II. DECISION SUMMARY

Atlantic Wood Industries, Inc. Site
Operable Units 1, 2 and 3

Portsmouth, Virginia

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DECISION SUMMARY

1. SITE NAME, LOCATION AND DESCRIPTION

The Atlantic Wood Industries, Inc. Superfund Site (site) is generally located south of Elm Avenue adjacent to the Southern Branch of the Elizabeth River in Portsmouth, Virginia. The site includes approximately 48 acres of land with contaminated soil on the industrialized waterfront area of Portsmouth, Virginia. This land is surrounded by the Norfolk Naval Shipyard, the operations center for the Portsmouth Public School District, the Southern Branch of the Elizabeth River and several other small industrial properties. See **Figure 1**. The site includes contaminated sediments in areas of the Elizabeth River generally extending from the Atlantic Wood Industries (AWI) facility east to the navigational channel, north to the eastern-most part of the Portsmouth Port and Industrial Commission property and south into sediments adjacent to the South Annex of the Norfolk Naval Shipyard. The site also includes contaminated ground water that has mostly remained underneath the AWI facility. See **Figure 2**.

Contamination exists at the site as a result of past wood-treating operations and disposal and migration of waste and/or hazardous substances from the Norfolk Naval Shipyard. The facility is split into eastern and western portions by the former Norfolk and Portsmouth Beltline Railroad and Burton's Point Road. Wood treatment processing operations and wood storage formerly occurred on the eastern portion of the property, and storage of treated and untreated wood, as well as disposal of tank bottoms and other wastes, occurred on the west side of the property. A significant portion of the western half of the property was leased to the Navy during World War II. The Navy filled low lying areas of the property to use the property as a storage area. Currently, AWI operates a pre-stressed concrete products manufacturing facility at the site. The site is about twelve miles from the Chesapeake Bay.

The U.S. Environmental Protection Agency (EPA) is the lead agency for site activities and the Virginia Department of Environmental Quality (VADEQ) is the support agency. The CERCLIS ID number for this site is VAD990710410.

2. SITE HISTORY AND ENFORCEMENT ACTIVITIES

From 1926 to 1992, a wood-treating facility operated at the site using both creosote and pentachlorophenol (PCP). The site was contaminated from the treatment operation, storage of treated wood, and disposal of wastes. At one time, the Navy leased part of the property from AWI and disposed of waste on-site, including used abrasive blast media from the sand blasting of ships. The Navy also disposed of calcium hydroxide sludge from the production of acetylene gas (used in torches to cut metal) in a wetland on the border of the Southgate Annex of the Shipyard and the AWI site. Sediments in the Elizabeth River contain visible creosote and calcium hydroxide sludge. The ground water and soil at the site are also heavily contaminated with creosote. Creosote contamination previously migrated into a storm sewer and discharged to an inlet (referred to as the Northern Inlet) of the Elizabeth River at the northeast corner of the site near the Jordan Bridge.

The original plant was constructed in 1926 by the Savannah Creosoting Company. According to site records, wood was never treated with chromated copper arsenate (CCA), a common wood treating chemical, although some CCA-treated wood was stored on-site. For a short period of time, a coal tar refinery was operated at the site. Over the history of the site, areas of the site have been filled including areas of the Elizabeth River such that the shoreline moved significantly eastward over time.

From 1926 until 1944, the site was operated as the Savannah Creosoting Company and was owned by the Savannah Creosoting Company, Inc. On December 28, 1944, the name of Savannah Creosoting was changed to Atlantic Creosoting Company, Inc., which eventually became Atlantic Wood Industries, Inc.

The original Savannah Creosoting Company facility consisted of two wood treatment retorts (pressurized cylinders), the existing office building, several existing maintenance and storage buildings, and an above-ground tank farm that was located adjacent to Elm Avenue. The above-ground tank farm consisted of four storage tanks, installed around 1940, and were of open-top steel construction. These tanks were originally used to store wood preserving chemicals, including creosote. In the past, two of the four tanks were used occasionally to store process water which may have contained PCP. Two of these tanks were removed in 1985, and the last two were removed by June 1986. Four other tanks were associated with a tar distillation unit that was located east of the office building. There was also a shallow concrete basin associated with the tar distillation unit. The tar distillation unit was disassembled in the 1940s. The basin was filled in and the four tanks were moved to their present location. Portions of the retaining wall around the basin are currently exposed.

From about 1940 until October 1985, there was a concrete process water recycling basin located immediately north of the retort building. This unit was used to recover wood preservative from process water, and until 1972, some excess process water was discharged to an area immediately south of the railroad spur that juts out into the Southern Branch of the Elizabeth River. AWI continued to use the unit to recover preservative and to recycle process water until it was removed in August 1985.

Creosote was the original treatment chemical. From the late 1950s through the early to mid-1960s, a PCP-related product known as "creo-penta" may also have been used. PCP was first used by itself in about 1972. The use of PCP as a preservative was discontinued in 1985. All wood treating operations ceased by 1992.

When the Clean Water Act was implemented in the early 1970s, the plant was required to stop discharging effluent from the oil/water separator directly into the Elizabeth River. At that time, a liquid incineration unit known as a "Liquidator" was constructed. This unit incinerated excess process water that was previously discharged through the oil/water separator into the river. AWI stopped using the Liquidator unit in 1984.

Sampling data collected during a preliminary site assessment were used to evaluate the relative hazards posed by the site using EPA's Hazard Ranking System (HRS). EPA uses the HRS to calculate a score for hazardous substances sites based upon the presence of potential and observed hazards. If the final HRS score exceeds 28.5, the site may be placed on the National Priorities List (NPL), making it eligible to receive Superfund monies for remedial cleanup. In 1985, an HRS score of 40.77 was calculated for the AWI site. This site was proposed for listing on June 10, 1986, and was formally added to the NPL on February 21, 1990.

On July 23, 1987, AWI entered into an Administrative Order by Consent (AOC) with EPA which required AWI to perform initial cleanup actions and conduct a remedial investigation and feasibility study (RI/FS) for the site.

In 1995, AWI, under another AOC with EPA, cleaned the Elm Avenue storm sewer and installed a polyethylene or fiber glass liner within all affected manholes, catch basins, and sewer lines because creosote that had leaked from nearby tanks was seeping into the sewer line. As part of this same action, AWI excavated approximately 660 cubic yards of contaminated sediments from an intertidal drainage ditch and the Northern Inlet.

The Navy and AWI, under a joint effort with EPA oversight, completed a removal action for the Acetylene Sludge Area in 2003 pursuant to a 2002 AOC between EPA and AWI and a concurrent agreement between AWI and the Navy. This action entailed excavation and offsite disposal of the calcium hydroxide sludge and wetland restoration. Calcium hydroxide sludge contamination in the river sediment was not addressed by this removal action. The calcium hydroxide is a contaminant of concern for the river sediments since it can have a pH over 12.5 and has the potential for direct dermal contact with industrial workers involved in navigational dredging activities. At the same time, the Navy excavated contamination (calcium hydroxide and abrasive blast medium [ABM]) from the Waste Lime Impoundment adjacent to and southwest of the Acetylene Sludge Area.

AWI completed the RI in 1992 and the FS in 1995 for OU1. In 1995, EPA issued a record of decision (ROD) that selected bioremediation, with low-temperature thermal desorption as a contingency remedy, to address creosote-contaminated soil and DNAPL. Thereafter, EPA took over the site as fund-lead. Based on the pre-remedial design investigation (PRDI), EPA concluded that, due to problems associated with the bioremediation treatability study and the discovery that the extent and complexity of the contamination (newly-found high concentrations of metals contamination) was far greater than found in the RI, the response action in the 1995 ROD would not adequately address the soil and DNAPL. EPA undertook a focused feasibility study (FFS) for OU1 to provide the information necessary to amend the 1995 ROD and began RI/FSs for OU2 and OU3. Associated risk assessments included Human Health Risk Assessments for OU1, OU2, and OU3, a Screening Level Ecological Risk Assessment for OU1, and an Ecological Risk Assessment for OU3. The feasibility studies for the three operable units were completed near the same time, so EPA issues this selected remedy to address all three operable units.

3. COMMUNITY PARTICIPATION

This selected remedy is based on site-related documents contained in the Administrative Record for the site, including the Final Pre-Remedial Design Investigation Report (June 2002) for OU1, the Final Remedial Investigation Report for OU2 Groundwater and OU3 River Sediment (April 2007), the Final Focused Feasibility Study for OU1 Soil and DNAPL (May 2007), the Final Feasibility Study for OU2 Groundwater (September 2006), the Final Feasibility Study for OU3 River Sediment (October 2006), the Final Human Health Risk Assessment Operable Unit 1 (March 2004), the Final Human Health Risk Assessment for Operable Unit 2 Groundwater (May 2007), the Final Human Health Risk Assessment for Operable Unit 3 Elizabeth River (July 2007), the Final Report Ecological Risk Assessment (June 2002), and the National Remedy Review Board Review Document (January 2007). The Administrative Record also includes the documents used to support the 1995 ROD. The complete Administrative Record can be examined on-line by going to http://www.epa.gov/reg3hwmd/super/sites/VAD990710410/index.htm and clicking "Administrative Record."

On July 11, 2007, EPA published a notice of availability in the *Virginian-Pilot* of a Proposed Remedial Action Plan that described EPA's preferred cleanup alternative for OU1, OU2, and OU3 at this site. The same notice also stated the availability of the Administrative Record, which contained the documents to support EPA's Proposed Plan. The notice also stated that the Administrative Record could be viewed from publicly available computers at the Portsmouth Public Library, the Chesapeake Library, the Kirn Memorial Library in Norfolk, and at EPA's Administrative Record Room in Philadelphia, Pennsylvania. A fact sheet describing EPA's preferred cleanup plan and providing notice of a public meeting was sent to approximately 15,000 addresses, including approximately 5,000 addresses within approximately one mile of the site. EPA also sent approximately 3,000 email notices to many people who received the mailing.

With the release of the Proposed Plan on July 11, 2007, EPA opened a 30-day public comment period to accept public comment on the remedial alternatives presented in the Proposed Plan and the other documents contained within the Administrative Record for the site. EPA received a timely request for a 30-day extension of the comment period and extended the comment period to September 10, 2007. On July 24, 2007, EPA held a public meeting to discuss the Proposed Plan and accept comments. A transcript of the meeting is included in the Administrative Record. EPA held a second public meeting on August 21, 2007, because a number of people did not receive the mailed notice before the July 24 public meeting and some who wanted to attend were at a City of Portsmouth public hearing that took place at the same time. A transcript of the second public meeting is also included in the Administrative Record. A summary of significant comments received during the public comment period and EPA's responses are included in the Responsiveness Summary, which is a part of this 2007 ROD (see page 115).

4. SCOPE AND ROLE OF THIS RESPONSE ACTION

This action is planned to be the final response action for the site. This 2007 ROD addresses all of the threats currently known to be posed by the contamination at this site. The abrasive blast medium area, which originally was planned to be addressed as part of the 2003 removal action, will be addressed as part of this final remedy. This selected remedy replaces the remedy in the 1995 ROD and includes additional remedial actions to address contaminated ground water and river sediments.

The Elizabeth River is one of EPA's eight national Urban River Restoration Initiative pilot projects. The Initiative began in 2002 through an agreement between EPA and the U.S. Army Corps of Engineers (USACE) (see http://www.epa.gov/oswer/landrevitalization/urbanrivers/). One of the goals of the initiative is to increase coordination and cooperation between the EPA and the USACE with respect to restoring degraded urban rivers. Each organization has authorities which can be used to help restore urban rivers (e.g., CERCLA and the Water Resources Development Act [WRDA]).

The Elizabeth River is one of three regions of concern on the Chesapeake Bay as designated in 1993 by the Executive Council of the Chesapeake Bay Program because of elevated levels of and impacts from chemical contaminants in sediment. This selected remedy at the AWI site will address the worst hotspot of sediment contamination in the Elizabeth River.

EPA, the National Oceanic and Atmospheric Administration (NOAA), the USACE, the U.S. Fish and Wildlife Service, the Commonwealth of Virginia, local governments and industries, researchers, and others are or have undertaken activities to improve the watershed. This work is being coordinated by the Elizabeth River Project (ERP), a local non-profit organization. Since at least the late 1990s, EPA has been participating in meetings three to four times per year with the ERP's Sediment Remediation Partnership. Besides the AWI site, EPA's Superfund Program is involved with the U.S. Navy's St. Julien's Creek Annex and NNSY Superfund sites and is conducting three other removal actions along the Elizabeth River or its tributaries (the Peck Iron & Metal site on Paradise Creek, the Hazel Court site at the location of the former Eppinger & Russell facility, and the Chesapeake Products site across the river and just downstream of the Jordan Bridge [see **Figure 3**]).

Other projects include work by the USACE to address PAH contamination at the confluence of Scuffletown Creek and the Southern Branch of the Elizabeth River using its WRDA authorities[1] and work by ERP to address PAH contamination in the Southern Branch of the Elizabeth River adjacent to the Money Point area of the City of Chesapeake. In 2005 and 2006, ERP convened

[1]This remedy will not impact the USACE project.

the Money Point Task Force to develop environmental improvements to the Money Point area and to address PAH contamination in the river. The Task Force included many of the same stakeholders involved with ERP's Sediment Remediation Partnership plus others including community members living in the Money Point area.

The PAH contamination in the Money Point area (over a mile upstream and across the river from the AWI site) is mainly from the former Eppinger & Russell wood-treating site. The Task Force reached a consensus decision on an cleanup alternative that included dredging and sediment capping. ERP is in the process of applying for permits to implement this cleanup using money set aside by Virginia that came from Maersk Line for mitigation from damaging benthic habitat as part of constructing a new port facility.

Collectively, these and other projects will bring vast improvement to the river. The river has undergone extensive monitoring to date and will so in the future which will provide information documenting the improvement. The cleanup at the AWI site will not only address risks at the site but will address a potential source of contamination to other parts of the river. As discussed in detail in section 7 on page 36, the sediments present a risk due to direct contact as well as contribute to risks from consumption of biota. The goals of the AWI cleanup include eliminating the direct contact risk and reducing risks associated with consumption of biota (see section 8 on page 55). EPA is not setting a specific risk-based remediation goal for consumption of biota in this ROD since there are other sources of contaminants in the river, including the same type of contaminants as at the AWI site. Estimating the risk reduction from just addressing the AWI site is difficult. However, this cleanup will add to the risk reduction resulting from other projects in the river. This cleanup will also prevent acute risks due to direct contact to creosote DNAPL in the sediment.

5. SITE CHARACTERISTICS

5.1 Site Setting

The AWI property, the location of a creosote and PCP wood-treating operation from 1926 until 1992, occupies approximately 48 acres of land on the industrialized waterfront area of Portsmouth, Virginia (see **Figure 1**). Elm Avenue runs along the northern property boundary, with the NNSY facilities to the north and northwest and the location of a former veneer mill and the former Wyckoff Pipe & Creosote facility north of the northeastern corner. The Southgate Annex of the NNSY and land occupied by the Portsmouth Public School District Operations Center lie along the southern border. The Southern Public Service Authority (SPSA) of Virginia's waste-to-energy facility is located adjacent to the northwest boundary of the AWI property. The Southern Branch of the Elizabeth River bounds the AWI property to the east and a Virginia Electric Power Company (VEPCO) right-of-way is located to the west. Across the right-of-way is the Navy's Paradise Creek Disposal Area consisting of (in part) a landfill, an oil reclamation area, and former liquid-waste holding tanks. The NNSY is a Superfund site on the NPL as well.

The Southern Branch of the Elizabeth River flows through a highly industrialized area, including the AWI facility, Navy facilities (present for over two hundred years), oil storage facilities, chemical manufacturing facilities, a fertilizer plant, a cement storage facility, several hazardous waste cleanup sites, and a power plant. Other known sources of pollution include the former Eppinger & Russell Creosoting Plant, former Republic Creosoting, and the Peck Iron & Metal Works (see **Figure 3**).

The banks of the Southern Branch of the Elizabeth River have significant areas of bulkhead, especially downstream of the AWI facility, but the river also has viable habitats. ERP is committed to the restoration and conservation of vegetated buffers, wetlands, and forests in the Elizabeth River watershed. In 2004, ERP was involved in the construction of an oyster reef across the river from the Wyckoff Inlet.

5.2 Adjacent Properties

The 3971 and 3975 Elm Avenue properties are located across Elm Avenue from the northeast portion of the AWI property. Most recently, the 3975 Elm Avenue property was the location of the Norfolk Veneer Mill, which operated from the 1950s to at least 1992. Prior to the veneer mill, the 3975 Elm Avenue property was the site of the Wyckoff Pipe & Creosoting Company. In the early part of the century, the Dickson Lumber Company was located on the 3971 Elm Avenue property. Before the Jordan Bridge was built in the late 1920s, the south end of the 3975 Elm Avenue property was all river front. By 1920, the Wyckoff facilities included a railroad spur from the property into the inlet north of the Jordan Bridge (called the Wyckoff Inlet on the figures). Currently all that is left of the railroad spur are pilings.

In 1990, an investigation of underground storage tanks at the veneer mill found DNAPL in the subsurface soil along Elm Avenue. At the time, the source of this contamination was attributed to AWI because it appeared to be the only source in the area. In 2006, EPA conducted a Site Inspection at the Elm Avenue properties. DNAPL was found in fill along the north edge of the Wyckoff Inlet, and the eastern, northern, and northwestern parts of the 3975 Elm Avenue property (see **Figure 2**). DNAPL was found only in the southeastern corner of the 3971 Elm Avenue property.

Although not immediately adjacent to the AWI property, the City of Portsmouth's Port and Industrial Commission owns a parcel of land adjacent to the sediment remediation area. At various times since 1900, the property has been the location of a fertilizer plant, a ship and barge repair and clean-out facility, and vacant land. At one time, a pier extended south into the river from the easternmost point of land. In 2004, a Phase II investigation for purposes of selling real estate, including soil borings and sampling, found petroleum and metals contamination, likely resulting from ship maintenance and repair activities that took place on the site. Much of the site is covered with fill, some of which contains abrasive blast medium (ABM). Coal-related or coal tar-related polynuclear aromatic hydrocarbons (PAHs) were detected in some of the soil samples, but no DNAPL was observed. Given the high level of DNAPL contamination detected on the eastern and southeastern part of the 3975 Elm Avenue property, as well as the DNAPL found in samples in an adjacent area of the river, it is likely that DNAPL is present in subsurface soils of the southwestern tip of this property.

The property immediately adjacent to the southern boundary of the west side of the AWI property is owned by the Portsmouth Public School District. The property is used as the school district's operations center and includes a school bus maintenance facility, a garage, an office building, a warehouse, an office trailer, and a records building. Four current or former underground storage tanks are registered with the VADEQ underground storage tank (UST) program. Only one tank is still active: a 550-gallon waste oil tank located on the north side of the garage. A fifth tank, an inactive 1000-gallon No. 2 fuel oil tank, was listed on a 1989 VADEQ inspection report, which noted that the tank was replaced. This tank is still on-site and is located immediately adjacent to the southern AWI property boundary.

During abandonment of a 6,000-gallon gasoline UST in 1990, dark bands of stained, possibly fuel oil-contaminated, soil were observed in the excavation. Approximately 150 cubic yards of contaminated soil were eventually removed. The suspected source of the contamination was an oil storage site owned by BP Oil Incorporated, immediately south of the tank. In 1994, VADEQ informed the Portsmouth Public School District that no further assessment or remedial action would be required at that time.

The NNSY surrounds much of the AWI site and is itself an NPL site. The part of the property closest to the AWI facility is a large parking area for the shipyard. In an Initial Assessment Study, the Navy did not identify any environmental sites within this parking area.

Most of the west side of the AWI site borders the Western Landfill of the Navy's Paradise Creek Disposal site, part of the NNSY Superfund site. The site contains dredge spoils, abrasive blast grit, paint residues, sanitary wastes, solvents, fluorescent tubes, oil and coal-fired plant fly ash, fuel boiler plant bottom ash, asbestos waste, and other industrial residues. In addition to the landfills, the Paradise Creek Disposal Area encompasses four Navy Installation Restoration (IR) sites, Sites 3, 4, 5, and 6, and has been designated as OU2 for the NNSY NPL site.

Site 4 consists of five chemical waste holding ponds (cyanides, acids, degreasers, solvents, alkali, and other unspecified materials) that operated between 1963 and 1980. Site 5 was used as an oil recovery area and included an area of floating product. During installation of a product recovery system, DNAPL containing dichloroethanes, trichloroethene, and tetrachloroethene, as well as some PAHs, was found in one of the recovery wells. The Navy noted that the DNAPL did not contain creosote. Site 6 was a disposal area for ABM and volatile liquid wastes from 1960 to 1977. With respect to ground water flow, the Paradise Creek sites are generally upgradient of the AWI facility.

A comprehensive RI of these Navy IR sites was performed in 2002. PAHs, phenols, and arsenic were found in surface soil located in the drainage ditch that runs in the VEPCO right-of-way between the Western Landfill and AWI. Subsurface soil contaminated with PAHs and metals was found at Site 6, across the VEPCO right-of-way from the Portsmouth Public School District property. Ground water in the upper Columbia Aquifer immediately adjacent to the western side of the AWI property and at Site 6 is contaminated with volatile organic compounds (VOCs) (including benzene, chloroform, vinyl chloride, and 1,2-dichloroethane) and semi-volatile organic compounds (SVOCs) (including PCP, 2,4-dimethylphenol, 4-methylphenol, 1,2-dichlorobenzene, and 1,3-dichlorobenzene). Metals were also detected in the Site 6 ground water. The chlorinated solvents found in this area are not likely to be from AWI because they are not found elsewhere in the ground water on the AWI property.

The property immediately adjacent to and south of the eastern portion of the AWI facility is the NNSY's Southgate Annex. The Annex, which includes waterfront on the Southern Branch of the Elizabeth River, is used by the Navy for mooring inactive ships and for storage. Interviews with former AWI employees indicated that the Navy also used the Annex for small boat maintenance and repair. From 1942 to the mid-1960s, the Navy manufactured acetylene gas on the main NNSY property. A byproduct of this gas production was calcium hydroxide sludge that was pumped through a pipeline across the AWI property and along the Annex's north property boundary to a low area adjacent to the river.

5.3 Site Description

The facility is split into eastern and western portions by the former Norfolk and Portsmouth Beltline Railroad (on property owned by the Portsmouth Company, which EPA believes is part of Norfolk Southern Corp.) and Burton's Point Road (see **Figure 1**). Beginning in 1926, wood treatment processing operations and wood storage formerly occurred on the eastern portion of the property, and storage of treated and untreated wood, as well as disposal of tank bottoms and other wastes, occurred on the west side of the property. A majority portion of the western half of the property was leased to the Navy during World War II. Low-lying areas of the western side of the property were filled with a material of unknown composition, which was likely undertaken during the Navy lease to use the property as a storage area. All wood-treating operations at AWI ended by 1992. The facility is now being used to manufacture pre-stressed and pre-cast concrete construction products.

For purposes of investigation, the AWI facility has been characterized based on past industrial uses. Refer to **Figure 1** for the area locations. The industrial use areas are:

- The Wood Treatment Area: the majority of the east side of the property. This includes the former tank area along Elm Avenue. Prior to the 1970s, tank bottoms may have been deposited close to the source tanks as well as in low-lying areas around the retort building and tank farms.

- The Wood Storage Area: the majority of the northern part of the west side of the property.

- The Open Dump Area: an approximately 200-foot by 200-foot area along the western edge of the AWI property that was used as an open dump.

- The Historic Disposal Area: an approximately 50-foot by 500-foot area that runs near the southern edge of the west side of the facility. Tank bottoms and other residuals were deposited in bermed lagoons from about 1970 to 1979. Treated and untreated wood scraps and steel bands were also placed there.

- The ABM Area: the southern edge of the east side, extending approximately 1,050 feet east from Burton's Point Road, where ABM waste exists. The Navy routinely used ABM to strip old paint from vessels being reconditioned at the NNSY immediately adjacent to the southern AWI fence, resulting in deposition of waste ABM on AWI property.

- The Acetylene Sludge Area: the southeast corner of the facility, from the ABM Area to the Southern Branch of the Elizabeth River. This area is now a restored wetland following a removal action completed by the Navy and AWI in 2003.

- The Navy Lease Area: includes much of the west side of the site, including the Wood Storage and the Historic Disposal Areas. A significant portion of the western half of the property, shown in **Figure 1,** was leased to the Navy during World War II. The Navy filled low-lying areas of the property to use the property as a storage area. During later earth-moving activities, AWI discovered a small number of buried ordnance-like objects in the Navy Lease Area and the Wood Treatment Area. Most objects were determined to be dummy test rounds or empty shells, although one may have been a live shell. No ordnance-like objects have been found on the property since May 1997.

- The Southern Branch of the Elizabeth River: Excess water from a recycling process to recover creosote preservative and conditioning water passed through an oil/water separator before being discharged to the Southern Branch of the Elizabeth River at a point just south of the AWI pier. Cracks in the Elm Avenue storm sewer that runs along the northern border of the AWI property allowed creosote in the surrounding soils to seep into the sewer and discharge to the river. The east end of the site has undergone extensive filling since the plant was first constructed. Some of this fill was waste, including DNAPL, which could have migrated from the fill into the river.

5.4 Surface Features, Surface Water, Geology and Hydrogeology, and Ecological Setting

5.4.1 Topography and Drainage

The AWI property is a low-lying section of land bordering the Southern Branch of the Elizabeth River. Elevations range from sea level along the river to approximately 9.5 feet above mean sea level (msl) along the bermed Historic Disposal Area. The property rises gently from the river to about 8 feet above msl along Burton's Point Road and then levels off along the west side. Burton's Point Road is slightly above the surrounding area and acts as a surface water drainage divide, separating the eastern and western drainage areas. The majority of the AWI facility is located within the 100-year flood plain boundary (designated as 8.5 feet msl), with the exception of the western edge of the AWI property and directly south of the Historic Disposal Area, which are at higher elevations (see **Figure 4**).

The Southern Branch of the Elizabeth River receives the majority of surface water runoff from the AWI facility via three permitted outfalls. Drainage ditches on and bordering the east side of the AWI property direct surface water eastward to the river via the Northern Inlet or the restored wetlands at the southern boundary of the property. Surface water on the west side flows to a drainage ditch on the western border. The water then enters storm drains and is ultimately discharged to Paradise Creek, a tributary to the Southern Branch of the Elizabeth River located south (upstream) of the site. There are several depressions on the property where water temporarily ponds during heavy rainfall events. These include the central part of the western side of the AWI property, between the Historic Disposal Area and southern property boundary, and along the southern border of the east side of the AWI property (in the ABM Area).

5.4.2 Surface Water

The Southern Branch of the Elizabeth River is a tidal estuary. The mean tidal range equals 2.8 feet, and the spring tide range equals 3.4 feet. The Southern Branch of the Elizabeth River flows north from the site and combines with the east and west branches of the Elizabeth River before joining the James River approximately ten miles north of the site. The James River empties into the Chesapeake Bay approximately two miles from the point where the James and Elizabeth Rivers converge. The Atlantic Ocean is less than 20 miles from the point where the James River discharges into the Chesapeake Bay.

The river is also part of the Intracoastal Waterway and is used by a variety of boats throughout the year ranging from recreational boats to larger commercial and naval craft. As mentioned earlier, the Southern Branch of the Elizabeth River flows through a highly industrialized area. Despite the industrialized nature of the river, there are active plans for the construction of residences (condominiums) across the river and downstream from the site. A city park with a boat ramp and much-used fishing pier is located at the confluence of Scuffletown Creek and the Southern Branch of the Elizabeth River, directly across the river from the AWI facility. Other current recreational activities on the river include boating and jet skiing.

The Commonwealth of Virginia (pursuant to 9 VAC 25-260-10) has designated all state waters and wetlands, including the Southern Branch of the Elizabeth River, for the following uses:

> [R]ecreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.

Virginia has designated the Southern Branch as Class IIB, signifying that the waters are estuarine and defining the water quality standards which are to be met for pH, dissolved oxygen, and inorganic and organic pollutants. The taking of shellfish from the Elizabeth River is prohibited by the Virginia Department of Health, due to the presence of bacteria.

5.4.3 Geology and Hydrogeology

The stratigraphic and hydrostratigraphic units that have been investigated at the site are described below and shown on **Figure 5**, which is a typical cross section through the site.

5.4.3.1 Geology

Starting at the surface, the stratigraphic/hydrostratigraphic units encountered on the land are: fill, the upper Columbia sand (upper Columbia Aquifer), the Columbia clay (Columbia confining unit), the lower Columbia sand (lower Columbia Aquifer), the Yorktown clay (Yorktown confining unit), and the Yorktown Formation (Yorktown Aquifer). Off-shore, two other units are found: recent river sediments and reworked clay (clay that has been eroded upstream, probably from the Columbia clay, and redeposited down stream).

- Fill is found across the AWI property, including within the saturated zone. The east end of the facility has been extensively filled in to build usable land. (See **Figure 6** for previous shoreline configurations.)
- The upper Columbia sand consists of fine- to medium-grained sand with discontinuous silt and clay layers that influence the distribution of DNAPL in some areas on shore. Also, in limited near-shore areas, it appears that the sand units act as conduits for DNAPL migration. Further from shore, the sands have largely been eroded by the river.
- The Columbia clay is up to 40 feet thick on the eastern end of the facility, but is much thinner over the western and central parts of the AWI property. In these areas, including the Historic Disposal Area, the clay may barely be present.
- The upper surface of the Columbia clay has been incised by historic channels. These channels are filled with upper Columbia sand, recent river sediments, or fill, and they can influence the distribution of DNAPL.
- The lower Columbia sand (lower Columbia Aquifer) is absent beneath the central Wood Treating Area, but is present in the western and eastern parts of the facility. There is considerably less silt and clay in this sand compared to the upper Columbia Aquifer.
- The Yorktown Clay is thickest on the extreme western side of the site, but thins eastward and is absent in the central to eastern end of the AWI property. A paleochannel has likely incised the upper Yorktown Formation, eroding away the clay.
- Recent river sediments consist of loose silts with some sand and occasional fill material (e.g., brick or wood). The sediments are found throughout the river sediment investigation area with the exception of the slopes of the navigation channel.
- The re-worked clay is a soft gray clay presumed to be Columbia clay that was eroded at upstream locations and redeposited downstream, often on top of the Columbia clay.

5.4.3.2 Hydrogeology

Ground water in the upper Columbia Aquifer flows radially outward from a ground water mound in the center of the western part of the facility (see **Figure 7**). A second mound, likely present in the center of the eastern part of the AWI facility, was observed in the water level measurements of the original AWI investigation. Since that time, the removal of particular wells prevents this observation. Along the west side, ground water is likely flowing into a 72-inch storm drain (or the bedding material around the drain) that discharges to Paradise Creek. Flow in the lower Columbia and Yorktown Aquifers is toward the river with a very shallow gradient (see **Figures 8** and **9**).

Vertical flow is downward across both confining units in the western part of the AWI property and upward across both aquifers adjacent to the river. All aquifers are influenced by the tides, although the tidal influence of the upper Columbia Aquifer is limited to the area near the river. In that area, the upper Columbia Aquifer alternately discharges to the river and is recharged by the river during a tidal cycle. The lower two aquifers, both likely hydraulically connected to the navigation channel, also alternately discharge to the river and are recharged from the river.

5.4.4 Ecological Setting

EPA conducted a screening-level ecological risk assessment (SLERA) for the facility soils in 2002 (the report was issued in 2004). A baseline ecological risk assessment of the Elizabeth River was completed in 2002.

5.4.4.1 Upland Habitat

The majority of the AWI property consists of active industrial areas and storage areas. Interspersed between the active areas are old-growth fields or disturbed areas. Inactive areas that were once disturbed by historic industrial activities are undergoing old field succession and are being invaded by pioneer weed species and shrubs. The largest examples of these habitats are located on the portions of the property that have remained unused for several years and where vegetation has grown in and around abandoned tanks and buildings. These larger old-growth fields are located in the former Wood Treatment Area on the eastern half of the AWI facility, along the northern border of the property, and in the Historic Disposal Area on the western half of the facility. Herbaceous species found in these fields include crown vetch (*Coronilla varia*), red clover (*Trifolium pratense*), common ragweed (*Ambrosia artemisiifolia*), common plantain (*Plantago major*), common dandelion (*Taraxacum officinale*), bull thistle (*Cirsium vulgare*), large salt marsh aster (*Aster tenuifolius*), seaside goldenrod (*Solidago sempervirens*), other goldenrod species and several grass species.

Shrub species, including Southern Wax Myrtle (*Myrcia certifera*) and marsh elder (*Iva frutescens*), are found infrequently through the fields. These shrubs are located toward the property edges or drainage ditches where industrial activity was unlikely to have occurred.

Wildlife observed in the fields include several bird species including killdeer *(Charadrius vociferus*), boat-tailed grackles (*Quiscalus major*), red-winged blackbirds (*Agelaius phoeniceus*), northern mockingbird (*Mimus polyglottos*), starlings (*Sturnus vulgaris*), house sparrows (*Passer domesticus*), purple finch (*Carpodacus purpureus*), and mourning doves (*Zenaida macroura*). An American kestrel (*Falco sparverius*) has been observed hunting over the site. Fox have been seen on the AWI property.

5.4.4.2 Wetland Habitat

Three wetlands associated with drainage ditches are located on the AWI site. On the eastern side of the AWI facility, a drainage ditch runs along the northern property boundary and discharges to the river. Where the ditch drains into the river, a narrow inlet of approximately 100 to 200 feet is formed (called the Northern Inlet on the figures). Thick shrub vegetation consisting of wax myrtle grows along the edges. Salt marsh cordgrass (*Spartina patens*) and reed grass (*Phragmites australis*) are also present along the drainage stream. At the southern boundary, a 2.7-acre tidal wetland was restored in 2003 as an element of the acetylene sludge removal action. An inventory of fish was performed by the Elizabeth River Project in 2005 using a fyke net and seine. A total of over 1,300 individual fish from 14 species, as well as blue crab, were counted. Wildlife observed in the tidal areas included a black crowned night heron (*Nycticorax nycticorax*), young red-winged blackbirds, fish crow (*Corvus ossifragus*), and boat-tailed grackles.

