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Draft Final

Proposed Remedial Action Plan for SWMUs 1, 15, and 24 NAS Oceana Virginia Beach, Virginia

Prepared for

Department of the Navy
Atlantic Division
Naval Facilities Engineering Command
Virginia Beach, Virginia

Contract No. N62470-95-D-6007
CTO-0105

August 2001

Prepared by

CH2MHILL

Baker
Environmental, Inc.

CDM
Federal Programs Corp.

Draft Final

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NAS Oceana
Virginia Beach, Virginia

Contract Task Order 105

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Under the

LANTDIV CLEAN II Program
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Herndon, Virginia

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Acronyms and Abbreviations

ARAR	Applicable or Relevant and Appropriate Requirement
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CMS	Corrective Measures Study
COC	Contaminants of Concern
COPC	Contaminants of Potential Concern
DoN	Department of the Navy
DPT	Direct Push Technology
ERA	Ecological Risk Assessment
FS	Feasibility Study
HHRA	Human Health Risk Assessment
IAS	Initial Assessment Study
MCL	Maximum Contaminant Level
MIP	Membrane Interface Probe
MNA	Monitored Natural Attenuation
mg/kg	milligrams per kilogram
NAS	Naval Air Station
NCP	National Contingency Plan
ORC	Oxygen Releasing Compound
PAH	Polynuclear Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
POL	Petroleum Oil Lubricant
PRAP	Proposed Remedial Action Plan
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RBC	Risk Based Concentration
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RI	Remedial Investigation
SWMU	Solid Waste Management Unit
TPH	Total Petroleum Hydrocarbons
USEPA	United States Environmental Protection Agency
µg/kg	micrograms per kilogram
µg/L	micrograms per liter

Acronyms and Abbreviations (Continued)

VDEQ	Virginia Department of Environmental Quality
VOC	Volatile Organic Compound

Introduction

The Department of the Navy (DoN) has identified preferred remedial alternatives to address contaminated soil and groundwater at Solid Waste Management Units (SWMUs) 1, 15, and 24 located on Naval Air Station (NAS) Oceana, Virginia Beach, Virginia. Based on the results of environmental investigations and human health and ecological risk assessments, the preferred remedial alternative for SWMU 1 is free-product removal with long-term monitoring of groundwater and institutional controls. The preferred remedial alternative for SWMU 15 is soil landfarming and long-term monitoring of groundwater with institutional controls. The preferred remedial alternative for SWMU 24 is long-term monitoring of groundwater with institutional controls. These preferred alternatives for SWMUs 1, 15, and 24 meet all National Contingency Plan (NCP) criteria in the most appropriate, applicable, and cost-effective manner. These alternatives are described in detail in this document.

This Proposed Remedial Action Plan (PRAP) is based on site-related documents contained in the DoN's Administrative Record. The Administrative Record can provide you with important background and site investigation information about the SWMUs. The Administrative Record is located at:

Virginia Beach Public Library
4100 Virginia Beach Boulevard
Virginia Beach, Virginia 23452
(757) 431-3000/3001

October 1 - May 31
Monday-Thursday: 10 a.m. to 9 p.m.
Friday and Saturday: 10 a.m. to 5 p.m.
Sunday: 1 p.m. to 5 p.m.

June 1 - September 30
Monday-Thursday: 10 a.m. to 9 p.m.
Friday and Saturday: 10 a.m. to 5 p.m.
Sunday: Closed

The DoN needs your comments and suggestions. The DoN, the U.S. Environmental Protection Agency (USEPA) Region III, and the Virginia Department of Environmental Quality (VDEQ) encourage the public to review and comment on the actions presented in this PRAP. The public comment period begins on August 13, 2001, and closes on September 12, 2001. Please send your comments, postmarked no later than September 12, 2001, to:

Commander
Atlantic Division
Naval Facilities Engineering Command
1510 Gilbert Street (Bldg. N-21)
Norfolk, Virginia 23511-2699
Attention: Public Affairs Officer, Mr. John E. Peters
Phone: (757)322-8005 / FAX: (757)322-8187
pao@efdlant.navfac.navy.mil

In addition, you are invited to a public meeting regarding the investigation of SWMUs 1, 15, and 24 at NAS Oceana. Representatives from the DoN will report on the status of these SWMUs and the DoN's preferred alternatives. The meeting is scheduled for:

Thursday, August 16, 2001 at 6:30 PM
NAS Oceana Officers Club
NAS Oceana, Virginia Beach, Virginia

This PRAP describes the DoN's preferred alternatives for SWMUs 1, 15, and 24. The DoN may modify the preferred alternatives or select other remedial alternatives if public comments or additional data indicate that such a change will result in more appropriate remedial actions. The DoN, in consultation with USEPA and VDEQ, will make a remedy selection for SWMUs 1, 15, and 24 in a Decision Document after the public comment period has ended and the comments and information submitted during that time have been reviewed and considered.

SWMUs 1, 15, and 24 were initially investigated following the requirements of the NAS Oceana Resource Conservation and Recovery Act (RCRA) 3008 (h) consent order. However, in July 1998, the Navy and the USEPA agreed to conduct future site remediation activities at NAS Oceana following the procedural and substantive requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program, 42 U.S.C. §§9601 et seq., 10 U.S.C. §2701 et seq., and Executive Order 12580 (23 Jan 1987). The DoN is issuing this PRAP as part of its public participation responsibilities under Sections 113(k) and 117(a) of CERCLA, as amended, commonly known as the "Superfund Program," and the National Environmental Policy Act of 1969. This PRAP focuses on SWMUs 1, 15, and 24.

Site Background

NAS Oceana is located in Virginia Beach, Virginia (Figure 1). The base has existed since 1940, when it was established as a small auxiliary airfield. Since 1940, NAS Oceana has grown to more than 16 times its original size and is now a 6,000-acre master jet base supporting a community of more than 9,100 Navy personnel and 11,000 dependents. The primary mission of NAS Oceana is to provide the personnel, operations, maintenance, and training facilities to ensure the deployment readiness of fighter and attack squadrons on aircraft carriers of the U.S. Atlantic Fleet.

A total of 60 SWMUs were recommended for study in the draft RCRA Consent Order issued by the USEPA. After reviewing the results of the Interim RCRA Facility Investigation (RFI), the Navy and USEPA determined that only 19 SWMUs required investigation under the RCRA consent order; the remainder of the RCRA Facility Assessment (RFA) identified SWMUs that are regulated under other federal and/or state programs. Because of the proximity of four of the RFA SWMUs, they were consolidated into two; therefore, 17 SWMUs were included in the RFI under the consent order. Subsequent investigation activities have involved a three-phase RFI, the preparation of the Corrective Measures Study (CMS) and associated studies, human health and ecological risk assessments, and corrective action, where applicable. The SWMUs at the NAS Oceana are categorized by consideration of the additional work required for SWMU closeout. SWMUs 1, 15, and 24 are categorized as requiring remedial action. The investigation results and conclusions for SWMUs 1, 15, and 24 are summarized below. The preferred remedial alternatives selected for SWMUs 1, 15, and 24 are also summarized in this document. The locations of SWMUs 1, 15, and 24 are shown in Figure 2.

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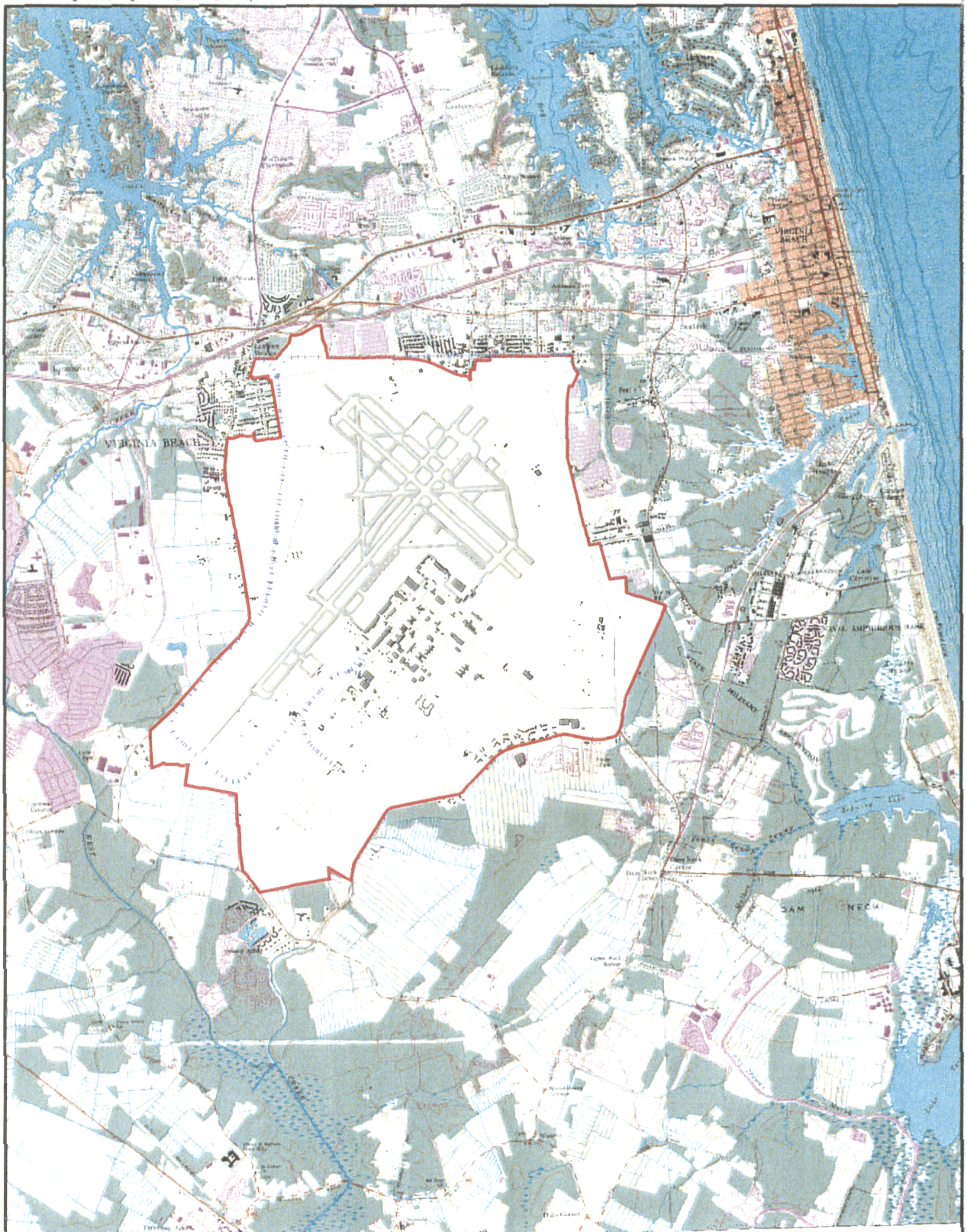

