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ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

Public Health Assessment for

NAVAL AMPHIBIOUS BASE LITTLE CREEK
VIRGINIA BEACH, VIRGINA
EPA FACILITY ID: VA5170022482
SEPTEMBER 25, 2003

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the agency=s opinion, indicates a need to revise or append the conclusions previously issued.

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PUBLIC HEALTH ASSESSMENT

NAVAL AMPHIBIOUS BASE LITTLE CREEK

VIRGINIA BEACH, VIRGINIA

EPA FACILITY ID: VA5170022482

Prepared by:

Federal Facilities Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements. The public health assessment program allows the scientists flexibility in the format or structure of their response to the public health issues at hazardous waste sites. For example, a public health assessment could be one document or it could be a compilation of several health consultations the structure may vary from site to site. Nevertheless, the public health assessment process is not considered complete until the public health issues at the site are addressed.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists evaluate whether or not these contacts may result in harmful effects. ATSDR recognizes that children, because of their play activities and their growing bodies, may be more vulnerable to these effects. As a policy, unless data are available to suggest otherwise, ATSDR considers children to be more sensitive and vulnerable to hazardous substances. Thus, the health impact to the children is considered first when evaluating the health threat to a community. The health impacts to other high risk groups within the community (such as the elderly, chronically ill, and people engaging in high risk practices) also receive special attention during the evaluation.

ATSDR uses existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries, to determine the health effects that may result from exposures. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further public health actions are needed.

Conclusions: The report presents conclusions about the public health threat, if any, posed by a site. When health threats have been determined for high risk groups (such as children, elderly, chronically ill, and people engaging in high risk practices), they will be summarized in the conclusion section of the report. Ways to stop or reduce exposure will then be recommended in the public health action plan.

ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, fullscale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records, and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E60), Atlanta, GA 30333.

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List of Abbreviations

AT	averaging time
ABM	abrasive blast material
ATSDR	Agency for Toxic Substances and Disease Registry
BW	body weight
CDC	Centers for Disease Control and Prevention
CEL	cancer effect level
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CREG	ATSDR's cancer risk evaluation guide
CRP	community response plan
EF	exposure frequency
ED	exposure duration
EMEG	ATSDR's environmental media evaluation guide
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
FS	feasibility study
IR	ingestion rate
IRP	installation restoration program
kg	kilogram
µg/dL	micrograms per deciliter
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
mg/kg	milligram per kilogram
mg/kg/day	milligrams per kilogram per day
MRL	ATSDR's minimal risk level
na	not analyzed
NAB	Naval Amphibious Base
nd	non detect
NPL	EPA's National Priorities List
PCBs	polychlorinated biphenyls
PCE	tetrachloroethylene
PCP	pentachlorophenol
PHA	public health assessment
PHAP	Public Health Action Plan
PLPP	The Navy's Pediatric Lead Poisoning Prevention
ppb	parts per billion
ppm	parts per million

List of Abbreviations (continued)

RAB	restoration advisory board
RBC	EPA's risk-based concentration
RfD	EPA's reference dose
RI	remedial investigation
RMEG	ATSDR's reference dose media evaluation guide
SSL	EPA's soil screening level
SVOCs	semi-volatile organic compounds
SWMU	solid waste management unit
TCE	trichloroethylene
VDEQ	Virginia Department of Environmental Quality
VDH	Virginia Department of Health
VMRC	Virginia Marine Resources Commission
VPDES	Virginia Pollutant Discharge Elimination System
VOCs	volatile organic compounds

Summary

The Agency for Toxic Substances and Disease Registry (ATSDR) prepared this public health assessment (PHA) to evaluate the potential for harm to human health posed by hazardous substances at the Naval Amphibious Base (NAB) Little Creek. The NAB Little Creek, a naval support facility, encompasses 2,147 acres in Norfolk and Virginia Beach, Virginia, and to the north borders more than 2 miles of Chesapeake Bay shoreline. The U.S. government formed the base in the 1940s by combining four World War II bases: (1) the Amphibious Training Base, (2) the Construction Battalion Training Center, (3) the U.S. Naval Section Base, and (4) the Armed Guard Training Center.

Former NAB Little Creek operations, which included vehicle and boat maintenance and construction and repair of buildings and piers and abrasive blasting operations, resulted in various fuel and chemical releases or spills. Some the released materials have reached underlying groundwater and the Little Creek Harbor. On May 10, 1999, the U.S. Environmental Protection Agency (EPA) included NAB Little Creek on its National Priorities List. This was mainly because of concern about hazardous substances potentially entering surface water and endangering wildlife. The primary contaminants of concern to ATSDR of those detected at the site are metals, such as lead in surface soil, and mercury and polychlorinated biphenyls (PCBs) in fish and crab.

In 1999 and 2002, ATSDR conducted site visits and met with representatives from NAB Little Creek. At the time of the visits, ATSDR did not identify any environmental hazards posing immediate threats to public health. Following the site visits, ATSDR conducted a review of base-related information and determined that exposure to hazardous substances in groundwater, surface water, and sediment do not pose a public health hazard. Groundwater beneath portions of the base contains volatile organic compounds (VOCs) such as those found in cleaning solvents. There is, however, no public exposure to groundwater contaminants. The groundwater underlying NAB Little Creek has never been used as a source of drinking water, nor will it be used for that purpose in the foreseeable future. NAB Little Creek and the surrounding community receive drinking water from municipal water supplies that draw from surface water sources meeting federal and state drinking water standards. Although NAB Little Creek probably has contributed to the pollutant load in surface water and sediment of the harbor, none of the hazardous substances are at levels that could cause long-term health effects for people who use the harbor for boating or swimming.

ATSDR identified two main ways people might come in contact with environmental contamination associated with the base: (1) contact with hazardous substances in surface soil and (2) consumption of Little Creek Harbor fish and shellfish. ATSDR evaluated whether exposures to detected contaminant levels via these pathways are expected to affect the health of people at or

in the vicinity of NAB Little Creek, and developed the following conclusions about potential exposure hazards associated with soil and fish/shellfish.

Surface Soil

On-base

ATSDR concluded that exposure to soil contaminants does not pose a public health hazard. Either contaminants in on-base soil were detected at levels below health concern, or such low-level contamination was in areas where public exposure was infrequent or unlikely. Surface soil at certain locations at NAB Little Creek was found to contain contaminants associated with former base activities. Generally, exposure has been prevented because soil contamination occurs in restricted access areas, is covered by pavement or grass, or has been removed. Occasional contact with surface soil contaminants, even at the highest levels reported, is not expected to pose a public health hazard for adults or children. Successful cleanup or removal of contamination will continue to reduce potential harmful exposures.

Off-base

Lead was detected frequently and at levels of health concern in surface soil at a former grit-blasting area and Water Tower 1553. In November and December 2000, the Navy removed surface soil contaminants from the area. Exposure to lead has the potential to cause harmful effects, particularly for young children. Under certain conditions, lead-contaminated soil or dust could have migrated from the base to a nearby off-base residential property located 100 feet from the water tower. Site-specific information does not exist to confirm whether, or to what extent, lead from the grit-blasting area/water tower settled on the nearby property. Matching the relevant data against several factors that influence a child's vulnerability to lead in soil, however, suggests that likely exposures to lead in soil were minimal, if they occurred at all. Other possible sources in the neighborhood might also contribute to a child's exposure to lead, including lead-based paint in homes built before 1978. ATSDR believes it is prudent for families who live in or near the Turner Road area to evaluate the potential for their children to be exposed to lead and follow the Centers for Disease Control and Virginia Department of Health recommendations to have potentially exposed children under age 6 screened for elevated blood-lead levels.

Little Creek Harbor Fish and Shellfish

Low levels of chemical contaminants, such as mercury, tributyltin, and PCBs, were found in a limited sampling of fish and crab from the harbor. Exposure to such low levels of these contaminants should not pose a health hazard to people who in the past ate fish or crab from the harbor. Other chemicals have not been tested. For security reasons, the base has, however, posted "No fishing or crabbing" signs along the harbor.

Shellfish in the Little Creek Harbor has been affected by bacterial contamination. In 1938, the Virginia Department of Health, Division of Shellfish Sanitation, restricted shellfish (molluscan bivalves) taking in Little Creek Harbor because of bacteriological contamination. The "restricted" status allowed shellfish taking during warm weather months, as long as the fisher had a permit (issued by marine police and VDH) and transferred the shellfish to another water body, where they would undergo a cleaning-out period. In 1990, the status was changed from "restricted" to "prohibited" to comply with the National Shellfish Sanitation Program. "Prohibited" means no shellfish taking is allowed. ATSDR corresponded with the Virginia Marine Resources Commission (VMRC) and NAB Little Creek about public notification of the harbor's shellfish prohibition. While signs warning the public about the prohibition are not currently posted in areas controlled by the Navy at the harbor, the VMRC has stated that they are available to post signs or provide signs following consultation with NAB Little Creek. Until signs are posted, people following the advisory and the security restrictions are protecting themselves against potential exposure to bacterial and chemical contaminants in shellfish as well as fish and crabs.

Should the Navy's future plans include lifting the security restrictions for fishing or crabbing or remove the "No fishing and crabbing" signs for Little Creek Harbor, ATSDR recommends that the Navy verify, through sampling conducted prior to their removal, that edible fish and crabs in the harbor are free from harmful levels of chemical contaminants and are safe to eat. At that time, the Navy in cooperation with VDH might find it prudent to determine chemical pollutant impact on the shellfish (molluscan bivalve) population near NAB Little Creek.

Background

Site Description and Operational History

Naval Amphibious Base (NAB) Little Creek is located on 2,147 acres in the Tidewater region of Virginia, near the mouth of the Chesapeake Bay. The base straddles the communities of Norfolk to the west and Virginia Beach to the east, and borders more than 2 miles of Chesapeake Bay shoreline to the north (Figure 1).

NAB Little Creek was formed in 1945 by the combining of four World War II bases: (1) the Amphibious Training Base, (2) the Construction Battalion Training Center, (3) the U.S. Naval Section Base, and (4) the Armed Guard Training Center. Today, the base is homeport to about 27 naval vessels and provides on-base logistic facilities and support services to meet the amphibious training needs of the United States armed forces (NEESA 1984). Training performed at the base includes beach training, assault operations, landing craft air cushion training, and demolition and explosives training. The Navy also conducts underwater explosive detonations in Little Creek Harbor (Geo-Marine Inc. 1997). As part of its support services exercises, NAB Little Creek maintains military vehicles and boats and constructs and repairs buildings and harbor piers. The base also provides other general or miscellaneous services including routine pesticide applications, electroplating of musical instruments, and operating a laundry and dry cleaning service.

Remedial and Regulatory History

Over the years, solid waste, industrial byproducts, paints, and plating materials have been disposed of, released, or accidentally spilled onto soil at NAB Little Creek. Such chemicals include heavy metals, polychlorinated biphenyls (PCBs), and pesticides. Some of that contamination has seeped into groundwater or entered nearby waterways (EPA 1999).

In 1984 a Navy Initial Assessment Study identified 17 potentially contaminated sites (NEESA 1984). Of these sites, six were further studied in 1993 and 1994 as part of remedial investigations (RIs) (Figure 2):

Site 7	*Naval Amphibious Base Landfill*
Site 9	*Driving Range Landfill*
Site 10	*Sewage Treatment Plant Landfill*
Site 11	*School of Music Plating Shop*
Site 12	*Exchange Laundry Waste Disposal Area*
Site 13	*PCP Dip Tank and Disposal Area*

Results of the RIs included a recommendation for long-term groundwater monitoring at Sites 9 and 10, source removal and monitoring at Site 11 (A&B), and further evaluation of Sites 7, 12, and 13.

Mitigation or additional monitoring was recommended or conducted at 4, 5, 8, 15, and 16. No further action was recommended at 1, 2, 6, 14, and 17. (Site 3 is being followed under a non-CERCLA program.) More than 140 potential Solid Waste Management Units (SWMUs) were identified, but only five SWMUs of greatest concern have been scheduled for further evaluation (Navy 1999).

On May 10, 1999, the U.S. Environmental Protection Agency (EPA) placed NAB Little Creek on its National Priorities List. It did so mainly because of concern about contaminants potentially entering surface water and endangering wildlife. In September 2000, a draft Federal Facilities Agreement (FFA) was submitted for legal review. An FFA outlines the work required at NAB Little Creek and defines the responsibilities of the Navy, EPA, and the state of Virginia during investigation and cleanup. Figures 3-8 show census information or land use, other features including floodplains and locations of SWMU and Sites

Agency for Toxic Substances and Disease Registry (ATSDR) Activities

Through the public health assessment (PHA) process, ATSDR assesses site conditions at NPL sites from a public health perspective. That is, ATSDR determines whether people can be exposed to site-related contaminants through contact with the groundwater/drinking water, surface water, soil, biota, or air. Thus ATSDR visited NAB Little Creek on July 19–23, 1999, and again on February 11–13, 2002. ATSDR collected information necessary to rank the NAB Little Creek according to its potential public health hazard, to identify public health issues related to environmental contamination at the base, and to identify community health concerns. During the visit, ATSDR staff met with Navy personnel and representatives from federal and state agencies. After the visit and after a preliminary review of the data, ATSDR did not find any health threats at NAB Little Creek requiring immediate attention. ATSDR did, however, identify potential exposure pathways that needed further study. ATSDR prepared this public health assessment to evaluate these pathways further (ATSDR 1999a).

ATSDR also gathered information about health concerns voiced by members of the community. ATSDR met with base personnel, reviewed the results of the base's survey of community concerns listed in the base's community relations plan, and generally reviewed concerns expressed by the community. In June 2000, ATSDR prepared a health consultation to address specific community concerns about exposures associated with NAB Little Creek. ATSDR concluded in the health consultation that NAB Little Creek posed little threat of imminent health hazard to the public (ATSDR 2000).

Demographics and Land Use

ATSDR examines demographic data (i.e., population information) to determine the number of people potentially exposed to environmental chemicals and to determine the presence of sensitive populations, such as children (age 6 and younger), women of childbearing age (see pages 15–44), and the elderly (age 65 and older). Demographic data also provide details on population mobility, which, in turn, helps ATSDR evaluate how long residents might have been exposed to environmental chemicals.

In addition to demographic information, ATSDR examines the many ways in which people near NAB Little Creek might use the land and its natural resources. ATSDR does this to determine what activities might put people at risk for exposure. This information is important because the types and frequencies of activities and land use affects exposure to contamination. In this PHA ATSDR uses this information as part of the evaluation of contamination and exposure. Both demographic and land use information used in that analysis are provided below.

NAB Little Creek is principally located in Virginia Beach, but straddles the Norfolk and Virginia Beach city lines. The base employs a workforce of about 9,200 military and 4,200 civilians. During the summer, the population increases with the influx of Navy and Marine Reservists who arrive at the base for amphibious training. About 3,600 military personnel at NAB Little Creek and family members live in on-base housing, which consists of 954 units located at one of seven housing areas. Another 1,667 military personnel live in on-base barracks. School-age children attend one of the off-base schools, but younger children may attend the on-base child-care facility. This child care facility is not near any areas of contamination. In 1990, 35,809 persons lived within a 1 mile buffer around NAB Little Creek, with 4,371 children under 6 years of age and 2370 adults age 65 and older (see Figure 3A). As of 2000, a total of 31,230 persons were living within 1 mile of the base, including 3,468 children under 7 years of age and 2,938 adults 65 and older (see Figure 3B).

The surface topography at NAB Little Creek is predominantly flat. Figure 4 shows elevation contours at the base. Land at NAB Little Creek tends to slope toward water bodies. On the western side of the base, the land surface slopes toward the Little Creek Cove and Desert Cove, while on the eastern side, the surface slopes toward Lake Bradford. Most of the 2,147 acres of the base are developed, with about 600 buildings and 400 structures (see Figure 5). Only a small portion of the property remains covered with grass or other vegetation. The Area around NAB Little Creek consists of residential, commercial, industrial, and recreational developments (EPA 1999).

Surface water runoff and drainage from most of the base's source areas empty into either Little Creek Cove or Desert Cove of the harbor area along the western portion of the base. Water from both coves flows into Little Creek Channel, which then empties into the Chesapeake Bay.

Collectively Little Creek Cove, Desert Cove, and Little Creek Channel are referred to as Little Creek Harbor. The low and relatively flat areas adjacent to coastal waters fall within a 100 year and 500 year floodplain (see Figure 6). Surface water from the base flows through wetlands before actually discharging into the harbor (see Figure 7) (NEESA 1984). Lakes at the base include Lake Bradford, Chub Lake, Little Creek Reservoir, Lake Whitehurst Reservoir, and Varian Lake. Surface water runoff along the eastern portion, where most of the residential property is located, drains into Lake Bradford and Chub Lake (NEESA 1984).

Water levels at some of the on-base lakes are regulated through the release of overflow into the on-base canals. These canals eventually drain into Little Creek Cove. For example, overflow from the Little Creek Reservoir and the Lake Whitehurst Reservoir is released to Little Creek Cove by canals. The 4,000 foot canal connecting Little Creek Reservoir to Little Creek Cove borders a landfill (NEESA 1984, Geo-Marine 1997).

Fishing and shellfishing are not allowed on the NAB Little Creek property at Desert Cove, Little Creek Cove, Little Creek Channel, Varian Lake, or Chub Lake. Fishing is, however, permitted at the on-base Lake Bradford and Little Creek Channel, outside the base's boundaries, and in the Chesapeake Bay, outside the harbor (NEESA 1984, Mike Tate, Manager of Little Creek Marina Harbor, personal communication regarding fishing advisory, June 2002).

NAB Little Creek has 29 stormwater outfalls which ultimately discharge into Little Creek Harbor. Most of the outfalls are within the industrial area of the base (Geo-Marine, Inc., 1997). These stormwater outfalls are subject to the Virginia Pollutant Discharge Elimination System (VPDES), a permit program that controls water pollution by regulating sources discharging into surface water. NAB Little Creek's VPDES permit contains limits on what can be ultimately discharged into the harbor and specifies acceptable levels of any pollutant in that discharge. According to provisions of the VPDES, the Navy is required to routinely sample its stormwater discharges and to notify Virginia Department of Environmental Quality (VDEQ) of its results. Collectively, these provisions ensure that the discharges entering Little Creek Harbor's are safe and that public health is protected.

At the base and in the communities of Norfolk, Virginia Beach, and Chesapeake drinking water is provided by surface water from Lake Smith, Lake Wright, Lake Whitehurst, Lake Lawson, Stumpy Lake, Little Creek Reservoir, and three lakes to the west of the city of Suffolk. Several of these drinking-water reservoirs are within a few hundred of feet of NAB Little Creek. Still, none of the potential sources of contamination at the base drains to these reservoirs or surface water bodies, and the water is treated and tested to ensure that it meets safe drinking water standards.

