**Final**

November 2020

# Fifth Five-Year Review

## Naval Base Kitsap

Keyport, Washington

**Department of the Navy**
**Naval Facilities Engineering Command Systems Northwest**
1101 Tautog Circle
Silverdale, WA 98315

# EXECUTIVE SUMMARY

The fifth five-year review (FYR) of remedial actions at Operable Units (OUs) 1 and 2 of Naval Base Kitsap (NBK) Keyport has been completed pursuant to Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. § 9621(c), and Section 300.430(f)(4)(ii) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. § 300.430(f)(4)(ii).

Because hazardous substances, pollutants, or contaminants remain in place at the OUs above levels that allow for unlimited use and unrestricted exposure, a statutory review (i.e., FYR) is required under CERCLA and the NCP. The purpose of a FYR is to determine whether the remedies selected for implementation in the decision document for a site remain protective of human health and the environment. The data review and technical assessment performed and resulting protectiveness determinations are documented in this FYR report, which also identifies issues that affect current and/or future protectiveness of the remedies and provides recommendations to address these issues.

This FYR was initiated in June 2019 and is based on analytical data generated between July 2014 and June 2019. This FYR report was prepared as part of the CERCLA FYR process using U.S. Navy and United States Environmental Protection Agency (EPA) guidance (U.S. Navy, 2004, 2011b, 2013c, 2014a; EPA, 2001, 2012, and 2016) and organized in accordance with EPA's 2016 recommended template – streamlined to minimize information that has been presented in the previous FYRs.

In accordance with U.S. Navy and EPA guidance, a technical assessment was conducted to determine if: a) the remedies are functioning as intended by the decision documents; b) exposure assumptions, toxicity data, cleanup levels and remedial action objectives identified in the decision documents and used during remedy implementation are still valid and protective; and c) other information has come to light that compromises the protectiveness of the remedies. As a result of the technical assessment, issues or findings (and subsequent recommendations) have been identified for OU 1, OU 2 Area 2, and OU 2 Area 8.

The remedy at OU 1 is short-term protective, as exposure pathways that could result in unacceptable risk are being controlled and monitored via LUCs while additional data are obtained and the conceptual site model is updated. Ecology, EPA, and the Suquamish Tribe do not concur with the Navy's protectiveness determination for OU 1 and feel that a determination of 'protectiveness deferred' would be more appropriate.

The remedy at OU 2 Area 2 is short-term protective. The remedy at OU 2 Area 8 is protective of human health and not protective of ecological receptors based on a finding of unacceptable risk, and contingency actions (i.e., including a supplemental remedial investigation, focused feasibility study, record of decision amendment, remedial design/remedial action, and shoreline repair, as needed) are not complete. As identified in the ecological risk assessments, acute and chronic exposure to accumulated site contaminants of concern in intertidal zone sediment on the beach adjacent to OU 2 Area 8 (referred to as the "Area 8 beach" from here forward) pose a current hazard to benthic organisms based on the bioassay results/endpoints.

# FIVE-YEAR REVIEW SUMMARY FORM

<table>
<tr><th colspan="5">SITE IDENTIFICATION</th></tr>
<tr><td colspan="5">Site Name (from WasteLAN): Naval Undersea Warfare Engineering Station (4 Waste Areas)</td></tr>
<tr><td colspan="5">EPA ID (from WasteLAN): WA1170023419</td></tr>
<tr><td colspan="2">Region: 10</td><td colspan="2">State: WA</td><td>City/County: Kitsap</td></tr>
<tr><th colspan="5">SITE STATUS</th></tr>
<tr><td colspan="5">NPL Status: Final</td></tr>
<tr><td colspan="2">Multiple OUs? Yes</td><td colspan="3">Has the site achieved construction completion? Yes, remedy construction is complete for all OUs at NBK Keyport.</td></tr>
<tr><th colspan="5">REVIEW STATUS</th></tr>
<tr><td colspan="5">Lead agency: U.S. Navy</td></tr>
<tr><td colspan="5">Author name (Federal or State Project Manager): Carlotta Cellucci</td></tr>
<tr><td colspan="5">Author affiliation: Naval Facilities Engineering Command Northwest</td></tr>
<tr><td colspan="5">Review period: July 2014 – June 2019</td></tr>
<tr><td colspan="5">Date of site inspection: September 19, 2019</td></tr>
<tr><td colspan="5">Type of review: Statutory</td></tr>
<tr><td colspan="5">Review number: 5 (Fifth)</td></tr>
<tr><td colspan="5">Triggering action date: December 2015</td></tr>
<tr><td colspan="5">Due date: December 2020</td></tr>
<tr><th colspan="5">Issues/Recommendations</th></tr>
<tr><td colspan="5">OU(s) without Issues/Recommendations Identified in the Five-Year Review:</td></tr>
<tr><td colspan="5">None</td></tr>
<tr><td colspan="5">Issues and Recommendations Identified in the Five-Year Review:</td></tr>
<tr><td rowspan="3">OU(s): 1</td><td colspan="4">Issue Category: Remedy Performance</td></tr>
<tr><td colspan="4">Issue: Investigations pursuant to recommendations from the fourth FYR (U.S. Navy, 2015b) have documented subsurface geology and contaminant distribution that differs significantly from the CSM understanding at the time of the ROD (U.S. Navy, EPA, and Ecology, 1998).</td></tr>
<tr><td colspan="4">Recommendation:<br>1. Complete the on-going investigations to update the CSM.<br>2. Complete the planned updates to the human health and ecological risk assessments using the updated CSM and incorporating the latest guidance and ARARs.<br>3. In collaboration with the project team, review and revise (as appropriate) the points of compliance and RAOs.<br>4. Based on the results of items 1 through 3, evaluate the need for any early remedial actions and/or a focused FS leading to an optimized remedy.</td></tr>
<tr><th>Affect Current Protectiveness</th><th>Affect Future Protectiveness</th><th>Implementing Party</th><th>Oversight Party</th><th>Milestone Date</th></tr>
<tr><td>No</td><td>Yes</td><td>U.S. Navy</td><td>Ecology</td><td>December 2023</td></tr>
</table>

<table>
<tr><td rowspan="3">OU(s): 1</td><td colspan="4">Issue Category: Remedy Performance</td></tr>
<tr><td colspan="4">Issue: Investigations pursuant to recommendations from the fourth FYR (U.S. Navy, 2015b) have documented an area of the landfill north of the north phytoremediation plantation with elevated PCB concentrations in soil that may represent a discrete source of the PCBs consistently detected in water from seep SP1-1, and a potential source of recontamination to an area of the wetland previously remediated.</td></tr>
<tr><td colspan="4">Recommendation:<br>1. Conduct an investigation to delineate and characterize the potential PCB source in soil.<br>2. In collaboration with the project team, evaluate the need for a removal action to address the PCB source.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Implementing Party</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>Yes</td><td>U.S. Navy</td><td>Ecology</td><td>December 2022</td></tr>
<tr><td rowspan="3">OU(s): 2, Area 2</td><td colspan="4">Issue Category: Remedy Performance</td></tr>
<tr><td colspan="4">Issue: The consistent vinyl chloride detections above the RG and recent increased concentration in well 2MW-6 may be an indication that cVOC mass detected in shallow groundwater (i.e., wells 2MW-1, 2MW-3, and MW2-10) during the RI may have since migrated deeper and further downgradient than revealed by the monitoring network.</td></tr>
<tr><td colspan="4">Recommendation: Conduct a limited data gap investigation to refine the CSM and verify the leading edge of the cVOC plume, both laterally and vertically, at OU 2 Area 2.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Party Responsible</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>Yes</td><td>U.S. Navy</td><td>Ecology</td><td>December 2022</td></tr>
<tr><td rowspan="3">OU(s): 2, Area 8</td><td colspan="4">Issue Category: Remedy Performance</td></tr>
<tr><td colspan="4">Issue: During this FYR period, the HHRA concluded that no contingency/additional actions are necessary to protect human health. However, the ERA concluded that acute and chronic exposure to accumulated contaminants in sediment poses a current potential hazard to benthic organisms at the adjacent beach based on the bioassay results/endpoints. This area of exposure with unacceptable risk is well delineated and of limited extent within the intertidal zone.</td></tr>
<tr><td colspan="4">Recommendation: Implement a contingent groundwater control action as required by the selected remedy (U.S. Navy, EPA, and Ecology, 1994). To identify a feasible contingent action, perform a supplemental RI and focused FS. Once identified and agreed upon by regulators and stakeholders, perform remedial design, implement the remedial action, and potentially conduct a shoreline repair to address elevated COC concentrations in intertidal sediment and on-going discharge of these COCs in seep water. Prepare a ROD amendment or Explanation of Significant Differences (ESD) to document the contingent action taken. Prepare a ROD amendment or Explanation of Significant Differences (ESD) to document the contingent action taken.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Party Responsible</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>Yes</td><td>Yes</td><td>U.S. Navy</td><td>Ecology</td><td>December 2024</td></tr>
</table>

| Protectiveness Statement(s) | | |
|---|---|---|
| **Operable Unit:** 1 | **Protectiveness Determination:** Short-Term Protective | **Addendum Due Date:** Not applicable |
| **Protectiveness Statement:** The remedy at OU 1 is short-term protective. Exposure pathways that could result in unacceptable risks are being controlled and monitored via LUCs while further information is being obtained. Investigation work is on-going to verify the risk conclusions in the OU 1 ROD, to allow evaluation of potential additional removal or remedial action(s) that could be taken to shorten the overall restoration timeframe, and to ensure the remedy is protective in the long term. | | |
| **Operable Unit:** 2 (Area 2 and Area 8) | **Protectiveness Determination:** Not Protective | **Addendum Due Date:** Not applicable |
| **Protectiveness Statement:** The remedy at OU 2 Area 2 is short-term protective. Exposure pathways that could result in unacceptable risks are being controlled and monitored via LUCs; however, the consistent vinyl chloride detections above the RG and recent increased concentration in well 2MW-6 may be an indication that cVOC mass detected in shallow groundwater (i.e., wells 2MW-1, 2MW-3, and MW2-10) during the RI may have since migrated deeper and further downgradient than revealed by the monitoring network. The remedy at OU 2 Area 8 is protective of human health; however, it is not protective of ecological receptors based on a finding of unacceptable risk, for which a contingent remedial action has not yet been implemented, as required by the ROD. To identify a feasible contingent groundwater control action, the Navy will perform a supplemental RI and focused FS. Once identified, and agreed upon by regulators and stakeholders, the Navy will perform remedial design, implement remedial action, and potentially conduct a shoreline repair to address elevated COC concentrations in intertidal sediment and on-going discharge of these COCs in seep water. A ROD amendment or Explanation of Significant Differences (ESD) will be prepared to document the contingent groundwater control action taken. The human health risk assessment at the Area 8 beach intertidal zone concluded that, despite the presence of several COCs in the beach sediment and clam tissue at concentrations exceeding background and reference area concentrations, the incremental site risk over reference area risk for Suquamish subsistence and recreational receptors meets target health goals. The ecological risk assessment concluded that there was no risk to higher trophic level species, but acute and chronic exposure to accumulated contaminants in sediment pose a current potential hazard to benthic organisms based on the bioassay results/endpoints. | | |
| **Operable Unit:** Sitewide | **Protectiveness Determination:** Not Protective | **Addendum Due Date:** Not applicable |
| **Protectiveness Statement:** The remedies at NBK Keyport are not protective based on a finding of unacceptable ecological risk at OU 2 Area 8. | | |

## SIGNATURE PAGE

Signature sheet for the Naval Base Kitsap Keyport fifth FYR report.

R.G. Rhinehart
Captain, U.S. Navy
Commanding Officer, Naval Base Kitsap

23 Nov 20
Date

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AFFF | aqueous film forming foam |
| ARAR | applicable or relevant and appropriate requirement |
| ATSDR | Agency for Toxic Substances and Disease Registry |
| AWQC | ambient water quality criteria |
| bgs | below ground surface |
| BTV | background threshold value |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| CLARC | cleanup levels and risk calculation |
| cm | centimeter |
| CO | contracting officer |
| COC | chemical of concern |
| COI | chemical of interest |
| CRA | contingent remedial action |
| CSM | conceptual site model |
| CTL | critical tissue level |
| cVOC | chlorinated volatile organic compound |
| DCA | dichloroethane |
| DCE | dichloroethene |
| EC | engineering control |
| Ecology | Washington State Department of Ecology |
| EPA | U.S. Environmental Protection Agency |
| ESS | environmental sequence stratigraphy |
| FFA | Federal Facilities Agreement |
| FS | feasibility study |
| g/day | gram per day |
| GC/MS | gas chromatograph/mass spectrometer |
| GRO | gasoline range organic |
| HCID | hydrocarbon identification |
| Health District | Kitsap County Health District |
| HHRA | human health risk assessment |
| HI | hazard index |
| HPT | hydraulic profiling tool |
| HQ | hazard quotient |
| IC | institutional control |
| kg | kilogram |
| KIC | Keyport Improvement Club |

| | |
|---|---|
| LEL | lower explosive limit |
| LHA | Lifetime Health Advisory |
| LOD | limit of detection |
| LTM | long-term monitoring |
| LUC | land use control |
| | |
| MCL | maximum contaminant level |
| µg/kg | microgram per kilogram |
| µg/L | microgram per liter |
| µg/m$^3$ | microgram per cubic meter |
| mg/kg | milligram per kilogram |
| mg/L | milligram per liter |
| MIP | membrane interface probe |
| MLLW | mean lower low water |
| MNA | monitored natural attenuation |
| MS&T | Missouri University of Science and Technology |
| MTCA | Model Toxics Control Act |
| MW | monitoring well |
| | |
| NAPL | non-aqueous phase liquid |
| Navy | U.S. Navy |
| NAVFAC NW | Naval Facilities Engineering Command Northwest |
| NBK | Naval Base Kitsap |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| NFA | no further action |
| NOAA | National Oceanic and Atmospheric Administration |
| NUWC | Naval Undersea Warfare Center |
| | |
| O&M | operation and maintenance |
| OM&M | operation, maintenance, and monitoring |
| ORO | oil range organics |
| OU | operable unit |
| | |
| PA | preliminary assessment |
| PAL | project action limit |
| PCB | polychlorinated biphenyl |
| PCE | tetrachloroethene |
| PED | polyethylene diffusion passive sampler |
| PFAS | per- and polyfluoroalkyl substances |
| PFBS | perfluorobutanesulfonic acid |
| PFOA | perfluorooctanoic acid |
| PFOS | perfluorooctanesulfonic acid |
| PHA | public health assessment |
| ppm | parts per million |
| PQL | practical quantitation limit |
| PUD | Public District Utility (Kitsap County) |
| | |
| RAB | Restoration Advisory Board |

| | |
|---|---|
| RAO | remedial action objective |
| redox | oxidation reduction |
| RG | remedial goal |
| RI | remedial investigation |
| ROD | Record of Decision |
| RPM | remedial project manager |
| RSL | regional screening level |
| | |
| SAP | sampling and analysis plan |
| SCO | sediment cleanup objective |
| SI | site investigation |
| SIM | selected ion monitoring |
| SMS | sediment management standards |
| SQS | sediment quality standard |
| SVOC | semi-volatile organic compound |
| | |
| TCA | trichloroethane |
| TCE | trichloroethene |
| TEQ | toxicity equivalent |
| TLV | threshold limit value |
| TOC | total organic carbon |
| TPH | total petroleum hydrocarbons |
| TRV | toxicity reference value |
| | |
| USGS | U.S. Geological Survey |
| UST | underground storage tank |
| UE | unrestricted exposure |
| UU | unlimited use |
| | |
| VI | vapor intrusion |
| VOC | volatile organic compound |
| | |
| XSD | halogen specific detector |
| | |
| WAC | Washington Administrative Code |
| WDOH | Washington Department of Health |
| WQC | water quality criteria |

# 1.0 INTRODUCTION

This report presents the results of the fifth five-year review (FYR) performed for Naval Base Kitsap (NBK) Keyport National Priorities List (NPL) site, including Operable Units (OUs) 1 and 2. The purpose of a FYR is to determine whether the remedies selected for implementation at sites in the associated Record of Decision (ROD) remain protective of human health and the environment. The data review and technical assessment performed, and protectiveness determinations developed during the FYR process are documented in this FYR report, which also identifies issues, if any, found during the FYR process, and provides recommendations to address these issues.

This FYR was prepared pursuant to Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. § 9621(c), and Section 300.430(f)(4)(ii) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 C.F.R. § 300.430(f)(4)(ii). Because hazardous substances, pollutants, or contaminants remain at the OUs and sites above levels that allow for unlimited use and unrestricted exposure (UU/UE) following implementation of the remedial action, a statutory review (i.e., FYR) is required under CERCLA and the NCP. This FYR was initiated in June 2019 and is based on data reports generated between July 2014 and June 2019. In addition, analytical data from ongoing studies have been summarized. The triggering action for this review is the execution of the fourth FYR (U.S. Navy, 2015b), which was signed on December 11, 2015. The previous FYRs for NBK Keyport were completed in 2000, 2005, 2010, and 2015 (U.S. Navy, 2000b, 2005a, 2010a, and 2015e).

This FYR report was prepared as part of the CERCLA FYR process using U.S. Navy and U.S Environmental Protection Agency (EPA) guidance (U.S. Navy, 2004, 2011b, 2013c, 2014a; U.S. EPA, 2001, 2012, and 2016), documenting the results of the review, identified issues, and recommended actions. This FYR report is organized in accordance with U.S. EPA's 2016 recommended template and has been streamlined to minimize information that has been presented in the previous four FYRs. The intent is to focus on activities and issues over the last five years, current protectiveness and recommendations for the next five years.

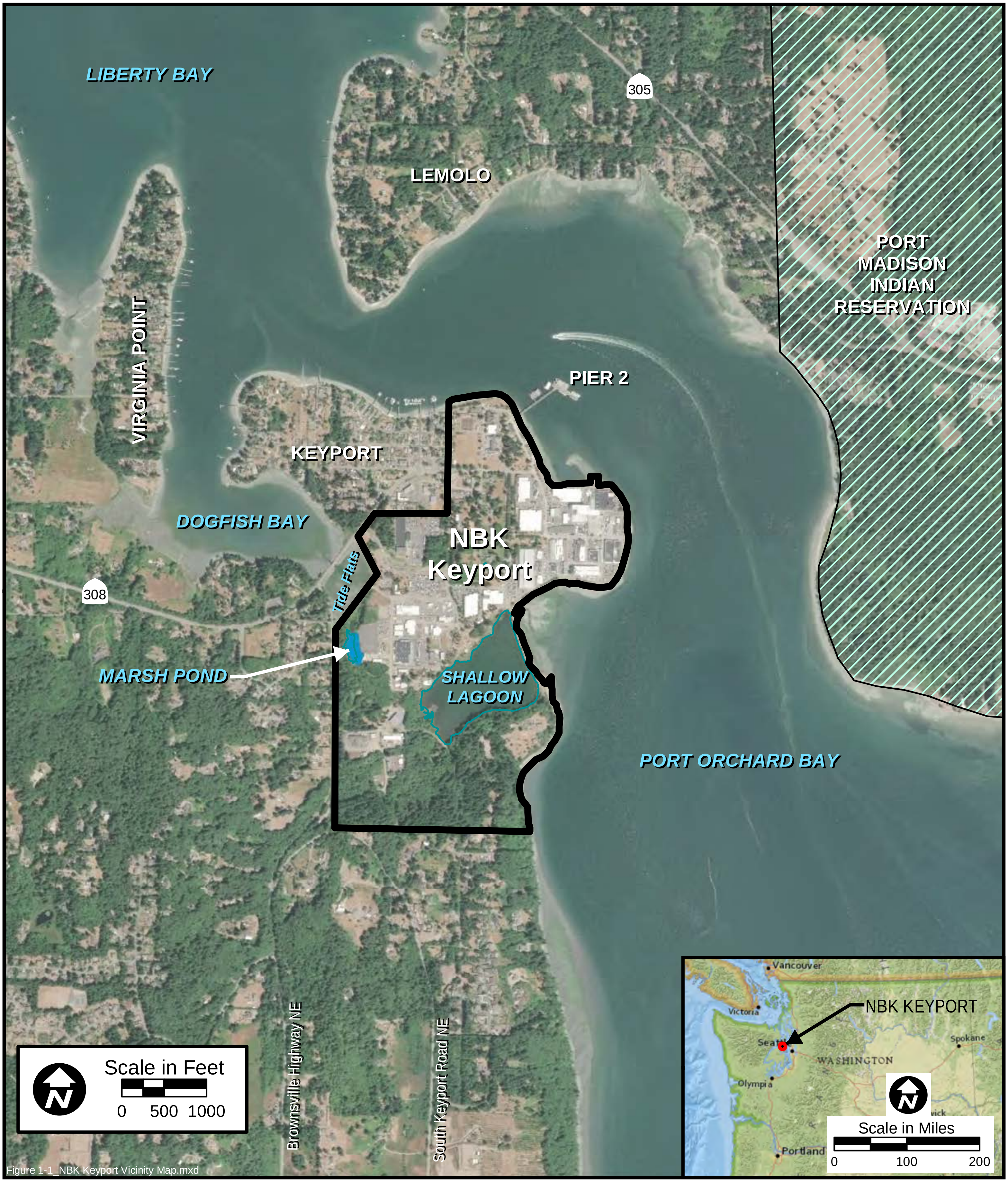
NBK Keyport is bordered by Liberty Bay on the north and northwest and Port Orchard Inlet on the northeast and east, and is adjacent to the town of Keyport (see Figure 1-1). Several areas and sites at NBK Keyport have been impacted by historical activities, resulting in environmental releases and hazardous substances, pollutants, or contaminants remaining above levels that allow for UU/UE. The areas and sites comprising OU 1 and OU 2 sites at NBK Keyport include the following:

- OU 1:
  - Area 1 – Former Landfill
- OU 2:
  - Area 2 – Van Meter Road Spill/Drum Storage Area
  - Area 3 – Otto Fuel Leak Area (no further action; not subject to FYR)
  - Area 5 – Sludge Disposal Area (no further action; not subject to FYR)
  - Area 8 – Plating Shop Waste/Oil Spill Area
  - Area 9 – Liberty Bay (no further action; not subject to FYR)

This FYR report covers the remedies selected in the Record of Decisions (RODs) for OU 1 and OU 2 (U.S. Navy, EPA, Ecology, 1998 and 1994, respectively). The OU 1 ROD specifies that the site "was also called Area 1 and is currently designated Operable Unit (OU) 1", so is referred to as OU 1 from here forward. The OU 2 ROD specifies that only Area 2 and Area 8 are subject to the FYR; no further action or FYR is required for Area 3; and only confirmation sampling was required at Areas 5 and 9. Because confirmation sampling (U.S. Navy, 1996a and 1996b) at both Areas 5 and 9 indicated contamination did not exceed any associated remedial goals (RGs), no further action was also required for Areas 5 and 9. Therefore, Areas 3, 5, and 9 meet UU/UE levels and, as such, are not subject to FYRs. OU 2 Areas 3, 5, and 9 are not carried further in this FYR and were not included in previous FYRs (U.S. Navy, 2000b, 2005a, 2010a, and 2015b).

In addition to OU 1 and OU 2, one LUCs-only site was included in previously FYRs: Site 23. Although Site 23 has LUCs, it was not included in the OU 1 or OU 2 RODs, and so is not subject to the FYR process. Therefore, neither Site 23 nor any of the other LUCs-only sites (i.e., Sites 7 and 22) at NBK Keyport have been included in this FYR to better follow FYR guidance.

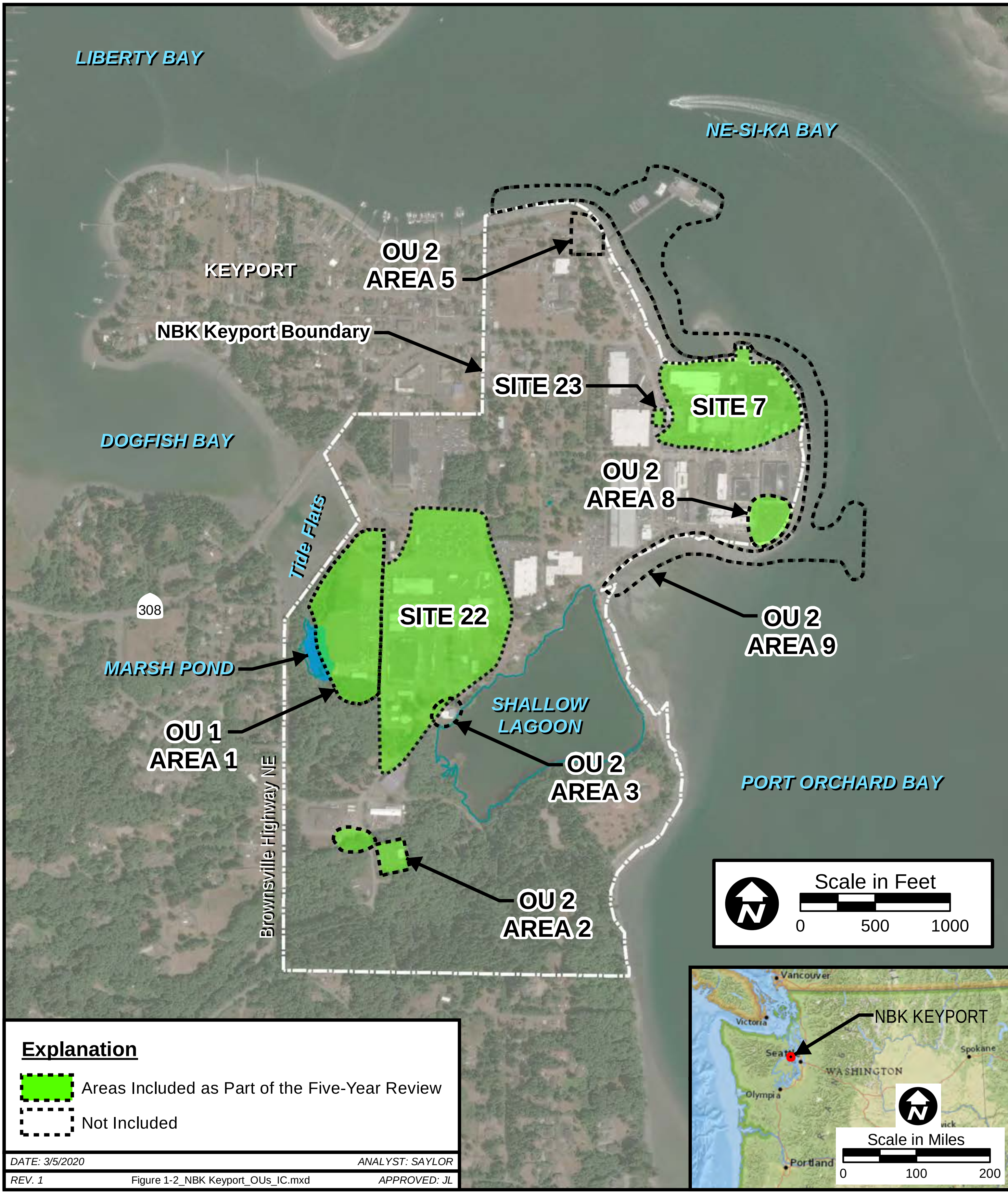
The areas that comprise OU 1 and OU 2 are shown on Figure 1-2. OU 1, OU 2 Area 2, and OU 2 Area 8 are shown in Figures 1-3 through 1-5, respectively. Figure 1-6 depicts the chronology of events at OU 1, OU 2 and sitewide. Table 1-1 summarizes the history of contamination, physical characteristics, primary threat, land and resource use, and removal actions performed at each of these sites. A more in-depth description of each site is available in the fourth FYR (U.S. Navy, 2015b).



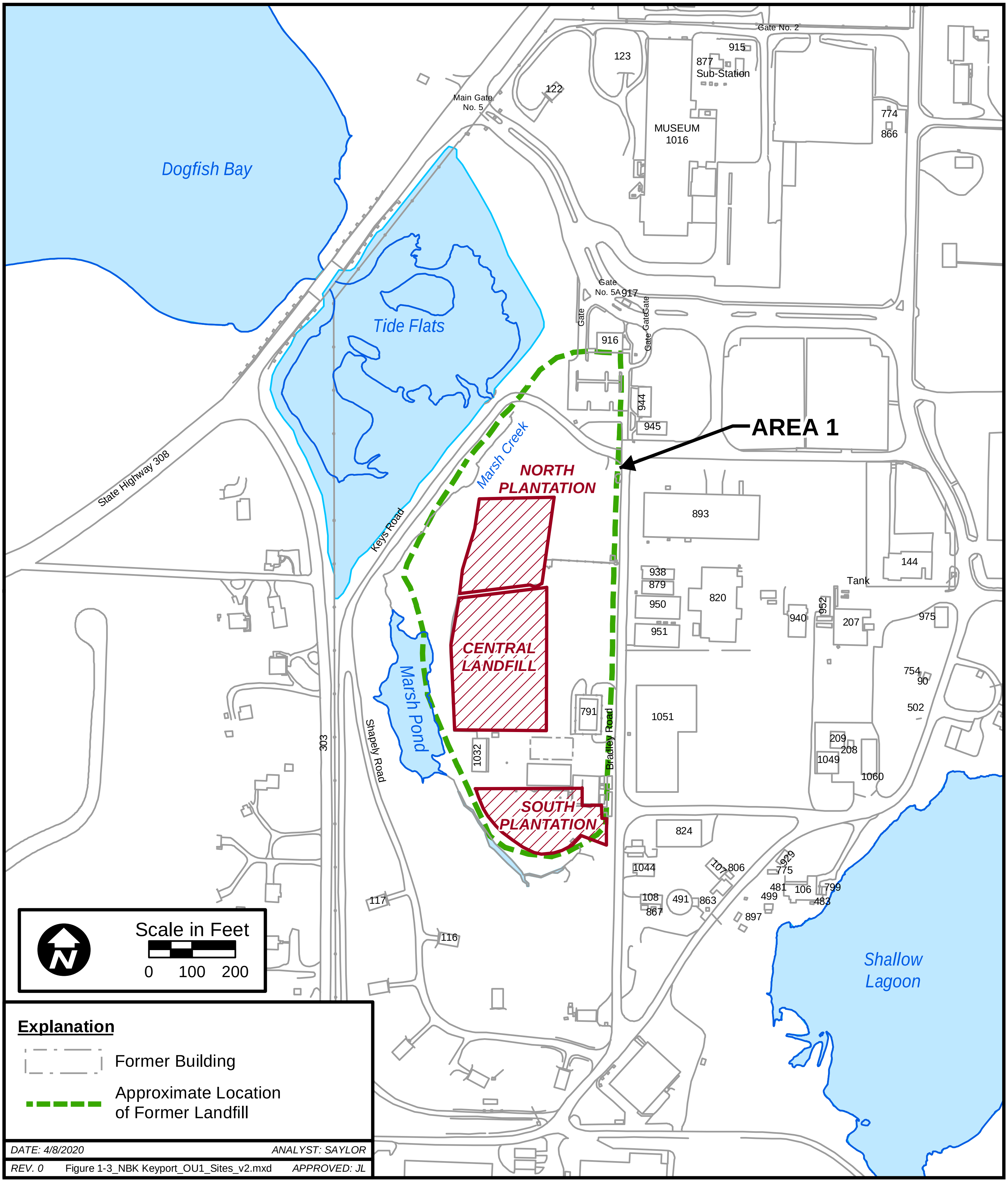

U.S. NAVY

**Figure 1-1**
**NBK Keyport Vicinity Map**

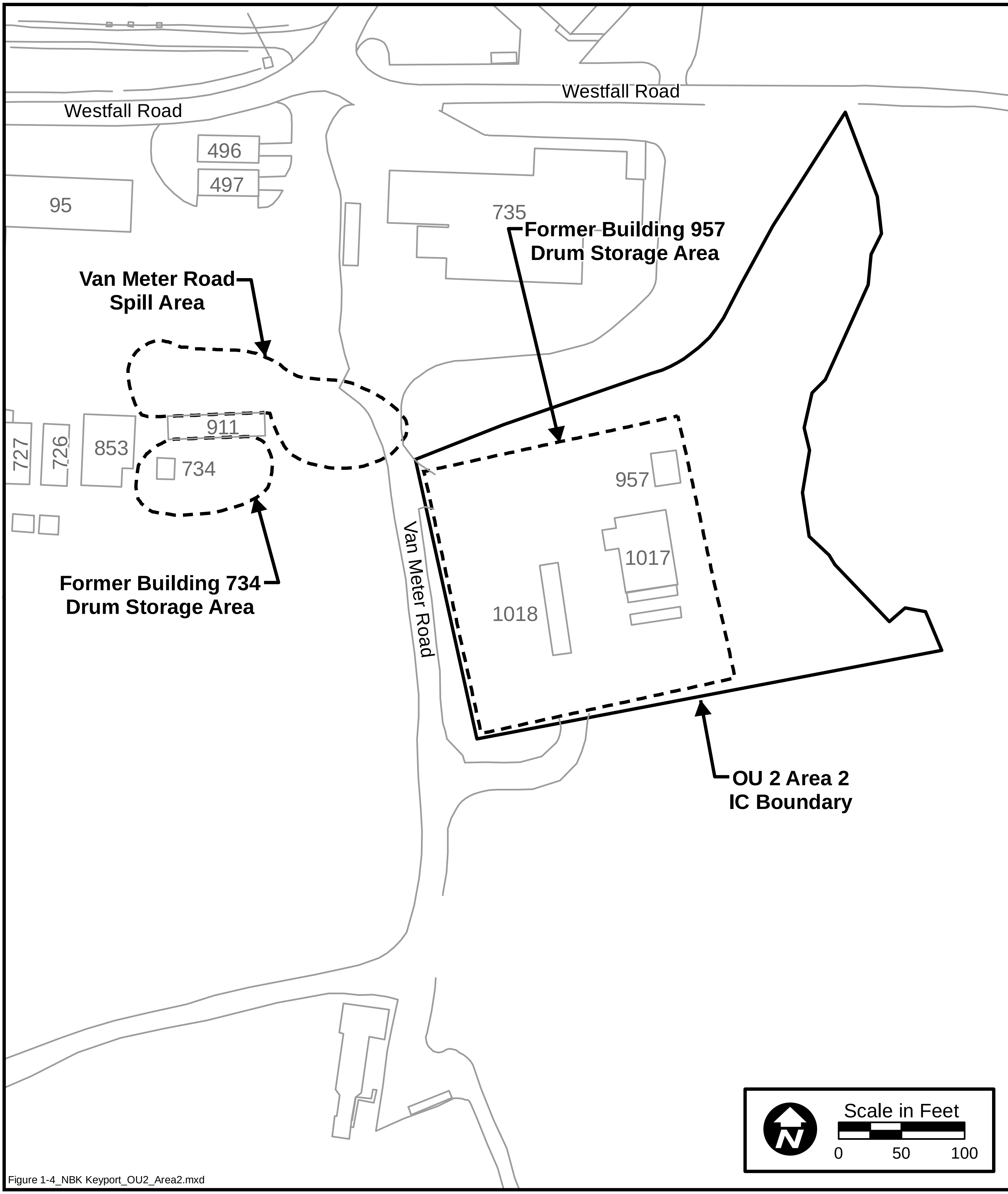
NBK KEYPORT
FIFTH
FIVE-YEAR REVIEW




| U.S. NAVY | **Figure 1-2**<br>**Locations of OU 1, OU 2, and Institutional Control Only Sites** | NBK KEYPORT<br>FIFTH<br>FIVE-YEAR REVIEW |
|---|---|---|




| | | |
|---|---|---|
| **U.S. NAVY** | **Figure 1-3**<br>**OU 1 Area 1 Site Map** | NBK KEYPORT<br>FIFTH<br>FIVE-YEAR REVIEW |




| | | |
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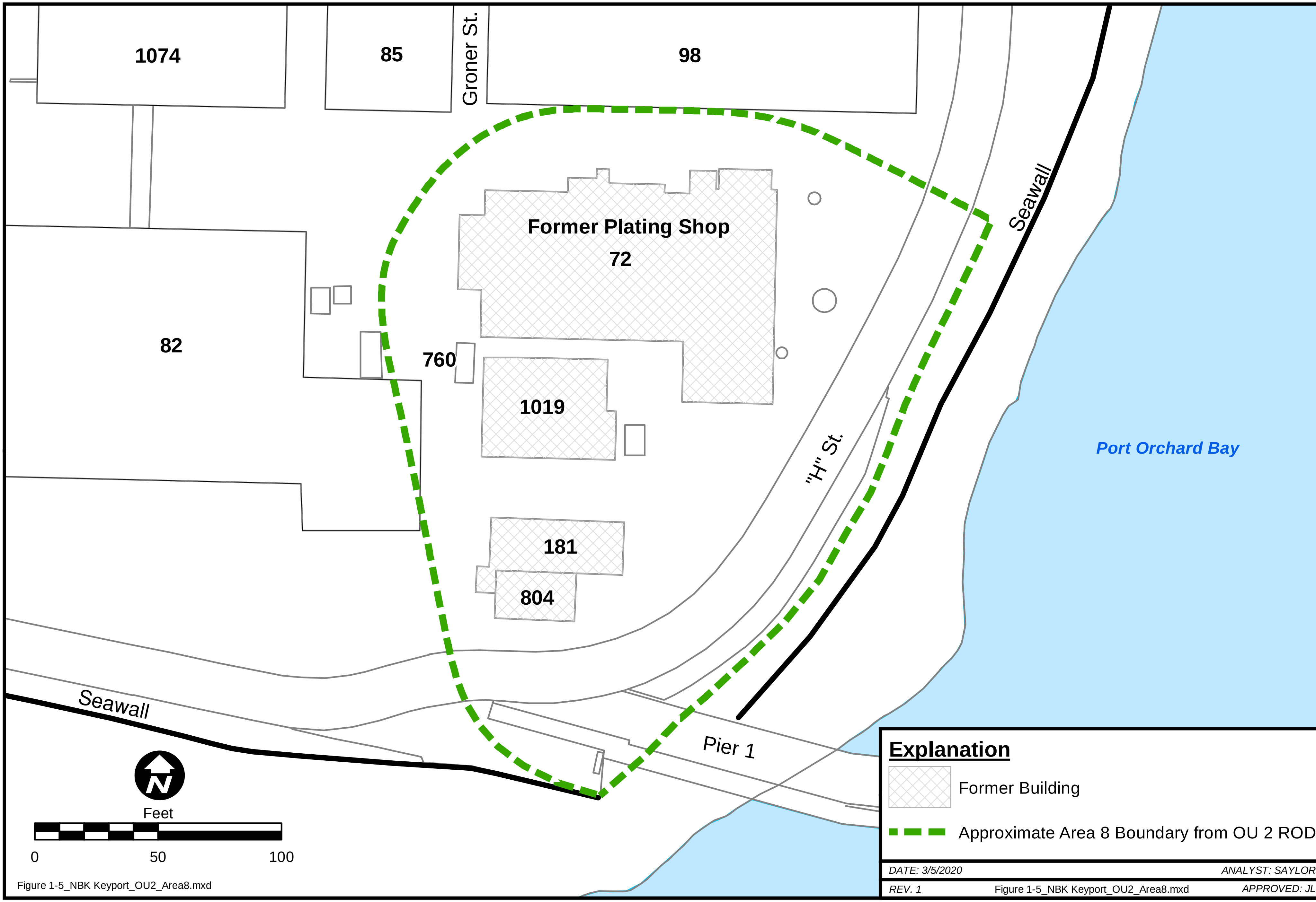
| **U.S. NAVY** | **Figure 1-4**<br>**OU 2 Area 2 Site Map** | NBK KEYPORT<br>FIFTH<br>FIVE-YEAR REVIEW |




| | | |
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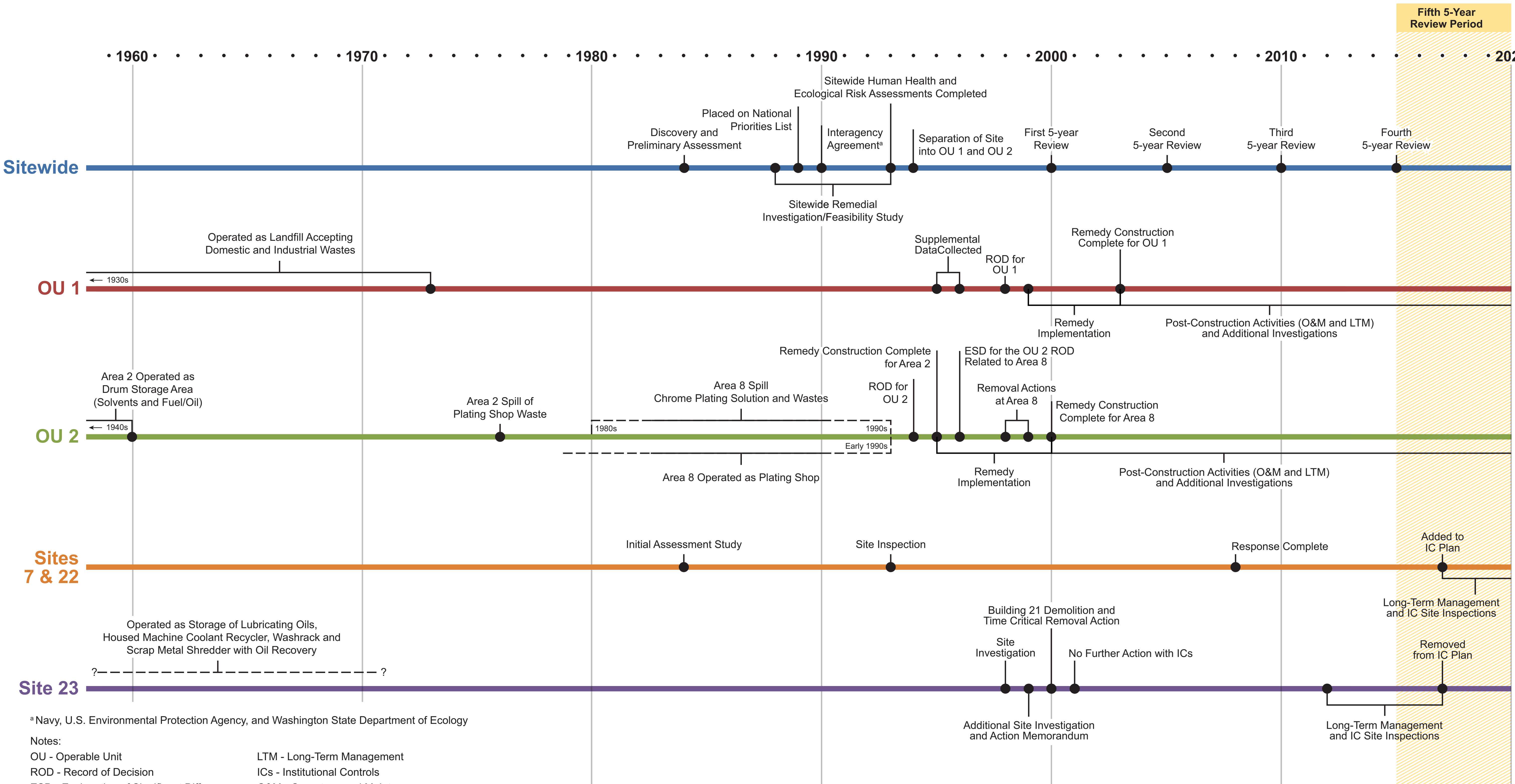
| **U.S. NAVY** | **Figure 1-5**<br>**OU 2 Area 8 Site Map** | NBK KEYPORT<br>FIFTH<br>FIVE-YEAR REVIEW |




[a] Navy, U.S. Environmental Protection Agency, and Washington State Department of Ecology

Notes:

| | |
|---|---|
| OU - Operable Unit | LTM - Long-Term Management |
| ROD - Record of Decision | ICs - Institutional Controls |
| ESD - Explanation of Significant Differences | O&M - Operatons and Maintenance |

FIGURE 1-9_CHRONOLOGY_KEYPORT_5TH FYR_v3.CDR

U.S. NAVY

**Figure 1-6**
**Chronology of Events at OU 1, OU 2, Sites 7 & 22, and Site 23**

NBK KEYPORT
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FIVE-YEAR REVIEW

**Table 1-1. Background Information Summary**

| Site/Area | History of Contamination | Physical Characteristics | Primary Threat | Land and Resource Use | Removal Actions Performed |
|---|---|---|---|---|---|
| | | | ***Operable Unit 1*** | | |
| Former Landfill | • 1930s until 1972 – Primary base landfill. Disposal area for domestic and industrial wastes generated by the base until closed.<br>• 1930s to the 1960s – Burn pile for trash and demolition debris located at the north end of the landfill. Unburned or partially burned materials from this pile were buried in the landfill or pushed into the marsh.<br>• 1930s to the 1960s – Trash incinerator was operated at the north end of the landfill and incinerator ash was disposed of in the landfill.<br>• | • Covers approximately 9 acres of the western part of the base.<br>• Is unlined, and covered with areas of grass, trees, concrete, and asphalt.<br>• Placed in the eastern portion of a marsh and stream complex, remnants of which remain to the west, flowing through tide flats and into Dogfish Bay.<br>• Groundwater is present in a shallow unconfined aquifer with a water table at 4 to 8 feet bgs. Shallow groundwater in this aquifer flows west towards the adjacent surface water with a deeper component of flow to the northwest. | • Chlorinated aliphatic hydrocarbons pose a risk to human health from drinking water and seafood ingestion pathways, and vapor intrusion at the landfill surface.<br>• Polychlorinated biphenyls (PCBs) pose a risk to human health from bioaccumulation, potentially impacting the seafood ingestion pathway. | • Occupied buildings for office space and industrial uses are adjacent to the former landfill east of Bradley Road.<br>• Two phytoremediation plantations occupy the majority of the northern and southern portions of the landfill. The central portion of the landfill is paved and currently used regularly for motorcycle training and as a parking lot. | • Removal of PCB-contaminated sediments from marsh to prevent PCBs from potentially migrating to the tide flats and Dogfish Bay. |
| | | | ***Operable Unit 2*** | | |
| Area 2 – Van Meter Road Spill/Drum Storage Area | • Comprised of three (3) areas: Building 734 former drum storage area, Building 957 former drum storage area and Van Meter Road spill area.<br>• 1940s through the 1960s – Drum storage areas were active and reportedly stored all chemicals used at the base (including solvents and fuel/oil). An estimated 4,000 to 8,000 gallons of these chemicals were discharged to the two unpaved areas as a result of spills and leaks.<br>• 1976 – Approximately 2,000 to 5,000 gallons of plating shop wastes spilled from a tanker truck on the pavement near Van Meter Road, impacting a nearby stream. | • Located in the southwest corner of the base and bounded to the north and east by Westfall Road, to the west by Keys Road, and to the south by a sharp topographical rise.<br>• Van Meter Road bisects the area in a north-south direction.<br>• Groundwater is present at a depth of approximately 4 to 8 ft bgs. | • Trichloroethene (TCE) and vinyl chloride were identified as chemicals of concern (COCs) in the drum storage areas during the Remedial Investigation/Feasibility Study (RI/FS) based on the risk analysis.<br>• No significant risk was identified at the Van Meter Road plating shop waste spill.<br>• No significant risk to terrestrial or aquatic organisms was identified at any of the three areas at Area 2. | • Area 2 is currently used for inert materials storage and intermittently for industrial purposes. | • None. |
| Area 8 – Plating Shop Waste/Oil Spill Area | • Past releases include spillage of chrome plating solution containing VOCs onto the ground; discharge of plating wastes into a utility trench; and leakage of plating solutions through cracks in the plating shop floor, waste disposal pipes, and sumps during plating shop operation.<br>• Petroleum hydrocarbons (i.e., diesel and heavy oil) were also released to the environment from leaking underground storage tanks (USTs) and underground concrete vaults located within Area 8. | • Occupies 1 acre on the eastern portion of the base and surrounds the location of the former plating shop (Building 72).<br>• Groundwater is present at a depth of approximately 10 ft bgs.<br>• Shallow groundwater from the site discharges into Port Orchard Bay. | • VOCs and metals (i.e., arsenic, cadmium, and chromium) were identified as COCs in groundwater based on residential use of groundwater as drinking water and inhalation during household use. Arsenic concentrations were suspected to be related to background concentrations; and therefore, dropped as a COC.<br>• VOCs, semi-volatile organic compounds (SVOCs), and total petroleum hydrocarbons (TPH) diesel were identified in 1998 and 1999 near the former fuel storage vaults. | • Area 8 is in a heavily industrialized part of the facility bordered by Port Orchard Bay to the south and east.<br>• The area is used for parking and has occupied buildings for office space and industrial uses. | • Removal and disposal of "hot-spot" metals-contaminated soil.<br>• Removal of TPH-contaminated soil, conducted under the UST Program as an independent action in accordance with Model Toxics Control Act (MTCA) regulations. |

# 2.0 RESPONSE ACTION SUMMARY

This section summarizes remedy implementation; actions subsequent to remedy implementation; and operations, maintenance, and monitoring at OU 1 and OU 2. A more detailed narrative description of the response actions at NBK Keyport is available in Section 4 of the third FYR (U.S. Navy, 2010a). Table 2-1 provides a remedial action summary, including reasonably anticipated land use, COCs requiring action, media, cleanup levels, remedial action objectives (RAOs), remedy components, remedy construction complete, and site closeout strategy for OU 1 and OU 2 sites.