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Figure 1
Base Location Map
NAS Oceana, Virginia Beach, Virginia

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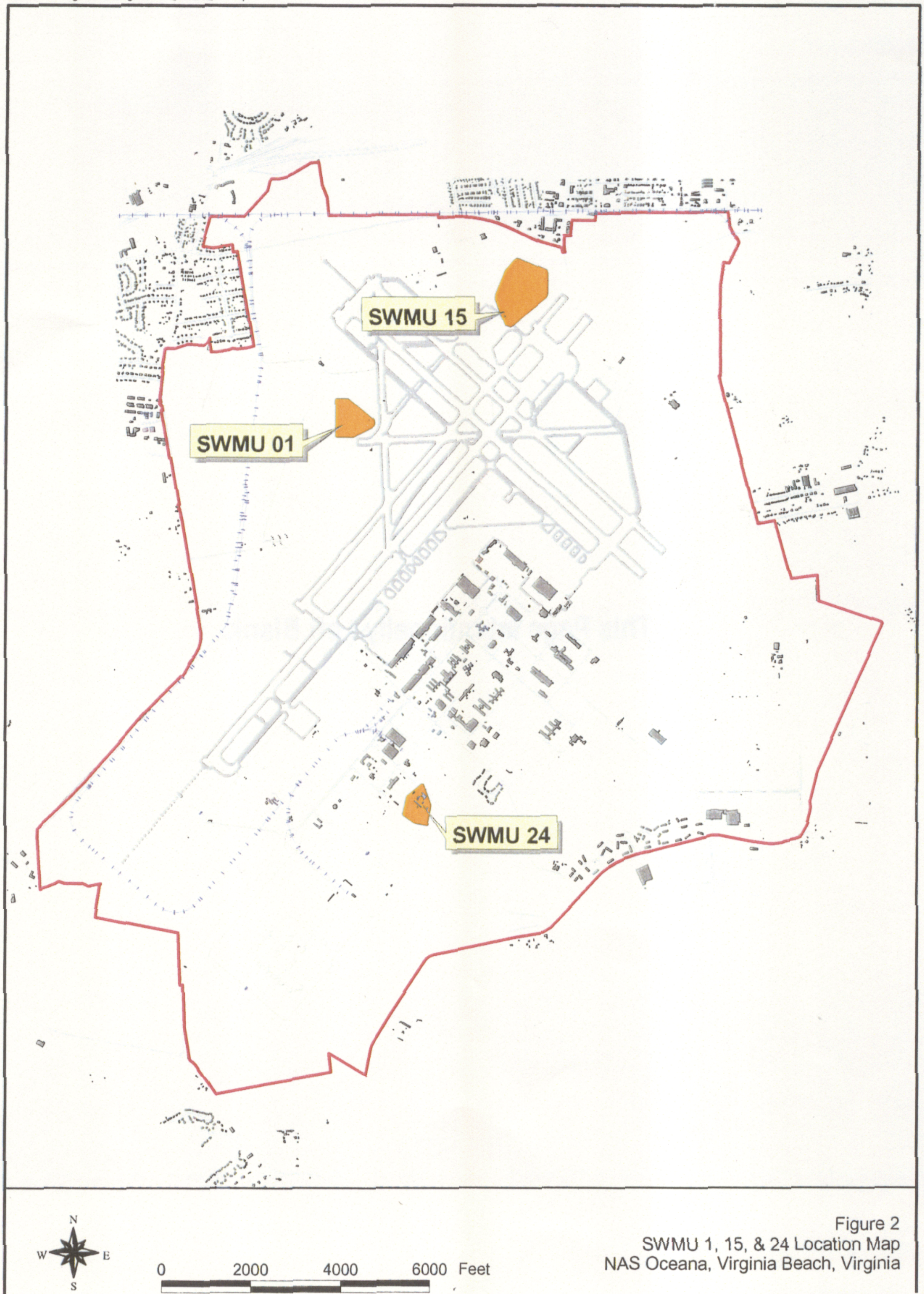

Figure 2
SWMU 1, 15, & 24 Location Map
NAS Oceana, Virginia Beach, Virginia

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SWMU Background and Investigation History

This section provides a site description, habitat evaluation, summary of investigations, nature and extent of contamination, human health site risks, and ecological site risks for SWMUs 1, 15, and 24.

SWMU 1 – West Woods Oil Disposal Pit

SWMU 1 – Site Description

SWMU 1 is located in the northwest part of NAS Oceana, approximately 1,000 feet west of abandoned Runway 9 (Figure 2). SWMU 1 was originally an open pit where approximately 110,000 gallons of waste oil, fuels, paints, and solvents were disposed of from the mid-1950s to the late 1960s. Drilling at this unit has shown that metal, concrete, and other debris were also disposed of in the pit or were included in the fill material. A 1958 aerial photograph of the unit shows that the pit was approximately 50 to 100 feet in diameter. In the late 1960s, the oil disposal pit flooded and its contents are believed to have washed into the main drainage ditch, 100 feet west of the pit. Waste disposal was discontinued, and the pit was filled with soil. The NAS boundary is approximately 1,000 to 2,000 feet west or northwest of the oil pit.

SWMU 1 – Habitat Evaluation

The immediate area around the pit is dominated by trees, shrubs, and grass. Although the site was forested in the past, the trees around the SWMU have been cut and the site and surrounding area is now maintained to limit the height of woody plants. A small emergent freshwater wetland is located approximately 250 feet east of the SWMU. The eastern perimeter of the SWMU is comprised of mowed and old field grasses and impervious surfaces. Surface drainage is directed toward north-south and east-west oriented drainage ditches. The north-south (main) drainage ditch has a permanent flow of surface water to the north. The ditch is approximately 12 to 15 feet wide with steep side slopes about 5 feet high. The ditch generally maintains a low-volume baseflow because it is excavated to a depth below the water table during normal precipitation conditions. Limited vegetation has been observed in the stormwater drainage ditch. The ditch at SWMU 1 is part of an engineered stormwater and spill control system for NAS Oceana. This ditch is maintained, as required, to ensure designed functionality. A second east-west trending tributary drainage ditch is located south of SWMU 1 and conveys stormwater drainage west into the main drainage ditch. This tributary ditch is perched approximately 2 feet above the base of the main drainage ditch and is dry except during heavy precipitation events. This ditch contains small shrubs, grass, and non-saturated soil. It does not provide significant habitat for aquatic life.

SWMU 1 – Previous Investigations

SWMU 1 was investigated seven times. The first investigation was the Initial Assessment Study (IAS). Results are published in the December 1984 IAS report. This was followed by the Phase I Verification Study. Results are published in the October 1986 Phase I Verification report. This was followed by the Interim RFI. The results are published in the August 1991 Interim RFI report. The Phase I RFI followed the Interim RFI. The results are published in the December 1993 Phase I RFI report. This was followed by the CMS. The results are published in the CMS Report dated November 1995. The CMS was followed by the Phase III RFI. The results are published in the Phase III RFI dated August 1999. An additional groundwater sampling investigation was conducted in November 1998. The results are published in the groundwater technical memorandum dated January 2000.

A comprehensive Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA), prepared in accordance with USEPA guidance, was issued in January and June 2001, respectively. These risk assessments did not involve the collection of new data.

SWMU 1 – Nature and Extent of Contamination

During the site investigations described above, the nature and extent of contamination was identified for SWMU 1 at NAS Oceana. The results of each of these investigations are summarized below.

Initial Assessment Study – The IAS included a records review, evaluation of site conditions, identification of possible contaminated media, and contaminant migration pathways and receptors. The IAS identified the site and inventoried the types of waste disposed of in the pit.

Phase I Verification Study – The Phase I Verification Study determined that the groundwater at SWMU 1 is contaminated locally with petroleum hydrocarbons. Sediment samples collected from the drainage ditch west of the former oil disposal pit also contained petroleum constituents.

Interim RCRA Facility Investigation – The Interim RFI activities at SWMU 1 supported the findings of the Phase I Verification Study.

Phase I RCRA Facility Investigation – The Phase I RFI investigation was conducted to determine the vertical and lateral extent of groundwater contamination and the hydraulic characteristics and flow regime of the shallow aquifer. The groundwater was sampled for Polynuclear Aromatic Hydrocarbons (PAHs) and Volatile Organic Compounds (VOCs). PAHs were not detected in groundwater. Benzene, toluene, ethylbenzene, and xylene (BTEX), common fuel constituents, were detected in groundwater in two of the six wells at concentrations of 67 parts per billion (μg/L) and 16 μg/L. Only one BTEX constituent, benzene, was detected in groundwater at a concentration (6 μg/L) that exceeded its Maximum Contaminant Level (MCL) of 5 μg/L. This well was also reported to contain free product. However, other wells that contained free product were not reported to contain BTEX constituents at concentrations above the MCLs. 1,1-Dichloroethane was detected in only one well at a concentration of 2 μg/L.

The Phase I RFI also characterized the nature and extent of soil contamination around the pit and the extent of sediment and surface water contamination. Petroleum hydrocarbon products were detected in several soil borings, including those north of the pit.

Corrective Measures Study – A CMS field investigation was performed to determine the extent of contamination in soil and groundwater. The field investigation included trenching at the site to determine the thickness of free product in the subsurface. The trenching confirmed the presence of free product contamination in soil on top of the water table. Product thickness was determined to be approximately 0.04 feet. An extraction well and monitoring system were installed at SWMU 1 to test the viability of extracting free product from the top of the water table. Two pilot tests were completed, however, no free product was recovered during either test due to the tightness of the silts that contained the product. The CMS recommended pulsed-pump extraction of free product as the preferred remedial alternative at SWMU 1.

Groundwater sampling completed during the CMS indicated that groundwater is essentially not contaminated with dissolved-phase VOCs, however benzene was detected. BTEX constituents were not detected at concentrations above MCLs in the groundwater samples collected during the CMS.

Phase III RCRA Facility Investigation - As part of the Phase III RFI, the Navy installed two solar-powered skimmers and began recovering the free phase petroleum product found in three wells and one temporary monitoring well. These skimmers are presently in use for free-product removal from existing wells at the SWMU. In addition, six subsurface soil samples were collected and analyzed for dioxins and furans. The analytical results were compared to the USEPA screening value of 1 micrograms per kilogram (μg/kg); no samples exceeded this screening value.

