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Watershed Contaminated Source Document for Willoughby Bay

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Acronyms and Abbreviations

AOC	Area of Concern
AST	Aboveground Storage Tank
ATSDR	Agency for Toxic Substances and Disease Registry
BERA	Baseline Ecological Risk Assessment
bgs	Below Ground Surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action
CNO	Chief of Naval Operations
CSM	Conceptual Site Model
CVs	Comparison Values
DEQ	Department of Environmental Quality
EDR	Environmental Data Resources, Inc.
EPCRA	Emergency Planning and Community Right-to-Know Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
HRSD	Hampton Roads Sanitary District
HSDB	Hazardous Substances Data Bank
IAS	Initial Assessment Study
IRP	Installation Restoration Program
LANTDIV	Atlantic Division, Naval Facilities Engineering Command
LTANKS	Leaking petroleum tanks
LUST	Leaking Underground Storage Tanks
MAIA	Mid-Atlantic Integrated Assessment
NFA	No Further Action
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NSN	Naval Station Norfolk
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act

RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SERA	Screening Ecological Risk Assessment
SSA	Site Screening Area
SSTS	Site 7 (FIFRA) Tracking System
STORET	Storage and Retrieval Database
SWMU	Solid Waste Management Unit
SWPPP	Storm Water Pollution Prevention Plan
TSCA	Toxic Substances Control Act
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VDEQ	Virginia Department of Environmental Quality
VPDES	Virginia Pollutant Discharge Elimination System
WBW	Willoughby Bay Watershed
WCSD	Watershed Contaminated Source Document

1 Introduction

The purpose of this report is to document potential sources of contamination in the watershed of Willoughby Bay, located adjacent to Naval Station Norfolk (NSN) near the confluence of the James River, Elizabeth River, and Chesapeake Bay in Norfolk, Virginia (Figure 1). Section 1 provides the purpose and scope of the document, Section 2 briefly describes the general setting of NSN, Section 3 discusses the data collection methodology, Section 4 presents the results, and Section 5 presents the conclusion and recommendations.

1.1 Purpose

As described in the Navy's *Policy on Sediment Site Investigation and Response Action* (CNO 2002), a watershed contaminated source document (WCSD) is a brief document that qualitatively evaluates the potential for both Navy and non-Navy sources to have contaminated sediments in water bodies that are located adjacent to Navy property. Areas evaluated within the Navy property are focused on Installation Restoration Program (IRP) sites. The WCSD identifies and qualitatively evaluates potential contaminant sources and known releases from different sources (both Navy and non-Navy) to a water body, as well as transport mechanisms, exposure routes, and receptors.

The main purposes of the WCSD are to assist in determining the Navy's clean-up responsibility, if any, in an off-site water body and/or to assist in evaluating the potential that a site that may be remediated by the Navy on or near the water body will become re-contaminated from other source areas after the remedial action is completed. Thus, the WCSD attempts to document, using existing information, possible sources of contamination to a water body determined to be, or likely to be, contaminated. This information can be used in the Navy's decision-making process to determine the appropriate course of action it should take regarding the water body.

1.2 Scope

The Navy has produced a draft fact sheet (CNO 2003) that explains when a WCSD is necessary, the contents of a WCSD, how the WCSD is used to determine the Navy's clean-up responsibility in a water body, and how a WCSD is used to evaluate the potential for Navy-remediated sediments to become recontaminated by other sources.

A WCSD is:

- Ideally performed early in (or prior to) the investigation process for a site (such as a Site Investigation or a Remedial Investigation)
- A brief summary report, the level of detail of which depends upon the complexity of the situation and the amount of information available for the water body
- Based upon pre-existing data and information that is publicly available

- Documentation that supports the development of a preliminary conceptual site model

A WCSD is not:

- Intended to identify potentially responsible parties, just other possible sources
- Intended to determine the degree of responsibility or any other legal determinations
- Intended to be a watershed investigation
- A comprehensive or exhaustive compendium of data or a quantitative evaluation of the available data
- Intended to be the sole basis for additional sampling and/or analysis unless the Navy is determined to be the only source, or as directed by the Chief of Naval Operations (CNO)

The impetus for the preparation of this WCSD was the presence of two Navy IRP sites located on Navy property adjacent to Willoughby Bay. These sites are Solid Waste Management Unit (SWMU) 14 (the Q-50 Satellite Accumulation Area) and Site 9 (the Q-Area Landfill), both located at the northwestern tip of NSN. Based upon preliminary information, there is the potential that these sites could be releasing, or could have released, chemical contaminants to Willoughby Bay. Since there is also the potential for non-Navy and non-site related sources to contribute contaminants to the bay, there was the need to conduct this WCSD.

The geographic scope of this WCSD includes the portion of NSN located within the watershed of Willoughby Bay, non-Navy areas located within the watershed of Willoughby Bay, and the portion of Chesapeake Bay immediately adjacent to the mouth of Willoughby Bay. No attempt is made to identify contaminant sources to Chesapeake Bay. The portion of Chesapeake Bay immediately adjacent to Willoughby Bay is considered a source/receptor for the purpose of this WCSD.

2 General Setting

2.1 Physical Characteristics of the Facility

NSN is situated on 4,631 acres of land (A.T. Kearney1992) in the northwestern portion of the City of Norfolk, Virginia (Figure 1). NSN is bounded by Willoughby Bay to the north, the confluence of the Elizabeth and James Rivers to the west, and by the City of Norfolk to the south and east. A portion of the facility boundary (to the east) is formed by Masons Creek.

NSN includes approximately 4,000 buildings, 20 piers, and an airfield. The western portion of the facility is a developed waterfront area containing the piers and facilities for loading, unloading, and servicing naval vessels. The remaining portions of the facility consist of a combination of industrial, commercial, and residential uses. Residential and recreational areas also border the facility to the south, east, and northeast.

2.2 Facility Operations

NSN began operations in 1917, when the U.S. Navy acquired 474 acres of land to develop a naval base to support World War I activities. NSN has continued to acquire and extend land through land transfers and dredging and fill operations. NSN provides support to vessels, aircraft, and other activities. The service and maintenance of ships includes utilities hook-up, on-board maintenance, and coordination of ship movements in the harbor. Additional functions include the loading, unloading, and handling of fuels and oils used aboard the vessels. Ship and aircraft repair operations consist of paint stripping, patching, parts cleaning, repainting, engine overhauls, and sandblasting.

3 Methods

The following subsections summarize the methods used to conduct the WCSD and identify the data sources consulted. The primary methods used were literature and internet searches, agency and organization contacts, and the compilation of facility-specific information from Navy sources and contacts.

3.1 Literature and Internet Searches

The Willoughby Bay Watershed (WBW) encompasses NSN and residential areas in the City of Norfolk, Virginia. Literature and internet searches were performed to gather information on the area's environmental setting and land use activities to evaluate potential Navy and non-Navy source areas within the WBW. In addition, the internet search provided links to government agencies and private organizations with information on the bay.