On the western side of the property, a drainage ditch extends north and south along the west property line and east across the central part of the west side. Large stands of reed grass grow along both sides of this drainage ditch completely obscuring the ditch from view.

5.4.4.3 River Habitat

Peripheral habitats along the Elizabeth River include intertidal mud flats, associated benthic habitats, shallow waters directly off-shore from the AWI facility, and the waters and sediments of the Southern Branch of the Elizabeth River both upstream and downstream of the facility. The benthic community of the river consists of a variety of invertebrates, including insects, annelids, molluscs, and crustaceans. A variety of terrestrial and aquatic species are known or expected to inhabit the site and associated habitats. Some of these aquatic species include: Atlantic croaker (*Micropogonias udulatus*), American shad (*Alosa pseudoharengus*), Atlantic menhaden (*Brevoortia tyrannus*), mummichog (*Fundulus heteroclitus*), blue crab (*Callinectes sapidus*), and eastern oyster (*Crassostrea virginica*). Avian species found in the watershed include: great blue heron (*Ardea herodias*), herring gull (*Larus agentatus*), marsh wren (*Cistothorus palustris*), black-crowned night heron (*Nycticorax nycticorax*), belted kingfisher (*Ceryle alcyon*), snowy egret (*Egretta thula*), and red-winged blackbird (*Agelarius phoeniceus*). Other aquatic bird species noted during a site visit include osprey (*Pandion haliaetus*), double crested cormorant (*Phalacrocorax auritius*), snowy egret (*Egretta thula*), laughing gull (*Larus articillia*), brown pelican (*Pelecanus occidentalis*), and mallard duck (*Anas platyrhynchos*). Some of the mammals that are expected to use the aquatic areas for food or habitat include muskrat (*Ondatra zibethica*), marsh rabbit (*Sylvilagus palustris*), rice rat (*Oryzomys palustris*), mink (*Mustrela vison*), opossum (*Didlphis marsupialis*), and raccoon (*Pryocyon lotor*).

The edges of the Southern Branch of the Elizabeth River have significant areas of bulkhead, especially downstream of the AWI facility, but it also has viable habitats. In 2004, ERP was involved in the construction of an oyster reef across the river from the Wyckoff inlet.

5.5 Nature and Extent of Contamination

The primary contaminants found at the site are PAHs (including DNAPL); benzene, toluene, ethylbenzene, xylenes (BTEX); various metals; PCP; and dioxin. Pesticides were also detected. The extent of contamination in soil, ground water, and river sediment, including areas where DNAPL is present, are shown on **Figure 2**.

5.5.1 Soil

Surface and subsurface soils over the entire AWI property are contaminated with a variety of organic compounds including PAHs, PCP, and dioxin, as well as several metals, including arsenic, copper, chromium, and zinc. In general, the entire east side of the facility is contaminated with PAHs and PCP in surface and subsurface soils. Dioxins contaminate the surface soils in the north central, central, and eastern part of the east side. The ABM Area is contaminated with PAHs and several metals, including arsenic, copper, and zinc. There currently is no system in place to control contaminated runoff from migrating to the restored wetlands.

Table 1 below describes generally the contamination on the west side of the AWI property.

Table 1: Contaminants on West Side of AWI Property

Area	Contaminants
Historic Disposal Area	PAHs, BTEX, PCP, dioxin, and metals (limited)
Open Dump Area	PAHs, PCP, dioxin
Wood Storage Area	PAHs (hot spots only), metals (widespread), PCP (limited)

5.5.2 Dense Non-aqueous Phase Liquid (DNAPL)

In the Wood Treatment Area/Former Tank Area, residual DNAPL remains in the fill and upper Columbia sand. Clay lamina in the upper Columbia sand inhibit downward migration of DNAPL in this area. In the Open Dump Area, DNAPL is present in the surface soils, and while the PAH levels decrease with depth, there is some indication that the contamination has migrated downward through sand layers to the top of the Columbia clay.

High levels of creosote contamination are found at the Historic Disposal Area, although lateral migration of the contamination beyond where it was originally disposed has apparently been limited. DNAPL has penetrated vertically downward through the Columbia clay layer into the lower Columbia sand via a former monitoring well (now abandoned). See **Figures 5** and **10** for the vertical distribution of DNAPL across the site and **Figures 11** and **12** for the distribution of total PAHs in the upper four feet of site soils.

Sources of DNAPL to the river include the former sewer line that discharged to the Northern Inlet, as well as a process discharge line that discharged south of the AWI pier. DNAPL that was originally deposited in fill along the eastern AWI shore may have migrated through either the fill or the upper Columbia sand into the river. The former Wyckoff facility is also a likely source of DNAPL from discharge during operations, subsurface migration, and/or perhaps freshly treated wood that may have been stored on the railroad pier that was located over the Wyckoff inlet. It is not possible with the data collected to date to determine the relative contributions of contamination from AWI and the former Wyckoff facility in the Wyckoff inlet.

In the river, there is evidence that DNAPL has migrated through the limited Columbia sand (very near shore), along the surface of the incised Columbia Clay or re-worked clay, and through fractures in the clay. Creosote DNAPL can also be found in the river just off the easternmost point of the Portsmouth Port and Industrial Commission. Heaviest DNAPL concentrations are found in the immediate area (south and east) of the AWI pier, in the Wyckoff Inlet, and just east of the Northern Inlet.

5.5.3 Ground Water

Contamination, primarily VOCs (including BTEX), PAHs, and metals, is found in the upper and lower Columbia Aquifers. PCP is found in limited areas in both of these aquifers, and low levels of dioxin are found in all three aquifers. Very limited contamination is found in the Yorktown Aquifer.

5.5.3.1 Upper Columbia Aquifer

The upper Columbia Aquifer, in both the Former Tank Area and in the southwest corner of the AWI property (near the Historic Disposal Area), is contaminated with BTEX. The extent of

VOCs north of the Former Tank Area has been defined by the northernmost monitoring well, located on Navy property (see **Figure 7**). BTEX contamination is also found in the southwest corner of the AWI property where it likely flows about 50 feet southwestward to the bed of the 72-inch storm drain, then southward, discharging to Paradise Creek. Low levels of BTEX have been found in the storm drain and Paradise Creek surface water, however the source of that BTEX is uncertain and may be the Navy's Paradise Creek disposal facility. Concentrations of BTEX in both areas have decreased significantly since first being detected in 1989 (see **Figure 13**).

The majority of the PAHs in the shallow aquifer are found in the Wood Treatment Area, with concentrations declining considerably downgradient and off site (to the northeast). No benzo(a)pyrene equivalents were detected in the northeast off-site wells (see **Figure 14**). No ground water samples were collected from the southwest corner of the 3971 Elm Avenue property, however, creosote and creosote odors were noted in the upper Columbia sand from soil borings drilled in that corner in 2006. This observation is consistent with the off-site migration of the contamination in that area. PAHs in the southwest corner of the facility were highest at monitoring well MW-30 (now abandoned), located along the southern property line near the Historic Disposal Area, where trace levels of DNAPL were observed.

PAH contamination in the southwest corner of the AWI property likely flows westward to the bed of the 72-inch storm drain, then southward, discharging to Paradise Creek. No PAHs were detected in surface water samples (collected by the Navy) from the storm drain or surface water downstream of the AWI site. PAHs were detected in sediment samples from the drain but at concentrations on the same order of magnitude as from an immediately upstream location on Paradise Creek, adjacent to NNSY IR Site 3. No sediment samples were collected from the storm drain upstream of the AWI site. Another likely source for the PAHs is runoff from roadways drained by the sewer line.

PCP is found to the southwest of the Historic Disposal Area, along the north edge of the AWI property (just west of Burton's Point Road), in the Wood Treatment Area, and in the ABM Area (see **Figure 15**). The off-site extent of PCP contamination has been defined for these areas, with the exception of north of the Wood Treatment Area towards the 3971 and 3975 Elm Avenue properties. Based on the limited extent of PCP migration from other more highly contaminated wells, the extent of PCP migration in this area is not expected to be significant. No PCP was detected in the surface water and stormwater samples collected by the Navy from Paradise Creek and/or the 72-inch storm drain.

Dioxin/furans are widespread in the upper Columbia Aquifer across the AWI facility, but concentrations only exceed EPA Region 3's risk-based concentration (RBC)[2] screening levels at on-site locations, and only exceed the maximum contaminant level (MCL) of 30 picograms per liter in the Wood Treatment Area and downgradient of the Historic Disposal Area (see **Figure 16**).

Arsenic, manganese, and iron are frequently found at concentrations exceeding the screening RBCs (see **Figure 17**). The iron and manganese concentrations do not exceed the background concentration at the nearest location with available data. The concentration of arsenic does exceed the background values at some locations; however, the concentrations of metals are primarily a concern only in the ABM Area where arsenic, cadmium, and lead exceed MCLs. Concentrations of these three metals in the off-site, downgradient sample did not exceed MCLs, although arsenic and manganese exceeded the screening RBC.

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[2]RBCs can be found at http://www.epa.gov/reg3hwmd/risk/human/index.htm. Note that RBCs can change over time.

The most mobile of these contaminants are the VOCs. The remaining contaminants are less soluble in water and will tend to adsorb to the particulate matter (fine clay and organic matter) in the aquifer. The upper Columbia Aquifer consists of silty and clayey sand with clay lenses and therefore provides material which would retard contaminant migration through the aquifer.

Contaminants in the central part of the AWI facility flow east toward the river, and those in the Former Tank Area flow northeast toward the NNSY and the 3971 and 3975 Elm Avenue properties. BTEX and SVOC contamination in the southwest corner of the AWI property likely flows westward to the bed of the 72-inch storm drain, then southward, discharging to Paradise Creek. As part of the Navy's Paradise Creek Landfill investigation, water in storm drains upstream and downstream of the Paradise Creek Disposal Area and AWI were sampled. The results of the analysis of samples from the storm drain that discharges in Paradise Creek showed that the site was not adversely impacting the creek. Upstream water contained higher levels of vinyl chloride (0.4 J μg/l)[3] than at the downstream end (0.1 J μg/l). The only other organic compound detected was di-n-butyl phthalate at a concentration of 1 J μg/l. No sediment was collected in the upstream location, but the sediment sample from the discharge point of that storm drain contained approximately 5 parts per million (ppm) total PAHs and 1 ppm bis-2-ethyl hexyl phthalate. Although the PAHs may be in part due to AWI, they may also be present from other sources along the drainage path (e.g., Paradise Creek Landfill and stormwater runoff).

Contamination can enter the lower Columbia Aquifer from the upper Columbia Aquifer by vertical flow in those parts of the site where the Columbia clay confining unit is thin and leaky, particularly in the western part of the AWI property near the Historic Disposal Area. In those areas where the Columbia clay is thicker (as well as in areas where it is thin), it is possible that contamination has migrated from the upper to lower aquifers through wells whose construction has connected the two aquifers (which have now been abandoned).

Oxidation-reduction potential readings taken in the upper Columbia ground water on the eastern side of the AWI property ranged from -21 to -223 milli-volts, with the stronger reducing potential measured in wells nearer the Elizabeth River. These readings indicate that the upper Columbia ground water is in a reducing condition, as would be expected due to the prevalence of organic ground water contamination.

5.5.3.2 Lower Columbia Aquifer

VOCs (mostly BTEX) have migrated to the lower Columbia Aquifer in the eastern side of the AWI facility (see **Figure 8**). Due to the proximity of the river, these contaminants would be expected to discharge to the river. South of the Historic Disposal Area on the Portsmouth Public School District property, the lower Columbia Aquifer is contaminated with VOCs (including BTEX), relatively high concentrations of acetone, as well as lower concentrations of trichlorobenzenes and dichlorobenzenes. The source of the non-BTEX contaminants is not clear. Elsewhere on the site, acetone was only detected in a limited area near the shoreline. A possible source for those chemicals in the school district property is the Navy's Paradise Creek disposal area located upgradient of the AWI site. Another potential source could be the school bus maintenance operations. The extent of these contaminants downgradient of the AWI property (to the east) has not been determined.

PAHs are found in the lower Columbia Aquifer at the east end of the AWI facility at fairly high concentrations (see **Figure 18**). The presence of contamination in this location is probably due to poor well construction as there is a significant thickness of clay that would be expected to prevent vertical migration from the upper Columbia Aquifer. PAHs are also found to a limited extent south of the Historic Disposal Area.

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[3]"J" means that the quantity was estimated.

The VOCs and the other contaminants in the lower Columbia Aquifer on the east end of the site most likely entered the aquifer via a poorly constructed well (MW-205, now abandoned). Concentrations of BTEX significantly decline (to 45 µg/l) 150 feet downgradient at MW-F69C2. Concentrations of total PAH in the lower Columbia are higher in MW-F69C2 (1,272 µg/l) than at MW-205 (403 µg/l). This difference may indicate that the PAHs were introduced into this aquifer as a "slug" when MW-205 was drilled and have slowly migrated eastward since then. One anomaly is the presence of 160 µg/l of acetone in MW-F69C2. (See **Figures 8** and **18**.)

PCP is only found in the lower Columbia Aquifer south of the Historic Disposal Area, and the downgradient extent has been determined (see **Figure 19**). Although the Columbia clay is thin (or absent) in this area, and ground water can flow downward from the more-contaminated upper Columbia Aquifer, a major source of contamination in the lower Columbia in this area was MW-30, which was screened across the thin clay, connecting the upper and lower Columbia Aquifers. In fact, creosote DNAPL was found in the bottom of this well, and the well was abandoned during the RI.

Dioxins/furans are found in nearly all of the lower Columbia Aquifer wells, but no concentrations exceeded the MCL (see **Figure 20**). The downgradient extent, east of the school district property, has not been determined.

Arsenic is the only metal that exceeds an MCL in the lower Columbia Aquifer. This exceedance is in the central Wood Treatment Area.

Contamination in the lower Columbia Aquifer flows eastward toward the river. Due to downward vertical gradients, dissolved contamination could be transported to the Yorktown Aquifer on the western part of the AWI property.

5.5.3.3 Yorktown Aquifer

No VOCs, PAHs, or PCP were detected in the Yorktown Aquifer at the AWI property. Very low levels (below the RBC and MCL) of dioxin/furans were detected at the well closest to the Historic Disposal Area and the well at the east end of the property (see **Figure 21**). The well downgradient of the Historic Disposal Area did not have any dioxin, indicating that the concentrations attenuate with ground water flow in the aquifer. Similar to the other aquifers, iron and manganese concentrations in all wells exceed the RBCs (see **Figure 22**). The only other metal that exceeds the RBC is arsenic in the well closest to the Historic Disposal Area. Downgradient arsenic was not detected, again indicating that concentrations attenuate with distance. Contaminants in the Yorktown Aquifer flow eastward to the river.

5.5.3.4 Evidence of Natural Attenuation

EPA's guidance on monitored natural attenuation (MNA)[4] lists three tiers, or lines of evidence, for demonstrating MNA. The top tier is "historical groundwater and/or soil chemistry data that demonstrate a clear and meaningful trend of decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points." In the upper Columbia Aquifer, there is a ring of 17 wells that surround what would be approximately the boundary of the waste management area that were sampled for BTEX and PAHs in 1989 and 2002. In the lower Columbia Aquifer, three wells were sampled for BTEX and PAHs in 1989 and 2002 or 2004.

In regard to BTEX in the upper Columbia Aquifer, seven of 17 wells that had detections in 1989 had significant reductions in concentrations in 2002 (see **Figure 13**). The reductions ranged

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[4]"Use Of Monitored Natural Attenuation At Superfund, RCRA Corrective Action, And Underground Storage Tank Sites," (OSWER DIRECTIVE 9200.4-17P, April 21, 1999).

from 39% to 100% with an average reduction of 88%. In regard to total PAHs in the upper Columbia Aquifer, 14 of the 17 wells had detections in 1989, 2002 or both. At nine locations, concentrations decreased an average of 82%. At four wells, total PAH concentrations increased very slightly (under 10 μg/l). Each of these locations is currently downgradient of an area where DNAPL will be removed from the west side of the AWI property. At the remaining well located along the north edge of the Wood Treatment Area, the total PAH concentration increased from 358 μg/l to 750 μg/l. This well is currently on the downgradient side of the Wood Treatment Area and likely at the edge of the proposed grading and soil cover area. Once the cover has been in place for a period of time, the well would no longer be downgradient resulting in an expected decline in the PAH concentrations.

Three wells were sampled in the lower Columbia Aquifer for BTEX and PAHs in 1989 and 2002. No contamination was detected in either year in one well located at the west end of the eastern half of the AWI property. In a well near the Historic Disposal Area, BTEX levels decreased slightly, while total PAH levels increased slightly. In a well located on the AWI property near the Elizabeth River, both BTEX and total PAH levels increased significantly. EPA has determined that the last two wells were poorly constructed, allowing contamination to migrate to the lower aquifer, and were abandoned.

In regard to metals in the lower and upper portions of Columbia Aquifer, 20 wells were sampled for arsenic, chromium, copper and zinc in 1989 to 1990 and 2002 or 2004. The contaminant levels are generally relatively low compared to MCLs. The levels vary over time in no recognizable pattern either temporally or spatially, but rather appear to have random variations.

Many of the planned remedial activities will increase the applicability of MNA to the ground water. The removal of the DNAPL from the Historic Disposal Area on the west side of the AWI property will remove the major source of ground water contamination beyond the waste management area to the PPSD property and the South Annex of the NNSY. The reduced rain water infiltration from the surface grading (to remove the low area in the middle of the west side of the AWI property) and the soil cover and/or pavement will reduce the ground water mound that is centered in the middle of the western portion of the AWI property which will help restore the natural ground water flow direction more directly toward the Southern Branch of the Elizabeth River.

5.5.4 River Sediment

The extent of elevated PAH contamination in the river sediments is generally bounded on the east by the navigation channel, on the north by the first railroad bridge north of the Jordan Bridge, and on the south to about Navy Pier C at Southgate Annex (see **Figure 2**). South of Pier B, the contamination adjacent to Southgate Annex is found at the eastern end of the piers (see **Figure 2**). In addition to data collected by EPA, information from a Navy PAH fingerprinting study performed in 2003 was used to estimate the extent of contamination in the area of the Southgate Annex piers.

Free-phase DNAPL and/or DNAPL staining are found in the Wyckoff Inlet, the AWI Northern Inlet, the south side of the AWI pier, and in the acetylene sludge near the discharge point of the wetlands. The DNAPL extends to low areas incised into the Columbia clay (either naturally or through dredging). In the heavily-contaminated Wyckoff Inlet, it is not clear whether DNAPL migrated downward through the highly contaminated recent river sediments or moved laterally, from either AWI or the former Wyckoff Pipe & Creosoting property, or both. Lateral migration could be via the upper Columbia sand or through fill. In this inlet, the vertical extent of DNAPL contamination was not determined either at the western end of the inlet and at a point about 250 feet north of the east end of the Jordan Bridge. At these locations DNAPL was found extending several feet into the top of the Columbia clay.

In some areas PAH contamination is only present as a thin layer (less than 0.5 feet). These areas include the perimeter of the Wyckoff Inlet and the area just north of the discharge point of the restored wetland. At a few points, generally located south of the AWI facility, PAH-contaminated recent sediment (and in some cases re-worked clay) is sandwiched between a layer of clean recent sediment above and a layer of clean re-worked clay or Columbia clay below.

The calcium hydroxide sludge (acetylene sludge) in the river is within a relatively small area at the mouth of the restored wetland. The vertical extent of this contamination has not been fully delineated. Both locations where sludge was encountered had over 11 feet of sludge, and the bottom of the sludge was not encountered in one boring.

Polychlorinated biphenyls (PCBs) were not detected in the recent river sediment samples, but have been found in a limited number of samples in the past. There are nearby sources of PCBs on Paradise Creek, which is a tributary to the Southern Branch of the Elizabeth River just upstream from the site. The highest concentrations of dioxins/furans were found near areas also containing high concentrations of PAHs and DNAPL: the Wyckoff Inlet, south of the AWI pier, just east of the Northern Inlet, and just north of the restored acetylene sludge wetland. The highest dioxin concentration was detected in a sample from the Wyckoff Inlet.

The dioxin in these samples were composed predominantly of 1,2,3,4,6,7,8,9-octachloro dibenzo-p-dioxin (OCDD) with minor amounts of 1,2,3,4,6,7,8-heptachloro dibenzo-p-dioxin (HpCDD). This composition is indicative of technical grade PCP as a source. PCP was not used in wood preserving prior to 1936. Since Wyckoff Pipe & Creosoting was likely not in operation (or near the end of its operation) in 1936, it is likely that the source of PCP-related dioxin in the Wyckoff Inlet is AWI.

Most of the sediment samples had concentrations of metals exceeding at least one of the Region 3 BTAG Screening Levels for Marine Sediments. The majority of the contaminated samples were collected from the silty recent sediments, and a few were collected from the re-worked clay.

Metals concentrations from 49 river sediment samples were compared to the lowest no observed adverse effect level (NOAEL) and the lowest lowest observed adverse effect level (LOAEL) derived for the five ecological receptors in the baseline ecological risk assessment. The majority of the samples exceeded the lowest NOAEL for arsenic, chromium, lead, and zinc. Fewer than 50% of the sediment samples exceeded the lowest LOAEL for these metals with no samples exceeding the lowest LOAEL for zinc.

Sediment samples were analyzed for tributyl tin (TBT) to determine if significant mixing of the recent sediment occurs due to propeller wash. The higher concentrations of TBT found in the surface investigation samples, relative to the lower concentrations in the deeper samples of the recent river sediment investigation, appear to indicate that recent sediments have not been significantly mixed. An exception to this is the area south of the AWI pier. No TBT samples were collected in this area, but spuds on barges loading and unloading materials to and from the AWI facility have clearly mixed the soft sediments in this area.

5.6 Conceptual Site Model

A Conceptual Site Model (CSM) diagrams contaminant sources, contaminant release mechanisms, and migration routes; exposure pathways; and potential human and ecological receptors.

Figure 23 shows a CSM for the area of the site that includes the AWI river bank and the Elizabeth River. It shows some of the release and transport mechanisms that exist or are expected to exist at the site. Based on how the site was operated, and the location of contamination, and ground water flow, creosote probably migrated to the river from both surface discharge and subsurface migration. EPA was not able to estimate the proportion of creosote in the river to due each transport mechanism. The high amount of DNAPL both at the shore line and in the river sediment and the amount of large concrete rubble along the shore line which prevented placement of borings right at the shore made evaluating the transport mechanisms difficult. Site receptors include individuals and ecological receptors that may be exposed to the contaminants in the soil, sediments, air, ground water, and the food chain.

6. CURRENT AND POTENTIAL FUTURE SITE USES

The AWI facility is currently the location of pre-stressed, pre-cast concrete manufacturing operations. AWI recently upgraded the facility by building a concrete batch plant at the facility. From discussions with AWI, EPA expects the operation to remain for the foreseeable future. AWI is planning on consolidating its operations to just one side of the property (most likely the east side). This would allow redevelopment to take place on the other side. EPA has had discussions with AWI and the Economic Development Department of the City of Portsmouth in an effort to facilitate redevelopment. The current plan is for the property to remain industrial.

The site is surrounded on three sides by the Norfolk Naval Shipyard (which is also an NPL site), other government facilities (the Portsmouth Public School District [PPSD] Operations Center and the SPSA incinerator), and other properties zoned for industrial use. The AWI facility sits on the banks of the Southern Branch of the Elizabeth River where it flows through a highly industrialized area. Besides those facilities mentioned above, oil storage facilities, chemical manufacturing facilities, a fertilizer plant, a cement storage facility, several hazardous waste cleanup sites, and a power plant are nearby.

Plans for the former J.G. Edwards facility across the river and just downstream from the site in the City of Chesapeake include cleanup and the construction of a multi-use development that includes residential areas (condominiums). A city park with a boat ramp and much-used fishing pier is located at the confluence of Scuffletown Creek and the Southern Branch of the Elizabeth River, directly across the river from the AWI facility. Other current recreational activities on the river include boating and jet skiing.

The Commonwealth of Virginia (pursuant to 9 VAC 25-260-10) has designated all state waters and wetlands, including the Southern Branch of the Elizabeth River, for the following uses:

> [R]ecreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.

Virginia has designated the Southern Branch as Class IIB, signifying that the waters are estuarine and defining the water quality standards which are to be met for pH, dissolved oxygen, and inorganic and organic pollutants. The taking of shellfish from the Elizabeth River is prohibited by the Virginia Department of Health due to the presence of bacteria.

The USACE maintains a navigational channel in the Southern Branch that runs past the site. The channel has an authorized depth (by Congress) of 40 feet. The USACE maintains the depth at 35 feet. During the OU3 sediment study, EPA found the depth near the site to be 35 to 40 feet. The main stem of the Elizabeth River is authorized to 45 feet. The USACE is studying the possibility of deepening the channel in the Southern Branch to 40 to 45 feet. At least one stakeholder upstream of the site has said that it can not bring in ships completely loaded with product because of inadequate channel depth. The Navy is conducting an Environmental Impact

Statement to evaluate deepening the channel to 47 to 50 feet, south to the just past the confluence of Paradise Creek and the Southern Branch, upstream of the site. The Navy's goal is to increase the operational capability of the channel for aircraft carriers.

No one is currently using the ground water at the site, and there are no known planned uses, although ground water in Portsmouth can legally be used for non-drinking water purposes.

7. SUMMARY OF SITE RISKS

This section of the ROD summarizes the results of the human health and the ecological risk assessments. Risk assessments were conducted to evaluate current and potential future risks to human health and the environment from exposure to contaminants in soil, ground water, air, sediment, and biota assuming that no active remediation would take place.

The baseline human health risk assessments (HHRAs) for each operable unit[5] were conducted in order to estimate the probability and magnitude of potential adverse human health effects from exposure to site-related contaminants, assuming no further response actions are undertaken. A screening-level ecological risk assessment was conducted to evaluate potential risks to ecological receptors from exposure to soil contamination (this risk assessment modified the ecological risk assessment conducted for OU1 before the 1995 ROD). A baseline ecological risk assessment was conducted to evaluate risks to ecological receptors from contamination in the river sediments. The risk assessments provide the basis for taking action and identify the contaminants and exposure pathways that need to be addressed by the remedial action at the site.

7.1 Human Health Risk Assessment

The risks to human health, both current and potential future, were evaluated in the following reports: Final Human Health Risk Assessment OU1 (report dated 3/16/04, EPA approval dated 12/6/06; Toxicological Profile Summaries added 7/8/07); Final Human Health Risk Assessment for OU2 Groundwater (report dated 5/29/07, EPA approval dated 6/11/07); and Final Human Health Risk Assessment (RA) for Operable Unit 3 River Sediment (report dated 7/5/07, EPA approval dated 7/8/07).

As discussed in the adjacent box, EPA evaluates both carcinogenic and non-carcinogenic risks. EPA generally determines that there are unacceptable risks when the carcinogenic risk is greater than $1x10^{-4}$ and the hazard index (HI) (used to estimate non-carcinogenic risk) is greater than one.

To determine whether there is an actual or a potential impact at the site, a complete exposure pathway must be established. A complete exposure pathway consists of the following components:

1. A source or mechanism for contaminants to be released to the environment;

2. A medium through which contaminants may be transported such as water, soil, sediment, or air;

3. A point of actual or potential exposure or contact for humans; and

4. A route or mechanism such as ingestion, inhalation, or dermal contact for exposure at the contact point.

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[5]A new HHRA for OU1 was conducted after the 1995 ROD.

Details of the operational history of the AWI facility coupled with the sampling data has provided information regarding sources and/or mechanisms for release of contaminants to the environment. These sources include at least one leaking storage tank, treatment chemicals dripping from treated wood, direct discharge to soil and surface water, filling of low-lying areas with contaminated fill, and other potential sources. Sampling data showed that contaminants have and/or can be transported by soil, ground water, surface water, sediment, air, and biota tissue.

Based on the operational history of the site, the location of the contaminants, the current site use, and potential future site use, EPA developed scenarios whereby humans do now and/or could in the future come into contact with contaminants from the site. The risks for a particular scenario were evaluated for each possible route of exposure; for example, someone wading in the river could ingest contamination in sediments and absorb contaminants though the skin.

Each of these evaluations consisted of a four-step process:

1. Identification of contaminants of potential concern (COPCs), i.e., chemicals that have the potential to cause adverse health effects;

2. An exposure assessment, which identified actual and potential exposure pathways, potentially exposed populations, and the magnitude of possible exposure;

3. A toxicity assessment, which identified the potential adverse health effects associated with exposure to each COPC and the relationship between the extent of exposure and the likelihood or severity of adverse effects; and

4. A risk characterization, which integrated the three earlier steps to summarize the potential and actual risks posed by hazardous substances at the site, including carcinogenic and non-carcinogenic risks. A summary of those aspects of the human health risk assessment which support the need for remedial action is discussed below.

WHAT IS RISK AND HOW IS IT CALCULATED?

A Superfund human health risk assessment estimates the "baseline risk." This is an estimate of the likelihood of health problems occurring if no cleanup action were taken at a site. A four-step process is used to estimate the baseline risk at a Superfund site:

Step 1: Analyze Contamination
Step 2: Estimate Exposure
Step 3: Assess Potential Health Dangers
Step 4: Characterize Site Risk

In Step 1, EPA looks at the concentrations of contaminants found at a site as well as past scientific studies on the effects these contaminants have had on people (or animals, when human studies are unavailable). Comparisons between site-specific concentrations and concentrations reported in past studies enables EPA to determine which contaminants are most likely to pose the greatest threat to human health.

In Step 2, EPA considers the different ways that people might be exposed to the contaminants identified in Step 1, the concentrations that people might be exposed to, and the potential frequency and duration of exposure. Using this information, EPA calculates the "reasonable maximum exposure" (RME) scenario, which portrays the highest level of human exposure that could reasonably be expected to occur.

In Step 3, EPA uses the information from Step 2 combined with information on the toxicity of each chemical to assess potential health risks. EPA considers two types of risk: cancer risk and non-cancer risk. The likelihood of any kind of cancer resulting from a Superfund site is generally expressed as an upper bound probability–for example, a "1 in 10,000 chance." In other words, for every 10,000 people that could be exposed to site contaminants, one extra cancer *may* occur as a result of the exposure. An extra cancer case means that one more person could get cancer than would normally be expected from all other causes. For non-cancer health effects, EPA calculates a "hazard index." The key concept here is that a "threshold level" (measured usually as a hazard index of less than one) exists below which non-cancer health effects are no longer predicted.

In Step 4, EPA determines whether site risks are great enough to cause health problems for people at or near the Superfund site. The results of the three previous steps are combined, evaluated and summarized. EPA adds up the potential risks from the individual contaminants and exposure pathways and calculates a total site risk.

7.1.1 Contaminants of Potential Concern

During the remedial investigations, a number of organic and inorganic chemicals were detected in multiple samples in site soils, sediments, ground water, and biota tissue. Soil, sediments, and ground water samples were analyzed for metals, VOCs, semi-volatile organic compounds, pesticides, PCBs, dioxins/furans (not every sample was analyzed for every contaminant) and, for sediments, TBT.

In order to determine which chemicals would be labeled as COPCs, the maximum concentrations and/or analytical method detection limits were compared to the RBCs. When the maximum concentration or method detection limit for a particular chemical exceeded its RBC, the chemical was retained in the risk assessment as a COPC, which means that it warranted a detailed evaluation.[6] Risk calculations were based on either the 95th percent upper confidence limit (UCL) of the arithmetic mean or the maximum detected concentration for each COPC. The lower of these two values was used in the risk calculations as the exposure point concentration in each medium where a chemical was a COPC. The use of these values helps produce a reasonable maximum exposure scenario. **Appendix C** lists the COPCs and summary statistics for the contaminant levels in soil, sediment, air, biota tissue, and ground water. Not all of the COPCs became contaminants of concern (COCs) for the site. The COCs can be found in **Tables 4** and **5**.

7.1.2 Exposure Assessment

7.1.2.1 Exposure Scenarios

Potential human health effects associated with exposure to the COPCs were estimated quantitatively or qualitatively through the evaluation of several actual or potential exposure pathways. These pathways were developed to reflect the potential for exposure to hazardous substances based on past, current, and potential future site use. The various scenarios that were evaluated are presented in **Table 2** below.

Table 2: Exposure Scenarios Evaluated in the Human Health Risk Assessments

Current Exposure Scenarios	Potential Future Exposure Scenarios
Operable Unit 1	
Industrial Worker (adult): incidental ingestion of and dermal contact with onsite surface soil; inhalation of airborne particulates from onsite surface soil	Industrial Worker (adult): incidental ingestion of and dermal contact with onsite soil; inhalation of airborne particulates from onsite soil
Onsite Other Worker (adult): incidental ingestion of and dermal contact with onsite surface soil and inhalation of airborne particulates from onsite surface soil for onsite office workers	Onsite Other Worker (adult): incidental ingestion of and dermal contact with onsite soil and inhalation of airborne particulates from onsite soil for onsite office workers; included an evaluation of vapor intrusion
Offsite Other Worker (adult): inhalation of airborne particulates from onsite surface soil for offsite shipyard workers	Offsite Other Worker (adult): inhalation of airborne particulates from onsite soil for offsite shipyard workers

[6] The identification of COPCs was performed utilizing the EPA guidance, "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening" (EPA Region 3, 1992).