Quality Assurance and Quality Control

In preparing this PHA, ATSDR reviewed and evaluated information provided in the referenced documents. Documents prepared for the CERCLA program must meet standards for quality assurance and control measures for chain-of-custody, laboratory procedures, and data reporting. The environmental data presented in this PHA are from Navy site documents and remedial investigations. Based on our evaluation, ATSDR determined that the quality of environmental data available in base-related documents for NAB Little Creek was adequate for making public health decisions discussed in this document.

Evaluation of Environmental Contamination and Potential Exposure Pathways

ATSDR identified two main ways those at or near NAB Little Creek could possibly come into contact with contaminants originating from the base.

MAIN EXPOSURE CONCERNS AT NAB LITTLE CREEK

- ***Soil Contamination***—Surface soils in certain locations at NAB Little Creek contain high levels of contaminants associated with former base activities. Some of the highest levels occurred near a former grit-blasting area and water tower where lead was found at levels of health concern. That contamination was removed. ATSDR evaluates whether people at the base or living nearby could have come in contact with potentially harmful levels of lead through skin contact or incidental ingestion of surface soil.

- ***Fish and Shellfish Contamination***—ATSDR evaluates the potential for people to consume fish and shellfish from Little Creek Harbor containing potentially harmful levels of contaminants. NAB Little Creek as well as other non-site sources may be responsible for the contamination in the harbor. NAB Little Creek releases as well as other non-site sources have contributed to the pollutant load in the harbor.

ATSDR analyzed environmental data for each of NAB Little Creek's installation restoration program (IRP) sites to determine if identified exposures could be past, present, or future public health hazards. Table 1 provides a description of each IRP site at NAB Little Creek and a summary of ATSDR's evaluation. Our review indicated that most IRP sites at NAB Little Creek are not associated with any known public health hazards. Many IRP sites are surrounded by perimeter fencing, covered surfaces, or both (e.g., vegetative growth, paved areas); these prevent or reduce potential exposure to contaminated soil. At other locations, harmful exposures are limited because either no site-related contaminants are present where exposure to the public could occur, or detected contaminant concentrations are too low to pose a health hazard. For some locations where levels were high enough to be a concern to regulators, cleanup efforts have successfully removed contaminated soil.

In the discussion that follows, ATSDR further evaluated environmental monitoring data and exposure information for the two main exposure scenarios to determine whether contact from either would result in harmful effects. ATSDR states the exposure concern associated with the complete or potential exposure pathway identified above, presents a brief summary of conclusions, and describes in more detail any identified exposure pathways and the basis for the conclusions. ATSDR's evaluation is also summarized by exposure situations in Table 2. In the *Community Health Concern* section, ATSDR discusses potential hazards associated with the subsurface soil gas near the Base Exchange and the use of the base golf driving range and baseball

diamond. To acquaint the reader with terminology and methods used in this public health assessment (PHA), Appendix A provides a glossary of environmental and health terms presented in the discussion and Appendix B describes ATSDR's exposure evaluation process. Appendix C contains ATSDR's responses to comments received during the public comment period (May 27 to July 11, 2003) for this PHA.

DISCUSSION OF: Contaminated Surface Soil

Summary

Contaminants, such as lead, arsenic, and polychlorinated biphenyls (PCBs), have been detected in surface soil at various IRP sites across NAB Little Creek. ATSDR believes that harmful exposures to contaminated soil at most areas of the base are largely prevented. The land surface is either paved, covered by grass or buildings, lies in restricted land use areas, or the contamination has been removed.

In November and December 2000, the Navy removed surface soil contaminants from a former grit-blasting area and Water Tower 1553, where lead was detected frequently and at levels of health concern. Exposure to lead has the potential to cause harmful effects, particularly for young children. Children living in base housing, however, are not likely to come into contact with lead in soil at the grist blasting area/water tower, as base housing areas are located away from this source of contamination.

An off-site residential neighborhood is located 100 feet from Water Tower 1553. Site-specific information does not exist to confirm whether, or to what extent, lead from the grit-blasting area/water tower settled on nearby property. However, matching the relevant environmental data collected near the water tower against several factors that influence a child's vulnerability to lead in soil suggests that likely exposures to lead in grit-blasting material were minimal, if they occurred at all. Other possible sources in the neighborhood might also contribute to a child's overall exposure to lead, including lead-based paint in homes built before 1978. The CDC and VDH recommend that young children be assessed for lead exposure. ATSDR believes it is prudent for families who live in or near the Turner Road area to also evaluate the potential for their children to be exposed to lead and follow the CDC and VDH recommendations.

Discussion

NAB Little Creek maintains vehicles and ships and in the past, also constructed and repaired the harbor piers. Some of these activities and associated waste disposal practices inadvertently released contaminants onto the ground surface (NEESA 1984). Areas of greatest concern are:

- *Abrasive Blasting Grit or Sandblasting Areas:* Several SWMUs are the sites of former ship maintenance activities, which included sandblasting and metal grinding. Many of the areas lacked release controls and, prior to removal, stored spent sandblasting grit on unpaved surfaces.

- *Water Towers:* Three base water towers constructed in the 1940s were maintained with lead-based paint. During repainting procedures, including those in the 1940s, 1950s, and 1960s, the exteriors of the towers were sandblasted to remove the paint layers. Some of the paint scrapings fell onto the ground around the towers. It is possible that during sandblasting activities some of the scrapings became airborne and traveled from the towers to nearby recreational and residential property.

- *Landfills and Operational Areas:* Materials disposed of at base landfills or released from base operations have contaminated on-base soil. Contaminated soil from base landfills could have migrated with overland surface water flow. The landfills have been covered with soil and closed, and some landfills also have future land use restrictions in place.

The Navy sponsored site and remedial investigations intended to characterize the type and amount of contamination in soil at base locations where contamination was suspected. Surface soil samples collected from IRP sites at the base were found to contain metals, semivolatile organic compounds (SVOCs), PCBs, and pesticides. Figure 2 shows following areas with ABM residue contamination or grit basting materials.

- SWMU 3, Pier 10 Sandblast Yard
- SWMU 5, Building 3986 Boat Painting Area
- SWMU 6, Seabee Area
- SWMU 7, Desert Cove Sandblasting Area
- SWMU 8, West Annex Sandblasting Area including Water Tower 1553 closest to the western base boundary and three other separated areas.

Some of the highest contaminant levels were concentrated in surface soil at a former grit-blasting area (SWMU 8) and at one of the base's water towers (1553) (see Figure 8). Of the contaminants detected, lead appeared frequently and in concentrations well above health concern levels (up to 1,820 ppm at the base of the tower—this exceeds EPA's residential soil screening level of 400 ppm.)

SWMU 8 is to the north of Midway Road and south of Guadalcanal Road at NAB Little Creek (OHM/IT 2001). Between 1949 and 1971, the Navy used the site for sandblasting ships and residue storage. Residue of reddish-brown abrasive blast material (ABM) and paint chips released from sandblasting operations accumulated on the ground to an average thickness of 4 inches.

Periodically, the residue was removed and disposed of off base. Since 1971, the area has been a vacant lot.

The sandblasting area is located adjacent to Water Tower 1553. Constructed in the 1940s, the water tower was maintained with lead-based paint for a majority of its use. During repainting procedures, the exterior of the tower was sandblasted to remove the existing layers of paint. Some of the sandblasting residue fell onto the ground around the tower. Turner Road, a residential and commercial neighborhood, borders the base perimeter fence line near the water tower area. About 100 feet separates the nearest home from the water tower.

During a preliminary field investigation in March 2000, the Navy visually delineated the extent of ABM in the area of SWMU 8 and the water tower (CH2M Hill 2000). No ABM material was observed within 50–75 feet of the fence line separating NAB Little Creek from the adjacent Turner Road residential property.

Why did ATSDR evaluate lead soil exposure at NAB Little Creek ?

Soil contaminants associated with a former grit-blasting area and with Water Tower 1553 possibly migrated to and settled on nearby off-base residential yards. ATSDR specifically focused our evaluation on potential exposure to lead in soil. Lead was the most commonly detected contaminant at the grit-blasting area and water tower, and if contacted at high enough levels would likely present a health hazard.

Since detecting elevated contaminant concentrations in surface soil at SWMU 8 and the water tower, the Navy has taken measures to reduce the contamination and any possible human exposure. Actions conducted in November and December 2000 included the removal from SWMU 8 and the nearby water tower of surface soil debris containing exposed ABM and contaminated soil. More than 4,500 tons of soil were removed to reduce lead levels to less than or equal to 400 ppm. Excavated material was shipped to an off-base disposal area. Confirmatory soil sampling following excavation within the delineated area confirmed that lead concentrations were below the EPA residential risk based concentration of 400 ppm. The confirmatory sampling also showed that no other constituents exceeding cleanup standards were left in place (NEHC 2003). Excavated areas were backfilled with certified-clean fill and covered with top soil and seeded (OHM/IT 2001). ATSDR noted during its February 2002 site visit that the grit (with the exception of sporadic occurrences of grit residue) had been removed from the property at SWMU 8 and the water tower and the area was covered with grass.

Evaluation of Public Health Hazards

Because young children are especially vulnerable to the effects of lead, ATSDR's assessment of potential health hazards focuses on whether children at or near NAB Little Creek could come in contact with harmful levels of site-related lead in surface soil. Children at potential risk of

exposure include (1) children living in on-base housing and (2) children living in the Turner Road neighborhood near Water Tower 1553. ATSDR assesses potential hazards by considering how often and how long the exposure at base housing or in the Turner Road area might have occurred and what contaminant concentrations might have been present in the soil at any likely point of contact. The evaluation is described below.

NAB Little Creek Exposures—SWMU 8 and Water Tower 1553

Lead levels in surface soil at SWMU 8 and Water Tower 1553 were above levels of health concern. For several reasons ATSDR determined, however, that children living at the base should not have come in direct contact with harmful levels of lead in those soils. First, in the past the areas of contaminated surface soils were generally inaccessible to the public. A perimeter fence with gated entrances limited—and continues to limit—unauthorized access to the base. An intact metal fence topped with barbed wire separates the SWMU 8 and the water tower lead-soil contamination from base housing areas as well as from nearby residential property. Additionally, there is little chance that in the past, young children susceptible to the effects of lead would have been left unattended at SWMU 8 or the water tower. Second, even if a child gained unauthorized access to the area of lead contamination, exposures would have been intermittent and brief. Such minimal, infrequent exposure to lead in soil, if it had occurred at all, would not reasonably be expected to cause illness or make someone sick. According to the NAB Little Creek–Boone Clinic base health officials, routine blood-lead screening of children that took place between 1995 and 1999 showed no cases of elevated blood-lead levels (above 10 µg/dL) for children living on base (ATSDR 1999c).

In November and December 2000, the Navy removed lead-contaminated soil from around SWMU 8 and Water Tower 1553, eliminating future exposures. Those remedial actions were conducted with oversight from the U.S. Environmental Protection Agency (EPA) and the VDEQ. Furthermore, accessibility to the base is and will remain restricted. **Given these findings, ATSDR concludes that soil contamination at SWMU 8 and Water Tower 1553 is not associated with any known public health hazard for children who live in on-base housing at NAB Little Creek.**

Off-Base Exposures—Turner Road Neighborhood

Residue of reddish-brown and darker abrasive blast material and paint chips were released during sandblasting operations at SWMU 8 between 1949 and 1971. Lead-paint chips were also dislodged from the exterior of the tower during maintenance activities after the 1940s. Under certain conditions (e.g., meteorological) during water tower sandblasting or operations at SWMU 8, lead might have deposited on soils in the nearby Turner Road residential property. Information characterizing whether or to what extent lead from these operations settled on soil within the adjacent neighborhood is not available. Without this information, ATSDR does not know with

certainty whether site-related lead exposure occurred at these yards. As a prudent public health measure, ATSDR evaluates possible exposure of nearby residents to lead in soil in the discussion below.

ATSDR's concerns about lead in soil

Although lead can cause adverse effects to people of all ages, ATSDR is principally concerned about the potential for children (6 years of age and younger) to come into contact with lead, as they are especially vulnerable to its effects (*see text box*). If airborne lead migrated to nearby residential properties, children might have come in contact with it. The most probable form of contact would be by handling surface soil or by inadvertently eating soil through hand-to-mouth activity. Breathing in soil particles is not considered to be an important source of lead exposure.

How does lead affect human health?

Health effects observed in children with elevated blood-lead levels include nervous system effects, delayed growth, and developmental brain damage. Children are more likely to be exposed to lead because of their frequent hand-to-mouth activity. They also have a greater tendency to absorb lead more efficiently than adults. The Centers for Disease Control and Prevention (CDC) recommend follow-up examinations, treatment, or both for children with blood-lead levels equal to or greater than 10 µg/dL.

If children or adults do contact lead-contaminated soil, the symptoms of such lead exposure are not always clear. With a simple blood test, physicians can find out how much lead is circulating in a person's bloodstream. Correlations between blood-lead levels and health effects have been studied extensively to evaluate the potential for lead exposure to cause adverse health effects. Since the 1980s, the Centers for Disease Control and Prevention (CDC) and the American Academy of Pediatrics have recommended that physicians evaluate the potential for lead exposure to children (9 months to 6 years of age) and when appropriate perform blood-lead screening (ATSDR 1999, AAP 1998). CDC recommends follow-up, treatment, or both for children with blood-lead levels equal to or greater than 10 µg/dL (ATSDR 1999b).

Blood-lead screening programs

Two applicable blood-lead screening programs serve families who live in or near the Turner Road neighborhood:

- *The Navy's Pediatric Lead Poisoning Prevention (PLPP) program.* Since approximately 1992, the Navy has operated a PLPP program that calls for physicians to administer annual questionnaires to guardians of children 6 years of age and younger, starting at their age-1 check-up. It also calls for blood-lead testing of all children at age 1, and of older children categorized as high risk on the basis of the questionnaire responses (NAVOSH n.d.,

Nielsen 2002b). Routine blood-lead testing by NAB Little Creek health officials at Boone Clinic between 1995 and 1999 disclosed no elevated blood-lead levels among children.

- *The Lead Safe Virginia program.* VDH's childhood lead-poisoning prevention program is known as Lead-Safe Virginia. Currently, the program recommends that physicians evaluate the risk for exposure to lead in all children at 1 year of age and again at 2 years of age, as well as any children 3 to 5 years of age who have not previously been evaluated. A blood-lead screening test is recommended for all at-risk children, including children whose adult parent or guardian's job or hobby involves exposure to lead, children living in a home built before 1978 that is undergoing renovation or has deteriorating paint, and children living in selected "high-risk" ZIP codes (VDH 1999). The Lead Safe Virginia program has the potential to serve non-Navy families living near the Turner Road neighborhood. Because, however, the program does not call for universal screening, it would not necessarily reach all potentially affected families.

Data about the populations served by the Navy's PLPP program and the Lead Safe Virginia program (including the percentage of children screened and the time period over which the screening occurred) and the results of any blood-lead screening of children who lived in or near the Turner Road area would allow ATSDR to provide greater perspective about the potential for adverse health effects to have occurred as a result of exposure to lead. Without these data, we can only estimate likely exposure based on factors that influence contact with contaminated soil and a child's vulnerability to lead.

Factors that influence contact with lead contaminated soil

Exposure can only occur if an individual comes in contact with the contaminated media, such as lead in surface soil. Soil sampling data are not available to confirm whether or to what extent residential property soil contains site-related lead. Several factors, however, help ATSDR determine whether lead from SWMU 8 and the water tower might be present in areas where children play.

- *Age/location of home.* Homes along Turner Road constructed before or during the time of active sandblasting operations at SWMU 8, the water tower or both (roughly 1940–1971) and in close proximity to the fence line near SWMU 8 and Water Tower 1553 could have been impacted by lead releases. Over time, lead released to the air could build up in soil. Lead deposited from the air is generally retained in the top 1 inch of soil. (Opportunities for exposure are therefore much greater for surface soil than for subsurface soil.) Homes built after sandblasting operations ceased (roughly after 1971) probably have less, if any, exposed site-related soil-lead contamination. Moreover, any contamination that migrated to off-base properties would likely have been turned over during construction, thereby moving lead residue down to deeper, more inaccessible subsurface soil layers.

- *Presence of soil cover.* Grass and other soil covers (e.g., asphalt, pavement) in a child's play area greatly minimize or eliminate direct contact with soil that could contain lead.

Factors that influence the relationship between exposure and health effects

Assessing the importance of an exposure to lead, such as possible NAB Little Creek lead in the Turner Road neighborhood, is an involved process. Health professionals typically consider several factors that influence the relationship between that exposure and blood-lead levels that could result in possible ill effects, including

- *Age and behavior patterns of an exposed child.* Pre-school children (6 years of age and younger) are usually most susceptible to the effects of lead. A young child's vulnerability to the effects of lead stems from a combination of factors, including their tendency to play in dirt and to place their hands and other objects in their mouths, thereby increasing the chances for soil ingestion. Children also have the ability to absorb lead from the gastrointestinal tract more efficiently than do adults and are more sensitive the effects of lead.

- *Concurrent exposure to other sources of lead.* Lead from other sources can also contribute to a child's increase in blood-lead level and the risk of developing health effects. For example, lead can be deposited in soil from flaking lead paint around the home, can be released to air from motor vehicles that used leaded gasoline, or can leach into drinking water from lead pipes.

Potential for exposure to lead from other sources

People can be exposed to lead in a variety of media, including ambient air, drinking water, food, soil, paint, and dust. Public health screening for lead in children indicates that lead paint in older homes (e.g., those built before 1978) is the most important risk factor for lead exposure in children. Children can be exposed to lead-based paint by chewing or mouthing painted surfaces or by accidentally ingesting paint chips, lead dust, or lead-contaminated soil through hand-to-mouth activity. Lead-based paint is considered a potential hazard if it is damaged (i.e., by chipping, cracking, chalking, or peeling) or if it is on a surface that is subject to impact or friction (such as stairs, doors, and windows) (ATSDR 1999d, EPA 2001a).