3.2 Agency and Organization Contacts

The government agencies and private organizations that were contacted for relevant information, or whose web sites were searched, included:

- U.S. Geological Survey (USGS) - The USGS provided topographic maps which were used to determine the watershed boundaries and land use within the WBW.
- City of Norfolk - The Department of Public Works, Environmental Stormwater Management Section provided a map with the City's drainage basins and drainage areas, as well as a copy of the National Pollutant Discharge Elimination System (NPDES) permit. The NPDES permit displays the locations of all the permitted outfalls in the City of Norfolk. Together, the map and the permit were used to help determine the boundary of the WBW.
- Virginia Department of Environmental Quality (VDEQ) - The Water Inspections and Monitoring Team, as well as the Water Quality Program Team, provided:
  - Virginia Pollutant Discharge Elimination System (VPDES) permit information
  - The Storm Water Pollution Prevention Plan (SWPPP) for NSN
  - A reference to an Agency for Toxic Substances and Disease Registry (ATSDR) public health assessment conducted for NSN (including Willoughby Bay)

  The VPDES and SWPPP documents helped define the watershed boundaries and provided information on both permitted and non-permitted outfalls to the bay. The 2002 ATSDR assessment provided information on sediment, surface water, and aquatic biota sample collection activities that have occurred in Willoughby Bay through 2002.

The VDEQ Air Inspections and Monitoring Team provided copies of Virginia Ambient Air Monitoring Data Reports that were used to evaluate the scope and type of air monitoring data that were available to evaluate air quality in the Willoughby Bay area.

- U.S. Army Corps of Engineers (USACE) - The Virginia Regulatory Section provided area-specific information on dredging and construction permits.
- Environmental Data Resources, Inc. (EDR) - This private organization provided information on sites listed under various regulatory programs (i.e., RCRA, CERCLA, UST) and reported releases on non-Navy properties within the WBW.
- National Oceanic and Atmospheric Administration (NOAA) - Provided a map of Willoughby Bay with navigational channel locations.

3.3 Facility-Specific Information

Facility-specific information for NSN provided by the Activity (NSN personnel) included:

- Environmental Setting - The Activity provided documentation on facility boundaries and physical characteristics, as well as information on topography, hydrology, geology, and hydrogeology for the area.
- Dredging and Construction Activities - The Atlantic Division, Naval Facilities Engineering Command (LANTDIV) Engineering/Design Division provided information on dredging and construction activities that have occurred on the facility.
- Outfall Information - The Navy's VPDES permit and SWPPP provided outfall locations (permitted and non-permitted), receiving water bodies, and associated buildings and/or activities.
- Listed Sites - LANTDIV provided the information used to determine the location and identification of Navy IRP Sites, Solid Waste Management Units (SWMUs), Site Screening Areas (SSA), Areas of Concern (AOCs), aboveground storage tanks (ASTs), underground storage tanks (USTs), spill areas, and oil/water separators.

3.4 Reconnaissance Survey

A reconnaissance survey of the Willoughby Bay shoreline was conducted on 21 November 2002 to verify the location and name of the marina on the southwestern portion of the bay.

4 Results

This section of the WCSD compiles, summarizes, and qualitatively evaluates the available data derived from Navy and non-Navy sources.

4.1 Willoughby Bay Watershed Description

4.1.1 Watershed Location/ Physical Characteristics

The WBW encompasses approximately 15 square miles of land located in the northwestern portion of the City of Norfolk, Virginia. The watershed is bounded by Willoughby Spit to the north, the confluence of the Elizabeth and James Rivers to the west, and the City of Norfolk to the south and east (Figure 2).

The watershed was delineated based on topography, drainage basins and areas, and the City of Norfolk's storm sewer system. The elevation ranges from sea level at the northern and western edges of NSN to approximately 15 feet above sea level in the southeastern portion of the watershed. Most surface water in the watershed drains toward Masons Creek and the remnants of Bousch Creek, which has been largely filled and replaced by a network of drainage ditches and culverts. Bousch Creek receives drainage from areas both on the NSN and offsite residential areas. Both creeks are tidal and connect to Willoughby Bay. Freshwater flows enter Willoughby Bay only during heavy rainfall events making the tidal flushing from Chesapeake Bay the primary mixing mechanism in Willoughby Bay.

4.1.2 Geology and Hydrogeology

The WBW is located in the outer Atlantic Coastal Plan Physiographic Province, which is characterized by low elevations and gently sloping relief. The watershed is underlain by more than 2,000 feet of gently sloping sandy sediment, ranging in age from Recent to Lower Cretaceous.

The uppermost geologic unit is the Columbia Group, composed of the Sand Bridge Formation and the underlying Norfolk Formation. The Columbia Group is approximately 60 feet thick. The upper 20 to 40 feet consist of unconsolidated fine sands and silts of low to moderate permeability. The lower 20 to 40 feet consist of relatively impermeable silt, clay, and sandy clay. The Yorktown Formation underlies the Columbia Group and is about 90 to 100 feet thick in the vicinity of NSN. It consists of moderately consolidated coarse sand and gravel with abundant shellfish shell fragments.

The two significant aquifer systems in the area are the water table aquifer in the upper 20 to 40 feet of the Columbia Group and the underlying Yorktown Aquifer. The water table aquifer is thin and consists of discontinuous heterogeneous sand and shell lenses. The depth to the water table is usually less than 8 feet. The Yorktown Aquifer is semi-confined beneath a clay layer in the upper Yorktown Formation. Water-bearing zones in the Yorktown Aquifer consist of fine to coarse sand, gravel, and shells.

4.1.3 Land Use

The watershed includes Navy (NSN) and non-Navy properties. Within this boundary lies residential, commercial, and industrial areas. Based upon available mapping, non-Navy property land use is comprised of approximately 78 percent residential, 14 percent recreational, 4 percent surface water, and 4 percent commercial/industrial area. The western portion of the watershed is mainly comprised of operation activities bordering the Elizabeth River and logistics and industrial processes. Activities bordering Willoughby Bay include personnel support and operation activities to the far east and west of the watershed boundary.

4.1.3.1 Navy Property

NSN is the largest operating naval base in the world, encompassing 4,631 acres of land in the northwestern portion of the City of Norfolk, Virginia. NSN includes approximately 4,000 buildings, 20 piers, and an airfield. The western portion of NSN is a developed waterfront area containing piers and facilities for loading, unloading, and servicing naval vessels. Housing, recreation areas, and a school are also located on Navy property within the watershed. As of 2002, there were 109 on-base housing units; additional military family housing is located near the base (Bridges 2000).

4.1.3.2 Non-Navy Property

Areas on the waterfront to the south of NSN provide shipping facilities and a network of rail lines. Residential and commercial areas primarily surround the Navy property to the north (Willoughby Spit), east, and south. The nearest residential area to NSN is the Glenwood Park Community, comprising about 3,600 people (ATSDR-DHAC 1998). This community is located west of NSN and east of Hampton Blvd. (Figure 1). A public marina is located on Willoughby Spit, the northern border of the bay. This area consists mainly of a low-density residential area used extensively throughout the summer for recreational activities.

4.2 Sampling in Willoughby Bay

In Fall 2002, ATSDR issued a public health assessment that evaluated the past, current, and potential future exposures to contaminants at NSN and adjacent areas. During the assessment, all available sediment, surface water, and aquatic biota samples collected from Willoughby Bay were compiled and reviewed by ATSDR. However, the majority of the samples collected were not validated. ATSDR obtained sampling data from the following:

- Baker Environmental, Inc.
- Mid-Atlantic Integrated Assessment (MAIA)
- U.S. Environmental Protection Agency - Chesapeake Bay Program and the Storage and Retrieval database (STORET)
- Virginia Department of Environmental Quality - Chesapeake Bay Program and the Water Division General, Water Quality Standards, Department of Shellfish Sanitation

ATSDR compared sediment and surface water data to human health-based surface soil and drinking water comparison values (CVs) because sediment and surface water CVs were not available. Concentrations of contaminants in biota samples were compared to human-health based fish CVs for initial screening. ATSDR selected these CVs to be used as a conservative screening method. The origin of these values are provided in the Public Health Assessment document. The long-term daily exposure assumed by the CVs is a conservative approach to the actual frequency by recreational exposure to surface water and sediment in the bay. Because Willoughby Bay is not used for drinking water, incidental ingestion of water would result in exposure doses significantly lower than those assumed by drinking water CVs (ATSDR 2002).