Current Exposure Scenarios	Potential Future Exposure Scenarios
Trespasser/Visitor (adult and child): incidental ingestion of and dermal contact with onsite surface soil; inhalation of airborne particulates from onsite surface soil	Trespasser/Visitor (adult and child): incidental ingestion of and dermal contact with onsite soil; inhalation of airborne particulates from onsite soil
Other (child): inhalation of airborne particulates from onsite surface soil for school children using the buses located in the Portsmouth City School Board property	Construction Worker (adult): incidental ingestion of and dermal contact with onsite soil; inhalation of airborne particulates from onsite soil
	Other (child): inhalation of airborne particulates from onsite soil for school children using the buses located in the PPSD property
Operable Unit 2	
No current exposure; note that the vapor intrusion pathway was considered for the current scenario, however, EPA concluded that it was not required to be evaluated based on current site conditions. If the site is redeveloped in the future, vapor intrusion could potentially be an issue due to the shallow depth to ground water (4 to 6 feet below ground surface).	Construction workers (adult): incidental ingestion, dermal contact, and inhalation of VOCs released from the shallow ground water during future excavating or trenching activities
	Maintenance workers (adult): incidental ingestion and dermal contact from mixed (shallow and intermediate depth) and deep ground water through the course of watering the landscape or other site maintenance activities.
	Industrial workers (adult): incidental ingestion, dermal contact, and inhalation of VOCs released from mixed (shallow and intermediate depth) and deep ground water used for drinking or showing
Operable Unit 3	
Subsistence Fishers (adult and children): Ingestion of contaminated crabs and oysters (adult) and crabs (children)	Subsistence Fishers (adult and children): Ingestion of contaminated crabs and oysters (adult) and crabs (children)
Recreational Fishers (adult and children): Ingestion of contaminated crabs and oysters (adult) and crabs (children)	Recreational Fishers (adult and children): Ingestion of contaminated crabs and oysters (adult) and crabs (children)
Recreational users of river (adult and children): incidental ingestion and dermal contact with contaminated sediments through setting crab pots, tonging for oysters, and other recreational activities (boating, jet skiing, or swimming)	Recreational users of river (adult and children): incidental ingestion and dermal contact with contaminated sediments through setting crab pots, tonging for oysters, and other recreational activities (boating, jet skiing, or swimming)
Construction worker (adult): incidental ingestion and dermal contact of contaminated sediments during construction activities	Construction worker (adult): incidental ingestion and dermal contact of contaminated sediments during construction activities
Industrial worker (adult): incidental ingestion and dermal contact of contaminated sediments during operation of dredges or other heavy equipment (includes operators, spotters, or barge workers)	Industrial worker (adult): incidental ingestion and dermal contact of contaminated sediments during operation of dredges or other heavy equipment (includes operators, spotters, or barge workers)

In addition, there is potential for these receptors to be exposed to high concentrations of PAHs (i.e., DNAPL) and acetylene sludge (calcium hydroxide) in the sediment. Therefore, these pathways were qualitatively evaluated in the HHRA because (1) EPA's risk assessment methodology does not easily evaluate acute risks and (2) a lack of analytical data for these pathways.

7.1.2.2 Exposure Assumptions

The soils and DNAPL HHRA evaluated risks to industrial workers, construction workers, office workers, and trespassers/visitors at the site and to other off-site workers (shipyard workers) for ingestion, skin contact, or inhalation of SVOCs, dioxins, and metals in surface soil. In evaluating risks, EPA uses conservative assumptions. The use of conservative assumptions helps ensure that risks are evaluated for a person that may be more sensitive to contamination, such as a child or a pregnant woman.

A number of assumptions are used in the risk assessment process to calculate the dose or rate of intake of a contaminant for each exposure pathway since it is seldom possible to measure a specific dose. See **Appendix D** for the exposure assumptions for each exposure scenario in **Table 2** above.

7.1.3 Toxicity Assessment

Excess lifetime cancer risks were determined for each exposure pathway by multiplying a daily intake level by the chemical-specific cancer potency factor. Cancer potency factors (called slope factors [SFs]) have been developed by EPA from epidemiological or animal studies to reflect a conservative upper bound of the risk posed by potentially carcinogenic substances. The resulting risk estimates are expressed in scientific notation as a probability (e.g., 1×10^{-6} or 1/1,000,000) and indicate (using this example) that an average individual is not likely to have greater than a one in a million chance of developing cancer over 70 years as a result of site-related exposure to the contaminant at the stated concentrations. All risks estimated represent an "excess lifetime cancer risk," or the cancer risk posed by exposure to site contaminants that is beyond risks from other common causes such as cigarette smoke or exposure to ultraviolet radiation from the sun. EPA's generally acceptable risk range for site-related exposure is 1×10^{-4} to 1×10^{-6}. Current EPA practice considers carcinogenic risks to be additive when assessing exposure to multiple hazardous substances, or exposure via multiple pathways. A summary of the cancer toxicity data applied to the COPCs for each OU is presented in **Appendix E.**

In assessing the potential for exposure to a chemical to cause adverse health effects other than cancer, a hazard index (HI) is calculated by dividing the daily intake level by the reference dose (RfD) or other suitable benchmark. EPA has developed RfDs for many chemicals which represent a level of exposure that is expected to result in no adverse health effects. RfDs are derived from epidemiological or animal studies and incorporate uncertainty factors to help ensure that the potential for adverse health effects will not be underestimated. A HI < 1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that harmful non-cancer effects from that chemical are unlikely. The HI is generated by adding the HIs for all COPCs that affect the same target organ (e.g., liver) within or across those pathways by which the same individual may reasonably be exposed. An HI < 1 indicates that harmful non-cancer health effects are not expected as a result of exposure to all of the COPCs within a single or multiple exposure pathway(s). A summary of the non-cancer toxicity data applied to the COPCs for each OU is presented in **Appendix E.**

7.1.4 Risk Characterization and Contaminants of Concern

The risk assessment concluded that there is unacceptable carcinogenic and non-carcinogenic risk for trespassers and on-site workers due to ingestion and skin exposure (see **Table 3** on page 42). The main risk drivers are arsenic, dioxin, and PAHs. Exposure by inhalation of wind-blown dust did not cause unacceptable risks to workers at or near the site.

Currently, there are no on-site or off-site users of the contaminated ground water in the upper and lower Columbia Aquifers or the Yorktown Aquifer beneath the site. EPA evaluated risks associated with potential future exposure to ground water. Shallow ground water at the site was used to evaluate exposure to future construction workers. Construction workers could come into contact with contaminated shallow ground water during future excavating or trenching activities at the site.

Mixed ground water (from the upper and lower Columbia Aquifers) and deep ground water were used to evaluate exposure to future facility maintenance and industrial workers who could come into contact with contaminated ground water via incidental ingestion and skin contact through the course of watering the landscape or performing other AWI facility maintenance activities if the ground water were used for such purposes. Future industrial workers could also use contaminated ground water for drinking or showering. Unacceptable carcinogenic and non-carcinogenic risks were calculated for both exposure scenarios. Arsenic, dioxin, PCP, and PAHs are the main risk drivers (see **Table 3** on page 42).

Currently, there is limited evidence of recreational activity on the river near the site. However, the likelihood for people to wade in the river or set a crab pot and thereby come into direct contact with river sediment may increase in the future. Condominiums, with a marina, are planned for construction across the Elizabeth River just downstream from the site. Similar plans have been considered for the Portsmouth Industrial and Port Commission property. In these future land use scenarios, recreational users and construction workers could come into contact with contaminated sediment via incidental ingestion and dermal contact. In addition, there is potential for recreational receptors to burn their skin from acute exposure to creosote DNAPL in the sediment.

Exposure to contaminated river sediment for trespassers and recreation users produces unacceptable carcinogenic and non-carcinogenic risks (see **Table 3** on page 42). The highest cancer and non-cancer risk was determined for the child recreational exposure scenario for such activities as swimming, boating, and crabbing. The main risk drivers are arsenic, dioxin, and PAHs. Therefore, recreational activities are discouraged in the western half of the Southern Branch of the Elizabeth River from the Southgate Annex of the NNSY north to the railroad bridge north of the Jordan Bridge.

Carcinogenic and non-carcinogenic risks to construction workers exposed to contaminated river sediment were not unacceptable.

Table 3: Summary of Risks for Receptors (Except Those Consuming Crabs and Oysters) Whose Risk Exceeded a Cancer Risk of $1x10^{-4}$ or Hazard Index=1

Exposure scenarios not in this table did not have unacceptable risk.[7]
C = Current Exposure Scenario F = Future Exposure Scenario
CR = Cancer Risk HI = Hazard Index (Non-cancer Risk)
COC = Contaminant of Concern
Note that the percent contribution may not add to 100% because of rounding errors.

Receptor	Media	Risk Level	COC	Contribution to Cancer Risk	Contribution to Hazard Index	Hazard Index Target Organ
Operable Unit 1						
Industrial Worker (C)	Surface Soil	CR=$8x10^{-4}$	arsenic	5%		
			dioxin	50%		
			PAHs	45%		
			PCP	1%		
Industrial Worker (F)	Soil	CR=$1x10^{-3}$	arsenic	3%		
			dioxin	30%		
			PAHs	67%		
			PCP	1%		
Other Worker (C)	Surface Soil	CR=$5x10^{-4}$	arsenic	6%		
			dioxin	59%		
			PAHs	35%		
Trespasser/ Visitor (child) (C)	Surface Soil	CR=$5x10^{-4}$	arsenic	6%		
			dioxin	60%		
			PAHs	34%		
Trespasser/ Visitor (adult) (C)	Surface Soil	CR=$5x10^{-4}$	arsenic	4%		
			dioxin	40%		
			PAHs	56%		

[7]For the "other (child): inhalation of airborne particulates from onsite soil for school children using the buses located in the PPSD property" exposure scenario (from **Table 2** on page 38), the modeled air concentrations for all contaminants were at or below screening criteria except lead, which has no air screening criteria. EPA's residential soil screening level for lead is 400 ppm. The average lead level at the site is between 450 and 500 ppm lead with the areas of highest concentration being on the east side of the AWI property away from the PPSD property. Since the residential soil screening level is based on significant direct exposure to soil and since the amount of dust in a school bus would be minimal by comparison to a dirt yard, EPA has concluded that there is no unacceptable risk for this scenario.

Receptor	Media	Risk Level	COC	Contribution to Cancer Risk	Contribution to Hazard Index	Hazard Index Target Organ
Other Worker (F)	Onsite Soil	CR=6x10^{-4}	arsenic	3%		
			dioxin	33%		
			PAHs	55%		
			PCP	8%		
Trespasser/ Visitor (adult) (F)	Onsite Soil	CR=7x10^{-4}	arsenic	3%		
			dioxin	29%		
			PAHs	67%		
			PCP	1%		
Trespasser/ Visitor (child) (F)	Onsite Soil	CR=7x10^{-4}	arsenic	3%		
			dioxin	29%		
			PAHs	67%		
			PCP	1%		
Construction Worker (F)	Onsite Soil	CR=1x10^{-4} HI=2 Skin/Vascular HI=1 Blood HI=1 Liver	arsenic	5%	100%	Skin Vascular
			dioxin	40%		
			PAHs	54%	10%/10%	Blood/Liver
			PCP	1%		
			antimony		20%	Blood
			iron		70%/70%	Blood/Liver
			thallium		20%	Liver
Operable Unit 2						
Construction Worker (F)	Shallow Ground Water (during construction activities)	CR=3x10^{-4} HI=13 Development HI=11 Kidney HI=10.1 Liver HI=1.1 Whole Body	dioxin	4%	100%	Human Development
			PAHs	6%	1%/ 100%	Kidney/ Whole Body
			PCP	90%	99%/100%	Kidney/Liver

Receptor	Media	Risk Level	COC	Contribution to Cancer Risk	Contribution to Hazard Index	Hazard Index Target Organ
Industrial Worker (F)	Ground Water (as tap water)	CR=2.5x10^{-2} HI=22 Human Development HI=17 Kidney HI=18 Liver HI=2 Blood HI=3.2 Whole Body HI=68 Respiratory System HI=1 CNS HI=2.2 Skin/Vascular HI=1.3 GI Tract	arsenic		100%	Skin/Vascular
			dioxin	4%	100%	Human Development
			benzene		23%	Blood
			PCP	88%	96%/99%	Liver/Kidney
			PAHs	8%	100%/ 1%/ 94%	Respiratory System/ Kidney/ Whole Body
			iron		4%/40%/ 89%	Liver/Blood/ GI Tract
			manganese		71%	CNS
			p-cresol		21%/ 6%	CNS/ Whole Body
			2,4-dimethyl-phenol		37%	Blood
			xylenes		8%	CNS
			copper		11%	GI Tract
Other Worker (F)	Ground Water (as tap water)	CR=1.4x10^{-3} HI=1.1 Human Development HI=1.1 Liver	arsenic	7%		
			dioxin	4%	100%	Human Development
			PCP	79%	79%	Liver
			PAHs	11%		
			iron		21%	Liver
Operable Unit 3						
Trespasser (adult) (C/F)	Shallow Sediment	CR=1x10^{-3} HI=1.3 Development	arsenic	1%		
			dioxin	8%	100%	Human Development
			PAHs	91%		
Trespasser (child) (C/F)	Shallow Sediment	CR=2.7x10^{-2} HI=98 Human Development HI=3.2 Skin/Vascular	arsenic	4%	100%	Skin/Vascular
			dioxin	5%	100%	Human Development
			PAHs	91%		
Recreation (Swimmer, Boater, Crabber) (adult) (C/F)	Shallow Sediment	CR=1x10^{-3}	arsenic	1%		
			dioxin	6%		
			PAHs	94%		

Receptor	Media	Risk Level	COC	Contribution to Cancer Risk	Contribution to Hazard Index	Hazard Index Target Organ
Recreation (Swimmer, Boater, Crabber) (child) (C/F)	Shallow Sediment	CR=2x10^{-2} HI=100 Human Development HI=3.3 Skin/Vascular	arsenic	1%	100%	Skin/Vascular
			dioxin	6%	100%	Human Development
			PAHs	94%		

See **Appendix F** for detailed results of the risk calculations summarized in the table above.

EPA recently evaluated the levels of contaminants in shellfish caught near the AWI site. Levels of contaminants were high enough to present a potential health risk to individuals who consume a high number of crabs over a lifetime from this stretch of the Southern Branch of the Elizabeth River. Pregnant women, women of child-bearing age, children, and other sensitive subgroups should limit their consumption to reduce their potential heath risk. When eating crabs, individuals should consider eating the meat only instead of the whole crab since the "yellow mustard" (hepatopancreas) of the crab contains the highest levels of contaminants.

EPA evaluated current and future risks to adult and child subsistence and recreational fishers consuming contaminated shellfish (i.e, crabs collected adjacent to the AWI site, crabs collected across the river near Scuffletown Creek, and oysters collected near the AWI site).[8] Adults were evaluated for both types of shellfish consumption, but children (ages 0 to 6 years) were evaluated only for crab consumption because children were assumed not to significantly ingest oyster meat.

EPA calculated risks using a number of various assumptions regarding the rates of consumption by varying the meal size. For subsistence and recreational fishers, EPA assumed meal sizes of six, twelve, and 24 crabs (whole and meat only) per meal for adults; one, three, and nine crabs (whole and meat only) per meal for children; and six, 24, and 72 oysters per meal for adults. EPA assumed that (1) adult subsistence fishers eat 156 meals of crabs per year or 104 meals per year of oysters, (2) child subsistence fishers eat 78 meals of crabs per year, (3) adult recreational fishers eat 52 meals of crabs or oysters per year, and (4) child recreational fishers eat 52 meals per year.[9]

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[8]The site could also be causing risks from the consumption of finfish. EPA decided to only evaluate risks from the consumption of shellfish for several reasons which generally relate to the anticipated smaller home range for crabs and oysters compared to the types of finfish that are generally consumed. EPA expected that it would be easier to document risks associated from site-related contaminants, as opposed to contaminants from other sources in the watershed, by evaluating risks from crabs and oysters as opposed to finfish. The Commonwealth of Virginia has issued a fishing advisory for the Elizabeth and James Rivers because of PCB and kepone contamination (see http://www.vdh.state.va.us/epi/publichealthtoxicology/JamesRiver.asp). The advisory is a "Do Not Eat" advisory for gizzard shad, carp, and blue and flathead catfish greater than 32 inches in length. For smaller catfish of these particular species and other finfish, the advisory restricts consumption to no more than two meals per month. Virginia also has a longstanding ban on collecting oysters and mollusks from the Elizabeth River because of elevated levels of bacteria and heavy metals.

[9]EPA understands that these are high consumption rates. However, as mentioned previously, EPA evaluates risk using conservative assumptions. Also, an angler survey of the James and Elizabeth Rivers (see http://www.cmiweb.org/human/CBP_fishadvisory04.html) showed that there are some people who consume fish from the area five or more times per week.

For the most part, cancer risks for subsistence and recreational fishers ingesting low, medium, and high frequency rates of crabs and oysters exceed $1x10^{-4}$. Every consumption scenario had unacceptable non-carcinogenic risks. As would be expected, those fishers consuming the whole crab (hepatopancreas or "yellow mustard" and muscle tissue) have the highest risk. The main risk drivers are arsenic, dioxin, PAHs, PCBs, cadmium, and zinc. Note that PCBs are not a site-related contaminant. See **Table 4** on page 46.

Note that there are several uncertainties associated with the crab and oyster risk analysis in the HHRA. The laboratories had trouble with the PCP analysis, especially for attaining detection limits at levels that would be considered acceptable. This problem could cause an underestimation of the risk. Dioxin, most likely from PCP (based on the predominance of the OCDD congener), can be found in the crabs and oysters. Another uncertainty involves arsenic. Arsenic is a contaminant at the site, but it also is known to be naturally high in the area ground water and is present in elevated levels in the crabs and oysters from the reference site in the York River. Arsenic can exist in various forms in the environment. The most toxic form of arsenic is inorganic arsenic. However, often a large percentage of arsenic in marine aquatic life (sometimes as high as 99% or more) is in organic forms, which is believed to be significantly less toxic, especially by comparison to inorganic arsenic. Determining the percentage of organic arsenic in crabs and oysters is difficult. Assuming all of the arsenic is in inorganic form can cause significant overestimation of risks. Even if high percentages of arsenic are assumed to be organic, risks in the above scenarios were found to be unacceptable. EPA is conducting arsenic speciation analysis of crabs and oysters at this time.

Table 4: Risks from Consuming Crabs and Oysters[10]
Major Risk Drivers at Assuming 1% inorganic Arsenic

CR = Cancer Risk HI = Hazard Index (Non-cancer Risk)
COC = Contaminant of Concern PCBs = Aroclor 1260
Note that the percent contribution may not add to 100% due to rounding errors. COCs in *italics* are not site-related COCs.

Media	Risk Level	COC	Contribution to Cancer Risk	Contribution to Hazard Index	Hazard Index Target Organ
AWI Crab Meat	CR=1.3x10^{-4} HI=1.3 Skin/Vascular HI=1.1 CNS	arsenic	19%	100%	Skin/Vascular
		dioxin	10%		
		PAHs	27%		
		*PCBs**	45%		
		mercury		91%	CNS
		selenium		9%	CNS
Scuffletown Creek Crab Meat	CR=3.3x10^{-5} HI=10.8 Skin/Vascular	arsenic	40%	100%	Skin/Vascular
		PCBs	60%		

[10]Appendix K of the OU3 HHRA contained risk evaluation results from consuming crab meat and whole crabs from the York River and oysters from Sarah's Creek just off the York River. OU3 HHRA risks resulting from various assumptions regarding the percent inorganic arsenic for the exposure scenarios in **Table 4**. These results can be found in **Appendix G** of this ROD.

Media	Risk Level	COC	Contribution to Cancer Risk	Contribution to Hazard Index	Hazard Index Target Organ
AWI Whole Crab	CR=2.x10^{-3} HI=17 Human Development HI=1.5 CNS HI=1.1 Kidney HI=2.2 GI Tract	cadmium	9%	100%	Kidney
		dioxin	53%	100%	Human Development
		dieldrin	5%		
		heptachlor-epoxide	2%		
		PAHs	8%		
		arsenic	2%		
		mercury		67%	CNS
		selenium		33%	CNS
		copper		100%	GI Tract
		PCBs	22%		
Scuffletown Creek Whole Crab	CR=1.0x10^{-3} HI=7.2 Human Development HI=1.1 CNS HI=1.1 Kidney HI=1.8 GI Tract HI=1.7 Liver	cadmium	16%	100%	Kidney
		dioxin	44%	100%	Human Development
		dieldrin	7%	14%	Liver
		heptachlor-epoxide	3%	35%	Liver
		PAHs	7%		
		arsenic	3%		
		mercury		67%	CNS
		selenium		33%	CNS
		copper		100%	GI Tract
		thallium		49%	Liver
		PCBs	20%		
AWI Oyster (Only data from native oysters collected from the upper part of the water column were used in the risk evaluation.)	CR=3.2x10^{-4} HI=1.9 Human Development HI=1.1 Kidney HI=3.3 GI Tract HI=6 Blood	dioxin	39%	100%	Human Development
		arsenic	2%		
		cadmium	59%	100%	Kidney
		copper		96%	GI Tract
		iron		4%/ 2%	GI Tract/ Blood
		zinc		98%	Blood

See **Appendix F** for detailed results of the risk calculations summarized in the table above, except that the calculations in **Appendix F** assume that all of the arsenic is inorganic.

To estimate risks that would apply to a greater portion of the population, EPA calculated how many crabs and oysters could be consumed per year over a long period of time that would result in a risk in the middle of EPA's acceptable risk range (i.e., $1x10^{-5}$) (see **Table 5** below).

Table 5: Number of Crabs Consumed Per Year Over a Lifetime That Would Result in a 1 in 100,000 Excess Risk of Contracting Cancer
(See **Appendix G** for further details.)

Assumption of Arsenic (As) Speciation[11]	**30% As^{+3}**	**20% As^{+3}**	**10% As^{+3}**	**5% As^{+3}**	**1% As^{+3}**
AWI Site Crab Meat	20	28	47	69	111
Scuffletown Creek Crab Meat	38	55	100	170	387
York River Crab Meat	51	70	111	156	233
AWI Site Whole Crab	5	6	7	8	9
Scuffletown Creek Whole Crab	10	11	14	16	17
York River Whole Crab	13	15	18	20	22

The table above shows the number of crabs collected from adjacent to Atlantic Wood, the Scuffletown Creek/Southern Branch of the Elizabeth River confluence, or the York River (the reference station) that an adult can eat per year for 30 years to produce an excess lifetime cancer risk of $1x10^{-5}$. EPA's target risk range for carcinogens, as promulgated in the National Oil and Hazardous Substances Contingency Plan (NCP) at 40 C.F.R. Part 300.430 (e)(2)(i)(A)(*2*), is 10^{-4} to 10^{-6}. EPA's risk assessments are designed to protect sensitive subpopulations (e.g., children and pregnant women). A greater degree of protection is provided at the lower end of the risk range. Analysis of the risks produced by ingesting crabs shows that the quantity can vary significantly while producing a risk within the NCP target range. For example, ingestion of meat from 690 crabs per year collected from the AWI site at 5% inorganic arsenic (which assumes that 95% of the arsenic is organic arsenic) would produce a $1x10^{-4}$ risk, while ingestion of just seven crabs per year would produce a $1x10^{-6}$ risk. PCBs, dioxin, benzo(a)pyrene and arsenic are the predominant sources of risk. EPA recommends that pregnant women, women of child-bearing age, children, and other sensitive subpopulations not consume quantities that produce a risk in excess of $1x10^{-6}$.

To further illustrate the values in the table, 111 crabs (from AWI site crabs, meat only, at 1% inorganic arsenic, $1x10^{-5}$ risk) is less than one meal per week of 12 crabs during June, July, and August. By comparison, 233 crabs (from York River, meat only, at 1% inorganic arsenic, $1x10^{-5}$ risk) is just under 20 meals of 12 crabs or about one meal per week for May, June, July, August, and September.

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[11]As discussed previously, the speciation of arsenic in marine seafood can be highly variable. The table shows the number of crabs that can be consumed per year over a lifetime assuming various types of arsenic were found in the samples that were collected. For example, "30% As^{+3}" means that 30% of the arsenic found in the sample was assumed to be inorganic and in the +3 valence state (as opposed to As^{+5} which would be arsenic in its +5 valence state) which is the most toxic form of arsenic. The other 70% was assumed to be an organic form of arsenic, which for the sake of the calculation was assumed to be non-toxic.

7.1.5 Uncertainty in Risk Characterization

Risk assessment provides a systematic means of organizing, analyzing, and presenting information on the nature and magnitude of risks posed by chemical exposures. Nevertheless, uncertainties are present in all risk assessments because of the quality of available data and the need to make assumptions and develop inferences based on incomplete information about existing conditions and future circumstances.

For example, there is a large degree of uncertainty associated with the oral-to-dermal adjustment factors (based on chemical-specific gastrointestinal absorption) used to transform the oral RfDs and SFs based on administered doses to dermal RfDs and SFs based on absorbed doses. It is not known if the adjustment factors result in an underestimate or overestimate of the actual toxicity associated with dermal exposure.

The uncertainties identified in each component of the risk assessment ultimately contribute to uncertainty in risk characterization. The addition of risks across pathways and chemicals contributes to uncertainty based on the interaction of chemicals such as additivity, synergism, potentiation, and susceptibility of exposed receptors. The simple assumption of additivity used for this assessment may or may not be accurate and may or may not over- or under-estimate risk; however, a better alternative is not available at this time.

Below is a brief discussion of the noteworthy uncertainties associated with the risk assessments for each operable unit.

7.1.5.1 Operable Unit 1 - Soil and DNAPL

- The future soil-exposure scenarios assume that the subsurface soil will become surface soil after the completion of any potential construction activities at the site, which could result in an overestimation of actual future risk. During many construction projects, clean fill material is placed over soil that is disturbed during excavation projects. The clean fill is generally needed to support growth of grass and other landscape plants.

7.1.5.2 Operable Unit 2 - Ground Water

- The ground water sampling conducted at the site focused on areas of known or suspected contamination. Wells in the shallow aquifer were located throughout the site and are representative of receptor exposure. Data may not be representative for the intermediate and deep aquifers due to lack of well coverage in certain areas. However, wells present are representative of areas of known contamination (i.e., Historic Disposal Area) that could have potentially migrated from the shallow aquifer to the deeper aquifers below due to the interconnectedness of the aquifers. Also, wells were placed downgradient, near the river, to obtain information on contamination that may be entering the river from the site. Concentrations of contaminants in ground water located in other areas of the site would most likely be less than those detected in the intermediate and deep aquifer wells located in the Historic Disposal Area. Therefore, the uncertainty in sampling and possibility of missing a contaminated location is expected to be minimal at this site. The uncertainty associated with the data analysis is minimal, as the data have been fully validated prior to use in the risk assessment. The general assumptions used in the COPC selection process were conservative to ensure that the true COPCs were not eliminated from the quantitative risk assessment and that the most reasonable risk was estimated.

- Another source of uncertainty is the use of the dioxin toxicity equivalent quotients (TEQs) based on the EPA's 1989 Interim Scheme. For this risk assessment, these values typically are higher than those calculated using the World Health Organization's 1998 scheme and were used in the risk assessment for conservatism. Therefore, risks associated with the use of these values may be higher than those risks incorporating dioxin TEQ values using the 1998 scheme.

- Tentatively Identified Compounds (TICs), which are compounds that are not on EPA's target list of sample analyses, were examined and found to consist mainly of unknown compounds, phenols, and hydrocarbons such as various PAHs and benzene constituents. TICs are not taken into account in the risk calculations, which may contribute to an underestimation of risk.

- The toxicity of 2,3,7,8-tetrachloro dibenzo-p-dioxin (TCDD) has been extensively examined in animal oral toxicity studies, and effects have been observed in most organs/systems. The animal studies have shown that the developing organisms are very sensitive to the toxicity of TCDD. The types of effects observed in the offspring of animals exposed to TCDD include fetal/newborn mortality, decreased growth, structural malformations, kidney anomalies, immunotoxicity, thymic atrophy, impaired development of the reproductive system, and neurodevelopmental effects. The most sensitive developmental effects are impaired development of the reproductive system and neurobehavioral effects.

  At the time of the issuance of OU2 risk assessment, the National Academy of Sciences Research Council had completed its review of EPA's 2003 draft dioxin reassessment. The Academy concluded that, although EPA presented a comprehensive review of the scientific literature in its 2003 draft reassessment, there were some weaknesses with the document. The Agency did not sufficiently quantify the uncertainties and variabilities associated with the risks, nor did it adequately justify the assumptions used to estimate them. The Academy recommended that EPA (1) re-estimate the risks using several different assumptions and better communicate the uncertainties in those estimates and (2) explain more clearly how it selects both the data upon which the reassessment is based and the methods used to analyze them. It is important to note that until a final Agency assessment has been released, the draft dioxin reassessment remains draft, does not represent a final position, and is not intended to serve as the basis or rationale for regulatory and other policy action.

- These uncertainties may not necessarily influence the determination of the degree of excess risk, since risks significantly exceed EPA's target risk range of $1x10^{-4}$ to $1x10^{-6}$ and HI=1.

7.1.5.3 Operable Unit 3 - Elizabeth River Sediments

- PCP was not reported by the laboratory for natural oysters collected during the May 2006 sampling event due to failures in calibration and quality control. PCP was successfully analyzed for during the July 2006 crab and caged oysters sampling, but at a detection limit (160 µg/kg) that exceeds the RBC value of 26 µg/kg. (The July 2006 crab samples were directly collected from the river bottom unlike the natural oysters which were collected off the concrete and rock rip-rap. Only one crab sample, CB-SCC-08HP, had a detected level of PCP, 24 J µg/kg.) In addition, PCP was not detected in shallow sediment samples collected at the same time as oyster samples nor in the 2005 sediment investigation samples; however, by design, this investigation targeted less-contaminated samples. EPA did not detect PCP in caged oyster tissue samples collected for the ecological risk assessment; however, they reported elevated detection limits, none lower than 8,600 µg/kg. High levels of PCP have been found in site soil, particularly in the Historic Disposal Area, the Wood Treatment Area, and the former tank area (at depth). On the east end of the site, PCP was almost non-detected, although at the east end of the ABM area, where it may have washed into the acetylene sludge wetland, concentrations were greater than 7,000 µg/kg. Therefore, this gap in usable data may contribute to an underestimation of risk.

- Another uncertainty involves arsenic, which is a predominant risk driver. Arsenic is a COC at the site, but it also is known to be naturally high in the area and shows up in elevated levels in the crabs and oysters from the reference site in the York River. In addition, arsenic concentrations from the laboratories, reported as total arsenic (inorganic plus organic), were used in the HHRA. The consensus in literature is that upwards of 85% to 90% of arsenic found in edible portions of marine fish and shellfish is organic arsenic (arsenobetaine, arsenocholine, dimethylarsinic acid) and that approximately 10% is inorganic arsenic. Organic arsenic is considered to be much less toxic than inorganic arsenic. The levels of organic vs. inorganic arsenic are highly species specific and can be influenced by the source of the arsenic. While arsenic is naturally high in ground water in the Tidewater area, arsenic is also found in site soils at elevated levels. Determining the percentage of organic arsenic involves a difficult chemical analysis procedure. Most arsenic in marine crustaceans is in the form of arsenobetaine, an organic arsenic believed to be relatively non-toxic. Assuming all or a high percentage of the arsenic is in inorganic form can cause significant overestimation of risks. Overestimating the amount of the arsenic that is in an organic form and assuming organic arsenic is completely non-toxic will cause an underestimation of risk.

  EPA Region 6 recommends a conservative estimate for inorganic arsenic of 30% of the total arsenic in edible freshwater fish tissue.[12] Even if it is assumed that 0% of the arsenic detected in the AWI biota samples is inorganic, risks still exceed the target cancer risk range of 10^{-4} to 10^{-6} and the HI of unity for several of the subsistence and recreational fisher receptor scenarios. **Table 4** on page 46 in presents risk calculations that include inorganic arsenic at varying percentages of the total arsenic in crabs and oysters.

- TICs identified in sediment samples were examined and found to consist mainly of unknown compounds and hydrocarbons such as various PAHs and benzene constituents. TICs are not taken into account in the risk calculations, which may contribute to the underestimation of risk. TICs were not reported in any of the biota data packages.

- DNAPL sample data were not collected from the sediment and therefore not evaluated in the risk assessment, which may contribute to the underestimation of risk for the receptors exposed to the sediment.

- Care was taken in dissecting the crabs to prevent cross-contamination of the meat with the hepatopancreas, which is the more contaminated portion of the crab. Since it is hard to totally remove the hepatopancreas when peeling steamed hard-shell crabs for just the meat, risks estimated from the crab meat consumption may be slightly underestimated. Additionally, it is unknown whether cooking crabs can release contamination from the hepatopancreas to the muscle tissue.

- Native oysters were collected from rip-rap along the shore of the AWI property and from the concrete under the west end of the Jordan Bridge. However, caged oysters were suspended in cages about one foot above the contaminated sediment. Native oysters were significantly less contaminated than the caged oysters, possible because the native

[12]See http://www.epa.gov/region6//6wq/ecopro/watershd/standard/arsenic.htm#inorg. However, due to the highly variable levels of inorganic arsenic by species, EPA also recommends that site-specific speciation analysis be conducted. EPA is currently conducting arsenic speciation analysis of crabs and oysters.

oysters were collected away from the immediate proximity of the contaminated sediment, in the upper portion of the water column, while the caged oysters were collected in close proximity to the contaminated sediment. The consumption risk calculated for the native oysters collected in the upper water column are most likely lower than risks from consuming native oysters collected near the river bottom, which would most likely be more contaminated as shown with the caged oyster results. Since there is already a ban on oyster collection in the Elizabeth River due to bacteria and heavy metals, this uncertainty has little effect on protection of human health. It would become more important if people began harvesting oysters near the river bottom from the oyster reefs that have been constructed in the Southern Branch of the Elizabeth River.