In all likelihood, for several reasons people living at the Turner Road neighborhood probably have had and continue to have minimal, if any exposure, to site-related lead in soil. First, over the years most soil has been covered with top soil, grass, or pavement. These covers minimize direct contact with potential lead in soil. For some properties, potentially contaminated soil has, possibly, been removed, turned over, or otherwise disturbed during home construction, thereby moving lead that settled on the surface down to deeper, more inaccessible soil. Second, releases of lead from SWMU 8 and water tower have ceased. Operations that produced airborne lead or

resuspended lead-contaminated soil/dust (active sandblasting operations at SWMU 8 or sandblasting during lead-paint removal/water tower maintenance operations) stopped after 1971. Third, the Navy delineated and then removed the entire area of soil contamination near the on-site water tower. Lastly, there are housing and recreational areas on base near other water towers and according to the NAB Little Creek–Boone Clinic base health officials, routine blood-lead screening of children that took place between 1995 and 1999 showed no cases of elevated blood-lead levels (above 10 µg/dL). Because many homes in the Turner Road area were built before 1978, many likely still contain lead-based paint. Parents, guardians, and care givers in the Turner Road area should evaluate their children's potential for lead exposure and follow the CDC and VDH recommendations to have potentially exposed children under age 6 screened for elevated blood-lead levels.

DISCUSSION OF : Contaminated Fish and Shellfish

Summary

ATSDR reviewed the limited sampling data to determine whether people could be eating contaminated fish or shellfish from Little Creek Harbor. The data available to ATSDR suggest that fish and crabs in the Little Creek Harbor have been impacted by chemical contaminants such as mercury, but at levels below those known to cause harmful health effects. No other information is available for other shellfish, including clams and oysters. There is no way, however, to determine how much of those contaminants originate from NAB Little Creek operations. Other non-base-related sources could contribute to the harbor pollution.

Shellfishing has been restricted since 1938 and prohibited since 1990 in Little Creek Harbor due to high levels of bacteriological contamination (NEESA 1984, CH2M Hill 2001a). Fishing and crabbing is not permitted at NAB Little Creek for security reasons. People following the restrictions are protecting themselves against potential exposure to biologic and chemical contaminants in fish and shellfish. Although commercial fishing is not allowed, sport fishing is common in the western, civilian half of the harbor. Should the Navy's future plans include removal of the signs for Little Creek Harbor, ATSDR recommends that the Navy verify, through sampling conducted prior to the signs' removal or lifting security restrictions, that seafood in the harbor are free from harmful levels of chemical contaminants and are safe to eat. If the harbor is dredged the sampling should be repeated.

Discussion

Little Creek Harbor and its Tributaries

Contamination has been detected in the water and sediment of Little Creek Harbor, including metals (e.g., cadmium, mercury, lead), polycyclic aromatic hydrocarbons (PAHs), and tributyltin. Some disposal areas at NAB Little Creek directly or indirectly drain into Little Creek Harbor (Old Dominion University 1992, ETS 1995). Contaminants from these areas could have been carried with groundwater and discharged into the surface water of Little Creek Harbor. Other contaminants have been released into channels that eventually discharge into Little Creek Harbor.

How do fish become contaminated?

Most contaminants settle to the bottom of the harbor and collect in sediment. Some contaminants do not decompose easily, so they may remain in the environment for many years after release. Even though contaminant levels in surface water or sediment of the harbor are relatively low or have been greatly reduced, certain contaminants—such as mercury—can persist and accumulate in fish tissue. Fish are exposed to contaminants when they eat smaller fish or sediment containing the contaminants. In this way, larger and older fish can build up high levels of contaminants.

Source: EPA 2000.

Several IRP sites at NAB Little Creek ultimately drain to Little Creek Harbor. For example, runoff from Site 7, a former landfill, drains via a drainage ditch to Little Creek Cove. Site 7 was once an arm of Little Creek Cove, but was filled with dredged soil before it was used as a landfill. The majority of the waste at the landfill likely consisted of municipal refuse. Potentially hazardous materials disposed of at the landfill include paints, acids, PCBs, and pesticides (NEESA 1984, EPA 1999). Site 12, the former Exchange Laundry Waste Disposal Area, dumped waste containing tetrachloroethylene (PCE), soap, and dyes into a catch basin, which emptied into a storm sewer. The sewer flows north form this site into a 9-foot-deep drainage canal connecting with Little Creek Cove. Contaminants, primarily metals, have been found in sediment along the drainage canal (NEESA 1984). (It is also important to note that the drainage canal stops about 3,000 feet before the Little Creek Cove and the surface water flows through wetlands before actually discharging into the harbor.) Other IRP sites include landfills at Sites 8, 9, and 10; a plating shop at Site 11; and a pentachlorophenol (PCP) dip tank and wash rack at Site 13.

In addition to IRP sites, activities at NAB Little Creek such as drilling at the mudflats and fueling, salvaging, and maintaining ships in the harbor affect the quality of the harbor's water and sediment. A number of non-base-related contaminant sources also contribute to contamination in the harbor.

Along Chesapeake Bay and Little Creek Channel one commonly encounters striped bass, spot, bluefish, croaker, sea trout, and blue crabs (NEESA 1984, CH2M Hill 2001a). Limited information is available on contaminant concentrations in fish and crabs inhabiting the harbor. In 1994 and 1995 NAB Little Creek collected fish (croaker and spot) and crab samples from the harbor. The samples were analyzed for mercury and tributyltin (see Table 3). Those contaminants were selected because of their presence in harbor sediment and, particularly for mercury, their ability to accumulate at high levels in fish and shellfish over time. The study found mercury in fish (0.132-0.148 ppm) and crab (0.097-0.225 ppm) in the samples obtained from the harbor (Baker Environmental, Inc., 1996). Tributyltin was only detected in fish (0.006 ppm) and crab (0.028 ppm) samples collected in 1995. Additional limited information is provided through the VDEQ 1998 fish sampling program along the Chesapeake Bay. As part of that sampling event, VDEQ collected and analyzed for PCBs two Little Creek Channel fish samples (mummichog and spot). PCB concentrations in the samples were 0.062 ppm and 0.127 ppm (VDEQ 1998).

Have chemicals been detected in Little Creek Harbor fish and shellfish?

Yes, mercury, tributyltin (a constituent of some marine paints), and PCBs have been detected in fish and/or crab collected from the harbor. The levels detected in 1995 were below levels associated with adverse health effects. Some of the contaminants may have originated from NAB Little Creek. The exact contribution cannot be determined since many sources contribute directly or indirectly to pollution in the harbor.

ATSDR has reviewed the scientific literature to gain a better understanding of the extent to which fish can accumulate mercury, tributyltin, and PCBs. EPA has compiled data on average mercury concentrations in fish commonly consumed by the U.S. population. A review of these data suggests that the average concentration of mercury in flat fish (such as spot or flounder) and blue crabs is 0.092 ppm and 0.117 ppm, respectively (ATSDR 1999d). A 1980–1981 survey by the U.S. Fish and Wildlife Service found the average concentration of PCBs in fish at 102 nationwide locations was 0.53 ppm. Another study by the EPA, conducted between 1986 and 1989, reported chemical residues in fish at 362 sites nationwide, including industrial and hazardous waste sites. In the study, PCBs were detected at an average concentration of 1.9 ppm in bottom feeding and game fish (ATSDR 2000b). *By comparison, PCB concentrations in Little Creek Harbor fish appear to fall within the range observed nationwide in the 1990s. But mercury concentrations in fish from the harbor appear to be slightly higher than levels typical in fish of like species.*

Shellfishing has been restricted since 1938 and prohibited since 1990 in Little Creek Harbor due to high levels of bacteriological contamination (NEESA 1984, CH2M Hill 2001a). The Navy has prohibited fishing and shellfishing at Little Creek Cove, Desert Cove, and Little Creek Channel on NAB Little Creek property for security reasons. Fishing is, however, allowed at sections of Little

Creek Channel lying outside NAB Little Creek property and in the Chesapeake Bay, outside the harbor.

On July 19–23, 1999, and again on February 11–13, 2002, ATSDR toured NAB Little Creek, surveying base water bodies and areas of public access. It was unclear during the site visit whether fish or shellfish including crab were ever harvested at NAB Little Creek or whether any recreational fishing or shellfishing takes place now in the freshwater, brackish, and saltwater bodies.

Evaluation of Potential Public Health Hazards

In 1994, 1995, and 1998 mercury, tributyltin, and PCBs were detected in fish and crab samples collected from Little Creek Harbor. Some of the chemical contamination in fish possibly originated from base-related activities. Still, additional sources of chemical pollutants include other naval activities (i.e., dredging, fueling operations, ship salvage and maintenance) and non-naval activities (i.e., railroad ferry, barge loading/unloading, private boat refurbishing).

Are fish and shellfish from Little Creek Harbor safe to eat?

No, primarily as a result of bacteriological contamination in harbor water. A shellfish taking restriction is in place to urge people to refrain from eating shellfish from Little Creek Harbor due to high coliform counts (bacteria). People can also avoid exposure to chemical (mercury, tributyltin, and PCBs) contamination by adhering to the shellfish taking and base security restrictions.

Shellfishing has been restricted since 1938 and prohibited since 1990 in Little Creek Harbor due to high levels of bacteriological contamination (NEESA 1984, CH2M Hill 2001a). The "restricted" status allowed shellfish taking during warm weather months, as long as the fisher had a permit (issued by marine police and VDH) and transferred the shellfish to another water body, where they would undergo a cleaning-out period. In 1990, the status was changed from "restricted" to "prohibited" to comply with the National Shellfish Sanitation Program. "Prohibited" means no shellfish taking is allowed.

To determine if the consumption of fish or shellfish containing the detected levels of chemical contaminants was or is detrimental to human health, ATSDR estimated doses for individuals who ate fish from the harbor in the past, or who continue to do so against restrictions in place at the harbor. Because uncertainty exists regarding how often people ate fish from the harbor and how large a portion was eaten, ATSDR conservatively assumed that each month an adult ate seven 8-ounce meals of Little Creek Harbor fish and shellfish. ATSDR assumed a child ate half the amount of an adult, or seven 4-ounce meals per month. This is likely a conservative assumption: individuals tend to get their fish from varied sources. ATSDR also assumed that fish consumed contained the highest probable level of contamination. Collectively, those health-protective

assumptions allow ATSDR to evaluate safely the likelihood, if any, that eating harbor fish and shellfish could cause harm to area consumers.

ATSDR then compared the estimated exposure doses to health-based guidance levels, such as ATSDR minimal risk levels (MRLs) and EPA's oral reference doses (RfDs). We also compared the doses to information on the detected contaminants in the toxicologic literature. The health guidance level is an amount of contaminant taken into the body per unit weight per day that is not likely to cause adverse health effects. This value is derived from the available scientific literature on exposure and health effects. At doses less than the guidance levels, no adverse health effects have been observed. Comparison of the estimated dose to the health guidance level allows ATSDR to evaluate the likelihood—if any—that mercury, tributyltin, or PCBs in fish and shellfish could be associated with adverse health effects. Appendix B describes in greater detail ATSDR's methods, assumptions, and health guidance levels.

For both an adult and a child the exposure doses estimated for mercury, tributyltin, and PCBs are lower than their respective screening values (ATSDR MRLs or EPA RfDs), and below levels associated with adverse health effects. This finding suggests that people who ate fish, shellfish, or crabs containing the detected levels of contaminant in the past are not at risk of developing adverse health effects. Contaminants such as mercury are persistent in the environment. Since the initial sampling in 1994–1995, the levels in fish may have increased or decreased. Thus as a prudent public health measure, ATSDR recommends that people minimize current and potential future exposure to chemical contaminants by following the restrictions for the NAB Little Creek Harbor.

Should the Navy's future plans include removal of the "No fishing and crabbing" signs for Little Creek Harbor, ATSDR recommends that the Navy verify, through sampling conducted prior to their removal, that edible fish and crabs in the harbor are free from harmful levels of chemical contaminants and are safe to eat. At that time, the Navy in cooperation with VDH might find it prudent to determine chemical pollutant impact on the shellfish population near NAB Little Creek. If the harbor is dredged the sampling should be repeated.

A shellfish prohibition due to bacterial contamination has been in place along Little Creek Harbor. Signs warning people of the shellfish prohibition are not currently posted along the harbor shoreline. ATSDR has talked with the Navy and the Virginia Marine Resources Commission (VMRC) about providing sufficient notification to the public about the harbor's shellfish prohibition. The VMRC has offered to provide or place signs relative to shellfish bacterial contamination along the harbor if, after further evaluation, the Navy judges it necessary to do so (VMRC 2003).

Community Health Concerns

ATSDR identified community health concerns through meetings with NAB Little Creek personnel and a review of base documents. A Restoration Advisory Board was formed in 1994. The following concerns have been identified:

- **Concern about harmful levels of indoor air contaminants entering the Base Exchange/Commissary from underlying groundwater plumes.**

  Volatile organic compounds (VOCs), including trichloroethylene (TCE) and tetrachloroethylene (PCE), have been detected in groundwater beneath Site 12, the former Exchange Laundry Disposal Area, and the site of the new Base Exchange/Commissary. Soil gases can seep into buildings located above groundwater contaminant plumes. In 1992 the Navy conducted a soil gas survey to characterize any releases beneath the former laundry facility (Target 1992). High levels of PCE (up to 198 µg/L [ppb]) were found in the southeastern portion of Site 12, and away from the proposed building location and other buildings. Other VOCs were found in scattered locations, but generally at low levels. As a precautionary measure, however, as part of the new construction the Navy installed a passive gas removal system. With the new system, gases collect in the coarse gravel/rock under the building and move through a series of pipes in the gravel to pipes that passively release the gas from the top of the building. This minimizes or can even eliminate adverse impacts on air quality inside the Base Exchange/Commissary.

  Groundwater near the Base Exchange/Commissary flows away from and toward a nearby surface water channel. Surface water and groundwater sampling has shown that the water in and beneath the channel is free of VOCs. VOCs in groundwater near the Base Exchange/Commissary also move toward a leaky sanitary sewer line. At the exit briefing for ATSDR's 1999 site visit, ATSDR recommended that the Navy conduct periodic sampling of gases in confined spaces (e.g., sewers), in the indoor air of nearby buildings, in structures in the migration path of the groundwater, and along the sewer line.

  A 2001 investigation along the north end of the sewer line found relatively low levels of PCE at 9 ppb, TCE at 1.4 ppb, and *cis*-1,2-dichloroethylene (DCE) at 1.7 ppb in the groundwater. The findings indicate that the VOCs are seeping through a crack in the sewer line where, during supplemental remedial investigation activities, PCE had been measured up to 72 µg/L. PCE is expected to dilute as it seeps out through the crack in the pipe and mixes with groundwater. A sample taken 20 feet north of the crack had PCE at only 1.7 µg/L. All 12 other samples were free of VOCs. The Navy, EPA, and VDEQ are in the process of evaluating remedial action alternatives; no remedy has been selected. Water in the sanitary sewer line is routed to a water treatment plant. If, however, findings from

future groundwater, soil gas, or sewer line monitoring suggest that contaminants move toward the Base Exchange/Commissary, ATSDR recommends additional studies to determine potential impacts to indoor air quality (CH2M Hill 2001b).

- **Concern about exposure to contaminants when using the base golf driving range or the baseball diamond.**

ATSDR does not expect that the public will come in contact with waste in the former trench-style landfills beneath the base driving range and portions of the baseball diamond. Waste buried at these sites during their operation in the 1950s included incinerator ash, unburned solid waste, and scrap metal. Small amounts of hazardous material, such as pesticides, PCBs, and motor oil, could have also been disposed of in the landfills. After closure each landfill was covered with 2 feet of vegetative soil cover. The soil cover prevents exposure of the public to materials or contaminants within the landfill.

Land use restrictions are proposed to limit activities that could threaten the integrity of the landfill cover and pose unacceptable harm to the public. The land use limits would restrict any: (1) digging into the cover or contents of the landfill, (2) use of groundwater beneath the sites, and (3) development of the site for residential use. As long as the cover on each landfill is undisturbed, ATSDR does not anticipate any public exposure to the materials contained within the landfill in the future. Leachate seeps have not been identified at the ground surface of the landfill, nor do leachate collection systems exist at either landfill.

Landfills can emit gases created from decomposing waste or from other non-methane organic compounds created when liquid or solid waste changes into vapors. By volume, landfill gas typically contains 45–60% methane and 40–60% carbon dioxide, with smaller amounts of non-methane organic vapors (e.g., VOCs) (ATSDR 2002a). Sometimes these gases can pose hazards when they travel through the soils and then upward into the indoor air of nearby buildings. Residents living in these buildings could then incur exposure when breathing air containing the contaminants. On occasion, these gases can also pose an explosive hazard. Several factors greatly influence how much gas a landfill currently releases and whether any gas releases might pose a public health hazard. A review of these factors suggests that the former landfills at the driving range and baseball diamond are not likely to release harmful amounts of gases at this time. These factors include

- *Age of the landfill.* Gases are usually emitted within 20 years after the waste is disposed of, peaking within 5–7 years after disposal. Only small volumes of gases would be expected after 50 or more years. Given this information, older landfills, such as those beneath the driving range and the baseball diamond—which accepted refuse almost 50 years ago—are beyond the age at which they should still generate substantial volumes of gases (ATSDR 2002a). However, this has not been verified.

- *Waste composition.* The more organic waste present in the landfill, the more landfill gases (e.g., methane and carbon dioxide) produced by bacterial decomposition. The contents of the landfills are reported to include organic compounds found in solid waste, household waste, and industrial waste. Nevertheless, groundwater monitoring indicates that VOCs are not present in the landfills. Therefore, these landfills are not likely to emit landfill gases that are created when VOCs change from liquids into vapors (ATSDR 2002a).

- *Presence of an impervious cap.* Protective impervious landfill caps tend to inhibit upward movement of certain gases. When upward movement is inhibited, these gases, such as methane, can move laterally out from beneath the landfill and build up in surrounding areas with lower gas concentrations. Build up of high levels of methane can pose an explosive hazard. The landfills at NAB Little Creek are not covered with an impervious cap, but rather with a 2-foot layer of soil. This soil layer should not inhibit the upward movement and diffusion of any remaining small volumes of landfill gases (NAB Little Creek 2001, ATSDR 2002a).

- *Proximity of buildings.* Finally, and perhaps most importantly, there are no nearby buildings within the immediate area of either former landfill that would be at risk of accumulating landfill gases.

Given the information about the former landfills and the current status of the area, ATSDR expects that people using either the golf range or the baseball field today will not reasonably come in contact with either landfill waste material or landfill gases. As a prudent public health measure, however, ATSDR recommends that the Navy consider potential movement of landfill gases before constructing any future buildings near the former landfills.

ATSDR Child Health Considerations

ATSDR's Child Health Considerations recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination of their water, soil, air, or food. Children are at greater risk than are adults from certain kinds of exposures to hazardous substances emitted from waste sites and from emergency events. In general, children are more likely to be exposed because they play outdoors and they often bring food into contaminated areas. They are shorter than adults, which means they breathe dust, soil, and heavy vapors close to the ground. Children are also smaller, so they receive higher doses of chemical exposure proportional to their body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Most importantly, most children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care.