At OUs 1 and 2, the remedies include land use controls (LUCs). The terminology LUCs, includes both institutional controls (ICs) and engineering controls (ECs). Historically at NBK Keyport, the term IC has been used to identify all LUCs, and this is not consistent with the current standard usage of these terms (U.S. Navy, 2001b). For consistency with Navy guidance (U.S. Navy, 2001b), this FYR uses the term "LUC" rather than "IC" to discuss both the ICs and ECs associated with each site.

## 2.1 Operable Unit 1

This section discusses the remedy construction; and investigations, operations, maintenance, and monitoring for OU 1 conducted during this FYR period (see Figures 1-2 and 1-3). Remedies identified in the ROD have been implemented; construction is complete for all elements; operation, maintenance, and monitoring activities are ongoing; and LUCs are in place.

### *2.1.1 OU 1 Remedy Construction*

Per the OU 1 ROD (U.S. Navy, EPA, Ecology, 1998), the remedy included the following components, which have been completed:

- April 1999 – Planted two phytoremediation plantations of hybrid poplar trees, referred to as the "north" and "south" plantations, designed to work in concert with monitored natural attenuation to remove and treat VOC-contaminated groundwater and reduce the long-term potential for VOC migration from the site.
- November 1999 – Upgraded the tide gate to improve the control of tidal flow between the tide flats and the marsh, thereby ensuring that the landfill is protected from tidal inundation that could erode its banks or adversely affect contaminant mobilization (U.S. Navy, 1999c).
- 1999 – Installed three wells (MW1-41 and two irrigation wells), 10 piezometers, and two lysimeters to monitor groundwater concentrations and water levels.
- 1999 – Removed PCB-contaminated sediment from a small area of the marsh near the tide flat to prevent PCB-contaminated sediment from potentially migrating to the tide flats and Dogfish Bay (U.S. Navy, 1999c).
- March 2003 – Prepared a contingent remedial action (CRA) plan, specifying the conditions under which the Navy will implement additional remedial actions if the identification of significant contaminant concentrations are found to be migrating from OU 1 to water supply wells in the area (U.S. Navy, 2003a). Consistent with CERCLA, the CRAs were evaluated against NCP criteria with awareness of the public involvement requirements of CERCLA.

The February 2012 revision of the CRA plan (U.S. Navy, 2012i) addressed recommendations from the third FYR regarding the addition of 1,4-dioxane to the CRA plan.

- January 2005 – Upgraded the asphalt landfill cover to prevent exposure from contact with soil and debris.

### *2.1.2 OU 1 Post-Remedy Construction Investigations*

During this FYR period, additional investigations have been conducted to address recommendations from the fourth FYR (U.S. Navy, 2015b). The activities associated with, and objectives of these investigations are discussed below. The data review and evaluation results are presented and discussed in Section 4.2.

**2014 Phase I Additional Investigation (U.S. Navy, 2015a):** The Phase I investigation included the collection of tree core samples for analysis of chlorinated volatile organic compounds (cVOCs) to identify potential contaminant hotspots in groundwater within and adjacent to the South Plantation, and west or downgradient of the Central Landfill. Geophysical surveys were conducted in the South Plantation and a portion of the Central Landfill to identify the presence or absence of subsurface anomalies that could represent potential contaminant sources and pose health risks for workers during future intrusive investigations. Evaluation of tree core and geophysical data resulted in a refined understanding of COC distribution, used to guide sampling effort conducted during the Phase II field effort.

**2016 and 2017 Phase II Additional Investigation (U.S. Navy, 2017a and 2018b):** A supplemental qualitative subsurface Phase II investigation was conducted to confirm the locations, extent and magnitude of potential hotspots and evaluate potential hotspot treatments that could be used to reduce the restoration timeframe. Based on initial study findings in 2016, an additional quantitative investigation was conducted in and around the South Planation and Central Landfill in the summer and fall of 2017. These supplemental investigations resulted in a revised understanding of site hydrogeology, identifying a single water table aquifer, rather than a shallow and an intermediate aquifer. In addition, these investigations delineated the location, depth, magnitude, and extent of site contaminants, which were found to extend deeper than the current LTM monitoring well network and farther into the marsh south of the landfill than previously known.

**2018 Vapor Intrusion (VI) Study (U.S. Navy, 2019a):** In 2018, VI study activities were conducted at 10 buildings (i.e., Buildings 916, 944, 945, 893, 951, 824, 1051, 108, 820, and 950) east of Bradley Road, adjacent to OU 1 during both later winter and summer timeframes. The overall objectives of the VI study were to: 1) evaluate whether the VI pathway is complete between the site and nearby buildings; 2) assess whether cVOCs in groundwater have contributed to indoor air concentrations via the VI pathway; and 3) collect information to support the selection of appropriate mitigation measures, if required. A preliminary screening was conducted in March 2018 and then indoor air, outdoor air, sub-slab, and exterior soil vapor samples were collected, and differential pressure was monitored in both late winter (March 2018) and summer (July 2018) at each of the 10 buildings.

**2018 Groundwater Model (U.S. Geological Survey [USGS], 2019):** A detailed site-specific numerical groundwater flow and solute transport model was constructed and calibrated that can be used to update the existing CSM, inform risk decisions, and evaluate possible remedial activities at OU 1.

**2018 Tidal Lag Study (USGS, 2019):** In 2018, the USGS conducted a tidal lag study to: 1) better understand nearshore groundwater-seawater interactions; 2) determine the optimal schedule/timing for groundwater sampling at different wells; and 3) inform a concurrent groundwater modeling effort at OU

1. Water levels were continuously monitored in existing groundwater monitoring wells and surface-water features of interest for approximately three weeks, a period that included neap and higher amplitude spring tides. The time-series data also included specific conductance at the surface-water features. However, although time-series data was also scoped to include specific conductance at monitored well locations, the equipment failed to record these data. Therefore, a vertical profile of specific conductance measured once in the screened interval of selected monitored wells during data logger deployment was used to determine if the freshwater/saltwater interface was present and to evaluate tidal lag. Therefore, this study is currently being repeated.

**2019 Source Area Investigation Study:** A source investigation was conducted to gather quantitative data to verify the migration path of 1,4-dioxane from the Central Landfill hotspots; determine the source of PCB contamination in site sediments; and better define the extent of contamination at the east side of the South Plantation, in the marsh area southeast of the South Plantation, and in Marsh Creek. Lithologic data were also collected to better map the regional aquitard contact within the site boundary and to conduct fate and transport modeling. An internal draft report has not yet been prepared for this investigation, so only a preliminary summary of this data is presented in this FYR. Data from these investigations will be used to update the existing CSM, allow better evaluation of remedy effectiveness, and support a focused feasibility study designed to evaluate alternatives for the treatment of identified hotspots to reduce restoration timeframe.

The conceptual site model (CSM) continues to be reevaluated based on data obtained from these supplemental investigations.

### *2.1.3 OU 1 Operations, Maintenance, and Monitoring*

**Operation and Maintenance.** Since the fourth FYR (U.S. Navy, 2015b), the Navy has continued operation and maintenance (O&M) of the OU 1 remedy. The O&M at OU 1 consists of the following:

- Phytoremediation tree health maintenance
- Tide gate inspection and maintenance

Phytoremediation O&M activities have been conducted since the trees were planted in 1999. The primary objective is to establish and maintain mature, healthy stands of trees to maximize contaminant uptake by the trees. Inspections are scheduled to occur eight times per year. The plantations are inspected/ monitored for overall condition, including general physical health, insect damage, water stress, nutrient deficiency, and disease symptoms. Scheduled maintenance actions include weeding, thinning, pruning, and identifying and reporting any pests found on a regular basis and applying fertilizer as directed by the Navy. Additional maintenance activities/corrective actions occur as necessary, such as treating infestations with pesticide and/or herbicide applications to maintain healthy stands of trees.

Tide gate inspection and maintenance occurs four times per year and has been performed since the tide gate was upgraded in 1999. The primary objective is to ensure that the tide gate is working as intended and designed to limit tidal flooding of the marsh, which could cause erosion of the landfill and/or adversely affect planation tree health. Routine tide gate maintenance, cleaning and testing are conducted during each inspection and include removing any biofouling, sediment or debris lodged or accumulated on any parts of the tide gate or upper culvert grate.

All inspection and maintenance activities since the last FYR were generally performed in accordance with the Inspection and Maintenance Plan (U.S. Navy, 2012h), Quality Control Plan (U.S. Navy, 2014b) and the revised O&M Plan (U.S. Navy, 2017d). This O&M Plan applies to long-term O&M of the phytoremediation plantations and tide gate system at OU 1 and includes recommendations from the 2015 and 2016 Annual O&M Reports (U.S. Navy, 2016a and 2017d), the Spring 2016 OU 1 LTM Report (U.S. Navy, 2017e), and the fourth FYR (U.S. Navy, 2015b).

**Monitoring.** As part of the remedy, a long-term monitoring (LTM) program was initiated in 1999, including phytoremediation monitoring, risk and compliance monitoring, and intrinsic bioremediation monitoring. Since the fourth FYR (U.S. Navy, 2015b), the Navy performed LTM, phytoremediation monitoring, and CRA monitoring of the OU 1 remedy in 2015 and 2016, as in past years. In 2017, activities to support site characterization were added to the LTM program with the concurrence of the Keyport EPA and Ecology Project Managers. In 2018 LTM at Keyport OU 1 was cancelled with the concurrence of the Keyport EPA and Ecology Project Managers, given the drastic change in the CSM and ongoing investigations. However, the LTM contractor was used to perform various sampling efforts in 2018 to support further site characterization. In 2019, the LTM program reverted to the 5-year sampling effort specified in the LTM Plan to support FYR evaluation. Intrinsic bioremediation monitoring by the USGS was conducted from 2002 through 2015, which consistently indicated that bioremediation was active at the site, so monitoring was discontinued, having met the objective in the ROD.

***Long-Term Monitoring***

The LTM program at OU 1 involves periodic sampling of groundwater, seep water, marine sediment, and marine tissue (clam). It also involves periodic water level measurements in wells set in the upper and intermediate portions of the aquifer to monitor the groundwater flow direction. The overall objective of the LTM program is to monitor trends in COC concentrations and evaluate whether the selected remedy meets the RAOs. Activities conducted under the LTM program since the fourth FYR (U.S. Navy, 2015b) have consisted of the following:

- Periodic groundwater elevation measurements throughout OU 1 in monitoring wells and piezometers screened in the upper and intermediate portions of the aquifer.
- Groundwater sampling and chemical analysis from monitoring wells screened within the upper, intermediate, and deeper portions of the water table aquifer, and in the deep, regional aquifer (deep aquifer wells are discussed under the CRA program section).
- Sampling and chemical analysis of surface water at specific locations and seep water at one location.
- Sampling and chemical analysis of sediment from specific locations.
- Sampling and chemical analysis of marine tissue (i.e., clams) from specific locations.

As discussed in the preamble to this monitoring section, LTM was discontinued in 2017, with more focused monitoring events performed in support of the site recharacterization. LTM will be resumed once the LTM plan has been revised in collaboration with the EPA, Ecology and Suquamish Tribe. The actual data collected during this FYR period are discussed in Section 4.2.

All OU 1 monitoring activities since the last FYR were performed in accordance with the regulator-approved LTM Work Plans (U.S. Navy, 2012h and 2017c) as amended by written approval and are based on regulator-approved recommendations in the fourth FYR. The current monitoring frequency exceeds the requirements specified in the ROD for groundwater, surface water, and seep water sampling, as requested by Ecology and with Navy concurrence. The frequency of sediment sampling meets the ROD-specified frequency of once every five years. Figure 2-1 depicts the various media monitoring locations sampled at OU 1 during this FYR period and Table 2-2 presents a list of these monitoring locations along with when these locations were sampled during this FYR period. The most recent monitoring results are discussed in Section 4.2. Details regarding groundwater elevation monitoring and chemical analysis monitoring of media are discussed below.

**Groundwater Elevations.** Groundwater level measurements are being collected biennially in even years concurrent with LTM sampling. This exceeds the ROD requirement of once every five years, but was requested by Ecology. These data are used to estimate groundwater gradient and flow directions beneath and downgradient of the former landfill in both the upper and intermediate portions of the aquifer. An effort is made to collect measurements near the time of low tide and data are reported with a reference to the tidal stage.

**Groundwater Sampling and Chemical Analysis.** Groundwater sampling monitors the extent and magnitude of VOC contamination in the upper and intermediate portions of the water table aquifer, and the deeper, regional aquifer beneath and downgradient of the former landfill. In addition to VOCs, wells MW1-09, MW1-38, MW1-39, Public Utility District (PUD), and Navy Supply Well #5 are also sampled to monitor for 1,4-dioxane. The analytical results are compared to the groundwater RGs established in the ROD (based on drinking water and seafood ingestion pathways), or in the case of 1,4-dioxane, the MTCA Method B cleanup level, since 1,4-dioxane monitoring was added via recommendations in the second and third FYRs. Long-term groundwater contamination trends are tracked to evaluate if the remedy is working as expected and/or if RGs/MTCA has been met.

**Surface Water Sampling and Chemical Analysis.** Five surface water samples and one seep sample (i.e., SP1-1) are sampled annually from three surface water locations and once every five years from two surface water locations, to monitor the fate, transport, and natural attenuation of VOCs in surface water. The seep is sampled once every five years for VOCs, and has been sampled biennially for PCBs since 2017. These sampling stations are in a series aligned upstream to downstream, beginning in the marsh pond adjacent to the landfill, through the outlet channel to the tide flats, and out to Dogfish Bay. Surface water samples are analyzed for VOCs and seep water samples are analyzed for VOCs and PCBs.

**Sediment Sampling and Chemical Analysis.** Sediment locations are distributed throughout the marsh, tide flats, and Dogfish Bay to monitor the fate and transport of contaminants migrating from the landfill through the marsh pond. Sediment samples from these locations are analyzed for PCBs and total organic carbon (TOC) once every five years and a one-time sample was collected at SP1-1 in 2019 to determine if a correlation exists between seep water and sediment PCB concentrations.

**Marine Tissue Sampling and Chemical Analysis.** Marine tissue sampling is conducted twice every five years at one location (i.e., TF21) with samples collected in 2017 and 2019 during this FYR period. Marine tissue (i.e., clam tissue) is analyzed for PCBs (U.S. Navy, 2017a).

***Phytoremediation Monitoring***

Phytoremediation monitoring activities since the last FYR have included the following:

- Periodic groundwater elevation measurements in monitoring wells and piezometers set in the upper portion of the aquifer in and around the plantations;

- Periodic groundwater sampling and chemical analysis from wells primarily in and around the plantations; and
- Periodic surface water and seep water sampling and chemical analysis from stations in the vicinity of the plantations.

Periodic groundwater elevation measurements in monitoring wells and piezometers throughout OU 1 occurred quarterly through 2011. The third FYR (U.S. Navy, 2010a) recommended reducing phytoremediation water-level measurements to once every 5 years to match the ROD-specified frequency. However, since most phytoremediation wells are also used for LTM and groundwater monitoring is conducted every two years, the Navy concluded that it was most efficient to sample wells and collect groundwater elevations throughout OU 1concurrently. These groundwater elevation measurements have been used to assess changes to the groundwater flow pattern in the shallow portion of the aquifer attributable to the phytoremediation plantations. Groundwater elevations are collected from all monitoring well and piezometer locations, as shown on Figure 2-1. Piezometers and passive diffusion samplers (a.k.a., peepers) are used to monitor intrinsic bioremediation at OU 1, so are discussed under the intrinsic bioremediation monitoring section.

All OU 1 phytoremediation chemical analysis monitoring activities since the last FYR were performed in accordance with the regulator-approved LTM Work Plans (U.S. Navy, 2012h and 2017c) and are based on recommendations in the third and fourth FYRs. The current monitoring frequency exceeds the requirements specified in the ROD. The most recent phytoremediation monitoring results are discussed in Section 4.2.

***Contingent Remedial Action Monitoring***
The CRA monitoring program was implemented in conjunction with the risk and compliance and phytoremediation monitoring programs. CRA monitoring includes sampling monitoring wells downgradient of the landfill to monitor for migration of contamination toward off-base domestic wells (U.S. Navy 2012i). All OU 1 CRA monitoring activities since the last FYR were performed in accordance with the regulator-approved LTM Work Plans (U.S. Navy, 2012h and 2017c). The current CRA plan provides a decision matrix for comparison of specific VOC and 1,4-dioxane concentrations in groundwater samples from “sentinel” wells that would trigger additional action to protect human health, such as hooking up affected properties to the public water supply or installing a new drinking water well at an affected properties to tap into the deeper, regional aquifer.

Wells included in CRA monitoring are MW1-09, MW1-38, MW1-39, Navy Supply Well #5, and the offsite PUD well. Groundwater samples collected under this program are analyzed for VOCs and 1,4-dioxane. Figure 2-1 depicts the location of CRA monitoring wells at OU 1 and Table 2-2 presents a list of these monitoring wells along with when these wells were sampled during this FYR period (U.S. Navy, 2003a).

***Intrinsic Bioremediation Monitoring***
The purpose of intrinsic bioremediation monitoring is to periodically: 1) ensure that intrinsic biodegradation conditions at the ROD-defined landfill source zones (North and South Plantations) remain favorable for degradation of cVOCs and 2) assess whether phytoremediation adversely affects conditions favorable to intrinsic biodegradation. As described in the summary data assessment report (U.S. Navy, 1997b) and OU 1 ROD (U.S. Navy, EPA, and Ecology, 1998), groundwater oxidation reduction (redox) conditions at the site appear to be generally favorable for complete degradation of cVOCs into their innocuous byproducts—carbon dioxide, water, and chloride. The favorable conditions identified are

strongly reducing groundwater beneath the source area (which is favorable for reductive dechlorination of TCE and some DCE), followed by mildly reducing groundwater downgradient of the source area (which is favorable for direct oxidation of DCE and vinyl chloride). Because phytoremediation activities could potentially affect redox conditions at the site, the ROD specified that performance monitoring should include the redox conditions beneath the plantations to check for potential adverse effects from phytoremediation. The ROD also allowed for an evaluation of natural attenuation processes in the event that the phytoremediation component of the remedy was discontinued.

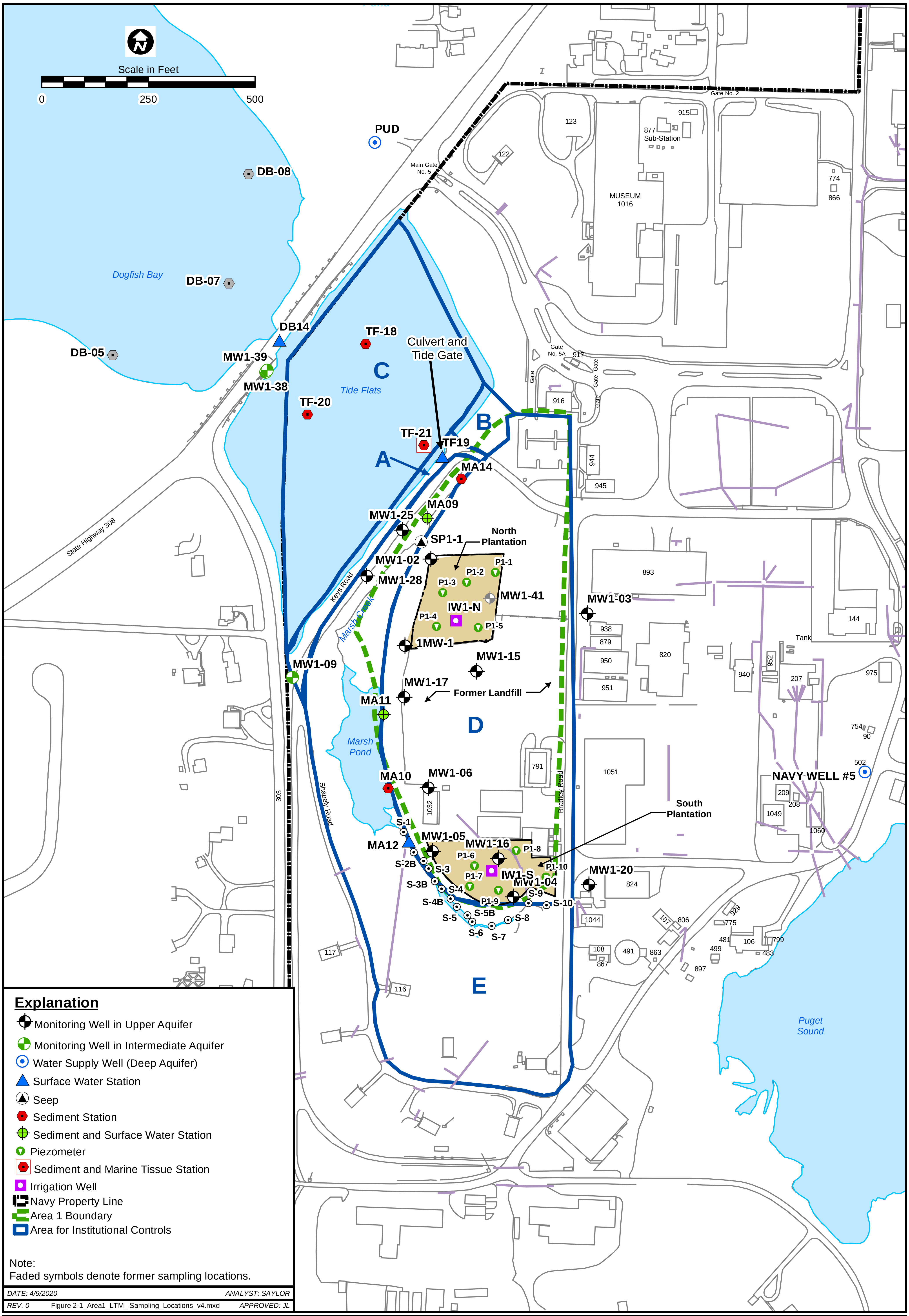
In 1995, the Navy began a cooperative effort with the USGS to investigate various natural attenuation mechanisms at OU 1 (USGS, 2003). The USGS monitored cVOC concentrations and geochemical conditions in groundwater and surface water on an annual basis from 2001 through 2015 to verify that conditions remain favorable for biodegradation. The USGS monitoring program was discontinued after the 2015 sampling event because the Navy concluded that the monitoring program had met its original objectives. The following monitoring wells and piezometers were measured for groundwater elevation and sampled for geochemical parameters, ethane, ethene, and cVOCs in 2015:

- Thirteen monitoring wells (i.e., 1MW-1, MW1-2, MW1-3, MW1-4, MW1-5, MW1-16, MW1-17, MW1-20, MW1-25, MW1-28, MW1-38, MW1-39, MW1-41 and background well MW1-33, which has been abandoned).
- Nine piezometers (i.e., P1-1, P1-3, P1-4, P1-5, P1-6, P1-7, P1-8, P1-9, and P1-10).

The following passive diffusion sampling sites were analyzed for cVOCs in groundwater in 2015:

- Fourteen passive diffusion (peepers) sampling locations (i.e., S-1, S-2, S-2B, S-3, S-3B, S-4, S-4B, S-5, S-5B, S-6, S-7, S-8, S-9, and S-10).

Although USGS did not analyze for cVOCs from wells 1MW-1, MW1-2, MW1-4, MW1-5, and MW1-16, these wells were sampled annually under the phytoremediation monitoring program. Figure 2-1 depicts all sampling locations and Table 2-2 presents a list of these sampling locations along with when these locations were sampled during this FYR period.




U.S. NAVY

**Figure 2-1**
**OU 1 Area 1 LTM Sampling Locations**

NBK KEYPORT
FIFTH
FIVE-YEAR REVIEW

**Land Use Controls.** As part of the remedy, LUCs were initiated in 2000 to prevent undue exposure to landfill contaminants in the future. These LUCs included tide gate inspections, preventing the installation of drinking water wells, preventing interference with remedial activities, and preventing development or activity that would disrupt the natural attenuation processes or disturb the landfill, tide flat, or adjoining marsh and shoreline in a manner that could lead to unacceptable risks to human health.

The updated IC Plan (U.S. Navy, 2017b) describes in detail the current land use and users, objectives of the LUCs, and implementation of the LUCs for OU 1. During this FYR period, annual LUC inspections were conducted to document that LUCs are being maintained and have met the following expectations stated in the OU 1 ROD:

- No new water wells have been installed, except for monitoring wells or wells that may be needed for future remedial actions.
- Access controls have been maintained and have prevented access.
- Current land use remains unchanged, or if changes have been made, the change has been reviewed and approved in collaboration with Ecology and the EPA.
- The asphalt landfill cover surface is present and documented to: 1) not require major repairs, or 2) repairs are recommended.
- No new drinking water wells have been installed on Navy property or within 1,000 feet of the landfill.
- Administrative procedures are in place to control digging at the landfill, and have been followed.

The objectives of the LUCs for areas within OU 1 identified in Figure 2-1 are as follows:

- **Area A** – Land use restrictions that prevent construction of water wells, except for monitoring wells or wells that may be needed for future remedial actions. This area is downgradient of the landfill.
- **Area B** – Land use restrictions that prevent construction of water wells, except for monitoring wells or wells that may be needed for future remedial actions. This area is, or may be, downgradient of the landfill.
- **Area C** – Land use restrictions that address procedures for controlling construction or maintenance activities to prevent activities that would interfere with or compromise the monitoring or other remedial actions for the site. The Navy will be able to conduct construction or maintenance activities. Prior approval of Ecology and EPA will be required for construction or maintenance activities that could affect the monitoring or remedy.
- **Area D** – Land use restrictions and requirements that address maintenance of the landfill cover (including the asphalt cover) and procedures for controlling activities that involve digging or construction at the landfill that could cause exposures to contaminants in soil, groundwater, or vapor within or from the landfill (see 2017 IC Plan for full description).
- **Area E** – Land use restrictions that address procedures for controlling construction or maintenance activities that would (1) disturb the wetlands adjacent to the landfill and could cause exposures to contaminants from the landfill that may be present in the sediments or surface water, or (2) interfere with or compromise the monitoring or other remedial actions for the site. The Navy will be able to conduct necessary construction or maintenance activities subject to (1)

taking measures to protect workers and prevent short-term and long-term risks from landfill contaminants and (2) complying with requirements of pertinent wetlands regulations.

- **All Areas** – NBK Keyport will remain a secure facility, limiting access to individuals with bona fide business with the Navy, or invitees. Should the United States decide to cease using the property for military operations (but continue to manage it), the need for and appropriate degree of fencing and securing measures will be reviewed and reestablished at such time by the Navy, with concurrence by Ecology and EPA.

The results of the annual LUC inspections are discussed in Section 4.3.

## 2.2 Operable Unit 2

This section discusses the remedy construction; investigations subsequent to remedy construction conducted during this FYR period; and operations, maintenance, and monitoring for OU 2 Areas 2 and 8 (see Figures 1-2, 1-4, and 1-5). The remedy for OU 2 has been implemented, construction is complete for all elements, operation, maintenance, and monitoring activities are ongoing, and LUCs are in place.

### *2.2.1 OU 2 Remedy Construction*

Per the OU 2 ROD (U.S. Navy, EPA, and Ecology, 1994), the remedy includes the following components:

Area 2:

- Install additional upgradient wells to confirm no upgradient source of COCs exists.
- Monitor natural attenuation.
- Implement LUCs to protect human health.

Area 8:

- July 1998 and March 1999 – Building 72 demolition and hot-spot soil removal based on cadmium and chromium concentrations exceeding MTCA Method B cleanup levels for soil ingestion.
- Monitor natural attenuation.
- Implement LUCs to protect human health.
- Assess human health and ecological risks based on tissue and sediment data.
- Perform a risk assessment, if warranted.
- Implement contingent groundwater control actions, if Area 8 groundwater discharge to the adjacent beach is demonstrated to represent a risk to human health or the environment.

In addition to the remedy components listed above, VOCs, SVOCs, and TPH as diesel in soil were characterized in 1998 and 1999 at OU 2 Area 8. The monitoring for the independent remedial actions under MTCA for diesel contamination has been completed, as detailed in the fourth FYR (U.S. Navy, 2015b). An Explanation of Significant Differences (ESD) was issued for OU 2 Area 8 in 1996, after initial monitoring requiring chromium speciation indicated that total chromium concentrations could be assumed to be 100 percent hexavalent chromium. Therefore, chromium speciation was discontinued based on the ESD.

### *2.2.2 OU 2 Post-Remedy Construction Investigations*

No additional actions or investigations were conducted at OU 2 Area 2 during this FYR period.

Additional investigations conducted during this FYR period at OU 2 Area 8 include:

- 2015 through 2020 marine investigations and subsequent human health and ecological risk assessments,
- 2017 and 2019 VI investigations, and
- 2018 USGS tidal lag study.

The activities associated with, and objectives of these Area 8 investigations are discussed below. The data review/results are presented and discussed in Section 4.2.

***Area 8 Marine Investigation and Subsequent Risk Assessments.*** A marine investigation report was completed in 2016 (U.S. Navy, 2016d), which documents the results of tissue, sediment, seep water, outfall, and surface water sampling conducted in 2015 and 2016 at the Area 8 beach. The report documents the results of clam tissue and sediment sampling (at ROD-established sampling locations [Stations SS01 to SS09]) and one-time sampling of clam tissue, sediment, seep water, marine water, and outfalls from new locations across the Area 8 beach. The purpose of the investigation was to collect additional data to determine the nature and extent of metals contamination at the Area 8 beach and to support human health and ecological risk assessment. In addition, because of some uncertainty associated with the northern extent of impacted seeps and sediments, additional data collection efforts were conducted to fully characterize the extent of contamination. The marine investigation report includes sampling methodology and data reporting only, without data interpretation, as the project team decided that data interpretation should be informed by the results of the associated risk assessments.

Subsequently, the Human Health Risk Assessment (HHRA)/Ecological Risk Assessment (ERA) (U.S. Navy, 2018a) was conducted to estimate human health and ecological risks associated with exposure to potentially contaminated media (i.e., clam tissue, sediment, seep water, outfall, and surface water) at the Area 8 beach, per the recommendations of the third and fourth FYRs (U.S. Navy, 2010a and 2015b). The specific objectives were to: 1) characterize human health and ecological site risks relative to background; 2) confirm the extent of contamination and update the conceptual site model; and 3) assess the need to implement contingent groundwater control actions based on the results of the risk assessments.

Due to potential risks to benthic organisms determined in the ERA, an ERA addendum was conducted based on Ecology’s Sediment Management Standards (SMS) regulation (i.e., an applicable or relevant and appropriate requirement [ARAR] under the OU 2 ROD) which allows the use of bioassay analysis in cases where chemical concentrations in sediment samples exceed the published numeric standards. Samples that pass the bioassay analysis are considered to not pose an unacceptable risk to benthic organisms.. The primary objective of the ERA addendum was to collect additional data needed to fully evaluate the potential risks to the benthic community from COCs originating from OU 2 Area 8 and finalize the ERA. To meet this objective, eight (8) OU 2 Area 8 sediment samples (including one duplicate), one (1) OU 2 Area 8 seep water sample, three (3) reference area sediment samples, and one (1) reference area seep water sample, were collected in June 2019, and tested under a bioassay program developed in collaboration with by EPA, Ecology and the Suquamish Tribe in July and August 2019.

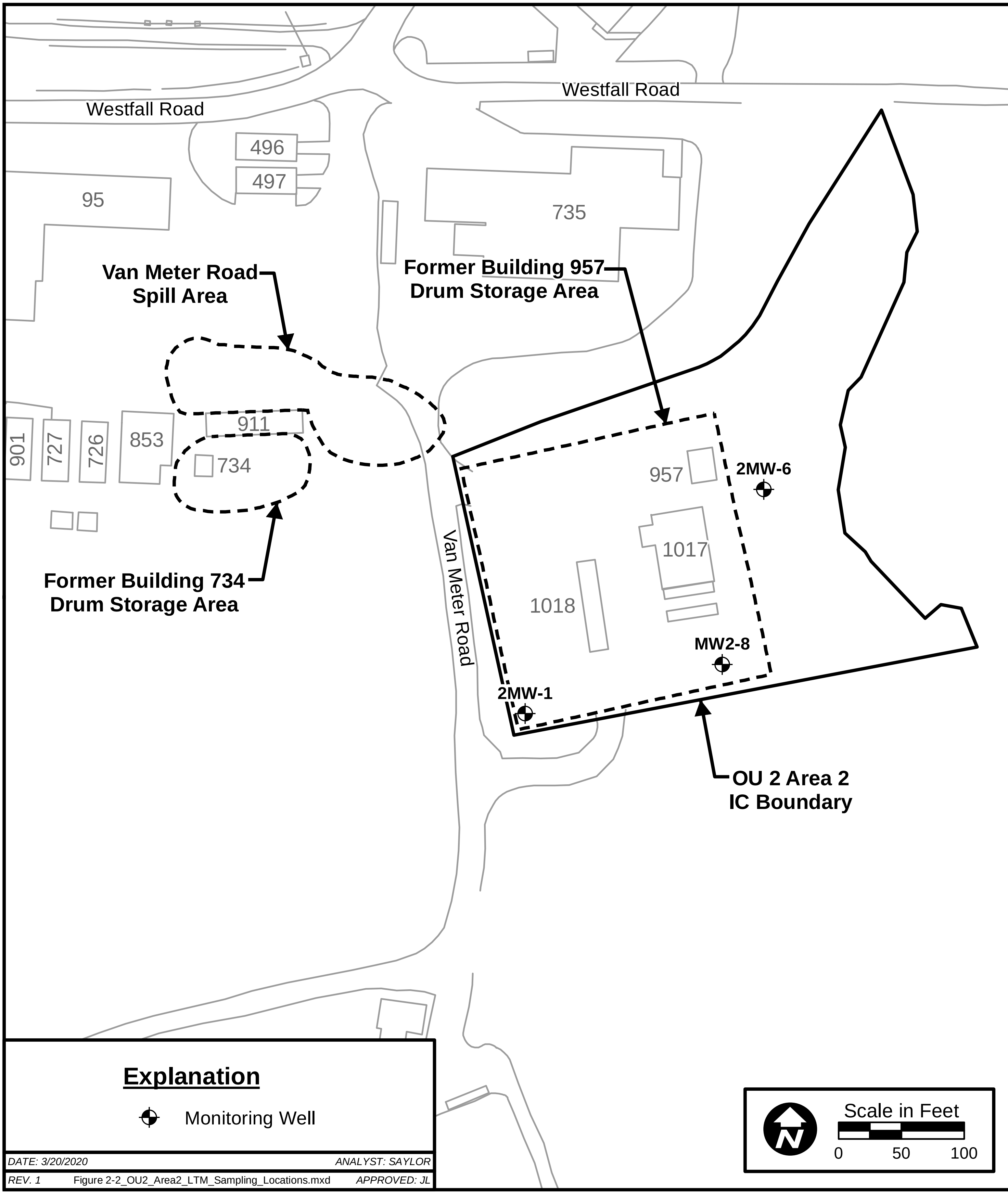
***2017 and 2019 Vapor Intrusion Investigations.*** A VI Study (U.S. Navy, 2018c) was conducted in fall 2017 at OU 2 Area 8 in response to the fourth FYR (U.S. Navy, 2015b), recommending a VI evaluation, including soil gas sampling adjacent to occupied buildings within 100 feet of monitoring wells exhibiting TCE concentrations exceeding 5 µg/L (i.e., VI default screening level). The objectives of the study were to determine: 1) if the concentrations of VOCs in soil vapor samples indicate the potential for VI into nearby buildings warranting further investigation, and 2) if the lateral or vertical distribution of VOCs in soil vapor are indicative of preferential vapor migration pathways that warrant further investigation. To address these questions, the scope of work consisted of collection and analysis of soil vapor samples from six (6) locations adjacent to buildings near known cVOC concentrations in groundwater. Based on the results and conclusions/recommendations of the 2017 investigation, an additional investigation of the VI pathway and VOC migration along preferential pathways was conducted in April and July 2019 in and around Buildings 82, 85, 98, and 1074 adjacent to OU 2 Area 8. The overall objectives of the VI study were to: 1) evaluate whether the VI pathway is complete between the site and nearby buildings; 2) assess whether the cVOCs in groundwater at OU 2 Area 8 have contributed to indoor air concentrations via the VI pathway; and 3) collect information to support the selection of appropriate mitigation measures, if required.

***USGS Tidal Lag Study.*** A tidal lag study was conducted by USGS from October to November 2017 to determine the optimal time during the semi-diurnal and neap-spring tidal cycles to sample groundwater for freshwater contaminants at OU 2 Area 8 monitoring wells. For the study, groundwater levels and specific conductance, along with marine water levels (tidal levels) in five monitoring wells (i.e., MW8-8, MW8-9, MW8-11, MW8-12, and MW8-14) were measured every 15 minutes during a 3-week duration to determine how nearshore groundwater responds to tidal forces. Monitoring wells included in the tidal lag study are shown on Figure 2-3. Time series data were collected during a period that included neap and spring tides. Vertical profiles of specific conductance were also measured in the screened interval of each monitoring well prior to instrument deployment to determine if a freshwater/saltwater interface was present in the monitoring well at that particular time.

### *2.2.3 OU 2 Operations, Maintenance, and Monitoring*

Since the fourth FYR (U.S. Navy, 2015b), the Navy has continued monitoring the OU 2 remedy. The monitoring and LUC programs at OU 2 are described below.

**OU 2 Area 2 Monitoring.** Since the OU 2 ROD (U.S. Navy, EPA, and Ecology, 1994), groundwater monitoring (i.e., LTM) has been conducted at OU 2 Area 2 to establish trends in COC concentrations and determine when LUCs can be discontinued. During this FYR period, the LTM program at Area 2 involved periodic sampling of groundwater from three point of compliance monitoring wells (i.e., 2MW-1, 2MW-6, and MW2-8) for vinyl chloride and 1,4-dioxane, with comparison of results to the RG for vinyl chloride and to the MTCA Method B cleanup level for 1,4-dioxane. The LTM program also involves periodic water level measurements to monitor the groundwater flow direction. Figure 2-2 depicts the LTM sampling locations for OU 2 Area 2. The results of the LTM program are discussed in Section 4.2.




DATE: 3/20/2020 ANALYST: SAYLOR

REV. 1 Figure 2-2_OU2_Area2_LTM_Sampling_Locations.mxd APPROVED: JL

| U.S. NAVY | Figure 2-2<br>OU 2 Area 2 LTM Sampling Locations | NBK KEYPORT<br>FIFTH<br>FIVE-YEAR REVIEW |
|---|---|---|

**OU 2 Area 2 Land Use Controls.** As part of the remedy, LUCs were implemented to prevent residential land use and construction of domestic wells. The updated IC Plan (U.S. Navy, 2017b) describes in detail the current land use and users, objectives of the LUCs, and implementation of the LUCs for OU 2 Area 2. During this FYR period, annual LUC inspections were conducted to document that LUCs are being maintained and have met the following expectations stated in the OU 2 ROD:

- No new water wells have been installed, except for monitoring wells or wells that may be needed for future remedial actions.
- Access controls have been maintained and have prevented access.
- Current land use remains unchanged (i.e., industrial or commercial purposes only), or if changes have been made, the change has been reviewed and approved in collaboration with Ecology and the EPA.
- Administrative procedures are in place to control digging at Area 2, and have been followed.

The results of the annual LUC inspections are discussed in Section 4.3.