7.2 Ecological Risk Assessment

Like a HHRA, an ecological risk assessment (ERA) serves to evaluate the potential for risks due to exposure to site contaminants specific to ecological receptors (such as wildlife, fish, and plants). Since the ERA evaluates many species that have drastically different exposure pathways, the ERA can appear complicated. Numerous environmental processes and ecological receptor groups (part of what is referred to as "assessment endpoints") are evaluated, and there are differences in contaminant exposures and sensitivity to contaminants between groups. For example, wildlife are mainly exposed through their diet, while soil organisms are exposed through direct contact with the soil in which they live. The complexity of the ERA arises from the need to evaluate the important exposure pathways to the relevant receptors. The toxicology varies between the different ecological groups. In addition, some contaminants are effectively transferred up the food chain, concentrating and thereby posing risks, while other contaminants are not transferred because they are either metabolized, biologically regulated, or simply not absorbed. Some compounds may be metabolized into more or less toxic daughter compounds, which may be transferable.

The original (pre-1995 ROD) ERA concluded that there was a continued potential for site-related contaminants to be transported to the Elizabeth River, thereby, impact aquatic habitats. Also, the ERA found that animal, bird, and amphibian species on-site were at risk due to on-site soil contamination. The 1995 ROD cleanup levels were developed based on ecological risk values from literature.

7.2.1 Risk Characterization

In 2004, EPA completed a screening-level ERA that evaluated risks to ecological receptors from the site soil and sediments in drainage areas using conservative assumptions. The ecological communities that were evaluated included soil invertebrates, plants, mammals, amphibians and reptiles, and birds. The potential risk from site contaminants to each ecological receptor is summarized below.

The soil invertebrate community at the site is at risk from exposure to dioxin, PAHs, PCP, and metals contamination in shallow soil. Risks to plants were evaluated, and levels of PAHs and metals at the site indicate potential risk. The food-chain models indicated risk to mammal receptors. Herbivorous mammals, represented by the vole, are primarily at risk from exposure to PAHs, PCP, arsenic, and lead found in soils throughout the AWI property. Insectivorous mammals, represented by the short-tailed shrew, are primarily at risk from exposure to heavy metals including antimony, arsenic, iron, lead, and thallium. Carnivorous mammals, represented by the red fox, are at risk from food-chain exposure to site contaminants, especially from arsenic and phenanthrene.

Insectivorous birds, represented by the killdeer, are at risk from exposure to PAHs and heavy metals, including arsenic, lead, iron, thallium, and zinc. Carnivorous birds are at risk from exposure to site contaminants, especially arsenic, lead, iron, thallium, and zinc, in prey items at the site. See **Table 6** in **Appendix B** for lists of NOAELs and LOAELs from exposure to soil contamination for various organisms.

The goal of the 2002 Elizabeth River ERA for river sediment was to evaluate potential threats to ecological receptors in the Southern Branch of the Elizabeth River from exposure to the AWI site contaminants. In 2000, samples of surface water, sediment, and fish tissue were collected to evaluate the risk associated with contamination in these three matrices. Sediment samples were also chemically analyzed and subjected to aquatic toxicity and bioaccumulation testing. Analytical data generated from the samples were used in food-chain exposure modeling to determine if they posed a risk to higher trophic-level organisms.

In a caged bivalve study, eastern oysters were placed in close proximity to sediment at three locations near AWI and at one reference location on the York River. Difference in growth rates indicated that exposure to AWI contamination had a negative impact on oyster growth. Correlations with PAHs in sediments indicated that, as contaminant concentrations increase, oyster growth decreased.

Contamination in the surface water included copper, lead, mercury, zinc, and TBT. Sediment contamination included 2,4-dimethylphenol; bis(2-ethylhexyl)phthalate; dibenzofuran; PCP; phenol; 2,4-dinitrotoluene; carbazole; 4-nitrophenol; 1,2-dichlorobenzene; 1,4-dichlorobenzene; acetone; chloroform; pesticides (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, dieldrin, and gamma-chlordane); and heavy metals (arsenic, copper, cadmium, lead, and zinc).

In addition to EPA's studies, the ecological health of the river has been the subject of numerous studies by educational institutions and state agencies. Investigations by the Virginia Institute of Marine Science have indicated that the mummichog, an abundant, small non-migratory fish, is an effective bio-indicator of adverse health effects attributable to pollutant exposure. In April 2000, VADEQ completed a report on mummichog histopathology as an indicator of environmental quality in the Elizabeth River. VADEQ found a correlation of liver alterations (cancerous and pre-cancerous lesions) to PAHs in sediment. Monitoring of mummichogs has been incorporated into the VADEQ Elizabeth River Monitoring Program. Incidence of some types of lesions can be as high as 85% in the Southern Branch of the Elizabeth River. The Elizabeth River mummichogs exist at a normal level of abundance but have been exposed to high levels of contamination for so long that they are now genetically different from mummichogs found elsewhere throughout the Chesapeake Bay.

The 2002 river ERA concluded that both aquatic and terrestrial biota are at risk from the contaminants associated with the AWI site. The benthic invertebrate and fish communities are at risk because of the observed toxicity associated with solid phase and elutriate tests using sediments collected from the vicinity of the AWI site. Laboratory toxicity tests performed with fish and benthic invertebrates showed acute toxicity associated with sediment collected in the immediate vicinity of the AWI site. A qualitative analysis of benthic macroinvertebrates indicated that there were significantly fewer taxa present in the AWI study area, compared with the York River reference area, indicating a lower population diversity.

Due to the ecological roles played by benthic invertebrates and their high potential for exposure to contaminants in the sediment, as well as their potential economic value (e.g., oysters), benthic invertebrates are of particular concern at the AWI site. Because it was not possible to evaluate each species present in the benthic community, representatives of the epifaunal and infaunal communities were selected for analysis (oysters, amphipods, and sandworms). The risk assessment process includes the assumption that observed toxicity to these receptor species was applicable to the entire benthic community. In addition, measurement was made of contaminants accumulated into the tissue of oysters and sandworms exposed to site sediments.

Concentrations of contaminants in the tissue of these receptor species were compared with benchmark toxicity values to predator species. The receptor species were also used as representative prey items in food-chain models. It was assumed that the concentrations of contaminants measured in the receptor species were representative of all benthic species.

Laboratory and field bioaccumulation assays indicated that benthic organisms living in AWI sediments can accumulate enough site-associated contaminants to pose a risk to the higher trophic-level organisms that feed on them (e.g., birds and mammals). A laboratory bioaccumulation study using sandworms indicated that sediment collected from the immediate vicinity of the AWI site showed either significant mortality of the exposed worms, or a high enough accumulation of contaminants in their tissues to pose a risk to organisms that eat them. A field bioaccumulation study using oysters indicated that oysters exposed to sediment in the vicinity of the AWI site showed a significant decrease in growth, and a significant accumulation of site-associated contaminants. Statistical analysis showed a strong correlation between sediment contamination and bioaccumulation.

Although low levels of PAHs are typically metabolized and excreted by vertebrates, forage fish collected from locations near the AWI site had measurable tissue burdens due to the high sediment concentrations of PAHs. Fish tissue concentrations were high enough to pose a risk to piscivorous birds and mammals.

Aquatic feeding birds and mammals were also determined through food-chain exposure models to be at risk from contaminants associated with the AWI site. Overall, the greatest model calculated risk was to the insectivorous avian community and the omnivorous mammal community from PAHs; PCBs; base, neutral, and acid extractable compounds; chromium; lead; selenium; and zinc. The greatest risk was associated with sediment sampling locations immediately adjacent to the AWI facility. Risk was also observed at some other locations, however, the magnitude of the calculated risk was lower.

The results of chemical analyses, toxicity testing, bioaccumulation studies, and surveys of biota clearly demonstrate that there is risk to receptor species living in and feeding on the Elizabeth River near the AWI site. This risk was driven primarily by high concentrations of high molecular weight PAHs in sediment and food items. Based on these results, food-chain exposure models were manipulated to determine risk-based cleanup ranges for total high molecular weight PAHs in sediments. Risk-based cleanup ranges were exceeded at all sediment sampling locations in the immediate vicinity of the AWI facility.

7.2.2 Uncertainty in Risk Characterization

- A major source of uncertainty arises from the use of toxicity values reported in the literature which are derived from single-species, single-contaminant laboratory studies. Prediction of ecosystem effects from laboratory studies is difficult and inexact. Laboratory studies cannot take into account the effects of site-specific environmental factors that may add to the effects of contaminant stress. NOAELs were generally selected from studies using single contaminant exposure scenarios. Species utilizing the AWI site and the Elizabeth River are exposed to a variety of contaminants.

- Some of the toxicity reference values utilized for determination of risk (water and sediment quality benchmarks) in this assessment are below the method detection limits for their respective contaminants. Method detection limits can vary depending on the sample matrix and the analytical methodologies utilized.

- This risk assessment did not examine the contribution of dermal absorption or inhalation exposure as part of the exposure pathway. This can result in an underestimation of risk.

- There is very little information available in the literature regarding the rates of incidental soil/sediment ingestion for wildlife species. In this risk assessment, with the exception of the raccoon, these values were based on estimates reported for species similar to the indicator species or calculated from an allometric equation. Additional uncertainty regarding incidental soil/sediment ingestion was introduced by simplifying the diet in the food-chain models. In reality, each receptor organism's diet is varied, and therefore, the associated soil/sediment intake fluctuates as different prey items are selected over time. This can lead to an over or underestimation of risk.

- A literature-reported LOAEL may not represent the lowest toxicity threshold for a species simply because lower concentrations were not tested in a study.

- A literature search was conducted to determine the chronic toxicity of the COC when ingested by the indicator species. If no toxicity values could be located for the receptor species, values reported for a closely related species were used. All studies were critically reviewed to determine whether study design and methods were appropriate. When values for chronic toxicity were not available, LD50 (median lethal dose) values were used. For purposes of this risk assessment, a factor of 10 was used to convert the reported LD50 to a LOAEL. Also, a factor of 10 was used to convert a reported LOAEL to a NOAEL. If several toxicity values were reported for a receptor species, the most conservative value was used in the risk calculations regardless of toxic mechanism. Toxicity values obtained from long-term feeding studies were used in preference to those obtained from single-dose oral studies. No other safety factors were incorporated into this risk assessment. If the only toxicity datum available in the literature was a NOAEL, a factor of 10 was used to convert it to a LOAEL. The use of toxicity values derived in this way can lead to an over or underestimation of risk.

- Water-ingestion rates used in the food-chain models were obtained from the literature. Risks were calculated assuming the ingestion of contaminated river water. The water from the Elizabeth River system in the vicinity of AWI is brackish (approximately 13 to 17 part per trillion [ppt] salinity). While many receptor species likely do not drink the brackish water, it was assumed that any freshwater (ground water or seeps) on the site would be contaminated similarly to the river water. This can lead to an over- or underestimation of risk.

8. REMEDIAL ACTION OBJECTIVES (RAOs)

EPA has developed the following remedial action objectives (RAOs) to mitigate current and/or potential future risks associated with contamination at the site. The RAOs are organized by media: soil, ground water, and river sediments.

8.1 Soil

8.1.1 Soil RAOs

- Reduce human health risks from exposure, including ingestion and dermal contact, to contaminants in the surface and subsurface soils to acceptable levels.

- Minimize the migration of contaminants from the unsaturated soils to the ground water.

- Reduce risks to environmental receptors from exposure to contaminants in the surface and subsurface soils to acceptable levels.

8.1.2 Soil Cleanup Criteria

In developing chemical-specific cleanup criteria for soil, EPA considered soil risk levels determined for each COC in soil identified in the HHRA and the ERA, available background values, the 1995 ROD cleanup criteria, and EPA guidance documents regarding dioxin in soils. Since many of the contaminants present unacceptable risk, EPA decided to simplify the implementation of the soil cleanup by developing criteria for only three contaminants, such that when those three criteria are met, risks from the other contaminants will have been addressed as well. Thus, EPA has developed soil cleanup criteria for only arsenic, benzo(a)pyrene (BaP) and dioxin. BaP and dioxin were selected due to their high toxicity and prevalence throughout the site. Arsenic was selected due to its prevalence at the site and, when coupled with BaP and dioxin, will address all areas of the site with unacceptable risks from soil.

The cleanup criterion for BaP is 3 ppm, which is based on a carcinogenic risk to human health of $1x10^{-5}$ for an industrial exposure scenario. This cleanup criterion also lies within the NOAEL-to-LOAEL range for ecological receptors (see **Table 6** in **Appendix B**). The cleanup criterion for arsenic is 76 ppm, which was the level selected in the 1995 ROD. It represents a carcinogenic risk to human health of approximately $5x10^{-6}$ for an industrial exposure scenario. While this arsenic level is above the LOAEL for several environmental receptors in **Table 6** in **Appendix B**, meeting this criteria will provide protection to these receptors by preventing the receptors from coming into contact with the contamination.

The cleanup criterion for dioxin is 1 ppb, which was the level selected in the 1995 ROD. This cleanup criterion is lower than the 5 to 20 ppb range recommended by EPA guidance[13] for cleanups for industrial use properties. A lower number is warranted based on risk. For example, the current Industrial Worker exposure scenario in **Table 3** on page 48 presents a cancer risk of $8x10^{-4}$, which exceeds the acceptable range in the NCP, with 50% attributed to dioxin and the rest to PAHs, arsenic and PCP. The dioxin exposure-point concentration for that scenario was 10 ppb, which is within the range recommended by EPA's national guidance on dioxin in soil at Superfund cleanups for industrial properties but too high to be protective of human health, given the specific situation presented at this site. A 1 ppb criterion would bring the contribution of dioxin to the total cancer risk to approximately $4x10^{-5}$. Since the area will be covered, there will not be a residual risk issue. See **Figure 24** for the area of the site that exceeds the soil cleanup criteria.[14]

8.2 Ground Water

8.2.1 Ground Water RAOs

- Reduce human health risks from exposure, including ingestion, inhalation, and dermal contact, to site-related contaminants in the ground water to acceptable levels.
- Reduce the ability of the creosote DNAPL present in the ground water to migrate deeper into the aquifer system.

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[13] See "Approach for Addressing Dioxin in Soil at CERCLA and RCRA Sites," OSWER 9200.4-26, April 1998, at http://www.epa.gov/superfund/policy/remedy/sfremedy/remedies/contaminant.htm#Dioxin.

[14] A middle portion of the east side of the AWI facility is below the arsenic and BaP(eq) criteria, this area is being remediated as well since it is in the middle of areas that do exceed the criteria and if numerical criteria were derived for all of the soil contaminants of concern, this area would exceed criteria as well.

- Prevent unacceptable risks to environmental receptors (such as benthic organisms) in the Southern Branch of the Elizabeth River from migration of dissolved contaminants in the ground water.

- Prevent the recontamination of sediments in the Southern Branch of the Elizabeth River from the migration of dissolved ground water contamination and/or DNAPL.

- Minimize the migration of site-related ground water contaminants to Paradise Creek through the existing storm drain, or its gravel bed, in order to limit any potential environmental impacts.

8.2.2 Ground Water Cleanup Criteria

While the Commonwealth of Virginia does not classify its ground water aquifers using EPA's ground water classification system, it does not allow for ground water to be designated as non-potable at Superfund sites. This policy is consistent with EPA's expectation "to return usable ground waters to their beneficial uses wherever practicable within a timeframe that is reasonable given the particular circumstances of the site" (40 C.F.R. 300.430(a)(1)(iii)(F)). Virginia supports passive remedial actions for ground water at sites where the action is technically appropriate and the ground water is not currently being used and is not expected to be used in the future, as at this site. The City of Portsmouth requires residences to be connected to the public water supply. The city allows wells for watering lawns, but there are no such wells in the immediate vicinity of the site. The site is located in an industrial area with the nearest residential area located approximately one-third mile away.

EPA is using cleanup criteria for ground water that are based on federal MCLs or Virginia Ground Water Standards. Not all of the ground water contaminants of concern have regulatory criteria, and the selected remedy does not set a cleanup criterion for these contaminants. However, by meeting the regulatory criteria that do apply, the non-regulated contaminants will be reduced as well since they are often co-located. Due to the industrial nature of the site and the surrounding area and the fact that no one is using the ground water, EPA has determined that these criteria will be protective of human health and the environment. **Table 7** in **Appendix B** lists the numeric criteria for the ground water contaminants.

The portion of the ground water plume where the selected remedy must meet the ground water cleanup criteria is the portion of the plume that extends beyond the edge of the soil cover or pavement that is required in this selected remedy, thus making the edge of the soil cover the point of compliance. This ground water remedy relies upon "a waste management area" (defined as the edge of the soil cover and/or pavement), as described in the preamble to the final NCP which states that "EPA believes that [ground water] remediation levels should generally be attained throughout the contaminated plume, or *at and beyond the edge of the waste management area, when the waste is left in place*" (emphasis added) (See 55 FR 8753). **Figure 25** shows the estimated waste management area. The area will include areas of the AWI facility that have been previously filled with contaminated material, such as approximately the eastern third of the east side of the site, the northern half of the west side, and the ABM area. It will include areas where DNAPL leaks have occurred, such as along Elm Avenue, and areas impacted by the migration of this DNAPL, such as underneath the ramp to the Jordan Bridge, which is property owned by the City of Chesapeake. It will also include areas where contaminated sediments from the Southern Branch of Elizabeth River will be consolidated after dredging, such as the majority of the west side of the AWI facility, the portion of the Wyckoff Inlet that will be filled, and the area to the east of the AWI facility that will be filled. Lastly, it will include the area between the east and west sides of the AWI facility, which is owned by the Portsmouth Company which is part of Norfolk Southern Corp.

Note that the boundary of a portion of the waste management area happens to coincide with the AWI facility boundary (see **Figure 25**). This is due to several reasons, including: (1) contamination may exist beyond the facility boundary in several areas (such as the northwest corner of the AWI facility), and if so, will be consolidated onto the facility; and (2) the NNSY NPL site is immediately adjacent to parts of the AWI facility. Most of the metals contamination on the AWI facility is from the NNSY, and the NNSY has similar contamination next to the AWI facility. In these areas, the extent of contamination in regard to the AWI site is the property boundary.

Note that for all of the alternatives, meeting MCLs (for whatever portion of the plume they would be ARARs, which varies for some of the alternatives) would not necessarily, except in some limited situations, mean the ground water could actually be used. Since the plume has migrated only slightly from the source(s) and there is other, non-AWI site related sources of contamination very near the site, pumping ground water from a well could cause contamination to migrate areas that had met the cleanup criteria, or would require so much monitoring to ensure that the water remained safe to use, as to make usage impracticable.

8.3 Elizabeth River Sediments

8.3.1 Elizabeth River Sediment RAOs

- Reduce human health risks from exposure, including ingestion and dermal contact, to contaminants in the sediments to acceptable levels.
- Reduce the risks to humans from the consumption of contaminated crabs and/or oysters taken from the site.
- Reduce risks to ecological receptors, including benthic aquatic organisms, fish, and birds, from contaminated sediments to levels that are acceptable.
- Do not inhibit navigation or the opportunity for future improvements to navigation.
- Prevent the migration of contaminated river sediments during any future river activity that involves disruption of the sediments.

8.3.2 Elizabeth River Sediment Cleanup Criteria

PAHs related to creosote are more pervasive in the river sediment than arsenic, copper, cadmium, lead, zinc, and dioxin. Therefore, EPA only developed a chemical-specific sediment cleanup criterion for total PAHs. The criterion, 45 ppm, was originally developed to protect ecological receptors in the river. However, the sediment cleanup criterion and the bulkheading of the river protect workers, trespassers, and recreational users (both adult and children) from direct exposure to the contaminated sediments by addressing acute and long-term threats by sediment removal and by practically eliminating the opportunity for a wading exposure scenario. Additionally, the cleanup criteria of 45 ppm tPAHs will reduce crab and oyster contaminant exposure and will thereby reduce consumption risks.

To facilitate the establishment of a final ecologically protective cleanup goal, EPA coordinated with the Elizabeth River Project, which worked with numerous federal, state, and local stakeholders in the development of a sediment cleanup criteria for tPAHs at the Money Point area of the Elizabeth River (about 1.5 miles upstream and across the river). The Money Point criterion is also 45 ppm tPAH.

To improve the cost effectiveness of the remedy, active remediation, such as dredging or capping, will occur when sediment contamination is above 100 ppm tPAHs. The remaining areas of contamination from 45 to 100 ppm tPAHs would be addressed through enhanced monitored natural recovery (MNR). The areas to be addressed by MNR are small enough such that, when coupled with active remediation, MNR will provide for the overall protection of the environment and is expected to reduce the risk to human health from the consumption of biota. The residual, post-remedy risk would be similar to that found in background (upriver) samples because the cleanup goal (45 ppm) is close to the background level (approximately 30 ppm, although it could be as high as 40 to 50 ppm). The risk to human health from the consumption of biota could be further reduced through the implementation of institutional controls (e.g., community education or some form of public health crabbing advisory). MNR will be enhanced with thin-layer capping[15] where necessary such that the top foot of sediment reaches 45 ppm tPAHs in a reasonable time frame and remains at or below this level.

The risk to human health from the exposure to DNAPL or calcium hydroxide sludge will be eliminated by the remedy because these contaminants would be removed and stabilized. As was done in the 2003 sludge removal action (on land), the river calcium hydroxide sludge cleanup can be performed on a visual basis because this material is quite distinctive compared to the natural sediments.

9. SUMMARY OF REMEDIAL ALTERNATIVES

A separate feasibility study was performed for each of the three operable units (soil and DNAPL, ground water, and river sediment) to evaluate various alternatives to clean up the contamination at the site. Components have been selected from each FS and combined in the Proposed Plan into seven site-wide remedial alternatives in such a way as to provide a range of alternatives, as required by the NCP, and to allow detailed analysis of some important stakeholder issues.

9.1 Common Elements Included in All Alternatives

All of the alternatives, except the "no action" alternative, contain some common elements that were considered in the evaluation process. The common elements include:

Long-Term Ground Water Monitoring: Due to the presence of DNAPL, EPA does not believe that the ground water can be returned to its beneficial use as drinking water in the area of DNAPL. However, EPA believes that the dissolved-phase contaminants will naturally attenuate[16] in areas away from the DNAPL source areas.[17] In addition, the weathering of

[15]Note that the objective of the thin-layer sediment cap is to enhance, if necessary, natural recovery processes in the sediments, not to act as a barrier to contain sediment contamination and eliminate direct contact threats or uptake by biota.

[16]Natural attenuation includes a variety of physical, chemical, or biological processes that act, without human intervention, to reduce mass, toxicity, mobility, volume, and/or concentration of contaminants in ground water. These processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants.

[17]Estimating time frames for reaching the ground water cleanup criteria is made difficult by the presence of the DNAPL which provides an on-going source of ground water contamination. With the removal of the DNAPL in the Historic Disposal Area, the grading and soil cover, and the fact that the levels of contamination are mostly decreasing and already near the cleanup criteria, the criteria should easily be met in two to four decades. Given the site conditions, EPA considers this a reasonable time frame.

DNAPL will, over time, decrease the amount of dissolved-phase contamination generated by the DNAPL. For each alternative, except Alternative 7 West Side, the goal of the ground water remediation is for the ground water cleanup criteria discussed earlier in this ROD to be attained for areas beyond the foot print of the cap or cover except to the south were the goal is to prevent any on-going migration of metals contamination since the Navy property also has metals contamination. For the west side of the site in Alternative 7, the goal of the ground water remediation is to meet the ground water cleanup criteria throughout the site in accordance with that aggressive remedial strategy. Each alternative includes monitoring dissolved-phase contamination in the upper Columbia, lower Columbia, and Yorktown Aquifers until contaminant levels fall and remain below EPA's clean-up levels. Ground water monitoring would be performed for PAHs, PCP, metals, and, less frequently, dioxin. On the east side of the site, ground water would be monitored at existing monitoring wells located north and south of the AWI property to detect potential off-site migration. Existing and new monitoring wells would be used to monitor the ground water contamination on the west side of the site.

Institutional Controls: ICs[18] would be implemented to ensure that (1) the land is not used for residential or other non-industrial purposes that may present an unacceptable risk to human health from contamination that might remain on-site after the cleanup is complete; (2) there is no human contact with the ground water without adequate protection; (3) the ground water is not used as a potable source; (4) the ground water is not pumped or otherwise altered in such a way as to cause a change in hydraulic conditions that could interfere with the ongoing protectiveness and effectiveness of the remedial action; and (5) any activities that may take place on the site after cleanup do not interfere with any components of the remedy and are conducted in a manner to protect the health of future construction and/or industrial workers and to reduce risks associated with the consumption of crabs and/or oysters. These ICs may include restrictions that would operate as a covenant running with the land burdening the property, City of Portsmouth ordinances, health and safety plans, and/or crab and oyster consumption advisories.

Wetlands Mitigation: Each of the alternatives would encroach on drainage ways containing wetlands on the AWI property and to varying degrees may impact wetlands along the west bank of the Southern Branch of the Elizabeth River. Mitigation or replacement of any disturbed wetland would be required. Any destroyed wetlands would be replaced at a ratio of 1:1. Wetlands will be delineated during the remedial design to determine the acreage requiring replacement.

Stormwater Management: All of the alternatives will impact stormwater management at the site. Any cap or cover would be graded, for example, to route stormwater to a series of drainage swales along the perimeter of the site and into a pair of detention basins before draining to an existing 72-inch storm drain on the west side of the site or to the Southern Branch of the

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This time frame also is consistent with an agreement between VADEQ and the Navy, which applies to the NNSY that surrounds three sides of the AWI site. The agreement (dated December 6, 2004 and revised November 30, 2006) states that when assessing beneficial use, "there are certain flexibilities in the process that can be used to develop a strategy in accordance with CERCLA, the NCP and site specific conditions." Under the agreement, one of the flexibilities that may be considered is the time frame: "Depending on the current use of the ground water the amount of time needed to reach cleanup goals may be flexible." MNA is given as an example of a technology that can be employed when ground water is not currently being used as a drinking water source and is not expected to be used as such in the near future. The document notes that additional factors can be used to support the time frame flexibility. As an example "existing ground water controls, regulations, ordinances etc. can be used to demonstrate that current restrictions are in place to manage water usage until the remedial action is complete."

[18]Institutional Controls are non-engineered instruments such as administrative and/or legal controls that minimize the potential for human exposure to contamination by limiting land or resource use. EPA generally relies on a combination of different ICs to ensure protection.

Elizabeth River on the east boundary of the site. Additionally, a portion of the runoff could be directly routed to the storm drain or river without being detained.

Possible locations for these detention basins are shown on the figures depicting each alternative in this section. Soil excavated to construct the basins would be managed with the soil remedy in each alternative. Construction of the basins could be combined with on-site wetlands mitigation, such as extending the restored wetland in the former Acetylene Sludge Area. See **Figures 26A** and **26B**.

SPSA Property Soil Sampling: The northwest corner of the Wood Storage Area is currently owned by the SPSA (see **Figure 1**). AWI previously owned the property and used it to store lumber before selling the property to SPSA in the 1980s. It is not known if the soil contamination extends onto this parcel because the soil was not sampled. Therefore, the soil in this area will be sampled during the remedial design. If soil contamination is found in excess of the cleanup criteria, then this area would be addressed by consolidating the soil onto the AWI property prior to constructing a cap or cover.

Unexploded Ordnance (UXO) Avoidance: Due to past discoveries, it is assumed that UXO may be present on-site in the areas formerly leased by the Navy located on the west side of the site. As a result, UXO clearance specialists would need to be present to clear areas prior to site activities in the former leased areas and to coordinate activities in the event that UXO is uncovered during remedial activities. UXO clearance would only be required down to native material.

Biota Monitoring: Each alternative includes monitoring of river biota (i.e., crabs and oysters) to evaluate the effectiveness of the remedy. Biota monitoring would be performed annually for the first five years following remedy implementation, whereupon the need for monitoring and its schedule would be reevaluated.

9.2 Remedial Alternatives

9.2.1 Alternative 1: No Action

Capital Cost: $0
Total Present Worth: $0
Annual Operations and Maintenance (O&M) Costs: $0

The "no action" alternative is included because the NCP requires that a "no action" alternative be developed as a baseline for evaluating other remedial alternatives. Under this alternative, no remedial measures would be implemented at the site to prevent exposure to the soil, DNAPL, ground water, and river sediment contamination or to reduce risks from consumption of crabs and oysters.

9.2.2 Alternative 2: Soil Cover, Monitored Natural Attenuation (MNA)/Ground Water Monitoring, On-Shore Sheet Pile Wall, Subaqueous Cap, and Enhanced Monitored Natural Recovery (MNR)

Capital Cost: $34,200,000
Total Present Worth: $37,700,000
Annual O&M Costs: $350,000

In addition to the common elements described above, Alternative 2 includes the following remedial measures: a soil cover, a sheet pile wall at the shore line, and a subaqueous sediment cap as shown in **Figure 27**.

Soil Cover: In order to protect site workers, trespassers, and ecological receptors from contaminated soils, this alternative includes the installation of a soil cover on top of the existing grade. The soil cover would be constructed over all soils above the cleanup criteria (essentially the entire AWI property) and all consolidated sediments dredged from the Elizabeth River. The soil cover would act as a physical barrier to prevent human and ecological exposure to contaminated materials via direct contact. A layer of geotextile would be placed over the contaminated soil to prevent mixing of clean and contaminated soils and sediments, to warn anyone who digs into the subsurface, and to prevent any erosion in the cover system to extend into the contaminated soil or sediment. The geotextile would be covered with 12 inches of a soil protective layer and a six-inch topsoil layer with appropriate seeding. The soil cover would be vegetated to prevent erosion and deterioration. A wear surface (such as six inches of crusher run or asphalt) could be substituted for the top soil and vegetation. The cover would be graded in such a way as to facilitate stormwater run off and minimize infiltration.

The construction of the cover would raise the majority of the site above the 100-year flood elevation of 8.5 feet msl, with the exception of the eastern portion of the site adjacent to the Southern Branch of the Elizabeth River, Elm Avenue, and the restored wetlands (former Acetylene Sludge Area).

DNAPL Monitoring: Alternative 2 makes use of existing monitoring wells to perform long-term monitoring of DNAPL contamination. On-site and off-site monitoring wells in the upper Columbia, lower Columbia, and Yorktown Aquifers would be sampled to monitor the extent of DNAPL contamination. Accumulated DNAPL thickness would be recorded for the wells containing measurable or trace amounts of DNAPL. Standing DNAPL would be bailed and disposed off-site. It was estimated that eight monitoring wells would be included in the sampling program.

Monitored Natural Attenuation (MNA): Alternative 2 makes use of MNA to lower the levels of contaminants in the ground water.

Many of the planned remedial activities will increase the applicability of MNA to the ground water. The removal of the DNAPL from the Historic Disposal Area on the west side of the AWI property will remove the major source of ground water contamination beyond the waste management area to the PPSD property and the South Annex of the NNSY. The reduced rain water infiltration from the surface grading (to remove the low area in the middle of the west side of the AWI property) and the soil cover and/or pavement will reduce the ground water mound that is centered in the middle of the western portion of the AWI property, which will help restore the natural ground water flow direction more directly toward the Southern Branch of the Elizabeth River.

The reliance on natural processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives for ground water within a time frame is reasonable. These natural processes include biodegradation; dispersion; dilution; sorption; volatilization; and chemical or biological stabilization, transformation, or destruction of contaminants.

Subaqueous Sediment Cap: Over the areas exceeding 100 ppm tPAHs, a cap consisting of a clean layer of sand topped with an armoring layer would be installed to isolate contaminants in the existing sediment and allow the creation of a clean habitable layer for organisms that feed in the area, seek cover in the rocks (such as fish), or potentially use rocks as substrate (such as oysters).

The armoring layer would consist of an appropriately sized rock to withstand disturbances such as prop wash. A thin filter layer of quarter-inch stone would be placed between the sand and armor layer to prevent resuspension of the sand. A sorbent material, such as activated carbon, may also be applied in some areas to reduce leaching of contaminants through the cap layers. Activated carbon could be mixed with the sand or placed between filter fabric layers. For cost-estimating purposes, it was assumed that sorbent material would not be needed. Approximately 14 acres of river sediment would be addressed with a subaqueous cap.

On-Shore Sheet Pile Wall: To prevent future releases of DNAPL to surface water and river sediments that could cause risks to workers, recreational users, and ecological receptors, Alternative 2 includes the installation of a sealed steel sheet pile wall along the shoreline north and south of the Jordan Bridge, see **Figure 27**. The exact location of the sheet pile wall has not been determined because it would depend on the location of large rocks and rubble near the shoreline. The wall may be located several feet on-shore to avoid the rubble or right at the shoreline. The sheet pile wall would also enhance the river front for improved industrial use by serving as a bulkhead with deep water access. Additional sheet piling would be placed on the east end of the Portsmouth Port and Industrial Commission property, not to contain DNAPL but to provide slope stability.

The sheet pile wall would consist of continuously interlocked steel pile segments driven into the ground and would tie into existing sheet pile at the northwest corner of the restored wetland. Site preparatory work would include the removal of large rubble that would obstruct the installation of the sheet piles. The sheet piles would be embedded into the Columbia clay to resist horizontal pressures. The small cavity at the intersection of neighboring segments would be filled with a sealant, such as bentonite, to form a tight seal between the interlocking sheets. In addition, *in-situ* solidification/stabilization (S/S) of the soil immediately behind the sheet pile wall would be performed to further enhance the wall's effectiveness as a barrier to DNAPL migration. It was assumed that the thickness of stabilized material behind the wall would be five feet. Common additives for binding the contaminants are Type 1 portland cement, fly ash, limestone, or a mixture of these materials.