Groundwater Sampling Investigation – Groundwater samples were collected from ten groundwater monitoring wells and five temporary monitoring wells at SWMU 1. The samples were analyzed for VOCs, PAHs, and total petroleum hydrocarbons (TPH), to confirm the presence or absence of potential groundwater contamination and to support an HHRA. In addition, an attempt was made to collect free-product from two temporary monitoring wells, two monitoring wells, and two skimmer tanks. Results indicated that shallow groundwater from six sampling locations contained benzene (maximum detected concentration of 6 μg/L) that exceeded its USEPA tap water screening level Risk Based Concentration (RBC) of 0.36 μg/L. One PAH, benzo(a)pyrene, was detected in one shallow groundwater sampling location at a concentration of 0.2 μg/L, which exceeded its RBC for tap water of 0.0092 μg/L. One deep well contained benzo(a)anthracene at a concentration of 0.23 μg/L, which exceeded its tap water RBC of 0.092 μg/L. The free-product was tentatively identified as degraded diesel fuel.

SWMU 1 – Summary of Site Risks

An HHRA and ERA were conducted to quantify potential risks to human health and ecological receptors from contamination at SWMU 1. The HHRA includes the identification of Contaminants of Concern (COCs), and their impact on humans in the event of exposure to these contaminants. The results of the HHRA are contained in a report entitled "Final Human Health Risk Assessment of SWMUs 1, 15, and 24, NAS, Oceana" dated January

2001. The SWMU as a whole was also evaluated for ecological risk. Ecological risk assessments identify the risks to animals and plants. The results of the ERA are documented in a report entitled "Final Baseline Ecological Risk Assessment, SWMUs 1 and 15, NAS, Oceana" dated June 2001. The results of these risk assessments are summarized below.

Human Health Risk Assessment

Employees, construction workers, visitors, and residents (adults and children) under either current or future scenarios were evaluated for human health risks at SWMU 1. Both carcinogenic and noncarcinogenic risks were evaluated. The likelihood of any kind of cancer resulting from a contaminated site (carcinogenic risk) is generally expressed as an upper bound probability, specifically, a "1 in 10,000 chance." In other words, for every 10,000 people that could be exposed, one extra cancer may occur as a result of exposure to site contaminants. An extra cancer case means that one more person could get cancer than normally would be expected to from all other causes. The HHRA also calculated Hazard Indices for chemicals that do not cause cancer (noncarcinogenic risk). A Hazard Index compares an existing amount of a chemical to an amount that might cause harmful noncancer effects in people. If the Hazard Index is greater than one, then there may be a concern that harmful effects will occur in people.

The only potential noncarcinogenic risk identified at SWMU 1 was under a future residential scenario if a child or adult resident is exposed to groundwater. The COC in groundwater is napthalene. No unacceptable carcinogenic or other noncarcinogenic risks were identified.

Ecological Risk Assessment

The final ERA concluded that no further action is necessary for protection of ecological receptors. This determination was made because the contaminant levels of inorganic Contaminants of Potential Concern (COPCs) identified in the soil, surface water, and sediment at SWMU 1 were generally consistent with basewide concentrations throughout NAS Oceana. Organic contamination in the soil poses relatively low risk and occurred only in localized areas. Based on this evidence, potential risk from organics in surface soils to ecological receptors is negligible.

Additionally, SWMU 1 contains a main drainage ditch and a tributary drainage ditch near the former oil disposal pit. No COPC exceeded both a screening value and an upgradient concentration in surface water or sediment. In addition, considering the relatively low habitat value of these ditches, which are periodically maintained as part of the stormwater system, wildlife is likely to forage elsewhere, where the habitat quality is better.

SWMU 15 – Abandoned Tank Farm

SWMU 15 – Site Description

SWMU 15 is located in the former North Station area, approximately 800 feet northwest of Runway 23R and 1,000 feet northeast of the area used to store recreation vehicles near the old CPO club (Figure 2). The abandoned tank farm served as the primary source of aircraft fuel for the North Station area when it was active from the mid-1950s to the mid-1970s. The tank farm consisted of six tanks: a 414,000-gallon tank used to store jet fuel, two 50,000-gallon concrete tanks used for aviation gas, and three adjacent 12,000- to 18,000-gallon tanks believed to be used for automotive fuel, kerosene, or lube oil.

According to a historical report, the tanks were emptied of fuel and filled with water after they were abandoned. Tank G-5 was later used to store waste oil. The tanks and their associated piping were dismantled and removed in the mid-1980s.

SWMU 15 – Habitat Evaluation

The area around SWMU 15 includes pavement, forests, shrubs, and wetlands. Old paved road surfaces and parking lots cover much of the site. In general, drainage of the site is towards the northeast. A shallow drainage ditch crosses the center of the site, bisecting a small depressional wetland, and drains south to a large emergent wetland. No outlet from the wetland has been observed. Water was observed in most of the ditch during a 1992 ecological survey, but the water did not appear to be flowing. In addition, as part of the soil removal action at SWMU 15, an area measuring approximately 150 feet by 125 feet was excavated to a depth approximately three feet beneath the water table, creating a small open water pond at the site.

A large stand of mature loblolly pine occurs immediately north of the former location of the tanks and mature hardwood stands occur mainly in the eastern half of the site. The shrub communities are located along old field areas and unpaved roadbeds. The area is colonized by upland grasses.

SWMU 15 – Previous Investigations

SWMU 15 was investigated seven times. The first investigation was conducted in 1982. The IAS followed the first investigation. The results are published in the December 1984 IAS report. An RFA was conducted in 1988. The results are published in the RFA Report dated August 1988. SWMU 15 was investigated during two phases of the RFI. The results are published in the Phase I RFI Report dated December 1993, and the Phase II RFI Report dated February 1995. The two phases of the RFI were followed by the CMS. The results are published in the CMS Report dated March 1996. A Monitored Natural Attenuation (MNA) study was conducted for groundwater at SWMU 15; the results are published in the Study of Monitored Natural Attenuation report dated April 2001.

A comprehensive HHRA and an ERA following USEPA guidance were issued in January and June 2001, respectively. These risk assessments involved the collection of new data to fill identified data gaps.

SWMU 15 – Nature and Extent of Contamination

During the site investigations described above, the nature and extent of contamination was identified for SWMU 15 at NAS Oceana. The results of each of these investigations are summarized below.

1982 Investigation – During the 1982 sampling investigation, free-phase product was discovered in test pits and well borings.

Initial Assessment Study – The IAS identified the tank farm as a potential hazard.

RCRA Facility Assessment – The RFA identified the tank farm as SWMU 15 and documented recommendations for additional investigations.

Phase I and Phase II RCRA Facility Investigation – SWMU 15 was investigated during two phases of the RFI. Phase I was completed in 1993 and Phase II was completed in 1995. The purpose of the RFIs was to characterize the extent of soil and groundwater contamination.

During the first phase of the RFI, twelve direct push groundwater samples were collected. The second phase of the RFI involved collecting seventeen additional direct push groundwater samples, installing and sampling eleven monitoring wells, collecting fifteen soil samples from seven locations, and assessing the extent of free-product contamination by excavating six test pits and installing six temporary monitoring wells.

Direct push groundwater samples collected from the top of the water table (7 to 9 ft bgs) indicated that concentrations of BTEX compounds were detected in the source area but were undetectable in the outermost groundwater samples. The free product investigation revealed that the accumulation of free product on the water table was minimal. The wells, screened between 4 and 14 feet, indicated that the monitoring well groundwater was found to contain BTEX in four wells. The remaining well samples were below the detection limit for BTEX constituents. No measurable free product was observed in any of the monitoring wells.

The test pit data supported the conclusion that the shallow soils were partially saturated with petroleum hydrocarbons, but little to no recoverable free product had accumulated and persisted at the water table surface. The soil data indicated that petroleum contamination of unsaturated soil was widespread, with total BTEX concentrations greater than 33 milligrams per kilogram (mg/kg) in eight of the samples.

Corrective Measures Study – A CMS was initiated in 1995 to define the extent of the groundwater contaminant plume (the occurrence of migrating contaminants in groundwater), characterize surface soil contamination, and obtain treatability data on contaminated soil and groundwater. Results of the investigations conducted at SWMU 15 indicated that surface soils contained Total Petroleum Hydrocarbons (TPH) ranging from less than 35 mg/kg to 67 mg/kg and PAHs ranging from 0.144 mg/kg to 5.4 mg/kg. Subsurface soils contained BTEX ranging from 0.01 mg/kg to 225.7 mg/kg and TPH ranging from less than 0.005 mg/kg to 1,706 mg/kg (exception was a detection of 15,530 mg/kg in one sample). Groundwater was found to contain free-phase product, BTEX (highest concentrations were of benzene at a maximum detected concentration of 740 µg/L), and TPH (maximum concentration of 1.6 µg /L). Vinyl chloride was detected at one sampling location at a concentration of 5.5 µg/L and isomers of 1,2-dichloroethylene were detected at concentrations ranging from 2.4 µg/L to 11 µg/L. The CMS recommended treatment for soil contamination and monitored natural attenuation of groundwater.

Based on recommendations from the CMS, a soil removal action was conducted at SWMU 15 in 1997 to remediate the BTEX contamination in the soil. An area measuring approximately 250 feet by 300 feet was excavated to the water table, creating a small pond. The pond is located southwest of the drainage ditch. Approximately 18,000 cubic yards of soil were treated on site by bioremediation and aeration (biopile). Bioremediation and aeration involved tilling and fertilizing the soil to promote natural degradation of BTEX in the soil. Confirmatory soil samples were collected and a HHRA was conducted on the remediated biopile soil. The HHRA of the biopile soil determined that the noncarcinogenic and carcinogenic risks for the exposure pathways evaluated in the assessment were within the USEPA's target risk levels based on residential and recreational exposure scenarios; therefore these soils present no unacceptable risk.

An ecological risk assessment performed on the biopile soils involved additional surface soil sampling to determine whether or not PAHs were still a concern to ecological receptors, and to demonstrate that PAH concentrations had decreased along with TPH concentrations in the biopile soil. Concentrations of the PAHs, specifically benzo(a)pyrene, benzo(k)fluoranthene, fluoranthene, and pyrene were elevated in a small portion of the samples, but when compared to equally high levels of the same PAHs in background soil samples, these were not seen as a concern. Summing the maximum detected concentration of each PAH compound as a worst-case exposure scenario (all maximum contaminant detections being co-located in a single sample) yielded a concentration of 6.7 mg/kg for total PAHs. The NAS Oceana Partnering Team had agreed to an action level of 40 mg/kg for total PAHs, as documented in the *Final SWMU 15 Biological Soil Remediation Project Closeout Report and Confirmatory Soil Sampling Technical Memorandum, Oceana Naval Air Station, Virginia Beach, Virginia,* dated March 2000. Thus, the total maximum PAH concentration, even when calculated as a worst case exposure scenario, was well below the team's agreed upon action level. The drop in PAHs and TPH was due to the re-treatment of the soil. Therefore, the ERA concluded that PAHs were not considered to be a concern in the biopile soils and no further action was necessary. The treated soils were distributed as topsoil for a runway restoration project.