4.2.1 Sediment

ATSDR identified 17 sediment sampling events in Willoughby Bay. Most of these samples were collected before 1988 and analyzed for total metals, PAHs, PCBs and selected pesticides. Several samples were collected from the central portion of the bay just north of NSN. The analytical results indicated that metals, PAHs, and PCBs were detected at concentrations exceeding their respective CVs; however, no pesticides were detected above the soil CVs.

In the mid-1990s, two sediment samples were collected from a lagoon located in Salt Marsh Park adjacent to Willoughby Bay. This lagoon is directly connected to the bay by a narrow channel. The analytical results showed that the concentrations of arsenic, benzo(a)pyrene, and benzo(b)fluoranthene exceeded CVs in the sediment samples (Baker 1996). This lagoon is located directly adjacent to (south of) SWMU 14/Site 9. The Navy is currently conducting a Remedial Investigation (RI) for these sites.

4.2.2 Surface Water

ATSDR identified 18 surface water samples that were collected in the bay between 1972 and 1995. Samples were collected from the center of the mouth of Willoughby Bay and from locations near the eastern end of IRP Site 13 (Past Industrial Wastewater Outfalls). Some of the samples were analyzed for metals and pesticides. Two of the samples were analyzed for PCBs. Several metals exceeded drinking water CVs in the samples collected from the mouth of the bay. Neither pesticides nor PCBs were detected.

In the mid-1990s, three surface water samples were collected from the lagoon located in Salt Marsh Park. The surface water samples exceeded the respective CVs for cadmium, iron, and lead.

4.2.3 Aquatic Biota

According to ATSDR, between 1971 and 2001 only limited numbers of fish and shellfish samples were taken from the bay. Prior to 2001, most of the sampling events were focused on oysters, however, spot, blue crab, and hard crab were also collected. Samples were collected from locations near the eastern end of IRP Site 13, near the center of Willoughby Bay, and to the south of the eastern end of Willoughby Spit. ATSDR concluded that the available data indicate slightly elevated levels of some metals, including arsenic, cadmium, chromium, lead, mercury, thallium, and zinc; however, most of the metals were not present at levels posing a potential public health hazard. In the summer of 2001, VDEQ collected a

variety of seafood species (including crabs, clams, and oysters) from Willoughby Bay and analyzed them for metals. No metals were found to exceed DEQ screening values in the biota samples. It was determined by ATSDR that the contaminant levels in these samples would not result in any long-term adverse public health effects.

4.3 Air Quality

VDEQ monitors ambient air quality in the City of Norfolk. The two closest monitoring stations are located approximately 6 and 7 miles south of Willoughby Bay. Station 181-V, located at the Post Office garage on Church Street in downtown Norfolk, measures carbon monoxide (CO) and Station 181-Z, at Norfolk State University, measures CO, sulfur dioxide (SO_2), and nitrogen dioxide (NO_2). Winds in this area are generally in an easterly direction and of moderate speed, ranging from six to eight knots (CH2M HILL, 1997). Because these air monitoring stations are not located over, or in the surrounding area of Willoughby Bay, they are not likely to be representative of the bay. Data on other chemicals, such as metals, that may deposit to the bay are not currently available.

Air permits were obtained by NSN, however, the permits were not available for non-Navy properties. The types of activities and equipment requiring an air permit at NSN include the installation and operation of steam-heated sludge dryers, construction and operation of boilers, operation of generators, and fuel storage tanks. NSN is responsible for complying with all local, state, and federal permit regulations.

4.4 Dredging/ Waterfront Construction Information

Possible contaminant release/mobilization can result from dredging or waterfront construction activities within or surrounding Willoughby Bay. These types of activities may contribute potentially contaminated substances from construction material, equipment emissions, or disturbance of sediments containing contaminants. Unlike the waterfront construction activities, the land-based construction activities are not included as a possible contaminant release to Willoughby Bay due to engineering controls set in place to prevent runoff to the Bay. Permits authorizing activities such as dredging and waterfront construction of breakwaters, terminal groins, and piers are obtained from the U.S. Army Corps of Engineers. The need for analytical testing of the dredged material is determined as part of the permitting process, however, there was no analytical data available for the permitted activities listed below.

The types of permits issued for activities in water and wetlands within the Willoughby Bay area are provided below; however, a permitted activity does not verify that the activity actually took place.

- In 1998, the NSN Environmental Programs Department requested a permit for construction of a 100-foot by 35-foot (bottom width) detached breakwater as well as the filling of a 10,000 square feet intertidal area with 1,200 cubic yards of clean sand to create an area of wetland vegetation in the northeastern portion of the bay. NSN also requested a permit for the construction of a 130-foot by 35-foot (bottom width) terminal groin at the site to prevent erosion at the shoreline and to provide beach nourishment.

- In 1998, the NSN Environmental Programs Department requested a permit for the construction of a 210-foot fishing pier, located within an established safety/security zone on the northeastern side of Sewells Point. The pier would be located within the "Q" area of NSN, approximately 155 feet off the Navy small boat channel.
- In 1997, the Lower Chesapeake Associates (a limited partnership trading as Willoughby Bay Marina) requested a permit for the replacement of an existing breakwater with reinforced concrete piles at the Willoughby Harbor Marina located on the western end of Willoughby Spit. The breakwater length would be approximately 1,247 feet with an additional 300 feet extending to the west along the current alignment.
- In 1996, the NSN Environmental Programs Department requested a permit for the placement of nesting platforms for osprey. These platforms were to be installed in Masons' Creek near the intersection of the I-64 overpass and Granby Street and in Willoughby Bay, 100 yards off-shore from NSN.
- In 1995, the Virginia Department of Transportation (VDOT) requested a permit for the widening of the Interstate 64 bridge deck from 30 to 41 feet. This construction would require dredging of approximately 9,800 cubic yards of sediment. Six thousand cubic yards of this sediment would be deposited on Craney Island and 3,800 cubic yards would be deposited on a section of Willoughby Beach.
- In 1994, the NSN Environmental Programs Department requested a permit for the construction of a breakwater at the Sailing Center/Marina on the northern border of NSN. Dredging was not requested for this activity.

4.5 Outfalls

The municipal storm sewer system is a system of conveyances that includes roadside ditches, man-made channels, and storm drains. Therefore, single conveyances, with the exception of pipes, that discharge into waters of the United States are considered outfalls (VPDES 2000). Stormwater discharge includes runoff from rainfall or snowmelt. However, there are other types of discharge (non-stormwater runoff) that pass through the outfalls as well. This includes stream condensate, sanitary cross connections, fuel spills, contaminated groundwater infiltration, and dumping of hazardous materials. VDEQ has a list of the types of non-stormwater discharges that are allowed; that includes discharges from fire fighting activities, irrigation drainage, lawn watering, external building washdown which does not use detergents, and springs.