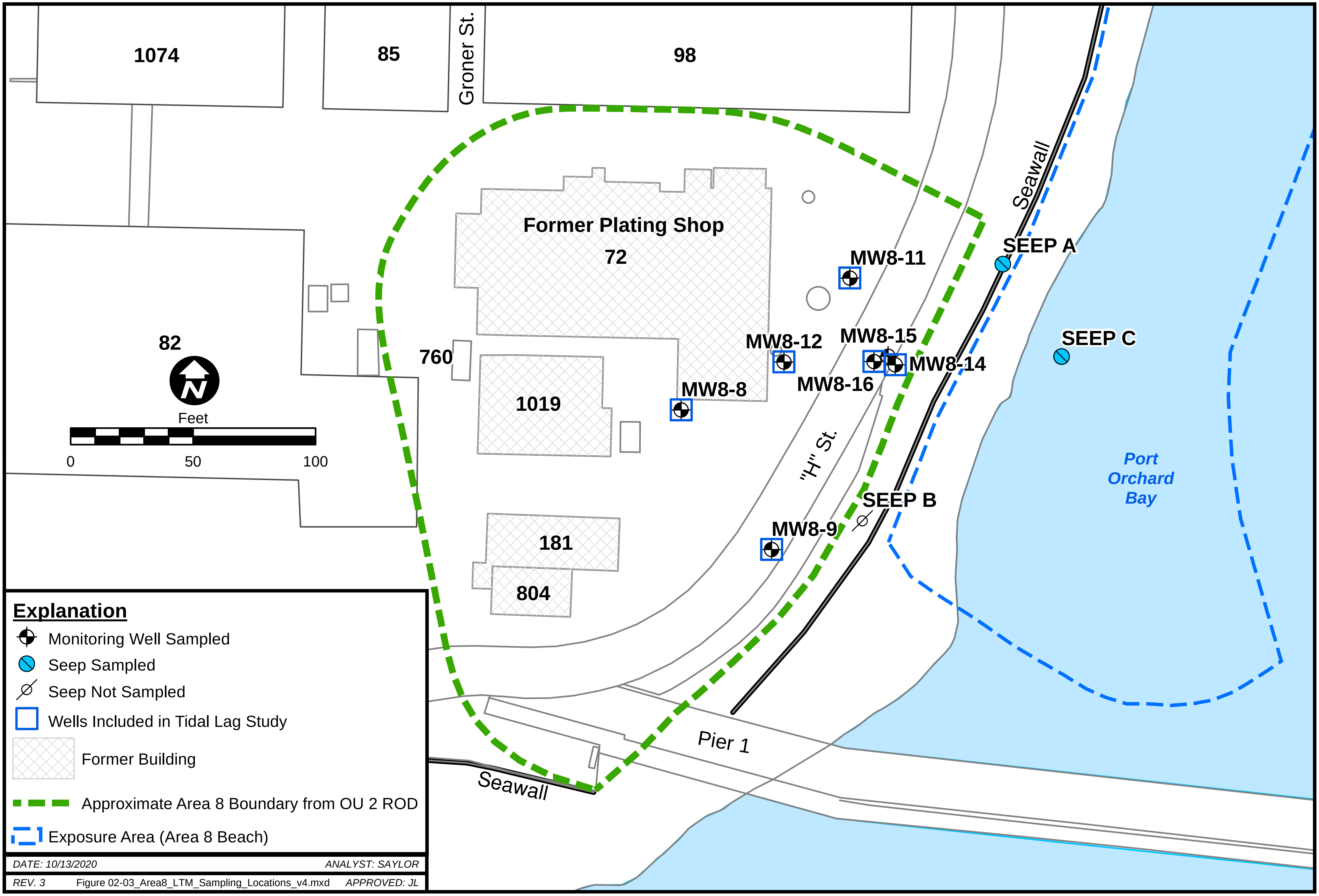
**OU 2 Area 8 Monitoring.** Since the OU 2 ROD (U.S. Navy, EPA, and Ecology, 1994), LTM has been conducted at Area 8 and included groundwater, seep water, surface water, sediment, and tissue sample collection and analysis. During this FYR period, all Area 8 monitoring activities were performed in general accordance with the regulator-approved LTM Work Plans (U.S. Navy, 2012h and 2017c). Groundwater monitoring is conducted on an annual basis and samples are collected and analyzed for VOCs, 1,4-dioxane, dissolved low-level mercury, and dissolved metals. Figure 2-3 depicts the locations for various media monitoring currently conducted at OU 2 Area 8. The results of the LTM program are discussed in Section 4.2.

**OU 2 Area 8 Land Use Controls.** As part of the remedy, LUCs were initiated in 2000 to prevent exposure to soil and groundwater during hypothetical future residential land use.

The updated IC Plan (U.S. Navy, 2017b) describes in detail the current land use and users, objectives of the LUCs, and implementation of the LUCs for OU 2 Area 8. During this FYR period, annual LUC inspections were conducted to document that LUCs are being maintained and have met the following expectations stated in the OU 2 ROD:

- Access controls have been maintained and have prevented access.
- No new water wells have been installed, except for monitoring wells or wells that may be needed for future remedial actions.
- Current land use remains unchanged (i.e., industrial or commercial purposes only), or if changes have been made, the change has been reviewed and approved in collaboration with Ecology and the EPA.
- Administrative procedures are in place to control digging at Area 8, and have been followed.

The results of the annual LUC inspections are discussed in Section 4.3.




**U.S. NAVY**

**Figure 2-3**
**OU 2 Area 8 LTM Sampling Locations**

NBK KEYPORT
FIFTH
FIVE-YEAR REVIEW

**Table 2-1. Summary of Remedial Action for OUs 1 and 2**

| OU, Site | Reasonably Anticipated Land Use | COC Requiring Action | Media | RGs | RAOs[a] | Remedy Component | Remedy Construction Complete | Long-Term Management or Site Closeout Strategy |
|---|---|---|---|---|---|---|---|---|
| OU 1 | Active military installation | VOCs | Soil, waste, vapor | No RGs were established in ROD. | • Prevent human exposure to soil and landfill waste.<br>• Prevent human exposure to landfill vapor.<br>• Prevent unacceptable risks to humans from soil and air above state MTCA B Levels. | • Upgrade and maintain the landfill cover – Initial upgrade construction is complete and maintenance ongoing.<br>• LUCs: ongoing. | Yes | • Maintain soil cover and phytoremediation plantation, as needed.<br>• Conduct annual LUC monitoring. |
| | | 1,1-DCA<br>1,2-DCA<br>1,1-DCE<br>cis-1,2-DCE<br>trans-1,2-DCE<br>PCE<br>1,1,1-TCA<br>TCE<br>Vinyl chloride<br>PCBs<br>1,4-dioxane (Not identified in ROD) | Ground-water | 800 µg/L<br>5 µg/L<br>0.5 µg/L<br>70 µg/L<br>100 µg/L<br>5 µg/L<br>200 µg/L<br>5 µg/L<br>0.5 µg/L<br>0.04 µg/L<br>0.44 µg/L (MTCA Method B Cleanup Level) | • Prevent human exposure to groundwater as drinking water.<br>• Prevent unacceptable risks to humans and aquatic organisms due to migration of groundwater into adjacent aquatic environments. | • Treat VOC hot spots in the landfill by phytoremediation: ongoing, including additional site characterization at south plantation for remedy optimization.<br>• Conduct LTM, including phytoremediation monitoring, intrinsic bioremediation monitoring, and risk and compliance monitoring: ongoing until RGs are met.<br>• LUCs: ongoing.<br>• Take contingent remedial actions for off-base domestic wells, if necessary: ongoing monitoring. | Yes | • Conduct LTM until RGs are met.<br>• Conduct annual LUC monitoring. |
| | | 1,1-DCA<br>1,2-DCA<br>1,1-DCE<br>cis-1,2-DCE<br>trans-1,2-DCE<br>PCE<br>1,1,1-TCA<br>TCE<br>Vinyl chloride<br>PCBs | Surface Water | None<br>59 µg/L<br>1.9 µg/L<br>None<br>33,000 µg/L<br>4.2 µg/L<br>41,700 µg/L<br>56 µg/L<br>1.9 µg/L<br>0.04 µg/L | • Prevent unacceptable risks to humans due to ingestion of seafood.<br>• Prevent unacceptable risks to aquatic organisms due to surface water exposure. | • Upgrade the tide gate: construction complete.<br>• Conduct LTM: ongoing until RGs are met. | Yes | • Conduct LTM until RGs are met.<br>• Conduct annual LUC monitoring. |
| | | 1,1-DCA<br>1,2-DCA<br>1,1-DCE<br>cis-1,2-DCE<br>trans-1,2-DCE<br>PCE<br>1,1,1-TCA<br>TCE<br>Vinyl chloride<br>PCBs | Sediment | State Sediment Quality Standards/Bioassays[b] | • Prevent unacceptable risks to humans due to ingestion of seafood as defined by concentrations in littleneck clams (see tissue).<br>• Prevent unacceptable risks to aquatic organisms due to sediment exposure. | • Remove PCB-contaminated sediments from seep location: completed.<br>• Upgrade the tide gate: construction complete.<br>• Conduct LTM: ongoing LTM to ensure that contaminant concentrations have not increased from the time of the ROD. | Yes | • Conduct LTM to monitor migration.<br>• Conduct annual LUC monitoring. |
| | | 1,1-DCA<br>1,2-DCA<br>1,1-DCE<br>cis-1,2-DCE<br>trans-1,2-DCE<br>PCE<br>1,1,1-TCA<br>TCE<br>Vinyl chloride<br>PCBs | Marine Tissue | 304 mg/kg<br>0.33 mg/kg<br>0.051 mg/kg<br>30 mg/kg<br>61 mg/kg<br>0.59 mg/kg<br>61 mg/kg<br>2.8 mg/kg<br>0.016 mg/kg<br>0.015 mg/kg | • Prevent exposure to humans due to ingestion of seafood above a cumulative incremental cancer risk of $1 \times 10^{-5}$ or above a noncancer hazard index of 1.0.<br>• Prevent exposure to aquatic organisms above the ecological risk-based screening levels (Appendix J of U.S. Navy [1997a]). | • Upgrade the tide gate: construction complete.<br>• Conduct LTM: ongoing LTM to ensure that contaminant concentrations have not increased from the time of the ROD. | Yes | • Conduct LTM to evaluate potential bioaccumulation of PCBs.<br>• Conduct annual LUC monitoring. |

**Table 2-1 (continued). Summary of Remedial Action for OUs 1 and 2**

| OU, Site | Reasonably Anticipated Land Use | COC Requiring Action | Media | RGs | RAOs[a] | Remedy Component | Remedy Construction Complete | Long-Term Management or Site Closeout Strategy |
|---|---|---|---|---|---|---|---|---|
| OU 2, Area 2 | Active military installation | TCE<br>Vinyl chloride | Groundwater | 5 µg/L<br>0.1 µg/L (assumed PQL at the time of the ROD; current PQLs can achieve current RG of 0.029 µg/L) | • Prevent human exposure to groundwater as drinking water and inhalation of volatiles while showering.<br>• Reduce concentrations of contaminants in groundwater to drinking water quality. | • Install additional upgradient wells to confirm no upgradient source of COCs exists: construction complete.<br>• Conduct LTM: ongoing until RGs are met for vinyl chloride (already met for TCE).<br>• LUCs: ongoing. | Yes | • Conduct LTM until RGs are met.<br>• Conduct annual LUC monitoring. |
| | | Arsenic<br>Benz(a)pyrene<br>Beryllium<br>Vinyl chloride | Soil | MTCA Method B Cleanup Levels | • Prevent human exposure to soil or vegetables grown in soil (residential). | • LUCs: ongoing. | | • Conduct annual LUC monitoring. |
| OU 2, Area 8 | Active military installation | Cadmium<br>Chromium III[c]<br>Chromium VI[c]<br>Chromium (total)<br>1,1-DCE<br>cis-1,2-DCE<br>PCE<br>1,1,1-TCA<br>TCE | Groundwater | 5 µg/L<br>16,000 µg/L<br>80 µg/L<br>50 µg/L<br>7 µg/L<br>70 µg/L<br>5 µg/L<br>200 µg/L<br>5 µg/L | • Prevent human exposure to groundwater as drinking water.<br>• Protect sediments and surface water quality offshore of Area 8 in Port Orchard Bay from contaminants in groundwater that could cause future adverse impacts or human health risks. | • Install additional monitoring wells: construction complete.<br>• Conduct LTM of groundwater, seep water, sediment, and tissue in the intertidal zone of Area 8: ongoing until RGs are met.<br>• LUCs: ongoing.<br>• Assess risks to human health and the environment using the sediment and tissue monitoring data: completed and presented in this FYR report.<br>• Implement contingent groundwater control actions if Area 8 groundwater is demonstrated to be a significant source of the chemicals that cause risk in sediments or tissue: to be completed based on recent ecological risk assessment. | Yes | • Conduct LTM until RGs are met.<br>• Conduct annual LUC monitoring. |
| | | Arsenic[d]<br>Cadmium<br>Chromium<br>VOCs<br>SVOCs | Soil | MTCA Method B Cleanup Levels | • Prevent human exposure to soil.<br>• Protect groundwater and surface water quality from soil containing COCs. | • Soil hot spot removal: construction complete.<br>• LUCs: ongoing. | | • Conduct annual LUC monitoring. |

[a]The RAO statements included in this table are summary versions of the RAO statements from the OU 1 and OU 2 RODs. Please refer to the RODs for the complete text of each RAO statement.
[b]Washington State Sediment Quality Standards (SQS) value of 12 mg/kg for PCBs was set at the time of the signed ROD. Current SQS values are applicable to all other COCs as established in the ROD. Bioassays will be performed if chemical results fail the SQS as established on page 95 of the ROD.
[c]Trivalent and hexavalent chromium (chromium III and VI, respectively) were dropped from COC list.
[d]Concentrations were found to be below background, so contaminant was dropped from COC list.
COC – chemical of concern
DCA – dichloroethane
DCE – dichloroethane
GRO – gasoline range organic
LTM – long-term monitoring
LUC – land use control
MTCA – Model Toxics Control Act
NTCRA – non-time critical removal action
PCB – polychlorinated biphenyl
PCE – perchloroethene
RG – remedial goal

**Table 2-1 (continued). Summary of Remedial Action for OUs 1 and 2**

ROD – Record of Decision
SI – site inspection
SVOC – semi-volatile organic compound
TCA – trichloroethane
TCE – trichloroethene
TCRA – time critical removal action
TPH – total petroleum hydrocarbon
VOC – volatile organic compound

**Table 2-2. Summary of LTM Program at OU 1 During this FYR Period**

| Sampling Location | Year | | | | |
|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 |
| ***Groundwater*** | | | | | |
| 1MW-1 | – | ✓ | – | – | ✓ |
| MW1-02 | – | ✓ | ✓ | ✓ | ✓ |
| MW1-04 | ✓ | ✓ | ✓ | – | ✓ |
| MW1-09 | – | ✓ | – | – | ✓ |
| MW1-14 | – | – | – | ✓ | ✓ |
| MW1-25 | – | – | – | ✓ | ✓ |
| MW1-28 | – | – | – | ✓ | ✓ |
| MW1-29 | – | – | – | – | ✓ |
| MW1-38 | – | ✓ | – | – | ✓ |
| MW1-39 | – | ✓ | – | – | ✓ |
| MW1-41 | – | – | – | ✓ | ✓ |
| MW1-60 | – | – | – | ✓ | – |
| MW1-05 | ✓ | ✓ | ✓ | – | – |
| MW1-16 | ✓ | ✓ | ✓ | – | – |
| MW1-17 | ✓ | ✓ | ✓ | – | – |
| MW1-20 | ✓ | ✓ | ✓ | – | – |
| MW1-03 | – | ✓ | – | – | – |
| MW1-06 | – | ✓ | – | – | – |
| MW1-15 | – | ✓ | – | – | – |
| IW1-N | – | ✓ | – | – | – |
| IW1-S | – | ✓ | – | – | – |
| PUD | ✓ | ✓ | ✓ | – | ✓ |
| Navy #5 | ✓ | ✓ | ✓ | – | ✓ |
| P1-01 | ✓ | – | – | ✓ | ✓ |
| P1-02 | – | – | – | – | ✓ |
| P1-03 | ✓ | – | – | – | ✓ |
| P1-04 | ✓ | – | – | – | ✓ |
| P1-05 | ✓ | – | – | – | ✓ |
| P1-06 | ✓ | ✓ | – | – | – |
| P1-07 | ✓ | ✓ | – | – | – |
| P1-08 | ✓ | ✓ | – | – | – |
| P1-09 | ✓ | ✓ | – | – | – |
| P1-10 | ✓ | ✓ | – | – | – |

**Table 2-2 (continued). Summary of LTM Program at OU 1 During this FYR Period**

| Sampling Location | Year | | | | |
|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 |
| ***Passive Diffusion Sampling Locations*** | | | | | |
| S-1 | ✓ | – | – | – | – |
| S-2 | ✓ | – | – | – | – |
| S-2B | ✓ | – | – | – | – |
| S-3 | ✓ | – | – | – | – |
| S-3B | ✓ | – | – | – | – |
| S-4 | ✓ | – | – | – | – |
| S-4B | ✓ | – | – | – | – |
| S-5 | ✓ | – | – | – | – |
| S-5B | ✓ | – | – | – | – |
| S-6 | ✓ | – | – | – | – |
| S-7 | ✓ | – | – | – | – |
| S-8 | ✓ | – | – | – | – |
| S-9 | ✓ | – | – | – | – |
| S-10 | ✓ | – | – | – | – |
| ***Seep*** | | | | | |
| SP1-1 | – | – | ✓ | – | ✓ (also SED) |
| ***Sediment (SED), Surface Water (SW), and/or Tissue (T)*** | | | | | |
| DB14 | – | – | – | – | SW |
| MA09 | SW | SW | SW | – | SW/SED |
| MA11 | SW | SW | SW | – | SW |
| MA12 | SW | SW | SW | – | SW |
| TF19 | – | – | – | – | SW |
| MA14 | – | – | – | – | SED |
| TF21 | – | – | T | – | SED |

SW – surface water
SED – sediment
T – marine tissue

# 3.0 PROGRESS SINCE LAST FIVE-YEAR REVIEW

Per EPA FYR Guidance (EPA, 2016), Table 3-1 details the protectiveness statements and determinations from the *Fourth Five-Year Review for NBK Keyport* (U.S. Navy, 2015b).

## 3.1 Status of Recommendations

In total, eight recommendations are presented in the *Fourth Five-Year Review for NBK Keyport* (U.S. Navy, 2015b) to ensure future long-term protectiveness of the remedies. Table 3-2 lists these recommendations and provides the current status of each recommendation (e.g., under discussion, ongoing, addressed in next FYR, considered but not implemented, or completed).

## 3.2 Additional Actions Taken

In addition to the recommendations and current status of these recommendations summarized in Table 3-2, the Navy has taken additional actions at OUs 1 and 2 to ensure the protectiveness of the remedies. These additional actions are described in the following subsections.

### *3.2.1 Analyte Change History Review*

In late 2019, during preparation of this FYR, the Navy initiated a review of the history of changes in the groundwater LTM programs over time for the sites in Operable Units (OUs) 1 and 2. The purpose of the research was to compare the analyte suites and sampled wells associated with the LTM program specified in the RODs, with the current monitoring program being performed at OU 1 and OU 2 Areas 2 and 8 to evaluate the timing and rationale for post-ROD changes to the chemical analyte suites, sampled wells RGs and monitoring frequencies over time.

This research included post-ROD changes to groundwater, seep water, surface water, sediment, and clam tissue monitoring (U.S. Navy, 2019g).

### *3.2.2 Tidal Lag Studies at OU 1 and OU 2*

During this FYR period the Navy contracted the USGS to perform tidal lag studies at both OU 1 and OU 2 Area 8. These studies were performed in support of groundwater LTM. The study performed at OU 1 was flawed and is being repeated. The study performed at OU 2 Area 8 provided refined information regarding how groundwater levels throughout OU 2 Area 8 respond to tidal fluctuations. This information was then used to determine the optimal times during the semi-diurnal and the neap-spring tidal cycle to sample for COCs in groundwater beneath the site. The optimal times for sampling are presumed to be when fresh water flowing seaward is least impeded by elevated tides, and those times are related to predicted tide levels by tidal lags, the durations between low tides and corresponding low groundwater levels. Specifically, the groundwater monitoring plan need to consider the timing of minimum groundwater levels following low tides as well as the relative proportions of fresh groundwater and seawater in wells throughout both the semi-diurnal and longer-term spring-neap tidal cycles. This information allows collection of groundwater samples and water level measurements that are least affected by groundwater-seawater interactions.

The tidal lag study was completed at OU 2 Area 8 during this FYR period (USGS, 2018), while the original study for OU 1 was in progress (USGS, 2019) and is currently being repeated.

**Table 3-1. Protectiveness Statement(s) and Determination(s) from the Fourth Five-Year Review**

| Operable Unit/Site | Protectiveness Determination | Protectiveness Statement(s) |
|---|---|---|
| 1 | Short-Term Protective | The remedy at OU 1 is protective in the short term. Exposure pathways that could result in unacceptable risks are being controlled and monitored while further information is obtained. The office worker exposures to potential COCs in indoor air at buildings east of Bradley Road are protective in the short term because the mass of contamination is over 100 feet away from the occupied buildings, and most of the buildings are large and well ventilated. Damage to the landfill cap is limited, and the remedy remains protective. In addition, an investigation of the former landfill to study the feasibility of optimizing the remedial action at the south plantation will be conducted. To ensure future long-term protectiveness, further information will be obtained by implementing Recommendations 2 and 3 presented in Section 8. Recommendation 2 calls for repair of damage to the landfill cap, and Recommendation 3 calls for performing the initial step of the VI evaluation, including soil gas sampling adjacent to occupied buildings within 100 feet of monitoring wells with TCE concentrations exceeding 5 µg/L. |
| 2 | Short-Term Protective | The remedy at OU 2 is protective in the short term.<br><br>The remedy has been implemented and performed as intended by the ROD at Area 2. The remedy implemented at OU 2 Area 2 is protective of human health and the environment because RGs have been met for TCE and risk-based levels (MTCA Method B cleanup level) have been met for cis-1,2-DCE in groundwater, and exposure pathways that could result in unacceptable risks are being controlled and monitored.<br><br>The remedy implemented at OU 2 Area 8 is protective in the short term. Exposure pathways that could result in unacceptable risks are being controlled and monitored while further information is obtained. The office worker exposures to potential COCs in indoor air at buildings are protective in the short term because the occupied buildings within 100 feet of the contaminant plume are large and well ventilated. To ensure future long-term protectiveness, further information will be obtained by performing the initial step of the VI evaluation, including soil gas sampling adjacent to occupied buildings within 100 feet of monitoring wells with TCE concentrations exceeding 5 µg/L, sampling marine surface water, sediment, and clam tissue to generate new data representative of current COC levels from the intertidal zone, and completing human health and ecological risk assessments (as required by the ROD) on the new data generated. |
| Sitewide | Short-Term Protective | The overall sitewide remedies are protective in the short term. Exposure pathways that could result in unacceptable risks are being controlled and monitored while further information is obtained. To ensure future long-term protectiveness, further information will be obtained at OU 1 and OU 2 Area 8. |

**Table 3-2. Status of Recommendations from the Fourth Five-Year Review**

| Item No. | Issue | Recommendation | Current Status | Current Implementation Status Description | Reference or Completion Date (if applicable) |
|---|---|---|---|---|---|
| ***Sitewide*** | | | | | |
| 1 | Changes to LTM are recommended in this FYR report, and the reporting limit for 1,4-dioxane is not low enough to meet the MTCA Method B value of 0.44 µg/L. | Revise the OU 1 and OU 2 LTM plans in collaboration with EPA, Ecology, and the Suquamish Tribe based on the FYR recommendations. Include in the plans the use of a laboratory analytical method that can achieve a reporting limit of 0.4 µg/L for 1,4-dioxane in groundwater to meet the MTCA Method B value of 0.44 µg/L. | Completed | The LTM plan covering OU 1 and OU 2 was updated in 2017 during this FYR period and was reviewed by EPA, Ecology, and the Suquamish Tribe. Comments received from these reviews were incorporated into the final plan. The revised plan explicitly incorporated changes recommended by the fourth FYR. During monitoring within this FYR period, a lab was chosen that could consistently achieve the target reporting limit of 0.4 µg/L for 1,4-dioxane in groundwater. The most recent LTM reports covering sampling in 2019 are not yet published, however comprehensive data sets showing report limits through 2019 are included in Appendices C, E, and G of this FYR. | U.S. Navy, 2017c |
| 2 | Ecology requested more rigorous LTM trend graphs for all areas. The use of one value to represent all reporting limits unrealistically biases the trend graphs. | LTM trend graphs will be completed according to Ecology's guidance on remediation by natural attenuation of petroleum-contaminated groundwater. It is recommended that the actual reporting limits are used in the trend graphs, rather than using one value to represent all reporting limits. For those reporting limits that are unrealistically biasing trends, it is recommended that the non-detected result be removed in consultation with Ecology. | Addressed in Next FYR | The trend analysis presented in OU 1 LTM reports prepared during this FYR period utilize a value of half of the reporting limit when analytes are not detected. The spring 2016 LTM report cites Ecology guidance as the basis for this approach; however, the guidance does not recommend using half of the reporting limit for analytes not detected.<br><br>The 2016-2018 OU 2 Area 8 LTM Reports use the reporting limits in the trend graphs for contaminants detected at concentrations below laboratory reporting limits (referred to as "non-detect" from here forward) results, which is a revised approach from LTM reports prior to the fourth FYR. The Navy is currently revising the LTM QAPP in collaboration with the project team. Trend analysis methods will be revised and the revised method approved by Ecology during this process. The 2019 LTM report and trend graphs were not available at the time of preparation of this FYR. | U.S. Navy, 2017d, 2019c, 2018e, 2017f, |

**Table 3-2 (continued). Status of Recommendations from the Fourth Five-Year Review**

| Item No. | Issue | Recommendation | Current Status | Current Implementation Status Description | Reference or Completion Date (if applicable) |
|---|---|---|---|---|---|
| | | | | ***OU 1*** | |
| 3 | Several deficiencies in the landfill cover were identified. | Perform landfill cover repairs. Ensure that future institutional control inspections of the landfill are comprehensive. | Addressed in Next FYR<br><br>Completed | To allow for slow release of vapors to the atmosphere such that vapor concentrations do not build up and migrate laterally in the soil away from the landfill boundary, a landfill venting evaluation has been awarded and landfill venting and cover upgrades will begin in FY 2021.<br><br>The following question was added to the annual IC Inspection Form starting in 2016: "For Area D, the former landfill, is there significant damage (e.g., cracking, seam separation, root damage, etc.) to asphalt surfaces that permits direct-contact exposure to underlying soils or that may significantly increase filtration of surface water/stormwater?" | U.S. Navy, 2016a, 2017b |
| 4 | Evaluation against current VI guidance has identified potential data gaps regarding worker exposure to potential VOCs in indoor air at facility buildings near OU 1. | Perform the initial step of a VI evaluation, including soil gas sampling adjacent to occupied buildings within 100 feet of groundwater wells exhibiting TCE concentrations exceeding 5 µg/L. | Completed | Soil vapor sampling was conducted along Bradley Road during the 2016 Phase II investigation and identified the migration of landfill COCs to the east. Based on recommendations from the Phase II investigation, indoor air, outdoor air, sub-slab, and exterior soil vapor samples were collected, and differential pressure was monitored in both late winter (March 2018) and summer (July 2018) in all buildings immediately east and northeast of the landfill. All indoor air concentrations were less than Ecology's Method C (industrial) screening levels and sub-slab and exterior soil vapor concentrations were less than Ecology's Method C (industrial) screening levels for eight of the ten buildings. For the remaining two buildings, indoor air concentrations were less than industrial screening levels, however there were a few sub-slab samples with concentrations greater than industrial screening levels. Detailed assessment of the magnitude, frequency, and nature of these detected concentrations in sub-slab vapor result in a conclusion that the potential for unacceptable VI risk at these two buildings is low. Therefore, the 2018 study concluded that no VI risk is present, so no further actions are necessary. | U.S. Navy 2017a, 2019a |

**Table 3-2 (continued). Status of Recommendations from the Fourth Five-Year Review**

| Item No. | Issue | Recommendation | Current Status | Current Implementation Status Description | Reference or Completion Date (if applicable) |
|---|---|---|---|---|---|
| 5 | Phytoremediation at OU 1 is not as effective at the south plantation as the north plantation. Although the ROD requirements are being met and the remedy remains protective in the short term, the expected restoration timeframe exceeds a timeframe that is considered reasonable by Ecology and EPA. In addition, surface water ARARs at station MA12 are consistently being exceeded. | a. Continue additional investigation to refine the conceptual site model regarding contaminant distribution at the south plantation and around well MW1-17.<br>b. Clarify remedial action objectives as intended by the ROD, including the surface water remediation goals and points of compliance for marsh water.<br>c. Evaluate the feasibility of optimizing the remedial action at the south plantation to shorten the restoration timeframe. | Ongoing | In response to recommendation a., an additional investigation was conducted in 2017 and provided new data towards revision of the conceptual site model covering the south planation and the central landfill area east of well MW1-17. Based on the results of this investigation, further investigation was performed in 2019, focused primarily on the north plantation area. These results are currently being used to update the conceptual site model. As agreed to by the Project Team, next steps for OU 1 include items b and c of this recommendation, once sufficient data has been obtained to support the decision. | U.S. Navy, 2018b, 2019e |
| 6 | PCB data from seep SP1-1, and in sediment at two stations, imply that PCB concentrations may be increasing. | Collect additional sediment samples at and in the vicinity of seep SP1-1 during the Phase II investigation and use the data to assess whether expanded, ongoing PCB monitoring should be initiated and risk assumptions reviewed. | Completed | Five sediment samples were collected on September 6 and 7, 2017 to assess PCB concentrations at historical sediment sample locations, and at one new location. Only the PCB concentrations in the sediment sample from location MA-09 exceeded the ROD RG, indicating that the lateral extent of PCBs exceeding the RG is limited to the vicinity of this station. Because the highest current PCB concentrations are not higher than those found at the time of the ROD and are limited to the immediately vicinity of station MA-09, the report recommended that the risk assessment regarding PCBs not be reopened in sediment until additional PCB concentration trend data are available. Additional data were collected at the same stations in 2019 (outside of the data review window for this FYR), and risk assessments are underway, with additional data collection planned in 2021. | U.S. Navy, 2018b, 2019e |

**Table 3-2 (continued). Status of Recommendations from the Fourth Five-Year Review**

| Item No. | Issue | Recommendation | Current Status | Current Implementation Status Description | Reference or Completion Date (if applicable) |
|---|---|---|---|---|---|
| ***OU 2 Area 8*** | | | | | |
| 7 | Evaluation against current VI guidance has identified potential data gaps regarding worker exposure to potential VOCs in indoor air at facility buildings. | Perform the initial step of a VI evaluation, including soil gas sampling adjacent to occupied buildings within 100 feet of groundwater wells exhibiting TCE concentrations exceeding 5 µg/L. | Completed | Seven soil-gas samples were collected in 2017. Between three and five of the 11 target VOC analytes were detected in each of the seven samples collected. The data indicated that additional investigation of the VI pathway at Area 8 was warranted based on a strict comparison of the measured concentrations of target VOCs to screening levels (i.e., MTCA Method C). Detected concentrations of VOCs in five of seven samples exceeded their respective screening level, with the concentrations of TCE in two samples exceeding the screening level for this compound by nearly two orders of magnitude.<br><br>Based on the 2017 results, an indoor air VI study was performed in 2019 in 4 buildings adjacent to Area 8. Interpretation and reporting of the results was underway at the time of this FYR. The VI investigation concluded VI is not occurring in any of the buildings, however, because some subslab vapor samples exceeded conservative vapor intrusion screening levels, the Navy intends to periodically inspect/monitor changes in building conditions that could affect the VI pathway. | U.S. Navy, 2018c, 2019f |

**Table 3-2 (continued). Status of Recommendations from the Fourth Five-Year Review**

| Item No. | Issue | Recommendation | Current Status | Current Implementation Status Description | Reference or Completion Date (if applicable) |
|---|---|---|---|---|---|
| 8 | The human health and ecological risk assessments for intertidal sediment required by the ROD have been completed, but data gaps were identified. | In conjunction with EPA, Ecology, and the Suquamish Tribe, collect necessary data and complete the human health and ecological risk assessments for intertidal sediment. Assess the need to implement contingent groundwater control actions based on the results of the risk assessments. | Completed | Human health and ecological risk assessments were completed during this FYR period and included additional intertidal sample collection. The HHRA concluded that despite the presence of several COCs in Area 8 beach intertidal sediment and clam tissue samples at concentrations exceeding background and reference area concentrations, the incremental site risk over reference area risk for Suquamish subsistence and recreational receptors met target health goals. As such, the project team agreed that no additional investigation or groundwater controls were necessary to protect human health.<br><br>The 2018 HHRA/ERA concluded that Area 8 groundwater discharging as seeps from the former plating facility may present a risk to benthic organisms at the Area 8 beach. Elevated cadmium concentrations occur in sediment and chronic exposure to accumulated contaminants in sediment pose a risk to benthic organisms based on the bioassay endpoints. Therefore, the ERA concluded that the existing remedy is not protective of ecological receptors.<br><br>Based on these results, the Navy is required by the ROD to implement contingent groundwater control actions. To support selection of a contingent groundwater control measure, a Supplemental Remedial Investigation will begin in 2021. | U.S. Navy 2018a, 2019b |

# 4.0 FIVE-YEAR REVIEW PROCESS

## 4.1 Community Notification, Involvement, and Interviews

There are specific requirements pursuant to CERCLA Section 117(a), as amended, for certain reports to be released to the public and the public notified of proposed cleanup plans and remedial actions. The community notification and involvement activities for NBK Keyport are described below.

### *4.1.1 History of Community Involvement*

The community has historically been informed of progress at NBK Keyport through fact sheets, public notices, open houses, public meetings, and bus tours of the sites. The community had substantial input into the remedy for OU 1 (i.e., the former landfill) causing the Navy to re-evaluate the proposed plan and segregate OU 1 from OU 2 to allow for continued public input at OU 1. The proposed plans for OUs 1 and 2 were circulated for public comment prior to finalization of the RODs. Key documents have been made available for review at Navy facilities; the Kitsap Regional Library in Bremerton, Washington; and the Poulsbo Branch Library in Poulsbo, Washington. In addition, a NAVFAC Northwest website repository was added, with the previous FYRs, current questionnaire, and LUC documentation, to support involvement in this FYR. The link to the website repository is: https://www.navfac.navy.mil/navfac_worldwide/pacific/fecs/northwest/about_us/northwest_documents/environmental-restoration/nbk_keyport.html.

A community relations plan was prepared in 1990 and most recently updated in 2008. In 1988, a Technical Review Committee was established, with representatives from the public and government entities. In March 1995, the Technical Review Committee was replaced with a Restoration Advisory Board (RAB). The RAB members included representatives of the Navy, regulatory agencies, civic groups, private citizens, tribal governments, local governments, and environmental activist groups. The RAB remained active through all phases of remedy constriction and implementation, but was ultimately disbanded in October 2004 due to lack of continued interest in maintaining the RAB.

The town of Keyport also has the Keyport Improvement Club (KIC), which was incorporated in 1921. Here is the link to their website: http://www.keyport98345.com/. KIC is a group of volunteers who work on events and projects to strengthen the community and make life better for Keyport residents. KIC serves as an unofficial link between the Keyport community and larger organizations such as Kitsap County government departments, the Navy, the Port of Keyport, and the Red Cross. KIC conducts periodic meetings to discuss community issues and concerns and also organizes community meetings, as needed, to connect Keyport to the larger network of Kitsap County. The Navy Remedial Project Manager (RPM) provides status updates to the tenant Commanding Officer (CO) of Naval Undersea Warfare Center (NUWC) Keyport regarding installation restoration activities at NBK Keyport, who then briefs KIC members, as requested. KIC has also invited NUWC Keyport personnel and the CO to attend their meetings and update them with regard to the CERCLA sites.

### *4.1.2 Community Involvement during the Five-Year Review Period*

During this FYR period, the Navy RPM provided a summary of the current site status for the CO to brief the community, at the communities' request. The CO presented this information to the Keyport community on January 10, 2017. In addition, KIC was contacted and provided an avenue for obtaining public input on the progress of the remedies at NBK Keyport.

A public notice was published by the Navy, informing the community that the Navy was intending to initiate this fifth FYR for NBK Keyport. The public notice was published in the following newspapers:

- *Kitsap Sun* (on September 6,7 and 8, 2019)
- *North Kitsap Herald* (on September 6, 13 and 20, 2019)
- *Central Kitsap Reporter* (on September 6, 8, 13 and 20, 2019)

The proofs of these public notices are provided as Appendix A. The public notice was also posted on the KIC website on October 7, 2019. The notification provided information on why the FYR was being conducted; what sites were included in the FYR; when the FYR would be completed; how the public could receive additional information; and established a 30-day review period for the public to provide questions or comments on the FYR process for NBK Keyport. The Navy did not receive any feedback or comments as a result of the public notice of intent.

Similar to the notice of intent to conduct the FYR, a notice of completion for the FYR will be published in the *Kitsap Sun, North Kitsap Herald, and Central Kitsap Reporter* as well as posted on the KIC website. The notice will include the protectiveness determinations and statements and website link to the completed FYR Report.

### *4.1.3 Interviews during the Five-Year Review Period*

As part of the FYR process, a variety of organizations and groups, including the EPA, Ecology, Kitsap Public Health District, the Suquamish Tribe, and community members, were contacted to participate in the interview process. A set of interview questions were developed and tailored to specific categories of interview candidates (i.e., either regulatory agency, community member, or Tribe). The interview questions and instructions were transmitted via email to the regulatory agencies and Tribe on October 15, 2019. The community member questionnaire was posted to the NAVFAC Northwest website on October 28, 2019. Instructions and link to the questionnaire were subsequently provided to KIC members via the KIC Secretary. In total, three (3) completed interview questionnaires were received and are provided in Appendix B. Table 4-1 lists the findings and recommendations detailed in each of these completed questionnaires. Highlights of the interview responses are summarized in the following sections.

***Regulatory Agencies.*** Interview questions were sent to seven (7) regulatory agency personnel, including EPA, Ecology, Kitsap Public Health District. A total of two (2) completed questionnaires were received, both from Ecology (i.e., the Ecology Project Manager and Ecology Sediment Specialist).

The Ecology Project Manager indicated that he is very familiar with the OU 1 and OU 2 RODs and has been involved with the OUs as regulatory oversight. He noted that the remedy for OU 1 has failed to meet the RAOs. The site does not seem to pose immediate danger to human health and environment, but may pose risk in the long-term/future. The site is going through re-characterization, source area assessments, and Tier II ecological and human health risk assessments.

He indicated that the remedy for OU 2 Area 2 remains effective, but has not achieved cleanup levels or is taking longer to achieve cleanup levels. He stated that the remedy for OU 2 Area 8 is not effective. Recent groundwater seeps bioassay results as part of ERA demonstrated adverse effects to ecological receptors. In addition, the site groundwater will not achieve drinking water quality standards in a reasonable timeframe, which calls into question the remedy of monitored natural attenuation (MNA). The remedy needs to be revised for groundwater treatment/control besides MNA and LUCs to obtain RAOs.

Overall, he felt that the progress made by the Navy at OU 1 has been good. However, it appeared that the entire site (not only the southern plantation which has the highest contamination) has some hot spot areas that need remediation. In addition, it appears the soil mound north of northern plantation is contaminated with TPH and PCBs (i.e., new findings). It needs further investigation and assessment to determine if this contamination poses any risks or hazards to human health and environment.

He indicated that the monitoring data and reports at OU 1 and OU 2 have been of acceptable quality. He stated that the Navy has made significant progress on the recommendations from the fourth FYR. All recommendations have been addressed to some degree; although, some milestone dates may have been missed. There are still issues at both OU 1 and OU 2 and Ecology expects this FYR will include more robust recommendations to move these sites closer to meeting RAOs. He also was aware of all the investigations being conducted at OU 1 and OU 2 Area 8. He noted that it was unknown whether per- and polyfluoroalkyl substances (PFAS) contamination exists or affects protectiveness at this time. He was aware that the Navy has performed a preliminary assessment (PA) for Keyport without any stakeholder involvement. He expects that the Navy will involve Ecology and the stakeholders in the next phase of assessment or investigation.

The Ecology Sediment Specialist indicated that he began providing technical support to the Ecology Project Manager since October 2015, specifically for sediment issues at OU 1 and OU 2 Area 8. He clarified that he was not familiar with OU 2 Area 2. This Ecology respondent indicated that while OU 1 seems to not pose any immediate risks to human health or the environment, recent sampling results suggest that the contamination present may pose risks in the long-term/future. He believed that the recently proposed Tier II HHRA and ERA, site re-characterization and source area assessment will provide important information related to remedy effectiveness and protectiveness. The respondent noted that the recent results from the groundwater seep bioassays as part of the OU 2 Area 8 ERA demonstrate adverse effects to receptors, suggesting that the remedy is not protective. At OU 2 Area 8, MNA has not been effective in achieving drinking water quality standards in groundwater or preventing impacts to sediments and shellfish.

The Ecology Sediment Specialist noted that the emergence of PFAS calls in question the protectiveness of the remedies, in particular at OU 2 Area 8. The presence of a metal plating shop upgradient of the beach is concerning, due to the use of PFAS as a fire suppressant during the electroplating process. Metal plating facilities have been identified as potential source areas during the PFAS PA at Puget Sound Naval Shipyard. He requested that Ecology's Project Manager be included in the next phase of PFAS assessment or investigation.

Both Ecology respondents indicated that they were not aware of any complaint, violation, or incident related to NBK Keyport or any community concerns. One respondent mentioned that he was only aware of the concerns raised by the Suquamish Tribe during the project meetings.

***Tribe Personnel.*** No responses were received from the Suquamish Tribe representatives. Their comments regarding the protectiveness of the remedies at OUs 1 and 2 have been received through review of this FYR Report. The Tribe does not agree with the Navy’s Short-Term Protective determination for OU 1, and feels that a protectiveness determination for OU 1 cannot be made at this time, believing a protectiveness statement of “protectiveness deferred” is more appropriate. However, the Tribe does concur with the “Short-Term Protective” and “Not Protective” determinations for OU 2 Areas 2 and 8, respectively. Detailed comments made by the Tribe are included in Appendix K.

**Table 4-1. Summary of Concerns and Recommendations from the FYR Interview Questionnaires**

| No. | Stakeholder | Concerns | Recommendations |
|---|---|---|---|
| 1 | Regulatory Agency (Ecology Project Manager) | • OU 1: The entire site (not only the southern plantation which has the highest contamination), has some hot spot areas that need remediation. In addition, it appears the soil mound north of northern plantation is contaminated with TPH and PCBs (i.e., new findings). It needs further investigation and assessment to see if this contamination poses any risks or hazards to human health and environment.<br>• OU 2 Area 8: The remedy is not effective. Recent groundwater seeps bioassay results (as part of ERA) demonstrated adverse effects to ecological receptors. In addition, site groundwater will not reach drinking water quality standards in a reasonable timeframe, which calls into question the remedy of MNA. The remedy needs to be revised for groundwater treatment/control besides MNA and LUCs to obtain RAOs.<br>• Concerned if PFAS contamination exists or affects protectiveness at this time. Ecology expects all the stakeholders to be involved in the assessment going forward. | • OU 1: Update the CSM such that remedial actions can be implemented to remediate not only the hot spots (i.e., source areas), but also the other areas, as needed, such that the surface water, sediment, and groundwater can be returned to their beneficial uses within a reasonable timeframe.<br>• OU 2: Needs to implement a groundwater remedy to protect the affected ecological receptors and restore the site groundwater to drinking water quality standards. |
| 2 | Regulatory Agency (Ecology Sediment Specialist) | • OU 1: The soil mound in the north plantation contains recently discovered TPH and PCB contamination, which will likely require further investigation.<br>• OU 2 Area 8: Recent results from the groundwater seep bioassays as part of ERA demonstrate adverse effects to receptors, suggesting that the remedy is not protective. MNA has not been effective in achieving drinking water quality standards in groundwater or preventing impacts to sediments and shellfish.<br>• PFAS as a contaminant of concern may call in to question the protection of the remedies (in particular at OU 2 Area 8). | • OU 1: Complete a site re-characterization to refine the CSM and initiate a Tier II HHRA and ERA.<br>• OU 2: Complete the HHRA and ERA, specifically seep bioassay's following project team's recommendation, that identified risks to sediment benthic organisms.<br>• Request Ecology's project manager be included in the next phase of PFAS assessment or investigation. |
| 3 | Community Member | • OU 1: There has been nothing of any great effect done to reduce the runoff from the former landfill into the "tide flats" and then into Dogfish Bay.<br>• Concerned that human receptors are unable to consume shellfish from Dogfish Bay. | • Navy to attend meeting of the KIC.<br>• Additional information on the real effects of the former landfill runoff on local water bodies, such as Dogfish Bay. |

***Community Members.*** A completed community interview questionnaire was received from one (1) community member. The community member is a resident of Dogfish Bay and feels it has been significantly affected by the OU 1 former landfill. The community member felt that there has not been anything done to reduce the runoff from the former landfill into the tide flats and then into Dogfish Bay. The community member felt the need for more active remediation measures. The respondent wanted the OU 1 and OU 2 sites cleaned up, so the community has the ability to consume the shellfish from Dogfish Bay. The community member also requested additional information on the real effects of run off into Dogfish Bay. The respondent also requested that the Navy attend KIC meetings.

## 4.2 Data Review

The following section presents a review and evaluation of the analytical data collected during this FYR period at OU 1, OU 2 Area 2, and OU 2 Area 8 of NBK Keyport.

### *4.2.1 OU 1*

The following section provides a review of the data generated during this FYR period, including from the 1) LTM program; 2) Phase I and Phase II Site Characterizations; 3) Source Area Investigation conducted in 2019; 4) VI study; and 5) USGS tidal lag study.

**Long-Term Monitoring Program.** As part of the LTM program, groundwater, surface water, seep water, and sediment samples were collected during this FYR period. Historical and recent monitoring data in all media for OU 1 are summarized in Appendix C.

***Groundwater.*** During this FYR period, groundwater was sampled annually from June 2015 through June 2017. In 2017, activities to support site characterization were also added to the LTM program with the concurrence of the Keyport EPA and Ecology Project Managers. In 2018, LTM at Keyport OU 1 was cancelled with the concurrence of the Keyport EPA and Ecology Project Managers, given the drastic change in the CSM and ongoing investigations and the recommendation of the 2017 Annual O&M Report based on ongoing investigations (i.e., the Phase I and II Site Characterizations and 2019 Source Area Investigation). However, the LTM contractor was used to perform various sampling efforts in 2018 to support further site characterization. In 2019, the LTM program reverted to the 5-year sampling effort specified in the LTM Plan to support FYR evaluation.