Monitored Natural Attenuation Study – The MNA study involved sampling of groundwater to determine the overall distribution of BTEX and its degradation products and the potential for BTEX to naturally attenuate within the aquifer. An innovative approach was used to collect the data needed to support a monitored natural attenuation site characterization. Monitoring well sampling was conducted to determine the overall distribution of the BTEX contaminant plume. Once the highest levels of contamination were located, direct-push technology (DPT) groundwater sampling was initiated at multiple depths to determine the depth at which the maximum levels of contamination resided. Then DPT groundwater sampling was conducted on a grid, at the depth of the highest detected contamination, to horizontally define the BTEX groundwater contaminant plume. At the same time, a membrane interface probe (MIP) rig was used to characterize the contamination around and upgradient of the pond. Groundwater and soil sampling was conducted around the pond to vertically profile the contaminant plume.

The results of the MNA study determined that the overall shape of the BTEX plume is consistent with a predominately south to southwest groundwater flow direction that intermittently shifts to a west to northwest direction during periods of heavy precipitation. The relatively flat hydraulic gradient and fluctuating groundwater flow direction might have kept the plume from migrating as far as it might have under a regime of a consistent groundwater flow direction. Specifically, BTEX was detected in silt and clay near the bottom of the Columbia Aquifer. Some BTEX was detected in near surface silt and clay as well.

In the MNA study, two hypotheses were evaluated for the conceptual site model of contaminant distribution and biodegradation at SWMU 15, and lines evidence supporting the conclusion that MNA is occurring at the site as well as the alternate conclusion that MNA is not occurring at the site were documented.

SWMU 15 – Summary of Site Risks

An HHRA and an ERA were conducted to quantify potential risks to human health and ecological receptors from contamination at SWMU 15. The HHRA includes the identification of COCs, and their impact on humans in the event of exposure to these contaminants. The results of the HHRA are contained in a report entitled "Final Human Health Risk Assessment of SWMUs 1, 15, and 24, NAS, Oceana" dated January 2001. The SWMU as a whole was also evaluated for ecological risk. ERAs identify the risks to animals and plants. The results of the ERA are documented in a report entitled "Final Baseline Ecological Risk Assessment, SWMUs 1 and 15, NAS Oceana" dated June 2001. The results of these risk assessments are summarized below.

Human Health Risk Assessment

Employees, construction workers, visitors, and residents (adults and children) were evaluated for human health risks at SWMU 15 under either current or future scenarios. Both carcinogenic and noncarcinogenic risks were evaluated. The likelihood of any kind of cancer resulting from a contaminated site (carcinogenic risk) is generally expressed as an upper bound probability, specifically, a "1 in 10,000 chance." In other words, for every 10,000 people that could be exposed, one extra cancer may occur as a result of exposure to site contaminants. An extra cancer case means that one more person could get cancer than normally would be expected to from all other causes. The HHRA also calculated Hazard Indices for chemicals that do not cause cancer (noncarcinogenic risk). A Hazard Index compares an existing amount of a chemical to an amount that might cause harmful noncancer effects in people. If the Hazard Index is greater than one, then there may be a concern that harmful effects will occur in people.

There are current carcinogenic risks to an industrial worker exposed to surface soil. Carcinogenic risk also was identified for a future industrial worker and resident exposed to soil, as well as to future residents from exposure to groundwater. In addition, a future resident exposed to soil and groundwater and a construction worker exposed to groundwater would result in a noncarcinogenic risk.

The COCs at SWMU 15 are arsenic, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene in soil, and benzene, chloroform, methylene chloride, napthalene, arsenic, iron, and manganese in groundwater.

Ecological Risk Assessment

The final ERA concluded that further action is necessary for protection of ecological receptors to organic contaminants (total PAHs) in surface soil adjacent to the former source area (the ponded excavation). In addition, three metals and three organic chemicals posed risk to ecological receptors in groundwater, and would need to be monitored to confirm that the contaminant concentrations do not increase over time.

Contaminant levels of inorganic COPCs identified in the soil, surface water, and sediment at SWMU 15 were generally consistent with basewide soil concentrations throughout NAS Oceana. In addition, the sediments in the pond at SWMU 15 are not true sediments, but are the sub-surface soils that existed under the surface soils that were removed. Over time, deposition of organic material will form true sediments in the pond. These new sediments will cover the mineral soils currently at the bottom of the pond, essentially covering the organic chemicals as well. Based on these factors, no remedial action is recommended for inorganic contaminants in soil, surface water and sediments at SWMU 15.

SWMU 24 – Bowser Building 840

SWMU 24 – Site Description

SWMU 24 is an area near Building 840 which contained a waste-oil bowser (a portable tank). Building 840 is in an industrial area of NAS Oceana, in southern portion of the station (Figure 2). The Naval Construction Battalion, based in Building 840 since 1972, are involved in construction at NAS Oceana and other local naval installations. Waste solvents and oils generated at the equipment maintenance garage in Building 840 were hand carried and poured into the bowser, which was typically located in the southernmost corner of the Building 840 compound. The bowser was then transported to the tank farm for disposal. During the visual site inspection, heavy staining of the ground was observed in the area surrounding the waste oil bowser at Building 840. Current practice is to dispose of waste oil in drums that are transported to the base hazardous waste lot, where they are disposed or recycled appropriately. The bowsers are no longer used. The site consists of a fenced gravel area surrounded by a perimeter of brush, forest, and mowed lawn.

SWMU 24 – Habitat Evaluation

SWMU 24 consists of a fenced gravel area surrounded by a perimeter of brush, forest, and mowed lawn. There is limited wildlife habitat in the immediate area of SWMU 24. Wildlife inhabits the forested areas surrounding SWMU 24.

SWMU 24 – Previous Investigations

SWMU 24 was investigated seven times. An RFA was conducted in 1988. The results are published in the RFA Report dated August 1988. SWMU 24 was investigated during three phases of the RFI. The results are published in the Phase I RFI Report dated December 1993, the Phase II RFI Report dated February 1995, and the Phase III RFI Report dated June 1999. A petroleum oil lubricant (POL) CMS was conducted in 1994. The results are published in a report entitled "A Corrective Measures Plan for Petroleum Contaminated Sites" dated October 1994. A CMS for groundwater was conducted in 1995. The results are published in the CMS Report dated March 1996. A direct push technology study and groundwater investigation was conducted in 1998. The results are published in the Technical Memorandum for the Groundwater Sampling at SWMU 24 dated January 2000.

A comprehensive HHRA and ERA, prepared in accordance with USEPA guidance, was issued in January 2001, and October 1999, respectively. These risk assessments did not involve the collection of new data.

SWMU 24 – Nature and Extent of Contamination

During the site investigations described above, the nature and extent of contamination was identified for SWMU 24 at NAS Oceana. The results of each of these investigations are summarized below.

RCRA Facility Assessment – Environmental problems at SWMU 24 were first recognized during the RFA in 1988 when oil staining was observed in surface soil surrounding a used oil bowser.

Phase I RCRA Facility Investigation – The Phase I RFI was conducted to delineate the source area and the extent of petroleum-contaminated soil. Two soil samples were collected and analyzed for metals, VOCs, PAHs, and TPH. Soil sampling results indicated that the SWMU should be further characterized for soil removal, which was conducted during the Petroleum Oil Lubricant Corrective Measures Study (POL CMS).

Petroleum Oil Lubricant Corrective Measures Study – The POL CMS delineated the removal of petroleum-contaminated soil at SWMU 24. Surface and subsurface soil was sampled at six locations and analyzed for TPH, PAHs, and metals. In addition, four temporary monitoring wells were installed and groundwater samples were analyzed for TPH, VOCs, PAHs, and metals. Most of the soils contained TPH in concentrations exceeding 100 mg/kg, the VDEQ storage tank guidance notification standard. The POL CMS recommended that the soil in excess of the VDEQ storage tank guidance notification standard of 100 mg/kg of TPH be excavated; this cleanup goal is not driven by risk. Groundwater samples were found to contain TPH and VOCs; the POL CMS recommended that groundwater contamination be further characterized during the Phase II RFI.

As a follow-on to the POL CMS a soil removal action was implemented; VDEQ and USEPA agreed to the 100 mg/kg cleanup goal for TPH in soils recommended in the POL CMS. Following the original excavation, confirmatory samples were collected, and additional soil was excavated due to exceedances of the cleanup goal in the confirmatory samples. Approximately 770 cubic yards of soil was excavated from SWMU 24, at which point any further excavation of soil ceased due to the proximity to the water table. Results of the soil removal action are documented in the 1995 Excavation, Transportation and Disposal of Petroleum-Contaminated Soils report.

Since excavation was ceased prior to meeting the cleanup goal, the USEPA requested additional confirmatory sampling at SWMU 24 after reviewing the POL CMS and the Excavation, Transportation and Disposal of Petroleum Contaminated Soils report, which was conducted as part of the Phase III RFI.

Phase II RCRA Facility Investigation – The Phase II RFI was conducted to further delineate groundwater contamination at SWMU 24. Nineteen groundwater samples were collected and analyzed for VOCs. In addition, six shallow monitoring wells were installed, sampled, and analyzed for VOCs, TPH, PAHs, total metals, and dissolved metals. Results indicated that although the petroleum-related contaminant plume was delineated, additional characterization of the chlorinated VOC plume was necessary, and was conducted during the CMS.

Corrective Measures Study – During the CMS, groundwater samples were collected and analyzed for VOCs, five shallow monitoring wells were installed and sampled, and four existing wells were resampled and analyzed for VOCs. The CMS determined that groundwater at SWMU 24 was contaminated with benzene (maximum detection of 20 μg/L), and chlorinated VOCs, specifically, vinyl chloride (maximum detection of 25 μg/L) , cis-1,2-DCE (maximum detection of 2,200 μg/L), and TCE (maximum detection of 81 μg/L).

In late 1996 and early 1997, an in-well aeration pilot study was initiated at SWMU 24. Contaminant concentrations in the source area were dramatically reduced using in-well aeration. The estimated mass reduction of cis-1,2-DCE ranged from 22-76 percent. However, some outlying areas of the contaminant plume were not treated and the need for additional remediation was investigated further in subsequent studies.

Phase III RCRA Facility Investigation - After excavation of the contaminated soils in 1995, confirmatory subsurface soil sampling was performed at SWMU 24 in 1997, as part of the Phase III RFI, to confirm that the removal of petroleum contaminated soil was effective. Ten confirmatory samples were collected from the native soil just outside of the perimeter of the original excavation and analyzed for VOCs and PAHs. The maximum detected concentrations were compared to the RBCs for the ingestion of soil by the residential receptor. There were no exceedances of RBCs in any of the subsurface soil samples collected.