Ground Water Management Behind the Wall: Surface water infiltration and the natural ground water gradient in the area may cause a buildup of the water table on the land side of the wall. Therefore, ground water discharge points consisting of gates of sand in the stabilized zone behind the sheet pile would be constructed to allow ground water to migrate to weirs or holes in the sheet pile wall, which would be strategically placed in areas of low contamination in the upper portion of the wall. These seepage openings would allow the top layer of the upper Columbia Aquifer ground water to flow unimpeded through the wall, while minimizing the migration of more highly-contaminated ground water in the deeper portions of the aquifer. Ground water may flow to the river or river water to the aquifer as the hydraulic gradient changes with the tide, rainfall, and other forces. Tidal fluctuations influence the water level elevation of the upper Columbia Aquifer by approximately two feet. The depth to water in the upper Columbia Aquifer at the east end of the site is approximately four feet below ground surface. More substantial controls may be necessary if the passive methods do not protect the river because of the amount of contamination in the ground water. Virginia Pollution Discharge Elimination System (VPDES) requirements will be used to help evaluate potential impacts to the river. The first upgrade would be to add a treatment agent to the sand gate such as activated carbon. If this upgrade is not adequate, pumping wells and/or a ground water collection trench and a treatment plant would be required at an increased cost.

Enhanced MNR: Alternative 2 includes enhanced MNR to address lower levels of contaminated sediment (i.e., tPAHs less than 100 ppm and greater than 45 ppm). MNR consists of natural processes that contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment. Generally for sediments where PAHs have been present for a long time, the predominant process is burial. At the site, MNR could be enhanced by placing a thin layer of sand over the sediment. The layer of sand would mix naturally with the surface sediments by biota (called bioturbation), water movement, and human activities (such as prop wash from a tug boat). This enhancement of MNR is different from the isolation capping proposed for areas greater than 100 ppm tPAHs. The thickness of the sand layer may be increased to the extent necessary to achieve the final goal of 45 ppm tPAHs in the top foot of sediments within a reasonable time frame. While not expected, as much as 12 inches of sand could be placed in some areas. Long-term sediment monitoring would be performed to determine whether natural sedimentation, biodegradation, and other MNR processes are adequately remediating the sediment such that the top foot reaches and remains at or below 45 ppm tPAHs. Approximately seven acres of river bottom with surface sediments that are below 100 ppm but over 45 ppm tPAHs would be addressed with enhanced MNR, as shown in **Figure 27.**

O&M: A monitoring and maintenance program would be implemented to ensure that cap integrity and effectiveness is maintained. A bathymetric survey would be performed every five years to evaluate the integrity of the cap. Long-term sediment (both on and outside of the cap area) and biota (i.e., crabs and oysters) monitoring would be required to evaluate the effectiveness of the subaqueous cap and enhanced MNR and to check for recontamination from upland or upstream sources. Ground water discharging from the weirs in the sheet pile wall would be sampled annually.

9.2.3 Alternative 3: Geomembrane Cap, MNA/Ground Water Monitoring, On-Shore Sheet Pile Wall, Partial Dredging with Subaqueous Cap and Enhanced MNR

Capital Cost: $45,200,000
Total Present Worth: $48,800,000
Annual O&M Costs: $350,000

In addition to the common elements described above, Alternative 3 includes the following remedial measures: a geomembrane cap, an on-shore sheet pile wall, and partial dredging with subaqueous cap as shown in **Figure 28.**

Geomembrane Cap: This alternative includes the construction of a geomembrane cap over soil where contaminant levels exceed the cleanup criteria to prevent direct exposure to underlying contamination and to minimize infiltration of precipitation to ground water. The geomembrane cap would be constructed with a combination of geosynthetic clay liner and a geomembrane with a 12-inch soil protective layer and 6-inch topsoil vegetative layer (or a wear surface).

DNAPL Monitoring: DNAPL monitoring would be performed as discussed in Alternative 2.

Monitored Natural Attenuation (MNA): MNA would be performed as discussed in Alternative 2.

On-Shore Sheet Pile Wall, Partial Dredging, Subaqueous Cap and Enhanced MNR: The river sediment component to this alternative contains all of the same elements as the subaqueous cap in Alternative 2 except that the upper three feet of sediment (equal to the proposed cap thickness) would be dredged and consolidated on-site prior to placing the cap to maintain the current mean water depth. Sediments could be dredged hydraulically, mechanically, or by a combination of the two methods. Mechanical dredging using a barge-mounted clamshell bucket has been assumed for cost-estimating purposes. Turbidity curtains and oil booms would be installed to limit the downstream transport of contaminants during dredging activities. Site preparatory work would include the removal of large rubble and old pilings from the river bottom that would interfere with dredging activities.

The sediment would then be spread across the west side of the site, mixed with solidification agents (if greater than 1,000 ppm tPAHs or as necessary to support the cover), and compacted using standard earthmoving equipment prior to construction of the proposed geomembrane cap. Assuming a 25 percent volume increase of the material to be solidified/stabilized, the ground surface elevation of the west side of the property would increase by approximately two feet prior to placement of the cap.

As opposed to Alternative 2, once the cap is placed, S/S would not be performed behind the on-shore sheet pile wall. Enhanced MNR, ground water management and O&M would be implemented as described in Alternative 2.

9.2.4 Alternative 4 (EPA's Selected Remedy): Soil Cover, Partial DNAPL Consolidation and Containment, MNA/Ground Water Monitoring, Dredging, Consolidation Behind Enhanced Off-Shore Sheet Pile Wall and at the West Side and Enhanced MNR

Capital Cost: $41,400,000 *Annual O&M Costs:* $348,000
Total Present Worth: $44,900,000

In addition to the common elements described above, Alternative 4 includes the following remedial measures: a soil cover, partial DNAPL consolidation, and dredging with consolidation both behind an enhanced off-shore sheet pile wall and on the west side of the site as shown in **Figure 29.**

Soil Cover: A soil cover would be constructed over all soils above the cleanup criteria as discussed in Alternative 2.

Partial DNAPL Consolidation (West Side): Under this alternative, the DNAPL/soil matrix on the west side of the site (approximately 7,200 cubic yards) would be excavated and consolidated on the east side of the property behind an off-shore sheet pile wall (described below). This alternative would contain the DNAPL-contaminated material in an area where the clay confining layer is very thick, as opposed to the west side where it is very thin in some parts, particularly in the Historic Disposal Area.

Excavating the contaminated DNAPL/soil matrix would require digging down to the Columbia clay layer, at depths down to 20 to 25 feet below ground surface (bgs), except in the east end of the Historic Disposal Area, where DNAPL contamination would be excavated from below the Columbia clay to a depth of 40 feet bgs. An alternative to this approach in the Historic Disposal Area would be to solidify/stabilize DNAPL *in-situ* where it is found at a depth impracticable for excavation. DNAPL excavation and consolidation has been assumed for the cost estimate. Overlaying clean soil would be excavated and stockpiled in order to access all subsurface DNAPL. Excavated areas would be backfilled with stockpiled and imported fill material as necessary. A stormwater detention basin could be constructed in the area that is excavated in the Historic Disposal Area (see **Figure 29**) to control run-off from the completed cap, as shown in **Figures 26A** and **26B.**

Excavation would be performed using standard earthmoving equipment. Site features that would need to be protected include monitoring wells and railroad tracks and the adjacent Portsmouth Public School District property. Significant dewatering would be required to conduct subsurface soil excavation. Sump pumping systems and temporary storage tanks probably would be used to reduce ground water infiltration into the excavation zone. Water that is extracted during the dewatering phase would be treated on-site before being discharged to the Southern Branch of the Elizabeth River or Paradise Creek. Treatment would involve filtration/sedimentation to remove sediments and carbon adsorption to remove organics.

DNAPL Monitoring (East Side): DNAPL on the east side of the site would be monitored as discussed in Alternative 2.

Monitored Natural Attenuation (MNA): MNA would be performed as discussed in Alternative 2.

Dredging With Consolidation Both Behind Enhanced Off-Shore Sheet Pile Wall and on the West Side and Enhanced MNR: The river sediment component of this alternative involves construction of an off-shore sheet pile wall, dredging, and enhanced MNR. An off-shore sheet pile wall would be driven into the Columbia clay confining unit as shown in **Figure 30.** A second off-shore wall would be constructed across the Wyckoff Inlet, as shown in **Figure 31**. The purposes of the off-shore sheet pile wall would be to: (1) prevent the migration of subsurface DNAPL from the land to the river sediment and surface water; (2) provide on-site containment for dredged contaminated sediment; (3) stabilize the perimeter slope prior to dredging the adjacent sediment; and (4) reduce the quantity of sediment requiring dredging. In addition, it would enhance the river front for improved industrial use by serving as a bulkhead with deep water access.

The off-shore sheet pile wall would consist of interlocked steel pile segments driven into the river bottom. The off-shore wall could extend onto the AWI property and be tied into the eastern tip of the existing sheet pile at the restored wetland as shown in **Figure 29**. The top of the off-shore wall would be at the existing shoreline elevation (approximately five to eight feet above mean sea level). The wall would be keyed into the low-permeability Columbia clay. The small cavity at the intersection of neighboring segments would be filled with a sealant, such as bentonite, to form a tight seal between the interlocking sheets. In addition, dredged sediment placed immediately behind the sheet pile wall would undergo *in-situ* S/S to create an additional five-feet-thick barrier to further enhance the wall's effectiveness to prevent DNAPL migration, as discussed in Alternative 2.

The south wall would be constructed approximately 200 feet off-shore from the AWI property and the north wall would be constructed approximately 550 feet off-shore from the west end of the Wyckoff Inlet. The sheet pile walls would not extend into the river past the established bulkhead line. The optimal wall configuration would be determined during remedial design considering such factors as adequate consolidation space, DNAPL location, minimizing the area of the river to be filled, and cost. Additional sheet piling would be placed on the east end of the Portsmouth Port and Industrial Commission property shore, not to contain DNAPL but to provide slope stability for dredging.

Approximately 157,000 cubic yards of contaminated sediments on the river side of the walls that are greater than 100 ppm tPAHs, as shown in **Figure 29**, would be dredged and consolidated behind the sheet pile wall or on the west side of the site. Dredging of areas greater than 100 ppm tPAHs would continue until remaining sediment contaminant levels are below 45 ppm tPAHs, as determined by confirmatory sampling. In most areas, dredging would not extend into the Columbia clay; however, in certain parts of the site, there is extensive contamination in the clay, including the area extending out from the Wyckoff Inlet and the area immediately south of the AWI pier. At these locations, all sediment greater than 100 ppm tPAHs would be dredged regardless of depth. This dredging would remove more heavy contamination from the river, reduce concerns about future dredging in the area for navigational purposes, and prevent recontamination of the sediments. In areas where the clay is exposed following dredging, one foot of sand would be placed to provide benthic habitat. Additionally, to address residuals sand may be placed in other areas as well. The same dredging methods, precautions, and water management procedures described in Alternative 3 would be applied.

Dredged material would be consolidated both on the land side of the walls, covering over DNAPL in sediments behind the sheet pile wall(s) and creating new land, and on the west side of the site. An estimated 53,000 cubic yards of sediment could be consolidated behind the south wall, and 16,000 cubic yards could be consolidated behind the north wall. The most heavily contaminated material would be consolidated behind the off-shore sheet pile wall. Excess dredged material that is less than 1,000 ppm tPAHs would be consolidated on the west side of the AWI property. There are currently areas of soil contamination on the west side with tPAH levels of approximately 4,000 ppm. With a small percentage of the sediments requiring S/S for geotechnical purposes, the ground surface elevation of the west side of the property would increase by approximately two feet prior to placement of the soil cover.

Site preparatory work would include the removal of large rubble and old pilings from the river bottom that would obstruct the installation of the sheet piles. Existing surface water pipes that discharge in the Wyckoff or Northern Inlets would be extended to the sheet pile wall to discharge to the river. The ground water behind the sheet pile wall would be managed as discussed in Alternative 2.

The approximately six acres of sediments with surface contaminant levels between 45 ppm and 100 ppm tPAHs would be addressed by MNR. Where necessary, a thin-layer of sand would be placed to enhance the MNR process as discussed in Alternative 2.

Ground water management and O&M would be implemented as described in Alternative 2.

Stabilization: The upper three feet of the consolidated sediment placed behind the wall would undergo S/S to provide a load-bearing surface. Three feet of stabilized material is assumed to be sufficient to ensure weight-bearing capacity (based on stabilization remedies used at other sites), but geotechnical analysis would be needed in the design phase to confirm this depth. S/S would be performed after the sediment is consolidated behind the wall. In addition, five feet of sediments placed immediately against the sheet pile wall would be mixed *in situ* with S/S agents, after preliminary dewatering through natural decantation, to further enhance the sheet pile wall's effectiveness as a barrier to contaminant migration as discussed in Alternative 2. The soil cover proposed in this alternative would extend out to the off-shore sheet pile walls, covering the consolidated sediment.

9.2.5 Alternative 5: *In-Situ* S/S of Soil and DNAPL, Soil Cover, MNA/Ground Water Monitoring, Enhanced On-Shore Sheet Pile Wall, Dredging with On-site Consolidation Except for Subaqueous Cap with Habitat Restoration in Wyckoff Inlet, and Enhanced MNR

Capital Cost: $57,600,000 *Annual O&M Costs:* $328,000
Total Present Worth: $60,800,000

In addition to the common elements described above, Alternative 5 includes the following remedial measures: *in-situ* S/S of soil and DNAPL, a soil cover, enhanced on-shore sheet pile wall, and dredging (with inland consolidation on the west side) except for a subaqueous cap with wetlands/mudflats restoration in the Wyckoff Inlet, as shown in **Figure 32.**

***In-Situ* S/S of Soil and DNAPL:** This alternative uses *in-situ* S/S to treat soil, contaminated above the cleanup criteria, and DNAPL. S/S would be applied to the depth of the water table (approximately four feet bgs) on all soil contaminated above the cleanup criteria, as shown in **Figure 32**. S/S additives may be injected and mixed to depths of up to 40 feet. In some areas, particularly the Historic Disposal Area, any large debris would require excavation prior to treatment. After stabilization, six inches of vegetated soil or a wear surface would be placed over the AWI property.

Monitored Natural Attenuation (MNA): MNA would be performed as discussed in Alternative 2.

Enhanced On-Shore Sheet Pile Wall, Dredging with On-site Consolidation and Enhanced MNR: The river sediment component to this alternative involves construction of a sheet pile wall inland from the shoreline, dredging/excavation and on-site consolidation, and enhanced MNR. All contaminated river sediments greater than the 100 ppm tPAHs would be dredged. Dredging of areas greater than 100 ppm tPAHs would continue until sediment contaminant levels are below 45 ppm tPAHs at the surface. Dredged sediment would be transported to the west side of the site for consolidation prior to S/S and construction of the soil cover. A sheet pile wall would be driven along the shoreline before dredging commences. The exact location of the sheet pile wall is undecided and would depend on the location of large rocks and rubble near the shoreline. For evaluation purposes, it was assumed that the sheet pile wall would be constructed approximately 50 feet inland from the Southern Branch of the Elizabeth River on the AWI property, as shown in **Figure 33**.

The new inland sheet pile wall would be tied into the eastern tip of the existing sheet piling on the north side of the former acetylene sludge restored wetland and would be constructed as described in Alternative 2. Additional sheet piling would be placed on the Portsmouth Port and Industrial Commission property, not to contain DNAPL but to provide slope stability for dredging. Ground water west of the sheet pile walls would be managed as discussed in Alternative 2.

Approximately 200,000 cubic yards of river sediment would be dredged. The same dredging methods and precautions to minimize contaminant dispersion described in Alternative 3 would be applied. Dredging would stop at the Columbia clay except in the areas described in Alternative 4. In addition, soil east of the wall would be excavated to the elevation of the adjacent sediment surface. Below that elevation, any soil with a tPAH concentration greater than the dredging criteria would be excavated. If all of the soil outside the wall is removed, the surface area of additional river bottom created would be 0.3 acres. In areas where the Columbia clay is exposed following dredging, one foot of sand would be placed to restore the benthic habitat.

Dredged sediment and excavated soil would be consolidated on the west side of the site as discussed in Alternative 3. It is estimated that the ground surface elevation of the west side of the property would increase by approximately 5.5 feet. Enhanced MNR, ground water management, and O&M would be implemented as described in Alternative 2.

Subaqueous Cap and Wetlands Restoration at the Wyckoff Inlet: To retain the shallow water habitat in the Wyckoff Inlet, an off-shore sheet pile cut-off wall would be installed across the inlet, approximately 550 feet from the west end of the inlet to prevent further migration of DNAPL in the deeper sediments. The sheet piling would be driven to a depth below the DNAPL contamination and anchored into the Columbia clay. Large stone or rip-rap may be placed against the east side of the off-shore wall on the river bottom for added structural support.

The wetland/mudflat habitat behind the sheet pile would be restored by excavating and replacing the upper five feet of sediment in the inlet. Approximately 1.5 acres of the inlet would be excavated, resulting in 12,000 cubic yards of sediment, which would be consolidated on the west side of the AWI property. A subaqueous cap would be installed over the remaining contaminated sediment, restoring the original bathymetry. The areas near the riverbank would then be sprigged with emergent wetland vegetation. The cap would consist of a geomembrane layer over the remaining contaminated sediment, a 2.5-foot sand drainage layer, a second geomembrane, and 2.5 feet of clean sediment, as shown in the cross-section on **Figure 34**. After the cap placement and wetland restoration is complete, the portion of the sheet pile cut-off wall sticking up above the sediment surface would be cut and removed.

On-shore sheet piling would be installed all along the Wyckoff inlet to prevent upland DNAPL from re-contaminating the restored wetlands and the rest of the river sediment following remediation. The shoreline sheet pile wall would be installed to a depth equal to the base of the sediment cap. Approximately five feet of soil immediately behind the on-shore and off-shore walls would be stabilized to further enhance their effectiveness as a barrier to DNAPL migration, as described in Alternative 2. Weep holes would be installed in the shore line and off-shore sheet pile walls to allow ground water to drain through the sand drainage layer.

9.2.6 Alternative 6: Low-Temperature Thermal Desorption of Soil, Pump and Treat DNAPL and Ground Water (West Side), MNA/Ground Water Monitoring, Enhanced On-Shore Sheet Pile Wall, Dredging with On-site Disposal Except for Subaqueous Cap with Habitat Restoration in Wyckoff Inlet, and Enhanced MNR

Capital Cost: $114,600,000 *Annual O&M Costs:* $444,000
Total Present Worth: $119,200,000

In addition to the common elements described above, Alternative 6 includes the following remedial measures: low-temperature thermal desorption (LTTD) of soil, pump and treat DNAPL and ground water (west side), ground water monitoring, enhanced on-shore sheet pile wall, and dredging with inland consolidation except for a subaqueous cap and wetlands restoration in the Wyckoff Inlet as shown in **Figure 35**. According to the 1995 ROD, contaminated soil would be excavated and treated to the cleanup criteria. The 1995 ROD stipulated *ex-situ* biological treatment; however, treatability studies conducted by AWI showed that biological treatment would have limited success. The contingency remedy in the ROD provided for the use of LTTD to treat contaminated soil. This alternative includes the contingency remedy specified in the 1995 ROD and consists of excavating the soil with contaminant levels above the cleanup criteria for on-site treatment using LTTD and backfilling the excavation area.

LTTD of Soil: Surface soil up to an estimated depth of four feet would be excavated and undergo LTTD. Approximately 135,300 cubic yards would be treated, as shown on **Figure 35**. Overlaying clean soil would be removed and stockpiled in order to access all soil contaminated above the cleanup criteria. After all material is backfilled, six inches of vegetated soil or a wear surface would be placed over the AWI property. LTTD would remove SVOCs and dioxins from excavated soils; however, it would not effectively remove the metals contamination. The treatment process uses temperatures, generally ranging from about 300 to 1,000 °F, which are low compared to incinerators, to volatilize the organic contaminants. The process would remove dioxins at the higher temperatures, given that dioxins boil at approximately 500 °F. The hydrocarbon vapors are generally treated in a secondary treatment unit (e.g., an afterburner, catalytic oxidation chamber, condenser, or carbon adsorption unit) prior to discharge to the atmosphere. Afterburners and oxidizers destroy the organic constituents while condensers and carbon adsorption units trap organic compounds for subsequent treatment or disposal. Concentrated waste streams generated by LTTD treatment, such as condensate and spent carbon, are typically sent off-site for treatment (e.g., condensate disposed at a wastewater treatment plant) and/or regeneration (e.g., spent carbon can be regenerated by thermal desorption with thermal oxidation off-gas treatment).

Some pre- and post-processing of soil is necessary when using LTTD. Excavated soils would need to be screened to remove large objects, which could be crushed or shredded and introduced back into the feed material. Alternatively, large objects may be decontaminated and disposed off-site. After leaving the desorber, soils are cooled, re-moistened to control dust, and stabilized (if necessary to treat metals) to prepare them for disposal/reuse. The 1995 ROD contingency remedy also called for the removal and off-site disposal of the acetylene sludge material. However, a removal action conducted by AWI and the Navy has addressed this area.

Pumping DNAPL from Extraction Wells: This alternative component is consistent with the DNAPL remedy specified in the 1995 ROD, and includes the use of eight existing and seven new recovery wells to pump DNAPL from the subsurface (see **Figure 35**). The estimated recovery well locations have been selected to target the estimated 151,000 gallons of DNAPL present in the subsurface. DNAPL recovered by the extraction wells would be treated and disposed off-site. This alternative would achieve a DNAPL mass reduction if the DNAPL is mobile and able to be pumped; however, a significant percentage (potentially as high as 90%) of the DNAPL mass would remain in pore spaces as residual DNAPL and continue to act as a source of ground water contamination. DNAPL recovery wells could be converted to ground water extraction wells for future remedial actions.

Pumping of the DNAPL/water mixture would commence at a rate of one gallon per minute (gpm) and would likely continue intermittently for approximately five years, when continuing operation would result in diminishing returns in DNAPL recovery. DNAPL recovery rates would be monitored closely, and when recovery rates decline, pumping would be temporarily halted to allow the wells to recover. The radial influence of the DNAPL pumps is not expected to be very extensive, and this pumping scheme will probably need to be modified or expanded based on field results. A system of transfer pipes would be installed to convey the contaminated extracted water/DNAPL from the extraction wells to the on-site treatment system. In addition, eight existing wells would be retrofitted with submersible pumps, piping, and fittings to connect to the on-site treatment plant.

Extracted DNAPL would be separated from the extracted ground water using decant tanks. Collected DNAPL would be transported off-site for disposal by incineration. The extracted water would be treated on-site using carbon adsorption and metals precipitation as necessary and then discharged to the Southern Branch of the Elizabeth River or an off-site publically owned treatment works.

Pump and Treat Ground Water (West Side) and MNA (East Side): This alternative involves a ground water pump-and-treat system to remediate the upper and lower Columbia Aquifers and hydraulically control the spread of contamination on the west side of the site. This control would be achieved through the installation of an estimated six new recovery wells to pump contaminated ground water from the subsurface on the west side of the site (see **Figure 35**). An estimated 14 gpm of ground water would be pumped from the ground. Ground water recovered by the extraction wells would be treated on-site and discharged to the Southern Branch of the Elizabeth River or Paradise Creek. On the east side of the site, MNA of ground water would be performed.

Enhanced On-Shore Sheet Pile Wall and Dredging with On-site Disposal: The river sediment component to this alternative involves construction of a sheet pile wall at or near the shoreline, dredging, and on-site consolidation. All sediments that are greater than 100 ppm tPAHs would be dredged except in the Wyckoff Inlet, as shown in **Figure 35**. Dredging of areas greater than 100 ppm tPAHs would continue until sediment contaminant levels are below 45 ppm tPAHs. Approximately 200,000 cubic yards of sediment would be dredged. Dredging would stop at the Columbia clay except in the areas described in Alternative 4. An additional 12,100 cubic yards would be dredged from the Wyckoff Inlet prior to placement of the subaqueous cap discussed below. Dredging methods would be performed as discussed in Alternative 3. The majority of the dredged material would be consolidated on the west side of the site, as described in Alternative 3, and a small amount would be consolidated behind the sheet pile wall, as described in Alternative 4. The sediment disposed on the west side of the site would be treated through the LTTD treatment unit prior to disposal. The ground surface elevation of the west side of the property would increase by approximately five feet due to disposal of this sediment.

Additional sheet piling would be placed on the Portsmouth Port and Industrial Commission property (7,000 square feet), not to contain DNAPL but to provide slope stability for dredging. The sheet pile wall construction, ground water management, and O&M would be performed as discussed in Alternative 2.

Subaqueous Cap and Wetlands Restoration: A subaqueous cap would be placed in the Wyckoff Inlet and wetland habitat would be restored as discussed in Alternative 5.

9.2.7 Alternative 7: Excavation with Off-site Disposal of Soil (West Side) and DNAPL (East & West), *In-Situ* S/S of Soil (East Side), *In-Situ* Chemical Oxidation of Ground Water (West Side), MNA, On-Shore Sheet Pile Wall, and Dredging with Off-Site Disposal

Capital Cost: $290,000,000
Total Present Worth: $293,200,000
Annual O&M Costs: $328,000

In addition to the common elements described above, Alternative 7 includes the following remedial measures: excavation with off-site disposal of soil (west side) and DNAPL, *in-situ* S/S of soil (east side), *in-situ* chemical oxidation of ground water (west side), ground water monitoring, on-shore sheet pile wall, and dredging with off-site disposal, as detailed below and shown in **Figure 36**.

Excavation with Off-site Disposal of Soil (West Side) and DNAPL: This alternative includes excavating soil on the west side of the site where contaminant levels exceed the cleanup criteria and all DNAPL on both sides of the site. Excavated material would be transported off-site for treatment and disposal. The excavation depths for soil are estimated to be up to four feet. The contaminated DNAPL/soil matrix would be excavated down to the Columbia clay layer, at depths of 20 to 25 feet bgs, except in the east end of the Historic Disposal Area, where DNAPL contamination is found below the Columbia clay to a depth of 40 feet bgs. Imported fill material would be used to backfill excavated areas after confirmatory soil sampling is completed to verify the limits of excavation.

Excavation and dewatering would be performed as described in Alternative 4. This alternative would require the transport of approximately 4,300 truckloads of contaminated soil for off-site disposal. Excavated areas would be backfilled with stockpiled and imported fill material. After all material is backfilled, six inches of vegetated soil or a wear surface would be placed over the AWI property.

***In-Situ* S/S of Soil (East Side):** *In-situ* S/S of soil would be performed as discussed in Alternative 5, except that it would only be applied to soil on the east side of the site.

***In-Situ* Chemical Oxidation of Ground Water (West Side) and MNA:** Under this alternative, an oxidizing agent (e.g., hydrogen peroxide, Fenton's Reagent, potassium permanganate, or ozone) would be injected into the ground water plumes in the upper and lower Columbia Aquifers on the west side of the site to destroy organic contaminants. The organic contaminants would be mineralized via oxidation. The treatment area for this alternative is shown in **Figure 36**. Chemical oxidants can be injected via direct push rig. On the east side of the site, MNA of ground water would be performed.

On-Shore Sheet Pile Wall and Dredging with Off-site Disposal: The river sediment contamination would be addressed as in Alternative 6 except that the dredged sediment would be disposed off-site. Dredged sediment would be dewatered, temporarily staged on-site, and sampled prior to transporting to an appropriately licensed off-site facility.

10. EVALUATION OF ALTERNATIVES

In this section, the alternatives are evaluated in detail to determine which would be the most effective in achieving the goals of CERCLA and, in particular, achieving the remedial action objectives for the site. Brief summaries of the seven alternatives are included in a header in this section of the ROD for easy reference. The alternatives are compared to each other based on the nine criteria set forth in the NCP at 40 C.F.R. 300.430(e)(9)(iii). The NCP categorizes these criteria in three groups: threshold criteria, primary balancing criteria, and modifying criteria.

The threshold criteria are requirements that an alternative must meet to be eligible for selection.

- *Overall Protection of Human Health and the Environment* addresses whether a remedy provides adequate protection to human health and the environment and describes how risks are eliminated, reduced, or controlled through treatment, engineering controls, or ICs.

- *Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)* addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of environmental statutes, regulations, and/or whether there are grounds for invoking a waiver.

The next five criteria are the primary balancing criteria. These criteria are used to distinguish the relative effectiveness of the alternatives so that decision makers can evaluate the strengths and weaknesses of each alternative.

- *Long-Term Effectiveness and Permanence* refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup goals are achieved.

- *Reduction of Toxicity, Mobility, or Volume through Treatment* addresses the degree to which alternatives will reduce the toxicity, mobility, or volume of the contaminants through treatment.

- *Short-Term Effectiveness* addresses the period of time needed to achieve protection and any adverse impacts on human health and environment that may be posed during the construction and implementation period until cleanup goals are achieved.

- *Implementability* addresses the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

- *Cost* includes estimated capital and operation and maintenance costs, usually combined as present worth cost.

The last two criteria are the modifying criteria.

- *State Acceptance* indicates whether the Commonwealth of Virginia concurs with, opposes, or has no comment on the selected remedy.

- *Community Acceptance* indicates whether the public supports the selected remedy.

List of Alternatives

1. No Action
2: Soil Cover, MNA, On-Shore Sheet Pile Wall, Sediment Cap, MNR
3: Geomembrane Cap, MNA, On-Shore Sheet Pile Wall, Partial Dredge w/Sediment Cap, MNR
4: Soil Cover, MNA, Partial DNAPL Consolidation, Off-Shore Sheet Pile Wall, Dredging, MNR
5: *In-situ* S/S, Soil Cover, MNA, Landward Sheet Pile Wall, Dredging, On-site Consolidation, Restore Wyckoff Habitat, MNR
6: LTTD, P&T DNAPL, On-Shore Sheet Pile Wall, Dredging, On-site Disposal, Restore Wyckoff Habitat, MNR
7: Excavation w/Off-site Disposal of Soil (W) and DNAPL, S/S Soil (E), Chem Ox GW (W), MNA (E), On-Shore Sheet Pile Wall, Dredge w/Off-site Disposal

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When evaluating alternatives, it is important to consider the concept of principal threat waste and low-level threat waste. Section 300.430(a)(l)(iii) of the NCP states that "EPA expects to use treatment to address the principal threats posed by a site, wherever practicable," that "EPA expects to use engineering controls, such as containment, for waste that poses a relatively low, long-term threat or where treatment is impracticable," and that "EPA expects to use a combination of methods, as appropriate, to achieve protection of human health and the environment." It also states that "EPA expects to use institutional controls...to supplement engineering controls as appropriate," and that ICs may be used "where necessary, as a component of the completed remedy." However, the NCP also states that ICs "shall not substitute for active response measures...as the sole remedy unless such active measures are determined not to be practicable...."

The concept of principal threat waste and low-level threat waste is applied on a site-specific basis when characterizing source material. "Source material" is defined as material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to ground water, to surface water, to air, or that acts as a source for direct exposure. Source materials are principal threat wastes when they contain high concentrations of toxic compounds (e.g., several orders of magnitude above levels that allow for unrestricted use and unlimited exposure) or are highly mobile and generally cannot be reliably contained.

At the AWI site, EPA considers DNAPL in the soil, ground water, and river sediments to be principal threat waste because it acts as a reservoir for on-going migration of contamination to ground water and surface water and acts as a source for direct exposure in the river. Each of the alternatives contains treatment of principal threat waste to varying degrees.

10.1 Overall Protection of Human Health and the Environment

A primary requirement of CERCLA is that the selected remedial action be protective of human health and the environment. An alternative is protective if it reduces current and potential future risks associated with each exposure pathway at a site to acceptable levels.

The "no action" alternative (Alternative 1) does not meet this threshold criterion for a number of reasons, including the following:

- Site occupants would be subject to potential health risks associated with exposure to contaminated surface soils.
- Contaminated surface soils and sediments would be prone to erosion and transport to downgradient stream channels, wetland areas, and the Southern Branch of the Elizabeth River, where they may negatively impact surface water and sediment quality.
- Although the contaminated aquifers are not used as a drinking water source, the potential exists for other ground water exposure pathways to develop during future activities at the site. Excavation or trenching activities below the water table would pose a risk to workers, as would any site use of the ground water.
- Any human health risks associated with consumption of crabs and oysters and exposure to river sediment, via recreational direct contact and occupational exposures, would remain.

- Ecological risks to the benthic macroinvertebrate and avian communities would remain above acceptable levels.

Since the "no action" alternative fails to meet this threshold criterion of protectiveness, it will not be evaluated further. Hereinafter, "each alternative" means Alternatives 2 through 7.

Alternatives 6 and 7 would provide the highest degree of overall protection of human health and the environment because they include the most aggressive cleanup actions (except in the Wyckoff Inlet) and rely the least on containment of waste or MNA (for ground water). Additionally, Alternative 7 does not rely on MNR to address risks to aquatic receptors since all sediment above the cleanup value of 45 ppm tPAHs would be dredged.

Alternatives 2, 3, 4, and 5 provide the same degree of protection to human health from direct contact with contaminated soil because the soil cover or geomembrane cap would separate the contaminated soil from a person on the surface. Each would rely on ICs to protect workers that would come into contact with contaminated soil during, for example, a construction project. Of these four, Alternatives 3 and 5 would offer a greater degree of protection of ground water from the soil contamination (and thus human health and the environment) because the geomembrane cap in Alternative 3 has a lower permeability than the soil cover in Alternatives 2 and 4 and the *in-situ* S/S of the soil in Alternative 5 would reduce the soil permeability and the soil contaminant mobility. Alternative 5 would offer a greater degree of protection of ground water from the DNAPL because the DNAPL would undergo S/S, significantly reducing its ability to leach contaminants. Alternative 4 would offer greater protection of ground water from DNAPL compared to Alternatives 2 and 3 because Alternative 4 requires the removal of DNAPL on the west side where the underlying Columbia clay layer is very thin in places.

Alternatives 2, 3, 4, 5, and 6 provide approximately the same degree of protection to human health from direct contact with the sediments and the consumption of shellfish and to aquatic receptors because they address the contaminated sediments to the same degree (active remediation when tPAHs are greater than 100 ppm and then MNR to 45 ppm[19]). Alternatives 5 and 6 would achieve a higher degree of protection of the river environment than the other three because they include the restoration of wetlands/mudflat in the Wyckoff Inlet and do not involve any filling of the river. In fact, Alternative 5 would reclaim about 0.3 acres of river bottom that had previously been filled. However, efforts in Alternatives 5 and 6 to restore habitat in the Wyckoff Inlet could pose a safety hazard to waders and boaters since there would be an unseen, underwater sudden drop-off where the sheet pile wall would be cut off at the sediment surface.