There are a total of 271 permitted outfalls within the WBW (Figure 3). Some of the stormwater outfalls have minor, intermittent dry weather flows. Many of these outfalls are located within the tidal zone and thus receive significant dilution with tidal water in the outfall prior to discharge. The following subsections discuss the outfalls located on Navy and non-Navy property.

4.5.1 Navy Property

There are a total of 175 outfalls located on Navy property within the WBW, 167 of which are permitted. Approximately 59 of the permitted outfalls border the bay. The outfalls either

drain directly into Willoughby Bay or indirectly by way of Masons Creek or the remnant tributaries of Bousch Creek. Most of the outfalls are storm water runoff associated with vehicle maintenance activities. Prior to the mid-1970s, NSN had outfalls carrying industrial discharge to the storm sewer system and ultimately to the Elizabeth River and Willoughby Bay; however, these discharges are now rerouted to the Hampton Roads Sanitary District (HRSD) (ESE 1983). In the late 1980's and early 1990's, designated outfalls were monitored for constituents of potential concern. Metals, phenol, and oil and grease were the main constituents from the outfalls (Sirrine 1988, 1990, 1992).

Table 1 lists the number of permitted outfalls (monitored and non- monitored) for each receiving water body and provides information, where known, about associated activities and monitoring parameters. The remaining eight storm water outfalls within the watershed are not permitted due to possible relocation or removal from service. For these, all associated buildings were removed, demolished, or are no longer active.

4.5.2 Non- Navy Property

There are 104 permitted outfalls located on non-Navy property within the WBW. These outfalls drain directly into Willoughby Bay or indirectly by way of Masons Creek or the remnant tributaries of Bousch Creek and are not monitored. Nine of the outfalls border the bay. Table 2 displays the number of outfalls draining into each water body within the watershed. Information on outfall-associated activities and potential constituents was not available; however, the activities and corresponding potential constituents were determined based on the land use in the vicinity of the outfall.

4.6 Listed Sites

For this WCSD, listed sites are defined as sites with recorded releases or sites that have the potential to release hazardous substances as defined by federal and state regulatory programs (CERCLA, RCRA, AST programs, UST programs) or listed in federal or state databases (LTANKS, SSTS, FIFRA, TSCA, and EPCRA). The following subsections summarize the known listed sites on Navy and non-Navy property.

4.6.1 Navy Property

The types of listed sites at NSN within the WBW have been divided into categories. The number of sites and specific sites per category are shown in Table 3 and displayed on Figure 3. The categories are defined below:

- Accumulation Areas (CERCLA) - Sites included in the IRP used to temporarily store waste materials. Potential releases may be associated with spillage or leaching of waste materials.
- Accumulation Areas (non-CERCLA) – Sites not included in the IRP used to temporarily store waste materials. Potential releases may be associated with spillage or leaching of waste materials.
- Aboveground Storage Tanks - Sites where aboveground storage tanks are located. Potential releases may result from spills or leaks in the tanks or piping systems.

- Underground Storage Tanks – Sites where underground storage tanks are located. Potential releases may result from spills or leaks in the tanks or piping systems.
- Chemical Fire Sites - Buildings where chemicals were stored and where fires occurred. Potential releases may have occurred as a result of firefighting activities.
- Industrial Process Areas - Buildings and associated drainage systems that were potentially contaminated during industrial processes. Potential releases may result from storage of wastes or leakage of drain systems.
- Landfill/Disposal Areas - Sites that were utilized to dispose of fill material, solid waste, and chemical waste. Potential releases can result from migration of waste products or dissolution of contaminants into the groundwater.
- Outfalls - Storm water discharges associated with maintenance activities and surface runoff that are discharged into local water bodies.
- Salvage Yard - Area used to process and recycle facility scrap materials. Potential releases include chemical spills, recycling activities, and incinerator operations.
- Storage Areas - Areas used to store various chemicals, equipment, and petroleum products for use in facility operations. Potential releases are associated with damaged chemical containers or spills that infiltrate the ground surface and potentially migrate or dissolve in groundwater.
- Oil and HAZMAT Release/Spill Areas - Sites where releases of liquid chemicals or wastes occurred from surface spills as well as leaks from tanks and underground pipelines. Some spills may result from shipboard activities and the fueling of small crafts. Two types of spill areas are included in this document; spill areas associated with the IRP and spill areas that are not within the IRP. Potential contaminate sources include petroleum, industrial waste water, metals, and caustic compounds (ICF Kaiser 1995).

The majority of the sites listed in Table 3 have been classified as No Further Action (NFA) sites under the CERCLA process. Currently, only 10 of these sites are actively undergoing investigation or remediation. These sites include Sites 1, 2, 3, 6, 18, 20, and 22 and SWMUs, 12, 14, and 16.

4.6.2 Non-Navy Property

A search of environment records from federal, state, and the Environmental Data Resources (EDR) proprietary historical databases was conducted to locate and identify listed non-Navy sites. Forty-three listed sites were identified within the WBW (Figure 3). Table 4 shows the types of non-Navy listed sites that were found and the number of sites in each category (EDR, 2002).

The most common types of non- Navy listed sites within the WBW are categorized under UST (registered underground storage tanks), LTANKS (sites currently containing leaking petroleum tanks), LUST (sites with leaking underground storage tanks), and SPILLS. Petroleum was the main contaminate product from the LUST sites. The main spill types listed under the SPILLS category were sewage, petroleum, and detergents.

4.7 Other Potential Contaminant Sources to Willoughby Bay

Potential contaminant sources are not limited to those described in the previous sections. This section identifies other potential sources that may contribute contaminants to the bay.

4.7.1 Interstate Highway 64

Another potential source of contamination to Willoughby Bay is Interstate 64 and the Hampton Roads Bridge Tunnel. This major transportation artery trends across the northern boundary of the watershed along Willoughby Spit. Road construction materials, surface water runoff, spills, and vehicle discharges are all possible sources of contamination to the bay.

4.7.2 Other Water Bodies

The water quality of Willoughby Bay is thought to be significantly influenced by water from Hampton Roads. These waters include the James River, Elizabeth River, and Chesapeake Bay, portions of which are documented to be substantially contaminated (ATSDR 2002). The water from these water bodies is carried into Willoughby Bay by tidal action (Boon 2001).

4.7.3 Navigation Waterways

There are two navigation channels into Willoughby Bay. The one to the north extends to and from the water in Hampton Roads to the tip of Willoughby Spit. The channel is 10 feet deep at mean low water, 300 feet wide, and 1.5 miles long. The channel to the southwest is about one mile long and extends to and from the water in Hampton Roads to the marina at NSN. Potential contaminant sources include chemicals and waste on ships as well as the materials transported across these waterways.

4.7.4 Boat and Piers

Two marinas are located in the bay. A public marina is located in the westernmost portion of Willoughby Spit and the other in the northwestern portion of NSN. Potential contaminant sources include chemicals and wastes carried on boats (fueling and maintenance) as well as creosote from wood preservatives found in pilings (Swihart 2000). Activities at the public marina that have the potential to pollute the Willoughby Bay water and sediments include high pressure washing, painting, paint stripping, and engine repair.

4.8 Conceptual Site Model

The compiled information in the previous sections was used to develop a preliminary conceptual site model (CSM) for Willoughby Bay that identifies potential sources and releases (both Navy and non-Navy) as well as possible transport mechanisms, exposure routes, and receptors (Figure 4). The following subsections describe the major components of the preliminary CSM.