Direct Push Technology Investigation – A direct push technology investigation was conducted in November 1998 to determine the boundaries of the cis-1,2-DCE groundwater plume at SWMU 24 and to assess the overall effectiveness of the in-well aeration pilot study. Monitoring wells were also sampled as part of this investigation. Results of the direct push sampling suggested the presence of a localized cis-1,2-DCE hot spot that had a limited areal and vertical extent. Residual groundwater contamination was found downgradient of the treatment well. No DCE concentrations exceeded the MCL of 70 μg/L when averaged over the three sampling depths in the shallow aquifer.

SWMU 24 – Summary of Site Risks

An HHRA and ERA were conducted to quantify potential risks to human health and ecological receptors from contamination at SWMU 24. The HHRA includes the identification of COCs, and their impact on humans in the event of exposure to these contaminants. The results of the HHRA are contained in a report entitled "Final Human Health Risk Assessment of SWMUs 1, 15, and 24, NAS, Oceana" dated January 2001. The SWMU as a whole was also evaluated for ecological risk. ERAs identify the risks to animals and plants. The results of the ERA are documented in a report entitled "Final Screening Ecological Risk Assessment, SWMUs 2C, 2D, 2E, 18, 19, 20, 23, and 24, NAS Oceana" dated October 1999. The results of these risk assessments are summarized below.

Human Health Risk Assessment

Employees, construction workers, visitors, and residents (adults and children) under either a current or future scenarios were evaluated for human health risks at SWMU 24. Both carcinogenic and noncarcinogenic risks were evaluated. The likelihood of any kind of cancer resulting from a contaminated site (carcinogenic risk) is generally expressed as an upper bound probability, specifically a "1 in 10,000 chance." In other words, for every 10,000 people that could be exposed, one extra cancer may occur as a result of exposure to site contaminants. An extra cancer case means that one more person could get cancer than normally would be expected to from all other causes. The HHRA also calculated Hazard Indices for chemicals that do not cause cancer (noncarcinogenic risk). A Hazard Index compares an existing amount of a chemical to an amount that might cause harmful noncancer effects in people. If the Hazard Index is greater than one, then there may be a concern that harmful effects will occur in people.

Future potential carcinogenic and noncarcinogenic risks to children and adults would result from the ingestion of groundwater, if the site were used as a residential area. The chemicals of concern identified in groundwater were cis-1,2-DCE, arsenic, iron, and manganese. No other unacceptable carcinogenic or noncarcinogenic risks were identified.

Ecological Risk Assessment

The final ERA performed for SWMU 24 concluded that complete exposure pathways do not exist at SWMU 24. Therefore, no further action was deemed necessary from an ecological risk perspective.

Remedial Action Objectives

Based on an evaluation of site conditions, risks, and legal requirements, site-specific remedial action objectives (RAOs) were identified to protect human health and the environment. The site-specific RAOs for SWMUs 1, 15, and 24 are summarized below.

SWMU 1

The RAO for groundwater at SWMU 1 is to prevent unacceptable risks to potential human receptors from groundwater.

Napthalene is a COC in groundwater at SWMU 1. As there is no legally enforceable MCL for napthalene, a risk-based preliminary remediation goal (PRG) was calculated in the feasibility study (FS) for the residential scenario, as presented in Table 1. The maximum detected concentration of napthalene is greater than its calculated risk-based PRG.

TABLE 1
Contaminant of Concern and Preliminary Remediation Goal in Groundwater at SWMU 1

Contaminant Of Concern	Maximum Detected Concentration (μg/L)	Human Health Residential Scenario Risk-Based PRG (μg/L)
Napthalene	208	0.17

SWMU 15

The RAOs identified for SWMU 15 are to minimize direct contact of human and ecological receptors from surface soil that may pose unacceptable risks, and to prevent unacceptable risks to potential human receptors from groundwater.

The COCs for SWMU 15 soil are PAHs, particularly, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. As there are no legally enforceable human health cleanup levels for contaminants in soil, risk-based PRGs were calculated in the FS for these constituents, as presented in Table 2. Although arsenic and benzo(k)fluoranthene also were identified as COCs in SWMU 15 soil, their maximum detected concentrations (2 and 16 mg/kg, respectively) were below their respective calculated risk-based PRGs (3.4 and 87 mg/kg, respectively), therefore no further action needs to be taken to address these specific contaminants.

The cleanup goal for protection of ecological receptors from total PAHs is 40 mg/kg, as determined during the biopile remediation effort at SWMU 15.

TABLE 2
Contaminants of Concern and Preliminary Remediation Goals in Soil at SWMU 15

Contaminant Of Concern	Maximum Detected Concentration (mg/kg)	Human Health Residential Scenario Risk-Based PRG (mg/kg)
Benzo(a)anthracene	23	8.7
Benzo(a)pyrene	29	0.87
Benzo(b)fluoranthene	49	8.7
Dibenzo(a,h)anthracene	34	0.87
Indeno(1,2,3-cd)pyrene	16	8.7

Benzene, chloroform, methylene chloride, arsenic, iron, and manganese are COCs in groundwater at SWMU 15. The PRGs for benzene, chloroform, and arsenic are their respective MCLs. As there are no legally enforceable MCLs for methylene chloride, iron, and manganese, risk-based PRGs were calculated for the residential scenario for these constituents, as presented in Table 3. Although napthalene also was identified as a COC in SWMU 15 groundwater, its maximum detected concentration (28 μg/L) was below its respective calculated risk-based PRG (170 μg/L), therefore no further action needs to be taken to address napthalene.

TABLE 3
Contaminants of Concern and Preliminary Remediation Goals in Groundwater at SWMU 15

Contaminant Of Concern	Maximum Detected Concentration (μg/L)	Human Health Residential Scenario Risk-Based PRG (μg/L)	Maximum Contaminant Level (μg/L)
Benzene	3,444	---	5
Chloroform	278	---	80
Methylene Chloride	216	86	---
Arsenic	19.6	---	10
Iron	15,400	15,000	---
Manganese	490	310	---

SWMU 24

The RAO for SWMU 24 is to prevent unacceptable risks to potential human receptors from groundwater.

Cis-1,2-DCE, arsenic, iron, and manganese are COCs in groundwater at SWMU 24. The PRGs for cis-1,2-DCE and arsenic are their respective MCLs. As there are no legally enforceable MCLs for iron and manganese, risk-based PRGs were calculated in the FS for the residential scenario for these constituents, as presented in Table 4.

TABLE 4
Contaminants of Concern and Preliminary Remediation Goals in Groundwater at SWMU 24

Contaminant Of Concern	Maximum Detected Concentration (μg/L)	Human Health Residential Scenario Risk-Based PRG (μg/L)	Maximum Contaminant Level (μg/L)
cis-1,2-DCE	500	---	70
Arsenic	224	---	10
Iron	69,300	2,300	---
Manganese	743	310	---

The alternatives provided in the next section were evaluated to determine the most appropriate remedy to achieve the RAOs for each of the SWMUs.

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Summary of Alternatives

This section summarizes the remedial alternatives developed in the FS for SWMUs 1, 15, and 24. Alternative 2 is recommended as the preferred alternative for SWMU 1. Alternative 2 involves Free-Product Removal and Institutional Controls with Long-term Monitoring of groundwater. Alternative 3 is the recommended alternative for SWMU 15. Alternative 3 involves long term monitoring of groundwater with institutional controls and soil landfarming. Alternative 2 is the recommended alternative for SWMU 24. Alternative 2 involves institutional controls with long-term monitoring of groundwater. A detailed analysis of these alternatives is presented in the FS. The analysis was conducted in accordance with USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)* and the National Oil and Hazardous Substances Pollution Contingency Plan or National Contingency Plan.

Remedial technologies were identified which could meet the RAOs for each SWMU. These technologies were then screened using site-specific information from previous investigations to determine the feasibility of each technology, and eliminate technologies that could not be implemented effectively. Subsequently, retained technologies were combined into several remedial alternatives for each SWMU. A summary of the remedial alternatives evaluated for each SWMU is provided below.

SWMU 1

Three remedial alternatives were developed for SWMU 1 based on the general response actions and the results of the screening of remedial technologies. The following alternatives were identified for detailed evaluation:

- Alternative 1 – No Action
- Alternative 2 – Free-Product Removal, Institutional Controls, and Long-Term Monitoring
- Alternative 3 – Use of Oxygen Releasing Compound (ORC), Free-Product Removal, Institutional Controls, and Long-Term Monitoring

The major components of each remedial alternative are defined below.

Alternative 1 – No Action

The no action alternative is required by the NCP and serves as the baseline alternative. All other remedial action alternatives are judged against the no action alternative. Under this alternative, no controls or remedial technologies would be implemented. CERCLA (Section 121(c)), as amended by SARA (1986), requires that the site be reviewed every 5 years since groundwater contamination would remain onsite.

Alternative 2 – Free-Product Removal, Institutional Controls, and Long-Term Monitoring

Alternative 2 consists of administrative measures (groundwater-use restrictions) with long-term monitoring conducted to track groundwater quality and the potential for offsite plume migration, along with continued use of skimmers to remove any free product from the water table. The major components of this alternative are discussed below.

Free-Product Removal

The Navy installed two solar-powered skimmers in 1997, which began recovering the free phase petroleum product found in two wells and two temporary monitoring wells. These skimmers are presently in use and free-product removal would continue under this alternative until less than 0.01 feet of free product is recoverable from the existing wells at the SWMU for three consecutive months. The Navy would continue to maintain and monitor the skimmers on a regular basis.

Institutional Controls

Institutional controls at SWMU 1 would include restrictions on future residential use of the groundwater within the site boundaries and within some distance downgradient of the site boundaries.

Long-Term Monitoring

The Navy would prepare a long-term monitoring plan, using the 1998 groundwater data collected at SWMU 1 as a baseline, to detail the procedure for periodic long-term monitoring of napthalene at the SWMU. Based on the long-term monitoring analytical results, the sampling and analysis scheme would be evaluated and potentially modified during the 5-year site review for the subsequent annual sampling events.

Alternative 3 – Use of Oxygen Releasing Compound (ORC), Free-Product Removal, Institutional Controls, and Long-Term Monitoring

Alternative 3 consists of the use of an Oxygen Releasing Compound (ORC) to enhance biodegradation and reduce contaminant levels, in addition to the administrative measures, free-product removal, and long-term monitoring included in Alternative 2.

ORC is a substance that when introduced to an aquifer, slowly releases oxygen and enhances the degradation of a contaminant. ORC is a proprietary formulation of magnesium peroxide, designed to provide a timed release of oxygen. ORC is manufactured as a powder, which can be mixed with water and injected into the aquifer.

Free-Product Removal, Institutional Controls, and Long-Term Monitoring

Free-product removal is currently being implemented. The institutional controls and long-term monitoring would occur as discussed under Alternative 2. The long-term monitoring program would begin after the ORC pilot test and full-scale applications (5th year).