Groundwater elevations are collected from across OU 1 every two years. The most recent groundwater elevations and potentiometric map is from September 2018 and presented as Figure 4-1. As shown in Figure 4-1, the shallow groundwater flow direction is predominantly towards the west across the site, with shallow groundwater flow at the south end of the landfill generally towards the west to southwest towards the marsh pond and groundwater flow at the north end of the landfill generally towards the northwest towards the tide flats. This general shallow groundwater flow pattern or direction is consistent with historical potentiometric maps for the site. Deeper within the upper aquifer, groundwater flow follows a regional flow direction to the northwest everywhere beneath the landfill. This hydrogeological model of multiple superimposed groundwater flow components within an aquifer system is consistent with the standard models of flow systems within regional drainage basins (see Figure 6.4, Fetter, 1980). At sites like OU 1 with substantial local relief and high annual precipitation, local groundwater flow


**U.S. NAVY**

**Figure 4-1**
**OU 1 Shallow Groundwater Potentiometric Head Contours and Groundwater Flow September 2018**

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systems become superimposed on the regional flow system. Local, near-surface flow systems are driven by recharge at local topographic highs and discharge at topographic lows. At OU 1, the effect of this local flow system is movement of shallow groundwater and contaminants from the landfill footprint into adjacent surface water, with groundwater flow vectors roughly normal to the flowline of Marsh Creek and the ephemeral stream south of the South Plantation. Because the flowlines of these surface water features vary from east-west to south-north, very localized groundwater flow vectors are observed, ranging from nearly due south in the eastern portion of the South Plantation to due west across much of the Central Landfill. Deeper in the aquifer, below the influence of local topographic relief, the regional flow direction to the northwest dominates, seemingly enhanced by paleotidal and paleofluvial channeling in the Olympia Formation.

Historical investigations relied upon in the OU 1 ROD and subsequent LTM program interpreted a relatively laterally continuous aquitard at approximately 15 ft bgs separating an “upper aquifer” and an “intermediate aquifer.” Although this aquitard was inferred to be missing in some areas of the site, and “leaky,” the interpretation of the presence of the aquitard influenced the selection of screened intervals for monitoring wells targeting the two aquifers. Most of the monitoring wells that are currently part of the LTM program and are located within the footprint of the landfill have screen depths ending at 15 ft bgs or shallower. However, laterally continuous fine-grained units above the Lawton Clay and Clover Park Aquitard that could be interpreted as a shallow aquitard were not observed to the total explored depth in the 2017 and 2019 investigations (discussed later in this subsection). In contrast to the interpretation from the ROD, two distinct water-bearing zones were not identified during the 2017 and 2019 investigations. The upper portion of the water-bearing zone was found to be contiguous with, and discharging to, the original salt marsh, which was filled and paved. The “intermediate aquifer” defined in the ROD was found to be vertically interconnected with the original marsh deposits, forming a single water bearing zone above the Clover Park/Lawton Clay aquitard.

Groundwater data for OU 1 have been collected under four monitoring programs: phytoremediation monitoring, risk and compliance monitoring, CRA monitoring, and intrinsic bioremediation monitoring. Results of cVOCs, 1,4-dioxane, and PCBs analyses in groundwater are discussed in the following subsections.

<u>Chlorinated Volatile Organic Compounds</u>
At OU 1, groundwater results for nine target cVOCs (1,1-dichloroethane [DCA], 1,2-DCA, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, tetrachloroethene [PCE], 1,1,1-trichloroethane [TCA], TCE, and vinyl chloride) have been included in LTM Reports. Groundwater monitoring data for target VOCs, organized by area (i.e., north landfill area, south landfill area, etc.) and depth (i.e., shallow versus deeper wells), are provided on Table C-1 in Appendix C, and discussed in the subsections below. Figure 4-2 presents the cVOC and 1,4-dioxane concentrations in groundwater during this FYR period. Of note, 1,1-DCA and 1,2-DCA are not presented in Figure 4-2 because both COCs have been below their respective groundwater RGs of 800 and 5 μg/L during this entire FYR period.

*Shallow Monitoring Wells*
Shallow monitoring wells in the North, Central and South Landfill Areas were sampled during this FYR period, as summarized below.


| MW1-39 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/22/16 | 0.5 U | 0.93 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | **1.8** | **0.85** |
| 06/17/19 | 0.2 U | 0.65 | 0.2 UM | 0.2 U | 0.2 U | 0.2 UM | **1.6** | 0.42 M |

| MW1-38 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/22/16 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | **2.2** |
| 06/19/19 | 0.2 UM | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.022 M | **1.7** |

| MW1-02 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane | Total PCB Aroclors | Total PCB Congeners |
| 06/21/16 | **1.2** | **330 D** | 11 | 0.5 U | 0.5 U | 1.2 | **89 D** | NS | NS | NS |
| 06/19/17 | **0.65** | **200 D** | 6.6 | 0.5 U | 0.5 U | 2.1 | **54** | NS | NS | NS |
| 09/19/18 | NS | NS | NS | NS | NS | NS | NS | **5.9** | 0.01 U | 0.0012 |
| 06/18/19 | **0.63** | **160 D** | 7 | 0.5 U | 0.2 U | 1.1 | **79 DM** | **7.6** | NS | NS |

| P1-03 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/27/19 | 0.2 UM | 0.085 JM | 0.2 UM | 0.5 UM | 0.2 U | 0.2 UM | 0.02 UM | **8.6** |

| MW1-28 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 09/19/18 | NS | NS | NS | NS | NS | NS | NS | **7.4** |
| 06/24/19 | **5.1** | **1,500 D** | 74 D | 0.5 U | 0.2 U | 0.2 U | **590 D** | **31 D** |

| P1-04 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/17/19 | **1.5** | **480 D** | 11 | 0.5 U | 0.2 UM | 0.28 | **150 D** | **24 D** |

| MW1-29 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/17/19 | NS | NS | NS | NS | NS | NS | NS | 0.2 UM |

| MW1-09 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/22/16 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.4 U |
| 06/27/19 | 0.2 U | 0.2 UM | 0.2 UM | 0.2 UM | 0.2 UM | 0.2 UM | 0.02 UM | 0.2 U |

| 1MW-1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/21/16 | 0.5 U | 13 | 25 | 0.5 U | 0.5 U | 0.5 U | **230 D** | NS |
| 06/11/19 | 0.12 JM | 9.9 | 23 | 0.5 U | 0.2 U | 0.2 U | **230 D** | **0.56** |

| MW1-60 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 09/18/18 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 UJ | NS |

| MW1-17 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/24/15 | **2.1 D** | **630 D** | 0.46 JD | 1 U | 1 U | 1 U | **120 JD** | NS |
| 06/21/16 | **1.6** | **440 D** | 0.45 J | 0.5 U | 0.5 U | 0.5 U | **100 D** | NS |
| 06/19/17 | **1.2** | **440 D** | 0.39 J | 0.5 U | 0.5 U | 0.5 U | **72** | NS |

| MW1-05 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/24/15 | 0.5 U | 0.53 | 0.08 J | 0.5 U | 0.5 U | 0.29 J | **7.7 J** | NS |
| 06/22/16 | 0.11 J | 5.5 | 1.2 | 0.5 U | 0.5 U | 0.46 J | **64** | NS |
| 06/19/17 | 0.09 J | 5.7 | 1.1 | 0.5 U | 0.5 U | 0.58 | **53** | NS |

| MW1-25 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 09/20/18 | NS | NS | NS | NS | NS | NS | NS | **31** |
| 06/20/19 | **2.9** | **1,100 D** | 20 | 0.5 UM | 0.2 U | 0.43 | **270 D** | **12/27 HDJ** |

| MW1-14 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane | Total PCB Aroclors | Total PCB Congeners |
| 09/19/18 | NS | NS | NS | NS | NS | NS | NS | NS | 0.83 PDJ | **108.3** |
| 06/11/19 | NS | NS | NS | NS | NS | NS | NS | 0.28 M | NS | NS |

| P1-02 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/19/19 | 0.2 UM | 0.1 J | 0.2 U | 0.5 U | 0.2 U | 0.2 U | 0.064 | **7.7** |

| P1-01 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane | Total PCB Aroclors | Total PCB Congeners |
| 09/19/18 | NS | NS | NS | NS | NS | NS | 0.02 UJ | 0.0046 | 0.02 UJ | 0.0046 |
| 06/11/19 | 0.2 U | 0.077 JM | 0.2 UM | 0.5 U | 0.2 U | 0.2 U | 0.02 UJ | 0.26 M | NS | NS |

| MW1-03 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/22/16 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | NS |

| MW1-41 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 09/19/18 | NS | NS | NS | NS | NS | NS | NS | **28** |
| 06/19/19 | 0.2 U | 0.16 J | 0.2 U | 0.2 U | 0.2 U | 0.2 U | 0.12 | **5.1 J** |

| P1-05 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/27/19 | 0.2 UM | 0.13 JM | 0.38 | 0.5 UM | 0.2 U | 0.2 UM | 0.02 UM | **6.6 D** |

| MW1-16 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/24/15 | 0.5 U | 1.1 | 0.93 | 0.5 U | 0.5 U | 0.31 J | **0.54 J** | NS |
| 06/22/16 | 0.5 U | 2 | 1.3 | 0.5 U | 0.5 U | 0.16 J | **1.5** | NS |
| 06/19/17 | 0.5 U | 0.69 | 0.41 J | 0.5 U | 0.5 U | 0.5 U | **0.54** | NS |

| MW1-20 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/24/15 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 UJ | NS |
| 06/22/16 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | NS |
| 06/19/17 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | NS |

| MW1-04 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sampling Date | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane |
| 06/24/15 | **2.9 D** | **1,800 D** | 16 D | 2.5 U | 2.5 U | **1,600 D** | **96 D** | NS |
| 06/23/16 | **2.9 D** | **1,800 D** | 14 D | 2.5 U | 2.5 U | **1,700 D** | **85 D** | NS |
| 06/19/17 | **6.6 JD** | **5,600 D** | 56 D | 10 U[1] | 10 U | **11,000 D** | **240 D** | NS |
| 06/19/19 | **1.3** | **580 D** | 7.3 | 0.5 U | 0.2 U | **680 D** | **34** | 0.2 U |

**Explanation**

- Piezometer
- Monitoring Well
- Base Boundary
- OU1 Area 1 Boundary
- Plantation Area
- Approximate Groundwater Flow Direction
- Approximate Location of Historical Shoreline

Notes:
All concentrations are in µg/L.
*There is no remedial goal for 1,4-dioxane; however, results are compared to the MTCA Method B Cleanup Level of 0.44 ug/L to allow for data evaluation.

**Bold** indicates detected value is equal to or exceeds the groundwater remedial goal.

µg/L – microgram per liter or parts per billion
D – result reported from a diluted analysis
DCE – Dichloroethene
J – analyte positively identified, but result is estimated
M – Manual integrated compound
NS – Not analyzed
P – The relative percent difference is greater than 40% between the results on the two PCB analytical columns
TCE – Trichloroethene
U – analyte was not detected at or above the indicated practical quantitation limit
U[1] – not detected at value shown and value exceeds remediation goal
UJ – analyte not detected, but the reported quantitation/detection limit is estimated

| Analyte | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | 1,4-Dioxane | Total PCBs |
|---|---|---|---|---|---|---|---|---|---|
| Remedial Goals* | 0.5 | 70 | 100 | 5 | 200 | 5 | 0.5 | 0.44 | 0.044 |

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**Figure 4-2**
**OU 1 cVOC and 1,4-Dioxane Concentrations in Groundwater as Part of LTM Program (2015-2019)**

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*North Landfill Area*

The following shallow North Landfill Area monitoring wells were sampled during this FYR period: 1MW-1 (2016, 2019), MW1-02 (2016, 2017, 2019), MW1-03 (2016), and MW1-41 (2019). In 1MW-1, concentrations of vinyl chloride were detected above the groundwater RG of 0.5 μg/L in 2016 and 2019. In MW1-02, concentrations of cis-1,2-DCE, 1,1-DCE, and vinyl chloride were detected above their respective groundwater RGs of 70, 0.5, and 0.5 μg/L in 2016, 2017, and 2019. No other cVOCs were detected above their groundwater RGs in 2016, 2017, and 2019.

The following shallow North Landfill Area piezometers were sampled in 2019: P1-01, P1-02, P1-03, P1-04, and P1-05. In P1-04, concentrations of cis-1,2-DCE, 1,1-DCE, and vinyl chloride were detected above their respective groundwater RGs of 70, 0.5, and 0.5 μg/L. No other cVOCs were detected above their groundwater RGs in 2019.

*Central Landfill*

MW1-17 was the only shallow monitoring well that was sampled during this FYR period in the Central Landfill (2015, 2016, 2017). In MW1-17, concentrations of cis-1,2-DCE, 1,1-DCE, and vinyl chloride were detected above their respective groundwater RGs of 70, 0.5, and 0.5 μg/L in 2015, 2016, and 2017. No other cVOCs were detected above their groundwater RGs in 2015, 2016, and 2017.

*South Landfill Area*

The following shallow South Landfill Area monitoring wells were sampled during this FYR period: MW1-04 (2015, 2016, 2017, 2019), MW1-05 (2015, 2016, 2017), MW1-16 (2015, 2016, 2017), and MW1-20 (2015, 2016, 2017). In MW1-04, concentrations of TCE, cis-1,2-DCE, 1,1-DCE, and vinyl chloride were detected above their respective groundwater RGs of 5, 70, 0.5, and 0.5 μg/L in 2015, 2016, 2017, and 2019. In MW1-05 and MW1-16, vinyl chloride was detected above its groundwater RGs in 2015, 2016, and 2017. No other cVOCs were detected above their groundwater RGs in 2015, 2016, 2017, and 2019.

*Intermediate and Deeper Monitoring Wells*

The following deeper groundwater monitoring wells were sampled during this FYR period: MW1-09 (2016, 2019), MW1-25 (2019), MW1-28 (2019), MW1-29 (2019), MW1-38 (2016, 2019), MW1-39 (2016, 2019), and MW1-60 (2018). In MW1-25 and MW1-28, concentrations of cis-1,2-DCE, 1,1-DCE, and vinyl chloride were detected above their respective groundwater RGs of 70, 0.5, and 0.5 μg/L in 2019. In MW1-39, concentrations of vinyl chloride were detected above the groundwater RG in 2016 and 2019. No other cVOCs were detected above their groundwater RGs in 2016, 2018, and 2019.

*Deep Domestic Wells*

The following deep regional aquifer domestic water supply wells were sampled during this FYR period: Navy Well #5 southeast of the landfill (2015, 2016, 2017) and the PUD Well northeast of the landfill (2015, 2016, 2017, 2019). No cVOCs were detected above their groundwater RGs in 2015, 2016, 2017, or 2019 (see Appendix C).

<u>1,4-Dioxane</u>
In 2016, 2018, and 2019, groundwater was sampled for 1,4-dioxane at various Central and North Landfill Area monitoring wells, domestic wells, and piezometers within OU 1. Groundwater data for 1,4-dioxane are presented in Figure 4-2 and provided on Table C-2 in Appendix C. Concentrations of 1,4-dioxane were detected above the MTCA Method B cleanup level of 0.44 µg/L at 1MW-1 (2019), MW1-02 (2018, 2019), MW1-41 (2018, 2019), MW1-25 (2018, 2019), MW1-28 (2018, 2019), MW1-38 (2016, 2019), MW1-39 (2016), P1-02 (2019), P1-03 (2019), P1-04 (2019), and P1-05 (2019).

<u>PCBs</u>
In September 2018, groundwater was sampled for PCBs at three North Landfill Area monitoring wells (i.e., MW1-02, MW1-14, and P1-01) to assess the PCB concentrations in the North Plantation to determine potential source areas for PCBs in downgradient sediment. Groundwater data for PCBs are provided on Tables C-3 and C-4 in Appendix C and shown in Figure 4-2. Total PCB concentrations (i.e., Aroclors and congeners) were detected above the MTCA Method B cleanup level of 0.044 µg/L at MW1-14 (i.e., at 0.83 PDJ µg/L). Note that the ARAR values upon which these RGs were based have changed since the time of the ROD. See Section 5.4 for additional details regarding these ARAR changes.

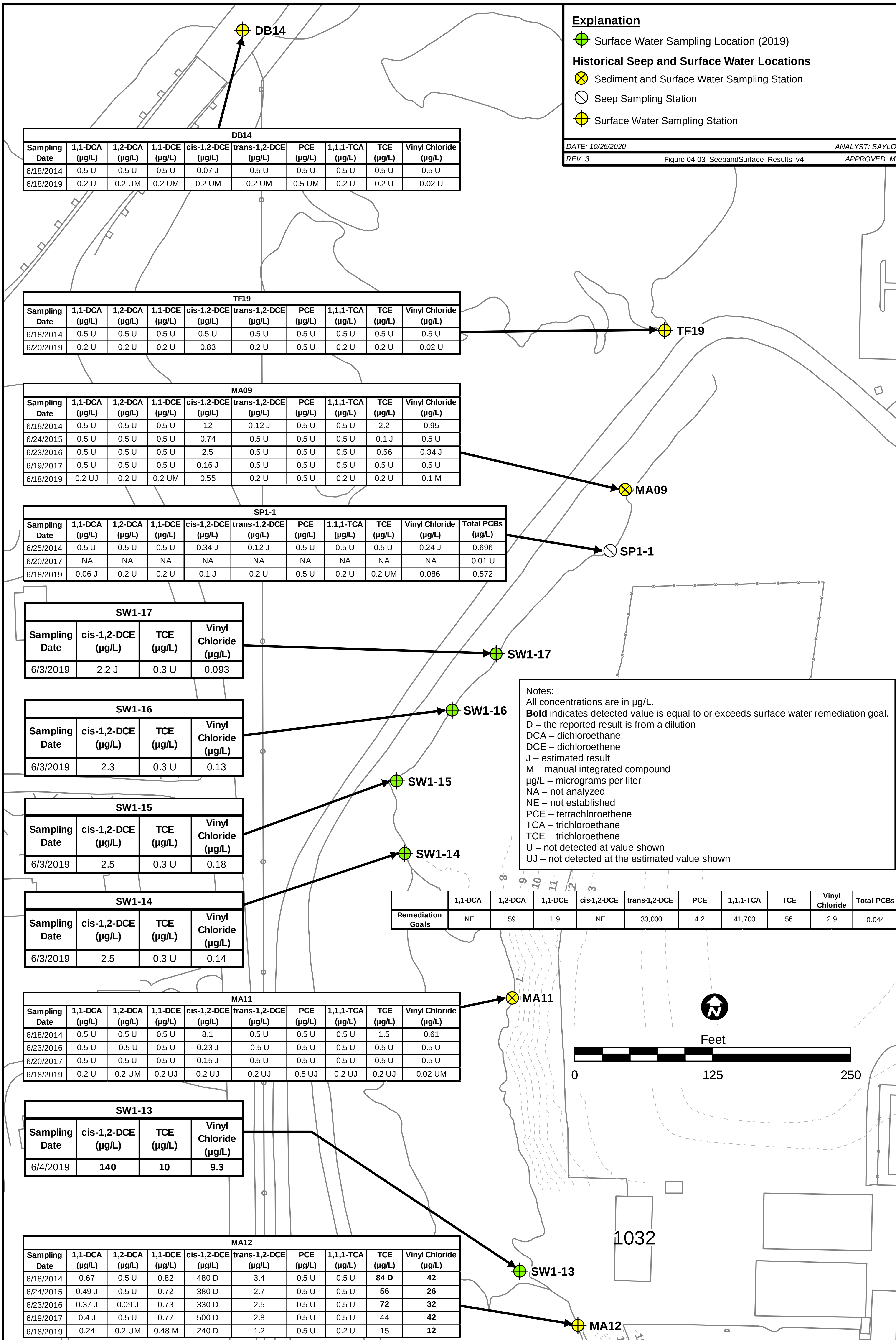
***Chlorinated VOCs in Surface Water and Seep Water.*** In 2015, 2016, 2017, and/or 2019, surface water was sampled for cVOCs at sampling stations MA09, MA11, and MA12. In 2019, additional cVOC surface water samples were collected at stations TF19 and DB14, and a seep water sample was collected for cVOCs at SP1-1. Surface water and seep water locations are shown on Figure 4-3 and data for cVOCs are provided on Table C-5 in Appendix C.

At MA12, TCE was detected above its surface water RG of 56 µg/L in 2016 and vinyl chloride was detected above its surface water RG of 2.9 µg/L in 2015, 2016, 2017, and 2019. No other cVOCs were detected above their surface water RGs in any of the other surface water and seep water samples collected in 2015, 2016, 2017, and/or 2019.

***PCBs in Seep Water and Sediment.*** In June 2017 and June 2019, seep water was sampled for PCB Aroclors at SP1-1 (see Figure 2-1). In 2019, the SP1-1 seep water sample was also sampled for PCB congeners. Seep water data for PCB Aroclors and PCB congeners are provided on Tables C-6 and C-7 in Appendix C. In June 2017, PCB Aroclors were not detected above laboratory limits of detection (LODs) in seep water at SP1-1. In June 2019, both total PCB Aroclors and total PCB congeners were detected at concentrations above the RG of 0.044 µg/L in seep water at SP1-1.

According to the LTM Work Plans (U.S. Navy, 2012h and 2017c), sediment sampling is conducted at the time of the FYR; thus, sediment sampling was conducted in June 2019. Sediment samples were collected from sampling stations SP1-1, MA09, MA14, and TF21 and analyzed for PCB Aroclors and PCB congeners (see Figure 2-1). The sediment data for PCB Aroclors and PCB congeners are provided on Tables C-8 and C-9 in Appendix C. Concentrations of both total PCB Aroclors and total PCB congeners (as mg/kg organic carbon) exceeded the SQS of 12 mg/kg organic carbon in sediment collected from SP1-1. None of the remaining sediment samples exceeded SQS criteria.

**Phase I and Phase II Site Characterization.** The Navy's 2012 evaluation of natural attenuation and intrinsic biodegradation at the landfill (U.S. Navy, 2012c) concluded that the RGs for discharge to surface water adjacent to the South Plantation would not be met within a reasonable restoration




## Explanation

- Surface Water Sampling Location (2019)

**Historical Seep and Surface Water Locations**

- Sediment and Surface Water Sampling Station
- Seep Sampling Station
- Surface Water Sampling Station

DATE: 10/26/2020 ANALYST: SAYLOR
REV. 3 Figure 04-03_SeepandSurface_Results_v4 APPROVED: MM

**DB14**

| Sampling Date | 1,1-DCA (µg/L) | 1,2-DCA (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | trans-1,2-DCE (µg/L) | PCE (µg/L) | 1,1,1-TCA (µg/L) | TCE (µg/L) | Vinyl Chloride (µg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 6/18/2014 | 0.5 U | 0.5 U | 0.5 U | 0.07 J | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 6/18/2019 | 0.2 U | 0.2 UM | 0.2 UM | 0.2 UM | 0.2 UM | 0.5 UM | 0.2 U | 0.2 U | 0.02 U |

**TF19**

| Sampling Date | 1,1-DCA (µg/L) | 1,2-DCA (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | trans-1,2-DCE (µg/L) | PCE (µg/L) | 1,1,1-TCA (µg/L) | TCE (µg/L) | Vinyl Chloride (µg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 6/18/2014 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 6/20/2019 | 0.2 U | 0.2 U | 0.2 U | 0.83 | 0.2 U | 0.5 U | 0.2 U | 0.2 U | 0.02 U |

**MA09**

| Sampling Date | 1,1-DCA (µg/L) | 1,2-DCA (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | trans-1,2-DCE (µg/L) | PCE (µg/L) | 1,1,1-TCA (µg/L) | TCE (µg/L) | Vinyl Chloride (µg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 6/18/2014 | 0.5 U | 0.5 U | 0.5 U | 12 | 0.12 J | 0.5 U | 0.5 U | 2.2 | 0.95 |
| 6/24/2015 | 0.5 U | 0.5 U | 0.5 U | 0.74 | 0.5 U | 0.5 U | 0.5 U | 0.1 J | 0.5 U |
| 6/23/2016 | 0.5 U | 0.5 U | 0.5 U | 2.5 | 0.5 U | 0.5 U | 0.5 U | 0.56 | 0.34 J |
| 6/19/2017 | 0.5 U | 0.5 U | 0.5 U | 0.16 J | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 6/18/2019 | 0.2 UJ | 0.2 U | 0.2 UM | 0.55 | 0.2 U | 0.5 U | 0.2 U | 0.2 U | 0.1 M |

**SP1-1**

| Sampling Date | 1,1-DCA (µg/L) | 1,2-DCA (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | trans-1,2-DCE (µg/L) | PCE (µg/L) | 1,1,1-TCA (µg/L) | TCE (µg/L) | Vinyl Chloride (µg/L) | Total PCBs (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| 6/25/2014 | 0.5 U | 0.5 U | 0.5 U | 0.34 J | 0.12 J | 0.5 U | 0.5 U | 0.5 U | 0.24 J | 0.696 |
| 6/20/2017 | NA | NA | NA | NA | NA | NA | NA | NA | NA | 0.01 U |
| 6/18/2019 | 0.06 J | 0.2 U | 0.2 U | 0.1 J | 0.2 U | 0.5 U | 0.2 U | 0.2 UM | 0.086 | 0.572 |

**SW1-17**

| Sampling Date | cis-1,2-DCE (µg/L) | TCE (µg/L) | Vinyl Chloride (µg/L) |
|---|---|---|---|
| 6/3/2019 | 2.2 J | 0.3 U | 0.093 |

**SW1-16**

| Sampling Date | cis-1,2-DCE (µg/L) | TCE (µg/L) | Vinyl Chloride (µg/L) |
|---|---|---|---|
| 6/3/2019 | 2.3 | 0.3 U | 0.13 |

**SW1-15**

| Sampling Date | cis-1,2-DCE (µg/L) | TCE (µg/L) | Vinyl Chloride (µg/L) |
|---|---|---|---|
| 6/3/2019 | 2.5 | 0.3 U | 0.18 |

**SW1-14**

| Sampling Date | cis-1,2-DCE (µg/L) | TCE (µg/L) | Vinyl Chloride (µg/L) |
|---|---|---|---|
| 6/3/2019 | 2.5 | 0.3 U | 0.14 |

**MA11**

| Sampling Date | 1,1-DCA (µg/L) | 1,2-DCA (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | trans-1,2-DCE (µg/L) | PCE (µg/L) | 1,1,1-TCA (µg/L) | TCE (µg/L) | Vinyl Chloride (µg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 6/18/2014 | 0.5 U | 0.5 U | 0.5 U | 8.1 | 0.5 U | 0.5 U | 0.5 U | 1.5 | 0.61 |
| 6/23/2016 | 0.5 U | 0.5 U | 0.5 U | 0.23 J | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 6/20/2017 | 0.5 U | 0.5 U | 0.5 U | 0.15 J | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U |
| 6/18/2019 | 0.2 U | 0.2 UM | 0.2 UJ | 0.2 UJ | 0.2 UJ | 0.5 UJ | 0.2 UJ | 0.2 UJ | 0.02 UM |

**SW1-13**

| Sampling Date | cis-1,2-DCE (µg/L) | TCE (µg/L) | Vinyl Chloride (µg/L) |
|---|---|---|---|
| 6/4/2019 | **140** | **10** | **9.3** |

**MA12**

| Sampling Date | 1,1-DCA (µg/L) | 1,2-DCA (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | trans-1,2-DCE (µg/L) | PCE (µg/L) | 1,1,1-TCA (µg/L) | TCE (µg/L) | Vinyl Chloride (µg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 6/18/2014 | 0.67 | 0.5 U | 0.82 | 480 D | 3.4 | 0.5 U | 0.5 U | **84 D** | **42** |
| 6/24/2015 | 0.49 J | 0.5 U | 0.72 | 380 D | 2.7 | 0.5 U | 0.5 U | **56** | **26** |
| 6/23/2016 | 0.37 J | 0.09 J | 0.73 | 330 D | 2.5 | 0.5 U | 0.5 U | **72** | **32** |
| 6/19/2017 | 0.4 J | 0.5 U | 0.77 | 500 D | 2.8 | 0.5 U | 0.5 U | 44 | **42** |
| 6/18/2019 | 0.24 | 0.2 UM | 0.48 M | 240 D | 1.2 | 0.5 U | 0.2 U | 15 | **12** |

Notes:
All concentrations are in µg/L.
**Bold** indicates detected value is equal to or exceeds surface water remediation goal.
D – the reported result is from a dilution
DCA – dichloroethane
DCE – dichloroethene
J – estimated result
M – manual integrated compound
µg/L – micrograms per liter
NA – not analyzed
NE – not established
PCE – tetrachloroethene
TCA – trichloroethane
TCE – trichloroethene
U – not detected at value shown
UJ – not detected at the estimated value shown

| | 1,1-DCA | 1,2-DCA | 1,1-DCE | cis-1,2-DCE | trans-1,2-DCE | PCE | 1,1,1-TCA | TCE | Vinyl Chloride | Total PCBs |
|---|---|---|---|---|---|---|---|---|---|---|
| Remediation Goals | NE | 59 | 1.9 | NE | 33,000 | 4.2 | 41,700 | 56 | 2.9 | 0.044 |

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# Figure 4-3
## Surface Water and Seep Locations at OU 1

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timeframe (i.e., 30 to 50 years). The evaluation recommended that an additional investigation of the South Plantation be performed to identify COC hotspots. This evaluation also recommended an additional investigation in the central portion of the landfill due to increasing VOC trends in well MW1-17. A two-phase approach was selected for these additional investigations, which is presented below.

***Phase I.*** Phase I of the OU 1 site recharacterization program consisted of a screening-level investigation to identify contaminant hotspots in soil and groundwater in the South Plantation and to identify possible source material in both the South Plantation and central portion of the landfill. Phase I field activities were conducted in August 2014 and the Phase I Site Recharacterization Report was completed in May 2015. This work was briefly referenced in the fourth FYR (U.S. Navy, 2015b); however, the specific field activities and results were not presented or discussed.

Phase I included the collection and analysis of tree core samples for COCs using Missouri University of Science and Technology (MS&T) Method 9 and geophysical surveys of the South Plantation and a portion of the Central Landfill area to identify subsurface anomalies that could represent potential primary contaminant sources. An overlay of the geophysical data onto COC concentrations detected in tree core samples and groundwater sample results, as available, were used to identify and provide evidence of previously unidentified contaminant sources. Phase I of the investigation was conducted with the knowledge that in Phase II, definitive, intrusive data would be collected to identify and delineate contaminant hotspots and investigate geophysical anomalies identified during the Phase I investigation.

***Phase II.*** The purpose of the Phase II investigation was to collect the data necessary to confirm the results of Phase I data, delineate identified hotspots and evaluate additional remedial alternatives designed to treat identified hotspots and reduce the restoration timeframe. Phase II of the OU 1 site recharacterization program was completed as two separate investigations, conducted in 2016 and 2017, respectively. The 2016 Phase II investigation consisted of a membrane interface probe (MIP) investigation and soil gas sampling activities. The 2017 Phase II investigation consisted of monitoring well installation and groundwater sampling, and soil, surface water, porewater, stormwater, and sediment sampling.

Table 4-2 summarizes the activities conducted during the Phase I and Phase II Site Characterization in the South, Central, and North Landfill Areas. Analytical results from the Phase I and Phase II Site Characterization efforts are presented on Tables D-1 through D-17 in Appendix D.

The results from both the Phase I and II investigations for the South Plantation; Central Landfill area; cVOC soil gas sampling; and PCBs in sediment and passive samplers are summarized in the following subsections.

*South Plantation*

During the Phase I investigation, cVOCs (specifically, PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1,1-TCA, and 1,1-DCA) were detected in tree cores throughout the South Plantation. The highest concentrations were detected west-northwest of location P1-7, west of location P1-9, and from one native tree within the marsh area near the stormwater outfall. Within the South Plantation, two areas of buried metal or voids were identified. Based upon the groundwater flow direction under the plantation, both of these areas are located upgradient of P1-7, where high concentrations of COCs are present in

**Table 4-2. Summary of Phase I and Phase II Site Recharacterization Activities**

| Activities | OU 1 - Areas | | |
|---|---|---|---|
| | **South Plantation Area** | **Central Landfill Area** | **North Plantation Area** |
| **Phase I (August 2014)** | Sampling Program:<br>• Collect 231 core samples from 212 trees within the south plantation<br>• Collect 21 core samples from 19 trees south and southwest of the south plantation<br>• Land Surveying<br>• Geophysical Surveying | Sampling Program:<br>• Collect 5 core samples from 4 trees near well MW1-17 (central landfill)<br>• Geophysical Surveying | Sampling Program:<br>• Collect 10 core samples from 10 trees within the north plantation |
| | Additional/Prior Data Evaluation:<br>• Groundwater sampling results from wells sampled under the Navy LTM program (MW1-4, MW1-5, MW1-16, and MW1-17) in June 2014<br>• Groundwater sampling results from USGS biodegradation study, including from piezometers (P1-6, P1-7, P1-8, P1-9, and P1-10) in June 2014 and passive diffusion bag (peeper) samplers (S-2, S-2B, S-3, S-3B, S-4, S-4B, S-5, S-5B, and S-6) in September 2014 | Additional/Prior Data Evaluation:<br>• Groundwater sampling results from wells sampled under the Navy LTM program (MW1-17) | Additional/Prior Data Evaluation:<br>• None (tree core sampling only) |
| **Phase II (August/September 2016)** | Sampling Program:<br>• Install 61 MIP borings<br>• Collect 6 soil gas samples at locations east of the south plantation (SV-01, SV-02, SV-03, SV-04, SV-05, and SV-06) | Sampling Program:<br>• Install 8 MIP borings | Sampling Program:<br>• Collect 3 soil gas samples at locations east of the north plantation (SV-11, SV-12, SV-13) |
| **Phase II (July – November 2017)** | Sampling Program:<br>• Collect soil and grab groundwater samples (target VOCs) from 34 direct-push soil borings<br>– Collect subset of samples to be analyzed for: full list VOCs, SVOCs, TPH, and PCB Aroclors<br>• Collect soil samples (target VOCs) from 10 auger borings in the south plantation, and from one boring west of the south plantation<br>– Soil samples collected from screened intervals of wells in apparent hotspots also analyzed for physical characteristics (i.e. grain size, dry bulk density, hydraulic conductivity, effective porosity, and TOC)<br>• Install 11 new groundwater monitoring wells and collect groundwater samples (target VOCs) from these wells<br>– Wells in apparent hotspots also analyzed for microbial population, PFAS, and 1,4-dioxane<br>– Collect water sample from irrigation well, IW1-S<br>• Collect 2 stormwater samples (target VOCs) from an outfall and manhole structure within south plantation<br>• Collect 4 push-point porewater samples (target VOCs) from south of the south plantation<br>• Collect 12 surface water samples (target VOCs) from waterways upstream of existing sampling station MA 12.<br>• Surveyed horizontal locations and top of casing elevations for newly installed wells and peeper sampling tubes. Collected depth-to-water measurements in new wells, subset of historical wells, and peeper tubes to prepare groundwater elevation contour map | Sampling Program:<br>• Collect soil and grab groundwater samples (target VOCs) from 41 direct-push soil borings<br>– Collect subset of samples to be analyzed for: full list VOCs, SVOCs, TPH, and PCB Aroclors<br>• Collect soil samples (target VOCs) from 7 auger borings in the central landfill area<br>– Soil samples collected from screened intervals of wells in apparent hotspots also analyzed for physical characteristics (i.e. grain size, dry bulk density, hydraulic conductivity, effective porosity, and TOC)<br>• Install 7 new groundwater monitoring wells and collect groundwater samples (target VOCs) from these wells.<br>– Wells in apparent hotspots also analyzed for microbial population, PFAS, and 1,4-dioxane<br>• Collect 6 push point porewater samples (target VOCs) from west of the central landfill area<br>• Surveyed horizontal locations and top of casing elevations for newly installed wells and peeper sampling tubes. Collected depth-to-water measurements in new wells and subset of historical wells to prepare groundwater elevation contour map | Sampling Program:<br>• Collect 6 sediment samples for PCB congeners and PCB Aroclors at locations north of the north plantation<br>• Utilized passive samplers (PEDs) to collect groundwater samples for total dissolved PCBs at two monitoring wells (MW1-2 and MW1-14) and two piezometers (P1-1 and P1-2)<br>• Utilized PEDs to collect 6 porewater and 4 surface water samples for total dissolved PCBs at locations north of the north plantation (Marsh Creek and tide flats area)<br>• Surveyed horizontal locations and top of casing elevations for newly installed wells and peeper sampling tubes. Collected depth-to-water measurements in subset of historical wells to prepare groundwater elevation contour map |

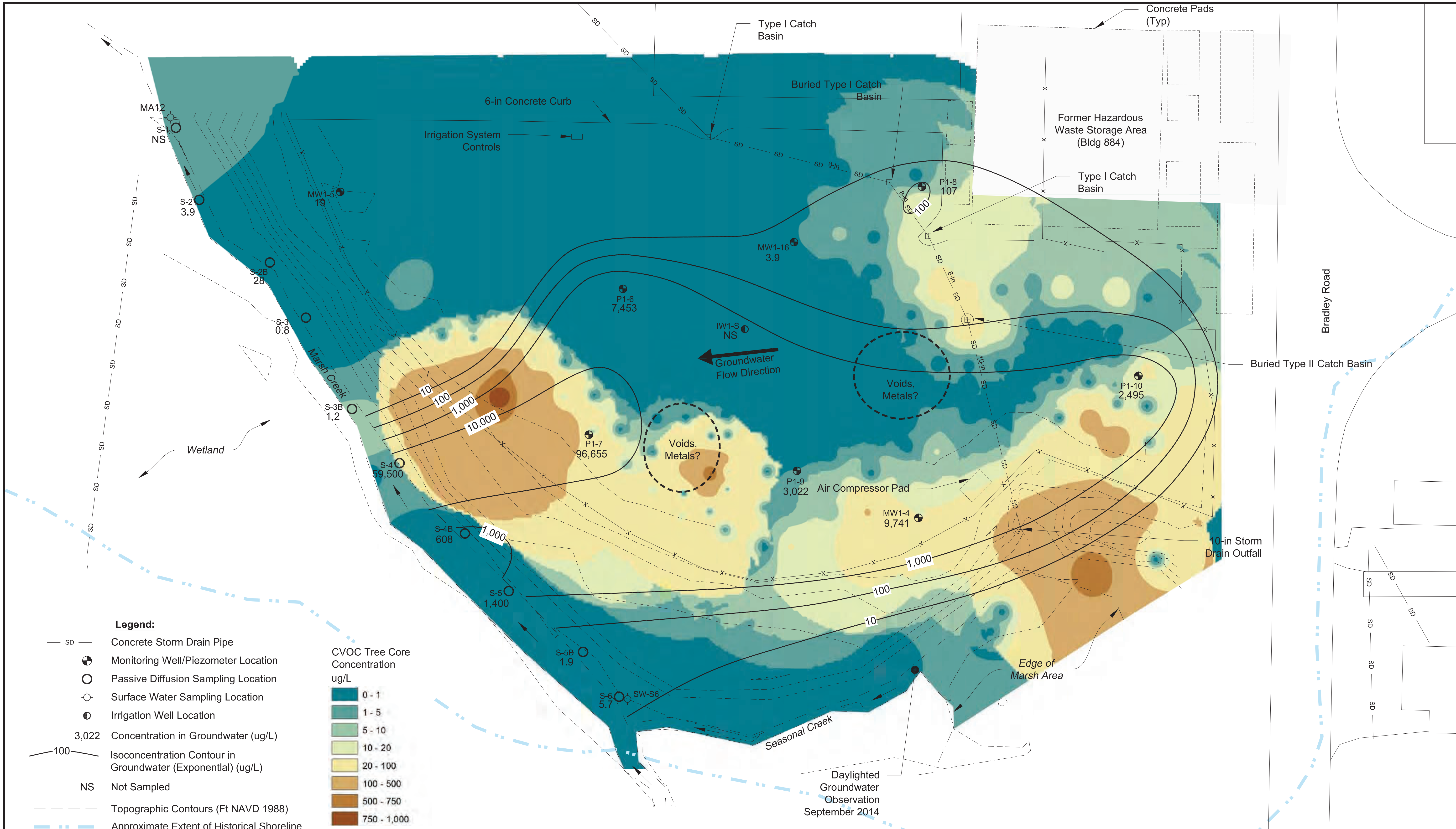
groundwater. These geophysical anomalies were not collocated with high COC concentrations in tree cores or groundwater; thus, the contaminant source is not expected to be a buried primary source. Chlorinated VOCs are detected throughout groundwater in the South Plantation with the highest concentrations detected at P1-7, P1-6, and MW1-4, and peeper location S-4.

An overlay of tree core, geophysical, 2014 groundwater monitoring results for total cVOCs from the Phase I investigation in the South Plantation is provided as Figure 4-4. As shown in Figure 4-4, cVOC tree core data and 2014 groundwater data indicate some correlation. Concentrations of TCE, cis-1,2-DCE, and trans-1,2-DCE in tree cores and groundwater generally correlate spatially in the South Plantation. Notably, concentrations of PCE, 1,1,1-TCA, and 1,1-DCA in tree cores and groundwater are not collocated. The southwestern area of the South Plantation near locations P1-7 and S-4 illustrate the greatest correlation between tree cores and groundwater, while the remainder of the South Plantation does not indicate significant correlation.

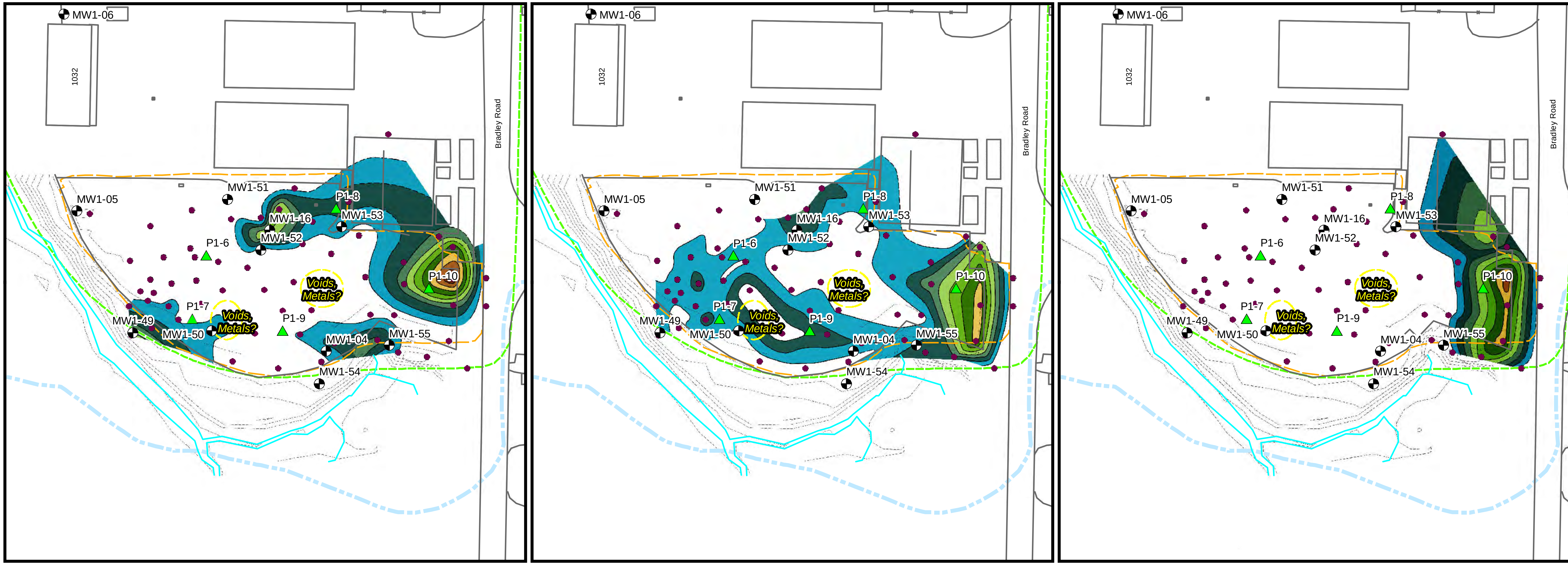
During the 2016 Phase II investigation, MIP boring locations were positioned to assess the apparent distribution of cVOCs in groundwater based on tree core sample results from the Phase I investigation and 2014 groundwater monitoring results from the LTM program. The MIP results were used to refine the apparent lateral and vertical extent of relatively higher concentrations of cVOCs in the upper portion of the aquifer. The MIP results from the Phase II investigation of the South Plantation are presented in Figure 4-5 and summarized below:

- The observations from the halogen-specific detector (XSD) responses suggest the presence of a significant residual source southeast of the Former Hazardous Waste Storage Area near the eastern edge of the landfill. The depth of the cVOC contamination appears to range from approximately 2 to 30 feet below ground surface (bgs) in the eastern portion of the South Plantation, and two hot spots at different depths were identified within this range. The XSD responses in this area indicate that contamination extends deeper than the existing monitoring well network, which extends to approximately 21 feet bgs.
- The XSD responses at the northcentral, southwestern, and southeastern portions of the South Plantation suggest the possible presence of additional source areas at depths as deep as 18 feet bgs.
- The XSD responses suggest that the deepest contamination observed does not extend into the Clover Park Silt (believed to have been encountered at approximately 31 to 33 feet bgs in the eastern portion of the South Plantation). This would indicate that the Clover Park Silt has not influenced the migration of cVOCs mass.
- The PID responses were reported at varying magnitudes at most of the MIP borings and generally corresponded with the locations and depths of the XSD responses.
- Several PID responses were observed to occur independently of XSD responses in the western portion of the South Plantation, suggesting the potential presence of contaminants other than cVOCs.