Each of the alternatives would protect terrestrial receptors by providing a clean "living layer" of soil by either covering soil contamination with clean soil or a geomembrane cap (Alternatives 2,

[19]As explained in the description of alternatives, sediment contamination greater than 100 ppm tPAHs would be dredged or capped. Within the 100 ppm tPAH dredge footprint, contaminated sediments would be dredged to 45 ppm tPAH, with an end result that large areas would be less than 100 ppm tPAHs for both dredging and capping. For dredging, the required slope of the dredge areas would also cause material less than 100 ppm tPAHs to be removed in some areas, although not significantly on the east side of the dredge area as the bank is sloped toward the navigation channel. Areas outside of the dredge or cap footprint exceeding 45 ppm tPAHs would be addressed with enhanced MNR. MNR would be enhanced with thin-layer sand placement to the extent necessary to achieve the final goal of 45 ppm tPAHs in the top foot of sediments within a reasonable time frame.

3, and 4), by treating soil and then placing six inches of clean soil on top (Alternatives 5, 6, and 7 East), or by removing and replacing the contaminated soil (Alternative 7 West).

The ICs in each alternative would provide protection of human health by ensuring future activities at the site are conducted in a manner to protect workers. Public education efforts would help reduce risks to recreational users of the river from consumption of crabs and/or oysters. For human health risks due to ground water, each alternative would address risks through the establishment of deed restrictions, which would prevent the use of ground water for domestic, industrial, or drinking purposes. Limitations would also be placed on intrusive work below the water table. A health and safety plan would be developed and implemented to protect workers from contact to ground water contaminants. Each alternative would include long-term monitoring of the ground water.

10.2 Compliance with ARARs

Any cleanup alternative considered by EPA must comply with all federal and state environmental ARARs. Applicable requirements are those substantive environmental standards, requirements, criteria, or limitations promulgated under federal or state law that are legally applicable to the remedial action to be implemented at the site. Relevant and appropriate requirements, while not directly applicable, address problems or situations similar to those encountered at the site and are well-suited to the particular site. EPA may waive an ARAR under certain conditions in accordance with CERCLA Section 121(d)(4). EPA is not waiving any ARARs in the remediation of this site.

Alternatives 2 through 7 meet this threshold criterion. A list of all of the ARARs for the selected remedy can be found in **Table 7** in **Appendix B**. Some of the major ARARs for the site include:

- *Clean Water Act:* Stormwater collected from the surface of a soil cover or cap would ultimately be discharged to the Southern Branch of the Elizabeth River. This discharge would need to meet the substantive requirements of a Virginia Pollution Discharge Elimination System (VPDES) General Permit Regulation for Discharges of Storm Water from Construction Activities permit (generally at 4 VAC 50-60), but a permit would not be required.

- *Wetland Regulations:* Federal and state wetlands requirements would be ARARs for all of the alternatives. Wetlands that are disturbed would require replacement so there is no net loss. A 1:1 replacement ratio has been assumed for each alternative. This remedy will mitigate any lost wetlands on-site by expanding the Acetylene Sludge Area restored wetlands. Wetlands will be delineated during the remedial design to determine the acreage requiring replacement.

- *Virginia Hazardous Waste Regulations:* Virginia regulations adopt by reference federal regulations promulgated pursuant to the Resource Conservation and Recovery Act (RCRA). Waste generated at the site must be characterized and could be determined to be any of the following RCRA-listed wastes: (1) K001–bottom sediment sludge from the treatment of wastewaters from wood preserving processes that use creosote and/or pentachlorophenol; (2) F032–wastewaters (except those that have not come into contact with process contaminants), process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that currently use or have previously used chlorophenolic formulations (this listing does not include K001 bottom sediment sludge from the treatment of wastewater from wood preserving processes that use creosote and/or pentachlorophenol); (3) F034–wastewaters (except those that have not come into contact with process contaminants), process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that use creosote formulations (this listing does not include K001 bottom sediment sludge); (4) K147–tar storage tank residues from coal tar refining; (5) K148–residues from coal tar distillation, but not limited to still bottoms; and (6) U051–soil and sediment contaminated by creosote that leaked from the storage tanks.

In addition to the above listings, waste generated at the site could be hazardous waste based on RCRA-defined characteristics (ignitability, corrosivity, reactivity, or toxicity).

RCRA has a number of disposal requirements for hazardous waste. Alternatives 2, 3, 4, and 5 have been designed to avoid disposal of hazardous waste. The on-shore containment of contaminated sediments in Alternatives 3, 4, and 5 involve consolidation of waste and not disposal as defined by RCRA. Therefore, RCRA disposal requirements are not ARARs for these alternatives. Alternative 6, which requires LTTD of soil and sediment, must meet the appropriate treatment standard(s) before the soil or sediment could be disposed at the site. Treatment standards for metals may not be met by LTTD, which would mean further treatment (S/S) would have to take place before disposal. RCRA disposal regulations would not be ARARs for Alternative 7 since the waste would be shipped off-site requiring compliance with all current laws and regulations. The alternatives that require some amount of *in-situ* S/S treatment would not need to meet any treatment standards because it would be conducted *in-situ* such that the treatment standards would not be ARARs.

For Alternatives 3, 4, 5, and 6, RCRA monitoring and inspection (during actual cap or cover construction) and closure/post-closure regulations would be ARARs. The closure regulations require that the final cover be designed and constructed to (1) provide long-term minimization of liquids through the closed landfill, (2) function with minimal maintenance, (3) promote drainage and minimize erosion or abrasion of the cover, (4) accommodate settling to maintain the integrity of the cover, and (5) have a permeability less than or equal to the permeability of any bottom liner. The post-closure regulations require that (1) the integrity and effectiveness of the cover be maintained, (2) any leachate collection system be operated, (3) the leak detection system be maintained and monitored, (4) a ground water monitoring system be maintained and monitored, (5) rain water run-on or run-off be prevented from eroding or otherwise damaging the cover, and (6) survey benchmarks be protected. For Alternative 6, the regulations would be applicable. For the others, the cover and ground water monitoring regulatory requirements would be relevant and appropriate.

For this site, EPA has determined that a cover with a low-permeability soil layer without a geomembrane will meet the "long term minimization of liquids" RCRA closure ARARs for Alternatives 2, 4, and 5. Other requirements of the final cover will be determined in the design considering the Subtitle C minimum technical guidance, "Reusing Superfund Sites: Commercial Use Where Waste Is Left in Place" (OSWER 9230.0-100), and site-specific conditions.

- *Clean Air Act and National Emission Standards for Hazardous Air Pollutants (NESHAPs):* Hydrocarbon vapors generated during LTTD treatment in Alternative 6 would be treated in a secondary unit, such as an afterburner, condenser, or carbon adsorption unit. Operation of the off-gas treatment unit would be designed to meet the substantive requirements of the Federal Clean Air Act, State Ambient Air Quality Standards, and other air quality ARARs including applicable NESHAPs.

- *Safe Drinking Water Act Ground Water MCLs:* MCLs currently exceeded in at least one sampling location in the upper Columbia Aquifer ground water include dioxin, benzene, benzo(a)pyrene, bis(2-ethylhexyl)phthalate, PCP, heptachlor epoxide, arsenic, cadmium, and copper. Off-site, the only contaminants to exceed an MCL are benzene in the upper Columbia Aquifer (on the Navy property across Elm Avenue from the Former Tank Area) and PCP in the lower Columbia Aquifer (south of the Historic Disposal Area on the PPSD property). Alternatives 2 through 5 address ground water with MNA with the point of compliance being the edge of the waste management area, which would be the edge of any cover or cap. Since Alternatives 6 and 7 involve treatment rather than containment of waste, the point of compliance would be throughout the site.

- *River Regulations:* All the alternatives, except Alternative 7, involve the discharge of material into the river through thin-layer sand placement. Additionally, several alternatives (2, 3, 5, and 6) include subaqueous capping. All alternatives must be designed to meet any substantive requirements of Section 404 of the Clean Water Act, Section 10 of the Rivers and Harbors Act, and the Virginia Water Protection Permit Regulation. For instance, subaqueous capping and sand placement would not reduce the water depth in the navigation channel and no sheet pile bulkhead would extend beyond established bulkhead lines, in accordance with the River and Harbors Act.

10.3 Long-term Effectiveness and Permanence

The evaluation of alternatives under this criterion considers the ability of an alternative to maintain protection of human health and the environment over time. The evaluation takes into account the residual risk remaining at the conclusion of remedial activities as well as the adequacy and reliability of containment systems and ICs. Each of the alternatives provides for long-term effectiveness and permanence, although to varying degrees, as long as the O&M activities (including monitoring) are conducted.

Because any containment system requires on-going O&M, Alternative 7, which includes *in-situ* treatment and excavation and dredging with off-site disposal, offers the highest degree of long-term effectiveness and permanence because it would permanently remove contaminants from the site or bind them within a solidified mass and, thus, would require minimal O&M. Alternative 7 does not rely on MNR but requires active remediation of sediment contamination to meet the 45 ppm tPAH sediment cleanup criteria.

Alternative 6 provides a high degree of long-term effectiveness and permanence for soil and dredged sediment through on-site LTTD treatment, which would permanently destroy organic contaminants (but not inorganics). However, the pump-and-treat system component for DNAPL and ground water in Alternative 6 provides a low degree of long-term effectiveness because significant contamination would remain adsorbed to the soil matrix in the aquifer, gradually leaching into the ground water and likely never achieving the ground water cleanup criteria, but merely containing the plume.

In regard to the sediment component, Alternatives 2 and 3 offer the lowest degree of long-term effectiveness and permanence. These alternatives rely on subaqueous capping over a large area to contain the contamination. While subaqueous capping can be an effective sediment remediation technology, the presence of the DNAPL makes capping more difficult. Significant upgrades to a simple sand cap would likely be necessary to effectively limit contaminant migration. A failure of the cap could result in a significant contaminant release. Factors that may impact the stability or integrity of the subaqueous caps in Alternatives 2 and 3 include steep slopes, high river flows, heavy river traffic, barge spuds, and future dredging activity. The subaqueous cap in Alternative 2 would reduce the mean water depth by three feet, thus reducing the existing draft available to boat and ship traffic. Both Alternatives 2 and 3 would limit any future expansion of navigational capacity in the river in order to protect the integrity of the subaqueous caps.

In the Wyckoff Inlet, Alternative 4 offers a higher degree of long-term effectiveness and permanence than Alternatives 5 and 6. The steps necessary to restore the Wyckoff Inlet habitat may not be effective in the long term at containing the contamination. To control the ground water level upgradient of the inlet, a drainage layer would be built into the sediment cap. Weep holes in sheet pile at both ends of the drainage layer would allow ground water to migrate to the river. The ground water flowing through the drainage layer would likely be highly contaminated. If the weep holes in the sheet pile or the sand drainage layer become clogged, significant repair work would be required. Maintenance of a sand weir in Alternative 4 would be simpler than Alternatives 5 and 6 because access to the sand weirs would be much easier. The passive hydraulic control approach may need to be upgraded to a pump-and-treat system to manage the contaminated ground water. The potential for future development of the Portsmouth Port and Industrial Commission or expansion of the Jordan Bridge could limit the long-term effectiveness of the restored wetlands/mudflat in Alternatives 5 and 6. At some point in the future, VMRC could grant a permit that would involve filling this area to help with redevelopment, thus eliminating the habitat in this area and nullifying the habitat revitalization effort.

Alternatives 2, 3, 4, and 5 require sheet pile walls, enhanced by five feet of S/S immediately behind the wall, to prevent DNAPL migration to the river and to control the discharge of contaminated ground water to the river. Each offers the same degree of long-term effectiveness and permanence. Each alternative would have areas with DNAPL just behind the enhanced wall. In the case of Alternative 4, the DNAPL would be from consolidation of heavily contaminated sediments behind the wall as well as DNAPL in pre-existing sediments behind the wall. In the case of the other three alternatives, there is DNAPL already existing at the shore that would be immediately behind the wall.

Compared to Alternatives 2 and 3, Alternatives 4 and 5 offer a higher degree of long-term effectiveness and permanence in regard to the subsurface DNAPL because in Alternative 4 the DNAPL most likely to migrate downward would be consolidated to an area of the site that has a thick clay confining unit, and in Alternative 5, all of the DNAPL would undergo S/S.

All of the alternatives, except Alternatives 6 and 7, have a soil cover or cap to minimize rain water infiltration. This reduces the amount of oxygen reaching the ground water and can change redox conditions which play an important role in the mobility of some contaminants. At the site, the upper Columbia Aquifer is already in a reducing condition, and as a result, there would be little difference in the mobilization of contaminants once a cap is installed. A cap would also reduce the ground water flow gradients, which are already very shallow, thus reducing the ability of ground water to migrate.

10.4 Reduction in Toxicity, Mobility, or Volume Through Treatment

This evaluation criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and/or significantly reduce the toxicity, mobility, or volume of the hazardous substances as their principal element.

Alternative 7 would provide the highest degree of reduction in the toxicity, mobility, or volume because it uses treatment in some form to address each of the contaminated media at the site. For all soils on the west side of the site, toxicity, mobility, and volume would be completely eliminated by the off-site treatment process. Incineration would destroy organics, and metals in the residues or ash would be stabilized prior to final disposal. The S/S treatment applied to soils on the east side of the site would significantly reduce the mobility of contamination in the soil and sediment. The addition of S/S binding agents may increase the volume by up to 35 percent (examples vary by site). The toxicity, volume, and mobility of organic contaminants in the ground water on the west side of the site would be reduced in Alternative 7. Chemical oxidation destroys organic contaminants, thereby reducing the toxicity and volume of contamination. The toxicity and volume of dissolved inorganic contaminants would not be reduced. Though chemical oxidation is not intended to address metals contamination, some reduction in the mobility of arsenic may be achieved as the dissolved arsenic may be oxidized to a higher valence state and precipitate from solution. However, this effect may be temporary as the potential exists for arsenic to revert to a lower valence state and redissolve if natural reducing conditions become reestablished in the aquifer after treatment is completed.

The toxicity, mobility, and volume of contaminated sediment would be eliminated in Alternative 7. All contaminated sediment above the sediment cleanup criteria of 45 ppm tPAHs would be removed from the river and transported off-site for treatment and/or disposal. The reduced concentrations of PAHs in the sediment achieved through removal would result in a reduction in toxicity to aquatic and benthic species. Concentrations of PAHs in shellfish, and thus the toxicity, would decrease over time in response to decreases in surface sediment concentrations.

Alternative 6 also employs multiple treatment technologies (LTTD and pump and treat) to achieve a high degree of reduction in toxicity, mobility, or treatment, although somewhat less than Alternative 7. PAHs and dioxins would be desorbed from soils and river sediments through LTTD treatment and then recovered in concentrated form or destroyed as part of off-gas treatment (e.g., condensation, carbon adsorption, and thermal oxidation). All sediment greater than 100 ppm tPAHs, and some between 45 and 100 ppm tPAHs, would be dredged and treated with LTTD along with surface soils greater than 3 ppm BaP before being disposed on the west side of the site. Concentrated waste streams generated by LTTD treatment, such as condensate and spent carbon, are also typically sent off-site for treatment (e.g., condensate disposed at a wastewater treatment plant) and/or regeneration (e.g., spent carbon is regenerated by thermal desorption with thermal oxidation off-gas treatment), resulting in further reduction of toxicity, mobility, and volume.

In Alternative 6, some reduction of DNAPL volume would also occur as a result of DNAPL extraction and treatment/disposal. However, the majority of DNAPL is expected to remain sorbed to soil and trapped in small pore spaces as residual, given its low solubility and immiscibility in water. DNAPL toxicity would not be reduced. The continuing presence of subsurface DNAPL would prevent reductions in toxicity and volume of dissolved contaminants.

Alternative 5 would achieve a high degree of reduction in the mobility of PAHs and inorganics in the soil and DNAPL through S/S treatment. The toxicity and volume of soil contaminants would not be reduced, and the addition of S/S binding agents may increase the volume of contaminated matter by up to 35 percent (examples vary by site). All river sediment greater than 1,000 ppm tPAHs would also be treated with S/S and disposed on the west side of the site, greatly reducing the mobility of contaminants from the river sediment. No reduction in toxicity, mobility, or volume of ground water contaminants would be achieved by Alternative 5.

S/S treatment would also be applied in Alternatives 2, 3, and 4 to reduce contaminant mobility, but to a lesser extent than in Alternatives 5 and 7. In Alternative 4, S/S treatment would reduce contaminant mobility to some of the sediment and excavated west-side DNAPL consolidated behind the off-shore sheet pile wall. The sealed off-shore sheet pile wall and the five feet of stabilized consolidated sediment behind the wall would be designed to prevent contaminant mobility to the river. In Alternative 3, sediment dredged from the upper three feet that is greater than 1,000 ppm tPAHs would undergo S/S and disposed on the west side of the site. No other treatment would be performed in Alternative 3. In Alternative 2, the only treatment that would be applied would be S/S of the five feet of soil behind the on-shore sheet pile wall, which would reduce the mobility of subsurface DNAPL on the east side of the site. Of all the alternatives, Alternative 2 would achieve the lowest degree of reduction in toxicity, mobility, or volume through treatment.

10.5 Short-term Effectiveness

This evaluation criterion addresses the effects of the alternative during the construction and implementation phase until RAOs are met. It considers risk to the community and on-site workers and available mitigation measures, as well as the time frame for the attainment of the response objectives.

It is anticipated that most of the work could be conducted using Level D and modified Level D personal protection, which is the lowest level of personal protection equipment. Conventional engineering controls would be used to prevent contaminated materials from migrating with runoff water or becoming airborne during construction. Sediment resuspension during capping or dredging operations proposed in each alternative could adversely affect water quality and downstream sediment temporarily, but turbidity curtains and oil booms would be installed to limit the dispersion of contaminants and dredging activities would be carefully monitored.

The potential presence of UXO materials at the site would require special ordnance avoidance precautions and equipment during intrusive activities, such as excavation, well installation, and *in-situ* S/S treatment. These precautions would include having a UXO avoidance contractor on-site to clear each location of intrusion. The presence of UXO would be a greater concern for the more intrusive alternatives (4, 5, 6, and 7) than the less intrusive alternatives (2 and 3).

In-situ chemical oxidation of ground water (Alternative 7) would pose significant short-term risks to construction workers, resulting from handling chemical oxidants and potential contact with contaminated soils and ground water during chemical injection. Alternative 7 also includes the unlikely potential for unreacted oxidants to migrate off-site or to Paradise Creek, but this risk should be avoided by conducting a pilot study to evaluate proper design parameters. Potential short-term risks also exist to workers from air releases during mixing of S/S agents in all alternatives, particularly in Alternative 5, which involves the largest volume of material treated with S/S. Alternatives 5, 6, and 7 involve the greatest handling of contaminated material, while Alternative 2 involves significantly less material handling. Alternatives 5 and 6 involve risks to divers associated with underwater work (cutting sheet piles). However, all of the above risks can be managed.

Dredging and capping activities would cause significant disruption to the river sediment inhabitants, but these impacts would be temporary (at least for dredging). The subaqueous capping alternatives (2 and 3) would require significant armoring to protect the integrity of the cap, resulting in different habitat conditions than those previously existing. New sediment deposition may improve habitat conditions over time. Dredging contaminated sediment would cause an initial removal of the benthic habitat, but would ultimately result in improved habitat conditions due to lower contaminant levels, particularly given that clean sand would be placed over clay that is exposed following dredging. The proposed sheet piling would provide slope stability when dredging near the shoreline. Alternative 4 ranks higher than Alternatives 5, 6, and 7 because less sediment would be dredged, and the dredged sediment, especially the most contaminated sediment, would not have to be transported to the far end of the site or off-site. Consolidating highly contaminated sediments to the west side of the AWI property would likely require more monitoring and odor controls to protect the employees at the PPSD Operations Center.

The estimated volumes of soil and sediment that would be disposed off-site in Alternative 7 are significant. Construction of the soil cover or geomembrane cap in each alternative would also require the delivery of a significant amount of clean soil (as would the backfilling of excavated areas in Alternative 7). Potential risks are involved from handling and transporting waste off-site for treatment and from delivery of clean fill. Conventional traffic controls for waste transport, such as defining specific travel routes through urban areas to/from the site for waste transportation vehicles and coordinating waste shipments to avoid peak traffic hours, would be used to minimize the potential for accidents. Transport of material via rail or barge is another possibility, depending on the location of the disposal facility.

All of the alternatives would result in increased boat traffic during construction and an increased occurrence in raising and lowering the Jordan Bridge to accommodate this boat traffic. Construction of all alternatives would need to work around on-going site operations. Alternatives 5, 6, and 7 would involve the greatest disruption to site operations because they involve S/S, LTTD, and/or *in-situ* chemical oxidation activities on the east side of the AWI property.

Alternatives 3 through 7 could have odor problems and possibly air emissions issues that could pose a risk to on-site and off-site workers and require mitigation efforts. Construction of all of the remedies could be completed in five to six years once design begins. The ground water extraction system in Alternative 6 could be in operation in excess of 30 years.

10.6 Implementability

The evaluation of alternatives under this criterion considers the technical and administrative feasibility of implementing an alternative and availability of services and materials required during implementation.

List of Alternatives

1. No Action
2: Soil Cover, MNA, On-Shore Sheet Pile Wall, Sediment Cap, MNR
3: Geomembrane Cap, MNA, On-Shore Sheet Pile Wall, Partial Dredge w/Sediment Cap, MNR
4: Soil Cover, MNA, Partial DNAPL Consolidation, Off-Shore Sheet Pile Wall, Dredging, MNR
5: *In-situ* S/S, Soil Cover, MNA, Landward Sheet Pile Wall, Dredging, On-site Consolidation, Restore Wyckoff Habitat, MNR
6: LTTD, P&T DNAPL, On-Shore Sheet Pile Wall, Dredging, On-site Disposal, Restore Wyckoff Habitat, MNR
7: Excavation w/Off-site Disposal of Soil (W) and DNAPL, S/S Soil (E), Chem Ox GW (W), MNA (E), On-Shore Sheet Pile Wall, Dredge w/Off-site Disposal

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Each of the alternatives is implementable, and the services and materials required for each alternative are readily available. However, some are more difficult to implement than others.

Construction of the final surface features such as a soil cover or cap in each alternative can be conducted using conventional heavy construction equipment and services, which are readily available in the commercial market. Construction of the soil cover or cap would temporarily impact on-going facility operations. In addition to the construction of the surface features, several alternatives involve handling and transport of significant volumes of contaminated material. Alternative 7 involves dredging and excavation of the greatest volume of soil and sediment and would therefore be the most difficult alternative to implement because of the significant volume of material to manage and transport off-site. A significant volume of soil would be treated with S/S in Alternative 7, as well. Alternatives 3, 4, 5, and 6 would involve less volume of material than Alternative 7, but greater material handling, such as the treatment using S/S and LTTD in Alternatives 5 and 6, respectively. Alternative 5 would also involve excavation of existing land from the east end of the AWI property after constructing the inland wall. Alternative 3 would involve handling of the least volume of contaminated material, and Alternative 2 would involve no handling of contaminated material. Therefore, Alternatives 2 and 3 would be among the most readily implementable alternatives.

Alternatives involving intrusive activities in the Historic Disposal Area would be more difficult to implement due to the presence of large pieces of debris and the depth of contamination. S/S treatment of DNAPL (Alternative 5) in the Historic Disposal Area would require excavation of debris prior to material handling. Significant difficulties would be encountered in the Historic Disposal Area for Alternatives 4 and 7 where excavation and dewatering could extend up to a depth of 40 feet. Dewatering of the excavation areas at this depth below the Columbia clay would be extremely difficult and may require construction of a barrier or cutoff wall. Also, locating small pockets of DNAPL at this depth would be difficult. The significant excavation depths could impact the stability of nearby buildings and may require shoring. To reduce some of these difficulties for Alternative 4, DNAPL found at depth may undergo S/S *in-situ*, rather than excavation. Excavating under the roadway in Alternative 7 could cause temporary closures of Elm Avenue.

Alternative 6 would require the most infrastructure to be built on the site for the ground water/DNAPL extraction and treatment system. Alternative 7 would require a significant number of temporary injection points to be installed at the site for *in-situ* chemical oxidation treatment of the ground water.

There are implementability issues involved with constructing an off-shore wall in Alternatives 4, 5, and 6; however, the construction can be achieved with conventional, barge-mounted construction equipment. Dredging and stabilization activities for Alternatives 3, 4, 5, 6, and 7 can also be performed with conventional equipment.

Dredging and sheet pile wall construction would need to be designed to accommodate any subaqueous utilities in the work area, and storm sewer pipes would need to be extended to the sheet pile wall for Alternatives 4, 5, and 6. Numerous pier pilings would need to be removed prior to dredging activities for Alternatives 3 through 7.

Restoration of the wetlands/mudflats in the Wyckoff Inlet for Alternatives 5 and 6 would involve difficulties such as installing two geomembrane caps underwater and underwater cutting of the off-shore sheet piles.

Subaqueous cap construction in Alternatives 2 and 3 may be difficult in steeply sloped areas or in areas where the sediment is too soft to provide an adequate base for the capping material. Removal of the upper three feet of the softest sediment should reduce the problem for Alternative 3. The cap in Alternative 2 would reduce the mean water depth by three feet, thus reducing the existing draft available to boat and ship traffic. This loss of water depth is of particular concern near the Southgate Annex, where the Navy has future dredging plans to maintain navigation channels. Future dredging would damage the subaqueous cap, which would, in turn, require repair. Therefore, subaqueous capping in Alternatives 2 and 3 is not very implementable at the Southgate Annex because protection of the cap limits the operational flexibility of the facility.

Dredging and/or cap placement around the piers at the Southgate Annex would require coordination of access and operational issues with the Navy. Remedial activities in the river would require coordination with the Commonwealth of Virginia because it owns the river bottom. This factor is most significant for Alternative 4, which would reduce the area of the river bottom with the off-shore sheet pile walls. VMRC in essence acts as the trustee of the river bottom for the Commonwealth and has stated that it cannot support a remedy that involves filling state-owned submerged lands. VMRC requires a permit for any type of filling activity and, among other things, requires mitigation for lost river bottom. While the selected remedy would meet any substantive requirements of a permit, CERCLA Section 121(e)(1) exempts response actions undertaken pursuant to CERCLA from Federal, state or local permitting requirements. Since there are no ARARs (which are promulgated laws and regulations) that require mitigation of the river bottom (only the wetland perimeter), the selected remedy only includes wetland mitigation. EPA would require access to Commonwealth-owned river bottom to implement the remedy. Access to the water associated with properties that would be cut off from the shore and ownership issues associated with the land created by implementation of Alternative 4 would provide additional complications.

10.7 Cost

Alternatives 6 and 7 are far more costly than Alternatives 2 through 5. However, there is a $23 million difference between Alternative 2 and Alternative 5. Alternative 4 is only slightly more costly than the lowest cost alternative, Alternative 2. Alternatives 2 through 5 are generally containment remedies, though Alternative 5 includes S/S of soils and DNAPL, resulting in a somewhat higher cost than the other containment alternatives. The estimated cost of restoring the wetland/mudflats in the Wyckoff Inlet in Alternatives 5 and 6 is approximately $6 million greater than the cost of disposing dredged sediment behind the off-shore wall in Alternative 4. Alternative 6 has been included as representative of a treatment remedy, with associated higher costs, and includes the soil and DNAPL components included in the 1995 ROD. Alternative 7 is the most costly because a significant volume of contaminated material would be disposed off-site, which is far more costly than on-site consolidation.

10.8 State Acceptance

VADEQ, the support agency for this site, reviewed the draft Record of Decision and concurred with the selected remedy, although with some reservation (see **Appendix H**). The reservations were expressed to EPA in a February 16, 2007, letter. The reservations are not dissimilar to comments submitted by VMRC during the public comment period which are discussed in the Responsiveness Summary (see page 115). The Commonwealth's Virginia Port Authority also submitted comments, which are also discussed in the Responsiveness Summary.

List of Alternatives

1. No Action
2: Soil Cover, MNA, On-Shore Sheet Pile Wall, Sediment Cap, MNR
3: Geomembrane Cap, MNA, On-Shore Sheet Pile Wall, Partial Dredge w/Sediment Cap, MNR
4: Soil Cover, MNA, Partial DNAPL Consolidation, Off-Shore Sheet Pile Wall, Dredging, MNR
5: *In-situ* S/S, Soil Cover, MNA, Landward Sheet Pile Wall, Dredging, On-site Consolidation, Restore Wyckoff Habitat, MNR
6: LTTD, P&T DNAPL, On-Shore Sheet Pile Wall, Dredging, On-site Disposal, Restore Wyckoff Habitat, MNR
7: Excavation w/Off-site Disposal of Soil (W) and DNAPL, S/S Soil (E), Chem Ox GW (W), MNA (E), On-Shore Sheet Pile Wall, Dredge w/Off-site Disposal

10.9 Community Acceptance

A number of stakeholders provided EPA with written comments on its proposed cleanup plan that the Agency released for public comment on July 11, 2007. The public comment period closed on September 10, 2007. On July 24, 2007, and August 21, 2007, EPA held public meetings to discuss the Proposed Plan and accept oral comments. Transcripts of the meetings are in the Administrative Record.

A number of stakeholders, including the City of Portsmouth, support the selected remedy. Other stakeholders have expressed dissatisfaction with the selected remedy for several reasons and expressed support for Alternative 5. The main reason is the desire to not fill the river, and especially to preserve the habitat in the Wyckoff Inlet. The other reason is the concern that the most highly contaminated sediments are being consolidated behind the sheet pile wall(s) where it will be right next to the river. Note that in both Alternative 4 and 5, the current, heavily contaminated habitat in the Wyckoff Inlet will be destroyed and rebuilt. Alternative 4 moves the habitat slightly upstream, while Alternative 5 would restore the habitat in its current location, but use engineering controls to contain DNAPL underneath the restored habitat. EPA does not believe that the engineering controls in Alternative 5 would be effective. In both alternatives, DNAPL would remain in very close proximity to the sheet pile wall(s) whether it is constructed at the current shore line (Alternative 5) or off-shore (Alternative 4). In fact, due to the mixing that will take place during dredging, Alterative 4 may result in less DNAPL located immediately behind the wall(s).

Several stakeholders wanted the sheet pile wall moved further off-shore in a configuration that may increase the utility of the area as a port and reduce the area requiring dredging.

The comments received during the comment period were very similar to feedback EPA received in November 2006. In November 2006, six possible site-wide alternatives (some differing from the combinations evaluated in this ROD) were presented to a diverse group of stakeholders at a meeting of the ERP's Sediment Remediation Partnership to obtain feedback that was used to further develop the alternatives and evaluate new components for some areas of the site. Some of the feedback provided by the stakeholders included the desire to have natural habitat restoration as part of the remedy, questions about the ability to stabilize dredged material to the required weight-bearing capacities, questions about the stability of the sheet pile wall, questions about how stormwater would be managed, concerns that the contaminants would only be contained rather than addressed more aggressively, and the preference to maintain flexibility in the potential future uses of the adjacent properties. VMRC and NOAA voiced strong objections to filling in a portion of the river in exchange for consolidation capacity, but area landowner(s) and the City of Portsmouth were in favor of this component of Alternative 4. The Portsmouth Public School District has expressed concerns about having extensive cleanup operations so close to its Operations Center.

11. SELECTED REMEDY

Following review and consideration of the information in the Administrative Record, the requirements of CERCLA and the NCP, and public comments, EPA has selected Alternative 4

(Soil Cover, Partial DNAPL Consolidation and Containment, MNA/Ground Water Monitoring, Dredging, Consolidation Behind Enhanced Off-Shore Sheet Pile Wall and at the West Side and Enhanced MNR) as the remedy for the Atlantic Wood Industries, Inc. Site, including OU1, OU2, and OU3.

11.1 Summary of the Rationale for the Selected Remedy

Based upon the comparison of the nine criteria summarized previously for each of the alternatives in this document, EPA's selected remedy is Alternative 4: Soil Cover, Partial DNAPL Consolidation, MNA, Dredging with Consolidation Behind an Enhanced Off-Shore Sheet Pile Wall and on the West Side, and Enhanced MNR. The total present worth of the selected remedy is $44.9 million.

The selected remedy meets the threshold criteria of overall protection of human health and the environment and compliance with ARARs. Although each of the alternatives meets most, if not all, of the RAOs, the selected remedy offers the following advantages:

- It is among the least costly of the alternatives.
- It effectively encapsulates the highly contaminated river sediments while minimizing the risk of recontamination.
- It reduces the risk of DNAPL migration to deeper aquifers in the Historic Disposal Area for significantly less cost than Alternatives 5, 6, and 7 and is substantially easier to implement than these other alternatives with fewer short-term impacts.
- It provides for flexibility in the reuse of the site for industrial or recreation purposes, as determined by state and local authorities, without any reduction in protectiveness.
- It provides for flexibility in future uses of adjacent properties, including the Navy Southgate Annex, the Portsmouth Port and Industrial Commission property, the City of Chesapeake property (potential future expansion of the Jordan Bridge), and the navigation channel.

Alternative 4 includes several cost-efficient components when compared to other alternatives, including the use of MNA for ground water, which saves significant treatment costs versus active remediation, and the design of the sheet pile wall with weep holes provides for passive discharge of ground water while reducing O&M costs. Similarly, dredging with enhanced MNR is substantially less expensive than dredging all of the sediment to 45 ppm tPAH, yet still meets the cleanup criteria. The soil cover provides appropriate reduction in risk from direct contact and a significant savings compared to soil treatment or excavation and off-site disposal. Although the river component of the selected remedy is more costly than a subaqueous cap, the additional approximately 15% in cost provides significant added benefits, such as the permanent removal of the worst of the contamination from the river and the freedom of relatively unrestricted dredging for future navigational purposes.