4.8.1 Potential Source Areas

Potential source areas within the WBW include listed sites and outfalls, dredging and construction sites, and roadways and transportation. In addition, contaminants may enter

Willoughby Bay from adjacent water bodies (e.g., Chesapeake Bay) through tidal flow and from upgradient sources through aerial deposition. Contaminants may be attributed to surface runoff, disturbance of sediments containing contaminants, polluting substances from construction materials, equipment and vehicle emissions, and releases of hazardous materials.

4.8.2 Hydrodynamic Conditions

Willoughby Bay is a depositional area receiving tidal inflow from the James and Elizabeth Rivers and Chesapeake Bay as mentioned in Section 4.7.2. Surface water parameters were measured during a study performed by CH2M Hill in 1995. Samples were collected from one location in the center of Willoughby Bay during the Spring, Summer, and Fall seasons at a depth of two to four meters. The sample location was established to minimize the influence of local discharges. The results show a slight variation in parameter measurements between seasons. Dissolved oxygen levels ranged from 8.6 mg/L in the Spring to 11.1 mg/L and the Summer. The pH measured 7.8 in the Spring, 8.5 in the Summer, and 8.1 in the Fall. Salinity measurements were the same in the Spring in Summer samples (23 ppt) with a slight decrease in the Fall (20 ppt). The salinity profiles in the area during the sampling periods indicated that the receiving waters were well mixed (CH2M HILL, 1999).

4.8.3 Transport Pathways and Exposure Media

A transport pathway describes the mechanisms whereby chemicals may be transported from a source of contamination to an exposure medium, such as sediment, where human and/or ecological exposures can occur. These transport pathways are shown on Figure 4.

Contaminants transported into Willoughby Bay can affect both surface water and sediment in the bay. Contaminants can be carried from adjacent water bodies to Willoughby Bay through incoming tidal flows, where they can remain in the water column or settle out onto the sediments. Storm water and outfalls can release chemicals to Willoughby Bay surface water through direct discharge and these chemicals may then partition to sediments. Contaminants in surface and subsurface soils may leach to groundwater and then discharge to Willoughby Bay. Contaminants in surface soils may also be transported to the bay via overland flow (runoff), either directly or via a storm water system. Contaminants in air from upgradient sources (such as power plants) can be directly deposited onto the surface water and sediments of Willoughby Bay or first deposited onto surface soil and eventually discharged into Willoughby Bay through groundwater or surface runoff. Contaminants in bay sediment and surface water may then be taken up and accumulated in the tissues of aquatic biota, and thus be transported to upper trophic-level receptors, including both human and ecological receptors, via food webs.

4.8.4 Exposure Pathways and Routes

An exposure pathway links a source of contamination with one or more receptors through exposure via one or more media and exposure routes. Exposure, and thus potential risk, can only occur if complete exposure pathways exist. Figure 4 shows the potentially complete exposure pathways to human and ecological receptors in Willoughby Bay.

An exposure route describes the specific mechanism(s) by which a receptor is exposed to a chemical present in an environmental medium. Unrooted, floating aquatic plants, and rooted submerged vascular aquatic plants and algae, may be exposed to chemicals directly from the water or (for rooted plants) from sediments. Animals, including humans, may be exposed to chemicals through: (1) direct inhalation of gaseous chemicals or of chemicals adhered to airborne particulate matter; (2) incidental ingestion of contaminated abiotic media (e.g., sediment) during feeding activities; (3) the direct ingestion of contaminated water; (4) the ingestion of contaminated plant and/or animal tissues for chemicals that have entered food webs; and/or (5) dermal contact with contaminated abiotic media. These routes, where applicable, are depicted on Figure 4.

Potentially complete exposure pathways to human receptors exist, but are likely to be limited to military personnel utilizing the bay for training exercises, construction workers involved in construction and maintenance activities, and recreational users, primarily fishermen (Figure 4). The primary exposure route for these human receptors is direct (dermal) contact with bay surface water and sediment. Military personnel may also be exposed via incidental ingestion of surface water. Recreational fishermen may be exposed through the consumption of fish or shellfish caught in the bay.

Potential exposures to terrestrial receptors utilizing the bay shoreline are likely to be minimal due to the developed nature of the bay shoreline. Potentially complete exposure pathways to aquatic (e.g., benthic invertebrates and fish) and semi-aquatic (e.g., ospreys) receptors that may inhabit Willoughby Bay exist. The primary route of exposure for lower trophic-level organisms, such as plants and benthic invertebrates, is via direct contact with surface water and sediment.

The primary route of exposure for upper trophic-level receptors, such as piscivorous birds, is via ingestion (food web) pathways. Due to the protection offered by hair or feathers, dermal exposures for upper trophic-level receptor species are not considered significant relative to ingestion exposures. Incidental ingestion of sediment during feeding, preening, or grooming activities is also likely to be minimal. Direct ingestion of drinking water by ecological receptors is generally only considered when the salinity is below 15 parts per thousand, the approximate toxic threshold for wildlife receptors (Humphreys 1988). Since the bay is saline, drinking water exposures are not likely to occur.

Based on the information provided in the latest Integrated Natural Resources Management Plan for NSN, birds are likely to be the most common and frequent upper trophic-level ecological receptors to utilize the bay. These include waterfowl and piscivorous species such as osprey. Marine mammals are uncommon in the waters of the lower Chesapeake Bay and the bay shoreline contains limited habitat for shoreline-dwelling species. Amphibians are not likely to regularly use the bay due to its saline nature. Reptiles, such as turtles, may be found in portions of the bay where suitable habitat exists.

4.8.5 Potential Receptors

As discussed in the previous subsection, human receptors utilizing the bay are likely to be limited to military personnel engaged in training exercises, construction workers involved in excavation and maintenance activities, and recreational users (Figure 4). Military personnel could use the bay for training exercises that may require total submersion in the

water, increasing the potential for incidental ingestion and direct contact with surface water. Construction workers may come in direct contact with Willoughby Bay surface water and sediments when working on docks, piers, or other structures on the bay shoreline or during dredging activities. The primary recreational use of the bay is likely to be fishing for both fin fish and shellfish, whereby a recreational user could come in direct contact with bay surface water and be exposed to bioaccumulative chemicals present in the fish.

The bay is likely to support a variety of benthic (sediment-dwelling) invertebrate, aquatic (water column) invertebrate, and fish species on a temporary or permanent basis. Aquatic plants may also be present in portions of the bay, especially the shallower, near-shore areas. As discussed in Section 3.8.3, birds are likely to be the most common and frequent upper trophic-level ecological receptors to utilize the bay. These include waterfowl (such as ducks and geese), waterbirds (such as gulls and terns), and piscivorous species (such as osprey). Marine mammals are uncommon in the waters of the lower Chesapeake Bay and the bay shoreline contains limited habitat for shoreline-dwelling species. Amphibians are not likely to regularly use the bay due to its saline nature. Reptiles, such as turtles, may be found in portions of the bay where suitable habitat exists.

5 Conclusions and Recommendations

The watershed of Willoughby Bay encompasses approximately 15 square miles which includes portions of NSN and the City of Norfolk. The watershed is bounded by Willoughby Spit to the north, the confluence of the Elizabeth and James Rivers to the west, and the City of Norfolk to the south and east. There are a number of potential sources of contamination to Willoughby Bay from both Navy and non-Navy property within the watershed which include dredging and construction activities, outfalls, listed sites, and roadways and transportation structures. Contaminants may also enter the bay from adjacent water bodies via tidal flows and from upgradient sources via atmospheric deposition.