An evaluation of the general lithology was completed based on responses from the electrical conductivity probe and the hydraulic profiling tool. Notably, the Clover Park Silt was thought to be observed between approximately 28 and 40 ft bgs across the South Plantation.




| | | |
|---|---|---|
| **U.S. NAVY** | **Figure 4-4**<br>**OU 1 2015 Phase I Site Characterization at South Plantation –**<br>**Summary of cVOCs in Groundwater, Tree Core, and Geophysical Results** | NBK KEYPORT<br>FIFTH<br>FIVE-YEAR REVIEW |




0 to 9 ft bgs

9 to 18 ft bgs

>18 ft bgs

Explanation

- MIP Locations
- Piezometer
- Monitoring Well
- Base Boundary
- OU1 Boundary
- Plantation Area
- Approximate Extent of Historical Shoreline

XSD Response (1,000 uV)

- >100-200
- >200-300
- >300-400
- >400-500
- >500-600
- >600-700
- >700-800
- >800-900
- >900-1,000
- >1,000

N

Scale in Feet

0 60 120

OU1_A1_XSD.mxd

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**Figure 4-5**
**OU 1 2017 Phase II Site Characterization at South Plantation - XSD Isoconcentration Maps**

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During the 2017 Phase II investigation, soil and grab groundwater samples were collected and results were used to identify cVOC hotspots in the South Plantation (see Figure 4-6). Hotspots identified in this evaluation were based on areas of dissolved COC concentrations above benchmark values (i.e., at 50,000 µg/L TCE or cis-1,2-DCE or 10,000 µg/L vinyl chloride) and areas encompassing sampling points where percent concentrations of 1,1,DCE were detected, indicating the potential for dense non-aqueous phase liquid to be present, yet no DNAPL was observed in the resulting groundwater well, suggesting the DNAPL is bound in the matrix of the formation. As shown in Figure 4-5, there are two relatively distinct hotspots in the South Plantation: one significant hotspot in the eastern portion of the landfill consistent with the XSD responses and one lesser hotspot surrounding well MW1-50.

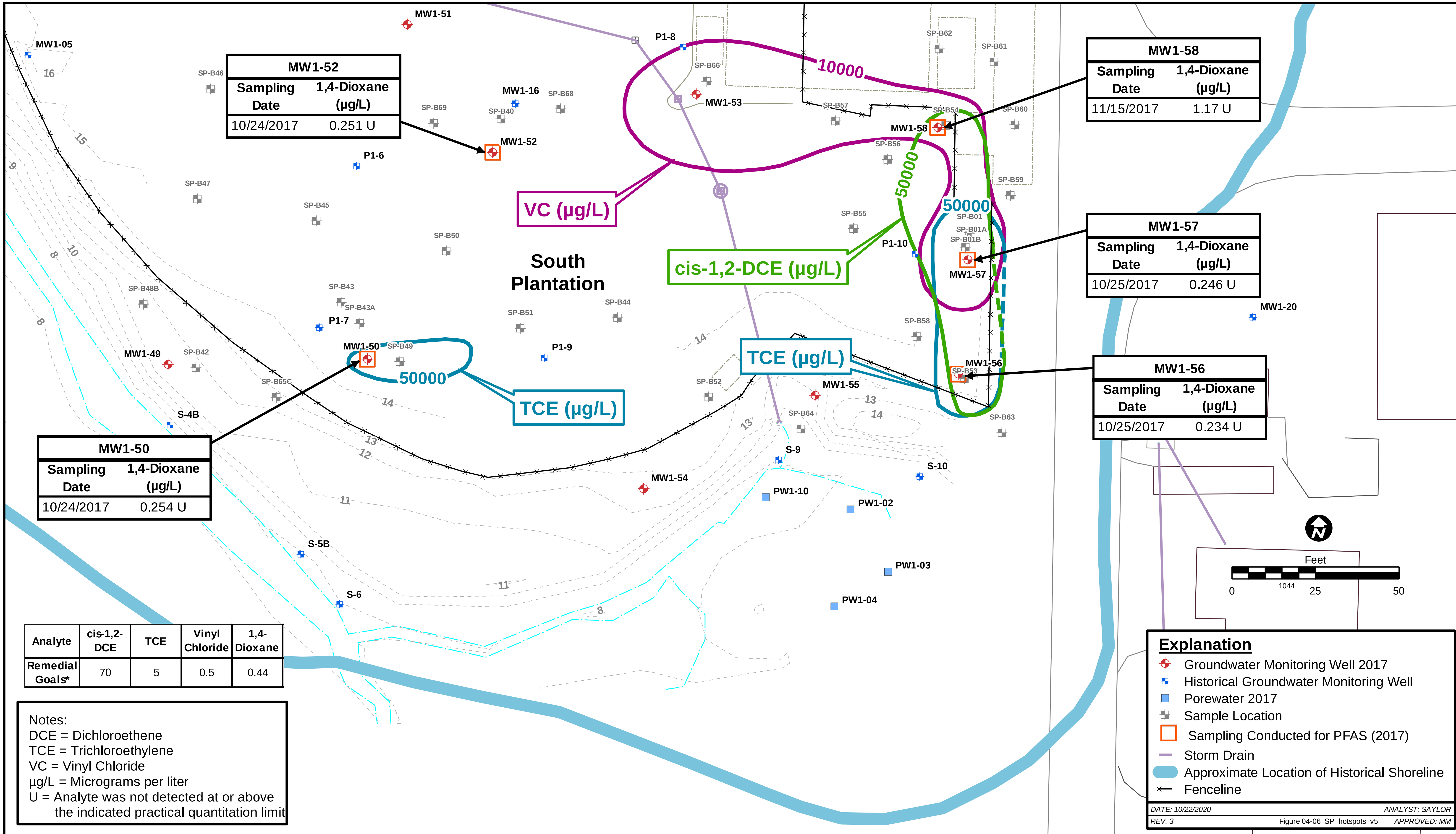
During the 2017 Phase II investigation, porewater and surface water samples were collected along the boundaries of the South Plantation (see Figure 4-7). As shown in Figure 4-7, concentrations of multiple cVOCs (i.e., TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and vinyl chloride) exceeded their respective PALs in all porewater samples collected adjacent to the eastern portion of the South Plantation (i.e., PW1-02, PW1-03, PW1-04, and PW1-10). Concentrations of two or three of the nine cVOCs exceeded their PALs in each of the surface water samples collected adjacent to the South Plantation. Concentrations of TCE and vinyl chloride exceeded their respective PALs in 10 of the 12 surface water samples, while concentrations of cis-1,2-DCE exceeded the PAL in 4 of the 12 samples. The highest cVOC concentrations in surface water were measured immediately adjacent to the eastern portion of the South Plantation at SW1-10, near peeper stations S-4 and S-4B where the highest cVOC concentrations in porewater have historically been measured. The push-point porewater and surface water sampling results are provided on Tables D-14 and D-15 in Appendix D.

Of the two stormwater samples collected in the South Plantation area, one COC was detected (cis-1,2 DCE at a concentration of 1.14 µg/L) in the sample from the outfall, south of the eastern portion of the South Plantation, and no COCs were detected in the sample from the manhole immediately upstream of the outfall. The stormwater sampling results are presented on Table D-16 in Appendix D.

*Central Landfill*

During the Phase I investigation, PCE and TCE were detected in all four tree core samples collected from four native trees located downgradient of well MW1-17. Daughter products of PCE and TCE were not reported in any of the tree core samples. Data overlays were not developed for the area adjacent to well MW1-17, because the tree core data were collected from west or downgradient of the well location. Within the Central Landfill area upgradient of well MW1-17, there was a significant variation in geophysical response. The northern portion of the area appears to have more anomalies than the southern portion. The data suggest areas of voids and metal exist within the landfill. The geophysical anomalies in the South Plantation were not typically associated with higher COC concentrations in tree cores, so this line of evidence did not provide insight as to which anomalies upgradient of MW1-17 should preferentially be investigated.

During the 2016 Phase II Investigation, MIP locations were positioned in the vicinity of well MW1-17 and surrounding the motorcycle training area to assess the presence or absence of a cVOC plume migrating toward well MW1-17 and the presence or absence of a cVOC plume migrating to the northwest from former Building 884 toward well MW1-17. Comparisons of MIP results between boring locations




| Analyte | cis-1,2-DCE | TCE | Vinyl Chloride | 1,4-Dioxane |
|---|---|---|---|---|
| Remedial Goals* | 70 | 5 | 0.5 | 0.44 |

Notes:
DCE = Dichloroethene
TCE = Trichloroethylene
VC = Vinyl Chloride
µg/L = Micrograms per liter
U = Analyte was not detected at or above the indicated practical quantitation limit

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**Figure 4-6**
**OU 1 Area 1 2017 Phase II Site Characterization at South Plantation – Hotspots based on Maximum Concentrations in Grab Soil and Groundwater Samples**

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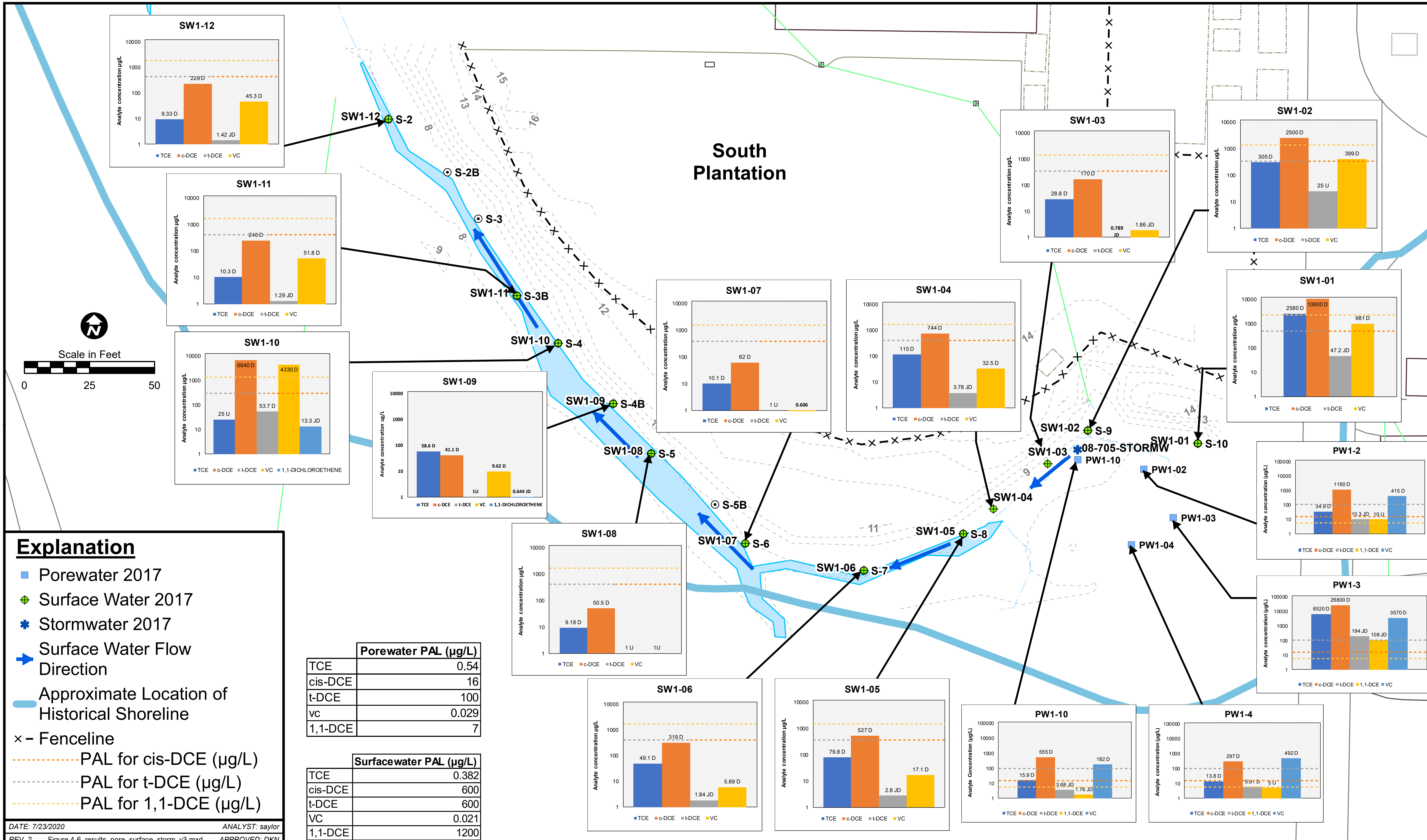


| | Porewater PAL (µg/L) |
|---|---|
| TCE | 0.54 |
| cis-DCE | 16 |
| t-DCE | 100 |
| VC | 0.029 |
| 1,1-DCE | 7 |

| | Surfacewater PAL (µg/L) |
|---|---|
| TCE | 0.382 |
| cis-DCE | 600 |
| t-DCE | 600 |
| VC | 0.021 |
| 1,1-DCE | 1200 |

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**Figure 4-7**
**OU 1 2017 Phase II Site Characterization at South Plantation – Porewater and Surface Water Data**

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were used to evaluate the presence or absence of a cVOC plume in the upper portion of the aquifer in this area. The MIP results are summarized below:

- No XSD response significantly greater than the baseline was reported from the ground surface to a depth of approximately 15 feet bgs.
- The XSD responses suggest the presence of a source near MW1-17. The XSD responses suggest that the deepest contamination observed does not extend into the Clover Park Silt (believed to have been encountered at approximately 32 ft bgs). However, the elevated XSD responses at depths between approximately 17 and 20 feet bgs indicate that contamination in this area extends deeper than the existing monitoring well network, which extends to 16 feet bgs.
- The PID responses were reported at varying magnitudes at most of the MIP borings and generally corresponded with the locations and depths of the XSD responses.
- No PID responses were observed to occur independently of XSD responses.
- The Clover Park Silt was believed to have been observed between 26 and 34 feet bgs in the Central Landfill.

Figure 4-8 presents the select tree core results, groundwater results from MW1-17, and geophysical results from the Phase I investigation and XSD responses from the Phase II investigation in the Central Landfill.

During the 2017 Phase II investigation, soil and grab groundwater samples were also collected and results were used to verify Phase I results and identify the magnitude and extent of cVOC hotspots in the Central Landfill (see Figure 4-9). Hotspots identified in this evaluation were based on areas of dissolved COC concentrations above benchmark values (i.e., at 10,000 μg/L cis-1,2-DCE or vinyl chloride or 1,000 μg/L TCE) and areas encompassing sampling points where non-aqueous phase liquid (NAPL) was observed or is indicated based on a lines of evidence analysis from EPA guidance. As shown in Figure 4-9, there was one relatively distinct hotspot in the Central Landfill, located west or upgradient of well MW1-17 surrounding wells MW1-46, MW1-47, and MW1-48.

During the 2017 Phase II investigation, push-point porewater samples were also collected from six locations west of the Central Landfill. Concentrations of cVOCs were not detected above the laboratory LOD in porewater samples from any of the sampling locations adjacent to the Central Landfill (PW1-01, PW1-05, PW1-06, PW1-07 and PW1-09).

*cVOC Soil Gas Sampling*

Soil gas sampling was proposed at locations along Bradley Road to evaluate the VI pathway from the landfill to occupied buildings east of Bradley Road. The sampling was designed to provide an updated evaluation of cVOC concentrations in soil gas in this area. Soil gas sampling was conducted at a total of nine sampling locations. The soil gas sampling results were compared to soil gas screening levels for sub-slab soil gas. The soil gas sampling results are presented in Figure 4-10 and summarized below:

- TCE concentrations in six of the nine samples and vinyl chloride concentrations in seven of the nine samples exceeded the applicable soil gas screening levels. Concentrations of other

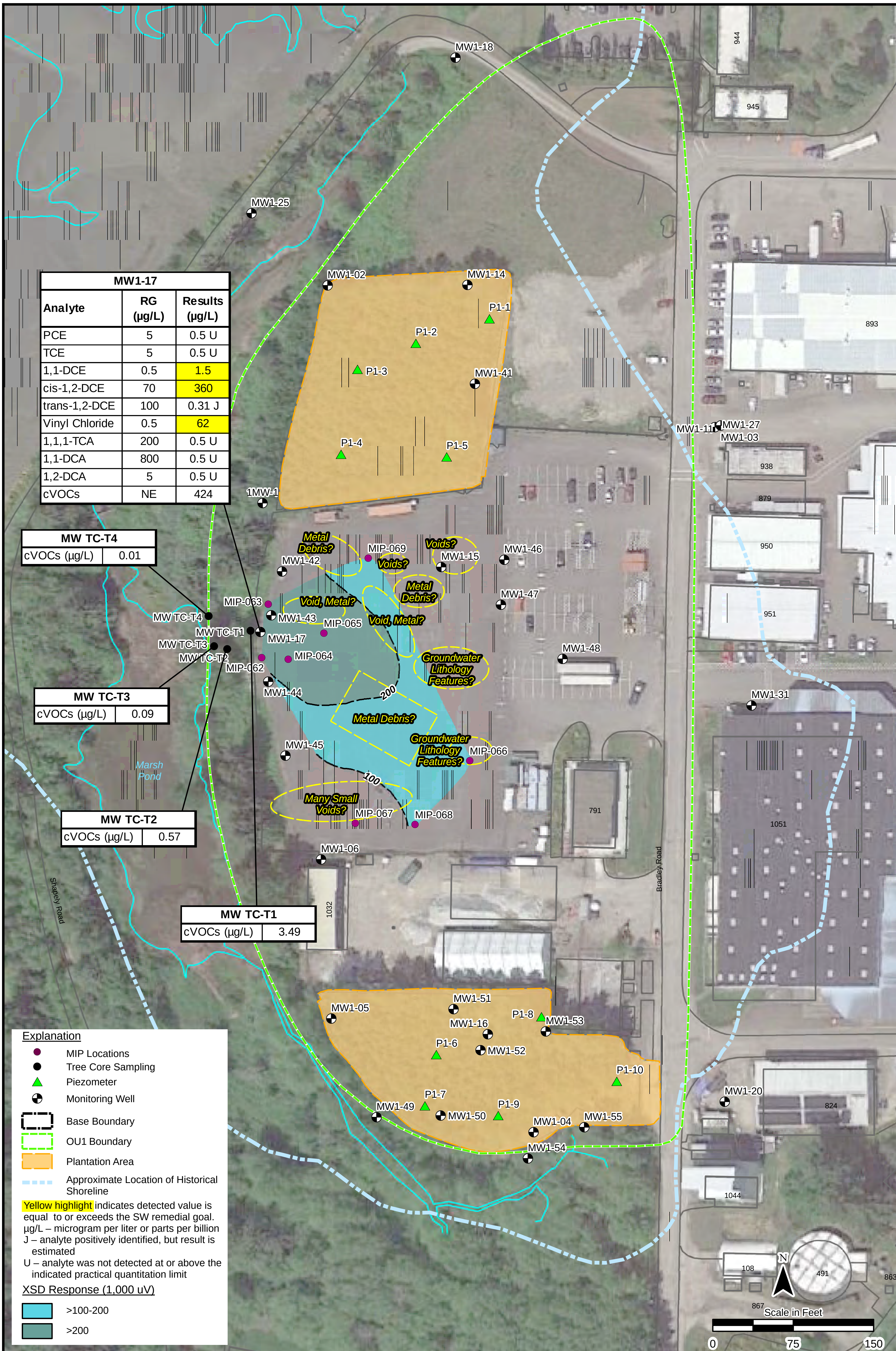


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**Figure 4-8**
**OU 1 Phase I & II Site Characterization at Central Landfill - Geophysical, Select Groundwater and Tree Core Sampling Results, and XSD Isoconcentration Map (greater than 15 ft bgs)**

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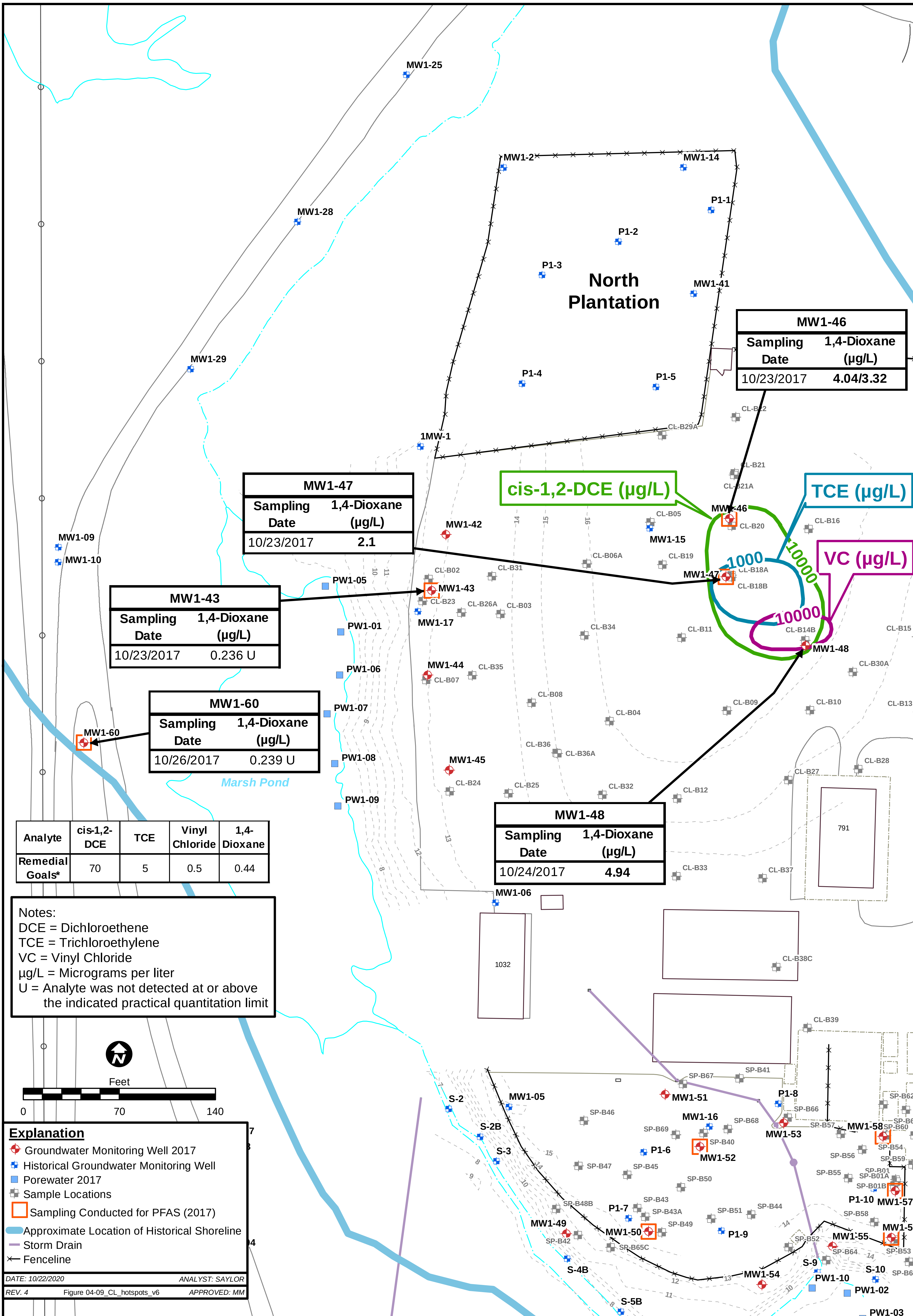


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**Figure 4-9**
**OU 1 2017 Phase II Site Characterization at Central Landfill – Hotspots based on Maximum Concentrations in Grab Soil and Groundwater Samples**

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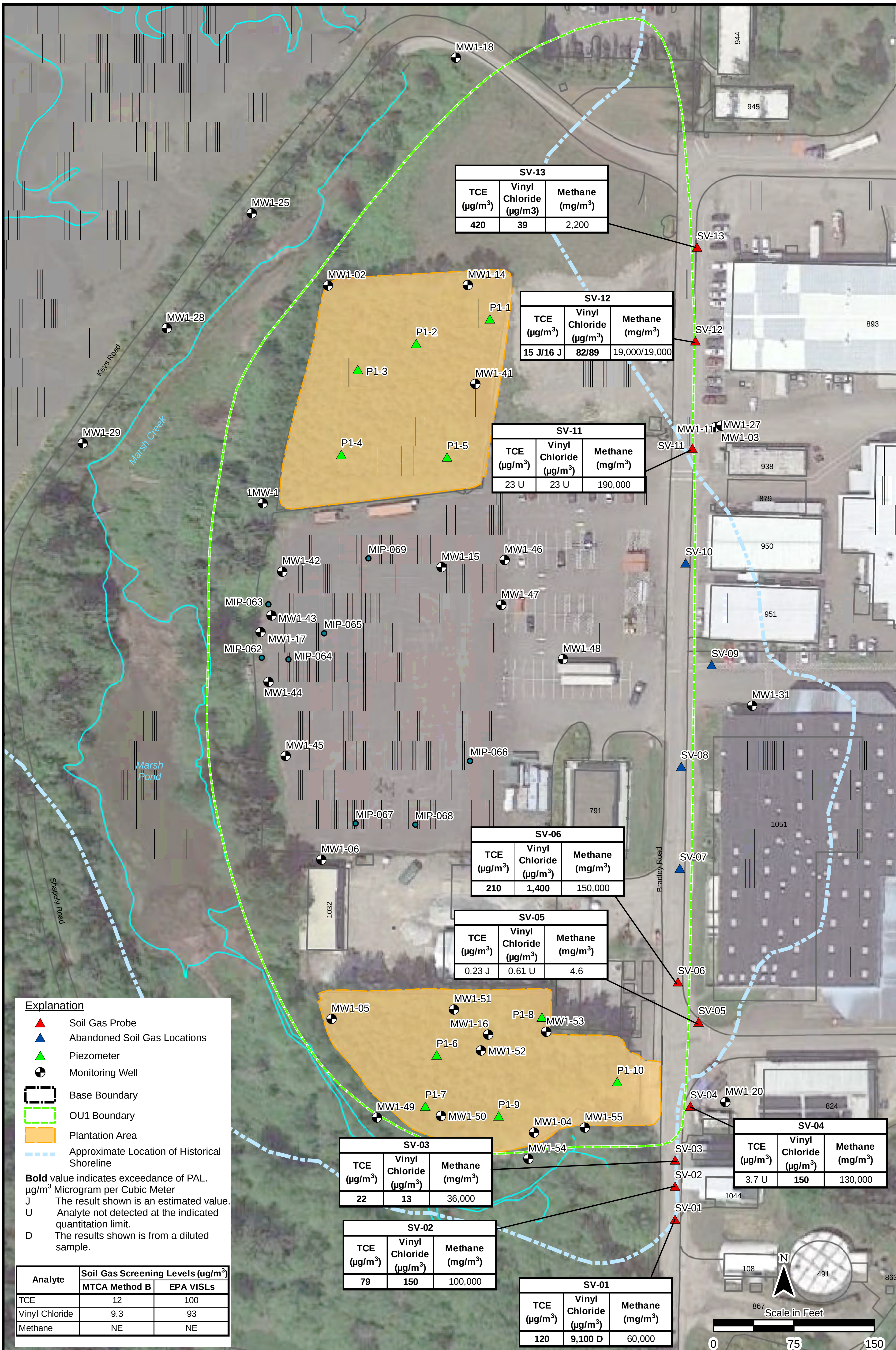



| SV-13 | TCE (µg/m³) | Vinyl Chloride (µg/m3) | Methane (mg/m³) |
|---|---|---|---|
| | **420** | **39** | 2,200 |

| SV-12 | TCE (µg/m³) | Vinyl Chloride (µg/m³) | Methane (mg/m³) |
|---|---|---|---|
| | **15 J/16 J** | **82/89** | 19,000/19,000 |

| SV-11 | TCE (µg/m³) | Vinyl Chloride (µg/m³) | Methane (mg/m³) |
|---|---|---|---|
| | 23 U | 23 U | 190,000 |

| SV-06 | TCE (µg/m³) | Vinyl Chloride (µg/m³) | Methane (mg/m³) |
|---|---|---|---|
| | **210** | **1,400** | 150,000 |

| SV-05 | TCE (µg/m³) | Vinyl Chloride (µg/m³) | Methane (mg/m³) |
|---|---|---|---|
| | 0.23 J | 0.61 U | 4.6 |

| SV-04 | TCE (µg/m³) | Vinyl Chloride (µg/m³) | Methane (mg/m³) |
|---|---|---|---|
| | 3.7 U | **150** | 130,000 |

| SV-03 | TCE (µg/m³) | Vinyl Chloride (µg/m³) | Methane (mg/m³) |
|---|---|---|---|
| | **22** | **13** | 36,000 |

| SV-02 | TCE (µg/m³) | Vinyl Chloride (µg/m³) | Methane (mg/m³) |
|---|---|---|---|
| | **79** | **150** | 100,000 |

| SV-01 | TCE (µg/m³) | Vinyl Chloride (µg/m³) | Methane (mg/m³) |
|---|---|---|---|
| | **120** | **9,100 D** | 60,000 |

| Analyte | Soil Gas Screening Levels (ug/m³) MTCA Method B | EPA VISLs |
|---|---|---|
| TCE | 12 | 100 |
| Vinyl Chloride | 9.3 | 93 |
| Methane | NE | NE |

| U.S. NAVY | **Figure 4-10**<br>**OU 1 2017 Phase II Site Characterization –**<br>**Soil Gas Sampling Results of cVOCs Exceeding a Screening Level** | NBK KEYPORT<br>FIFTH<br>FIVE-YEAR REVIEW |
|---|---|---|

- COCs were either less than the screening levels or reported at concentrations below laboratory reporting limits (referred to as “non-detect” from here forward).
- TCE concentrations were highest at SV-13 (420 $\mu g/m^3$) and SV-06 (210 $\mu g/m^3$).
- Vinyl chloride concentrations were highest at SV-01 (9,100 $\mu g/m^3$) and SV-06 (1,400 $\mu g/m^3$).
- Methane concentrations were greater than the lower explosive limit (LEL) of 5 percent at all locations except SV-05, SV-12, and SV-13.

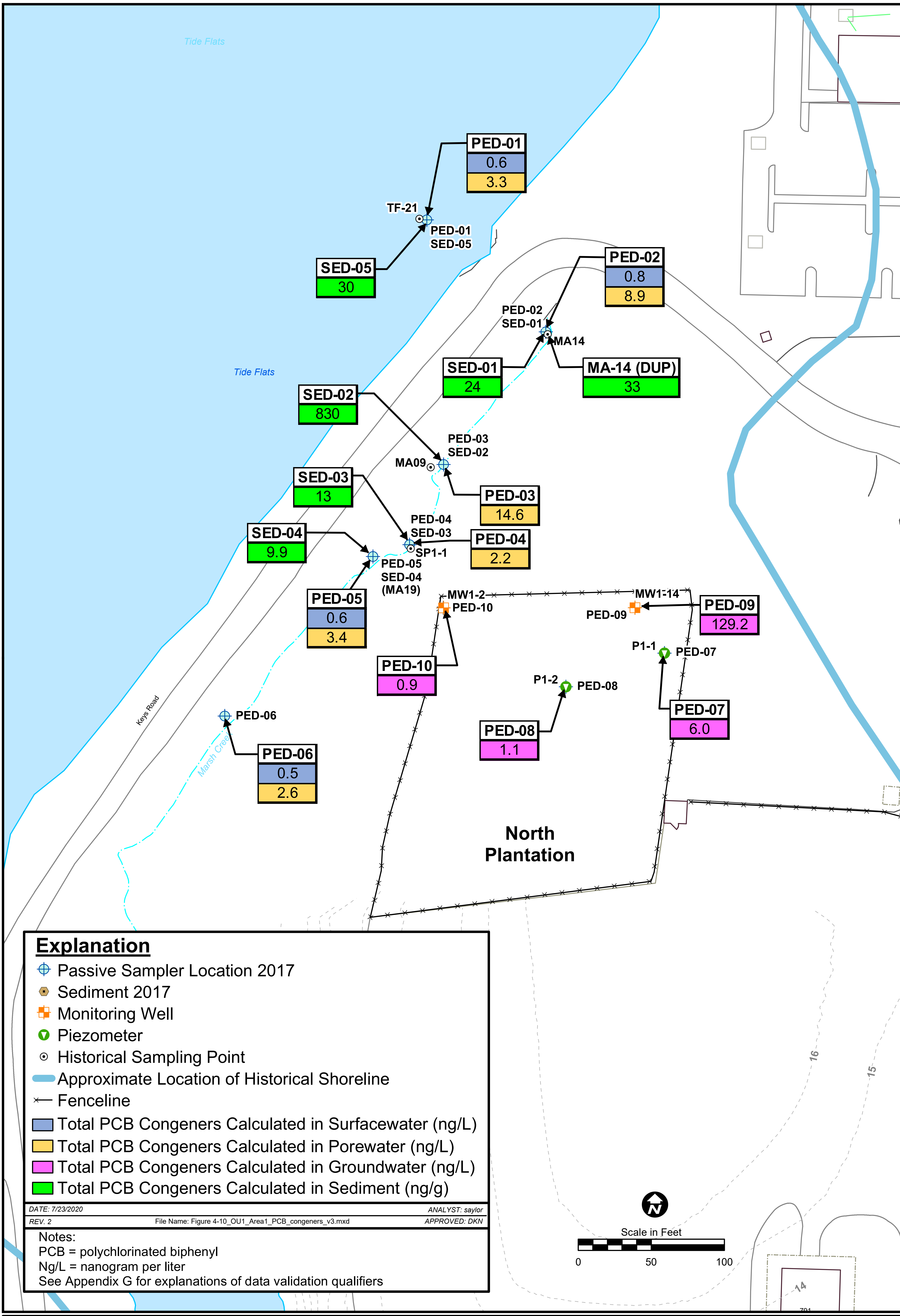
Based on these soil gas sampling results, the 2016 Phase II Investigation Report recommended further investigation of potential VI at buildings east of Bradley Road. The soil gas sampling results are provided in on Table D-17 Appendix D.

*PCBs in Sediment and Passive Samplers*

During the 2017 Phase II investigation, sediment samples and passive sampler samples (i.e., surface water, porewater, and groundwater) were collected within and northwest of the North Plantation to identify or determine the source of PCB contamination at seep SP1-1. Figure 4-11 presents the sediment, surface water, porewater, and groundwater results for total PCB congeners.

The total PCB (congeners) concentration for sediments in MA-09 exceeded both freshwater and marine sediment cleanup objectives (SCOs). The total PCB (congeners) concentrations at the other Marsh Creek and the tide flats sampling locations did not exceed the SCOs. Total PCB concentrations in sediments, from the summation of the congeners, are provided on Table D-11 in Appendix D. PCB Aroclors were detected also detected in MA-09 and no other sediment samples. Two Aroclors (1254 and 1260) were detected in the sample from MA-09, at concentrations of 350 µg/kg and 120 µg/kg, respectively. Overall, the 2017 PBC data are similar to pre-ROD/pre-sediment removal concentrations. PCB Aroclor concentrations are provided on Table D-12 in Appendix D.

Using the passive samplers, the highest dissolved PCB concentration in groundwater was measured in monitoring well MW1-14 (at 129.2 ng/L). The dissolved PCB concentrations in the other three groundwater samples were much less, ranging from 0.9 to 6.0 ng/L. PCBs were also measured at marsh stations MA-09 (at 14.6 ng/L) and MA-14 (at 8.9 ng/L) located downstream from seep SP1-1. The area of the seep itself (station SP1-1) exhibited porewater concentrations of 2.2 ng/L which is similar to those obtained at MA19 (3.4 ng/L) just upstream of SP1-1 and the new location further upstream at PED-06 (2.6 ng/L). A similar concentration was also measured in the tide flat (station TF-21, 3.3 ng/L). The surface waters displayed a narrow range of concentrations from 0.5 to 0.8 ng/L. The results of the calculated total PCB concentrations in the passive sampler-sampled waters are summarized in Figure 4-11 and provided on Table D-13 in Appendix D.




| | | |
|---|---|---|
| U.S. NAVY | **Figure 4-11**<br>**OU 1 2017 Phase II Site Characterization –**<br>**PCB Congeners in Sediments and Passive Samplers** | NBK KEYPORT<br>FIFTH<br>FIVE-YEAR REVIEW |

*Summary of Phase II Investigation Results*

Based on the results presented in the 2017 Phase II Site Recharacterization Report, the following conclusions were made regarding the nature and extent of contamination at OU 1:

- The highest concentrations of COCs beneath the South Plantation and in the adjacent wetlands are summarized as follows:
  - Laterally in an east-west direction, the highest COC concentrations are located beneath the eastern portion of the South Plantation, from Bradley Road on the east to approximately the centerline of former Building 884 on the west (SP-B55). In a north-south direction, these highest concentrations are found from approximately the southern edge of former Building 884 to the marsh (see Figures 4-5 and 4-6).
  - The highest COC concentrations beneath the eastern portion of the South Plantation extend vertically from the waste body of the landfill at approximately 5 to 7 ft bgs and penetrate the upper portion of what is believed to be the Lawton Clay at approximately 30 to 35 ft bgs.
  - Other areas of high COC concentrations (but lower than described above), are evident around historical well MW1-16 and from east of piezometer P1-7 westward to the marsh. In contrast to the eastern portion of the South Plantation, the highest COC concentrations in these areas appear to be shallower, typically found from 8 to 15 ft bgs.
  - Although the areas described in the items above exhibit the highest COC concentrations, exceedances of the ROD RGs are found throughout the South Plantation, and at all surface water sampling locations adjacent to the South Plantation.
- The likeliest discharge points along transport pathways from high COC concentration areas at the South Plantation to the adjacent wetlands are: 1) from the eastern portion of the South Plantation discharging to the area of the marsh immediately adjacent to Bradley Road and south of the South Plantation, east of the stormwater outfall, and 2) from the vicinity of piezometer P1-7 discharging toward monitoring well MW1-49 and peeper sampling stations S-4 and S-4B.
- In the Central Landfill, residual cVOC sources exist upgradient of well MW1-17. Residual sources are located in the vicinity of monitoring wells MW1-46, MW1-47, and MW1-48, and appear to represent more than one discrete residual source resulting in a commingled plume. The highest COC concentrations in this area are found in the depth range of 17 to 33 ft bgs.
  - Residual source(s) also exist in the area of direct-push borings CL-B03, CL-B04, CL-B35, and CL-B36. These residual sources appear to be separated from those in the vicinity of MW1-46, MW1-47, and MW1-48 by an area of relatively lower concentrations. The highest COC concentrations in this area are found in the depth range of 13 to 22 ft bgs.
  - Based on the absence of detectable cVOCs in porewater samples located due west of the Central Landfill, and the pattern of highest cVOC concentrations observed in grab groundwater samples, cVOCs from the Central Landfill do not appear to be discharging to surface water in this area. Rather than the cVOC plume implied by the groundwater

monitoring well data, contaminant transport beneath the Central Landfill appears to be toward the northwest along a more regional groundwater flow direction.

- Based on the continuous soil cores logged in 2017 and the 2016 MIP results, a laterally continuous aquitard does not exist in the central portion of the landfill, between what was defined in the ROD as the shallow and intermediate aquifers, upgradient of well MW1-17, or anywhere investigated in 2016 and 2017. This finding does not support the geologic interpretation presented in the ROD, but is consistent with that presented in the RI/FS.
- The 2017 PCB data are similar to concentrations measured pre-ROD. The 2017 result at MA-09 could indicate a temporal increase in PCBs at location MA-09, or a spatial variation in sediment concentrations in this area. The measured concentrations could be residual pre-ROD concentrations, given the selective nature of the sediment removal to protect root systems. Because of the uncertainty regarding concentration trends based on the 2017 results, a recommendation was provided for three additional annual sampling events performed at the five stations sampled in 2017, using the same sampling techniques and analytical procedures.
    - ➢ The elevated concentrations of PCBs in groundwater at well MW1-14, combined with the groundwater flow direction to the northwest and the location of the highest PCB concentrations in sediment and porewater at location MA-09 (downgradient of MW1-14), imply that recontamination may be occurring from a source within the landfill. In accordance with the recontamination requirements of the SMS (WAC 173-204-500[5][b][iii]), the potential for an uncontrolled source in the landfill should be assessed.
    - ➢ Because the highest current PCB concentrations are not higher than those found at the time of the ROD and are limited to the immediate vicinity of station MA-09, a recommendation was provided of not reopening the risk assessment regarding PCBs in sediment until additional PCB concentration trend data are available.

Figure 4-12 presents and summarizes the current contaminant transport pathways understood at OU 1 based on the Phase I and Phase II investigations. The 2017 Phase II Site Recharacterization Report concluded that a revised physical/chemical CSM is warranted and specific additional data collection are needed to refine the CSM. Once these additional data are collected, then a list of remedial technologies to decrease the restoration timeframe can be developed.

**2019 Source Area Investigation.** In 2019, an additional source area investigation was conducted at OU 1. The investigation was designed to collect quantitative data to:

1) Verify the migration path of VOCs and 1,4-dioxane from the Central Landfill hotspots toward wells on the causeway between the tide flats and Dogfish Bay;
2) Identify the source of PCB contamination in site sediments; and
3) Better define the extent of contamination:
    a) At the east side of the South Plantation;
    b) In the marsh area southeast of the South Plantation; and
    c) In Marsh Creek.

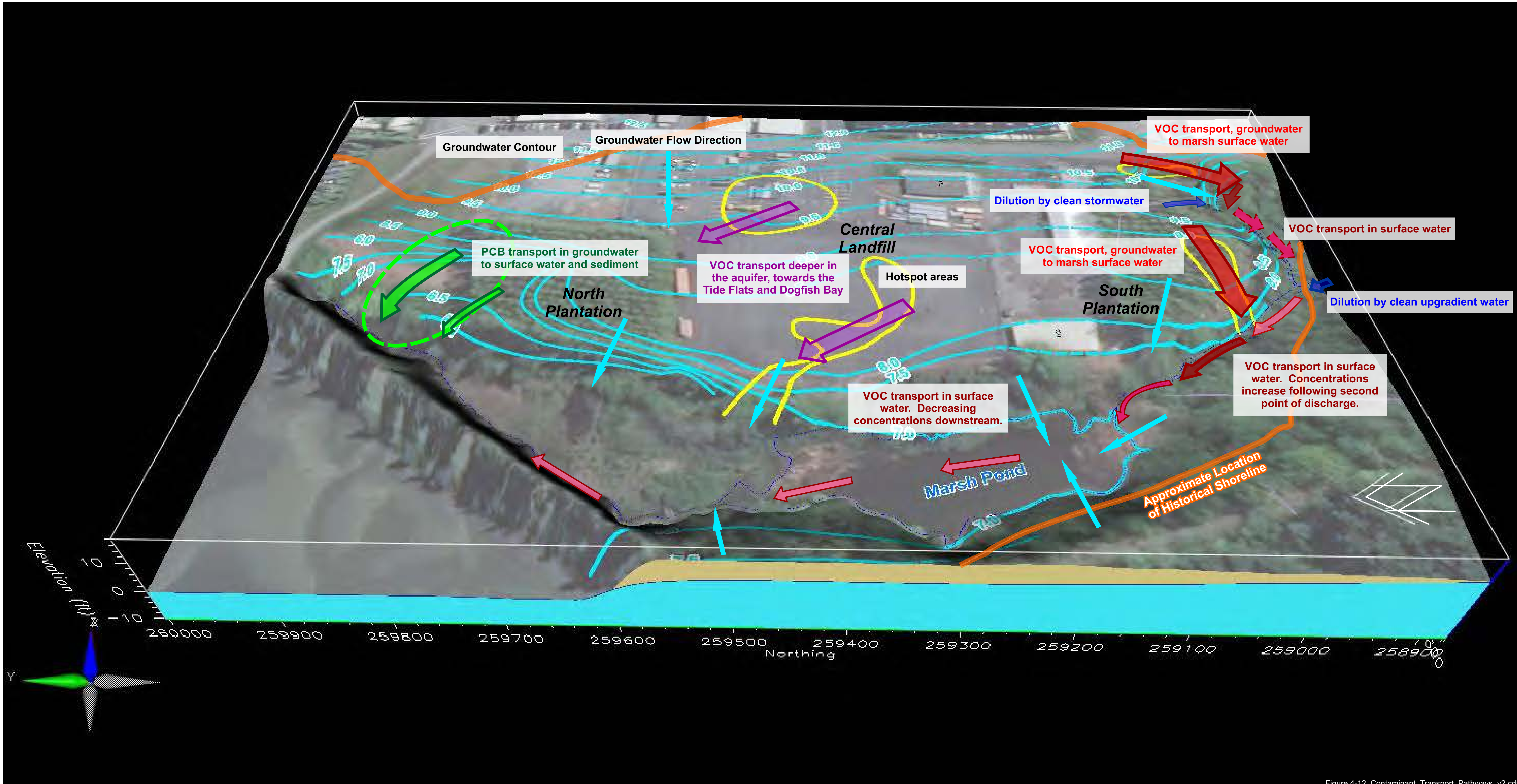



Figure 4-12_Contaminant_Transport_Pathways_v2.cdr

| U.S. NAVY | Figure 4-12<br>OU 1 Area 1 2017 Phase II Site Characterization – Contaminant Transport Pathways | NBK KEYPORT<br>FIFTH<br>FIVE-YEAR REVIEW |
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Lithologic data were also collected to improve mapping of the regional aquitard contact within the site boundary and to conduct fate and transport modeling.