SWMU 15

Four remedial alternatives were developed for SWMU 15 based on the general response actions and the results of the screening of remedial technologies. The following alternatives were identified for detailed evaluation:

- Alternative 1 – No Action

- Alternative 2 –Monitored Natural Attenuation, Institutional Controls, Soil Landfarming
- Alternative 3 –Long-Term Monitoring, Institutional Controls, Soil Landfarming
- Alternative 4 – Downgradient Reactive Curtain of Oxygen Releasing Compound (ORC), Long-Term Monitoring, Institutional Controls, Soil Landfarming

The major components of each remedial alternative are defined below.

Alternative 1 – No Action

The no action alternative is required by the NCP and serves as the baseline alternative. All other remedial action alternatives are judged against the no action alternative. Under this alternative, no controls or remedial technologies would be implemented. CERCLA (Section 121(c)), as amended by SARA (1986), requires that the site be reviewed every 5 years, since soil and groundwater contamination would remain onsite.

Alternative 2 – Monitored Natural Attenuation, Institutional Controls, Soil Landfarming

Alternative 2 consists of groundwater sampling to monitor the natural attenuation of contaminants, with administrative measures to restrict groundwater use, and landfarming of surface soil to reduce PAH concentrations around the ponded area. The major components of this alternative are discussed below.

Monitored Natural Attenuation

Natural attenuation may be considered for contamination that is easily biodegradable or otherwise may naturally be reduced to concentrations below cleanup levels. Natural processes such as biodegradation, dilution, volatilization, and adsorption to aquifer soils can remove the risk to humans from contaminated groundwater. Natural attenuation may be able to stabilize the contaminant plume, thereby preventing offsite migration to any potential receptors, primarily through biodegradation. Because the main contaminant of concern at SWMU 15 is a volatile petroleum hydrocarbon (benzene), the contamination at SWMU 15 a good candidate for evaluation of attenuation through naturally occurring biodegradation and volatilization. However, additional studies, based on the April 2001 MNA report, would be required to characterize more effectively the natural attenuation process.

MNA of the groundwater at SWMU 15 would involve annual groundwater sampling from all the wells in the MNA network in order to assess the rate at which biodegradation of BTEX is occurring. The frequency of groundwater sampling is considered appropriate due to the slow groundwater velocity. The groundwater would be sampled for Low Concentration Volatiles (including BTEX), and other MNA parameters such as ferrous iron, ferric iron, chloride, nitrate, nitrite, sulfate, methane, ethane, and ethene. Field parameters such as dissolved oxygen, temperature, pH, conductivity, and redox potential would also be collected.

An MNA evaluation would be performed after 5 years of monitoring to confirm contaminant biodegradation rates, re-evaluate the data collected, and document lines of evidence for MNA. The models would be run again. New information would be used to modify model inputs to match site conditions more closely, to more accurately determine the time necessary to achieve remediation goals, and to determine the length of time appropriate for the monitoring activities to continue.

Institutional Controls

Institutional controls at SWMU 15 would include restrictions on future residential use of the groundwater within the site boundaries and within some distance downgradient of the site boundaries. Restrictions also would be placed on activities that would involve excavations into the shallow water table aquifer that would cause non-consumptive contact with the groundwater.

Soil Landfarming

Unacceptable risks were found to an industrial worker and ecological receptors from soil under current conditions at the SWMU, as well as to industrial workers and residents under a future scenario. The HHRA notes that there are no industrial workers currently at the site and the site's future development for residential purposes is highly unlikely, however, the remediation of the contaminated soil performed under this alternative would mitigate potential current risks from surface soil. As determined during sampling, concentrations of PAHs posing risk to human health and ecological receptors occur along the southern and eastern boundaries of the man-made pond created after the initial soil excavation at SWMU 15. Similar to the biological re-treatment that was performed for the bottom 3 feet of the biopile, the soil in these areas would be treated through landfarming (soil tilling). Landfarming enhances the naturally occurring biological processes of microorganisms to degrade organic contaminants by providing oxygen to increase the rate of degradation of the contaminants.

Confirmatory samples would be collected; if results were found to be below the human health and ecological PRGs, no further action would be necessary for soil remediation. However, if results still exceeded the PRGs, additional tilling cycle(s) and possibly the addition of other nutrients such as water or nitrogen would be necessary, followed by another confirmatory surface soil sampling event(s).

Alternative 3 – Long-Term Monitoring, Institutional Controls, Soil Landfarming

Alternative 3 consists of administrative measures (groundwater-use restrictions) with long-term monitoring to track groundwater quality and the potential for offsite plume migration. The major components of this alternative are discussed below.

Long-Term Monitoring

Long-term monitoring at SWMU 15 would be conducted to track groundwater quality and the potential for offsite plume migration. The Navy would prepare a long-term monitoring plan, using the 2000 groundwater data collected at SWMU 15 as a baseline, to detail the procedure for periodic long-term monitoring of benzene at the SWMU. Based on all the long-term monitoring analytical results, the sampling and analysis scheme would be evaluated and potentially modified during the 5-year site review for the subsequent annual sampling events.

Institutional Controls and Soil Landfarming

The administrative measures to prevent groundwater exposure would be the same as included in Alternative 2.

Alternative 4 – Use of Oxygen Releasing Compound, Long-term Monitoring, Institutional Controls, Soil Landfarming

Alternative 4 consists of the use of a downgradient reactive curtain of ORC to enhance biodegradation of contaminants, with the administrative measures and landfarming of surface soil discussed in Alternative 2. The major components of this alternative are discussed below.

Downgradient Reactive Curtain of Oxygen Releasing Compound

ORC is a substance that when introduced to an aquifer, slowly releases oxygen and enhances the degradation of a contaminant. ORC has been successfully applied to BTEX plumes in a wide range of conditions. The purpose of the reactive curtain would be to prevent the migration of the highest concentrations of contaminants associated with the source areas from moving downgradient by introducing oxygen into the contaminated groundwater to promote the degradation of the BTEX. The application of a downgradient reactive curtain of ORC was modeled in the April 2001 MNA report. The model indicated that the ORC curtain has potential application at this site, however, site-specific studies would be required as part of this alternative. Long-term monitoring would be necessary to monitor the effectiveness of the ORC curtain and the remaining contaminants of concern.

Institutional Controls and Soil Landfarming

The administrative measures to prevent groundwater usewould be the same as included in Alternative 2. The landfarming of the surface soil around the pond would be completed before the ORC system is implemented and direct push injection is performed around the perimeter of the pond.

SWMU 24

Three remedial alternatives were developed for SWMU 24 on the basis of the general response actions and the results of the screening of remedial technologies. The following alternatives were identified for detailed evaluation:

- Alternative 1 – No Action
- Alternative 2 – Institutional Controls, and Long-Term Monitoring
- Alternative 3 – Use of Oxygen Releasing Compound (ORC), Institutional Controls, and Long-Term Monitoring

The major components of each remedial alternative are defined below.

Alternative 1 – No Action

The no action alternative is required by the NCP and serves as the baseline alternative. All other remedial action alternatives are judged against the no action alternative. Under this alternative, no controls or remedial technologies would be implemented. CERCLA (Section 121(c)), as amended by SARA (1986), requires that the site be reviewed every 5 years, since groundwater contamination would remain onsite.

Alternative 2 – Institutional Controls, and Long-Term Monitoring

Alternative 2 consists of administrative measures (groundwater-use restrictions) with long-term monitoring conducted to track groundwater quality and the potential for offsite plume migration. The major components of this alternative are discussed below.

Institutional Controls

Institutional controls at SWMU 24 would include restrictions on the use of groundwater as a potable residential water supply within the site boundaries and within some distance downgradient of the site boundaries.

Long-Term Monitoring

The Navy would prepare a long-term monitoring plan, using the 1998 groundwater data collected at SWMU 24 as a baseline, to detail the procedure for periodic long-term monitoring of *cis*-1,2-DCE, arsenic, iron, and manganese at the SWMU. Based on all the long-term monitoring analytical results, the sampling and analysis scheme would be evaluated and potentially modified during the 5-year site review for the subsequent annual sampling events.

Alternative 3 – Use of a Oxygen Releasing Compound, Institutional Controls, and Long-Term Monitoring

Alternative 3 consists of the use of ORC to enhance biodegradation of contaminants, with the administrative measures and long-term monitoring discussed in Alternative 2.

ORC is a substance that when introduced to an aquifer, slowly releases oxygen and enhances the degradation of a contaminant. ORC is a proprietary formulation of magnesium peroxide, designed to provide a timed release of oxygen. ORC is manufactured as a powder, which can be mixed with water and injected into the aquifer. Through this process, *cis*-1,2-DCE could be reduced to vinyl chloride, which is in turn degraded. Also, arsenic, iron, and manganese could be reduced to insoluble forms.

Institutional Controls and Long-Term Monitoring

The administrative measures to prevent groundwater use would be the same as in Alternative 2. The long-term monitoring would also be implemented as in Alternative 2. The new wells would be installed coincident with the ORC injection so that sampling of the wells would provide information to apply the ORC most efficiently. The long-term monitoring program would begin after the ORC pilot test and full-scale applications (5^{th} year).

Evaluation of Alternatives

The National Contingency Plan outlines the approach for comparing remedial alternatives. Evaluating alternatives involves applying "threshold criteria," "primary balancing criteria," and "modifying criteria." All alternatives are to be evaluated against threshold and primary balancing criteria, which are based on environmental protection, cost, and engineering feasibility. To be considered for selection as the remedial approach, an alternative must meet two threshold criteria. The threshold criteria are: (1) "overall protection" of the environment, and (2) "compliance with applicable or relevant and appropriate requirements (ARARs)" and other guidance. The primary balancing criteria [including (1) reduction of toxicity, mobility, or volume through treatment, (2) long-term effectiveness, (3) short-term effectiveness, (4) ease of implementation, and (5) cost] are then considered to determine which alternative provides the best combination of attributes. The alternatives are further evaluated against two additional modifying criteria: (1) acceptance by USEPA and VDEQ, and (2) acceptance by the community. The remedial alternatives presented for each SWMU were evaluated in the FS against the first seven of the nine criteria identified in the National Contingency Plan. Table 5, 6 and 7 present a summary and comparison of the alternatives at SWMUs 1, 15, and 24, respectively. The FS provides a more detailed analysis.