ATSDR has attempted to identify populations of children in the vicinity of NAB Little Creek and any completed exposure pathways to these children. The community surrounding NAB Little Creek contains residential neighborhoods with children and schools. Demographic data for 2000 indicate that 3,468 children under 6 years of age live in communities within a 1-mile radius of the NAB Little Creek. Children in these communities cannot easily trespass onto NAB Little Creek property due to perimeter fencing and military security measures.

Following a careful evaluation of these pathways as they relate to children, ATSDR determined that no harmful exposures have occurred at NAB Little Creek in the past, nor are they expected to occur—either now or in the future. Although contaminants have been detected at NAB Little Creek, children cannot access the site or contaminated areas on the base.

If parents choose not follow the fish or shellfish restrictions for the Little Creek Harbor, children might eat fish and seafood taken from Little Creek Harbor. If children do eat locally caught fish/shellfish/crabs, they could be exposed to low levels of chemicals present in that fish and seafood. ATSDR recommends that children and parents observe the restrictions and advisory for Little Creek Harbor.

Lead-contaminated soil or dust might have migrated from the former grit-blasting area and from the Water Tower 1553 area to a nearby residential property about 100 feet from the tower. Children are especially vulnerable to the effects of lead. Site-specific information does not exist to confirm whether or to what extent exposure has occurred. ATSDR believes, however, that most children playing in the neighborhood have not come in contact with harmful levels of lead from NAB Little Creek. Depending on factors influencing exposure (e.g., age of home, age of child at exposure, play habits, concurrent lead exposures), certain children could be at greater risk of developing lead-related effects. ATSDR recommends blood-lead screening for all children age 6 and younger as recommended by CDC and VDH. These exposure pathways are discussed in the

Evaluation of Environmental Contamination and Potential Exposure Pathways section of this PHA.

Conclusions

Conclusions regarding potential past, current, and future exposure situations on and in the communities near NAB Little Creek are based on an evaluation of site investigation data and observations made during site visits. Conclusions about exposures are described below. (A description of the public health hazard conclusion categories is included in the glossary.)

1. Surface soil at certain locations at NAB Little Creek was found to contain contaminants associated with former base activities. Most often, exposure has been prevented because soil contamination occurs in restricted access areas, is covered by pavement or grass, or has been removed. Occasional contact with surface soil contaminants, even at the highest levels reported, is not expected to pose a public health hazard for adults or children. Successful cleanup or removal of contamination will continue to reduce potential harmful future exposures. Exposure to contaminants in surface soil at NAB Little Creek poses **no apparent public health hazard**.

2. SWMU 8 and Water Tower 1553 are located about 100 feet from the Turner Road neighborhood. Airborne lead or resuspended lead-contaminated soil/dust (active sandblasting operations at SWMU 8 or sandblasting during lead-paint removal or other water tower maintenance operations) could have migrated off site. Data are not available to confirm whether site-related lead settled in nearby residential yards in the past. ATSDR evaluated available on-site data and possible exposure situations to assess possible health hazards associated with lead. Based on this assessment, ATSDR concluded that people living in the Turner Road neighborhood probably incurred minimal, if any, exposure to site-related lead in soil or lead dust for several reasons. Foremost, soil has been covered at neighboring properties over the years with top soil, grass, or pavement. For some off-base properties, potentially contaminated soil has possibly been removed. For others, the soil was turned over or otherwise disturbed during home construction, which has had the effect of moving lead that settled on the surface down to the deeper, inaccessible subsurface soil. No exposure is occurring now. Operations that produced airborne lead or resuspended lead-contaminated soil/dust stopped after 1971. Exposure to contaminants possibly in surface soil from base operations at Turner Road neighborhood near NAB Little Creek poses **no apparent public health hazard.**

   There are housing and recreational areas on base near other water towers and according to the NAB Little Creek–Boone Clinic base health officials, routine blood-lead screening of children that took place between 1995 and 1999 showed no cases of elevated blood-lead levels (above 10 μg/dL).

3. Homes built before 1978 probably have lead-base paint. ATSDR believes it is prudent for families who live in or near the Turner Road neighborhood area to evaluate the potential

for they and their children to be exposed to lead. Families should also follow the CDC and VHD guidelines and have potentially exposed children under the age of 6 screened for elevated blood-lead levels.

4. Low levels of mercury, tributyltin, and PCBs have been found in a limited sampling of fish and crabs from the harbor. Exposure to the low levels of those contaminants should not pose a health hazard to those who in the past ate fish or crabs from the harbor. Other chemicals have not been tested. Shellfishing (molluscan bivalves) has been restricted since 1938 and prohibited since 1990 in Little Creek Harbor due to high levels of bacterial contamination. Fishing and crabbing are not permitted at NAB Little Creek for security reasons. Still, people can best protect themselves from exposure to chemical and bacterial contaminants in fish and shellfish by adhering to the existing restrictions for the harbor. Consumption of fish, crabs, and shellfish from Little Creek Harbor is expected to pose **no apparent public health hazard** for the chemical contaminants sampled.

5. Based on previous studies which indicate that older landfills , such as those beneath the driving range and base ball diamond—which accepted refuse almost 50 years ago—are beyond the age at which they should still generate substantial volumes of gases. ATSDR concluded that the landfills at NAB Little Creek pose **no apparent health hazards**.

Recommendations

1. If additional soil sampling is to be conducted, ATSDR recommends that the Navy consider sampling surface soil at residential property near SWMU 8 and Water Tower 1553.

2. Because some homes in the Turner Road neighborhood were constructed when lead-based paint was commonly used, ATSDR believes that it is prudent for families who live in the neighborhood to evaluate the potential for they and their children to be exposed to lead. Families and individuals should follow the CDC and VDH recommendations to have potentially exposed children under 6 screened for elevated blood-lead levels.

3. ATSDR also recommends that NAB Little Creek, in cooperation with the Virginia Marine Resource Commission, and Virginia Department of Health provide public notification about the shellfish (molluscan bivalves) prohibition at Little Creek Harbor.

4. Should the Navy's future plans include removal of the "No fishing and crabbing" signs for Little Creek Harbor, ATSDR recommends that the Navy verify, through sampling conducted prior to their removal, that edible fish and crabs in the harbor are free from harmful levels of chemical contaminants and are safe to eat. At that time, the Navy in cooperation with Virginia Department of Health might find it prudent to determine chemical pollutant impact on the shellfish (molluscan bivalve) population near NAB Little Creek if shellfish prohibition is lifted.. If the harbor is dredged the sampling should be repeated.

5. As prudent public health measure ATSDR recommends that the Navy consider potential movement of landfill gases before constructing any future buildings near the former landfills.

Public Health Action Plan

The Public Health Action Plan (PHAP) for NAB Little Creek contains a description of actions taken and those to be taken by ATSDR, the Navy, the EPA, and Virginia Department of Environmental Quality at and in the vicinity of the site after the completion of this public health assessment. The purpose of the PHAP is to ensure that this public health assessment not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The public health actions completed, being implemented, or planned are as follows:

Completed Actions

1. Under the Installation Restoration Program, the Navy has identified and conducted, or plans to conduct, environmental investigations at 17 base locations.

2. Additional monitoring or mitigation was recommended or conducted at site 8. No further action was recommended at Sites 1, 2, 4, 5, 6, 14, 15, and 16. (Sites 3 and 17 are under a non–Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] program.)

3. The Navy has identified more than 140 potential Solid Waste Management Units (SWMUs), and has recommended further investigations at 5 SWMUs of greatest concern.

4. Long-term groundwater monitoring is underway at Sites 7, 9, and 10.

5. The Navy has removed contaminated soil, covered and revegetated the area, or both at former landfill Sites 7, 9, and 10.

6. In 1987 Navy Building 3323 at Site 12 was demolished and the catch basin and a portion of the storm sewer were removed. Eventually the rest of the storm sewer was removed and the area was regraded to prepare for the construction of the Base Exchange/Commissary. A 1992 soil gas survey found that soil gas concentrations were not elevated near the new Commissary. Still, the Navy installed a passive gas removal system beneath the new building that was constructed in 1993.

7. The Navy removed the surface soil debris containing visible abrasive blast material and contaminated soil from SWMU 8 and nearby Water Tower 1553. More than 4,500 tons of soil was removed to levels less than or equal to 400 ppm. Excavated areas were backfilled with certified clean fill and covered with top soil and seed.

8. In 1996 and 2002, the Navy prepared a community relations plan (CRP) providing guidance for community involvement in the remediation process. Subsequent to the CRP, the Navy sponsored community interviews to gain a better understanding of community awareness of environmental issues at NAB Little Creek. Restoration Advisory Board meetings are scheduled quarterly to semi-annually to inform the community of environmental restoration activities. NAB Little Creek also maintains an active Web site to provide information.

Ongoing and Planned Actions

1. The Navy will continue monitoring groundwater at Sites 7, 9 and 10.

2. The Navy will continue to monitor groundwater near Site 11, 11A, 12, and 13 and evaluate multiple options for groundwater remediation in the Feasibility Study.

3. The municipal water suppliers regularly monitor their water supply to ensure that the water delivered to their customers, including NAB Little Creek, is free from contamination at levels of health concern. Regular monitoring includes collecting samples from groundwater supply wells and analyzing the samples for volatile organic compounds.

4. Members of the community and the NAB Little Creek participate in regularly scheduled Restoration Advisory Board meetings. These meetings serve as a forum for communication of ongoing and planned activities at NAB Little Creek to the community and for communication of community concerns to NAB Little Creek personnel.

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Tables

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
Installation Restoration Program (IRP) and Miscellaneous Sites				
Site 4 - Reserve Center Oil Disposal Area	Site 4 is the location of an outdoor vehicle maintenance pad, where about 2,000 gallons of waste oils and antifreeze a year were disposed of into a storm sewer between 1967 and 1981. Oil in the ground around the pad would be expected to migrate to the groundwater and then to Piers 9 and 10, about 300 feet to the northeast.		Mitigation measures were recommended for this site to prevent migration of contaminants from oil soaked soils to nearby surface waters. The site is closed with no further action required under CERCLA..	No information provided for evaluation.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
Site 5 - Building T-9 and T-11 Motor Oil Disposal Area	Site 5 consist of Building T-9 and Building T-11. Reportedly, 50,000 gallons of oil and antifreeze were dumped on the ground between the two buildings. But Marsden matting (solid steel plates under steel braces) in the disposal area would have made it virtually impossible for disposal of this magnitude to have occurred. Also, 43,000 gallons of oil and antifreeze were reportedly dumped in cable tanks in Building T-11. No physical/visual evidence was ever found, however, to substantiate improper disposal either between the building or in Buildings T-11.	**Groundwater:** Volatile organic compounds (VOCs) and lead were detected in groundwater but at levels below the EPA's risk-based concentrations (RBC) for tap water. **Soil:** Low levels of total petroleum hydrocarbons were detected.	No further action is planned.	No identified public health hazards are associated with this IRP site under past or present use. There is limited potential or public contact with contaminated soil and no one uses the groundwater at the site as a drinking water source.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
Site 7 - Naval Amphibious Base (NAB) Landfill	The 30-acre landfill located in the south-central portion of the facility operated from 1962 to 1979, initially as a trench-style landfill then as an area landfill. The area was once an arm of Little Creek Cove, but was filled with dredged soil before it was used as a landfill. The majority of the waste at the landfill likely consisted of municipal refuse. Potentially hazardous materials disposed of at the landfill include paints, acids, polychlorinated biphenyls (PCBs), and pesticides. After closure in 1979, the area was used as a metal collection and transfer station. No waste storage or burning activities have occurred since the 1980s. Runoff/drainage drains the site via a drainage ditch toward Little Creek Cove.	**Groundwater**: Metals were detected. **Surface Soil**: Semivolatile organic compounds (SVOCs), metals, and PCBs, as Aroclor 1260, were detected in the soil.	Buildings and traveled roads are prohibited at the site. At the time of closure the landfill was covered with 24 inches of soil. In October 1994 two to three additional layers of topsoil were spread over the area and then revegetated. As part of the remedial investigation in 1998,610 cubic yards of soil were removed, 20,000 cubic yards of soil were then added and vegetated, and the fence around the landfill was replaced. Also in 1998, groundwater sampling for long-term monitoring began at the site. Today, because of the additional soil cover, the landfill waste lies below ground surface.	No identified public health hazards are associated with this IRP site under past or present use. There is limited potential or public contact with contaminated soil from the contents of the landfill and no one uses the groundwater at the site as a drinking water source. Some contamination could have reached Little Creek Harbor via a drainage canal, possibly contaminating harbor sediment and fish. Recreational swimmers should not come in contact with harmful levels of contaminants in sediment and restrictions against taking fish or shellfish has been issued for the harbor. ATSDR recommends that the Navy consider potential movement of landfill gases before constructing any future buildings near the former landfills