In selecting Alternative 4, EPA considered the issues important to various stakeholders. Alternative 4 does not restrict future dredging to change the water depth because it does not have a subaqueous cap. By removing the contamination from the river, property owners impacted by the cleanup, including AWI, the City of Portsmouth, the Dixxon Company, and the U.S. Navy would have more options for future use and development of the waterfront. By mitigating wetlands on-site, as opposed to restoring them in the Wyckoff Inlet, a more permanent net gain of wetlands is achieved. If wetlands were restored to the Wyckoff Inlet, any future expansion or replacement of the Jordan Bridge would most likely negatively impact the restored wetlands. In addition, restored wetlands in the Wyckoff Inlet could be subject to filling if private landowners obtained proper permits. Wetlands mitigated on the AWI property, as part of a stormwater management system, would be a permanent fixture.

Stakeholders are divided in their support of or objection to Alternative 4. Those that support Alternative 4 tend to be more focused on redevelopment while those that objected to Alternative 4 were mainly concerned with the filling of the Wyckoff Inlet and the consolidation of the sediments near the river. VADEQ has concurred with the selected remedy, although they expressed some reservations about it.

Overall, based on the information currently available, EPA (the lead agency) has determined that Alternative 4 provides the best balance of tradeoffs among the alternatives with respect to the balancing and modifying criteria. The selected remedy satisfies the statutory requirements of CERCLA Section 121(b) by being protective of human health and the environment; complying with ARARs; being cost-effective; and utilizing permanent solutions and alternative treatment technologies to the maximum extent practicable. The selected remedy does not satisfy the statutory preference for treatment as a principal element, even though it includes treating the sediment and/or soil directly behind the sheet pile with S/S, because most of the principal threat waste (i.e., the DNAPL) will not be treated. The volume of material that is contaminated at the site is too great to increase the amount of treatment as a principal element and also remain cost-effective, which is equally required by the statute.[20] For example, Alternative 7 incorporates treatment as an element of the remedy for each contaminated medium, but the projected cost is approximately $300 million, a cost that would likely guarantee that the remedy is never undertaken and the site remains forever the risk to human health and the environment that it currently is.

EPA has carefully considered remedial alternatives that would not restrict access to the navigable waters of the Southern Branch of the Elizabeth River. However, the Agency has determined that the other alternatives, which do not impact water access to the same degree[21] did

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[20]EPA also considered whether or not treating discrete pockets of DNAPL near the site margins could increase the degree of protectiveness and long-term effectiveness and permanence and/or reduce the area of contaminated ground water in a cost-effective manner. EPA has determined that treating only a partial amount of the DNAPL would not significantly add to the overall protectiveness or long-term effectiveness or permanence of the remedy; thus, addressing, for example, smaller areas of DNAPL on the east side of the site is not cost-effective.

There are approximately three DNAPL areas on the east side: one area at the former creosote tanks, one near the river, and one between the previous two. EPA does not believe that there is any added benefit to addressing one or two of these areas compared to addressing all three as included in several alternatives. If one assumes S/S as the treatment technology, the cost associated with treating these areas is approximately $2 million for each area with limited environmental benefit for the cost. As a further disincentive, remedial action to partially address the DNAPL contamination would create significantly more short-term impacts and implementability issues because of on-going AWI operations at the site, and S/S in these areas would not reduce the area of contaminated ground water.

Addressing only part of the DNAPL would not eliminate or reduce the other aspects of the selected remedy, such as the elimination of the S/S behind the sheet pile wall at the river. Treating or removing the DNAPL pockets would cause significant disruptions to traffic flow across the Jordan Bridge, especially for the middle DNAPL area and the former tank area. This bridge is a major commuter route for workers, especially employees of the Norfolk Naval Shipyard.

[21]Alternative 5is the only alternative evaluated that would not impact water access for any area property. Alternatives 2, 3, 6, and 7 may not impact water access for some properties, depending on the placement of the sheet pile walls.

not rank well against five of the nine criteria required by the NCP for remedial decisions (long-term effectiveness, implementability, short-term impacts, community acceptance, and/or cost[22]).

One of the ways to prevent impacting water access would be to use sediment capping technology (as described in Alternatives 2 and 3). However, while not preventing access to the water, capping would significantly restrict the types of access and future use of the river to protect the integrity of the subaqueous cap.

Alternatives 5 and 6 require restoration of the Wyckoff Inlet, which EPA has determined ranks poorly in terms of long-term effectiveness. Restoring the Wyckoff Inlet would also restrict the type of access and the future use of the river although to a lesser extent than in Alternatives 2 and 3. Alternative 7 is extremely costly and would have the greatest short-term impacts. EPA received a number of comments supporting Alternative 4.

EPA intends to work closely with the Commonwealth of Virginia to design the remedy in a manner that minimizes any negative impact on water access as a result of implementation of the selected remedy.

11.2 Description of the Selected Remedy and Performance Standards

11.2.1 Enhanced Off-Shore Sheet Pile Wall

11.2.1.1 Containment wall(s) made of sheet piles shall be constructed. The wall(s) shall be constructed at locations such that the volume available to be filled between the wall and the existing shore line shall, at a minimum, contain all of the sediments with total PAH concentration greater than 1,000 ppm from the area generally shown in **Figure 29**. The available volume must also be sufficient to accommodate more sediments from this area, if the volume of sediments with total PAH concentrations of less than 1,000 ppm is greater than can be contained on the west side of the AWI facility. Efforts should be made to minimize the area of the river bottom that will be lost to filling. The sheet pile walls shall not extend into the river past the USACE's established bulkhead lines. The OU3 FS estimated that a wall would extend approximately 200 feet from the shore of the AWI facility and a second wall would extend approximately 545 feet from the west end of the Wyckoff Inlet.

11.2.1.2 The exact location of the sheet pile wall(s) shall be identified in the remedial design and subject to EPA approval.

11.2.1.3 The ends of the containment wall(s) shall extend to the south to tie into the current sheet pile wall along the north side of the restored acetylene sludge wetland (see **Figure 29**), and extend to the north to such a location at the 3975 Elm Avenue property or at the Portsmouth Port and Industrial Commission property that creosote NAPL from the AWI site or the Wyckoff facility can no longer either migrate to the river or provide a significant source of PAHs to the river.

11.2.1.4 The sheet pile wall(s) shall be located to prevent NAPL that is underneath Virginia Highway 337 from migrating to the river, and its installation shall not cause damage to the Jordan Bridge. The remedial design shall evaluate whether it

[22]EPA understands that some of the major cost differences with some of the alternatives relates to differences with components that do not involve the river or shore line.

is more advantageous for the sheet pile wall(s) to tie into the bridge base or to be positioned further away from the shore and go underneath the bridge.

11.2.1.5 The sheet pile wall(s) shall be shaped, to the extent practicable, to facilitate docking of boats, barges, etc. and minimize cost.

11.2.1.6 The elevation of the sheet pile wall(s) shall match the current ground elevation, plus any soil cover, or be above the high high tide, whichever is greater.

11.2.1.7 The barrier shall have a permeability of $1x10^{-7}$ centimeters per second (cm/sec) or less except in the areas of planned passive ground water release, discussed below. The permeability shall be attained by sealing the joints of the sheet piles. Sealing the sheet pile joints could be performed through the use of sheet pile with interlocks designed for sealing, by modifying typical sheet pile joints such that they can be sealed, by welding and/or other method. A sealant shall be used that is compatible with the river water, the stabilization additive used behind the wall, and the contaminated ground water, including creosote DNAPL. The method of sealing shall be subject to EPA approval.

11.2.1.8 The sheet pile wall(s) shall prevent any NAPL from migrating to the river.

11.2.1.9 Any existing piping, swales or other methods of conveyance to the river shall be extended to and tied into the sheet pile wall. The extensions shall utilize appropriate technology (piping, swales, etc.). The joints of the sheet pile wall(s) and any conveyances shall be sealed to prevent preferential flow paths of ground water from forming.

11.2.1.10 Location and installation of sheet piles shall take into account the presence of underground or overhead utilities. Currently, EPA does not know of any underground utilities in the area of the sheet pile shown in **Figure 29**, except potentially an abandoned pipeline owned by the Navy.

11.2.1.11 The material of construction and wall thickness shall be such that the wall would be expected to maintain adequate wall thickness in excess of 100 years.

11.2.1.12 The wall shall be driven into the Columbia clay to a depth to successfully support any cantilevered load that will need to be supported after the dredge and fill operation. Technologies such as tie-backs can be used to help support the load.

11.2.1.13 Rip-rap shall be placed at the riverside foot of the wall to help support and protect the wall. The rip-rap will also provide hard surface substrate for oyster habitat.

11.2.1.14 Engineering controls, such as oil booms and turbidity curtains, and operational constraints shall be used to control NAPL releases and excessive turbidity caused by the installation of the sheet piles.

11.2.1.15 Rubble and/or pilings that will interfere with the installation of the sheet piles shall be removed.

11.2.2 Sheet Pile Wall at the Eastern End of Portsmouth Port and Industrial Commission Property

11.2.2.1 If necessary to provide shoreline stability, a sheet pile wall shall be constructed at the eastern end of the Portsmouth Port and Industrial Commission property of sufficient length, depth, and strength to provide shore stability when dredging is undertaken at the northern most required area (see **Figure 29**).

11.2.2.2 The wall shall be constructed in such a way, to the extent practicable, to support use of that area of the river as a port.

11.2.3 Dredging With Consolidation Both Behind Sheet Pile Wall and on the West Side

11.2.3.1 Delineation of Area to Be Dredged

11.2.3.1.1 The area containing sediments with greater than 100 ppm tPAHs in the area generally shown in **Figure 29** (the size of the area may vary in the remedial design) shall be delineated to such accuracy as to create dredging cut lines that will balance the cost of delineation against (1) minimizing the potential for missing contaminated sediments and (2) the cost of significant overdredging to capture the contaminated sediments. Areas that have contaminated sediments with tPAHs greater than 100 ppm shall be further delineated vertically to define the depth at which the tPAH concentration is 45 ppm or less. The delineation vertically shall not extend into the Columbia or Yorktown clay[23] except in the area extending out from the Wyckoff Inlet and the area immediately south of the AWI pier (see **Figures 31** and **37**)[24], which shall be delineated to 100 ppm regardless of depth.

11.2.3.1.2 Field analytical techniques verified by laboratory samples may be used.

11.2.3.1.3 The area to be dredged shall include any calcium hydroxide sludge (from the Navy's production of acetylene gas) that is in the river near the mouth of the recently restored acetylene sludge wetland.

11.2.3.1.4 Areas beyond that defined in section 11.2.3.1.1, above, shall be sampled for other contaminants, especially metals, but also PCBs and dioxin, to determine if there is contamination outside, but in close proximity to, the area defined in section 11.2.3.1.1 that must be included in the area to be dredged in order to prevent the area defined in section 11.2.3.1.1 from becoming adversely recontaminated after dredging. The final area to be dredged shall be subject to EPA approval.

11.2.3.1.5 Studies shall be conducted to determine if removal of the sediments defined pursuant to section 11.2.3.1 will weaken or otherwise adversely impact neighboring facilities such as the Jordan Bridge, piers at the South Annex of the NNSY, the South Annex bulkhead, and the restored acetylene sludge wetland. If so, the remedial design shall require mitigation measures which could include modification to the facility(ies) and/or modification to the dredge footprint (which could also involve some sediment capping). If design plans are available for the Jordan Bridge replacement, the remedial design shall include steps to minimize impacts to future bridge construction.

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[23]During the Elizabeth River sediment RI, a layer of sediment was found that was labeled "re-worked clay," (see section 5.4.3.1 on page 26 and **Figures 5** and **37**). Contaminated re-worked clay must be removed regardless of location.

[24]During the remedial design or the actual dredging, DNAPL is found in the top of the clay in other locations, that DNAPL shall be removed as well.

11.2.3.1.6 During the remedial design, an evaluation of the bulkhead at the South Annex of the NNSY shall take place to determine whether or not seepage is occurring that could cause sediment recontamination once the dredging is complete. If EPA determines that it is necessary as part of this evaluation, environmental samples shall be collected.

11.2.3.2 Removal of Obstructions

11.2.3.2.1 AWI Facility: The dilapidated pier structure off-shore of the AWI facility, including pilings, shall be removed to such an extent as is necessary to construct the sheet pile wall and to dredge, consolidate, and/or treat the sediment.

11.2.3.2.2 Wyckoff Inlet: Any remaining pier pilings shall be removed to such an extent as is necessary to construct the sheet pile wall and to dredge, consolidate, and/or treat the sediment.

11.2.3.2.3 Navy: The Navy piers shall not be removed.

11.2.3.2.4 Other: Other obstructions, such as rubble and sunken barges, shall be removed to such an extent as is necessary to construct the sheet pile wall and to dredge, consolidate, and/or treat the sediment.

11.2.3.2.5 All obstructions removed shall be recycled to the maximum extent practicable. Obstructions that cannot be recycled shall be put in the containment area created by the sheet pile wall as long as they do not cause settling or other detrimental problems. Any remaining obstructions shall be disposed of off-site.

11.2.3.3 Dredging

11.2.3.3.1 The contaminated sediments above 100 tPAHs delineated pursuant to section 11.2.3.1, above, and outside the containment sheet piles walls shall be dredged.

11.2.3.3.2 All available engineering controls shall be used to minimize, to the maximum extent practicable, transport of sediments and contamination away from the dredging area. Examples of the types of controls to consider include increasing the percentage water intake at the cutter head (if using hydraulic dredging), using silt curtains, using oil booms and simmer pumps, adjusting the rate of bucket movement (for mechanical dredging), and other alterations to dredging (e.g., equipment, cycle time, pausing in the water column, targeting tidal cycles, etc.). A silt curtain system could include a series of both permeable and impermeable silt curtains (inner and outer containment areas), a bedload baffle system, floating booms and skirt, and a bubble curtain.

11.2.3.3.3 River velocity measurements shall be conducted during dredging activities. When river water velocity exceeds one foot per second, additional observations shall be made to ensure that any silt curtains are performing adequately.

11.2.3.3.4 Dredging operations shall cease at any time the monitoring standards are not being met until such time as EPA determines that operations can continue.

11.2.3.3.5 The remedial design shall specify the dredging approach by location that shall provide the least opportunity of recontamination of areas already dredged. This approach may involve dredging the areas of highest concentration first, dredging to ensure dredged sediment is transported over sediments that are still contaminated, and/or leaving the last pass(es) until all other dredging is completed.

11.2.3.3.6 A statistically significant number of samples shall be taken after dredging to ensure that the sediments remaining on the river bottom are below the site-specific clean-up criteria of 45 ppm tPAHs.

11.2.3.3.7 If the sampling results from section 11.2.3.3.6, above, are greater than 45 ppm tPAHs but less than 100 ppm tPAHs, clean sediments from an EPA-approved source which meets specifications to be determined during the remedial design shall be placed over all such areas to a depth of just greater than six inches to cover any residual contamination from the dredging operation and to create a one-foot sediment habitat layer with tPAH concentration of 45 ppm or less.

11.2.3.3.8 Clean sediments from an EPA-approved source which meets specifications to be determined during the remedial design shall be placed over all areas where dredging extends to or into the Columbia clay, to create a one-foot sediment habitat layer above the clay.

11.2.3.4 Monitoring During Dredging

11.2.3.4.1 Monitoring for sediment and contaminant transport shall be performed downstream from the dredging area. The remedial design shall specify unacceptable levels of sediment transport that require dredging to be temporarily halted or modified. These levels shall be submitted to EPA for approval prior to dredging. Downstream monitoring shall be compared to monitoring upstream.

11.2.3.4.2 Monitoring methods (including parameters, locations/depths, frequency/schedule, background surveys, visual monitoring, and equipment) shall be specified in the remedial design.

11.2.3.4.3 Monitoring parameters shall include visual observations, such as the presence of any of the following occurring outside containment barriers (where present): high turbidity that might reasonably result in exceedance of compliance triggers, sheens or other visible contamination in the water, and distressed or dying fish. If an oil sheen or other visible contamination in the water and/or distressed or dying fish are observed, immediate corrective actions must be taken to modify the operation to prevent further degradation, or the activity must cease.

11.2.3.4.4 Floatable debris introduced into the river as a result of any construction activity shall be collected and suitably disposed of.

11.2.3.4.5 Water quality monitoring, at a minimum, shall be conducted for the following parameters: turbidity, temperature, dissolved oxygen, pH, and PAHs.

11.2.3.4.6 Sampling depths for both the field and laboratory parameters will be located at approximately the top, middle, and bottom of the water column if the water depth permits collecting samples from three intervals separated by at least 5 feet from each other. Top and bottom samples will be taken one foot below the surface of the water and above the mud line, respectively.

11.2.3.4.7 Upstream monitoring shall take place during dredging activities to monitor background conditions and to help determine what impact the dredging activities are having on the river.

11.2.3.4.8 Upstream and downstream monitoring locations shall take into account the tidal cycle.

11.2.3.4.9 Laboratory samples shall be used to verify the accuracy of field measurements, especially in regard to any contaminant monitoring.

11.2.3.4.10 Temporary increases or exceedances of water quality parameters may be unavoidable in order to address the very high levels of contamination in the sediment at the site. However, no exceedances shall be allowed that cause permanent detrimental impacts beyond the dredge area.

11.2.3.5 Consolidation of Dredged Sediment

11.2.3.5.1 Sediments dredged pursuant to 11.2.3.3 shall be contained behind the sheet pile wall(s), covering the DNAPL in the sediments behind the wall(s), or on the west side of the AWI facility. Dredged sediments shall not be consolidated to the west side to any areas that do not exceed the contaminant levels in section 11.2.10.1 on page 96.

11.2.3.5.2 No sediments with contaminant concentrations above 1,000 ppm tPAHs shall be contained on the west side of the AWI facility.

11.2.3.5.3 Enough sediments shall be contained on the west side to fill in the low area in the middle of the west side, but not more than would raise the elevation greater than approximately two feet above the elevation of the non-low areas.

11.2.3.5.4 Handling of the dredged sediment shall take place in such a way as to maximize, to the extent practicable, the drainage of water.

11.2.3.5.5 No water draining from the sediments shall be allowed to discharge to the river if EPA determines that it will cause an unacceptable harm to human health or the environment.

11.2.3.5.6 The remedial design shall outline what steps shall be taken to minimize, to the maximum extent practicable, the spillage of dredged sediments.

11.2.4 Enhanced MNR

11.2.4.1 MNR shall be used to address remaining sediment contamination in the top one foot of sediments with a tPAH concentration less than 100 ppm and greater than 45 ppm.

11.2.4.2 The recovery process shall be monitored until the top one foot of sediment has a tPAH concentration less than or equal to 45 ppm averaged over an area to be determined during the remedial design.

11.2.4.3 The remedial design shall include a study to determine the most significant lines of evidence to document that the recovery is occurring in the sediments. The results of this study shall be used to estimate the time frame expected for MNR to address the remaining sediment contamination.

11.2.4.4 If EPA determines that the time frame determined pursuant to 11.2.4.3 is unreasonably long (greater than five years), the remedial design shall include the placement of a thin layer of sand to enhance or jump-start the MNR process. The thin-layer sediment cap shall be constructed if EPA determines it is necessary.

11.2.4.5 The remedial design shall include a list of specific parameters and locations to be monitored during the recovery process to evaluate trends in the recovery. These parameters may include, but not be limited to, contaminant levels, sediment deposition levels, and benthic recovery.

11.2.4.6 If thin-layer capping is required, the remedial design shall include a list of chemical acceptance criteria for the cap material, as well as criteria for gradation and total organic carbon. The design shall also specify the sampling rate at which these parameters shall be monitored.

11.2.4.7 The thin-layer capping material shall be suitable for benthic habitat.

11.2.4.8 The remedial design shall identify a reference station to be used to help evaluate the MNR data.

11.2.4.9 The thin-layer cap shall be placed in such a way as to minimize: (1) widespread physical impacts on existing sediment biological communities, (2) a plume of fines, (3) mixing of bottom sediments into capping materials, and (4) resuspension of the *in-situ* bottom sediments. The remedial design shall include the utility of using placement of shallow layers, mounds, or windrows (longitudinal hills) of clean sediment to accomplish these objectives.

11.2.5 On-going Business Operations

11.2.5.1 <u>AWI Facility</u>

11.2.5.1.1 Efforts shall be taken to minimize the disruptions to AWI's on-going pre-cast concrete manufacturing operations.

11.2.5.1.2 The following are examples of steps that shall be considered or taken in an effort minimize disruptions: capping/paving operations shall abut foundations of equipment, building, etc. without requiring destruction of the foundations if the equipment, buildings, etc. have a significant expected remaining useful life; the dredged sediment containment area off-shore from the AWI property may need to be constructed in two cells such that AWI can continue to access the river for product deliveries; coordinate with AWI during the installation of the sheet pile wall and dredging, if AWI decides to rebuild its pier to allow water access during remedial action; and schedule and/or construct the soil cover/pavement at times that minimize disruptions to AWI's manufacturing process.

11.2.5.2 <u>Other Properties</u>

11.2.5.2.1 Coordinate dredging activities at the South Annex of the NNSY with the Navy to minimize burdens on the operational use of the South Annex.

11.2.5.2.2 If prior to completion of the dredging activities, redevelopment activities begin taking place on the 3975 Elm Avenue property or the Portsmouth Port and Industrial Commission property, coordinate with the property owner(s) and/or developers in an effort to minimize disruption of redevelopment activities.

11.2.5.2.3 Coordinate with the City of Chesapeake regarding activities around the Jordan Bridge.

11.2.6 Unexploded Ordnance (UXO) Avoidance

11.2.6.1 Due to past discoveries, it is assumed that UXO may be present on-site in the areas formerly leased or used by the Navy (generally the west side of the AWI property and the southwestern portion of the east side of the AWI property). The remedial design shall outline the areas requiring UXO clearance.

11.2.6.2 UXO clearance specialists shall be present to detect and clear areas of UXO prior to site activities in the area defined in section 11.2.6.1. UXO clearance shall only be required down to native material.

11.2.7 Partial DNAPL Consolidation (West Side)

11.2.7.1 The DNAPL/soil matrix at the Historic Disposal Area and in the center of the west side of the AWI property shall be excavated and consolidated on the east side of the property behind the sheet pile wall constructed off-shore from the AWI facility line. Excavating the contaminated DNAPL/soil matrix will likely require digging down to the Columbia clay layer, at depths up to 20 to 25 feet bgs, except in the east end of the Historic Disposal Area, where DNAPL contamination is likely below the Columbia clay to a depth of 40 feet bgs.

11.2.7.2 The cleanup criteria for the activities in section 11.2.7.1 shall be visible creosote contamination.

11.2.7.3 *In-situ* S/S of DNAPL can be substituted as the remedy for DNAPL contamination in the Historic Disposal Area and in the center of the west side of the AWI property if it is determined by EPA to be a more appropriate method to minimize the DNAPL as a continuing source of ground water contamination while protecting the ground water during construction of the remedy.

11.2.7.4 Overlaying clean soil would be excavated and stockpiled in order to access all subsurface DNAPL and then reused as fill.

11.2.7.5 Excavated areas would be backfilled with stockpiled and imported fill material as necessary to either the original grade or a lower elevation if a stormwater retention basin or drainage swale is to be installed in either of these areas. In no case shall contaminated sediment be used to fill the excavations to the original grade. If the area above an excavation could be developed in the future, the backfill shall be compacted in such a way to support construction activities.

11.2.7.6 The remedial design shall identify steps that must be taken during the remedial action to protect such things as nearby monitoring wells and railroad tracks and the adjacent Portsmouth Public School District property from damages that could be caused by the excavation activities.

11.2.7.7 Dewatering activities shall be conducted as necessary to allow the subsurface soil excavation. Sump pumping systems may be used to reduce ground water infiltration into the excavation zone. Any water produced from such activities shall be treated, if necessary, prior to any discharge to the river. Any treatment would most likely involve filtration/sedimentation to remove sediments and carbon adsorption to remove organics.

11.2.7.8 Any debris encountered during the excavation shall be handled as described in section 11.2.3.2.5 on page 90.

11.2.8 Stabilization/Solidification

11.2.8.1 Areas Requiring Stabilization/Solidification

11.2.8.1.1 The upper three feet of the consolidated sediment placed behind the wall(s) shall be solidified/stabilized to provide a load-bearing surface. Three feet of stabilized material is assumed to be sufficient to ensure bearing capacity of typical heavy equipment, but geotechnical analysis shall be conducted to determine this depth. S/S shall be performed after the sediment is consolidated behind the wall.

11.2.8.1.2 A minium of five feet of sediments placed immediately against the sheet pile wall(s) shall undergo *in-situ* S/S, after a time of natural or forced dewatering as appropriate, to further enhance the effectiveness of the sheet pile wall(s) as a barrier to contaminant migration. Depending on the technology used to mix the treatment agent with the sediments, a thickness greater than five feet may be necessary to ensure proper overlap of treatment areas. The depth of the *in-situ* S/S shall extend into the native material to such a depth as DNAPL has been found or to five feet below the sediment surface outside the sheet pile wall containment area(s), whichever is greater in depth.

11.2.8.1.3 Sediments contained on the west side of the AWI property shall undergo S/S to the extent necessary to prevent settling that would interfere with the soil cover's function or integrity and to support reasonable redevelopment activities.

11.2.8.2 Solidification/Stabilization Requirements: S/S shall involve thoroughly mixing the soils/sediments with a cementitious or pozzolanic reagent mixture or other agent that can meet the performance standards. The five-foot zone behind the sheet pile wall(s) shall be treated to such an extent as to lower the permeability to less than $1x10^{-7}$ cm/sec. The specific stabilization agent shall be identified in the remedial design and approved by EPA. Different agents can be used for different areas of the site.

11.2.9 SPSA Property Soil Sampling

11.2.9.1 The northwest corner of the Wood Storage Area is currently owned by the SPSA (see **Figure 1**). The soil in this area shall be sampled during the remedial design. If soil contamination is found in excess of the soil cleanup criteria discussed in section 11.2.10.1 on page 96, then the contaminated soil shall be excavated and consolidated onto the AWI property requiring a soil cover in section 11.2.10.1.

11.2.9.2 The remedial design shall identify, like the SPSA property, that may require sampling. Several possible examples include the shoulder of Elm Avenue, the PPSD property, and underneath Burton's Point Road. If soil contamination is found in excess of the soil cleanup criteria discussed in section 11.2.10.1 on page 96, then the contaminated soil shall be excavated and consolidated onto the AWI property requiring a soil cover in section 11.2.10.1. Such areas shall be sampled during the remedial design.

11.2.9.3 Any area excavated shall be backfilled with clean fill and vegetated.

11.2.10 Soil Cover

11.2.10.1 The area of soil with contamination above 76 ppm arsenic, 3 ppm benzo(a)pyrene, or 1 ppb dioxin (TEQ) or where sediments have been consolidated shall be covered with clean soil or paved.[25]

11.2.10.2 The soil cover shall have a minimum one foot layer with a maximum permeability of $1 x 10^{-5}$ cm/sec and a minimum six inch top layer of top soil with vegetation. Pavement with bound aggregate, such as concrete or asphalt, shall have a minimum thickness of six inches. Pavement with unbound aggregate, such as crusher run, shall have a minimum thickness of one foot. Each shall have a maximum permeability of $1 x 10^{-5}$ cm/sec.

11.2.10.3 In determining the actual permeability and thickness of the various cover components, the remedial design shall include an analysis of the expected infiltration at the site to ensure that the cover system shall reduce infiltration to such an extent that the MCLs and MCLGs listed in **Table 7** in **Appendix B** are met at the edge of the waste management area..

11.2.10.4 Prior to the soil cover or pavement being placed over contaminated areas, a layer of geotextile shall be placed over the contaminated soil to prevent mixing of clean soil or pavement materials and contaminated soils, to warn anyone who digs into the subsurface, and to prevent any erosion in the cover system to extend into the contaminated soil or sediment.

11.2.10.5 The remedial design shall identify chemical acceptance criteria for soil that is used for the cover and shall specify performance standards for any paving activities.

11.2.10.6 The soil cover or pavement shall extend to the off-shore sheet pile walls, covering the consolidated sediment.

11.2.10.7 The soil cover or pavement shall be designed and constructed: to function with minimum maintenance; to promote drainage and minimize erosion or abrasion of the cover; to prevent rain water run-on; and to accommodate settling so that rain water does not pool on the cover.

11.2.10.8 The soil cover shall be re-vegetated in such a way as to provide protection from erosion from rain or wind in various climates, including drought, and provide a high-quality habitat for wildlife to the maximum extent practicable. The types of vegetation shall be identified in the remedial design.

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[25]EPA understands that paving generally costs more than a soil cover. The goal of flexibility of cover types in the selected remedy (e.g., soil or pavement) is not to enhance the infrastructure at the site to, for example, foster redevelopment. At this site, the flexibility in acceptable cover materials can result in a cost savings for several reasons. One, some areas of the site, especially the AWI's operating area on the east side, would need pavement anyway to protect the soil cover. It would be a waste of resources to install a soil cover and pavement when pavement alone would provide the protection required of the remedy and the soil alone would be insufficient. Two, there are plans to redevelop the west side. If the timing of any redevelopment coincides with the timing of the construction of the soil cover, the flexibility allows certain redevelopment activities such as road construction and building slabs to act as the low permeability layer, thus reducing the cost of the cover system.

11.2.10.9 The soil cover, pavement and/or building structures located in areas delineated pursuant to 11.2.10.1 shall be maintained in a manner which minimizes the infiltration of water.

11.2.10.10 In designing the cover system, the remedial design shall consider site-specific conditions and the guidance on design and construction of cover systems listed in **Table 7** in **Appendix B.**

11.2.11 Wetlands Mitigation

11.2.11.1 Any wetlands lost as a result of the dredging activities, consolidation of dredged sediments, or the construction of the soil cover shall be replaced.

11.2.11.2 The wetlands that will be directly affected by the soil cover construction and/or sediment consolidation shall be delineated to determine wetland type prior to remedial action using the USACE's "Wetlands Delineation Manual, Technical Report Y-87-1, January 1987, Final Report."

11.2.11.3 The wetlands shall be replaced with newly constructed wetlands at the site. The wetlands shall be replaced in a 1:1 ratio in like kind of wetlands (i.e., tidal for tidal and non-tidal for non-tidal). If on-site mitigation is not achievable, off-site mitigation shall be performed.

11.2.11.4 Tidal wetlands shall be constructed to the west of, and connected to, the newly restored acetylene sludge wetland.

11.2.11.5 Non-tidal wetlands may be incorporated into the stormwater management facilities, if appropriate.

11.2.11.6 The newly created wetlands shall be successfully established. A complete restoration program shall be developed during remedial design. This program shall, at a minimum, identify factors which are key to a successful restoration program including, but not limited to, replacing and regrading soils and establishment of vegetation. The program shall be implemented. Other appropriate measures, including but not limited to, periodic maintenance (e.g., re-planting) may also be necessary to ensure long-term restoration.

11.2.11.7 A variety of wetland species common to the area shall be used to vegetate the wetlands.

11.2.11.8 The newly constructed wetlands shall be located and constructed in such a manner as to prevent the runoff from the adjacent uplands from destroying or de-stabilizing the new wetland.

11.2.11.9 A long-term wetland monitoring plan shall be developed during remedial design. This long-term wetland monitoring plan shall include, at a minimum, wetland structure and function, wetland vegetation, wetland success criteria, monitoring and control of invasive species, frequency of monitoring, and reporting requirements. The plan may also provide for the monitoring of both the density and diversity of the benthic community. The plan will be developed to ensure and document the success of the wetland mitigation areas. The monitoring plan shall identify appropriate reference locations.

11.2.12 Stormwater Management System

11.2.12.1 A stormwater management system shall be designed and constructed to control the runoff from the areas covered with the soil cover or pavement. See **Figures 26A** and **26B** for potential locations of stormwater ponds.

11.2.12.2 The system shall incorporate best management practices (BMPs) to the maximum extent practicable in an effort to maximize the habitat value of the system. This would include the use of elements of natural stream design in the remedial design.

11.2.12.3 The system shall be designed to handle the appropriate stormwater flow and to filter the stormwater prior to discharge.

11.2.12.4 The system shall also use filter runoff from Elm Avenue if it has the potential to recontaminate the areas that are dredged.

11.2.12.5 The system shall be designed to operate with minimum maintenance.

11.2.12.6 The system shall be designed and constructed in such a way to not exacerbate the potential for flooding on adjacent properties.

11.2.13 Passive Ground Water Mounding Control

11.2.13.1 Phytoremediation

11.2.13.1.1 During the remedial design, the use of trees (phytoremediation), by themselves or in conjunction with the system detailed in section 11.2.13.2 below, to control the mounding of ground water behind the wall(s) and subsequent migration around the wall(s) shall be evaluated. The following factors shall be considered during the evaluation: the ability of trees to control or contribute significantly to controlling the ground water mound, long-term monitoring requirements, appropriate plant type(s), habitat value, the potential for cross-media contamination, space requirements in areas being used for manufacturing and product handling, and site security.

11.2.13.1.2 Based on the evaluation above, EPA will determine if phytoremediation is a viable technology to control the ground water mound, either by itself or in conjunction with the system described in section 11.2.13.2 below. If EPA determines that phytoremediation is a viable technology, phytoremediation shall be implemented.

11.2.13.2 Passive Ground Water Release to River

11.2.13.2.1 If EPA determines that phytoremediation cannot adequately work by itself or is not viable for the site, ground water discharge points consisting of gates of sand in the stabilized zone behind the sheet pile wall(s) shall be constructed to allow ground water to migrate to weirs or holes in the sheet pile wall to prevent any mounding of ground water behind the wall(s) and subsequent migration around the wall(s).

11.2.13.2.2 The gates shall be strategically placed in areas of low contamination in the upper portion of the wall. These seepage openings shall allow the top layer of the upper Columbia Aquifer ground water to flow unimpeded through the wall, while minimizing the migration of more highly-contaminated ground water in the deeper portions of the aquifer.