TABLE 5
Relative Ranking of Alternatives for SWMU 1

Criterion	Alt. 1	Alt. 2	Alt. 3
Overall Protection	○	●	●
Compliance with ARARs and Other Guidance	○	●	●
Reduction of Toxicity, Mobility and Volume through Treatment	○	◗	●
Long-Term Effectiveness	○	●	●
Short-Term Effectiveness	●	●	◗
Implementability	●	●	◗
Cost Effectiveness	●	◗	○

● = High Ranking
◗ = Moderate Ranking
○ = Low Ranking

TABLE 6
Relative Ranking of Alternatives for SWMU 15

Criterion	Alt. 1	Alt. 2	Alt. 3	Alt.4
Overall Protection	○	●	●	●
Compliance with ARARs and Other Guidance	○	●	●	●
Reduction of Toxicity, Mobility and Volume through Treatment	○	◗	◗	●
Long-Term Effectiveness	○	●	●	●
Short-Term Effectiveness	●	●	●	◗
Implementability	●	◗	●	◗
Cost Effectiveness	●	◗	●	○

● = High Ranking
◗ = Moderate Ranking
○ = Low Ranking

TABLE 7
Relative Ranking of Alternatives for SWMU 24

Criterion	Alt. 1	Alt. 2	Alt. 3
Overall Protection	○	●	●
Compliance with ARARs and Other Guidance	○	●	●
Reduction of Toxicity, Mobility and Volume through Treatment	○	◗	●
Long-Term Effectiveness	○	●	●
Short-Term Effectiveness	●	●	◗
Implementability	●	●	◗
Cost Effectiveness	●	◗	○

● = High Ranking
◗ = Moderate Ranking
○ = Low Ranking

Preferred Alternative

As previously stated, SWMUs 1, 15, and 24 were initially investigated following the requirements of the NAS Oceana RCRA 3008 (h) consent order; however, the Navy and the USEPA later agreed to conduct future site remediation activities at NAS Oceana following the procedural and substantive requirements of the CERCLA program. This PRAP documented the nature and extent of contamination at SWMUs 1, 15, and 24, and presented a summary of risks posed by conditions at these SWMUs as determined by previous investigations and risk assessments. The results of the RCRA investigation of SWMUs 1, 15, and 24 are documented in the RFIs and the CMSs. However, as these reports only assessed potential risk to human health and ecological receptors qualitatively, an HHRA and ERA were conducted after the Navy and the USEPA agreed to conduct future site remediation activities following the requirements of the CERCLA program. The RCRA documents and the risk assessments conducted at these SWMUs are the functional equivalents to a CERCLA remedial investigation (RI), as defined in 40 CFR Section 300.430(d). An objective of a CERCLA RI is to assess risks to human health and the environment and to support the development, evaluation, and selection of appropriate response alternatives.

In accordance with 40 CFR Section 300.430(f)(2), the assessment of risk information as related to both human health and the environment is detailed in the preceding Summary of Site Risks sections for each of the SWMUs. These sections provide the investigation summary information and rationale to determine that each of these SWMUs require further action in order to be protective of human health and the environment.

Based on information currently available, the Navy believes the preferred alternatives (as described below) meet the threshold criteria and provide the best balance of tradeoffs among the other alternatives with respect to the balancing and modifying criteria. The Navy expects the preferred alternatives for these SWMUs to satisfy the statutory requirements of CERCLA § 121(b).

The Navy, VDEQ, and USEPA support the preferred alternative for each SWMU. However, their final concurrence with the preferred alternatives will be provided following review of all comments received during the public comment period. The preferred alternatives could change based on public comments.

SWMU 1

Alternative 2, Free-Product Removal and Institutional Controls with Long-term Monitoring, provides a high level of overall protection to human health and the environment by continuing to remove free petroleum product from the groundwater, by monitoring groundwater quality over time, and by preventing potable use of groundwater. Alternative 3, Use of ORC, Free-Product Removal, Institutional Controls, and Long-Term Monitoring, also has a high level of protection of human health and the environment. However, pilot testing would need to be conducted to ensure site-specific feasibility, and with institutional controls in place, Alternative 3 adds minimal benefit by using ORC to reduce contamination levels.

Alternative 3 also has an increased implementation time, and is not cost-effective. Alternative 1 (no action) does not provide protection of human health and the environment.

Figure 3 shows the location of the long-term monitoring wells at SWMU 1 under implementation of Alternative 2. The total estimated present worth cost to implement Alternative 2 is $1,617,700.

SWMU 15

Alternative 3, Long-Term Monitoring with Institutional Controls and Landfarming, provides a high level of overall protection to human health and the environment through the use of landfarming to reduce PAH concentrations in the soil (to meet the human health and ecological PRGs), monitoring of groundwater quality over time, and administrative measures to prevent groundwater exposure to construction workers during any potential excavation and by preventing potable use of groundwater. Alternative 2, Monitored Natural Attenuation with Institutional Controls and Landfarming, and Alternative 4, Downgradient Reactive Curtain of ORC, Long-Term Monitoring, Institutional Controls, and Landfarming, also provide a high level of protection of human health and the environment. However, Alternative 2 would require additional study and implementation time to determine the feasibility of benzene concentration reductions, at a higher cost. Alternative 4 would require additional implementation time to determine site-specific feasibility, and application of this technology may not be warranted if the concentrations of dissolved contaminants in groundwater concentrations meet current regulatory guidelines before adversely affecting potential downgradient receptors, especially with institutional controls in place. Alternative 1 (no action) does not provide protection of human health and the environment.

Figure 4 shows the location of long-term monitoring wells at SWMU 15, and Figure 5 shows the location of the proposed landfarming area at SWMU 15 under implementation of Alternative 3. The total estimated present worth cost to implement Alternative 3 is $1,561,100.

SWMU 24

Alternative 2, Institutional Controls with Long-term Monitoring, provides a high level of overall protection to human health and the environment through the use of institutional controls to prevent potable use of groundwater and by tracking groundwater quality over time. Alternative 3, Use of ORC, Institutional Controls, and Long-Term Monitoring, also provides a high level of protection of human health and the environment. However, with institutional controls in place, Alternative 3 adds minimal benefit by using ORC to reduce contamination levels. In addition, Alternative 3 would require additional implementation time to determine site-specific feasibility (the less permeable contaminated zones may not be degraded as readily under this Alternative) and is not cost effective. Alternative 1 (no action) does not provide protection of human health and the environment.

Figure 6 shows the location of long-term monitoring wells at SWMU 24 under implementation of Alternative 2. The total estimated present worth cost to implement Alternative 2 is $1,348,600.

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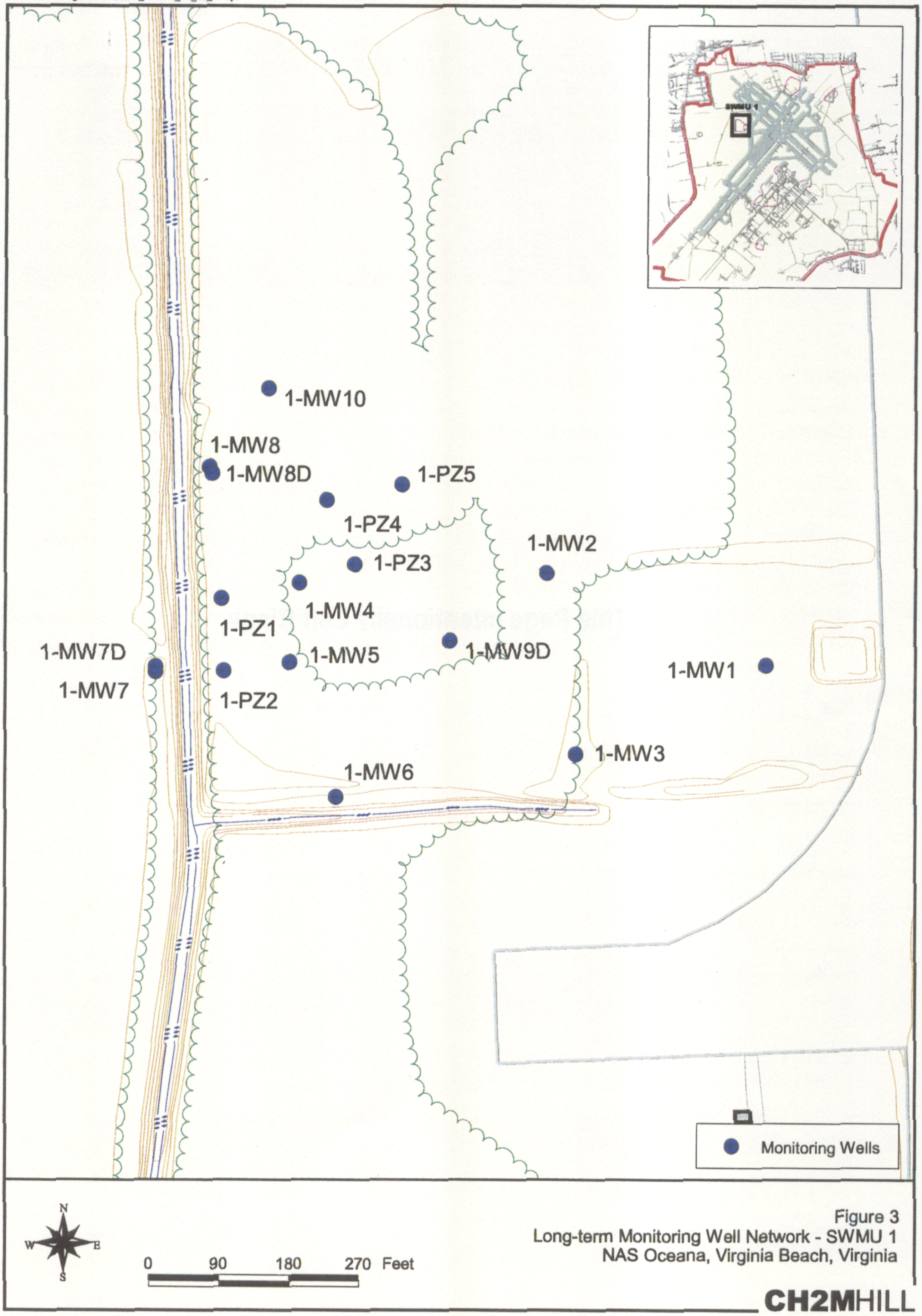

Figure 3
Long-term Monitoring Well Network - SWMU 1
NAS Oceana, Virginia Beach, Virginia

