

RESPONSE: The sentence is intended to state that Alternatives 4 and 5, which include NAPL removal and treatment of groundwater in non-NAPL areas (see response to Comment No. 3), do not provide a significant improvement in terms of COPC mass removal **relative to Alternative 3,** which includes NAPL removal and natural attenuation. Thus, this section does not contradict the assumption that NAPL removal would provide the most significant reduction of contaminant mass in the subsurface. This section will be modified for clarity.

COMMENT NO. 57: Table 1-2: The lettered footnotes do not have corresponding letters in the table.

RESPONSE: The table will be revised accordingly.

COMMENT NO. 58: Appendix B is provided as a sample ordinance. It is important to note that this sample includes certain exceptions, such as wells being "grand fathered in", and those with connections outside a certain distance not being required to use public water. Any exceptions in such an ordinance at the Site would have to be carefully evaluated to ensure protectiveness.

RESPONSE: CBS concurs with this comment, and references to this appendix will be modified accordingly.

COMMENT NO. 59: Also, any additional information from the installation of the two additional bedrock wells as approved in the February 3, 2000 submittal titled "Proposed Plan (Revision 2.0)- Installation of Additional Bedrock Groundwater Monitoring Wells/Abandonment of Well M-11B" for the Westinghouse Sharon Site should be included, either in the revised OU-2 FS Report, or in a separate

addendum. Included should be an analysis of bedrock cleanup alternatives based on the information obtained from the additional well installation. Please notify the Department at least one week prior to the commencement of field activities or if there are any scheduling problems.

RESPONSE: The revised OU-2 FS Report will include the most up-to-date information available on the bedrock groundwater assessment activities. CBS anticipates that a separate addendum will be required to incorporate the results of the assessment and analysis of bedrock remedial alternatives.