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
Site 8 - Demolition Debris Landfill	The 2-acre Demolition Debris Landfill was operated from 1971 to 1979 for the disposal of demolition debris. Material disposed of at the landfill potentially contained mercury-contaminated carpet, building debris, and concrete piping.	**Groundwater:** Metals, including arsenic, were detected. **Soil:** During 1998 site investigation activities, metals and pesticides (dieldrin) were detected. **Sediment:** Polycyclic aromatic hydrocarbons (PAHs) and metals were detected in sediment.	The Navy will conduct another round of groundwater sampling to support a quantitative baseline human health and ecological risk assessment. The Navy is also in the process of preparing a remedial investigation RI/ feasibility study (FS) report for Site 8.	No identified public health hazards are associated with this IRP site under past or present use. There is limited potential for public contact with contaminated soil or the contents of the landfill and no one uses the groundwater at the site as a drinking water source. ATSDR recommends that the Navy consider potential movement of landfill gases before constructing any buildings in the future near the former landfills.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
Site 9 - Driving Range Landfill	Site 9 is the 6-acre Driving Range Landfill that served as the base's primary disposal area for solid waste between 1952 and the 1960s. This unlined landfill was situated in the northeastern section of the base, about 500 feet south of the shoreline of the Chesapeake Bay. Solid waste could have included pesticides refuse, solvents, heavy metals, PCBs, and incinerator ash. Before landfilling operations were started, the area was a marshy lowland. After closure, sludge from the Hampton Roads Sanitation Treatment Plant was added to encourage growth of grass. The area has since been used as a driving range. Runoff from the area moves towards a golf course lake and the Chesapeake Bay.	**Groundwater**: Metals, including arsenic, barium, beryllium, lead, nickel, and zinc, have been detected. **Surface Soil**: VOCs (toluene) and pesticides (DDD, DDE, dieldrin, endrin) were detected.	Long-term groundwater monitoring is underway at the site. The site contains cover.	No identified public health hazards are associated with this IRP site under past or present use. There is limited potential for public contact with contaminated soil or the contents of the landfill and no one uses the groundwater at the site as a drinking water source. Contamination in surface runoff is not directed toward Little Creek Harbor, possibly Therefore, recreational swimmers at the harbor should not come in contact with harmful levels of contaminants in sediment.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
Site 10 - Sewage Treatment Plant Landfill	Site 10, the 7-acre Sewage Treatment Plant Landfill, is located in the northeast portion of the base, about 500 feet south of the Chesapeake Bay. Between 1941 and 1952, solid waste generated from base activities was deposited at the landfill. Waste was mostly non-hazardous, but could have included pesticides, paints, solvents, PCBs, and heavy metals. Early on, waste was deposited directly into the water at Desert Cove, eventually filling in 5 acres of land. Runoff from the landfill is believed to enter Desert Cove.	**Groundwater**: Metals, including arsenic, barium, beryllium, lead, nickel, and zinc, have been detected. **Surface Soil**: VOCs (toluene) and pesticides (DDD, DDE, dieldrin, endrin, and chlordane) were detected.	Today, the landfill is covered with soil and grass and a portion of the site has been used for baseball diamonds. Corrective actions were completed for underground storage tanks and long-term groundwater monitoring is underway at the site.	No identified public health hazards are associated with this IRP site under past or present use. There is limited potential for public contact with contaminated soil or the contents of the landfill and no one uses the groundwater at the site as a drinking water source. Contaminants may enter Desert Cove with runoff from Site 10, possibly contaminating harbor sediment and fish. Recreational swimmers should not come in contact with harmful levels of contaminants in sediment and restrictions against taking fish or shellfish has been issued for the harbor. ATSDR recommends that the Navy consider potential movement of landfill gases before constructing any buildings in the future near the former landfills.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
Site 11 - School of Music Plating Shop, including the Neutralizing Tank, Contaminated Soil, and Groundwater	Site 11 is the tank, contaminated soil and groundwater associated with the School of Music Plating Shop, located in Building 3651 along the eastern portion of the base. Between 1964 and 1974, musical instruments were electroplated at the shop. Plating bath solutions containing silver cyanide, copper cyanide, chromic acid, nickel, acids, and lacquers were disposed of down a drain inside the shop. The material was then carried by an acid-resistant pipe to a concrete neutralization pit about 10 feet from the shop, before emptying into a storm sewer. Runoff from the area moves toward Desert Cove and Little Creek Cove.	**Groundwater**: VOCs and metals were detected. Recent investigations indicated that only the lower portion (17-21 feet below ground surface) of the surficial aquifer was contaminated with VOCs, where trichloroethylene (TCE) and dichloroethylene (DCE) were measured. Concentrations in the shallow portion (8-12 feet below ground surface) of the surficial aquifer are being investigated. **Soil**: Metals were detected.	During 1995 and 1996, the tank and its contents and inlet and outlet piping were removed. About 190 gallons of hazardous liquids and about 11 tons of debris were removed. Contaminated materials along the pipeline and below the tank also were removed, including 94 tons of contaminated soil and almost 11 tons of debris (tank, concrete floor, piping). Following the removal, the excavated area was backfilled, the floor and cooling towers were replaced, and the area was spread with topsoil.	No identified public health hazards are associated with this IRP site under past or present use. There is limited potential for public contact with contaminated soil and no one uses the groundwater at the site as a drinking water source. Contaminants may reach Desert Cove and Little Creek Cove in runoff from Site 11, possibly contaminating harbor sediment and fish. Recreational swimmers should not come in contact with harmful levels of contaminants in sediment and restrictions against taking fish, crabs, and shellfish have been issued for the harbor.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
Site 11A - Area of Elevated TCE Contamination	Site 11A is a separate area discovered during the investigation of Site 11. The TCE contamination is unrelated to Site 11 and the source of contamination at Site 11A has not yet been determined. The TCE contamination is believed to be as a result of an isolated dumping of a small volume of TCE.	**Groundwater**: TCE concentrations were detected at levels slightly above EPA's MCL and ATSDR's CV of 5 ppb.	This site is being worked on along with Site 11.	No identified public health hazards are associated with Site 11A because no one uses the groundwater at the site as a drinking water or industrial water source.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
Site 12 - Exchange Laundry Waste Disposal Area	Site 12, the Exchange Laundry Waste Disposal Area, consists of Building 3323 the site of base dry cleaning operations from 1973 until 1978. Waste containing tetrachloroethylene (PCE), soap, and dyes were dumped into a catch basin which emptied into a storm sewer. The sewer flows north into a 9-foot-deep drainage canal that connects with Lake Bradford and Little Creek Cove. A Base Exchange/ Commissary was built on the property in 1993. Runoff /drainage via a drainage canal moves from the area toward Little Creek Cove.	**Groundwater**: VOCs (primarily PCE) were detected. **Surface Soil**: VOCs, SVOCs, and lead were detected in soil. **Surface Water/Sediment:** In 1993, VOCs (TCE and PCE) were detected in the canals, but in 1991 and 1997 sampling VOCs were not detected.	In 1987 Building 3323 was demolished and the catch basin and a portion of the storm sewer were removed. Eventually the rest of the storm sewer was removed and the area regraded to prepare for the construction of the Base Exchange/Commissary. The Navy has equipped the new building with a passive gas removal system to remove vapors in the event they should seep into the building from nearby groundwater contamination. The Navy is evaluating multiple options for groundwater remediation in the Feasibility Study.	No identified public health hazards are associated with this IRP site under past or present use. There is limited potential for public contact with contaminated soil and no one uses the groundwater at the site as a drinking water source. Some contamination could have reached Little Creek Cove via a drainage canal, possibly contaminating harbor sediment and fish. Recreational swimmers should not come in contact with harmful levels of contaminants in sediment and restrictions against taking fish or shellfish has been issued for the harbor. Groundwater contamination in the area is not expected to affect indoor air quality of the new Base Exchange/ Commissary.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
Site 13 - Pentachlorophenol (PCP) Dip Tank and Wash Rack Area	Between 1960 and 1975 a PCP Dip Tank and a Wash Rack were used to treat wood with PCP. Wash racks near the dip tank were used for cleaning vehicles and equipment with steam or solvents and the drying rack was used for treated wood. Solutions on the treated materials could have dripped onto the ground. Runoff from the area is directed toward Little Creek Cove.	**Groundwater**: VOCs (TCE and PCE) were detected. **Surface Soil**: SVOCs were detected.	All PCP contaminated soil was removed in 1999. In 2000, a pilot study was conducted using Oxygen Release Compound to remediate groundwater at the site. Several remedial alternatives are being evaluated for groundwater remediation.	No identified public health hazards are associated with this IRP site under past or present use. There is limited potential for public contact with contaminated soil and no one uses the groundwater at the site as a drinking water source. Runoff from Site 13 enters Little Creek Cove, possibly transporting contaminants that could be taken up by harbor sediment or fish. Recreational swimmers should not come in contact with harmful levels of contaminants in sediment restrictions against taking fish or shellfish has been issued for the harbor.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
Site 15 - PCB Capacitor Spill - Fire Station No. 1	Site 15 is the soil beneath the capacitor pole behind Fire Station No. 1, where a capacitor was damaged by lightening in the early 1980s. Reportedly, less than 5 gallons of dielectric fluid leaked onto the ground in the immediate area of the spill. Migration of the contaminants is unlikely.	**Groundwater:** No data were available. **Soil:** PCBs (up to 170,061 milligrams per kilogram [mg/kg]) were detected.	PCB contaminated soils were removed in 2002. No further action for this site.	Under past or present use no identified public health hazards are associated with this IRP site. There is only limited potential for public contact with contaminated soil, and no one uses the groundwater at the site as a drinking water source.
Site 16 - Pole # 425 PCB Capacitor Spill	Site 16 is the location of a PCB-containing dielectric fluid leak. The spill of less than 5 gallons resulted when lightening struck the capacitor on pole #425 pole.	**Soil:** PCBs, as Aroclor 1260, were detected in soil.	The PCB-contaminated soil, the pole, and the surrounding vegetation were removed in 1995, as approved by the state and EPA. PCB contaminated soils were removed in 2002. No further action for this site.	Under past or present use, no identified public health hazards are associated with this IRP site. There is only limited potential for public contact with contaminated soil and no one uses the groundwater at the site as a drinking water source.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
SWMUs				
SWMU 1 - Small Transformer Storage Area	Beginning in 1975, the Navy used this area for storage of small, non-PCB transformers and repairs of PCB transformers. , Whether releases of PCBs have occurred is, however, unknown.	**Groundwater:** None tested. **Soil:** PCBs were detected but at levels below risk-acceptable, industrial risk-based concentrations (RBCs). SVOCs and pesticides were also detected.	This site is proposed for no further action.	No identified public health hazards are associated with this SWMU under past or present use. There is only limited potential for public contact with contaminated soil and no one uses the groundwater at the site as a drinking water source.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
SWMU 3 - Pier 10 Sandblast Yard	From 1962 to 1984 this area was used for sandblasting activities for boats, and from 1980 to 1995 for anchors and anchor chains. Items were sandblasted on a concrete pad. Periodically, the residue was removed from the area. No hazardous materials were found on the site, but some residue was found along the unpaved ground extending from the concrete pad to the shore of Little Creek Harbor. In 1982 a fence was constructed to limit windblown residue migration, and, in 1993 an asphalt cover and catch basin were added.	**Groundwater**: VOCs and metals detected in groundwater. **Soil**: Metals and PAHs were detected in soil. **Sediment**: Metals and PAHs were detected in sediment.	Additional groundwater monitoring and completion of a quantitative risk assessment are proposed for this SWMU. This SWMU will also be followed as part of a multi-site ecological risk assessment.	No identified public health hazards are associated with this SWMU. A fence limits any possibility of public contact with contaminated soil and no one uses the groundwater at the site as a drinking water source.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
SWMU 4 - Special Boat Squadron 2 Battery Storage Yard	This 300 to 400-square foot area was used from 1943 to 1980 for storage of lead-acid batteries, paint waste, and scrap metals. The site is surrounded by a fence and a controlled security gate. Pavement covers the area, except in the grassy area along the fence and near a building.	**Groundwater**: Metals were detected in groundwater. **Soil**: Metals were detected in soil.	This SWMU could be recommended for further investigations.	No identified public health hazards are associated with this SWMU under past or present use. A fence limits the possibility for public contact with contaminated soil and no one uses the groundwater at the site as a drinking water source.
SWMU 6 - SeaBee Area	The General Services Administration used the area to stockpile mineral ores. Most of the ores have been removed. Currently, the ore storage area consists of three grass-covered piles ranging from 40 to 70 feet high.	**Groundwater**: VOCs were detected, but generally at low levels. Antimony, arsenic, beryllium, cadmium, chromium, and lead were also detected. **Surface Soil**: No data were available. **Sediment**: Sediment contained PAHs and PCBs, but generally at low concentrations.	The area has been paved.	No identified public health hazards are associated with this SWMU under past or present use. Pavement covering the area prevents public exposure with exposed soil and no one uses the groundwater at the site as a drinking water source.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Site	Site Description and History	Investigation Results/Environmental Monitoring Results[1]	Corrective Action and/or Current Status	Evaluation of Public Health Hazard
SWMU 8 - West Annex Sandblasting Areas	This SWMU consists of a vacant lot which 1949 to 1971 was used for sandblasting of boats . Sandblasting residue accumulated on the ground to an average thickness of 4 inches. Periodically, the residue was removed and disposed of off base.	**Groundwater**: VOCs and metals were detected in groundwater. **Soil**: Metals, primarily lead, and PAHs were detected in surface soil. **Sediment**: Metals and PAHs were detected in soil.	The Navy delineated the boundaries of grit at SWMU 8 and a nearby water tower. the Navy also removed lead contaminated soil within those areas to levels for residential settings.	No identified public health hazards are associated with this SWMU IRP site under past or present use. Contaminated soil has been removed from this SWMU and no one uses the groundwater at the site as a drinking water source. Residential property lies about 100 feet from the water tower. ATSDR is concerned that in the past lead-contaminated soil could have migrated to the off-base property where children might live or play. No sampling or comprehensive exposure (blood lead levels) data are available to state definitely whether lead exposure could have or has occurred. ATSDR recommends blood lead level screening for all children age 6 or under.

Sources: NEESA 1984, OHM/IT 2001.

Table 1. Evaluation of Sites at Naval Amphibious Base, Little Creek (continued)

Key

ATSDR	Agency for Toxic Substances and Disease Registry	PCBs	polychlorinated biphenyls
DCE	dichloroethylene	PCE	tetrachloroethylene
EE/CA	engineering evaluation/cost analysis	RBC	EPA's risk based concentration
µg/L	micrograms per liter = ppb	ROD	record of decision
µg/kg	micrograms per kilogram = ppb	SVOCs	semivolatile organic compounds
mg/kg	milligrams per kilogram = ppm	SWMU	solid waste management unit
PAH	polycyclic aromatic hydrocarbons	TCE	trichloroethylene
		VOCs	volatile organic compounds

Table 2. Exposure Pathways Evaluation Table

Pathway Name	Exposure Pathway Elements					Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Potentially Exposed Population	
Completed Exposure Pathway						
Consumption of Local Fish and Shellfish from Little Creek Harbor	Mercury, tributyltin, and PCBs from the NAB Little Creek operations and numerous other sources associated with routine harbor activity	Local fish and shellfish populations	Consumption of locally caught fish and shellfish	Ingestion	Local anglers and harvesters of crab (who disregard the no fishing /shellfishing advisory)	**Past:** Fish and crab in Little Creek Harbor have been impacted by mercury and tributyltin. Contaminant levels in local fish/shellfish/crab could have posed a public health hazard if consumed in sufficient quantities. **Current and Future:** To best protect themselves against exposure to biologic and chemical contaminants, people should adhere to the Little Creek Harbor restrictions and advisory.

Table 2. Exposure Pathways Evaluation Table (continued)

Pathway Name	Exposure Pathway Elements					Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Potentially Exposed Population	
Potential Exposure Pathways						
Surface Soil - On base	Several areas of soil contamination associated with former site activities exist throughout NAB Little Creek.	Surface soil	Surface soil at nearby residential property	Dermal contact and incidental ingestion	Nearby off-base residents	**Past:** Exposure to contaminated surface soil at NAB Little Creek sites is largely prevented because the majority of the land's surface is paved, covered by buildings, fenced, or is in restricted land use locations. Any sporadic contact with or incidental ingestion of the contaminants detected in the base surface soil is not expected to have harmful effects. **Current and Future:** No public health hazards are occurring or are expected to occur.

Table 2. Exposure Pathways Evaluation Table (continued)

Pathway Name	Exposure Pathway Elements					Comments
	Source of Contamination	Environmental Medium	Point of Exposure	Route of Exposure	Potentially Exposed Population	
Surface Soil - Off base	NAB Little Creek SWMU 8 and Water Tower 1553. Lead is the primary contaminant of concern. Exposure to contaminated surface soil at other NAB Little Creek sites is largely prevented because the majority of the land's surface is paved, covered by buildings, fenced, or is in restricted land use locations.	Surface soil	Surface soil at nearby off-base residential property	Dermal contact and incidental ingestion	Nearby off-base residents	**Past:** Children at certain homes in the Turner Road area could have been exposed to site-related lead in soil if lead migrated from the base. Data are not available to confirm whether or to what extent migration occurred. **Current and Future:** No exposures are expected to occur; the grit has been removed from SWMU 8/ water tower. Furthermore, soil cover at the residential properties greatly reduces contact with possible residual lead in soil. Cumulative exposure to all possible sources of lead in the neighborhood could pose a risk for some children.

Table 3. Contaminant Concentrations in Fish and Crab From Little Creek Harbor

Study	Sample Location	Species	Number of Individual Samples	Total Mercury (mg/kg)	Tributyltin (mg/kg)	PCBs (mg/kg)
Base Study 1994	Little Creek Harbor	Fish (Spot)	3	0.132	nd	na
		Fish (Croaker)	1	0.134	nd	na
		Crab	8	0.225	nd	na
		Crab	7	0.193	nd	na
Base Study 1995	Little Creek Canal	Crab	composite samples	0.097	0.028	na
	Pier 58	Fish (Croakers)	composite samples	0.148	0.006	na
VDEQ 1998	Little Creek Channel	Fish (Mummichog)	1	na	na	0.127
		Fish (Spot)	1	na	na	0.062

Source: Baker Environmental Inc. 1996.

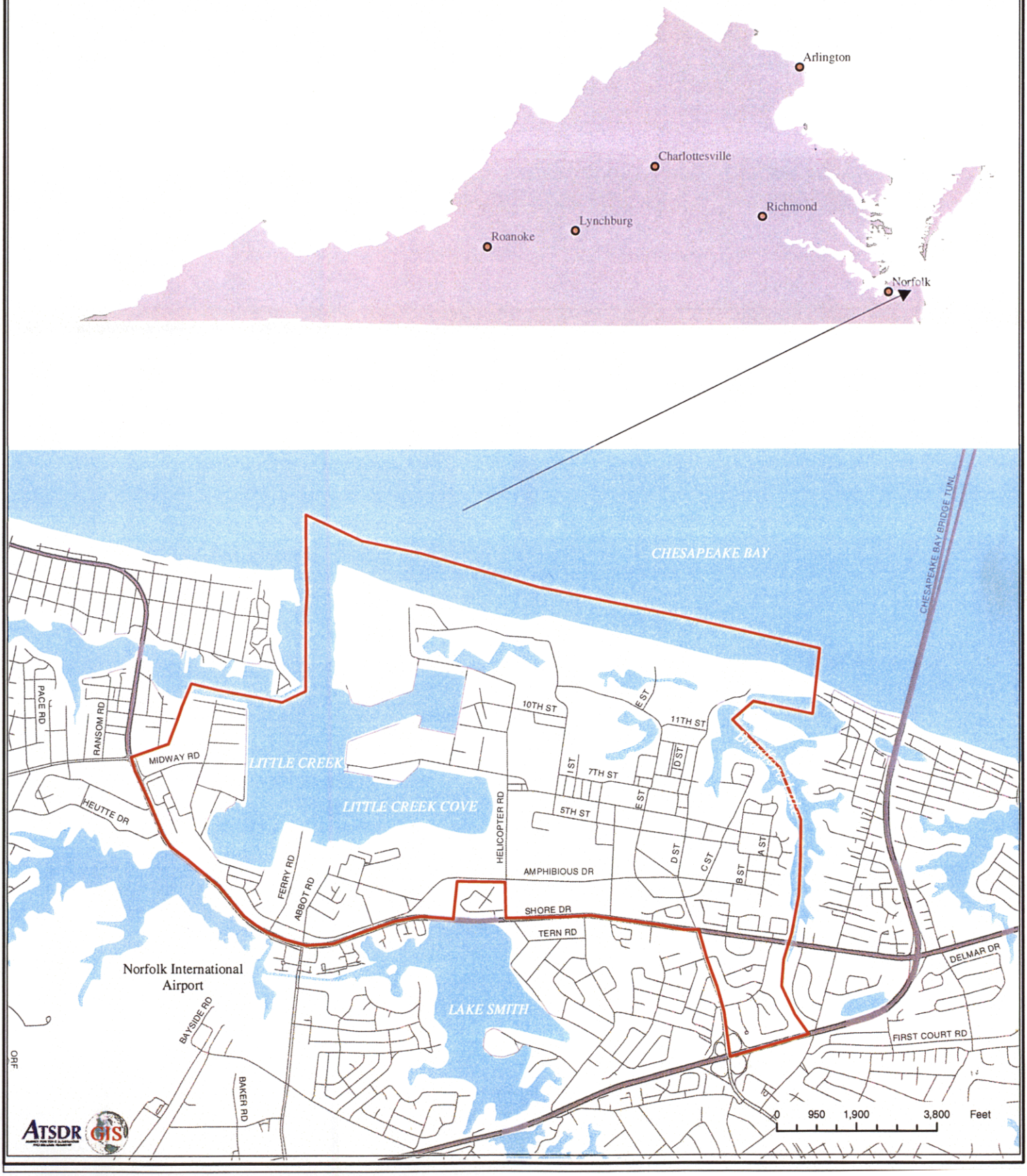
Key: mg/kg = milligrams per kilogram; na = not analyzed; nd = not detected.

Note: EPA risk-based concentrations (RBCs) for contaminants detected in Little Creek Harbor fish/crab are: mercury, 0.14 mg/kg; tributyltin, 0.41 mg/kg; and PCBs, 0.0016 mg/kg. Concentrations of mercury and PCBs in fish and crab exceeded EPA's RBCs. Nevertheless, ATSDR's evaluation determined that exposure to the detected levels of these contaminants in fish/shellfish should not pose a health threat to those who ate fish or crab from the harbor in the past. The Navy currently maintains a no fishing advisory for the harbor based on bacteriological contamination. People can best protect themselves from exposure to all contaminants in fish and shellfish by adhering to the existing advisory.