Contaminants may be transported into Willoughby Bay through a number of potential pathways, where they can remain in the water column or settle onto the sediments. Surface water runoff and water from adjacent water bodies can directly discharge contaminants into the bay. Contaminants can reach the bay from surface and subsurface soils through leaching to groundwater or directly through overland flow and the storm water system. Contaminants transported through air can be directly deposited onto the bay or deposited onto the surrounding surface soil and eventually reach the bay through surface runoff or groundwater. Contaminants in bay surface water and sediments may then be accumulated in the tissues of aquatic biota and then transported to upper trophic–level receptors, including ecological and human receptors, via food webs.

The bay is likely to support a variety of benthic and aquatic invertebrates, and fish species on a temporary or permanent basis. Aquatic plants may also be present in portions of the bay, especially the shallower, near-shore areas. Birds are likely to be the most common and frequent upper trophic-level ecological receptors to utilize the bay; these include waterfowl, waterbirds, and piscivorous species. Marine mammals are uncommon in the waters of the lower Chesapeake Bay and the bay shoreline contains limited habitat for shoreline-dwelling species. Amphibians are not likely to regularly use the bay due to its saline nature. Reptiles, such as turtles, may be found in portions of the bay where suitable habitat exists. Human receptors are likely limited to military personnel engaged in training exercises, construction workers involved in excavation and maintenance activities, and recreational users.

Potentially complete exposure pathways to human receptors exist. The primary exposure route for these human receptors is direct (dermal) contact with bay surface water and sediment. Military personnel may also be exposed via incidental ingestion of surface water. Recreational fishermen may be exposed through the consumption of fish or shellfish caught in the bay.

Potential exposures to terrestrial receptors utilizing the bay shoreline are likely to be minimal due to the developed nature of the bay shoreline. Potentially complete exposure pathways to aquatic (e.g., benthic invertebrates and fish) and semi-aquatic (e.g., ospreys) receptors that may inhabit Willoughby Bay exist. The primary route of exposure for lower trophic-level organisms, such as plants and benthic invertebrates, is via direct contact with surface water and sediment. The primary route of exposure for upper trophic-level receptors, such as piscivorous birds, is via ingestion (food web) pathways.

Based upon the results of the WCSD, the ambient conditions in Willoughby Bay should be considered before conducting site-specific investigations involving sediments or exposure to sediments in Willougby Bay or its embayments (e.g., the lagoon near Site 9/SWMU 14). Contaminant contributions from tidal inflows to Willoughby Bay from the James River and Chesapeake Bay and from stormwater discharges associated with the City of Norfolk outfalls are of particular concern.

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INSERT FIGURES 1 THROUGH 4

TABLE 1
Permitted Outfalls on Navy Property
Norfolk, Virginia

Receiving Water Body/Outfall Type[1]	Number of Outfalls	Associated Constituents	Associated Activities/Comments
Willoughby Bay			
Monitored	15	metals[2]	Most outfalls are storm water runoff associated with vehicle maintenance, scrap waste, and public warehouse storage. One outfall is an industrial drain for vehicle maintenance. One outfall is a process wastewater discharge from water treatment activities, and another for low volume discharges from demineralizer unit.
Non-Monitored	71	petroleum products, metals	Most outfalls are storm water runoff not associated with a regulated industrial activity where no monitoring is required. Some outfalls are storm water runoff from airport activities, flying fields, petroleum and petroleum products and others from industrial drainage, oil/ water separator and discharges.
Masons Creek			
Monitored	5	petroleum products, metals, glycols	Outfalls are from storm water runoff from airports, flying fields, and airport terminals. Other outfalls carry storm water associated with icing/deicing activities and aircraft runaway operations.
Non-Monitored	44	petroleum products, metals	Outfalls are from storm water runoff not associated with a regulated industrial activity where no monitoring is required. Others are from a regulated activity, aircraft runaway operations, public warehousing, flying fields, and airport terminals.
Bousch Creek			
Monitored	1	petroleum products, lead, BTEX	Treat wastewater discharging from groundwater remediation activities.
Non- Monitored	29	petroleum products, metals	Most outfalls are storm water runoff not associated with a regulated industrial activity where no monitoring is required. Some outfalls carry storm water runoff from airport activities, flying fields, and vehicle maintenance. Other outfalls carry storm water runoff associated with fuel/oil storage with and without oil/ water separators. One outfall is associated with industrial drainage.
Unidentified			
Non- Monitored	2	metals, solvents	Outfalls are storm water runoff not associated with a regulated industrial activity where no monitoring is required.

Notes:

[1] Monitoring is not required at the non-monitored outfalls

NA = Not Applicable

[2] Flow, pH, total dissolved solids, total recoverable aluminum, and dissolved cadmium, chromium, copper, iron, and zinc are are monitored under VPDES Permit No. VA0004421.

TABLE 2
Permitted Outfalls on Non-Navy Property
Norfolk, Virginia

Receiving Water Body	Number of Outfalls	Associated Constituents	Associated Activities/Comments
Willoughby Bay	**11**		
		petroleum products, raw sewage	Commercial (including wholesale trade, retail trade, offices, financial services, personal services, business services, repair services, and professional services)
		petroleum products, pesticides, herbicides	Single Family Residential
Masons Creek	**81**		
		petroleum products, pesticides, herbicides	Single Family Residential
		petroleum products, pesticides	Recreational (including cultural sites, public assembly sites, amusement sites, recreational sites, resort/group camps, parks, cemeteries, and productive open space)
		petroleum products	High Density Residential (five families or more in the same structure, group quarters, mobile home parks, and residential hotels/motels)
		petroleum, pesticides	Institutional (including public administration, educational facilities, churches, and other institutions)
		petroleum products, dry cleaning solvents	Commercial
Bousch Creek	**12**		
		petroleum products, other unidentified constituents possible	Single Family Residential
		See Table 1	Military

TABLE 3
Type and Number of Listed Sites at Naval Station Norfolk
Norfolk, Virginia

Category	Number of Sites	Site Number
Accumulation Areas		
CERCLA:	4	SWMU 1,SWMU 4, SWMU 14, SWMU 16
Non-CERCLA:	19	Bldg. X336, V88, NM-14,LP167, A81, V61, LP24, LP33, LF59B, CA483, LF59A, LP34, AFDM 10, CD3, LF53, LP100, SP2, SP31, SP356
Oil and HAZMAT Release		
Spill Area (associated with IRP)	5	Site 14, Site 15, Site 20, SWMU 7, SWMU 37
Spill Area (not with the IRP)	4	LP24, LP78, LP179, V27, V45
AST and UST		
AST	221	Refer to Figure 4-1 for locations
UST	17	CD11, LP Fuel Farm (LP161) (LP39) (LP40) (LP41) and (LP42), MCE224, N26,NH139, NH19, NH95, NM154, NM72, P2, SP366, SP85, W Fuel Farm
UST with reported releases	43	A127, BEN126, LP22, CA13, CEP200, CEPFF, FTC-FF-School, Gate 2, LAG11, LF53, LF54, LP22, LP100, LP117, LP166, LP205, LP209, LPFF, MWR225, NH35, NH94, NM37, NM71, P64, Q65, Q81, SC407, SC413/124, UST CA-501-2, SP314, SP356, SP362, SPFF, U79B, U113, U117, U132, V28, V-28-2, V64, V146, Z- Area Pipeline, NCTAMSLANT Bldg. M-51
Misc. Other Listed Sites		
Chemical Fire	1	Site 16
Industrial Process Area	6	Site 11, Site 19, Site 23, SWMU 5, SWMU 6, SWMU 24
Landfill/Disposal Area	24	Site 1, Site 2, Site 5, Site 6, Site 7, Site 8, Site 9, Site 10, Site 12, SWMU 9, SWMU 10, SWMU 11, SWMU 12, SWMU 13, SWMU 26, SWMU 27, SWMU 29, SWMU 30, SWMU 34, SWMU 35, SWMU 38, SWMU 39, SWMU 40, SWMU 41
Outfall	2	Site 13, SWMU 36
Salvage Yard	1	Site 22
Storage Area	4	Site 3, Site 4, Site 18, Site 21,