The 2019 source investigation report was not published by June 2019 (i.e., the end of this FYR period), so only a preliminary summary of the field procedures, activities and data are presented below. Data from these investigations will be used to update the existing CSM, allow better evaluation of remedy effectiveness, and support a focused feasibility study designed to evaluate alternatives for the treatment of identified hotspots to reduce the restoration timeframe at the site. The 2019 source investigation consisted of two mobilizations:

First Mobilization – June 2019

- A total of 33 direct push borings were installed across the North Plantation, Central Landfill, and South Plantation; a total of 102 soil samples were collected; and a total of 67 grab groundwater samples were collected. All samples were analyzed for the target VOCs listed in the Sampling and Analysis Plan (SAP) (Battelle, 2019), consisting of the nine cVOC COCs identified in the ROD and chloroethane. Additional subsets of samples were analyzed for 1,4-dioxane, PCB Aroclors, TPH-Diesel, and/or TOC (soil only).
- A total of 16 porewater samples were collected from areas south of the South Plantation, downstream of Marsh Pond, and along Marsh Creek. The samples collected from south of the South Plantation and downstream of Marsh Pond were analyzed for the target VOCs, and the samples collected along Marsh Creek were analyzed for PCB congeners.
- A total of eight (8) surface water samples were collected. Five (5) surface water samples were collected from Marsh Pond and from surface water downstream of Marsh Pond, and analyzed for target VOCs. Three (3) surface water samples were collected from areas near Seep SP1-1 and analyzed for PCB congeners.
- A total of seven (7) sediment samples were collected at, or in the vicinity of, historical sediment sample locations. These samples were collected for PCB congeners.

Second Mobilization – September/October 2019

- A total of 17 sonic borings were installed. A total of nine (9) monitoring wells were installed: three (3) in the South Plantation, one (1) in the Central Landfill, and five (5) in the North Plantation.
- A total of 27 soil samples were collected from the sonic boreholes. These samples were analyzed for the target VOCs, with additional subsets of samples analyzed for PCB congeners, TPH-Diesel, and/or TOC.
- A total of 10 grab groundwater samples were collected from the sonic boreholes. These samples were analyzed for the target VOCs, with an additional subset of samples analyzed for 1,4-dioxane.
- A total of 34 groundwater samples were collected from the nine (9) newly installed monitoring wells and twenty (20) pre-existing monitoring wells. All of these groundwater samples were analyzed for the target VOCs. Wells located in apparent hotspots that were

expected to be the focus of potential future remedial action were additionally analyzed for microbial population, PFAS, PCBs, TPH-Diesel, 1,4-dioxane, and biodegradation parameters (i.e., methane, ethane, nitrate, nitrite, sulfate, chloride, dissolved organic carbon, and sulfide). PFAS results are presented on Table D-28 in Appendix D, shown on Figures 4-4 and 4-8 and discussed in Section 5.0 (U.S. Navy, 2018b).

- A total of three (3) porewater samples were collected in October 2019. These samples were collected from west/southwest of the South Plantation and were analyzed for the target VOCs.
- To update the CSM, the majority of the sonic borings were advanced to greater depths than in previous investigations. The soil cores were continuously logged from these locations to identify the upper contact of the regional aquitard within the site boundary.

The data collected from the 2019 source investigation have not yet been comprehensively analyzed or published; however, there preliminary findings to date indicate that contaminant mass in groundwater is migrating towards the northwest to surface water. Figure 4-13 presents the contoured maximum grab groundwater concentrations of cis-1,2-DCE, vinyl chloride, and 1,4-dioxane from Geoprobe borings in the North Plantation. Vinyl chloride was detected in sediment pore water samples adjacent to the creek, which indicates contaminant mass discharge to the creek along a much longer reach of creek than previously understood (i.e., previously, discharge to the creek was only known to occur at the South Plantation).

The off-site transport of contaminant mass in groundwater towards the northwest has been known since before the time of the ROD; however, the source investigation has found contaminant mass substantially deeper and at greater concentrations. For example, monitoring well MW1-64, located in the northwest corner of the North Plantation, was installed to a completion depth of 55 ft bgs with the screened interval set from 45 to 55 ft bgs. The bottom of the well screen was set to the top of a silty clay layer encountered at 55 ft bgs, assumed to be the upper contact of the regional aquitard. Concentrations of cis-1,2-DCE, vinyl chloride, and 1,4-dioxane were detected in MW1-64, indicating groundwater contamination deeper than previously understood. Additionally, at sonic boring SP-B144 (MW1-68, located in the eastern portion of the South Plantation), a soil sample was collected at 50 ft bgs, below a 16-ft thick clay layer encountered from 30 to 46 ft bgs. TCE (at 53 µg/Kg) was detected in the soil sample, indicating cVOC soil contamination below the clay layer. Monitoring well MW1-68 was installed to a completion depth of 47 ft bgs, with the screened interval set from 37 to 47 ft bgs. The bottom of the well screen was set to just below the bottom contact of the 16-ft clay layer. Cis-1,2-DCE, TCE, and vinyl chloride were detected in the groundwater sample, indicating cVOC groundwater contamination within and below the clay layer.

Additionally, high concentrations of PCBs and TPH-Diesel were observed in shallow soil samples collected from the northern edge of the North Plantation (i.e., borings NP-B119, NP-B120, NP-B121, NP-B122, NP-B123, NP-B124, and NP-B125 installed during the first mobilization, and borings NP-B137 and NP-B138 installed during the second mobilization). The co-located presence of relatively high TPH concentrations and high PCB concentrations in soil generally did not result in detectable PCB concentrations as Aroclors in groundwater; PCBs as Aroclors were not detected in groundwater in 2019. However, PCBs as congeners were detected in shallow and deeper groundwater in 2019.

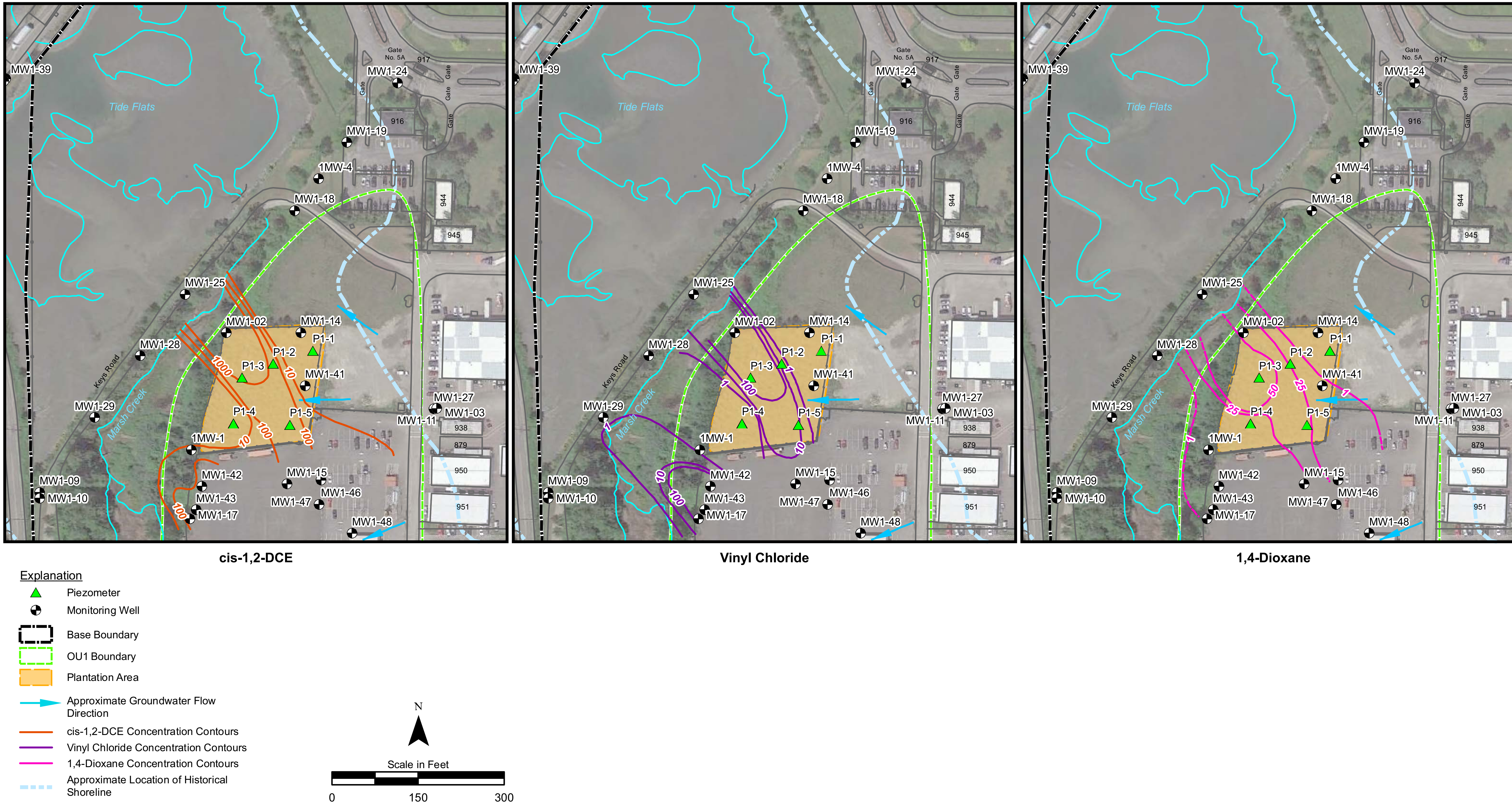


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**Figure 4-13**
**Initial Results from 2019 Source Investigation at OU 1 – Contoured Maximum Concentrations of cis-1,2-DCE, Vinyl Chloride, and 1,4-Dioxane**

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Preliminary data analysis suggests that PCBs and TPH-Diesel are migrating together in groundwater; however, conflicting evidence was observed regarding flow characteristics (i.e., shallow dissolution of PCBs followed by vertical migration to deeper groundwater vs. deeper dissolution of PCBs followed by lateral migration of groundwater). It should be noted that concentrations of PCBs detected in deeper groundwater samples were below the PAL and below the Aroclor detection limit. To evaluate the impact to the environment of PCB–contaminated groundwater discharging to surface water, further statistical analyses of sediment samples from the area of the creek downgradient of seep SP1-1 is scheduled to be conducted in the winter of 2020-2021.

As part of the source investigation, an Environmental Sequence Stratigraphy (ESS) interpretation of the geology at the site was also conducted and suggests tidal channel deposits overlying a package of fluvial channels, with a primary paleo tidal channel oriented roughly southeast to northwest potentially acting as a preferential pathway for deep contaminant mass migration to the northwest.

**Vapor Intrusion Study.** In 2018, VI study activities were conducted at 10 buildings (i.e., Buildings 916, 944, 945, 893, 951, 824, 1051, 108, 820, and 950) east and northeast of Bradley Road, adjacent to the OU 1 former landfill during both later winter and summer timeframes. The overall objectives of the VI study were to: 1) evaluate whether the VI pathway is complete between the site and nearby buildings; 2) assess whether cVOCs in groundwater have contributed to indoor air concentrations via the VI pathway; and 3) collect information to support the selection of appropriate mitigation measures, if required.

Preliminary screening with a portable gas chromatograph/mass spectrometer (GC/MS), landfill gas meter, and differential pressure monitors was performed from March 12 to 16, 2018, immediately prior to the first sampling event, in each of the 10 buildings selected for further investigation. The portable GC/MS and landfill gas meter were used to identify potential background indoor air sources, soil vapor entry points, and preliminary breathing zone concentrations. The preliminary screening results were used to inform final placement of Summa canisters to collect time-integrated samples. Cross-building differential pressure monitoring was performed during preliminary screening to provide an indication of whether the inside of each building tends to be more or less pressurized as compared to outdoor conditions.

For sub-slab and exterior soil vapor sampling, Vapor Pin® FLX-VP stainless steel probes with compression fittings and stainless steel secure flush mounted covers were installed using a rotary hammer drill. Sub-slab and exterior soil vapor probes were installed from March 19 to 22, 2018. Indoor air, outdoor air, sub-slab, and exterior soil vapor samples were collected, and differential pressure was monitored in both late winter (March 2018) and summer (July 2018). The VI sampling results for each building are provided on Tables D-18 through D-27 in Appendix D. The preliminary screening and air sampling results for each building are summarized below:

<u>Buildings 916, 944, 945, 893, 951, 824, 1051, 108:</u>

- During preliminary screening, no background indoor air sources were identified, with the exception of Building 893. In Building 893, an air freshener in the second-floor men's restroom was identified as a background indoor air source. Since Summa canister samples were not collected on the second floor and concentrations of compounds off-gassing from the air freshener were low relative to industrial screening levels, the air freshener was not removed from the building prior to sampling.

- Corrected indoor air concentrations were greater than zero for various cVOCs, 1,4-dioxane, and/or methane in both late winter and summer. However, the corrected indoor air concentrations were less than MTCA Method C (industrial) and Method B indoor air screening values, which indicates that the VI contributions, if any, to indoor air quality in these buildings was not significant.
- Indoor air, sub-slab, and/or exterior soil vapor concentrations in both late winter and summer were less than the MTCA Method C (industrial) and Method B screening levels for all target compounds. **Therefore, no further action for the VI pathway is warranted in these buildings.**

Building 820:

- During preliminary screening, no background indoor sources were identified.
- In March, corrected indoor air concentrations were greater than zero in Building 820 for PCE, TCE, cis-1,2-DCE, 1,4-dioxane, and methane. In July, corrected air concentrations were greater than zero in Building 820 for PCE, TCE, trans-1,2-DCE, 1,4-dioxane, and methane. However, the corrected indoor air concentrations were less than MTCA Method C (industrial) and Method B indoor air screening values, which indicates that the VI contribution, if any, to indoor air quality in Building 820 is not significant.
- Indoor air concentrations in both late winter and summer were less than the MTCA Method C (industrial) screening levels for all target compounds detected in Building 820. Sub-slab soil gas concentrations for all target compounds except TCE were less than the MTCA Method C (industrial) and Method B screening levels. The only TCE exceedance was for the field duplicate sub-slab soil gas sample from the warehouse, with the primary sample and all subsequent samples at least three times less than the industrial screening level.
- Ongoing monitoring was not warranted for Building 820 because there were no exceedances of indoor air industrial screening levels and only one exceedance of the TCE sub-slab soil gas industrial screening level out of 16 sample locations. The one TCE exceedance was for a field duplicate sample with an estimated result that had more than 25% relative percent difference as compared to the result for the primary sample. **It was determined that no further action for the VI pathway is warranted in Building 820.**

Building 950:

- During preliminary screening, no background indoor air sources were identified.
- In March, corrected indoor air concentrations were greater than zero in Building 950 for PCE, TCE, cis-1,2-DCE, vinyl chloride, 1,4-dioxane, and methane. In July, corrected air concentrations were greater than zero in Building 950 for PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and methane. The corrected indoor air concentrations for all contaminants were less than MTCA Method C (industrial) and Method B indoor air screening values, which indicates that the VI contribution, if any, to indoor air quality in Building 950 is not significant.

- Indoor air concentrations in both late winter and summer were less than the MTCA Method C (industrial) screening levels for all target compounds detected in Building 950. Sub-slab soil gas concentrations for all target compounds except methane were less than the MTCA Method C (industrial) and Method B screening levels. Methane levels were slightly greater than the screening levels in July, but less than the screening levels in March.
- Ongoing monitoring was not warranted for Building 950 because methane concentrations in sub-slab soil gas were only slightly greater than the screening level at 10.4% and 10.7% of the LEL in July and an order of magnitude less than the screening level in March. Concentrations of methane in indoor air were only slightly greater than those for the nearest upwind outdoor air location. **It was determined that no further action for the VI pathway is warranted at Building 950.**

Figure 4-14 presents a site map of the 10 buildings included in the VI study performed in March and July 2018. It was noted, however, that the former landfill will be vented in 2020, which will reduce the concentrations of cVOCs and methane in soil gas over time.

**USGS Tidal Lag Study.** In 2018, the USGS attempted to conducted a tidal lag study to: 1) better understand nearshore groundwater-seawater interactions; 2) determine the optimal schedule/timing for groundwater sampling at different wells; and 3) inform a concurrent groundwater modeling effort at OU 1. To meet these objectives, water levels were continuously monitored in 19 existing groundwater monitoring wells (see Figure 4-15) and five surface-water features of interest from July 12, 2018 to August 8, 2018, a period that included neap and higher amplitude spring tides. The pressure transducer in one well failed to log data; therefore, the results are only presented for 18 groundwater monitoring wells. The time-series data also included specific conductance at the surface-water features. However, although time-series data for specific conductance was also scoped to be collected in the monitoring wells used, the data loggers did not function correctly, so did not record specific conductance over time. A vertical profile of specific conductance was measured once in the screened interval of selected monitored wells to determine if the freshwater/ saltwater interface was present at the time and was used to make conclusions with regard to the project objectives.

Based on this data, the USGS reported that the optimal times for sampling groundwater for freshwater contaminants originating from OU 1 is when fresh groundwater flowing seaward is least impeded by elevated tides. Those times are related to predicted tide levels by tidal lags (i.e., the duration between low tides and corresponding low groundwater levels). For the USGS study, tidal lag times were determined relative to tidal levels in Liberty Bay (rather than in the more nearby Tide Flats) because the predicted tides for the Poulsbo, WA Station that are used to schedule groundwater sampling represent open-water conditions in the area and the sill that separates Dogfish Bay from the Tide Flats clearly affects the timing and magnitude of low-low tides in the Tide Flats (see Figures 1-2 and 1-3).

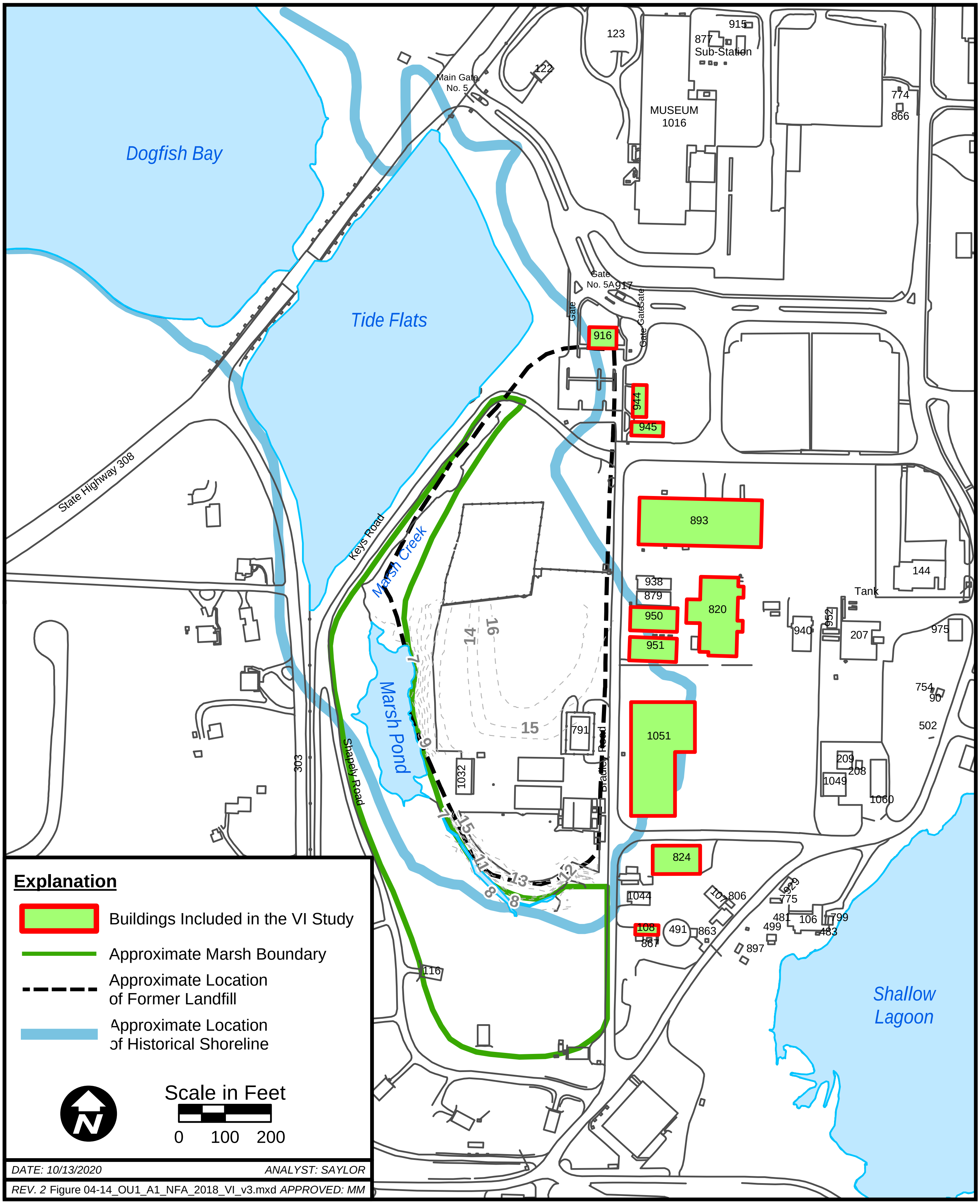


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**Figure 4-14**
**OU 1 No Further Action Summmary of 2018 Vapor Intrusion Investigation**

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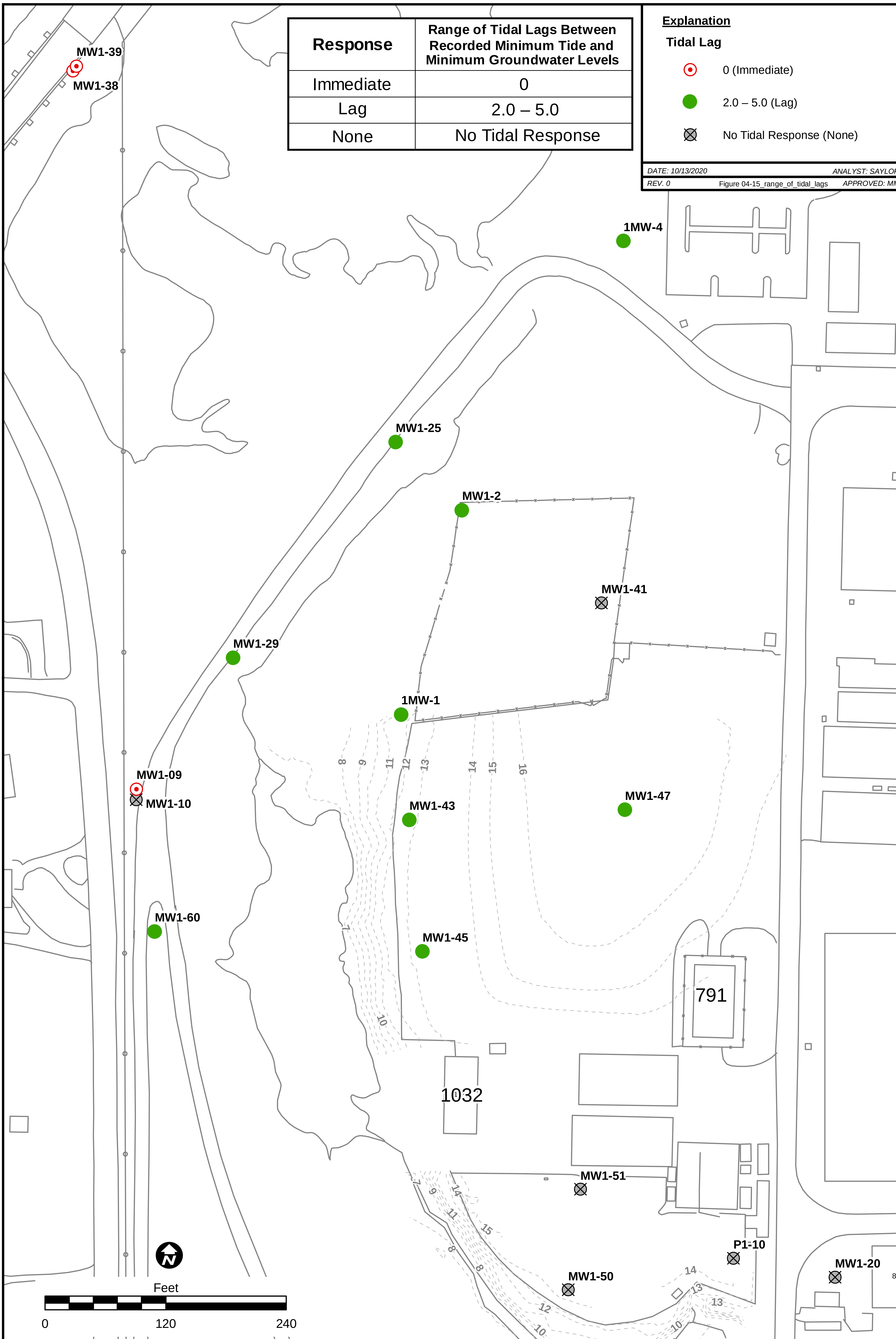


| Response | Range of Tidal Lags Between Recorded Minimum Tide and Minimum Groundwater Levels |
|---|---|
| Immediate | 0 |
| Lag | 2.0 – 5.0 |
| None | No Tidal Response |

**Explanation**

**Tidal Lag**

- 0 (Immediate)
- 2.0 – 5.0 (Lag)
- No Tidal Response (None)

DATE: 10/13/2020 ANALYST: SAYLOR
REV. 0 Figure 04-15_range_of_tidal_lags APPROVED: MM

| U.S. NAVY | Figure 4-15<br>OU 1 Tidal Lag Study Monitoring Locations | Naval Base Kitsap Keyport |
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Using the tidal levels and time-series water level data, the calculated tidal lag times at each monitoring wells fell into three general categories:

| Monitoring Well | Range of tidal lags between recorded minimum tide and minimum groundwater levels (hours) | Response |
|---|---|---|
| MW1-9*, MW1-38*, MW1-39* | 0 | Immediate |
| MW1-60, MW1-2*, MW1-29*, MW1-25*, 1MW-1*, MW1-43, MW1-47, MW1-45, 1MW-4* | 2.0 – 5.0 | Lag |
| MW1-10*, MW1-41, MW1-50, MW1-51, MW1-20, P1-10 | No Tidal Response | None |

*Specific conductance also measured at the top, middle, and bottom of each saturated screen interval.

Groundwater levels in the middle group of wells appeared to respond primarily together with tidal level changes in the Tide Flats rather than tidal level changes in Liberty Bay. The study found that when sampling during spring (rather than neap) tides, as has generally been the standard practice at OU 1, the optimal time to sample the 12 monitoring wells influenced by tides would be to add the tidal lags of the predicted low-low tide for Liberty Bay as measured at the Poulsbo, WA Station. Sampling schedules for the six monitoring wells where groundwater levels were only minimally influenced by tides need not be constrained by tidal conditions.

The discrete groundwater specific conductance data collected were used to determine if a seawater/freshwater interface was present at any of the monitoring wells, and to inform decisions on what depth groundwater should be sampled in existing wells. Vertical water quality profiles were measured once in the screened interval of nine monitoring wells. The profiles included measurements at the top, middle, and bottom of each saturated screen interval. As has been the standard practice, the study found that groundwater samples can still be collected from the middle of the saturated screened interval since no tidal-induced changes in the seawater/freshwater interface were identified in the screened interval of the wells. However, it was noted that collection of time-series specific conductance data would more thoroughly confirm this practice. Therefore, the USGS is currently repeating this study and sample timing will be based on the results of the existing study until revised results are obtained.

### *4.2.2 OU 2 Area 2*

The following section provides: 1) a review of the selected remedy, particularly the LTM program; 2) a discussion of LTM results during this FYR period and trends over time; 3) a data gap evaluation based on current LTM results and results from the RI (U.S. Navy, 1993a and 1993b); and 4) a discussion of 1,4-dioxane groundwater monitoring results. Figure 2-2 depicts the LTM sampling locations at OU 2 Area 2. Appendix E presents all historical groundwater monitoring results from OU 2 Area 2, including cVOCs (i.e., vinyl chloride, TCE, and cis-1,2-DCE) in Table E-1 and 1,4-dioxane in Table E-2.

***Review of LTM Program.*** As described in Section 2.0 and the ROD (U.S. Navy, EPA, and Ecology, 1994), the selected remedy for OU 2 Area 2 includes:

- Monitored natural attenuation.
- LTM to establish trends in COC concentrations and determine when LUCs can be discontinued.
- LUCs to prevent residential land use and construction of domestic wells.

Per the ROD, the COCs for OU 2 Area 2 are vinyl chloride and TCE with RGs of 0.023 and 5 μg/L, respectively, both the MTCA B cleanup level. At the time of the ROD, the RG for vinyl chloride was below the practical quantitation limit (PQL) of standard EPA methods for drinking water. In such cases, the MTCA B cleanup level was based on the PQL (per WAC 173-340-700[6]) and the expected PQL for vinyl chloride was 0.1 μg/L. In 2012, the RG for vinyl chloride was updated to 0.029 μg/L based on the calculated MTCA B cleanup level using the current oral slope factor. Using improved analytical techniques, the PQL has been below this updated RG of 0.029 μg/L since June 2012.

At OU 2 Area 2, groundwater samples were collected and analyzed for TCE with concentrations compared to the RG of 5 μg/L. Although not identified as a COC in the ROD, groundwater samples were similarly collected and analyzed for cis-1,2-DCE with concentrations compared to the MTCA B cleanup level of 16 μg/L. Groundwater samples for both TCE and cis-1,2-DCE analyses were collected from November 1995 through June 2014 until both analytes were discontinued from the monitoring program based on recommendations in the fourth FYR (U.S. Navy, 2015b), noting that concentrations were below their respective cleanup levels during the entire previous FYR period.

Groundwater samples were collected and analyzed for 1,4-dioxane from the three monitoring wells (i.e., 2MW-1, 2MW-6, and MW2-8) as a one-time sampling event in June 2007 to evaluate if this chemical of emerging concern was present at the site. There is no RG established for 1,4-dioxane, as it is not a COC in the ROD; however, the current MTCA B cleanup level is 0.44 µg/L, which is a decrease from the previous cleanup level of 4 µg/L in 2007. Due to this decrease in the MTCA B cleanup levels (i.e., 4 to 0.44 µg/L), the fourth FYR (U.S. Navy, 2015b) recommended two additional annual monitoring events using a laboratory analytical method that can achieve a reporting limit of 0.4 µg/L. Monitoring would be discontinued if the two additional annual monitoring events demonstrate that 1,4-dioxane is not detected above 0.44 µg/L.

***LTM Results and Trends Over Time – Vinyl Chloride.*** During this FYR period, groundwater samples were collected and analyzed for vinyl chloride from three monitoring wells (i.e., 2MW-1, 2MW-6, and MW2-8) in June 2016, September 2018, and June 2019. Figure 4-16 presents a site map of OU 2 Area 2 with the vinyl chloride results from this FYR period. As shown in Figure 4-16, vinyl chloride concentrations were consistently below the RG of 0.029 μg/L in well 2MW-1. Vinyl chloride was detected above the RG in well MW2-8: non-detect in June 2016, 0.049 J μg/L in September 2018, and then non-detect in June 2019. In well 2MW-6, vinyl chloride concentrations were above the RG during all three LTM events, ranging from 0.073 to 1.4 μg/L.

Vinyl chloride concentrations have consistently been above the RG of 0.029 μg/L in well 2MW-6. Figure 4-17 presents a time-series plot of vinyl chloride concentrations in well 2MW-6 from November 1995 through June 2019, the entire dataset. As shown in Figure 4-17, concentrations had been demonstrating a decreasing trend with concentrations decreasing from 5 μg/L in September 1996 to as low as 0.073 μg/L in June 2016. In September 2018, concentrations increased to 1.4 μg/L and then decreased to 0.16 M μg/L in June 2019.

To ensure concentrations were still demonstrating a decreasing trend despite this increased concentration observed in September 2018, a nonparametric statistical analysis, specifically GSI's Mann-Kendall Toolkit, was used to evaluate the dataset as part of this FYR. Appendix F presents the output results from GSI's Mann-Kendall Toolkit. Over the entire dataset (i.e., November 1995 through June 2019), vinyl chloride concentrations are demonstrating a statistically significant decreasing trend in well 2MW-6. To evaluate more recent data, results from the four most recent LTM events were entered into the Toolkit, the minimum number of data points required for the program. Over these four most recent LTM events (i.e., June 2014 through June 2019), vinyl chloride concentrations are demonstrating neither an increasing nor decreasing trend (i.e., no trend) at well 2MW-6 (see Appendix F).

***Data Gap Evaluation – Vinyl Chloride.*** Although vinyl chloride concentrations in well 2MW-6 are demonstrating a statistically significant decreasing trend over the entire dataset, there was an increased concentration observed in September 2018 (at 1.4 μg/L). Because of this observation in well 2MW-6, current LTM results and results from the RI (U.S. Navy, 1993a) were re-evaluated as part of this FYR to determine if there are any data gaps, which if filled, would provide an updated/further understanding of the CSM for OU 2 Area 2.

Figure 4-18 presents a geological cross-section through OU 2 Area 2 parallel with the approximate groundwater flow direction. This geological cross-section was developed from the RI and also includes the projected location of well 2MW-6. As depicted in Figure 4-18, cVOCs were detected in shallow wells 2MW-1, 2MW-3, and MW2-10 during the RI and 2MW-6 during current LTM events, while shallow well 2MW-2 and deeper wells MW2-7 and MW2-6 were non-detect during the RI (U.S. Navy, 1993a).

At OU 2 Area 2, the Clover Park Aquitard serves as the confining layer at approximately 30 to 35 ft bgs. There are five geological units above the Clover Park Aquitard (i.e., 2A, 2B, 2F, 2G, and 2H). The shallow aquifer is present in all five geologic units above the Clover Park Aquitard, with a water table at approximately 4 to 8 ft bgs. The more permeable layers are near the top (i.e., 2A, 2B, and 2F) and base (i.e., 2H) of the aquifer and a less permeable unit (i.e., 2G) separates the two more permeable zones (see Figure 4-18). Regardless, it appears that the two more permeable zones at the top and base of the aquifer are hydraulically connected (U.S. Navy, 1993a).

As shown in Figure 4-18, well 2MW-6 is screened within the shallow zone at approximately 6.5 to 16.5 ft bgs and located furthest downgradient with vinyl chloride concentrations consistently detected above the RG of 0.029 μg/L. The consistent detections above the RG in well 2MW-6 (and recent increased concentration) may be an indication that cVOC mass detected in the shallow zone (i.e., wells 2MW-1, 2MW-3, and MW2-10) during the RI may have since migrated to deeper depths and further downgradient than the current monitoring network. As such, these observations in well 2MW-6 may not be providing a full understanding of the nature and extent of the cVOC plume. Given this information, a data gap investigation may be warranted to delineate the lateral and vertical leading edges of the cVOC plume at OU 2 Area 2.

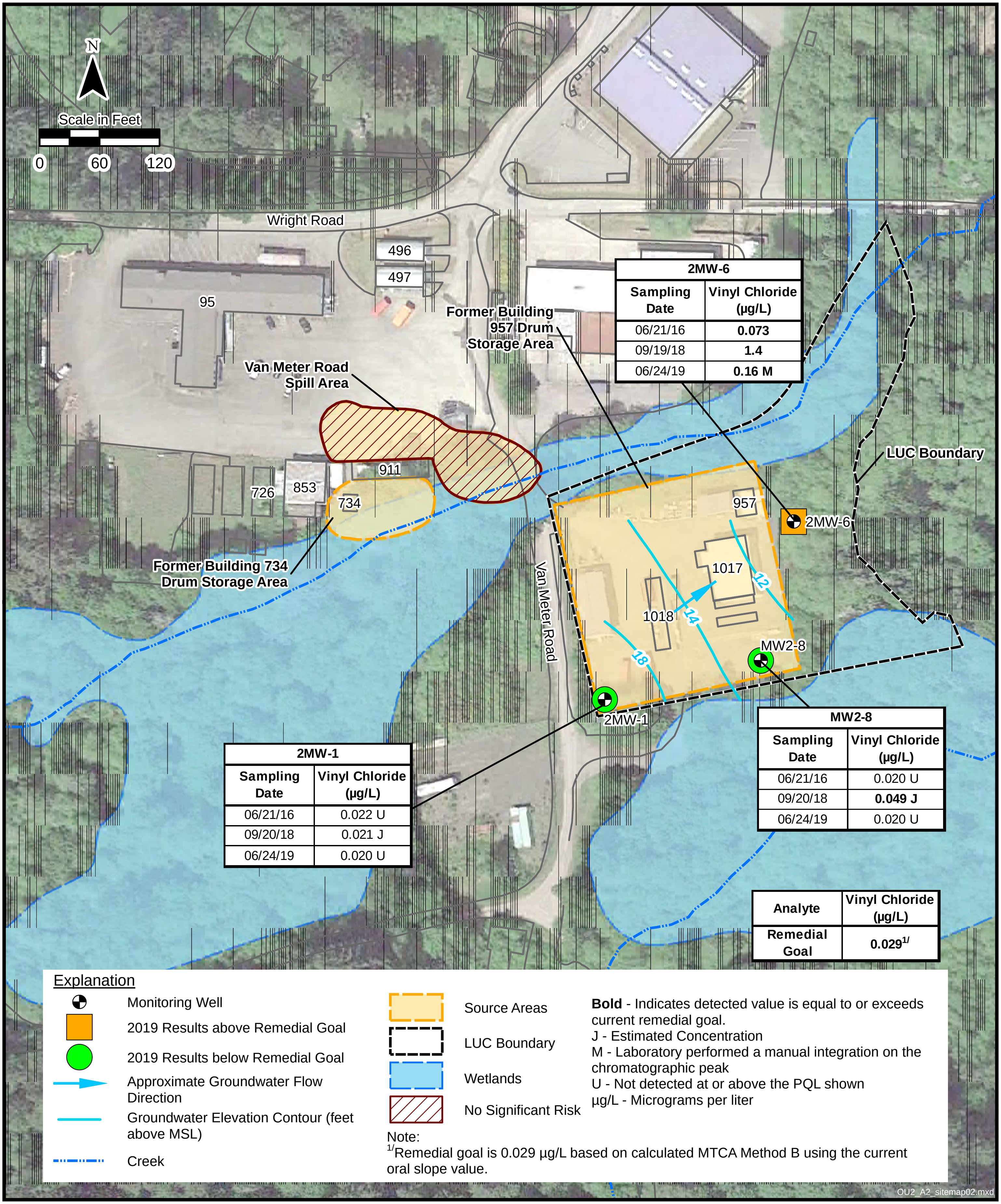


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**Figure 4-16**
**OU 2 Area 2 Potentiometric Map and Vinyl Chloride Concentrations in Groundwater (2016-2019)**

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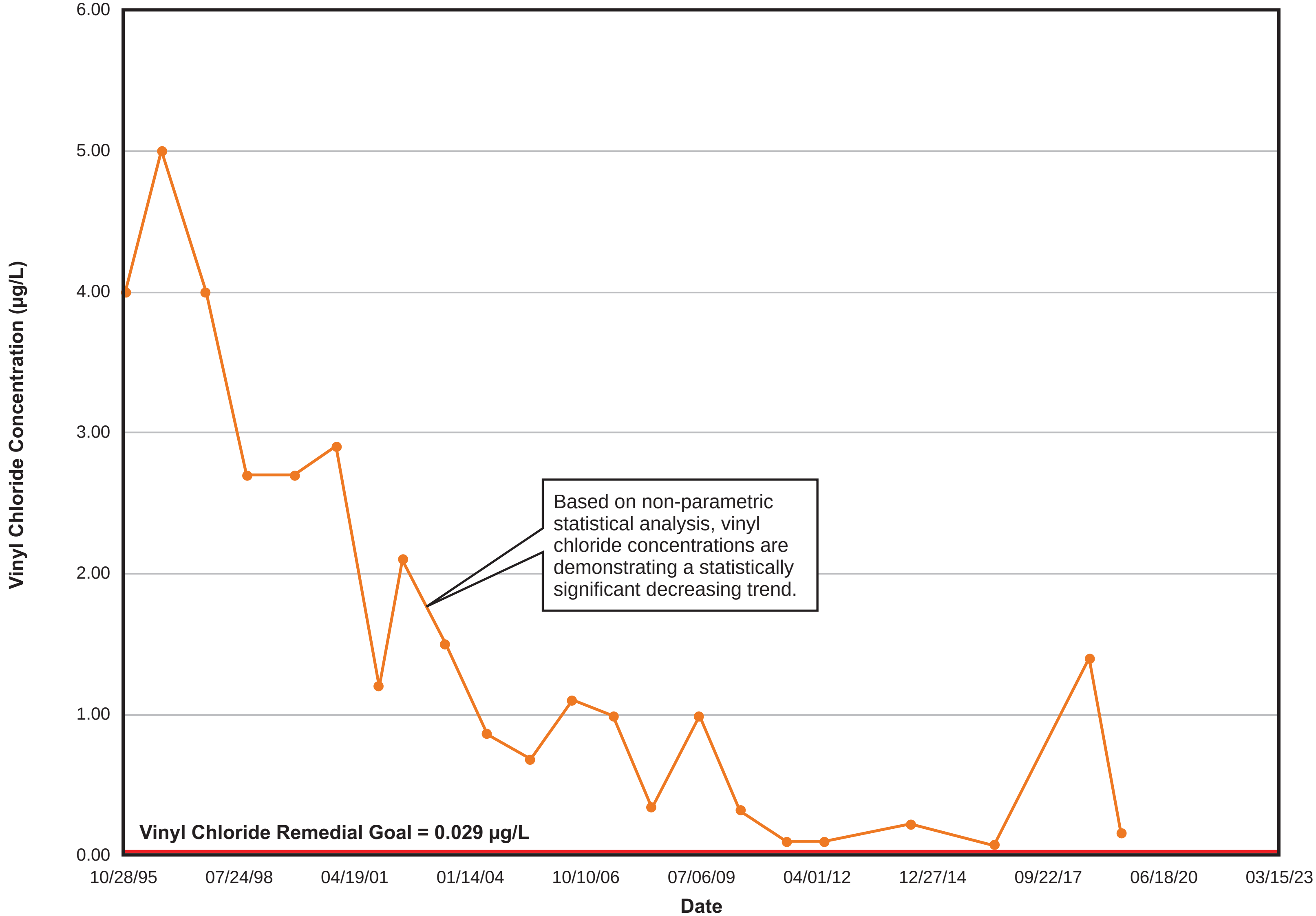


OU2A2_VC_2MW-6.CDR

| | | |
|---|---|---|
| **U.S. NAVY** | **Figure 4-17**<br>**OU 2 Area 2 Vinyl Chloride Concentrations in Groundwater at 2MW-6 Over Time** | NBK KEYPORT<br>FIFTH<br>FIVE-YEAR REVIEW |

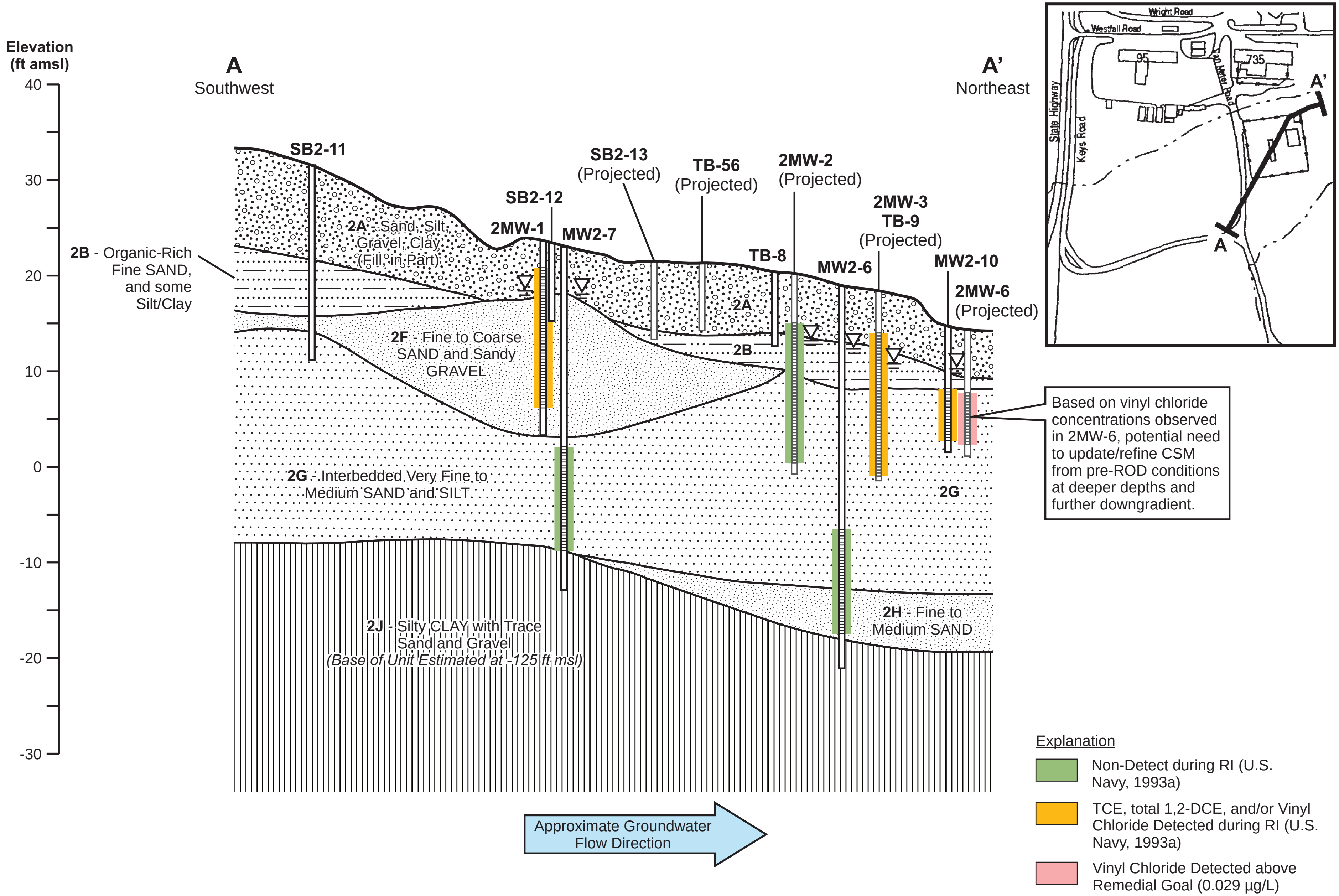


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**Figure 4-18**
**OU2 Area 2 Geologic Cross Section with Data Gap Evaluation**

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***1,4-Dioxane Monitoring Results.*** During this FYR period, groundwater samples were collected and analyzed for 1,4-dioxane from three monitoring wells (i.e., 2MW-1, 2MW-6, and MW2-8) in June 2017, September 2018, and June 2019. All results were non-detect with the exception of one detection (i.e., at 0.17 J µg/L) in September 2018 in well 2MW-6. Regardless, this detected concentration is well below the MTCA B cleanup level of 0.44 µg/L, indicating that 1,4-dioxane is not present in groundwater at levels that pose an unacceptable risk. Table E-2 in Appendix E presents all 1,4-dioxane groundwater results from OU 2 Area 2, including results from this FYR period and June 2007.