Figures

Figure 1. Area Map

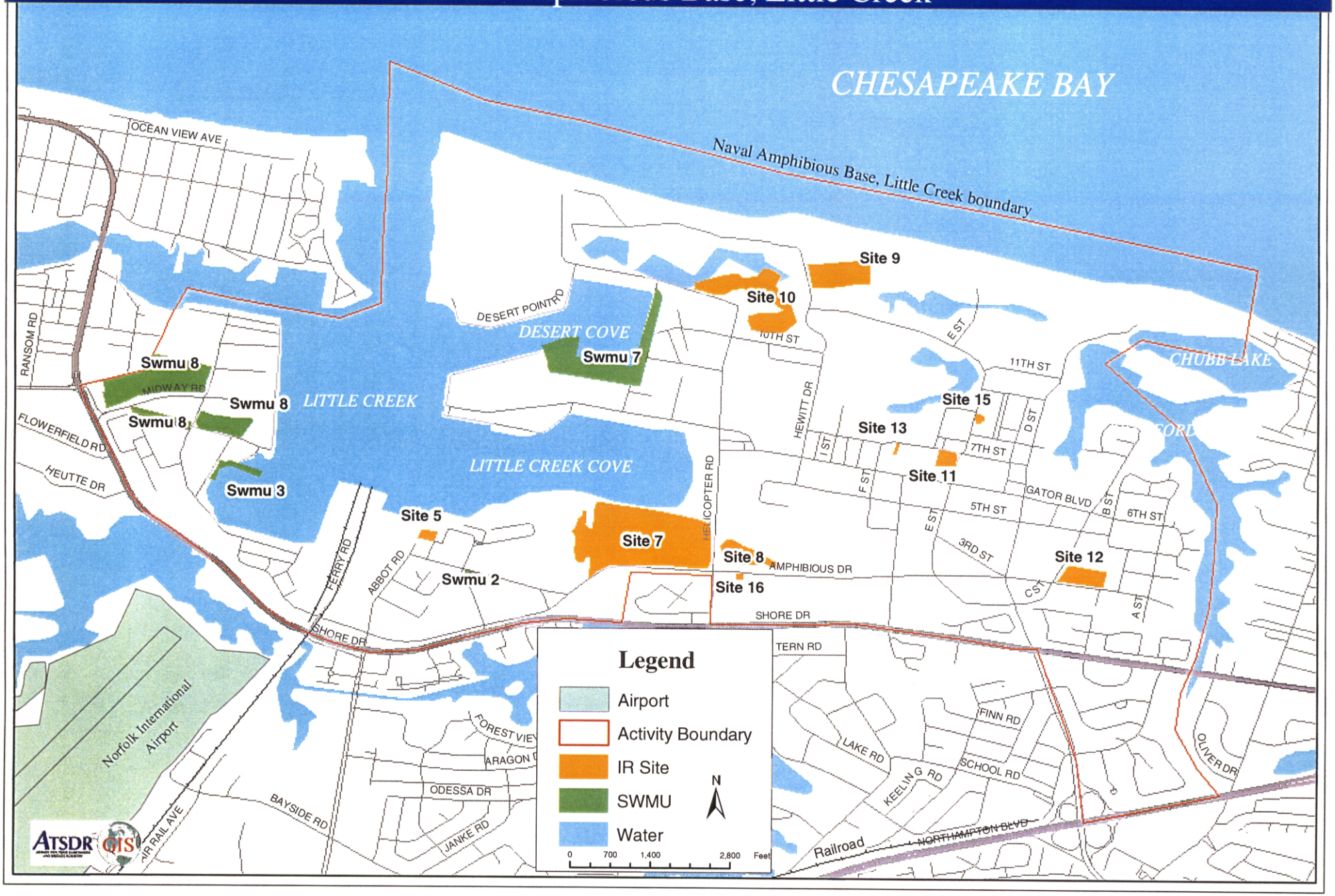
Naval Amphibious Base, Little Creek



Agency for Toxic Substances and Disease Registry

Figure 2. Site Map

Naval Amphibious Base, Little Creek

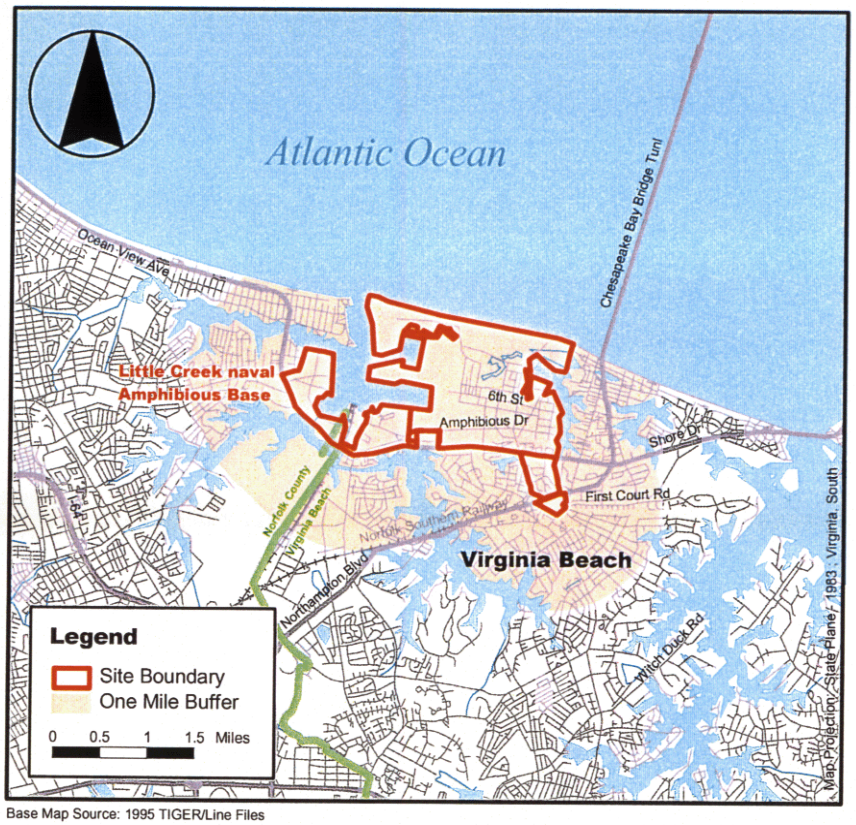


Little Creek Naval Amphibious Base

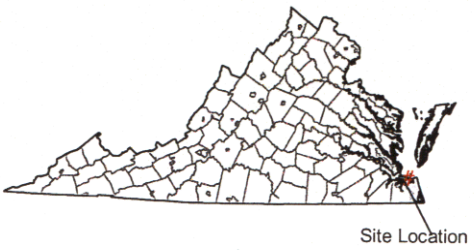
FIGURE 3A. Demographics

Norfolk, Virginia

EPA Facility ID VA5170022482



Base Map Source: 1995 TIGER/Line Files

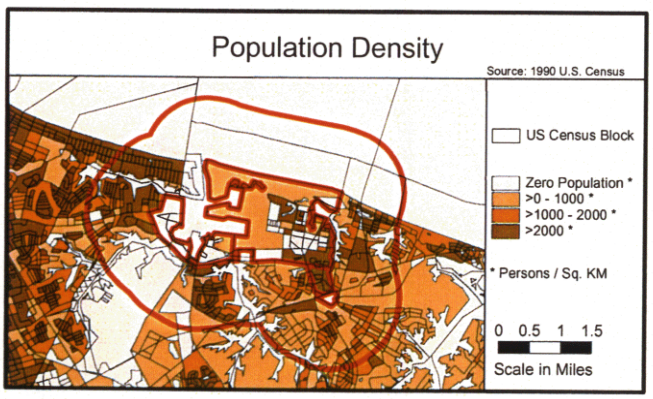


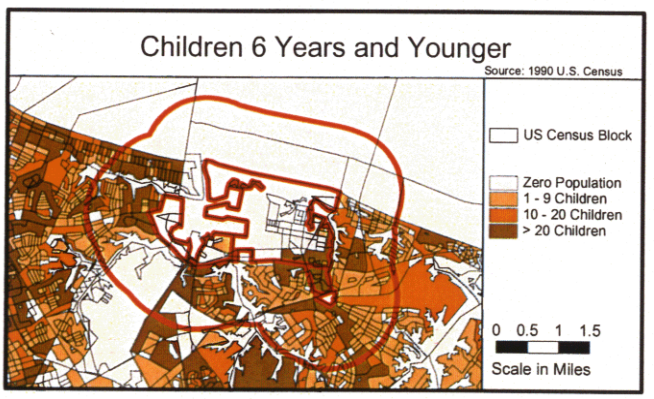
Virginia Beach (City), Virginia

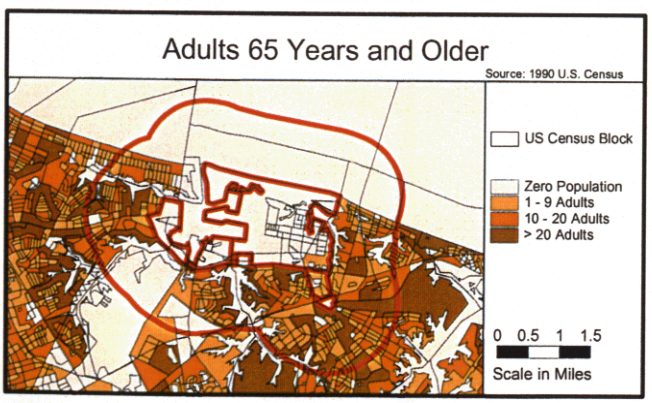
Demographic Statistics
Within One Mile of Site*

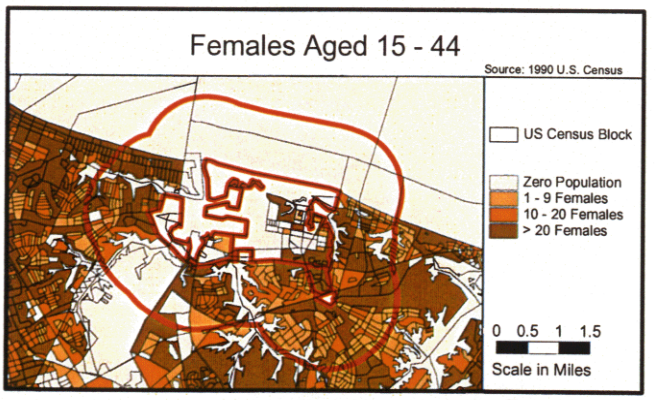
Total Population	35809
White	28240
Black	5955
American Indian, Eskimo, Aleut	141
Asian or Pacific Islander	855
Other Race	616
Hispanic Origin	1467
Children Aged 6 and Younger	4371
Adults Aged 65 and Older	2370
Females Aged 15 - 44	8491
Total Housing Units	13349

Demographics Statistics Source: 1990 US Census
*Calculated using an area-proportion spatial analysis technique









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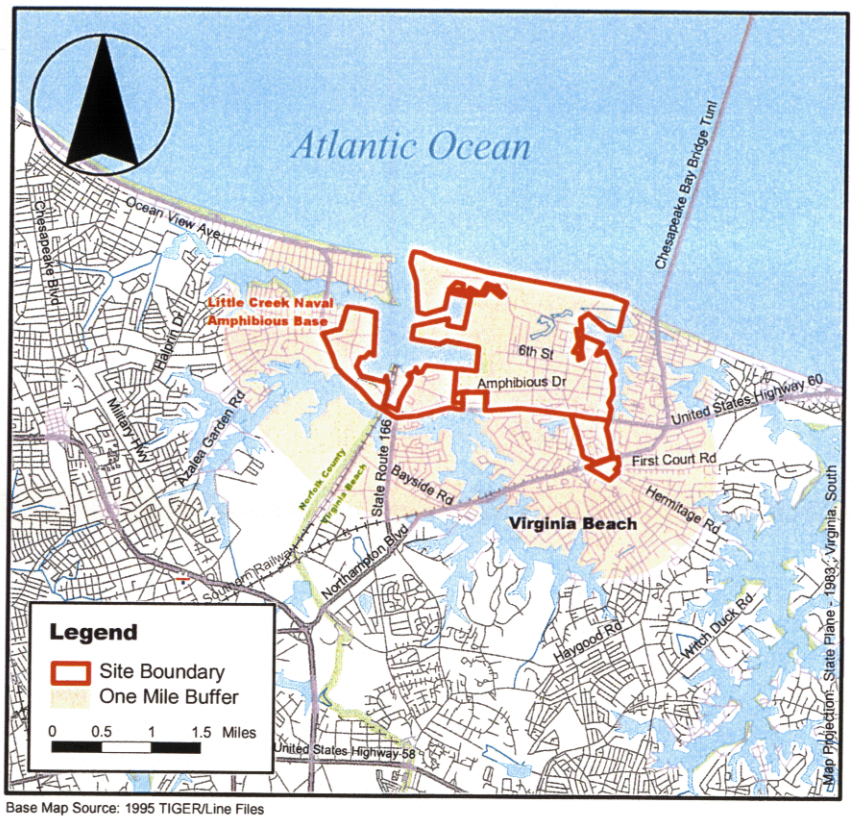
ATSDR SAAGIS

Little Creek Naval Amphibious Base

FIGURE 3B. Demographics

Norfolk, Virginia

EPA Facility ID VA5170022482

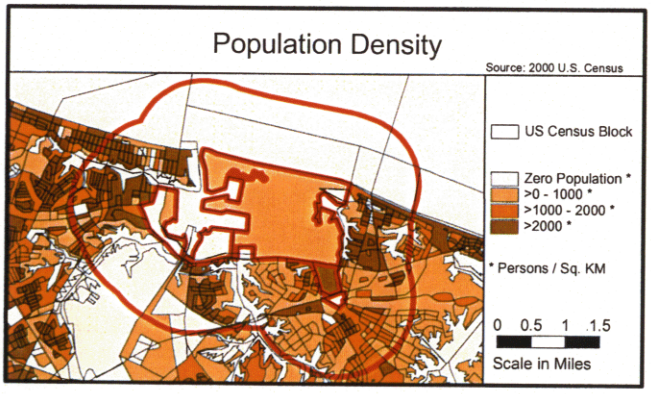


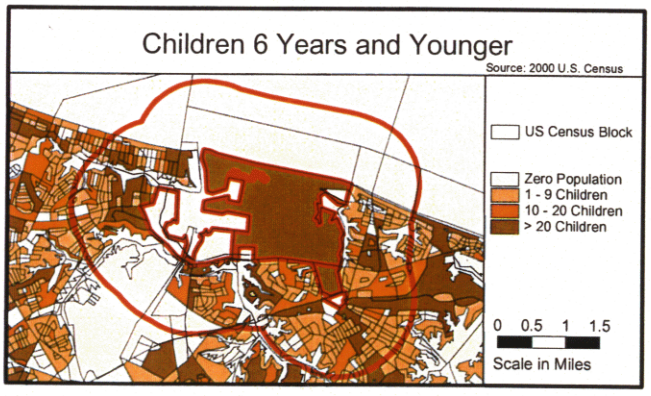
Base Map Source: 1995 TIGER/Line Files

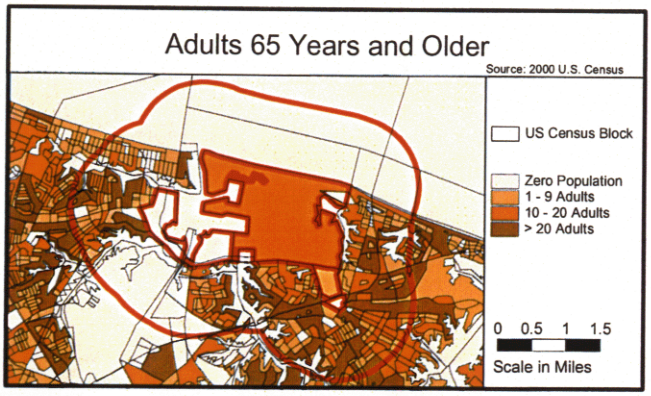
Virginia Beach (City), Virginia

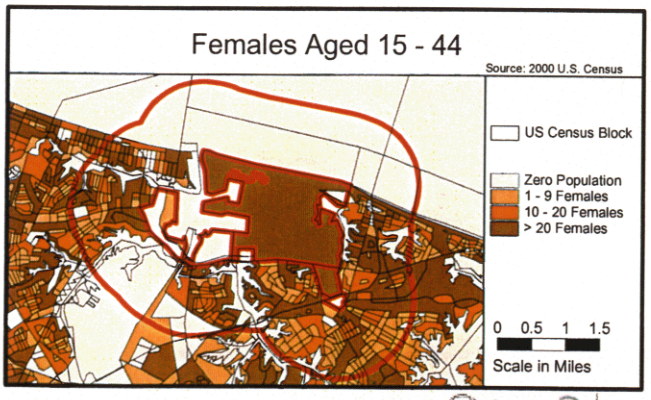
Demographic Statistics Within Area of Concern*	
Total Population	31230
White alone	22255
Black alone	6220
Am. Indian and Alaska Native alone	157
Asian alone	958
Native Hawaiian and Other Pacific Islander alone	29
Some other race alone	619
Two or More races	991
Hispanic or Latino	1473
Children Aged 6 and Younger	3468
Adults Aged 65 and Older	2983
Females Aged 15 - 44	7259
Total Housing Units	12565

Demographics Statistics Source: 2000 US Census
*Calculated using an area-proportion spatial analysis technique









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Agency for Toxic Substances and Disease Registry