TABLE 4
Type and Number of Listed Sites on non-Navy Property
Norfolk, Virginia

Data Base and Type of Listed Site	Number of Sites*
Accumulation Areas	
CERCLIS: Potentially hazardous waste sites. Proposed to or on the National Priorities List (NPL).	1
CERCLIS-NFRAP: Designated as a “No further Remedial Action Planned” site removed from CERCLIS.	1
Oil and HAZMAT Release	
LTANKS: Sites currently containing leaking petroleum tanks.	14
SPILLS: Reported spills.	13
ERNS: Reported releases of oil / hazardous substances.	7
RCRA	
RCRIS: Sites that generate, store, treat, or dispose hazardous waste (RCRA).	10
AST and UST	
AST: Sites with registered aboveground storage tanks.	1
UST: Sites with registered underground storage tanks.	26
LUST: Sites with leaking underground storage tanks.	14
Misc. Other Listed Sites	
FINDS: Miscellaneous database including some of those previous described.	14
CEDS: Sites with Virginia Water Protection Permits, Pollution Discharge System Permits, and/ or Pollution Abatement Permits	3
FTTS: Sites with administrative cases and pesticide actions and compliance activities over the previous 5 years.	1
SSTS: Sites with registered pesticide-producing facilities.	1
TRIS: Sites that release reportable quantities under SARA Title III of toxic chemicals to the air, water, and land.	1

Notes: * Sites may be linked to one or more types of listed sites.

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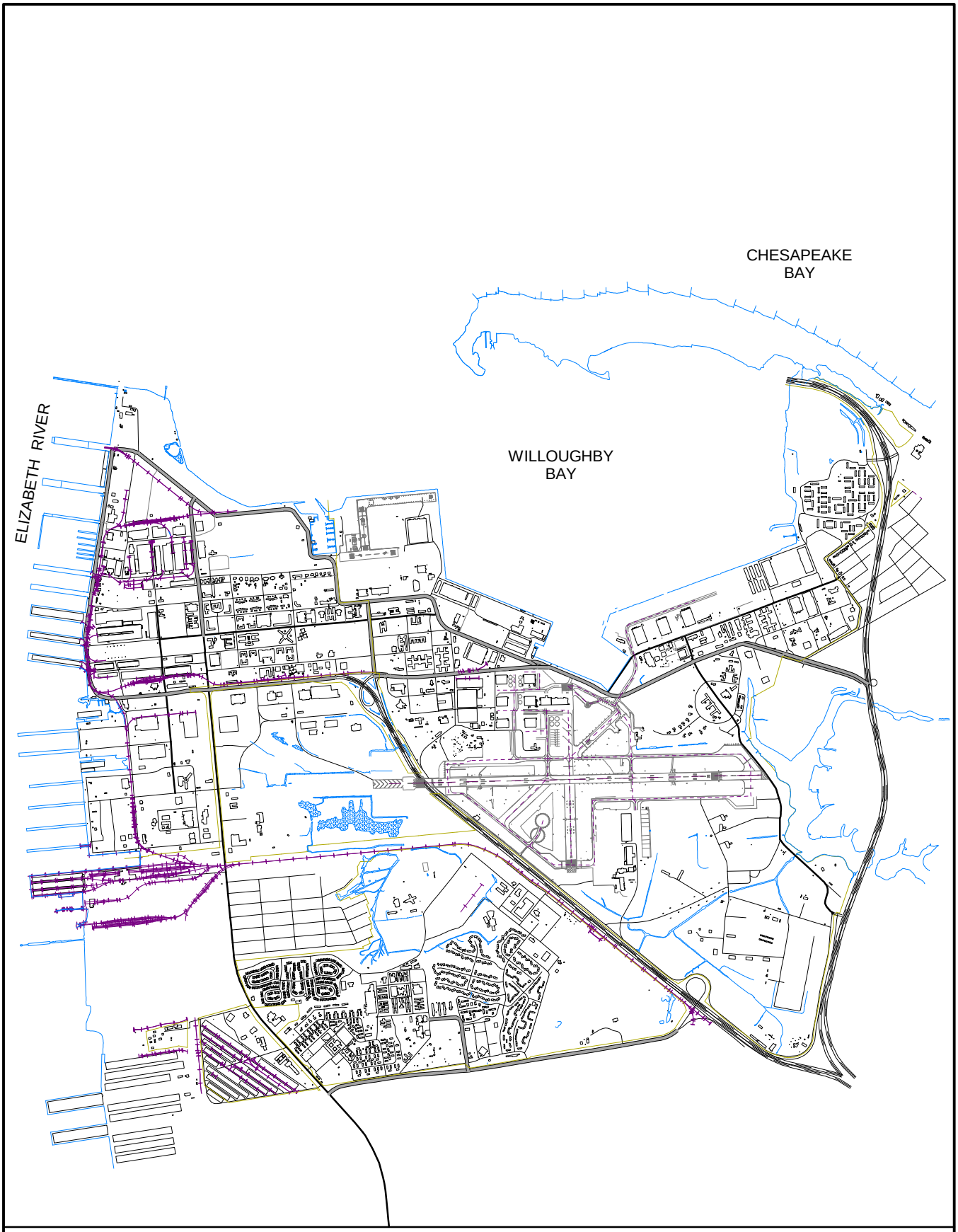

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0 2000 4000 Feet

Figure 1
Location Map
Watershed Contamination Source Document
Naval Station Norfolk
Norfolk, Virginia

CH2MHILL

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LEGEND

Navy Boundary

Non-Navy Boundary

N

Figure 2
Willoughby Bay Watershed Boundaries
Watershed Contaminated Source Document
Naval Station Norfolk
Norfolk, Virginia