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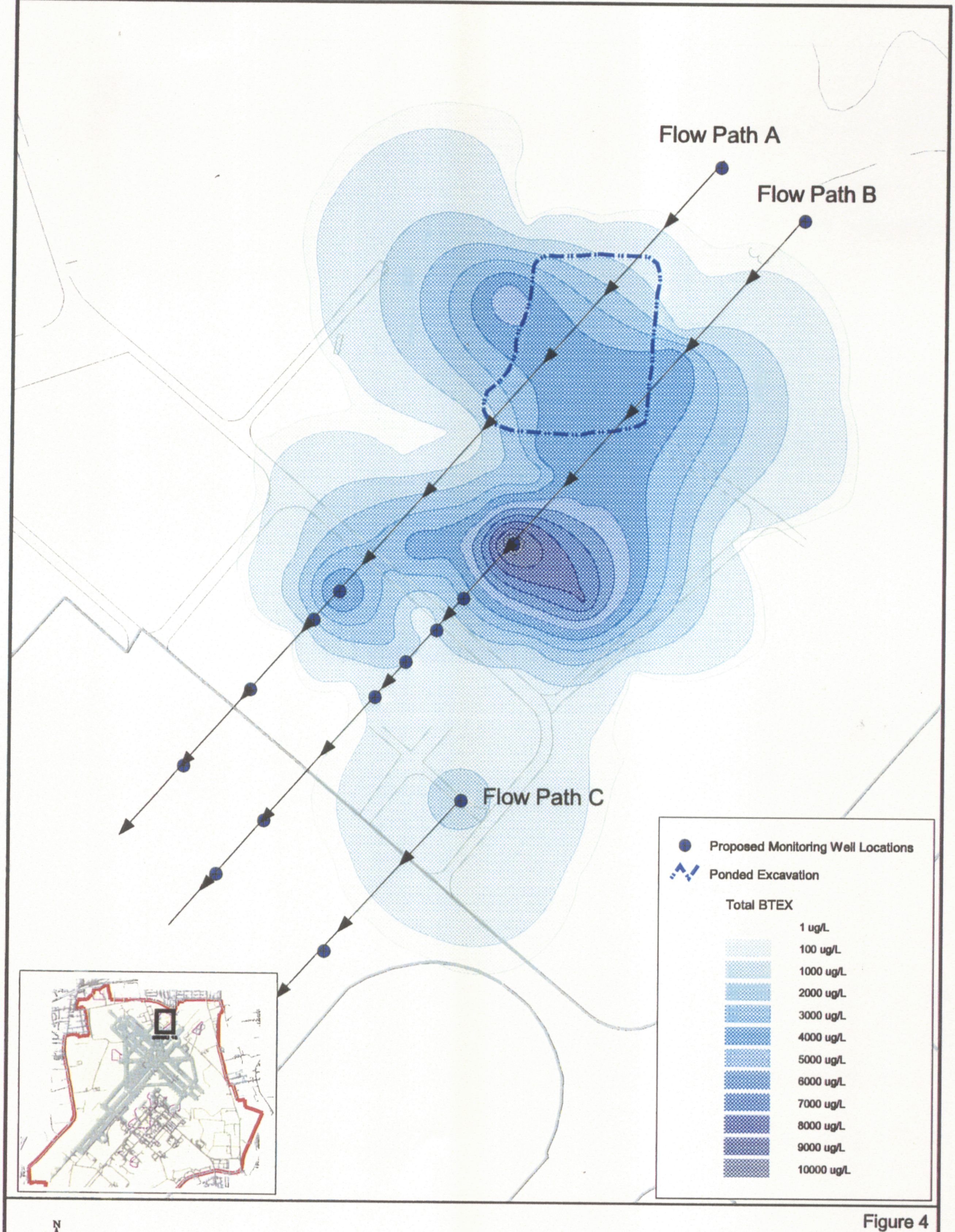

Figure 4
Proposed Monitoring Well Locations
for Long-Term Monitoring - SWMU 15
NAS Oceana, Virginia Beach, Virginia

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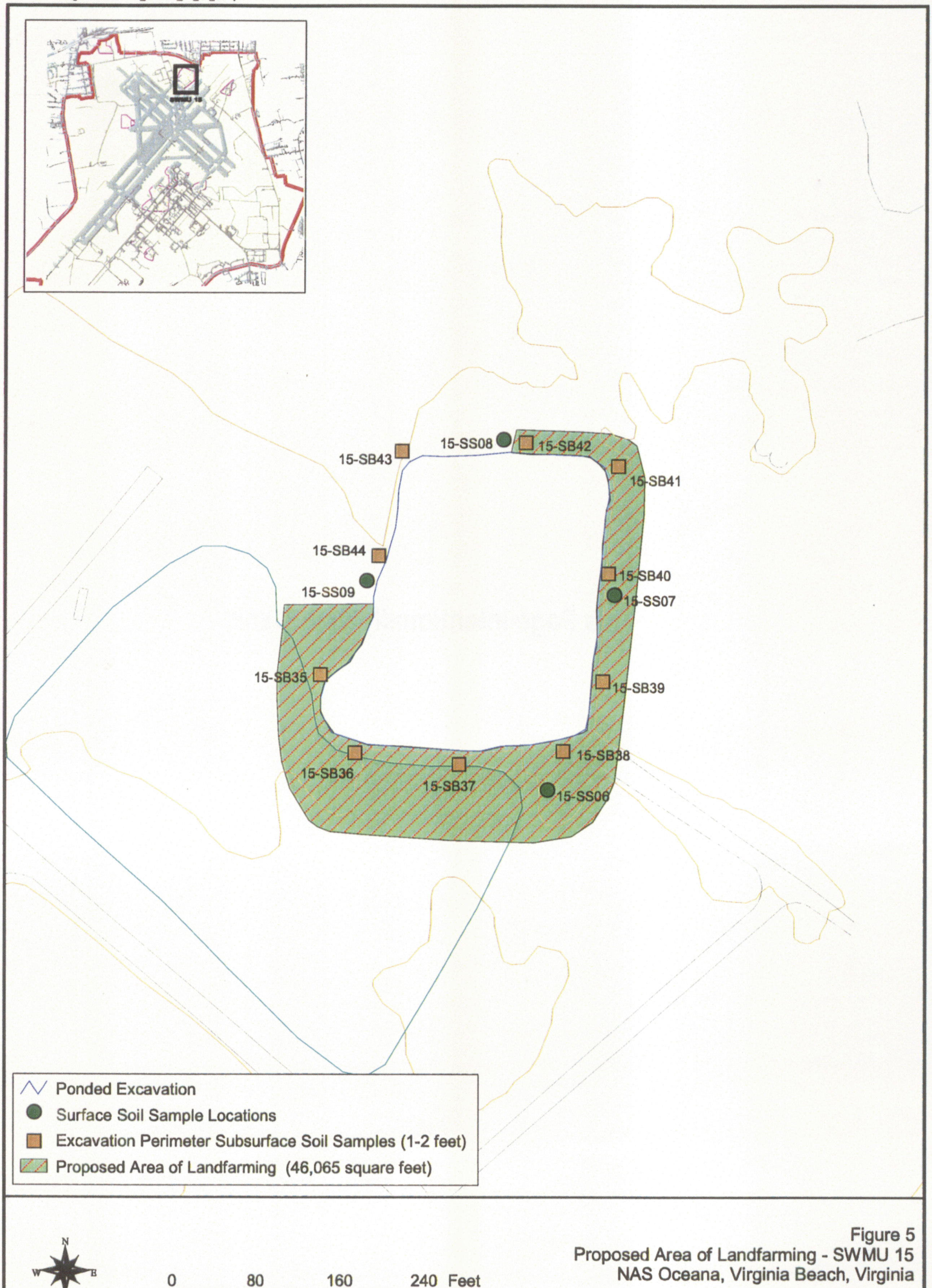

Figure 5
Proposed Area of Landfarming - SWMU 15
NAS Oceana, Virginia Beach, Virginia

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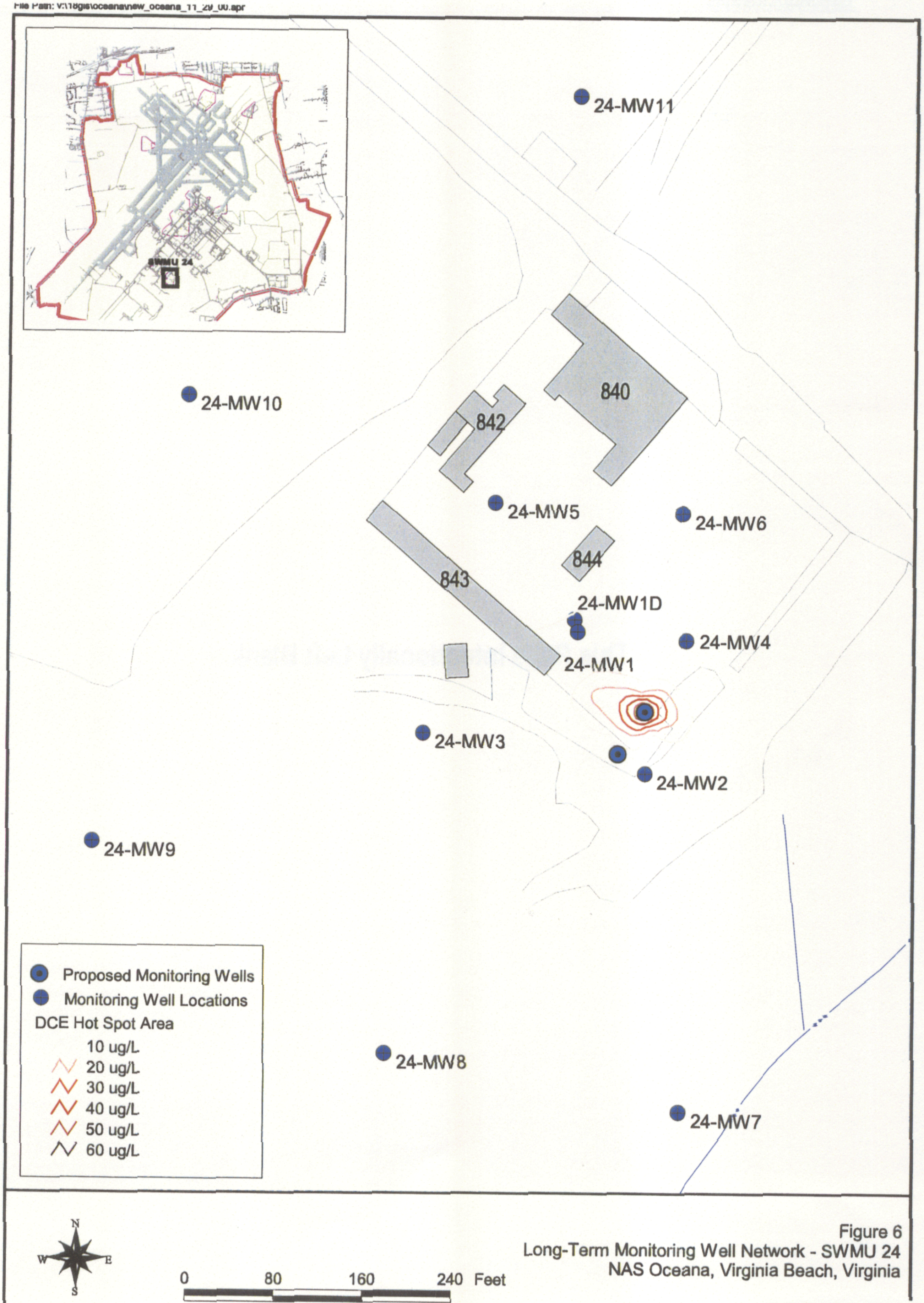

Figure 6
Long-Term Monitoring Well Network - SWMU 24
NAS Oceana, Virginia Beach, Virginia

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