### *4.2.3 OU 2 Area 8*

The following section provides a review of the data generated during this FYR period, including from the 1) LTM program, including groundwater monitoring for PFAS compounds; 2) marine investigation and subsequent HHRA and ERA; 3) 2017 and 2019 VI investigations; and 4) USGS tidal lag study. Figure 1-5 presents a site map of OU 2 Area 8.

***Long-Term Monitoring Program.*** The LTM program for OU 2 Area 8 includes groundwater, seep water, surface water, and sediment sampling, which have been conducted in accordance with the regulator-approved LTM Work Plans (U.S. Navy, 2012h and 2017c) and presented and discussed in LTM Reports. Figure 2-3 depicts the LTM sampling locations at OU 2 Area 8. Tables G-1 through G-8 in Appendix G present recent and historical monitoring data in all media for OU 2 Area 8.

*Groundwater*. Groundwater was sampled on an annual basis from monitoring wells MW8-8, MW8-9, MW8-11, MW8-12, MW8-14, and MW8-16 from June 2015 through June 2019, and from monitoring well MW8-15 in June 2019. Results of VOCs, 1,4-dioxane, dissolved metals, and PFAS analyses are discussed in the following subsections.

At OU 2 Area 8, groundwater is sampled and analyzed for five target VOCs (i.e., TCE, PCE, 1,1-DCE, cis-1,2-DCE, and 1,1,1-TCA). Figure 4-19 presents the groundwater monitoring results for these five target VOCs during this FYR period and Table 4-3 presents summary statistics for all VOC results during this FYR period to support this discussion. The following subsections discuss data trends for VOCs during this FYR period with respect to their RGs and the RAOs. The OU 2 ROD tabulates both groundwater RGs and surface water RGs. Because groundwater at the site discharges to surface water, monitoring results are compared to the RGs for both media.

*Trichloroethene*

TCE was detected above the drinking water RG of 5 µg/L at MW8-8, MW8-11, and MW8-12 from 2015 through 2019. TCE was detected above the drinking water RG at MW8-9 in 2015 and at MW8-16 (intermediate screen) from 2015 through 2017, but concentrations have since decreased to below the RG of 5 µg/L. During this FYR period, TCE was either non-detect or detected at concentrations below the RG at MW8-14 (shallow screen) and was non-detect at MW8-15 (deep screen).

*Tetrachloroethene*

PCE was detected above the drinking water RG of 5 µg/L solely at MW8-8 from 2015 through 2019. During this FYR period, PCE was either non-detect or detected at concentrations below the RG in all

**Table 4-3. Summary Statistics for VOC Results at OU 2 Area 8 During this FYR Period**

| Analyte | RG[a] | No. of groundwater samples | No. of detections | No. of exceedances above an RG | Minimum detected concentration (µg/L) | Maximum detected concentration (µg/L) | MWs with at least one exceedance | Notes/Comments |
|---|---|---|---|---|---|---|---|---|
| TCE | DW: 5<br>SW: 81 | 31 | 25 | 19 | 0.031 | 63 | MW8-8, MW8-9, MW8-11, MW8-12, MW8-16 | All exceedances above DW RG, but below SW RG |
| PCE | DW: 5<br>SW: 8.9 | 31 | 24 | 5 | 0.014 | 8.4 | MW8-8 | All exceedances above DW RG, but below SW RG (all concentrations < 10 µg/L) |
| cis-1,2-DCE | DW: 70<br>SW: NE | 31 | 23 | 0 | 0.027 | 28 | -- | No exceedances since 2006 (MW8-16) |
| 1,1-DCE | DW: 7<br>SW: 3.2 | 31 | 17 | 0 | 0.02 | 0.5 | -- | No exceedances since 2006 (MW8-11) |
| 1,1,1-TCA | DW: 200<br>SW: 42,000 | 25 | 17 | 0 | 0.074 | 6.3 | -- | No exceedances since 1998 (MW8-11) |
| Chloroform | DW: 7.2<br>SW: 470 | 31 | 21 | 0 | 0.009 | 3.0 | -- | None |

**Table 4-3 (continued). Summary Statistics for VOC Results at OU 2 Area 8 During this FYR Period**

| Analyte | RG[a] | No. of groundwater samples | No. of detections | No. of exceedances above an RG | Minimum detected concentration (µg/L) | Maximum detected concentration (µg/L) | MWs with at least one exceedance | Notes/Comments |
|---|---|---|---|---|---|---|---|---|
| CT | DW: 0.34<br>SW: 4.4 | 13 | 5 | 2 | 0.029 | 0.86 | MW8-11, MW8-12 | Both exceedances in 2018: above DW RG, but below SW RG (both concentrations < 1 µg/L) |
| 1,1-DCA | DW: 800<br>SW: NE | 26 | 7 | 0 | 0.063 | 0.9 | -- | None |
| 1,2-DCA | DW: 5<br>SW: 5.9 | 13 | 4 | 0 | 0.006 | 0.02 | -- | ND in all MWs sampled during 2019 event |
| trans-1,2-DCE | DW: 100<br>SW: 33,000 | 31 | 19 | 0 | 0.11 | 3.0 | -- | None |
| 1,1,2-TCA | DW: 5<br>SW: 81 | 14 | 4 | 0 | 0.019 | 0.23 | -- | ND in all MWs sampled during 2019 event |
| Toluene | DW: 1,000<br>SW: 49,000 | 18 | 7 | 0 | 0.1 | 1.1 | -- | Not sampled in 2018 or 2019 |
| Total Xylenes | DW: 10,000<br>SW: NE | 18 | 3 | 0 | 0.11 | 0.13 | -- | Not analyzed in 2018 or 2019 |
| 1,4-dioxane [b] | DW: NE<br>SW: NE | 31 | 18 | 12 | 0.16 | 16 | MW8-8, MW8-11, MW8-12 | ND in MW8-9, MW8-14, MW8-16 from 2017 - 2019 |

[a] RGs are based on the MTCA Method B cleanup levels.
b No RG established for 1,4-dioxane – concentration compared to MTCA Method B cleanup level of 0.44 mg/L.
DW – drinking water
NE – not established
SW – surface water

other monitoring wells (i.e., MW8-9, MW8-11, MW8-12, MW8-14 [shallow screen], MW8-15 [deep screen], and MW8-16 [intermediate screen]).

*1,1-Dichloroethene, cis-1,2-Dichloroethene, and 1,1,1-Trichloroethane*

During this FYR period, 1,1-DCE, cis-1,2-DCE, and 1,1,1-TCA concentrations have been either non-detect or detected at concentrations below their drinking water RGs of 7, 70, and 200 µg/L, respectively, at all monitoring wells. Of note, analysis of 1,1,1-TCA was not completed in 2018 due to laboratory accreditation issues.

*Other Detected VOCs*

VOCs other than the five target VOCs listed above have been detected in one or more monitoring wells during this FYR period. These VOCs include chloroform, 1,1-DCA, toluene, trans-1,2-DCE, total xylenes, carbon tetrachloride, 1,2-DCA, and 1,1,2-TCA. With the exception of CT in 2018, none of these VOCs has been detected above their respective drinking water or surface water RGs. In 2018, CT was detected above the drinking water RG of 0.34 µg/L in monitoring wells MW8-11 and MW8-12, but dropped below RGs in 2019.

During this FYR period, all VOCs in groundwater were either non-detect or detected at concentrations below their respective surface water RGs, demonstrating that VOC concentrations in groundwater would not cause future adverse impacts or human health risks via surface water exposures.

*1,4-Dioxane*

1,4-Dioxane was first sampled in spring 2007, but based on a recommendation in the third FYR, 1,4-dioxane was added to the OU 2 Area 8 LTM program beginning in 2011. The 1,4-dioxane sampling results from 2007 through 2019 are tabulated on Table G-3 in Appendix G. Figure 4-19 presents the groundwater monitoring results for 1,4-dioxane during this FYR period.

There is no RG established for 1,4-dioxane, so concentrations are compared to the MTCA Method B cleanup level (carcinogenic) of 0.44 µg/L for data evaluation. During this FYR period, 1,4-dioxane was detected in three of the seven OU 2 Area 8 wells (i.e., MW8-8, MW8-11, and MW8-12 – the same wells in which TCE was detected) at concentrations above the MTCA Method B cleanup level. In the past three years of sampling (2017 through 2019), 1,4-dioxane was non-detect in wells MW8-9, MW8-14, MW8-15 (2019), and MW8-16.

At OU 2 Area 8, groundwater is also sampled and analyzed for 10 dissolved metals (i.e., cadmium, total chromium, arsenic, copper, lead, mercury, nickel, silver, thallium, and zinc). During the baseline risk assessment, cadmium and chromium were identified as groundwater COCs for the hypothetical future residential scenario (based on residential use of groundwater as drinking water and inhalation during household use). As such, Figure 4-20 presents the groundwater monitoring results for cadmium and chromium during this FYR period. Table 4-4 presents summary statistics for all metals results during this FYR period to support this discussion. The following subsections discuss data trends for dissolved metals during this FYR period with respect to their RGs and the RAOs.

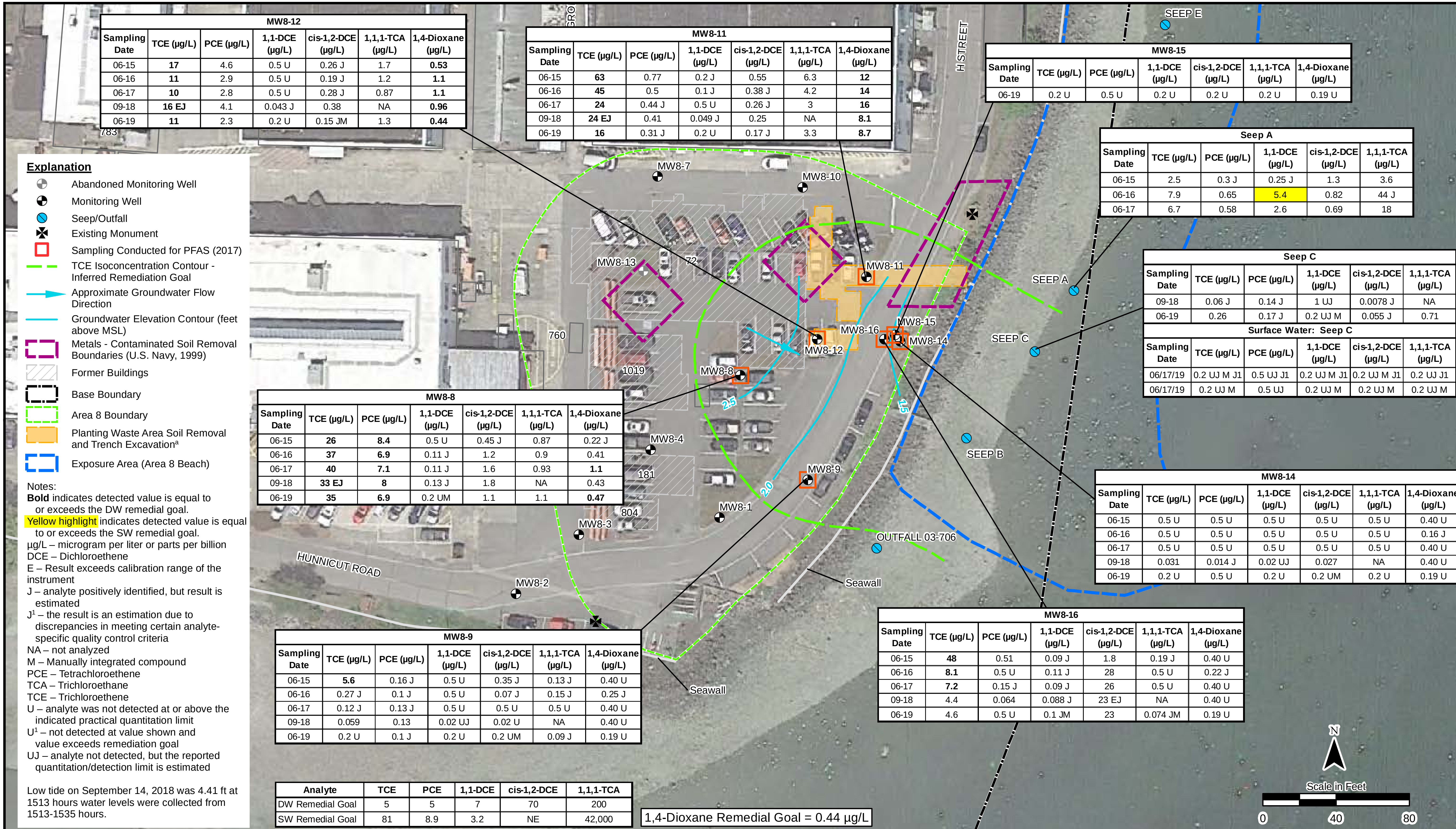
*Dissolved Cadmium*

For cadmium, the drinking water RG is 5 µg/L and the surface water RG is 8 µg/L. During this FYR period, dissolved cadmium was detected at concentrations exceeding both RGs in wells MW8-11 (2015

**Table 4-4. Summary Statistics for Metals Results at OU 2 Area 8 during this FYR Period**

| Analyte | RG[a] | No. of groundwater samples collected from MWs | No. of detections in MWs | No. of exceedances above an RG | Minimum detected concentration (µg/L) | Maximum detected concentration (µg/L) | MWs with at least one exceedance | Notes/Comments |
|---|---|---|---|---|---|---|---|---|
| arsenic | DW: 0.05<br>SW: 0.14 | 31 | 31 | 31 | 0.23 | 2.6 | MW8-8, MW8-9, MW8-11, MW8-12, MW8-14, MW8-15, MW8-16 | All exceedances below site background value of 12 µg/L |
| cadmium | DW: 5<br>SW: 8 | 31 | 27 | 10 | 0.006 | 161 | MW8-11, MW8-14 | None |
| total chromium | DW: 50<br>SW: NE | 31 | 30 | 15 | 0.28 | 182 | MW8-8, MW8-11, MW8-12 | None |
| copper | DW: 590<br>SW: 2.5 | 31 | 27 | 5 | 0.06 | 5.75 | MW8-11 | All exceedances above SW RG, but below DW RG |
| lead | DW: 15<br>SW: 5.8 | 31 | 18 | 2 | 0.008 | 12 | MW8-9, MW8-11 | Both exceedances in 2016: above SW RG but below DW RG |
| mercury [b] | DW: 2<br>SW: 0.025 | 12 | 12 | 0 | 0.00034 | 0.0114 | -- | Not analyzed since 2016 |
| nickel | DW: 100<br>SW: 7.9 | 31 | 31 | 4 | 0.26 | 19.1 | MW8-11 | All exceedances above SW RG, but below DW RG |
| silver | DW: 48<br>SW: 1.2 | 31 | 25 | 5 | 0.008 | 4.21 | MW8-11 | All exceedances above SW RG, but below DW RG |
| thallium [b] | DW: 1,1<br>SW: 1.6 | 12 | 5 | 0 | 0.007 | 0.029 | -- | Not analyzed since 2016 |
| zinc | DW: 4,800<br>SW: 77 | 31 | 29 | 1 | 0.22 | 85 | MW8-11 | Only exceedance in 2016 - above SW RG, but below DW RG |

a RGs are MTCA Method B cleanup levels
b analyzed in 2015 and 2016 only
Concentrations of metals is dissolved metals
Hexavalent chromium was not analyzed during FYR period
DW – drinking water; SW – surface water




**Explanation**

- Abandoned Monitoring Well
- Monitoring Well
- Seep/Outfall
- Existing Monument
- Sampling Conducted for PFAS (2017)
- TCE Isoconcentration Contour - Inferred Remediation Goal
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour (feet above MSL)
- Metals - Contaminated Soil Removal Boundaries (U.S. Navy, 1999)
- Former Buildings
- Base Boundary
- Area 8 Boundary
- Planting Waste Area Soil Removal and Trench Excavation[a]
- Exposure Area (Area 8 Beach)

Notes:
**Bold** indicates detected value is equal to or exceeds the DW remedial goal.
Yellow highlight indicates detected value is equal to or exceeds the SW remedial goal.
µg/L – microgram per liter or parts per billion
DCE – Dichloroethene
E – Result exceeds calibration range of the instrument
J – analyte positively identified, but result is estimated
J[1] – the result is an estimation due to discrepancies in meeting certain analyte-specific quality control criteria
NA – not analyzed
M – Manually integrated compound
PCE – Tetrachloroethene
TCA – Trichloroethane
TCE – Trichloroethene
U – analyte was not detected at or above the indicated practical quantitation limit
U[1] – not detected at value shown and value exceeds remediation goal
UJ – analyte not detected, but the reported quantitation/detection limit is estimated

Low tide on September 14, 2018 was 4.41 ft at 1513 hours water levels were collected from 1513-1535 hours.

**MW8-12**

| Sampling Date | TCE (µg/L) | PCE (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | 1,1,1-TCA (µg/L) | 1,4-Dioxane (µg/L) |
|---|---|---|---|---|---|---|
| 06-15 | **17** | 4.6 | 0.5 U | 0.26 J | 1.7 | **0.53** |
| 06-16 | **11** | 2.9 | 0.5 U | 0.19 J | 1.2 | **1.1** |
| 06-17 | **10** | 2.8 | 0.5 U | 0.28 J | 0.87 | **1.1** |
| 09-18 | **16 EJ** | 4.1 | 0.043 J | 0.38 | NA | **0.96** |
| 06-19 | **11** | 2.3 | 0.2 U | 0.15 JM | 1.3 | **0.44** |

**MW8-11**

| Sampling Date | TCE (µg/L) | PCE (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | 1,1,1-TCA (µg/L) | 1,4-Dioxane (µg/L) |
|---|---|---|---|---|---|---|
| 06-15 | **63** | 0.77 | 0.2 J | 0.55 | 6.3 | **12** |
| 06-16 | **45** | 0.5 | 0.1 J | 0.38 J | 4.2 | **14** |
| 06-17 | **24** | 0.44 J | 0.5 U | 0.26 J | 3 | **16** |
| 09-18 | **24 EJ** | 0.41 | 0.049 J | 0.25 | NA | **8.1** |
| 06-19 | **16** | 0.31 J | 0.2 U | 0.17 J | 3.3 | **8.7** |

**MW8-15**

| Sampling Date | TCE (µg/L) | PCE (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | 1,1,1-TCA (µg/L) | 1,4-Dioxane (µg/L) |
|---|---|---|---|---|---|---|
| 06-19 | 0.2 U | 0.5 U | 0.2 U | 0.2 U | 0.2 U | 0.19 U |

**Seep A**

| Sampling Date | TCE (µg/L) | PCE (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | 1,1,1-TCA (µg/L) |
|---|---|---|---|---|---|
| 06-15 | 2.5 | 0.3 J | 0.25 J | 1.3 | 3.6 |
| 06-16 | 7.9 | 0.65 | 5.4 | 0.82 | 44 J |
| 06-17 | 6.7 | 0.58 | 2.6 | 0.69 | 18 |

**Seep C**

| Sampling Date | TCE (µg/L) | PCE (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | 1,1,1-TCA (µg/L) |
|---|---|---|---|---|---|
| 09-18 | 0.06 J | 0.14 J | 1 UJ | 0.0078 J | NA |
| 06-19 | 0.26 | 0.17 J | 0.2 UJ M | 0.055 J | 0.71 |

**Surface Water: Seep C**

| Sampling Date | TCE (µg/L) | PCE (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | 1,1,1-TCA (µg/L) |
|---|---|---|---|---|---|
| 06/17/19 | 0.2 UJ M J1 | 0.5 UJ J1 | 0.2 UJ M J1 | 0.2 UJ M J1 | 0.2 UJ J1 |
| 06/17/19 | 0.2 UJ M | 0.5 UJ | 0.2 UJ M | 0.2 UJ M | 0.2 UJ M |

**MW8-8**

| Sampling Date | TCE (µg/L) | PCE (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | 1,1,1-TCA (µg/L) | 1,4-Dioxane (µg/L) |
|---|---|---|---|---|---|---|
| 06-15 | **26** | **8.4** | 0.5 U | 0.45 J | 0.87 | 0.22 J |
| 06-16 | **37** | **6.9** | 0.11 J | 1.2 | 0.9 | 0.41 |
| 06-17 | **40** | **7.1** | 0.11 J | 1.6 | 0.93 | **1.1** |
| 09-18 | **33 EJ** | **8** | 0.13 J | 1.8 | NA | 0.43 |
| 06-19 | **35** | **6.9** | 0.2 UM | 1.1 | 1.1 | **0.47** |

**MW8-14**

| Sampling Date | TCE (µg/L) | PCE (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | 1,1,1-TCA (µg/L) | 1,4-Dioxane (µg/L) |
|---|---|---|---|---|---|---|
| 06-15 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.40 U |
| 06-16 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.16 J |
| 06-17 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.40 U |
| 09-18 | 0.031 | 0.014 J | 0.02 UJ | 0.027 | NA | 0.40 U |
| 06-19 | 0.2 U | 0.5 U | 0.2 U | 0.2 UM | 0.2 U | 0.19 U |

**MW8-16**

| Sampling Date | TCE (µg/L) | PCE (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | 1,1,1-TCA (µg/L) | 1,4-Dioxane (µg/L) |
|---|---|---|---|---|---|---|
| 06-15 | **48** | 0.51 | 0.09 J | 1.8 | 0.19 J | 0.40 U |
| 06-16 | **8.1** | 0.5 U | 0.11 J | 28 | 0.5 U | 0.22 J |
| 06-17 | **7.2** | 0.15 J | 0.09 J | 26 | 0.5 U | 0.40 U |
| 09-18 | 4.4 | 0.064 | 0.088 J | 23 EJ | NA | 0.40 U |
| 06-19 | 4.6 | 0.5 U | 0.1 JM | 23 | 0.074 JM | 0.19 U |

**MW8-9**

| Sampling Date | TCE (µg/L) | PCE (µg/L) | 1,1-DCE (µg/L) | cis-1,2-DCE (µg/L) | 1,1,1-TCA (µg/L) | 1,4-Dioxane (µg/L) |
|---|---|---|---|---|---|---|
| 06-15 | **5.6** | 0.16 J | 0.5 U | 0.35 J | 0.13 J | 0.40 U |
| 06-16 | 0.27 J | 0.1 J | 0.5 U | 0.07 J | 0.15 J | 0.25 J |
| 06-17 | 0.12 J | 0.13 J | 0.5 U | 0.5 U | 0.5 U | 0.40 U |
| 09-18 | 0.059 | 0.13 | 0.02 UJ | 0.02 U | NA | 0.40 U |
| 06-19 | 0.2 U | 0.1 J | 0.2 U | 0.2 UM | 0.09 J | 0.19 U |

| Analyte | TCE | PCE | 1,1-DCE | cis-1,2-DCE | 1,1,1-TCA |
|---|---|---|---|---|---|
| DW Remedial Goal | 5 | 5 | 7 | 70 | 200 |
| SW Remedial Goal | 81 | 8.9 | 3.2 | NE | 42,000 |

1,4-Dioxane Remedial Goal = 0.44 µg/L

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**Figure 4-19**
**OU 2 Area 8 VOC and 1,4-Dioxane LTM Sampling Results (2015-2019)**

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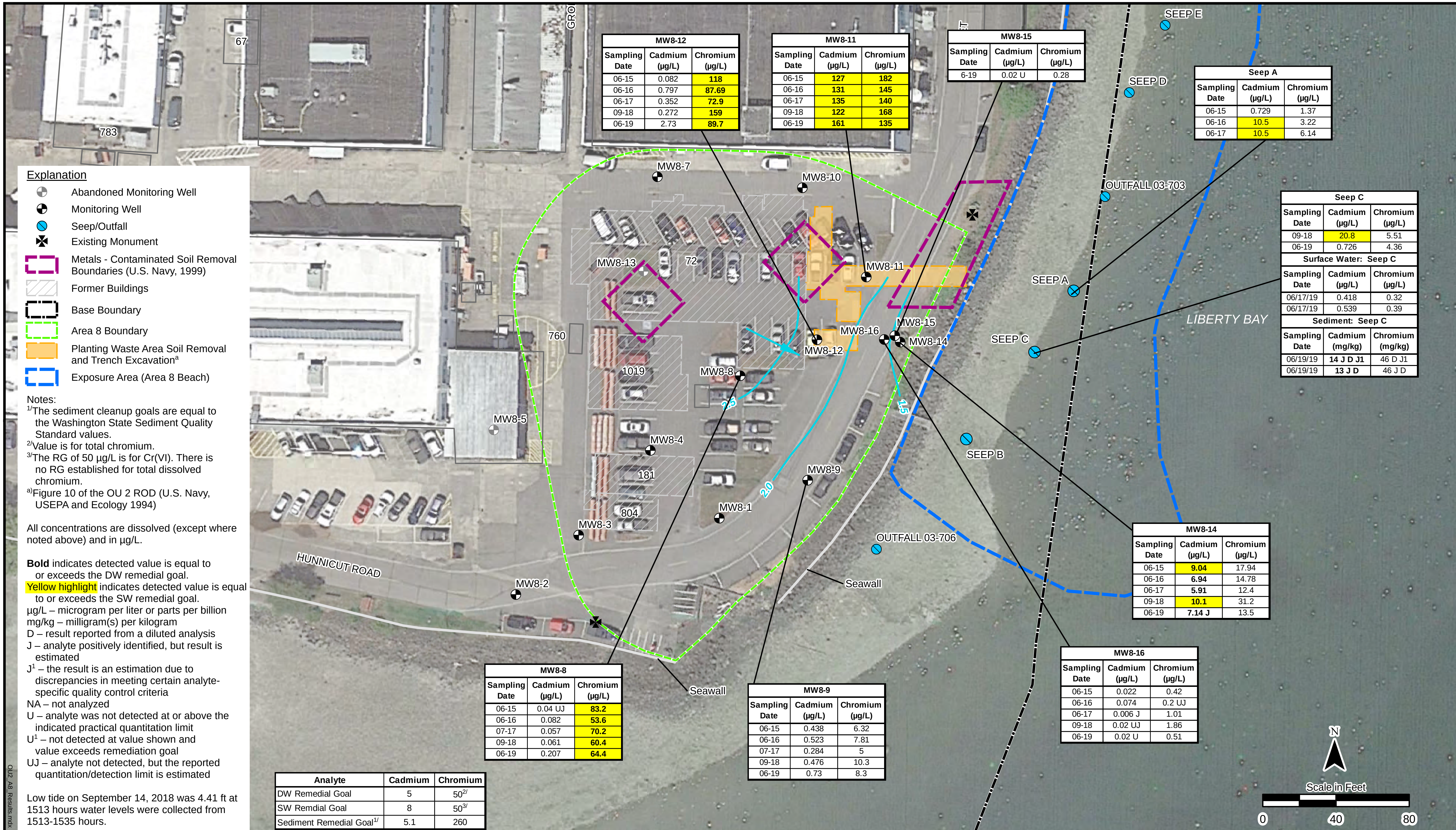


Explanation

- Abandoned Monitoring Well
- Monitoring Well
- Seep/Outfall
- Existing Monument
- Metals - Contaminated Soil Removal Boundaries (U.S. Navy, 1999)
- Former Buildings
- Base Boundary
- Area 8 Boundary
- Planting Waste Area Soil Removal and Trench Excavation[a]
- Exposure Area (Area 8 Beach)

Notes:
[1/] The sediment cleanup goals are equal to the Washington State Sediment Quality Standard values.
[2/] Value is for total chromium.
[3/] The RG of 50 µg/L is for Cr(VI). There is no RG established for total dissolved chromium.
[a)] Figure 10 of the OU 2 ROD (U.S. Navy, USEPA and Ecology 1994)

All concentrations are dissolved (except where noted above) and in µg/L.

**Bold** indicates detected value is equal to or exceeds the DW remedial goal.
Yellow highlight indicates detected value is equal to or exceeds the SW remedial goal.
µg/L – microgram per liter or parts per billion
mg/kg – milligram(s) per kilogram
D – result reported from a diluted analysis
J – analyte positively identified, but result is estimated
J[1] – the result is an estimation due to discrepancies in meeting certain analyte-specific quality control criteria
NA – not analyzed
U – analyte was not detected at or above the indicated practical quantitation limit
U[1] – not detected at value shown and value exceeds remediation goal
UJ – analyte not detected, but the reported quantitation/detection limit is estimated

Low tide on September 14, 2018 was 4.41 ft at 1513 hours water levels were collected from 1513-1535 hours.

**MW8-12**

| Sampling Date | Cadmium (µg/L) | Chromium (µg/L) |
|---|---|---|
| 06-15 | 0.082 | **118** |
| 06-16 | 0.797 | **87.69** |
| 06-17 | 0.352 | **72.9** |
| 09-18 | 0.272 | **159** |
| 06-19 | 2.73 | **89.7** |

**MW8-11**

| Sampling Date | Cadmium (µg/L) | Chromium (µg/L) |
|---|---|---|
| 06-15 | **127** | **182** |
| 06-16 | **131** | **145** |
| 06-17 | **135** | **140** |
| 09-18 | **122** | **168** |
| 06-19 | **161** | **135** |

**MW8-15**

| Sampling Date | Cadmium (µg/L) | Chromium (µg/L) |
|---|---|---|
| 6-19 | 0.02 U | 0.28 |

**Seep A**

| Sampling Date | Cadmium (µg/L) | Chromium (µg/L) |
|---|---|---|
| 06-15 | 0.729 | 1.37 |
| 06-16 | 10.5 | 3.22 |
| 06-17 | 10.5 | 6.14 |

**Seep C**

| Sampling Date | Cadmium (µg/L) | Chromium (µg/L) |
|---|---|---|
| 09-18 | 20.8 | 5.51 |
| 06-19 | 0.726 | 4.36 |
| **Surface Water: Seep C** | | |
| **Sampling Date** | **Cadmium (µg/L)** | **Chromium (µg/L)** |
| 06/17/19 | 0.418 | 0.32 |
| 06/17/19 | 0.539 | 0.39 |
| **Sediment: Seep C** | | |
| **Sampling Date** | **Cadmium (mg/kg)** | **Chromium (mg/kg)** |
| 06/19/19 | **14 J D J1** | 46 D J1 |
| 06/19/19 | **13 J D** | 46 J D |

**MW8-14**

| Sampling Date | Cadmium (µg/L) | Chromium (µg/L) |
|---|---|---|
| 06-15 | **9.04** | 17.94 |
| 06-16 | **6.94** | 14.78 |
| 06-17 | **5.91** | 12.4 |
| 09-18 | **10.1** | 31.2 |
| 06-19 | **7.14 J** | 13.5 |

**MW8-16**

| Sampling Date | Cadmium (µg/L) | Chromium (µg/L) |
|---|---|---|
| 06-15 | 0.022 | 0.42 |
| 06-16 | 0.074 | 0.2 UJ |
| 06-17 | 0.006 J | 1.01 |
| 09-18 | 0.02 UJ | 1.86 |
| 06-19 | 0.02 U | 0.51 |

**MW8-8**

| Sampling Date | Cadmium (µg/L) | Chromium (µg/L) |
|---|---|---|
| 06-15 | 0.04 UJ | **83.2** |
| 06-16 | 0.082 | **53.6** |
| 07-17 | 0.057 | **70.2** |
| 09-18 | 0.061 | **60.4** |
| 06-19 | 0.207 | **64.4** |

**MW8-9**

| Sampling Date | Cadmium (µg/L) | Chromium (µg/L) |
|---|---|---|
| 06-15 | 0.438 | 6.32 |
| 06-16 | 0.523 | 7.81 |
| 07-17 | 0.284 | 5 |
| 09-18 | 0.476 | 10.3 |
| 06-19 | 0.73 | 8.3 |

| Analyte | Cadmium | Chromium |
|---|---|---|
| DW Remedial Goal | 5 | 50[2/] |
| SW Remdial Goal | 8 | 50[3/] |
| Sediment Remedial Goal[1/] | 5.1 | 260 |

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**Figure 4-20**
**OU 2 Area 8 Metals LTM Sampling Results (2015-2019)**

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through 2019) and MW8-14 (2015 and 2018), located within the plating waste area soil removal and trench excavation area and downgradient, respectively. Dissolved cadmium was either non-detect or detected at concentrations below both RGs in all other monitoring wells (i.e., MW8-8, MW8-9, MW8-12, MW8-15 and MW8-16).

*Dissolved Chromium*
For total chromium, both the drinking water and surface water RG is 50 µg/L. During this FYR period, dissolved chromium was consistently detected at concentrations above both RGs in wells MW8-8, MW8-11, and MW8-12, a similar lateral extent as TCE contamination. Dissolved chromium was either non-detect or detected at concentrations below both RGs in all other monitoring wells (i.e., MW8-9, MW8-14, MW8-15, and MW8-16).

*Dissolved Arsenic*
For arsenic, the drinking water RG is 0.05 µg/L and the surface water RG is 0.14 µg/L. Dissolved arsenic exceeded both the drinking water and surface water RG in all seven monitoring wells during each sampling event from 2015 through 2019 (i.e., MW8-15 sampled in 2019 only). However, the concentrations detected were well below the background value of 12 µg/L for arsenic in groundwater at OU 2 Area 8, as determined during the RI (U.S. Navy, 1993a and 1993b).

*Dissolved Copper, Lead, Mercury, Nickel, Silver, Thallium, and Zinc*
During this FYR period, dissolved copper, lead, mercury, nickel, silver, thallium, and zinc have more often than not been non-detect or detected at concentrations below their respective drinking water and surface water RGs. The following summary details exceptions to this finding during this FYR period:

| Dissolved Metal | Drinking Water RG (µg/L) | Surface Water RG (µg/L) | Exceptions during FYR Period |
|---|---|---|---|
| Copper | 590 | 2.5 | Detected above the surface water RG in MW8-11 from 2015 through 2019. |
| Lead | 15 | 5.8 | Detected above the surface water RG in MW8-9 and MW8-11 in 2016. |
| Mercury | 2 | 0.025 | No longer analyzed for after 2016, detected below drinking water protection and surface water RGs. |
| Nickel | 100 | 7.9 | Detected above the surface water RG in MW8-11 in 2015, 2016, 2017, and 2019. |
| Silver | 48 | 1.2 | Detected above the surface water RG in MW8-11 from 2015 through 2019. |
| Thallium | 1.1 | 1.6 | No longer analyzed for after 2016, detected below drinking water and surface water RGs. |
| Zinc | 4,800 | 77 | Detected above the surface water RG in MW8-11 in 2016. |

During this FYR period and previous FYR periods, dissolved metals concentrations in groundwater more often than not exceed their respective surface water RGs rather than their drinking water RGs, as detailed above. These findings indicate that dissolved metals concentrations in groundwater, particularly cadmium and chromium, require further investigation to assess risk from surface water exposures. Therefore, in accordance with the OU 2 ROD, an HHRA and ERA for OU 2 Area 8 was completed during this FYR period and are discussed below. The HHRA concluded that no unacceptable risk to human health or higher trophic level ecological receptors is present in the intertidal zone, but that an unacceptable risk to benthic invertebrates is present in the intertidal zone of the Area 8 beach, based on bioaccumulation of metals concentrations.

PFAS

At OU 2 Area 8, groundwater samples were collected and analyzed for PFAS compounds in 2018 and 2019 (see Figure 4-17) (U.S. Navy, 2019c, 2020). There is no promulgated cleanup level for PFAS compounds; however, EPA's health advisory level is 70 ng/L for perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) concentrations, separately or combined. In 2018, combined concentrations of PFOA and PFOS in groundwater were detected above 70 ng/L at MW8-11 (i.e., 74 ng/L) and MW8-12 (i.e., 77 M ng/L). In 2019, separate and combined concentrations of PFOA and PFOS in groundwater were not detected above 70 ng/L in any monitoring wells. In addition to PFOS and PFOA, perfluorobutanesulfonic acid (PFBS) has an EPA Regional Screening Level (RSL) of 400,000 ng/L. PFBS was detected in five of the seven groundwater samples at concentrations between 0.77 and 4.7 ng/L, which are well below the EPA RSL. PFAS results are further discussed and evaluated in Section 5.0 with regards to human health risk assessment assumptions. Groundwater monitoring data for PFAS are provided on Table G-5 in Appendix G.

*Seep Discharge*. At OU 2 Area 8, seep water samples have been historically collected from Seep A, Seep B, and Seep C, located along the shore of Port Orchard Bay (see Figure 2-3). This sampling has been conducted to determine if OU 2 Area 8 groundwater is adversely impacting the adjacent marine environment, as required by the ROD. As a result of consistently low and stable VOC and dissolved metals concentrations, sampling at Seep B was discontinued in 2012, as recommended in the third FYR. Starting in September 2018, Seep C was sampled instead of Seep A under the LTM program. Seep C has historically shown higher VOC concentrations than Seep A. Therefore, the U.S. Navy determined that Seep C was more representative of worst-case conditions related to seepage of groundwater to surface water at OU 2 Area 8.

During the 2015 to 2017 sampling efforts conducted at Seep A, 1,1-DCE (in 2016) was the only target VOC detected above the surface water RG of 3.2 μg/L (at 5.4 μg/L). This exceedance is most likely an indication of biodegradation along the flow path from monitoring well MW8-11 (which demonstrates the greatest TCE concentrations in groundwater) to Seep A (with 1,1-DCE, a daughter product of TCE). Several VOCs (including cis-1,2-DCE, PCE, 1,1,1-TCA, TCE, chloroform, trans-1,2-DCE, and 1,1-DCA) were detected, but at concentrations below their respective surface water RGs (or drinking water RG if a surface water RG has not been established). Arsenic was detected above the surface water RG of 0.14 μg/L in 2015, 2016, and 2017, and cadmium was detected above the surface water RG of 8 μg/L in 2016 and 2017. Concentrations of all other dissolved metals at Seep A from 2015 through 2017 were either non-detect or detected at concentrations below their respective surface water RGs (see Figures 4-19 and 4-20; see Appendix G).

During the 2018 and 2019 sampling conducted at Seep C, no VOCs were detected at concentrations exceeding their respective surface water RGs. Concentrations of cis-1,2-DCE, PCE, 1,1,1-TCA (2019 only), and TCE were detected in 2018 and 2019 at concentrations below the surface water RGs at Seep C. Arsenic was detected above the surface water RG of 0.14 μg/L in both years, and cadmium was detected above the surface water RG of 8 μg/L in 2018. Concentrations of all other dissolved metals at Seep C in 2018 and 2019 were either non-detect or detected at concentrations below their respective surface water RGs (see Figures 4-19 and 4-20; see Appendix G).

Similar to groundwater detections, the concentrations of arsenic detected at Seep A (2015 through 2017) and Seep C (2018 and 2019) were less than the OU 2 Area 8 background concentration for arsenic in groundwater of 12 μg/L established during the RI (U.S. Navy, 1993b).

*Surface Water.* In 2019, a surface water sample (and duplicate) was collected from the Seep C location and analyzed for VOCs and dissolved metals. None of the target VOCs were detected above laboratory reporting limits in this sample. Arsenic was detected above the surface water RG, but significantly below the OU 2 Area 8 background concentration of 12 μg/L. Concentrations of all other metals at Seep C surface water were either non-detect or detected at concentrations below their respective surface water RGs. The surface water VOC and dissolved metals results are presented in Figures 4-19 and 4-20 and summarized on Tables G-6 and G-7 in Appendix G, respectively.

*Sediment.* In 2019, a sediment sample (and duplicate) was collected from the Seep C location and analyzed for metals. The data were compared to the sediment cleanup goals, which were set to equal the Washington State SQS. An estimated concentration of cadmium was detected above the sediment cleanup goal of 5.1 mg/kg. All other metals at the Seep C location were detected at concentrations below the sediment cleanup goal. The Seep C sediment metals results are presented in Figure 4-20 and summarized on Table G-8 in Appendix G.

The historical and current cadmium exceedances in groundwater (MW8-11, MW8-14), seep water (Seep A, Seep C), and sediment (Seep C) appear in the same general vicinity. The 2019 surface water sampling results indicate low cadmium concentrations in surface water at the Seep C location. Despite historical chromium exceedances in groundwater (MW8-8, MW8-11, and MW8-12), chromium concentrations have remained below RGs in seep water, surface water, and sediment at the Seep C location.

***Marine Investigation.*** A marine investigation report was completed in 2016 (U.S. Navy, 2016d), which describes and presents the results of the tissue, sediment, seep water, outfall, and surface water sampling conducted in 2015 and 2016 at OU 2 Area 8. The report documents the results of the sampling of clam tissue and sediment (at ROD-established sampling locations [Stations SS01 to SS09]) and one-time sampling of clam tissue, sediment, seep water, marine water, and outfalls from new locations across the Area 8 beach. The purpose of the investigation was to collect additional data to support a determination of the nature and extent of metals contamination and to support future HHRA/ERAs. In addition, because of some uncertainty associated with the northern extent of impacted seeps and sediments, additional data collection efforts were conducted to fully characterize the extent of contamination (U.S. Navy, 2016d).

The following sampling activities were conducted, as identified in the QAPP:

- <u>Reference Area Tissue and Surface Water Collection</u> – Twenty-two (22) tissue sampling stations and eight (8) marine water stations were sampled on June 2 and 3, 2015, at the reference area, Penrose Point State Park on Carr Inlet. The surface water was submitted for laboratory analysis of metals, and the clams were weighed, measured, and submitted for laboratory analysis of metals and percent moisture content.
- <u>OU 2 Area 8 Tissue Collection</u> – Clam tissue samples were collected at 41 sampling stations on the beach adjacent to OU 2 Area 8 (Area 8 beach) during June 2015 and June 2016. The clams were weighed, measured, and submitted for laboratory analysis of metals and percent moisture content.

- OU 2 Area 8 Sediment Collection – Sediment samples were collected from 66 Area 8 beach sampling stations in June 2015 and June 2016. Sediment samples were collected from the biologically active zone of 0 to 10 centimeters (cm) at all 66 stations, and from a depth of 10 to 24 cm at 10 of the 66 stations. The physical characteristics of the sediment samples were recorded, and the June 2015 samples were submitted for laboratory analysis of metals, acid volatile sulfide/simultaneously extracted metals [AVS/SEM], TOC, total solids, and grain size. The June 2016 samples were only analyzed for metals, and a subset of samples were analyzed for AVS/SEM (i.e., the 2016 samples were not analyzed for TOC, total solids, or grain size).
- OU 2 Area 8 Surface Water Collection – Marine surface water samples were collected near the surface water/sediment interface at nine (9) Area 8 beach sampling locations in June 2015. The marine surface water samples, collected as tide was rising and seeps were inundated with water, were submitted for laboratory analysis of dissolved metals.