11.2.13.2.3 The remedial design shall estimate the contaminant loading in the ground water migrating from these gates to the river. If it is anticipated that the loadings will cause an exceedance(s) of VPDES limits, the gates shall be designed and constructed with treatment materials in the sand, such as activated carbon, to treat the ground water to such an extent to not cause exceedances VPDES discharge limits.

11.2.13.2.4 The ground water migrating from the gates shall be monitored for both flow rate and contaminant levels.

11.2.13.2.5 If the original construction does not require treatment materials, but the monitoring shows exceedances of VPDES substantive requirements, the gates shall be upgraded with the addition of treatment materials.

11.2.13.2.6 If, at any time, suitable treatment materials cannot be found, the gates shall be sealed and active hydraulic controls shall be installed to control any ground water mounding. These controls may involve recovery wells or trenches and recovered ground water treatment systems.[26]

11.2.14 Long-term Ground Water Monitoring, including DNAPL Monitoring

11.2.14.1 Ground water in the upper Columbia, lower Columbia, and Yorktown Aquifers shall be monitored according to a plan developed in the remedial design that specifies the monitoring locations (new wells may be required), frequency, parameters, and data evaluation and reporting requirements.

11.2.14.2 On-site and off-site monitoring wells in the upper Columbia, lower Columbia, and Yorktown Aquifers shall be monitored for PAHs, PCP, EPA Contract Lab Program Target Analyte List metals, and DNAPL thickness beginning on a semi-annual basis. Wells shall also be sampled and analyzed for dioxins/furans on a biannual basis. The appropriate number and location of wells to be sampled, the duration of sampling, and the parameters and methods for analysis shall be specified the remedial design.

11.2.14.3 For the ground water to the north of the soil cover constructed pursuant to section 11.2.10 on page 96, monitoring shall continue until the ground water consistently meets the MCLs described in **Table 7** in **Appendix B**. Monitoring shall continue thereafter at least once every five years to ensure that the ground water remains at or below the MCLs to show that the MNA and soil cover remain effective.

[26]If, in the worst case, active ground water removal from the sand weirs and treatment is necessary, the additional cost is minimal compared to the overall remedy. The remedy includes \$376,000 for constructing a temporary ground water treatment plant to treat ground water from the excavation pit where the DNAPL would be removed from the west site. This estimate is 80% of the estimated capital cost of \$469,000 for a long-term ground water treatment system, as most of the equipment would be suitable for both uses. The additional costs for a long-term treatment system would be for installation of extraction wells and the piping network. The estimated annual cost for O&M of a ground water treatment system is \$60,000. Even if none of the temporary ground water treatment plant could be used, the net present value of the capital and operations and maintenance costs would be around \$1 million. These costs are included in the \$44.9 million estimated cost of the selected remedy (see **Table 8** in **Appendix B**).

11.2.14.4 For the ground water to the south of the soil cover constructed pursuant to section 11.2.10 on page 96, monitoring shall continue until the ground water consistently meets the non-metal MCLs described in **Table 7** in **Appendix B**. Monitoring shall continue thereafter at least once every five years to ensure the ground water remains at or below the non-metal MCLs.

11.2.14.5 The water table level in each of the three aquifers shall be monitored at the same time as samples are collected for contaminant level measurement. For the upper Columbia Aquifer, the monitoring data shall be used to determine whether or not, and/or at what rate, the ground water mound which causes ground water to migrate in all 360 degrees of the compass has dissipated such that the ground water over almost all of the AWI facility flows toward the Elizabeth River. The 72-inch storm sewer line immediately west of the AWI facility may always cause some ground water migration from the facility to the line itself or the stone bedding underneath. If at some point the ground water mound has dissipated everywhere except in the immediate vicinity of the sewer line, an evaluation shall be made as to the potential for contaminant migration to the storm sewer and then to Paradise Creek to be occurring at such a rate as to cause unacceptable adverse impacts to Paradise Creek. At this time, there is no evidence that the ground water from the site is causing any unacceptable adverse impact to Paradise Creek.

11.2.14.6 RI data and initial monitoring data shall be used to determine the current rate of migration of metals with MCLs listed in **Table 7** in **Appendix B**. The type of evaluation shall take place on a regular basis to demonstrate that the reduction in rain water infiltration has minimized the migration of metals to the south of the soil cover to the maximum extent practicable.

11.2.14.7 Any DNAPL found in any wells to be monitored pursuant to this section 11.2.14 shall be recovered and disposed of off-site.

11.2.15 Biota Monitoring

11.2.15.1 Caged bivalve monitoring as was conducted in the OU3 RI shall be used to monitor the immediate impact (improvement) of the dredging activities. This type of monitoring shall be conducted three times during the first five years after the dredging is completed to monitor the expected decrease in contaminant level.

11.2.15.2 Crab and native oyster monitoring as was conducted in the OU3 RI shall be conducted three times during the first five years after the dredging is completed to monitor the expected contaminant level decrease.

11.2.15.3 Monitoring described in 11.2.15.1 and 11.2.15.2 shall be conducted in the dredge area, at the Scuffletown Creek confluence with the Elizabeth River, and at a reference station.

11.2.15.4 The biota monitoring shall include, during the first five years after the completion of the dredging, benthic density and diversity evaluations at the dredged area and at a reference station.

11.2.15.5 The biota monitoring shall include, during the first five years after the completion of the dredging, an evaluation of the tumor frequency in mummichogs found in the dredged area as an indicator of expected improvements to the health of the river.

11.2.16 Institutional Controls

11.2.16.1 Objectives: ICs shall be implemented to ensure that:

11.2.16.1.1 The land is not used for residential or other non-industrial purposes (such as a day care center or agricultural development) that may present an unacceptable risk to human health from contamination remaining on-site after the cleanup is complete.

11.2.16.1.2 The ground water is not used as a potable water source.

11.2.16.1.3 The ground water is not pumped or otherwise altered in such a way as to cause a change in hydraulic conditions that could interfere with the ongoing protectiveness and effectiveness of the monitored natural attenuation remedy.

11.2.16.1.4 Any activities that may take place on the site after the cleanup do not interfere with any components of the remedy and are conducted in a manner to protect the health of future construction and/or industrial workers from exposure to contaminated soil, ground water, or vapors that may intrude into a building.

11.2.16.1.5 Risks associated with the consumption of crabs and/or oysters are minimized through public education.

11.2.16.2 Implementation of Institutional Controls

11.2.16.2.1 ICs may include title notices, land use restrictions through easements and covenants, orders from or agreements with EPA requiring restrictions and/or compliance with health and safety plans, local ordinances,[27] informational letters issued to parties such as utilities and local and state governmental agencies, and public education regarding risks from crab and oyster consumption.

11.2.16.2.2 The remedial design shall include an IC implementation plan that will provide the specifics of the ICs to be employed at the site and steps that must be taken to implement the ICs. The plan shall include maps that show where the various ICs apply. At a minium, ICs are needed at the locations identified in **Figure 25** as the waste management area or ground water plume. The IC implementation plan shall evaluate the distance away from the plume that is necessary to prevent the installation of wells, both to ensure a margin of safety in protecting the public and to ensure that a change in the ground water flow direction does not occur that could cause ground water contamination to migrate in an unexpected direction.

11.2.16.2.3 As a result of information obtained during the remedial design and remedial action, EPA may determine that there is a need for more ICs than the ones specified below in sections 11.2.16.3, 11.2.16.4, and 11.2.16.5 to ensure the overall protectiveness of human health and the environment.

[27]The City of Portsmouth previously adopted an ordinance that requires a special excavation permit when subsurface work is required at or in the vicinity of the Abex Superfund site. The ordinance ensures that work that may disturb contaminated soils be done so in such a way as to protect the workers, the public, and the environment. EPA will discuss with the City the option of adopting a similar requirement at this site.

11.2.16.3 Land Use Controls

11.2.16.3.1 Orders from or agreements with EPA shall require respondents who are property owners of the site, and their successors, to: (1) notify EPA, and/or its successors, of the property owner's(s') intent to convey any interest in the site properties no later than 60 days before such conveyance is scheduled to occur; and (2) consummate any planned conveyance of title, easement, or other interest in the property(ies) only if EPA agrees that there is adequate and complete provision for continued maintenance and protection of the selected remedy.

11.2.16.3.2 Orders from or agreements with EPA shall prevent respondents who are property owners of the site from instituting legal proceedings, by way of quiet title or otherwise, to remove or amend these ICs unless EPA, and/or its successors, has given the property owners, and/or their successors, advance written approval.

11.2.16.3.3 Orders from or agreements with EPA shall require respondents who are property owners of the site to modify deeds to the affected properties to give notice to the public regarding past land disposal practices, releases and threats of releases of hazardous substances that have affected their respective parcels, and the health and safety plan for future subsurface work required by section 11.2.16.4. EPA will seek to have property owners of the site who are not subject to orders from or agreements with EPA modify their deeds in the same manner.

11.2.16.3.4 Covenants and easements will also be used to address land use so that residential, agricultural or other inappropriate land uses (e.g., child daycare centers) are not allowed.

11.2.16.3.5 The Code of the City of Portsmouth, Virginia, Chapter 38, Article II, Section 32, which requires that all premises must be connected to the public water and public sewer, will function as an IC to prohibit use of ground water as drinking water.

11.2.16.4 Health and Safety Plan for Future Subsurface Work

11.2.16.4.1 Restrictions on work practices associated with disturbing the subsurface, in the form of a health and safety plan to protect workers against exposure to contaminated soils and ground water, shall be developed, and complied with, for all future subsurface work.

11.2.16.4.2 The health and safety plan shall include a waste management section. This section shall discuss procedures for testing any soil excavated post-remedial action to determine of it is a RCRA hazardous waste. If so determined, the soil shall be handled and disposed of as such.

11.2.16.4.3 Requirements implemented by one or more of the enforcement tools indicated in section 11.2.16.2 on page 101 (e.g., any orders from or agreements with EPA shall require respondents who are property owners to comply with the health and safety plan) will prohibit breach of the soil cover or pavement, unless undertaken in accordance with the health and safety plan described by section 11.2.16.4.1.

11.2.16.4.4 A copy of the draft health and safety plan for future subsurface work will be sent to the City of Portsmouth, the City of Chesapeake, and VADEQ for their comment. The final health and safety plan for future subsurface work will be sent to the City of Portsmouth, including specifically the City of Portsmouth Public School District; local utility companies; and VADEQ for dissemination to employees who may be called upon to undertake future subsurface work at the site.

11.2.16.4.5 The final health and safety plan for future subsurface work will be sent to the City of Portsmouth, including specifically the Portsmouth Public School District; local utility companies; and VADEQ for dissemination to employees who may be called upon to undertake future subsurface work at the site.

11.2.16.5 Public Education

11.2.16.5.1 Data from, and risk analysis of, the crab and oyster monitoring, as well as the speciation results, shall be provided to the local health departments and to the public.

11.2.16.5.2 Public education efforts shall be commensurate with the risks potentially posed by the consumption of crabs and oysters.

11.2.16.5.3 The remedial design shall evaluate whether or not additional education will be necessary during and/or immediately after the dredging operations due to a potential temporary increase in contaminant body burdens of aquatic life.

11.2.17 Operations & Maintenance (O&M)

11.2.17.1 An O&M plan shall be developed and implemented for each portion of the remedy. The plan shall include the monitoring requirements already discussed, such as the passive ground water migration monitoring described in section 11.2.13.2.4 on page 99, as well as other monitoring requirements necessary to ensure the on-going performance of the remedy, such as inspections (annually at a minimum) of the sheet pile wall(s) and the soil cover and pavement. The O&M plan shall specify reporting requirements. The plan shall detail the activities required for an adequate inspection and the health and safety requirements for all the O&M activities.

11.2.17.2 Long-term O&M of the soil cover and pavement and associated stormwater management facilities shall take place to ensure that their functional integrity is maintained. O&M activities shall generally include routine inspection, mowing to control vegetative growth, clearing of accumulated sediment/debris from drainage channels, repair of cover vegetation and soils that are damaged by erosion, differential settlement, and/or other factors, and pavement repairs.

11.2.17.3 All requirements of the approved O&M plan shall be carried out.

11.2.18 Other Performance Standards

11.2.18.1 Applicable or Relevant and Appropriate Requirements

11.2.18.1.1 The selected remedy shall attain, at a minimum, all ARARs listed in **Table 7** in **Appendix B**.

11.2.18.1.2 The remedial design shall include a section that states how the remedial action shall comply with the ARARs.

11.2.18.2 Health and Safety

11.2.18.2.1 Air monitoring for site-related contaminants shall be performed during remedial action activities, including dredging, sufficient to adequately to evaluate the potential migration of particulate and contamination to areas at and adjacent to the site where people could be exposed to dust and contamination.

11.2.18.2.2 Engineering controls, such as dust suppression, limiting the size of excavations, and use of foam or coverings shall be used to ensure that people nearby who are not associated with the remedial action are provided with protection during the remedial activities.

11.2.18.2.3 Security fencing shall be installed to prevent trespassing at the AWI facility and to prevent unauthorized access in areas set for ongoing remedial activities.

11.2.18.2.4 Nearby residents, businesses, and public health and safety officials shall be notified in a timely manner of the remedial action activities.

11.2.18.2.5 A health and safety plan shall be developed and complied with for AWI employees to ensure their health is protected until the remedial action is complete.

11.2.18.2.6 The potential for intrusion of unacceptable levels of VOCs shall be evaluated before the construction of any new structures where people will occupy indoor, enclosed areas. If such evaluation predicts unacceptable risks, mitigation components shall be designed and constructed as part of the new structure.

11.2.18.3 Investigation-Derived Waste (IDW)

11.2.18.3.1 IDW or waste from decontamination activities shall be, to the extent practicable, put in the appropriate containment areas.

11.2.18.3.2 IDW or waste from decontamination activities that cannot be handled on-site shall be disposed of off-site.

11.2.18.4 Erosion and Sediment Control

11.2.18.4.1 An erosion and sediment control plan shall be prepared as part of the remedial design. The plan shall be implemented.

11.2.18.4.2 Surface water run-on shall be diverted away from any disturbed and contaminated areas.

11.2.18.4.3 In the event of rain or potential site flooding during remedial action activities, steps shall be taken to prevent contaminant migration.

11.2.18.5 Decontamination: All equipment that comes into contact with contaminated media shall be decontaminated before entering uncontaminated areas. The design and specifications for the decontamination facilities shall be approved by EPA as part of the remedial design.

11.2.18.6 Traffic

11.2.18.6.1 Attempts shall be made to minimize the necessity of lifting the Jordan Bridge during rush-hour traffic.

11.2.18.6.2 Activities that may result in temporary restrictions to traffic on Elm Avenue shall be conducted to avoid the complete road closure.

11.2.18.6.3 A traffic management plan shall be developed that evaluates the impact of traffic associated with the transport of cleanup equipment and material. Efforts shall be made to minimize the traffic required by remedial activities on Victory Blvd.

11.2.18.7 Restored Acetylene Sludge Wetland Storm Drain: The wetland in the acetylene sludge area that was restored during the 2002 removal shall be surveyed for a 15-inch storm drain, which was reported to EPA during the public comment period, coming from the South Annex of the NNSY. If the storm drain exists, it shall be monitored for the discharge of contamination. If such discharge is found, the remedial design shall evaluate whether or not the discharge poses an unacceptable risk to the environment. If EPA determines that there is an unacceptable risk, the contaminant migration must be addressed prior to initiation of dredging activities.

11.3 Summary of the Estimated Remedy Costs

The estimated present worth cost of the selected remedy is $44,900,000. This cost amount includes capital costs of $41,400,000 and a net present value cost of O&M of $3,500,000. A discount rate of money of seven percent was used to calculate the present worth cost of the annual operation and maintenance costs. The details of this cost estimate are presented in the detailed cost summary in **Table 8** in **Appendix B**.

The information in the cost estimate summary table is based on the best available information regarding the anticipated scope of the response action. This estimate is an order-of-magnitude engineering cost estimate that is expected to be within +50% to -30% of the actual project cost. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the selected remedy.

11.4 Expected Outcomes of the Selected Remedy

This section presents a summary the expected outcomes of the selected remedy in terms of resulting land and ground water uses and risk reduction achieved as a result of the response action.

11.4.1 Enhanced Off-Shore Sheet Pile Wall

The enhanced off-shore sheet pile wall(s) will prevent the river from becoming recontaminated after the dredging activities, thus providing protection to users of the river, both human and ecological, as well as protecting the major investment made in the dredging itself. The wall(s) will also provide enhanced river front property for industrial uses of the area.

11.4.2 Sheet Pile Wall at the Eastern End of Portsmouth Port and Industrial Commission Property

The sheet pile wall at the eastern end of the Portsmouth Port and Industrial Property will prevent the land from sliding or eroding into the river when dredging takes place immediately off-shore in an area where the river bottom has a steep slope. This wall will allow dredging to remove to the contaminated sediments and protect the river from sloughing during such activity. The wall will also provide enhanced river front property for industrial uses of the area. The wall will also protect the river from any possible recontamination from soils from a property that has had a long industrial history.

11.4.3 Dredging With Consolidation Both Behind Sheet Pile Wall and on the West Side

The dredging will remove large amounts of heavily contaminated sediments from the river, including sediments with mobile DNAPL, which currently pose threats to (1) human health, through direct contact and consumption of crabs and oysters and (2) the environment, through direct contact and passage through the food chain. This area is the most contaminated location in the Elizabeth River, which is the most contaminated tributary to the Chesapeake Bay. The Elizabeth River has been designated an area of concern by the Executive Council of the Chesapeake Bay Program because of the presence of contaminated sediments. The dredging should provide reduction in risks from the consumption of aquatic biota from a reduction in PAHs and dioxin and potentially arsenic.

The dredging, combined with the enhanced MNR, will remediate approximately 23 acres of river bottom, including areas that are heavily contaminated with DNAPL. The area of sediment consolidation is approximately 4 acres, resulting in approximately 19 acres of river bottom with viable habitat for aquatic life, and with the wetlands mitigation described below, no net loss of wetlands.

The dredging will allow the river to not have any restrictions on future changes to its bathymetry to enhance navigational use of the river (except at the base of the wall). The creation of land behind the sheet pile wall(s) creates additional opportunities for industrial use.

11.4.4 Enhanced MNR

The enhanced MNR will address the contamination remaining after the dredging in the range of 100 ppm tPAHs to the final site sediment cleanup criteria of 45 ppm tPAHs. This activity will result in the long-term protection of aquatic receptors. Through the use of thin-layer sand placement (the enhancement) if necessary, the time range to reach the 45 ppm tPAHs will be reduced, providing protection in a shorter time frame, as well as ensuring there is suitable material to provide benthic habitat. Using MNR for the lower levels of contamination reduces the cost associated with dredging.

11.4.5 On-going Business Operations

By coordinating the timing and implementation of the remedial action with the on-going business operations at the site, a potential cost savings is attained in several ways: (1) business activities that would take place anyway may be able to serve as components of the cleanup, such as paving a road; (2) the cleanup will avoid any temporary business relocation claims; (3) since AWI is one of the parties that is potentially responsible for the cleanup, a viable and healthy business could provide more resources for the cleanup; and (4) AWI could provide such resources as concrete and pilings, which are produced at the site as part of its business.

By coordinating with the Navy, the cleanup activities will not unduly interfere with the operational capabilities of the South Annex of the NNSY.

11.4.6 Unexploded Ordnance (UXO) Avoidance

The UXO avoidance measures will help ensure that UXO does not present a threat to cleanup workers.

11.4.7 Partial DNAPL Consolidation (West Side)

By consolidating the creosote DNAPL from the west side of the AWI property to the east side, an on-going source of ground water contamination will be moved to an area where the geology is much more suitable for long-term containment. The Columbia clay is so thin on the west side that it does not prevent the downward migration of contamination from the DNAPL. This activity will help the ground water MNA be successful.

11.4.8 Stabilization/Solidification

The S/S immediately behind the sheet pile wall(s) will help ensure that the sheet pile wall provides long-term containment, preventing contamination on-shore from recontaminating the river. The S/S of the upper portion of the consolidated sediments will provide a safe, useful surface which can support heavy equipment allowing businesses to utilize the river front access. This part of the S/S activity will also minimize the infiltration of rainwater, which will minimize the potential for ground water contamination to migrate to the river and minimize the potential for active ground water remediation at the river front, which would, in turn, increase the cost of the cleanup.

11.4.9 SPSA Property Soil Sampling

Sampling activities at this and possibly other adjacent properties will ensure that all necessary soil contamination will be covered, thus reducing any direct contact threats to human or ecological receptors.

11.4.10 Soil Cover

The soil cover or pavement will serve a number of purposes: (1) it prevents the direct contact threat to trespassers who are often present walking from one part of the shipyard to another part; (2) it prevents a direct-contact threat to onsite workers during normal business activities; (3) it minimizes the infiltration of rain water, thus lowering the ground water mound in the middle of the AWI facility, which, in conjunction with the reduced infiltration, will help achieve the MNA cleanup goals.

11.4.11 Wetlands Mitigation

Replacing the wetlands lost at the Wyckoff Inlet and other areas of the site, such as the low-lying area in the middle of the east side, will result in the remedy having no net loss of wetlands. Wetlands provide many beneficial uses in protecting the environment and humans. Additionally, the location of the new wetland will allow the wetland to remain as a wetland free from development pressure. Since a majority of the river in this area has hardened river banks, this wetland can provide a valuable resting and feeding location for aquatic species migrating through the area.

11.4.12 Stormwater Management System

The stormwater management system will ensure that the soil cover or pavement and their associated reductions in ground water infiltration do not result in an increased rate of runoff to surface water during a typical storm which otherwise could add to the flooding potential of the storm. Additionally, the system will provide filtration of contaminants from road runoff and sediment load before the runoff drains to the Elizabeth River. Urban runoff is a significant cause of the high background levels of PAHs in urban rivers.

11.4.13 Passive Ground Water Release to River

The passive ground water release system to the river will ensure that ground water migrating to the river through the gates in the sheet pile wall(s) is not causing an environmental harm to the river. Additionally, by making all efforts to accomplish the release passively, as opposed to active ground water recovery and treatment, O&M activities and costs associated with this component are significantly reduced.

11.4.14 Long-Term Ground Water Monitoring, including DNAPL Monitoring

The long-term ground water monitoring will ensure that MNA is adequately meeting the ground water cleanup criteria and that DNAPL is properly contained. This activity will provide the information to help EPA determine whether or not the selected remedy is functioning as designed.

11.4.15 Biota Monitoring

The biota monitoring will provide information regarding the recovery of the river and the success of the river cleanup. Some of this information will allow EPA to educate the public regarding risks associated from consuming aquatic biota.

11.4.16 Institutional Controls

Since the remedial action will not allow for unrestricted access or unlimited use, ICs will help make sure the remedy remains in place and functioning and the site use remains as anticipated in selecting the final remedy so the remedy functions as designed. The ICs will also ensure that ground water is not used for drinking or accessed without appropriate safety measures and that subsurface work is performed in a way that ensures the protection of the workers. The public education efforts regarding the risks from consuming crabs and oysters will provide citizens with the information necessary to reduce risks from exposure to the contamination.

11.4.17 Operations & Maintenance (O&M)

The O&M requirements will ensure that the remedy functions as designed as long as necessary to provide protection to human health and the environment.

11.4.18 Health and Safety

Air monitoring activities will ensure the protection of nearby workers during the actual cleanup. The requirement to evaluate potential vapor intrusion for any new construction that will have an enclosed occupied space will provide protection to future workers at the site. The number of workers at the site could increase through redevelopment activities.

11.4.19 Erosion and Sediment Control

The erosion and sediment control activities will ensure that run off during the remedial action does not result in the unacceptable spread of contamination, which can result in increased risks and additional cleanup costs.

11.4.20 Traffic

By developing a traffic plan, EPA can minimize the impact to the community from increased truck traffic both on Victory Boulevard and the Jordan Bridge as well as minimize the impact associated with additional bridge closures caused by moving of dredging equipment.

12. STATUTORY DETERMINATIONS

12.1 Statutory Mandates that the Selected Remedy Must Meet

EPA's primary responsibility at Superfund sites is to undertake remedial actions that are protective of human health and the environment. In addition, Section 121 of CERCLA, 42 U.S.C. § 9621, establishes several other statutory requirements and preferences. These requirements specify that, when complete, the selected remedial action for each site must comply with applicable or relevant and appropriate environmental standards established under federal and state environmental laws unless a statutory waiver is invoked. The selected remedy also must be cost effective and utilize treatment technologies or resource recovery technologies to the maximum extent practicable. Finally, the statute includes a preference for treatment as a principal element. The following sections discuss how the selected remedy for this site meets these statutory requirements.

12.1.1 Protection of Human Health and the Environment

The selected remedy provides overall protection of human health and the environment. It provides overall protection of human health by:

- Requiring a soil cover or pavement over contaminated soil to separate workers at the site and trespassers from the contaminated soil;
- Requiring site security and compliance with a health and safety plan to protect site workers and trespassers until the soil cover or pavement is in place;
- Preventing exposure to ground water contamination by preventing ground water wells from being installed in or near areas of unacceptable ground water contamination;
- Monitoring the ground water contamination as it naturally attenuates to ensure the ground water contaminant plume does, in fact, shrink;
- Requiring work that may involve workers coming into contact with contaminated soil or ground water (such as subsurface construction work) to do so in compliance with a health and safety plan to ensure the workers' protection;
- Requiring evaluation and any necessary mitigation actions to prevent vapor intrusion of VOCs from causing unacceptable risks to people who may occupy a new structure with indoor, enclosed space;
- Removing and isolating sediment contamination to prevent direct contact threats posed to recreational and industrial users of the river;
- Requiring public education to reduce the potential for subsistence and recreational fishers from consuming unacceptably high levels of aquatic life from the Southern Branch of the Elizabeth River; and
- Requiring the sealed sheet pile wall(s) to be installed with controlled ground water release, which will prevent the recontamination of the river.

The selected remedy will protect the environment by:

- Requiring a soil cover or pavement over contaminated soil to separate soil organisms from the contaminated soil, protecting both the soil organisms and their predators;
- Removing and isolating sediment contamination to prevent direct-contact threats posed to benthic organisms, crabs, oysters, and other aquatic life, protecting both these organisms and consumers of these organisms such as birds and other aquatic life; and
- Requiring the sealed sheet pile wall(s) to be installed with controlled ground water release, which will prevent the recontamination of the river.

12.1.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy will attain all ARARs, which are specified in **Table 7** in **Appendix B** of this ROD (see section 11.2.18.1.1 on page 103).

12.1.3 Cost Effective

The selected remedy is cost effective in that it eliminates or mitigates the risks posed by the contaminants at the site, meets all requirements of CERCLA and the NCP, and its overall effectiveness in meeting the remedial action objectives is proportional to its cost. The selected remedy (Alternative 4) is only slightly more costly than the least expensive alternative evaluated in the ROD and only one seventh the cost of the most expensive alternative evaluated in the ROD. Compared to the alternatives that are closer to each other in terms of cost (Alternatives 2 to 5), the selected remedy ranks well in terms of long-term effectiveness and permanence, reduction in toxicity, mobility or volume through treatment, and short-term effectiveness.

12.1.4 Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

The selected remedy utilizes permanent solutions and treatment technologies to the maximum extent practicable. The selected remedy removes almost all of the site-related contamination from the Southern Branch of the Elizabeth River which is the part of the site where contamination can and does cause the most harm. Treatment (*in-situ* S/S) is required to enhance the ability of the sheet pile wall(s) to prevent migration of contamination back to the river. The same treatment is also required on the top of the consolidated sediments near the river so the consolidation area can be used by heavy equipment. Of those alternatives evaluated in this ROD, EPA has determined that the selected remedy provides the best balance of tradeoffs, in terms of long-term effectiveness and permanence, reduction in toxicity, mobility, or volume through treatment, short-term effectiveness, implementability, and cost, while also considering the statutory preference for treatment as a principal element, and state and community acceptance.

12.2 Statutory Preference for Treatment as a Principal Element

As discussed in Section 10 (and in particular on page 73), EPA considers DNAPL in the soil, ground water, and river sediments to be principal threat waste. While the selected remedy does require treatment and some principal threat waste will be treated, most of the principal threat waste (i.e., the DNAPL) will not be treated. Therefore, the selected remedy does not meet CERCLA's preference for treatment as a principal element. Alternatives 5, 6, and 7 would meet this preference. In these alternatives, practically all of the principal threat waste would be treated. Alternative 5 would require *in-situ* S/S throughout much of the AWI facility, Alternative 6 would require low-temperature thermal desorption, and Alternative 7 would require a combination of *in-situ* S/S, *in-situ* chemical oxidation, and offsite disposal where any principal threat waste would be treated.

After giving careful consideration to the alternatives and the site characteristics both before and after implementation, EPA has determined that it is not appropriate at this site to meet the statutory preference for treatment as a principal element. In each of the alternatives that would meet this preference, there would still be high levels of contamination contained adjacent to the river, with Alternatives 5 and 6 using a much less effective combination of containment and treatment at the Wyckoff Inlet area than the selected remedy. These alternatives would still rely on ICs to the same degree and would still leave hazardous substances at the site. Any added benefit that would result from meeting the preference for treatment would cost significantly more, and EPA has determined that the cost would not be proportional to the benefit.

12.3 Five-Year Review Requirements

Because the remedy will result in hazardous substances remaining on-site above levels that will allow for unlimited use and unrestricted exposure, a review will be conducted at least every five years after initiation of the remedial action pursuant to CERCLA Section 121(c) and the NCP (40 C.F.R. 300.430(f)(5)(iii)(C)) in order to ensure that the remedy continues to provide adequate protection of human health and the environment.

13. DOCUMENTATION OF SIGNIFICANT CHANGES

EPA released the Proposed Plan for the site in July 2007. The Proposed Plan identified Alternative 4 (Soil Cover, Partial DNAPL Consolidation and Containment, MNA/Ground Water Monitoring, Dredging, Consolidation Behind Enhanced Off-Shore Sheet Pile Wall and at the West Side and Enhanced MNR) as EPA's preferred alternative. The selected remedy described in detail in section 11.2 on page 87 is substantially the same as EPA's preferred alternative in the Proposed Plan. However, EPA has incorporated several changes, including some that resulted from the Agency's review of the comments submitted during the public comment period that are described below.

The cost of the preferred alternative in the Proposed Plan was $44.4 million. The cost of the selected remedy is $44.9 million. The increase is a result of two changes to the cost estimate: (1) EPA increased the estimated quantity of dredged sediment from 157,300 cubic yards to 161,100 cubic yards because a portion of the Columbia and Yorktown clays that must be removed in the Wykcoff Inlet was not included in the original quantity estimate, and (2) EPA added costs associated with constructing an approximately one-acre tidal wetland by increasing the size of the restored acetylene sludge wetland. In both cases, the action was part of the preferred alternative, but the cost for the activities were not in the original cost estimate.

The Proposed Plan stated that "the preferred alternative satisfies the statutory preference for treatment as a principal element to a limited extent by treating the sediment and/or soil directly behind the sheet pile with S/S." Upon further review of selected remedy, EPA has determined that it does not meet the statutory preference for treatment. See section 12.2 on page 110 for a discussion regarding this statutory preference.

The Proposed Plan contained soil cleanup criteria for BaP and arsenic. The Proposed Plan stated that the application of criteria for these two contaminants would result in the cleanup of all areas of soil that require remediation. Upon further review of the RI data, EPA has added to the selected remedy a soil cleanup criterion for dioxin of 1 ppb in order to ensure that all areas of soil contamination that require remediation are, in fact, remediated (see section 8.1.2 on page 56). This addition does not change the area of soil remediation anticipated by EPA's preferred alternative as described in the Proposed Plan.

One of the ground water RAOs in the Proposed Plan was to "reduce human health risks from . . . site-related contaminants in the ground water to acceptable levels, except on the south side of the site where the objective for the metals contamination is to minimize migration to the maximum extent practicable." The exception for the south side of the site accounted for metals contamination found at Site 9 of the NNSY Superfund site. Site 9 included the Waste Lime Impoundment, which was located adjacent to and southwest of the Acetylene Sludge Area. When preparing the Proposed Plan, EPA reviewed data collected by the Navy in the 1990's, which showed high levels of metals in this area and which could have been a source of ground water contamination such that MNA at the AWI site would not result in attainment of the MCLs for the metals contamination. After the Proposed Plan was issued, EPA reviewed documents that described the excavation of this area as part of a removal action conducted by AWI and the Navy at the Acetylene Sludge Area. However, this part of the removal was conducted by the

Navy since it was all on the NNSY site. Since this potential source of ground water contamination was removed, EPA now expects that MNA at the AWI site will reduce the level of metals contamination in the ground water in this area to meet the MCLs. As a result, EPA has modified this RAO (see section 8.2.1 on page 56).

A commenter suggested that EPA consider the use of plants to control mounding of ground water behind the sheet pile wall(s) (see comment 3.6.10 on page 144). As discussed in EPA's response to the comment, the selected remedy includes the requirement to evaluate the use of phytoremediation to control or help control the ground water mounding (see section 11.2.13.1 on page 98).

A commenter informed EPA that there is a storm drain from the South Annex of the NNSY that empties into the restored acetylene sludge wetland and could carry contamination to the wetland and then the river (see comment 3.2.14 on page 125). EPA acknowledges the concern and has included in the selected remedy the requirement that this outfall be identified and monitored for the discharge of contamination, and if any discharge is found that could pose a risk to the environment, that the contamination be addressed prior to any river cleanup (see section 11.2.18.7 on page 105).

A commenter suggested that EPA reconsider the excavation of the creosote DNAPL from the west side of the AWI property. The commenter stated that if the DNAPL must be addressed, then S/S should be considered because of a concern about the amount of ground water that may flow into the excavation (see comment 3.4.16 on page 137). EPA acknowledges the comment and has added to the selected remedy the ability to use of S/S be evaluated to address the DNAPL on the west side if EPA determines it is more appropriate than excavation (see section 11.2.7.3 on page 94).