CH2MHILL

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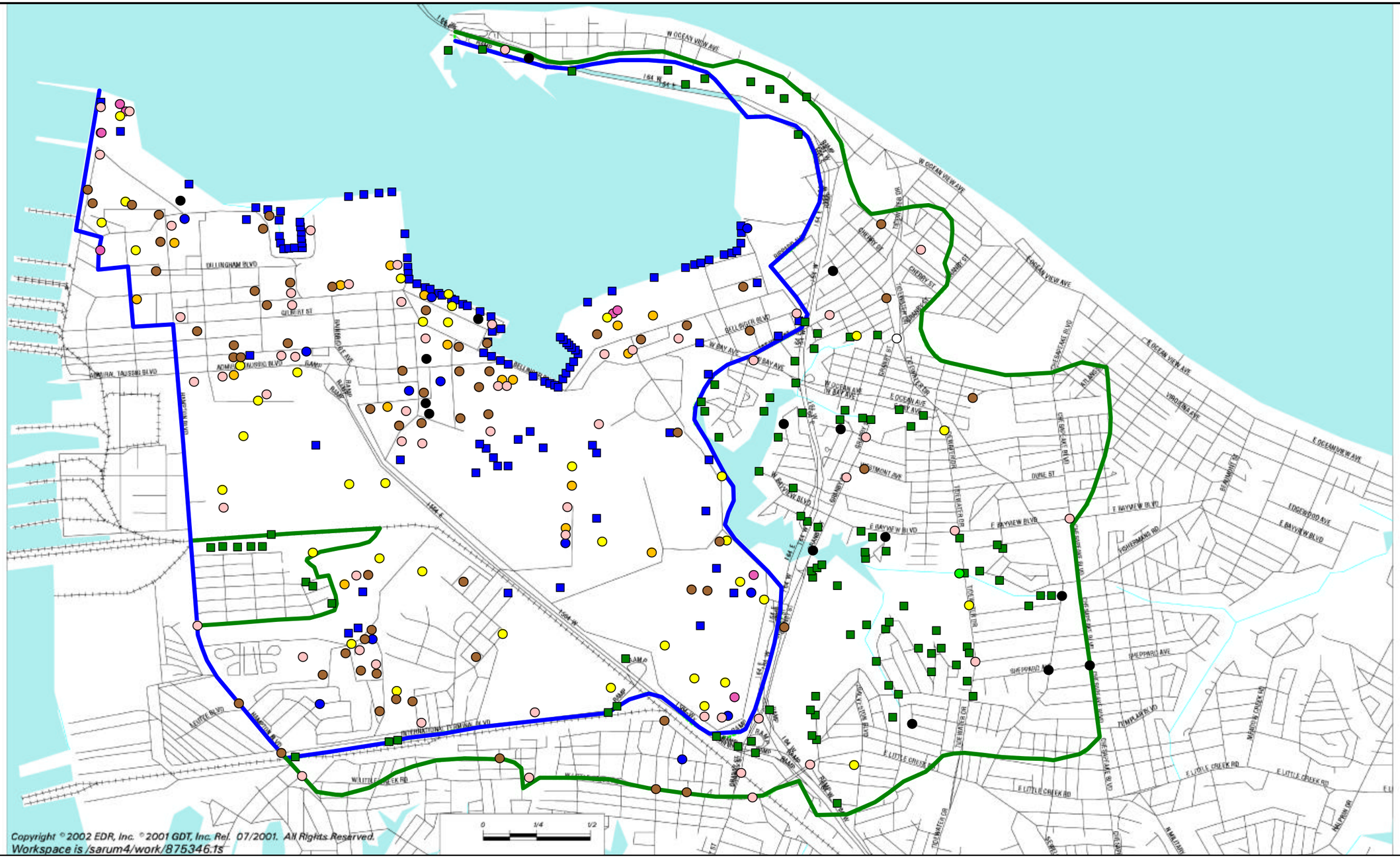

LEGEND

Naval Station Norfolk Boundary
Watershed Boundary

Outfalls
- Navy Outfalls
- Non-Navy Outfalls

Listed Sites
- Accumulation Areas (Non-CERCLA)
- Belongs to more than one category
- CERCLA - NFA
- CERCLA
- Leaking UST - UST with reported release
- Misc. other listed site
- Oil or other HAZMAT release
- RCRA
- UST or AST

N

Figure 3
Potential Source Areas Within the Willoughby Bay Watershed
Watershed Contaminated Source Document
Naval Station Norfolk
Norfolk, Virginia

CH2MHILL

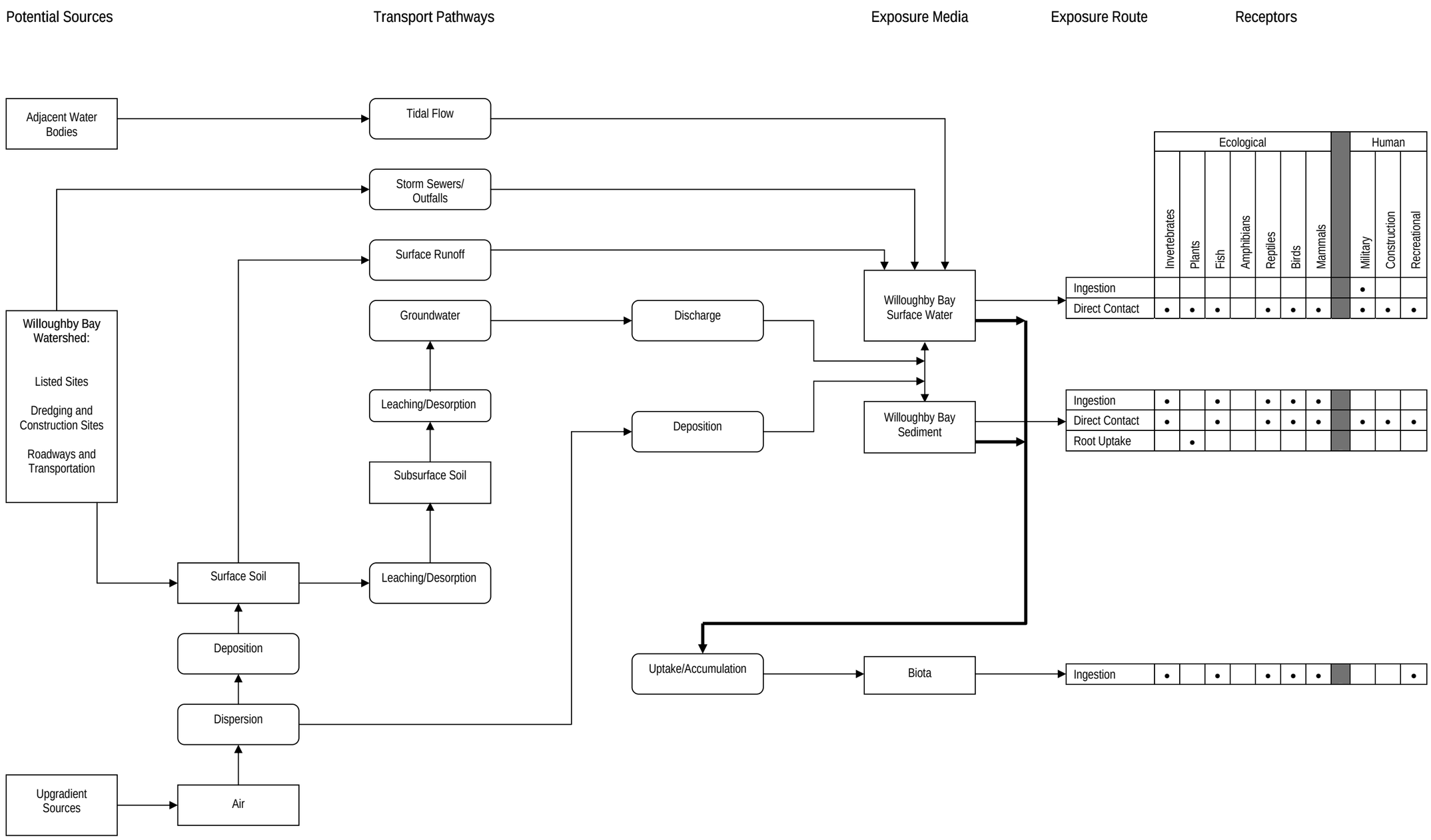

FIGURE 4
DIAGRAMMATIC CONCEPTUAL SITE MODEL