Figure 4. Topographical Site Map

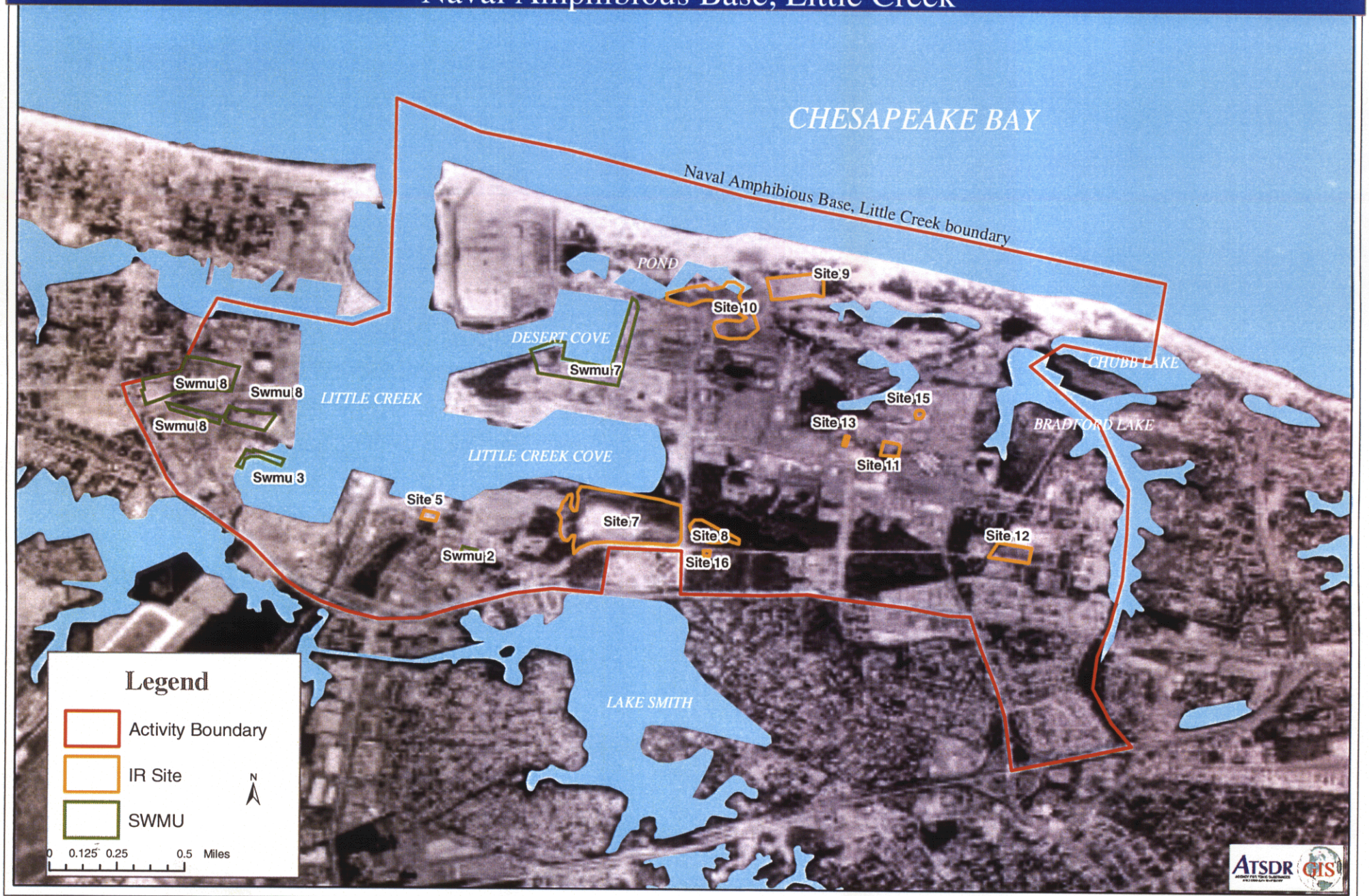
Naval Amphibious Base, Little Creek

source: USGS

Agency for Toxic Substances and Disease Registry

Figure 5. Aerial Photo Map

Naval Amphibious Base, Little Creek

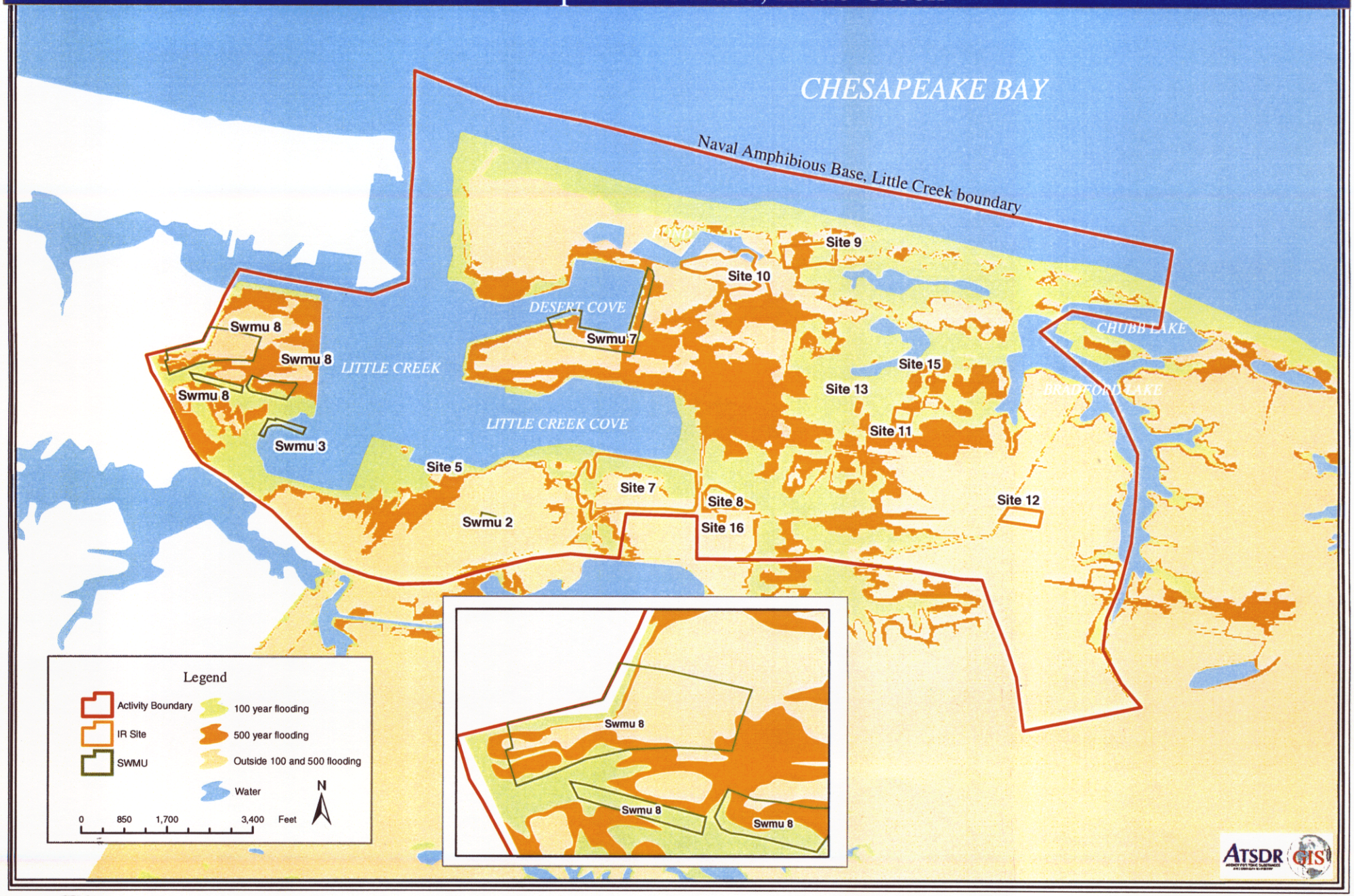


source: Microsoft Terraserver

Agency for Toxic Substances and Disease Registry

Figure 6. Flood Plane Site Map

Naval Amphibious Base, Little Creek



source: FEMA

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Figure 7. Wetlands Map

Naval Amphibious Base, Little Creek

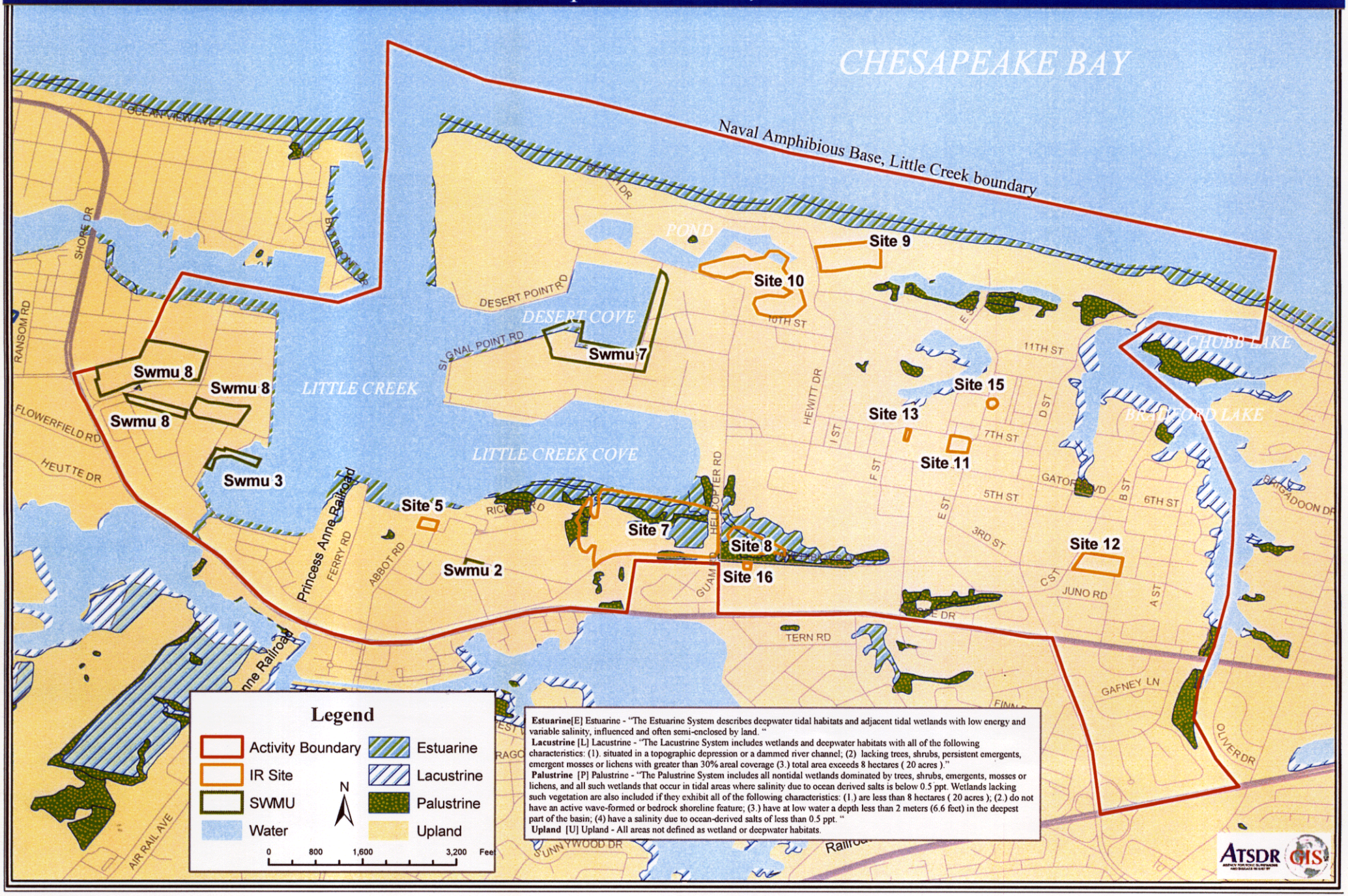

Figure 8

Solid Waste Management Unit (SWMU) 8 Near Water Tower 1553

Appendix A. Glossary

Adverse Health Effect: A change in body function or the structures of cells that can lead to disease or health problems.

ATSDR: The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Background Level: An average or expected amount of a chemical in a specific environment. Or, amounts of chemicals that occur naturally in a specific environment.

Cancer: A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control.

Carcinogen: Any substance shown to cause tumors or cancer in experimental studies.

CERCLA: See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure: A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic.*

Completed Exposure Pathway: See **Exposure Pathway.**

Comparison Value: (CVs) Concentrations or the amount of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA): **CERCLA** was enacted in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

Concern: A belief or worry that chemicals in the environment might cause harm to people.

Concentration: How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant: See **Environmental Contaminant**.

Dermal Contact: A chemical getting onto your skin. (see **Route of Exposure**).

Dose: The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day".

Duration: The amount of time (days, months, years) that a person is exposed to a chemical.

Environmental Contaminant: A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than that found in **Background Level**, or what would be expected.

Environmental Media: Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

U.S. Environmental Protection Agency (EPA): The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Epidemiology: The study of the different factors that determine how often, in how many people, and in which people will disease occur.

Exposure: Coming into contact with a chemical substance.(For the three ways people can come in contact with substances, see **Route of Exposure**.)

Exposure Assessment: The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway: A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:

1 Source of Contamination,
2 Environmental Media and Transport Mechanism,
3 Point of Exposure,
4 Route of Exposure, and
5 Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Frequency: How often a person is exposed to a chemical over time; for example, every day, once a week, twice a month.

Hazardous Waste: Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effect: ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Indeterminate Public Health Hazard: The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.

Ingestion: Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation: Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

MRL: **M**inimal **R**isk **L**evel. An estimate of daily human exposure—by a specified route and length of time—to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.

NPL: The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

No Apparent Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals could have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

PHA: **P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and reports whether people could be harmed from coming into contact with those chemicals. The PHA also reports whether possible further public health actions are needed.

Plume: A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney or contaminated underground water sources or contaminated surface water (such as lakes, ponds and streams).

Point of Exposure: The place where someone can come into contact with a contaminated environmental medium (air, water, food or soil). Examples include

an area of a playground with contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or a backyard area where someone might breathe contaminated air.

Population: A group of people living in a certain area; or the number of people in a certain area.

Public Health Assessment(s): See **PHA**.

Public Health Hazard: The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria: PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each are defined in the Glossary. The categories are:

1. Urgent Public Health Hazard
2. Public Health Hazard
3. Indeterminate Public Health Hazard
4. No Apparent Public Health Hazard
5. No Public Health Hazard

Receptor Population: People who live or work in the path of one or more chemicals, and who could come into contact with them (See **Exposure Pathway**).

Reference Dose (RfD): An estimate, with safety factors (see **safety factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is <u>not</u> likely to cause harm to the person.

Route of Exposure: The way a chemical can get into a person's body. The three exposure routes are
- breathing (also called inhalation),
- eating or drinking (also called ingestion), and
- or getting something on the skin (also called dermal contact).

Safety Factor: Also called **Uncertainty Factor**. When scientists do not have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is not likely to cause harm to people.

SARA: The **S**uperfund **A**mendments and **R**eauthorization **A**ct in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from chemical exposures at hazardous waste sites.

Source (of Contamination): The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

Special Populations: People who might be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older persons are often considered special populations.

Superfund Site: See **NPL**.

Toxic: Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

Toxicology: The study of the harmful effects of chemicals on humans or animals.

Tumor: Abnormal growth of tissue or cells that have formed a lump or mass.

Uncertainty Factor: See **Safety Factor**.

Urgent Public Health Hazard: This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.

Appendix B. ATSDR's Exposure Evaluation Process

INFORMATION ON HOW ATSDR ASSESSES EXPOSURE

What is meant by exposure?

ATSDR's public health assessments are driven by exposure or contact. Chemicals released into the environment have the potential to cause harmful health effects. Nevertheless, *a release does not always result in exposure.* People can only be exposed to a chemical if they come in contact with that chemical. If no one comes into contact with a chemical, then no exposure occurs, thus no health effects could occur. Often the general public does not have access to the source area of the environmental release; this lack of access becomes important in determining whether the chemicals are moving through the environment to locations where people could come into contact with them.

The five elements of an exposure pathway are: (1) source of contamination, (2) environmental media, (3) point of exposure, (4) route of human exposure, and (5) receptor population. The source of contamination is where the chemical was released. The environmental media (i.e., groundwater, soil, surface water, air, etc.) transport the chemical. The point of exposure is where people come in contact with the contaminated media. The route of exposure (i.e., ingestion, inhalation, dermal contact, etc.) is how the chemical enters the body. The persons actually exposed are the receptor population.

The route of a chemical's movement is the *pathway.* ATSDR identifies and evaluates exposure pathways by considering how people might come into contact with a chemical. An exposure pathway could involve air, surface water, groundwater, soil, dust, or even plants and animals. Exposure can occur by breathing, eating, drinking, or by skin contact with a substance containing the chemical.

How does ATSDR determine which exposure situations to evaluate?

ATSDR scientists evaluate site-specific conditions to determine whether people are being exposed to site-related contaminants. When evaluating exposure pathways, ATSDR identifies whether exposure to contaminated media (soil, water, air, waste, or biota) is occurring through ingestion, dermal (skin) contact, or inhalation.

If exposure is possible, ATSDR scientists then consider whether contamination is present at levels that might affect public health. ATSDR selects chemicals for further evaluation by comparing

them against health-based comparison values. Comparison values are developed by ATSDR from available scientific literature concerning exposure and health effects. Comparison values are derived for each of the media and reflect an estimated chemical concentration that is *not expected* to cause harmful health effects for a given chemical, assuming a standard daily contact rate (e.g., amount of water or soil consumed or amount of air breathed) and standard body weight.

Comparison values are not thresholds for harmful health effects. ATSDR comparison values represent chemical concentrations many times lower than levels at which no effects were observed in experimental animal or human epidemiologic studies. If chemical concentrations are above comparison values, ATSDR further analyzes exposure variables (e.g., duration and frequency) for health effects, including the toxicology of the chemical, other epidemiology studies, and the weight of evidence.

Some comparison values used by ATSDR scientists include ATSDR's environmental media evaluation guides (EMEG), reference dose media evaluation guides (RMEG), and cancer risk evaluation guides (CREG). EMEGs, RMEGs, and CREGs are non-enforceable, health-based comparison values developed by ATSDR for screening environmental contamination for further evaluation. Risk-based concentrations (RBCs) and soil screening levels (SSLs) are health-based comparison values developed by EPA Region III to screen sites not yet on the National Priorities List (NPL), respond rapidly to citizens inquiries, and spot-check formal baseline risk assessments.

More information about the ATSDR evaluation process can be found in ATSDR's Public Health Assessment Guidance Manual at http://www.atsdr.cdc.gov/HAC/HAGM/ or by contacting ATSDR at 1-888-42-ATSDR. For reference, Appendix A defines some of the technical terms used in this public health assessment and a List of Acronyms is available after the Table of Contents.

If someone is exposed, will they get sick?

Exposure does not always result in harmful health effects. The type and severity of health effects that occur in an individual as the result of contact with a chemical depend on the exposure concentration (how much), the frequency and duration of exposure (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of chemicals). Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how that individual absorbs, distributes, metabolizes, and excretes the chemical. Taken together, these factors and characteristics determine the health effects that can occur as a result of exposure to a chemical in the environment.

Considerable uncertainty exists regarding the true level of exposure to environmental contamination. To account for that uncertainty and to protect public health, ATSDR scientists typically use high-end, worst-case exposure level estimates to determine whether harmful health

effects are possible. These estimated exposure levels are usually much higher than the levels to which people are really exposed. If the exposure levels indicate harmful health effects are possible, a more detailed review of exposure, combined with scientific information from the medical, toxicologic, and epidemiologic literature about the health effects from exposure to harmful substances, is performed.

Overview of ATSDR's Methodology for Evaluating Potential Public Health Hazards

To evaluate exposures at NAB Little Creek, ATSDR evaluated available data to determine whether contaminants were above ATSDR's comparison values. For those that were, ATSDR derived exposure doses (see text box for definition) and compared them against health-based guidelines. ATSDR also reviewed relevant toxicologic and epidemiologic data to obtain information about the toxicity of contaminants of interest. Exposure to a certain chemical does not always result in harmful health effects. The type and severity of health effects expected to occur depend on the exposure concentration, the toxicity of the chemical, the frequency and duration of exposure, and the multiplicity of exposures.

> An exposure dose is the amount of chemical a person is exposed to over time.

Comparing Data to ATSDR's Comparison Values

Comparison values are derived using conservative exposure assumptions. Comparison values reflect concentrations that are much lower than those that have been observed to cause adverse health effects. Thus, comparison values are protective of public health in essentially all exposure situations. As a result, *concentrations detected at or below ATSDR's comparison values are not considered to warrant health concern.* While concentrations at or below the relevant comparison value may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a comparison value would be expected to produce adverse health effects. It cannot be emphasized strongly enough that comparison values are not thresholds of toxicity. The likelihood that adverse health outcomes will actually occur depends on site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure, and not an environmental concentration alone.

For this public health assessment ATSDR reviewed soil data that were collected from SWMU 8 and water tower 1553 because these areas are located near off-base residential property. We also reviewed fish and crab tissue data collected from Little Creek Harbor to determine whether people were exposed to contaminant concentrations that exceeded ATSDR's comparison values. The majority of detected contaminants fell at or below comparison values and were not evaluated further. Contaminants that were above comparison values were evaluated further, prompting ATSDR to estimate exposure doses using assumption specific to this site.

Deriving exposure doses

ATSDR derived exposure doses for those contaminants that were detected above ATSDR's comparison values or did not have comparison values. Exposure doses are expressed in milligrams per kilogram per day (mg/kg/day). When estimating exposure doses, health assessors evaluate chemical concentrations to which people could be exposed, together with the length of time and the frequency of exposure. Collectively, these factors influence an individual's physiological response to chemical exposure and potential outcomes. Where possible, ATSDR used site-specific information about the frequency and duration of exposures. In cases where site-specific information was not available, ATSDR applied several conservative exposure assumptions to estimate exposures for on-base and off-base residents and recreational users.

Exposure Dose Equation for Soil and Fish Exposures

$$\text{Estimated dose} = \frac{\text{Conc.} \times \text{IR} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

where:

Conc.:	Maximum concentration (mg/kg)
IR:	Ingestion rate: **Soil** -- adult = 100 mg per day; child = 200 mg per day **Fish** -- adult = 54 mg per day; child = 27 mg per day
EF:	Exposure frequency, or number of exposure events per year of exposure: 365 days/year
ED:	Exposure duration, or the duration over which exposure occurs: adult = 30 years; child = 6 years
BW:	Body weight: adult = 70 kg; child = 16 kg *
AT:	Averaging time, or the period over which cumulative exposures are averaged (6 years or 30 years x 365 days/year for noncancer effects; 70 years x 365 days/year for cancer effects)

* ATSDR assumes that older children (i.e., toddlers) would be more likely to play and eat fish
† Soil has a conversion factor of 1 x 10-6.

Using exposure doses to evaluate potential health hazards

ATSDR analyzes the weight of evidence of available toxicologic, medical, and epidemiologic data to determine whether exposures might be associated with harmful health effects (noncancer and cancer). As part of this process, ATSDR examines relevant health effects data to determine whether estimated doses are likely to result in harmful health effects. As a first step in evaluating noncancer effects, ATSDR compares estimated exposure doses to conservative health guideline values, including ATSDR's minimal risk levels (MRLs) and EPA's reference doses (RfDs). The MRLs and RfDs are estimates of daily human exposure to a substance that are unlikely to result in noncancer effects over a specified duration. *Estimated exposure doses that are less than these*

values are not considered to be of health concern. To maximize human health protection, MRLs and RfDs have built in uncertainty or safety factors, making these values considerably lower than levels at which health effects have been observed. The result is that even if an exposure dose is higher than the MRL or RfD, it does not necessarily follow that harmful health effects will occur.

For carcinogens, ATSDR also calculates a theoretical increase of cancer cases in a population (for example, 1 in 1,000,000 or 10^{-6}) using EPA's cancer slope factors (CSFs), which represent the relative potency of carcinogens. This is accomplished by multiplying the calculated exposure dose by a chemical-specific CSF. Because they are derived using mathematical models which apply a number of uncertainties and conservative assumptions, risk estimates generated by using CSFs tend to be overestimated.

If health guideline values are exceeded, ATSDR examines the health effect levels discussed in the scientific literature and more fully reviews exposure potential. ATSDR reviews available human studies as well as experimental animal studies. This information is used to describe the disease-causing potential of a particular chemical and to compare site-specific dose estimates with doses shown in applicable studies to result in illness. For cancer effects, ATSDR compares an estimated lifetime exposure dose to available cancer effects levels (CELs), which are doses that produce statistically significant increases in the incidence of cancer or tumors, and reviews genotoxicity studies to understand further the extent to which a chemical might be associated with cancer outcomes. This process enables ATSDR to weigh the available evidence in light of uncertainties and offer perspective on the plausibility of harmful health outcomes under site-specific conditions.

Using other methods to evaluate potential health hazards

When dealing with exposure to lead, ATSDR uses an additional approach to the traditional methodologies described above. A substantial part of human health effects data for lead are expressed in terms of blood lead level rather than exposure dose. Thus, ATSDR developed a secondary approach to utilize regression analysis with media-specific uptake parameters to estimate what cumulative blood lead level might result from exposure to a given level of contamination. This is accomplished by multiplying the detected concentration by a media-specific slope factor, which is 0.0068 micrograms per deciliter (µg/dL) per mg/kg of lead ingested in soil (ATSDR 1999c). The Centers for Disease Control and Prevention (CDC) has determined that health effects are more likely to be observed if blood lead levels are at or above 10 µg/dL.

Essential nutrients (e.g., calcium, magnesium, potassium, and sodium) are important minerals that maintain basic life functions; therefore, certain doses are recommended on a daily basis. Because these chemicals are necessary for life, MRLs and RfDs do not exist for them. They are found in many foods, such as milk, bananas, and table salt. Ingestion of these essential nutrients at the concentrations found at NAB Little Creek will not result in harmful health effects.

Sources for health-based guidelines

By Congressional mandate, ATSDR prepares toxicological profiles for hazardous substances found at contaminated sites. These toxicological profiles were used to evaluate potential health effects from contamination at NAB Little Creek. ATSDR's toxicological profiles are available on the Internet at http://www.atsdr.cdc.gov/toxpro2.html or by contacting the National Technical Information Service at 1-800-553-6847. EPA also develops health effects guidelines, and in some cases, ATSDR relied on EPA's guidelines to evaluate potential health effects. These guidelines are found in EPA's Integrated Risk Information System (IRIS)—a database of human health effects that could result from exposure to various substances found in the environment. IRIS is available on the Internet at http://www.epa.gov/iris. For more information about IRIS, please call EPA's IRIS hotline at 1-301-345-2870 or e-mail at Hotline.IRIS@epamail.epa.gov.

Evaluation of Health Hazards Associated with Contamination at NAB Little Creek

Surface Soil at SWMU 8 and Water Tower 1553

The majority of the chemicals in the surface soil at SWMU 8 and water tower 1553 were detected below comparison values. Table B-1 lists the chemicals that were detected above comparison values, including benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, arsenic, and lead.

ATSDR estimated exposure doses from incidental ingestion of surface soil for each chemical listed in Table B-1 using the formulas and assumptions described previously. Exposure doses for all chemicals except lead are compared to ATSDR's MRLs or EPA's RfDs. As indicated in Table B—1, the exposure doses are below their respective MRL or RfD and, therefore, are not at levels of health concern. Given this finding, those exposed via incidental ingestion even to the highest detected level of contaminants in surface soil at NAB Little Creek (specifically SWMU 8 and the water tower) are not expected to develop adverse health effects.

To conservatively assess potential increase in blood lead levels for a child eating soil, ATSDR multiplied the maximum concentration of lead in soil (1,820 ppm) by the media-specific slope factor for soil of 0.0068 micrograms per deciliter (µg/dL) per mg/kg of lead ingested in soil. As mentioned, the CDC has determined that health effects are more likely to be observed if blood lead levels are at or above 10 µg/dL. ATSDR estimated contribution to blood lead levels for a child eating soil containing the *maximum contaminant concentration detected on base* is 12 µg/dL. While this level is slightly higher than CDC's recommended action level of 10 µg/dL, ATSDR believes that children in the Turner Road neighbor probably incurred much lower lead exposures, if any, and are not at risk of developing adverse health effects. In effort to be protective, ATSDR had evaluated the maximum detected concentration found ***on base*** , recognizing that, in any reasonable exposure situation, it is highly unlikely that a child could have been continuously exposed to the similarly high concentrations in their yards over time.

Consumption of fish, shellfish, crab from Little Creek Harbor

ATSDR estimated exposure doses to the maximum levels of mercury, tributyltin, and PCBs in fish or crab using the formulas and assumptions described previously. All exposure doses were at or below their respective MRLs and RfDs and therefore not at a level of health concern. Given the findings and the conservative assumptions used in deriving the estimates, ATSDR does not expect those who ate fish or crab from the harbor to incur any adverse health effects from the chemicals that were sampled.

Table B-1
Exposure Doses for Chemicals Above Comparison Values at NAB Little Creek

Chemical	Maximum Detected Concentration (mg/kg)	Estimated Exposure Dose (mg/kg/day)		Oral Health Guideline (mg/kg/day)	Basis for Health Guideline
		Adult	Child		
Surface Soil at SWMU 8 and Water Tower 1553					
Benzo(a)anthracene	2.7	0.000003	0.00003	0.03 (for pyrene)	chronic RfD
Benzo(a)pyrene	1.7	0.000002	0.00002	0.03 (for pyrene)	chronic RfD
Benzo(b)fluoranthene	2.7	0.000003	0.00003	0.03 (for pyrene)	chronic RfD
Dibenz(a,h)anthracene	0.51	0.0000007	0.000006	0.03 (for pyrene)	chronic RfD
Ideno(1,2,3-cd)pyrene	1.3	0.000001	0.00001	0.03 (for pyrene)	chronic RfD
Arsenic	16	0.00002	0.0002	0.0003	chronic MRL
Lead	1,820	0.002	0.02	no value	
Fish and Crab from Little Creek Harbor					
Mercury	0.225	0.0001	0.0003	0.0003	chronic MRL for
Tributylin	0.028	0.00002	0.00004	0.0003	chronic RfD
PCBs	0.0016	0.000001	0.000002	0.00002	chronic MRL

Appendix C. ATSDR's Responses to Public Comments

The Agency for Toxic Substances and Disease Registry released the Naval Amphibious Base (NAB) Little Creek Public Health Assessment (PHA) for public review and comment on May 27, 2003. The public comment period was announced in a press release on June 10, 2003. Copies of the PHA were made available for review at the Bayside Area and Central Libraries in Virginia Beach and the Little Creek and the NAB Little Creek Libraries in Norfolk, Virginia. The PHA was also sent to state and federal agencies and interested members of the general public.

ATSDR received the following comments during the public comment period (May 27 to July 11, 2003).

1. **Comment:** Two reviewers commented that the date listed in the summary of the public health assessment for NAB Little Creek placement on the National Priorities List (NPL) is incorrect.

   Response: ATSDR has modified the text in the Summary section of the PHA to reflect the correct date of May 10, 1999, that the U.S. Environmental Protection Agency added NAB Little Creek to the NPL.

2. **Comment:** One reviewer commented that the discussion on page 9 of the PHA about pollution sources affecting Little Creek Harbor should include NAB Little Creek operations as well as other non-base sources.

   Response: ATSDR has stated in several places in the PHA that sources other than NAB Little Creek operations have contributed to the pollutant load in the harbor. As suggested, ATSDR has also added this information to page 9 of the PHA.

3. **Comment:** One reviewer commented signs about bacterial contamination of fish and shellfish should be posted at Little Creek Harbor.

   Response: ATSDR agrees that the public should be notified about bacterial contamination of fish and shellfish at NAB Little Creek Harbor. Due to this contamination, shellfish taking from the harbor is prohibited. In 1938, the Virginia Department of Health (VDH), Division of Shellfish Sanitation, restricted shellfish taking in Little Creek Harbor because of bacteriological contamination. The "restricted" status allowed shellfish taking during warm weather months, as long as the fisher had a permit (issued by marine police and VDH) and transferred the shellfish to another water body, where they would undergo a cleaning-out period. In 1990, the status was changed from "restricted" to "prohibited" to comply with the National Shellfish Sanitation Program. "Prohibited" means no shellfish taking is allowed. Signs are currently in place along the harbor at NAB Little Creek

warning people against fish and crabbing due to security reasons. Through the PHA assessment process, ATSDR has coordinated discussion with Virginia Marine Resources Commission (VMRC), Navy Environmental Health Center (NEHC) and NAB Little Creek on the signage at the base that warns about the shellfish prohibition along Little Creek Harbor. VMRC has offered to provide or post signs along the harbor if the Navy judges it necessary to do so.

4. **Comment:** One reviewer commented that the PHA states that the primary contaminants of concern listed in the Summary is misleading. The reviewer comments that the discussion is too vague with respect to distribution of contaminants in soil at NAB Little Creek. The reviewer adds that EPA's Hazard Ranking System, which was the supporting document for the NPL listing of NAB Little Creek, made no such reference to the aforementioned contaminants in fish and crabs.

   Response: The reference to contaminants of concern in the Summary section of the PHA is not meant to describe which contaminants placed NAB Little Creek on the NPL. Rather, this sentence is intended to note those contaminants that are of concern to ATSDR from a public health perspective. ATSDR has modified the sentence to clarify this distinction.

5. **Comment:** One reviewer commented that generic reference to groundwater contamination beneath the base in the Summary of the PHA is misleading because the contamination is not base wide. The reviewer adds that VOC contamination should be defined by location.

   Response: ATSDR has modified the statement in the Summary of the PHA to reflect that localized contamination appears in groundwater in certain portions of the base.

6. **Comment:** A reviewer noted that the Summary of the PHA implies that the Navy removed only the highest levels of surface soil when, in fact, the Navy removed all surface soils at levels above residential cleanup standards.

   Response: ATSDR has modified the sentence in the Summary to indicate that the Navy removed surface soil with levels above residential guidance in the area of the water tower.

7. **Comment:** Several comments took exception to ATSDR's discussion about possible contaminant migration to off-base properties. They state that there is no supporting evidence that contamination, particularly lead, from SWMU 8 (or the water tower) was transported to the residential area adjacent to Turner Road. They further state that the PHA should explain that the Navy has delineated the area of contamination and removed all the lead contaminated soil in the vicinity of the former sandblasting area and the water tower and that soil concentrations between the abrasive blasting material (ABM) source area and the residential area showed no elevated concentrations of lead, or contaminant gradient between the ABM source area and the residential area.

Response: ATSDR emphasizes that the goal of its PHA is to help put environmental data into meaningful public health perspective for the community. That is, ATSDR tries to answer the question of whether environmental exposure occurred and whether any such exposure might be harmful. One of the challenges we face is to evaluate potential health hazards given the lack of environmental monitoring data at points of human exposure. As noted, sampling showed that lead was present in soil at the water tower and SWMU 8, and decreased in concentration with distance from the tower. However, the area between the water tower and residential areas are in areas of flood plains and increased drainage of surface water and transport of associated material. Although vegetated along the banks part of the drainage ditch near the fence line is deeply eroded and scouring is ongoing. Information on the different wind direction and wind speeds during each of the paint removal operations is not available. Sampling data to help us understand soil quality off base near the SWMU 8 and water tower, where local residents live, was not available. While the available information about contaminant concentrations helps in our evaluation, without information at the point of exposure, ATSDR cannot state with certainty whether contaminants might have migrated off site.

8. **Comment:** Several comments noted incorrect demographics data in the Demographics section of the PHA.

Response: ATSDR has updated its demographics discussion to reflect the correct demographic statistics for the area around NAB Little Creek as presented in Tables 3A and 3B of the PHA.

9. **Comment:** A reviewer noted that surface water collected from various surface water sources undergoes treatment and testing by public utilities.

Response: The comment refers to drinking water at the base and in the communities of Norfolk, Virginia Beach, and Chesapeake that is drawn from Lake Smith, Lake Wright, Lake Whitehurst, Lake Lawson, Stumpy Lake, Little Creek Reservoir, and three lakes to the west of the city of Suffolk. ATSDR has added the treatment and testing information to the text of the PHA.

10. **Comment:** A reviewer noted that the landfills at NAB Little Creek were closed in accordance with Virginia landfill closure regulations, which consisted of a 2-foot soil cover and a long-term monitoring program to ensure the integrity of the remedy.

Response: ATSDR has added information about the soil cover depth and long-term monitoring groundwater monitoring to its discussion on landfill closure as suggested.

11. **Comment:** A reviewer commented that soil sampling conducted after the removal action confirmed that no soil contaminants (not just lead) were left in place that exceeded residential risk-based criteria.

Response: This comment addresses the extent of soil removed from the water tower area located near SWMU 8. ATSDR has modified the text to reflect that the confirmatory sampling conducted at and near SWMU 8 verified that soil contaminated with lead and other contaminants was removed to levels below or at residential cleanup standard for each contaminant.

12. **Comment:** One reviewer expressed concern that ATSDR's information on sites 7, 9 , 10, 11, 12, and 13 contributing to Little Creek Harbor is misleading. The comment adds that the Navy has undertaken many measures to prevent site releases from entering Little Creek Harbor at these sties. These measures include adding soil covers and conducting groundwater monitoring at Sites 7, 9, and 10, and removing contaminated soil and implementing groundwater pilot studies at Sites 11 and 13.

Response: The comment refers to ATSDR's discussion that mentions that these six sites contribute runoff or were connected to canals or drainage systems that eventually led to Little Creek Harbor. ATSDR's discussion that mentions these sites is intended to describe surface water flow pattern at the base that might discharge water into the harbor. ATSDR is aware of and commends the Navy's efforts on the measures they have taken to reduce or prevent contamination from entering surface water that might reach the harbor. These measures help ensure that contamination now and in the future will not enter the harbor.

13. **Comment:** One reviewer comments on the sentence "For some properties, potentially contaminated soil has possibly been removed." This sentence is in the conclusion section of the PHA. The reviewer suggests that ATSDR remove the word *possibly* from the sentence as the Navy has conducted confirmatory sampling in these locations.

Response: The comment refers to ATSDR's conclusions about exposure to lead in soil at and near the on-base SWMU 8 and the water tower. ATSDR acknowledges that the Navy has removed contaminated soil to residential standards on base near SWMU 8 and the water tower. The particular sentence in question, however, refers to soil at the neighboring off-base properties along Turner Road. While ATSDR does not know with certainty, we believe that it is possible that some soil at these off-base properties has been removed over time when homes were constructed or landscaped.

14. **Comment:** Several comments provided ATSDR with updated information on the status of site activity at NAB Little Creek.

Response: ATSDR has updated information into the Public Health Action Plan and/or Table 1 (Evaluation of Sites at Naval Amphibious Base, Little Creek) portions of the PHA as suggested, including:

- Sites 1, 4, 15, and 16 have been closed out by the Navy, EPA, and VDEQ with nor further action required under CERCLA IR program.
- Site 17 has been removed from the CERCLA process and included in the UST program.
- The Navy will continue to monitor groundwater at Sites 11, 11a, and 13 and will evaluate options for groundwater treatment
- Site 4 is closed with no further action required under the CERCLA IR program.

15. **Comment:** One comment indicated that surface water runoff and groundwater from Site 9 are not directed toward Little Creek Harbor.

Response: This comment notes the description of surface water runoff and groundwater flow from at Site 9 in Table 1 of the document. ATSDR has modified the description in the text to reflect the suggested the change.