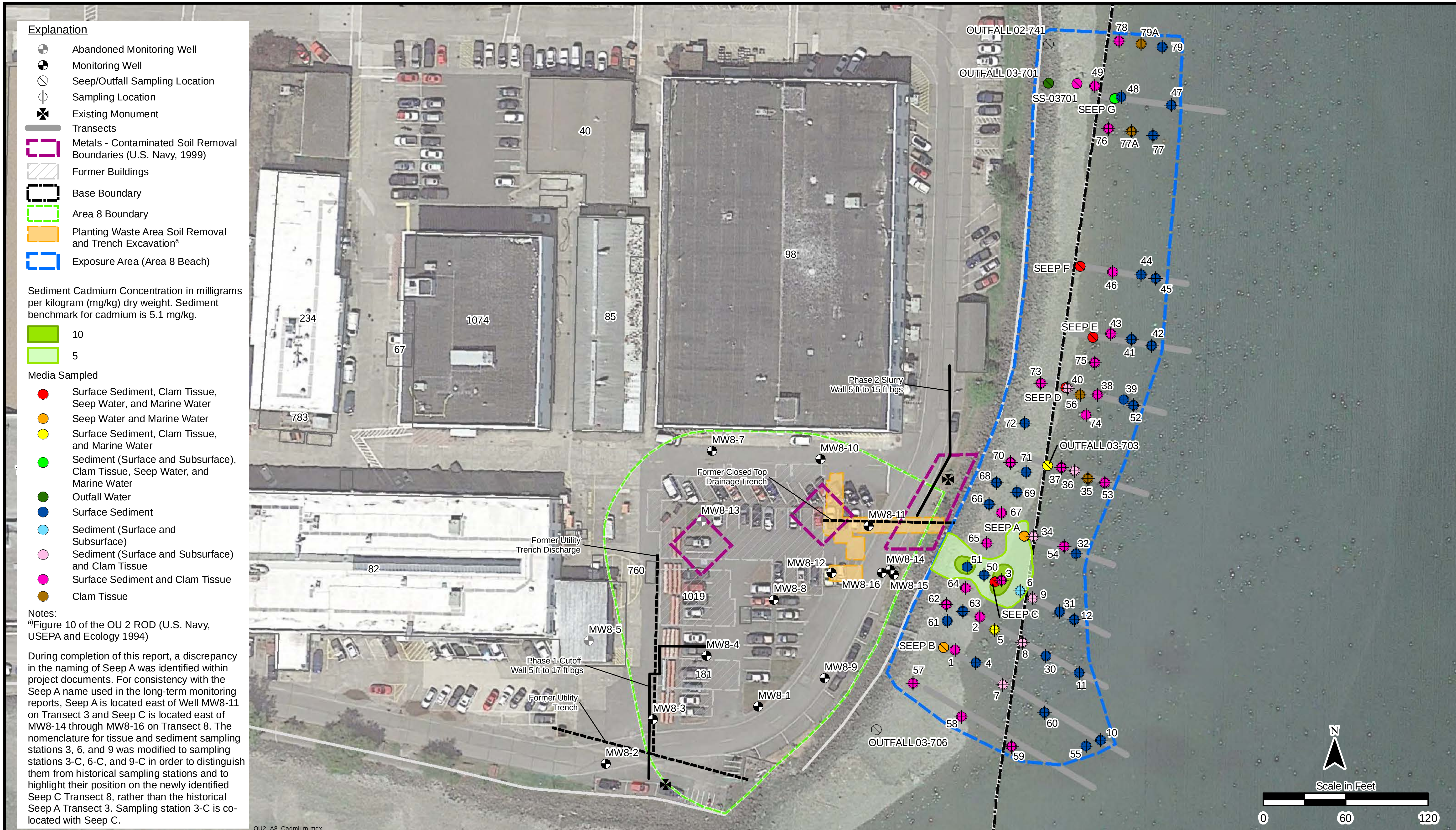
Figure 4-21 presents the tissue, sediment, seep water, outfall, and surface water sampling locations from the marine investigation. A drain in Building 98 under a hydraulic pressure tank used to test torpedo systems in potable water was the source of intermittent flow from outfall 03-701. Therefore, one sample of potable water and two samples of process water were collected from this location and submitted for laboratory analysis of dissolved metals. All analytical results from the marine investigation are tabulated in Appendix H including: Tables H-1 and H-2 (tissues), Tables H-3 through H-5 (sediment), Table H-6 (seeps and outfalls), Table H-7 through H-9 (marine water), and Table H-10 (B98 water). Based on these results, it was determined that the potable water at Keyport exceeds ecological surface water criteria for copper. The predominance of the test water used is recycled; however, any water remaining in the bottom of the tank is discharged to the outfall and was determined to be the source of copper concentrations in the sample from outfall 03-701. Therefore, although potable water discharge is permitted under the NBK Keyport stormwater permit, the discharge line from Building 98 hydraulic tank was rerouted to the sanitary sewer to stop the continual discharge to the beach north of the Area 8 beach.

The marine investigation report included sampling methodology and data reporting only, without any data interpretation, as the project team decided that data interpretation should be informed by the results of the associated risk assessments. Therefore, the data interpretation was included in the HHRA/ERA.

***Human Health and Ecological Risk Assessments.*** Subsequently, the HHRA/ERA (U.S. Navy, 2018a) was conducted to estimate human health and ecological risks associated with exposure to potentially contaminated media at the Area 8 beach (i.e., clam tissue, sediment, seep water, and marine water), per the recommendations of the third and fourth FYRs. The specific objectives were to: 1) characterize human health and ecological site risks relative to background; 2) confirm the extent of contamination; 3) update the CSM; and 4) assess the need to implement contingent groundwater control actions based on the results of the risk assessments.

*Human Health Risk Assessments*

For the HHRA, data collected during the marine investigation in 2015 and 2016 were compared to background and reference area data. Additionally, the HHRA evaluated the potential human health risks associated with subsistence-level and recreational-level exposures to COCs in clam tissue and sediment.




U.S. NAVY

**Figure 4-21**
**Area 8 Beach Cadmium Sediment and Seep Concentrations Greater than Ecological Benchmarks**

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FIFTH
FIVE-YEAR REVIEW

*Background and Reference Area Evaluation - Results*
The results of the single-point comparison of the site and reference area concentrations are summarized below:

- Arsenic concentrations were consistent with background and reference area concentrations.
- Cadmium concentrations exceeded reference area data in sediment near Seep A, Seep C, Seep D, and Outfall 03-703.
- Cadmium concentrations exceeded the background threshold value (BTV) in clam tissue near Seep A, Seep C, and Outfall 03-703. However, the cadmium concentrations in clam tissue are generally consistent with reference area concentrations, as the magnitude of exceedance over BTV is low.
- Several sporadic exceedances of the chromium, copper, lead, nickel, zinc, and mercury BTVs in sediment and clam tissue were noted, indicating that seeps and outfalls may be contributing these metal concentrations to Port Orchard Bay.
- For silver, nearly 50% of the sediment samples and nearly all of the clam tissue samples exceed their relative BTVs. These results indicate that the seeps may be contributing to silver concentrations in sediment and clam tissue above reference area concentrations, but do not demonstrate a pattern with respect to specific potential point sources to Port Orchard Bay.

The population to population (site versus background) comparison concluded that concentrations of cadmium and silver in sediment are statistically higher than the background concentrations, and that concentrations of lead, nickel, silver, and methylmercury in clam tissue are statistically higher than those measured in the reference clam tissue samples.

*Suquamish Subsistence Receptors - Results*
For Suquamish subsistence receptors at the Area 8 beach, the non-cancer hazard index (HI) from ingestion of clam tissue is 4 and 5 for child and combined child/adult receptors, respectively, and the cancer risk is $3 \times 10^{-4}$. At the reference area, the non-cancer HIs and cancer risks are the same as those for the Area 8 beach when rounded to one significant figure. These results indicate that exposure to COCs in clams collected from the Area 8 beach is not substantially different than the exposure to reference area clams, and the incremental site non-cancer HIs are 0.6 and 0.7 for child and combined child/adult receptors, respectively. For exposure to sediment at the Area 8 beach, non-cancer HIs are less than the target health goal of 1 for both the child and combined child/adult receptors and the cancer risk is $6 \times 10^{-6}$, slightly above EPA's de minimis cancer risk level of $1 \times 10^{-6}$. As stated in the risk assessment report (U.S. Navy, 2018a), non-cancer HIs and cancer risks calculated based on the natural background sediment concentrations actually resulted in slightly higher hazard and risk estimates than those estimated for Area 8 beach sediments. Thus, there is no unacceptable incremental non-cancer hazard or cancer risk to human health from sediment. The contribution of sediment exposures to the cumulative hazard and risk estimates based on combined exposure to clam tissue and sediment is insignificant.

These results indicate that while the hazard and risk estimates calculated for the Area 8 beach slightly exceed target health goals, non-site related sources from background or other ubiquitous sources contribute significantly to the concentrations of COCs measured at the site. Because the incremental non-cancer hazard and cancer risk estimates are below target health goals, there is no unacceptable site-related risks to human health for Suquamish subsistence receptors.

*Recreational Receptors – Results*

At the Area 8 beach, the non-cancer HI from ingestion of clam tissue by recreational receptors is 0.2 and 0.1 for child and combined child/adult receptors, respectively, below the non-cancer target health goal of 1. The cancer risk is $2 \times 10^{-6}$, slightly above the EPA's de minimis cancer risk level of $1 \times 10^{-6}$. At the reference area, the non-cancer HIs and cancer risks are the same as those for the Area 8 beach when rounded to one significant figure. Again, these results indicate that exposure to COCs in clams collected from the Area 8 beach is not substantially different than the exposure from the reference area. In addition, the incremental site non-cancer HIs are 0.03 and 0.02 for child and combined child/adult receptors, respectively, well below the target health goal.

Because the non-cancer hazard estimates calculated for the 2 Area 8 beach are below target health goals, there is no unacceptable health risk for recreational receptors at the site, even without considering the contribution from background sources. Though the cancer risk estimates calculated for the Area 8 beach slightly exceed the de minimis target cancer risk level, non-site related sources from natural background or other ubiquitous sources contribute significantly to the concentrations of COCs measured at the site. Because the incremental non-cancer hazard and cancer risk estimates are well below target health goals, there is no unacceptable site-related risks to human health for recreational receptors.

*HHRA Conclusions*

Despite the presence of several COCs in Area 8 beach sediment and clam tissue at concentrations exceeding background and reference area concentrations, the incremental site risk over background for Suquamish subsistence and recreational receptors meets target health goals. Therefore, no risks to human health were identified and contingency/additional actions, such as groundwater controls, are not necessary to protect human health from Area 8 contaminants.

The ERA for the Area 8 beach evaluated the potential environmental hazards to ecological receptors potentially exposed to residual metal COCs. The ecological receptors of concern were subdivided into primary categories: sediment benthos (e.g., shellfish); aquatic life (e.g., aquatic plants, aquatic invertebrates, and fish during high tide); semi-aquatic avians (e.g., northwestern crow) and mammalian predators (e.g., river otter). The media evaluated included seep water, surface water, sediments, and clam tissue. Table 4-5 presents a summary of the findings from the ERA.

Cadmium concentrations in sediment and seep water exceeding ecological benchmarks are delineated in Figure 4-21. As shown in Figure 4-21, these exceedances are along Transect 8, including Seep C, and into Transect 3 at Seep A.

Based on the finding of no significant risk to free-swimming aquatic life, semi-aquatic birds or mammals, contingency/additional actions, such as groundwater controls, are not necessary to protect these receptor groups from contaminants migrating at OU 2 Area 8. Lines of evidence were proposed in the ERA which suggest that the risks to benthic organisms are low despite the localized, elevated concentrations of cadmium in sediment and seep water. These lines of evidence included:

- Surface water and sediment benchmark comparisons that indicate localized impacts.

- Cadmium clam tissue concentrations that are not elevated relative to reference area tissue levels.
- The presence of sufficient AVS where the data are available to indicate sediment impacts are minimal.
- The findings of the 2008 bioassay tests at the highest cadmium seep and sediment concentrations to indicate cadmium is not toxic based on the SMS Rule.

Ecology's SMS regulation (i.e., an ARAR under the OU 2 ROD) allows the use of bioassay analysis in cases where chemical concentrations in sediment samples exceed the published numeric standards. Samples that pass the bioassay analysis are considered to not pose an unacceptable risk to benthic organisms. Therefore, to ensure OU 2 Area 8 COCs do not pose unacceptable risk to benthic organisms, an ERA addendum was conducted. The primary objective of the ERA addendum was to collect additional data needed to fully evaluate the potential risks to the benthic community from COCs originating from OU 2 Area 8 and finalize the ERA. To meet this objective, eight (8) sediment samples (including a duplicate) and one (1) seep water sample were collected from the Area 8 beach; and three (3) sediment samples and one (1) seep water sample were collected from the reference area in June 2019 and tested under a bioassay program in July and August 2019.

Figure 4-22 presents these sediment and seep water sampling locations at the Area 8 beach. The sediment samples were collected in the intertidal zone of the Area 8 beach, in the biologically active zone of 0 to 10 centimeters, and the seep water sample was collected from Seep C, which has the highest contaminant concentrations. The reference area samples were collected from Penrose Point State Park, consistent with characterizations during previous sampling events and similar to the Area 8 beach sediment. The results of the Area 8 beach and reference area sediment and seep water samples are tabulated on Tables H-11 through H-25 in Appendix H.

Figure 4-22 also presents the sediment and seep bioassay results. As shown in Figure 4-22, the cadmium concentration in water from Seep C was 28 μg/L, exceeding the seep benchmark of 7.9 μg/L in the 100%, as well as at the 75% (21 μg/L) and 50% (14 μg/L) dilution series concentrations used in the bioassay test. However, there is no statistically significant difference in mussel development between Seep C and reference area seep water; therefore, contaminants present in seep water, do not pose an unacceptable risk to benthic organisms.

Acute exposure to contaminants in sediment did not indicate a hazard to benthic organisms relative to reference area results based on the amphipod bioassay results. However, acute exposure to accumulated contaminants in sediment pose a potential hazard to benthic organisms based on the bioassay results for larval mussels at two locations (and possibly at SS64; see Figure 4-22):

- Location SS03-C reduced normal development in survivors relative to reference.
- Location Seep A reduced normal development in survivors relative to reference.

Additionally, chronic exposure to accumulated contaminants in sediment pose a potential hazard to benthic organisms based on the bioassay endpoints of both reduced survival and growth for juvenile polychaetes at two locations (see Figure 4-22):

- Location SS64, reduced growth relative to reference.
- Location Seep A, reduced growth relative to reference.

**Table 4-5. Summary of Area 8 Beach Ecological Risk Assessment Findings**

| Exposure Medium | Measures of Effect | Assessment Findings |
|---|---|---|
| ***Benthic Invertebrates*** | | |
| Sediment | Comparison of measured concentrations in sediment to conservative sediment risk- based screening benchmarks. | **Cadmium.** Cadmium exceedances of sediment benchmarks occurred at five locations, four of which are located along Transect 8 near Seep C[a] (SS50, SS51, SS03-C[a], and SS06-C[a]) and one at the discharge point of Seep A[a]. Based on statistical comparison and in conjunction with bioassay results below, cadmium concentrations in sediment present No Significant Risk. |
| | | **Silver.** Silver concentrations in sediment exceeded the sediment benchmark at two locations. Both locations are near Outfall 03-703, where seep concentrations also exceed the surface water benchmark. The sediment 95UCL does not exceed sediment benchmark; significant number of clams at Outfall 03-703, indicating the silver does not appear to be adversely affecting clam populations, so silver concentrations in sediment present No Significant Risk. |
| | Comparison of the sum of simultaneously extracted divalent metals to concentrations of acid volatile sulfides to assess bioavailable fraction of divalent metals. | AVS/SEM ratios less than one indicating divalent metals are not bioavailable for uptake by biota and sufficient AVS available or other lines of evidence exist indicating cadmium in sediment is not likely a contributing source to tissue cadmium levels, so presents No Significant Risk. |
| | Evaluation of existing bioassay tests | No significant toxicity was noted in the sediment sample with the highest cadmium concentration, so cadmium presents No Significant Risk. |
| Seep Water | Used as a line of evidence to assess seep data in conjunction with AVS/SEM as a potential source for metals accumulation in shellfish tissue. | Seep water is most likely the source of cadmium in clam tissue. However, based on shellfish abundance studies and risk findings for mammals and birds (hazard quotients less than one based on cadmium clam tissue concentrations), bioaccumulation of seep water is not significant, so presents No Significant Risk. |
| Clam Tissue | Comparison of measured concentrations of metals in littleneck clam tissue to critical tissue levels (CTLs) and statistical comparison to Penrose Point Reference Area Concentrations. | Although arsenic and cadmium CTL exceedances were detected at all sample locations, arsenic and cadmium tissue concentrations were considered statistically similar to Penrose Point reference tissue concentrations, so present No Significant Risk. |

**Table 4-5 (continued). Summary of Area 8 Beach Ecological Risk Assessment Findings**

| Exposure Medium | Measures of Effect | Assessment Findings |
|---|---|---|
| ***Aquatic Plants, Invertebrates and Fish*** | | |
| Marine Surface Water<br>Seep Water | Comparison of measured concentrations in seep water and surface water to conservative risk-based water quality benchmarks. | Cadmium concentrations in seep water samples exceeded water quality benchmarks, but there were no cadmium exceedances in marine surface water, the more relevant exposure medium. So cadmium in surface water presents No Significant Risk. |
| ***Semiaquatic Birds and Mammals*** | | |
| Sediment and Clam Tissue | Calculation of hazard quotients based on average daily doses for indicator bird and mammal species and comparison to chemical- and receptor-specific toxicity reference values (TRVs) | Calculated hazard quotients of less than one, so No Significant Risk. |

*Notes:*
[a] During completion of the ERA, a discrepancy in the naming of Seep A was identified within project documents. For consistency with the Seep A location used in long-term monitoring reports, Seep A is located east of Well MW8-11 on Transect 3 and Seep C is located east of MW8-14 through MW8-16 on Transect 8. The nomenclature for SS03 and SS06 was modified to sampling stations SS03-C and SS06-C in order to distinguish them from historical sampling stations and to highlight their downgradient position from the newly identified Seep C Transect 8, rather than the historical Seep A Transect 3 locations.
Sample location SS03-C is collocated with Seep C.
AVS/SEM = acid-volatile sulfide/simultaneous extracted metal

The ecological risk assessment identified no risk to higher trophic level biota, but concluded that acute and chronic exposure to accumulated contaminants in sediment pose a current potential hazard to benthic organisms based on the bioassay results/endpoints. The area of exposure with unacceptable risk is well delineated and of limited extent within the Area 8 beach intertidal zone. Based on the identification of risk at the Area 8 beach, the OU 2 ROD requires a contingent remedial action be implemented as part of the selected remedy, to protect the benthic community. Therefore, the Navy will begin a supplemental remedial investigation at OU 2 Area 8 in 2021 to better understand site hydrogeology, current contaminant magnitude and extent and allow evaluation of remedial alternatives to control the release of contaminant to the Area 8 beach.

***2017 and 2019 Vapor Intrusion Investigations.*** A VI Study (U.S. Navy, 2018c) was conducted in fall 2017 at OU 2 Area 8 in response to a recommendation in the fourth FYR (U.S. Navy, 2015b), to conduct a VI evaluation, including soil gas sampling adjacent to occupied buildings within 100 feet of monitoring wells exhibiting TCE concentrations exceeding 5 μg/L (i.e., VI default screening level).

The overall objectives of the VI study were to: 1) evaluate whether the VI pathway is complete between the site and nearby buildings; 2) assess whether the cVOCs in groundwater at OU 2 Area 8 have contributed to indoor air concentrations via the VI pathway; and 3) collect information to support the selection of appropriate mitigation measures, if required. To address these questions, the scope of work consisted of collection and analysis of soil vapor samples from six (6) locations adjacent to buildings near known cVOC concentrations in groundwater.

Soil vapor locations SV-1 through SV-5 were installed as dual nested multi-depth probes, with each nested probe completed with a sample point at a shallow depth (4.5 to 5 feet bgs) and a deeper depth (8 feet). Soil vapor location SV-6 was installed as a single depth point at 5 feet bgs due to saturation in soils observed at approximately 7 feet bgs. Ultimately, samples were not collected from the deeper sampling depths, with the exception of well SV-3, due to the presence of water or insufficient soil vapor volume encountered during purging and/or sampling efforts; therefore, a total of seven soil vapor samples were collected. Figure 4-23 presents the soil vapor locations and results for cVOCs exceeding PALs at OU 2 Area 8.

As shown in Figure 4-23, trans-1,2-DCE, TCE, 1,1,2-TCA, and PCE in soil vapor exceeded their respective PALs of 2,000, 66.7, 6.67, and 1,333 $\mu g/m^3$ at one or more locations. All other VOCs were non-detect or detected at concentrations below their respective PAL. In addition, the deeper sample at SV-3 (at 8 ft bgs) demonstrated greater VOC concentrations. This deeper sample is closer to groundwater containing VOCs, suggesting that the source of VOCs in soil vapor may be contaminated groundwater. Also, the greatest VOC concentrations were detected in samples from two of the locations farthest from known VOC concentrations in groundwater (i.e., SV-1 and SV-2). These two locations are near an underground electrical corridor, which appears to have a spur aligned to the east and terminating within the area of known VOCs in groundwater (see Figure 4-23). One interpretation of these results could be that VOC vapors are migrating along the backfill of this electrical corridor.

Based on these finding, an additional investigation of the VI pathway and VOC migration along preferential pathways was warranted and ultimately conducted in April and July 2019 at Buildings 82, 85, 98, and 1074 adjacent to OU 2 Area 8. The overall objectives of the investigation were to: 1) evaluate potential health risk from worker inhalation exposures through the VI pathway and 2) collect information to support the selection of appropriate mitigation measures, if needed.

Explanation

- Abandoned Monitoring Well
- Monitoring Well
- June 2015 Seep/Outall Sampling Location
- 2019 Seep Bioassay Sample Location
- June 2015 Sediment Sampling Location
- June 2016 Sediment Sampling Location
- 2019 Sediment Bioassay Sample Location
- Existing Monument
- Transects
- Metals - Contaminated Soil Removal Boundaries (U.S. Navy, 1999)
- Former Buildings
- Base Boundary
- Area 8 Boundary
- Planting Waste Area Soil Removal and Trench Excavation[a]
- Exposure Area (Area 8 Beach)

Sediment Cadmium Concentration in milligrams per kilogram (mg/kg) dry weight. Sediment benchmark for cadmium is 5.1 mg/kg.

- 10
- 5

Notes:

[a]Figure 10 of the OU 2 ROD (U.S. Navy, USEPA and Ecology 1994)

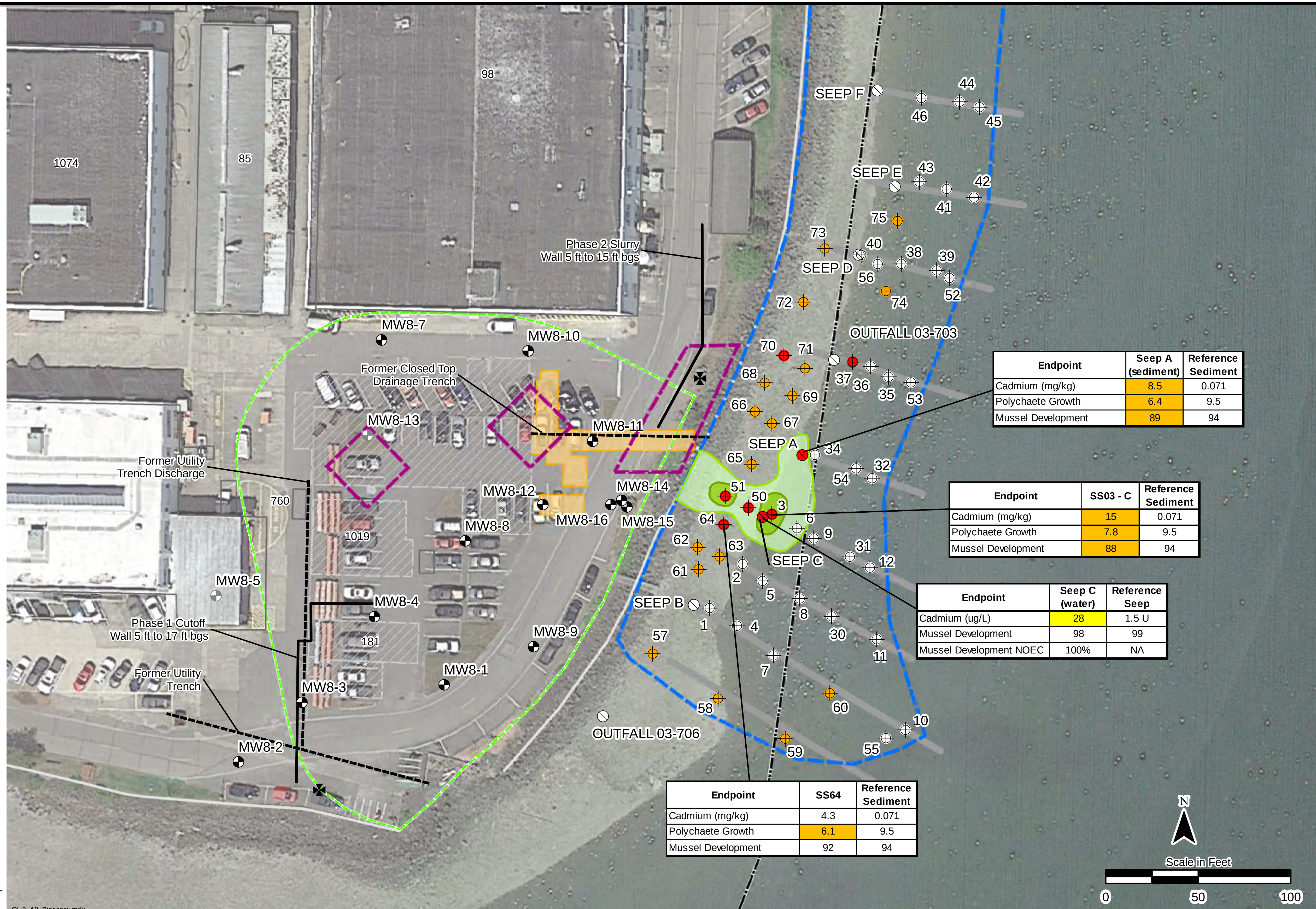
Reference sediment was collected from station PPSP-2 and reference seep water was collected from station PPSP-1.

2. Sediment values shown in highlited in orange indicate the following:

a. Cadmium - The value is greater than the Sediment Cleanup Objective (SCO) of 5.1 milligrams per kilogram.
b. Polychaete Growth - There is a statistically significant difference between the value and the associated laboratory control and/or reference sediment.
c. Mussel Development - There is a statistically significant difference between the value and the associated laboratory control and reference sediment.

3. Cadmium value for Seep C (water) shown highlighted in yellow indicates the concentration is greater than the applicable water quality benchmark of 7.9 micrograms per liter. The cadmium concentrations at the 75% (21 µg/L) and 50% (14 µg/L) also exceed the benchmark, while the 25% (7 µg/L) and 12.5% (3.5 µg/L) were lower than the benchmark.

4. There was no statistically significant difference in mussel development between the Seep C water and the reference seep.




| Endpoint | Seep A (sediment) | Reference Sediment |
|---|---|---|
| Cadmium (mg/kg) | 8.5 | 0.071 |
| Polychaete Growth | 6.4 | 9.5 |
| Mussel Development | 89 | 94 |

| Endpoint | SS03 - C | Reference Sediment |
|---|---|---|
| Cadmium (mg/kg) | 15 | 0.071 |
| Polychaete Growth | 7.8 | 9.5 |
| Mussel Development | 88 | 94 |

| Endpoint | Seep C (water) | Reference Seep |
|---|---|---|
| Cadmium (ug/L) | 28 | 1.5 U |
| Mussel Development | 98 | 99 |
| Mussel Development NOEC | 100% | NA |

| Endpoint | SS64 | Reference Sediment |
|---|---|---|
| Cadmium (mg/kg) | 4.3 | 0.071 |
| Polychaete Growth | 6.1 | 9.5 |
| Mussel Development | 92 | 94 |

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**Figure 4-22**
**Area 8 Beach Locations of Predicted Bioassay Impacts and Beach Cadmium Sediment and Seep Concentrations Greater Than Ecological Benchmarks**

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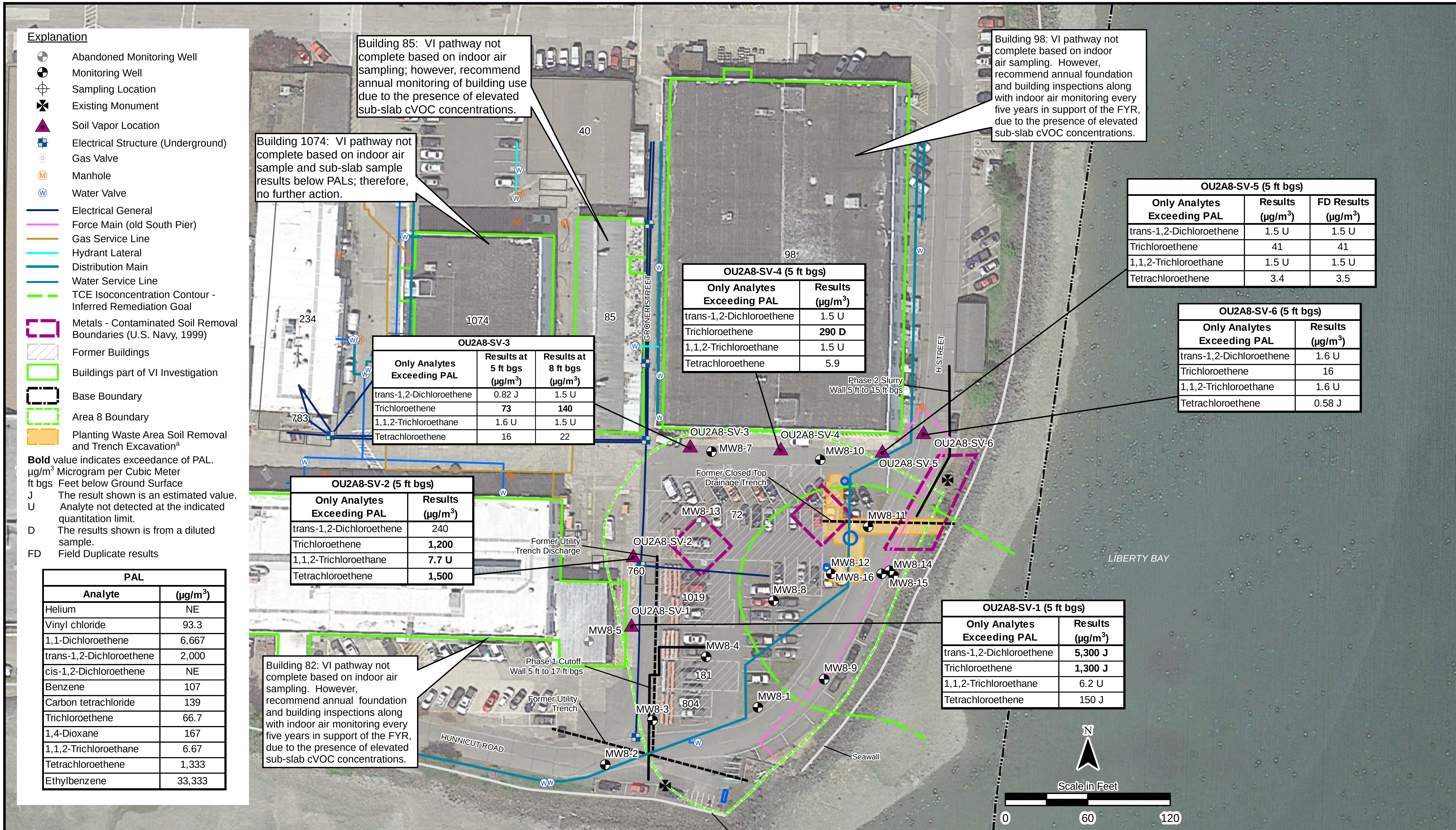


PAL

| Analyte | (μg/m³) |
|---|---|
| Helium | NE |
| Vinyl chloride | 93.3 |
| 1,1-Dichloroethene | 6,667 |
| trans-1,2-Dichloroethene | 2,000 |
| cis-1,2-Dichloroethene | NE |
| Benzene | 107 |
| Carbon tetrachloride | 139 |
| Trichloroethene | 66.7 |
| 1,4-Dioxane | 167 |
| 1,1,2-Trichloroethane | 6.67 |
| Tetrachloroethene | 1,333 |
| Ethylbenzene | 33,333 |

OU2A8-SV-3

| Only Analytes Exceeding PAL | Results at 5 ft bgs (μg/m³) | Results at 8 ft bgs (μg/m³) |
|---|---|---|
| trans-1,2-Dichloroethene | 0.82 J | 1.5 U |
| Trichloroethene | **73** | **140** |
| 1,1,2-Trichloroethane | 1.6 U | 1.5 U |
| Tetrachloroethene | 16 | 22 |

OU2A8-SV-4 (5 ft bgs)

| Only Analytes Exceeding PAL | Results (μg/m³) |
|---|---|
| trans-1,2-Dichloroethene | 1.5 U |
| Trichloroethene | **290 D** |
| 1,1,2-Trichloroethane | 1.5 U |
| Tetrachloroethene | 5.9 |

OU2A8-SV-5 (5 ft bgs)

| Only Analytes Exceeding PAL | Results (μg/m³) | FD Results (μg/m³) |
|---|---|---|
| trans-1,2-Dichloroethene | 1.5 U | 1.5 U |
| Trichloroethene | 41 | 41 |
| 1,1,2-Trichloroethane | 1.5 U | 1.5 U |
| Tetrachloroethene | 3.4 | 3.5 |

OU2A8-SV-6 (5 ft bgs)

| Only Analytes Exceeding PAL | Results (μg/m³) |
|---|---|
| trans-1,2-Dichloroethene | 1.6 U |
| Trichloroethene | 16 |
| 1,1,2-Trichloroethane | 1.6 U |
| Tetrachloroethene | 0.58 J |

OU2A8-SV-2 (5 ft bgs)

| Only Analytes Exceeding PAL | Results (μg/m³) |
|---|---|
| trans-1,2-Dichloroethene | 240 |
| Trichloroethene | **1,200** |
| 1,1,2-Trichloroethane | **7.7 U** |
| Tetrachloroethene | **1,500** |

OU2A8-SV-1 (5 ft bgs)

| Only Analytes Exceeding PAL | Results (μg/m³) |
|---|---|
| trans-1,2-Dichloroethene | **5,300 J** |
| Trichloroethene | **1,300 J** |
| 1,1,2-Trichloroethane | 6.2 U |
| Tetrachloroethene | 150 J |

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**Figure 4-23**
**OU 2 Area 8 Summary of 2017 and 2018 Vapor Intrusion Investigations**

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Preliminary screening was performed immediately prior to the first sampling event in each of the four buildings to inform final placement of Summa canisters to collect time-integrated samples, as shown below:

| Screening Method | Purpose | Target Analytes |
|---|---|---|
| portable GC/MS (INFICON HAPSITE®) | To identify potential background indoor air sources, soil vapor entry points, and preliminary breathing zone concentrations. | PCE, TCE, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride |
| ppbRAE (PID) | | Total VOC screening |
| differential pressure monitors | To provide an indication of whether the inside of each building tends to be more or less pressurized as compared to outdoors (i.e., more or less susceptible to VI). | NA |

Indoor air, outdoor air, and sub-slab vapor samples were collected, and differential pressure was monitored in both early spring (April 2019) and summer (July 2019) to account for the seasonal variability of VI potential. All indoor air and outdoor air samples were collected using 6-L Summa canisters, whereas sub-slab vapor samples were collected using 1-L Summa canisters. All samples were analyzed for the six (6) target cVOCs: PCE, TCE, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride via EPA Method TO-15 SIM. In April 2019, six outdoor air samples, 30 indoor air samples, and 28 soil vapor samples were collected. In July 2019, four outdoor air samples, 29 indoor air samples, and 28 soil vapor samples were collected.

The results of the VI investigation indicate that the VI pathway is incomplete. Contaminants that were detected in indoor air above PALs were shown to be the result of indoor background sources and although elevated contaminant concentrations were detected in sub-slab vapor from underneath three of the four buildings, elevated concentrations were not detected in the paired indoor air samples, indicating the VI pathway is incomplete. In addition, the PAL algorithm is extremely conservative and often does not produce concentrations that represent a VI concern, especially considering the attenuation factors for industrial buildings present at the site. Annual foundation inspections were recommended for Buildings 82, 85, and 98 and VI monitoring, including collection and analysis of indoor and outdoor air samples and subslab vapor samples conducted every 5 years was recommended for Buildings 82 and 98. No further action was recommended for Building 1074, since indoor air and sub-slab vapor concentrations were below PALs (see Figure 4-23). The results and recommendations of the VI investigation are currently in Draft form. Final recommendations for VI inspections and monitoring at OU 2 Area 8 will be documented in the Final OU 2 Area 8 VI Report.

***USGS Tidal Lag Study.*** A tidal lag study was conducted by USGS from October to November 2017 to determine the optimal time during the semi-diurnal and neap-spring tidal cycles to sample groundwater for freshwater contaminants at OU 2 Area 8 monitoring wells (USGS, 2018). For the study, groundwater levels and specific conductance in five monitoring wells (i.e., MW8-8, MW8-9, MW8-11, MW8-12, and MW8-14) , along with marine water levels (tidal levels) were measured every 15 minutes during a 3-week duration to determine how nearshore groundwater responds to tidal forces. Time series data were collected during a period that included neap and spring tides. Vertical profiles of specific conductance were also measured in the screened interval of each monitoring well prior to instrument deployment to determine if the freshwater/saltwater interface was present in the monitoring well at that time.

Based on the data collected, the following observations were made regarding groundwater response to tidal influences:

Specific-Conductance Time-Series Data:

- Evidence of substantial saltwater intrusion into the screened intervals of most shallow monitoring wells.
- Data consistently indicated that groundwater had the lowest specific conductance (was least mixed with seawater) during the same period when groundwater levels were lowest.
- Data suggest that it is the heights of the actual high-high and low-low tides (regardless of whether or not they occur during the neap or spring part of the cycle) that allows seawater intrusion into the nearshore aquifer of OU 2 Area 8.

Vertical Profiles of Specific Conductance Data:

- The landward-most well (MW8-8) was completely freshwater, while one of the most seaward wells (MW8-9) was completely saline/seawater.
- A distinct saltwater interface was measured in the three other shallow wells (MW8-11, MW8-12, and MW8-14), with the topmost groundwater occurring as freshwater underlain by higher conductivity water/seawater.

Lag Time Data:

- Lag times were surprisingly long considering the monitoring wells are all located within 200-ft of the shoreline and the local geology is largely coarse-grained glacial outwash deposits.
- Various manmade subsurface features (i.e., cutoff walls and backfilled excavations) most likely influence and complicate the hydraulic connectivity between seawater and groundwater.

Based on the USGS study findings, the optimal time for sampling the shallow monitoring wells at OU 2 Area 8 is centered on a 2 to 5-hour period following the predicted low-low tide during neap tide, with due consideration of local atmospheric pressure and wind conditions that have the potential to generate tides that can be substantially higher than those predicted from lunar-solar tidal forces. The optimal time for sampling the deeper monitoring wells at OU 2 Area 8 would be during the 6 to 8-hour period following a predicted low-low tide, also during the neap tide part of the tidal cycle. These periods are when groundwater in the monitoring wells is mostly freshwater and least diluted by saltwater intrusion (USGS, 2018).

The USGS study recommended collecting undisturbed samples from the top of the screened interval (or top of the water table if below the top of the interval) to best characterize contaminant concentrations in freshwater (USGS, 2018). However, additional consideration should be given to this recommendation, given that cVOCs detected in groundwater at OU 2 Area 8 vertically migrate to deeper depths within the aquifer; thus, worst-case scenario concentrations may be found in the lower portions of the screened interval. In addition, climate change effects and particularly weather pattern changes (i.e., local atmospheric pressure and wind conditions) may significantly impact the magnitude and duration of saltwater intrusion and ultimately, the timeframe when best to sample groundwater for freshwater contaminants.

## 4.3 Results of Site Inspections

The following subsections summarize the results of the annual LUC inspections and FYR site inspections at NBK Keyport.

### *4.3.1 Land Use Control Inspections*

LUCs have been implemented at the various OUs at NBK Keyport to prevent exposures to contaminants and to limit or prohibit activities that may interfere with the integrity of a remedial action (U.S. Navy, 2017b). To ensure effectiveness of the LUCs, physical and records inspections within the LUC boundary are conducted on an annual basis. These inspections are guided by the inspection checklists provided in the IC Plans (U.S. Navy, 2016a and 2017b). Table 4-6 presents a summary of the LUC inspection results from 2015 through 2019.

As shown in Table 4-6, there were no instances/findings of LUC deficiencies during this FYR period, demonstrating that LUCs have been adequately implemented. The LUCs are preventing exposure to residual contamination and have controlled, limited, or prohibited activities that may interfere with the integrity of the completed remedial actions. That noted, in 2019, there was an observation of several newer, deeper cracks, approximately 1-inch wide, in the western portion of the motorcycle training area at OU 1. Several other smaller cracks were also observed, similar to previous years, but there appears to have been some settling (see Table 4-6).

### *4.3.2 Five-Year Review Site Inspection*

An inspection of OU 1, OU 2 Area 2, and OU 2 Area 8 was conducted in accordance with EPA guidance for FYRs (EPA, 2001). The site inspection provided a means to verify that the remedies are protective of human health and the environment and to assist in identifying recommendations for additional/corrective actions to ensure that the remedies continue to be protective.

The site inspections for this fifth FYR were conducted on September 19, 2019 by the following personnel:

| Name | Organization | Role |
|---|---|---|
| Carlotta Cellucci | NAVFAC Northwest | Remedial Project Manager |
| Michael Meyer | Battelle | Project Manager |
| Angela Paolucci | Battelle | FYR Task Manager |

A FYR site inspection checklist along with photographs were used to guide the visual inspections at each site and ultimately, assess the protectiveness of the remedies. The completed FYR site inspection checklists and photographic log are provided in Appendices I and J, respectively.

There were no significant observations made at OU 2 Area 2 or OU 2 Area 8 during the FYR site inspections; however, specific observations regarding OU 1 are provided below:

- ***Tide Gate:*** The tide gate was observed/noted and based on regular inspections and maintenance documented in the 2018/2019 Annual O&M Report (U.S. Navy, 2019h), the tide gate is working as intended and designed to limit tidal flooding of the marsh, which could cause erosion of the landfill and/or adversely affect plantation tree health (see Section 4.2.1 and Appendix J).
- ***Phytoremediation:*** Consistent with the 2018/2019 Annual O&M Report (U.S. Navy, 2019h), tree health stress was observed in both plantations; however, stress was notably more apparent in the North Plantation (compared to the South Plantation), including leaf curl and burn and low leaf density (see Section 4.2.1 and Appendix J).
- ***Landfill Cover:*** Similar to the fourth FYR (U.S. Navy, 2015e), there are several ~1-inch wide cracks traversing the Central Landfill from east to west and north to south; there is significant bulging and cracking caused by tree roots outside the southeast corner of the North Plantation; and water ponding in the southern portion of the Central Landfill (see Appendix J).
- ***Landfill Infringements:*** Similar to the fourth FYR (U.S. Navy, 2015e), alder trees and other brush are growing up through penetrations in the asphalt near old foundations in the southern portion of the Central Landfill (see Appendix J).

Site conditions observed at OU 1, OU 2 Area 2, and OU 2 Area 8 indicated that LUCs requirements are currently being met, as confirmed in Section 4.3.1.

**Table 4-6. Summary of Annual LUC Inspections at NBK Keyport**

| Inspector's Checklist | Response (Yes/No) | | | | | Findings/Comments |
|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | |
| ***OU 1 – Former Landfill[(a)]*** | | | | | | |
| Has access to OU 1 been maintained (have security procedures for base entry served to maintain a restricted access)? | Yes | Yes | Yes | Yes | Yes | – |
| Have drinking water wells been installed on Navy property within 1,000 feet of the landfill? | No | No | No | No | No | – |
| For Area A, the land between the tide flats and the marsh, have water wells been installed, except those for monitoring or remedial action purposes? | No | No | No | No | No | – |
| For Area B, the land between the tide flats and the Pass and ID Building parking lot, have water wells been installed, expect those for monitoring or remedial action purposes? | No | No | No | No | No | – |
| For Area C, the tide flats and adjacent shoreline owned by the Navy, have any activities occurred that could interfere with or compromise monitoring or remedial actions? | No | No | No | No | No | – |
| For Area D, the former landfill, have water wells been installed, expect those for monitoring or remedial action purposes? | No | No | No | No | No | – |
| For Area D, the former landfill, are any employees permanently assigned to work in buildings within this area? | No | No | No | No | No | – |
| For Area D, the former landfill, have there been any land use activities other than remedial activities, storage, parking, and facilities that involve only occasional occupancy by workers? | No | No | No | No | No | – |
| For Area D, the former landfill, have activities that involve digging and construction within this area been controlled by the base excavation/dig permit procedure and other pertinent base instruction? | Yes | Yes | Yes | Yes | Yes | – |
| For Area D, the former landfill, is there significant damage (e.g., cracking, seam separation, root damage, etc.) to asphalt surfaces that permits direct-contact exposure of people to underlying soils or that may significantly increase infiltration of surface water/stormwater? | – | No | No | No | No | Cracks and seams are minimal and do not permit direct contact in 2016, 2017, and 2018. In 2019, several deeper cracks in western portion of motorcycle training area. |
| For Area D, the former landfill, if activities requiring an excavation/dig permit were conducted, were there any instances in which the permit requirements were not effective in maintaining the requirements of the Institutional Controls Plan? | No | No | No | No | No | – |
| For Area E, the marsh pond and marsh system, have there been any new construction or maintenance activities that disturbed the wetlands adjacent to the landfill and resulted in an exposure hazard? | No | No | No | No | No | – |
| For Area E, the marsh pond and marsh system, have there been any new construction or maintenance activities that interfere with or compromise the monitoring or remedial actions for the landfill? | No | No | No | No | No | – |
| ***OU 2 Area 2 – Van Meter Road Spill/Drum Storage Area*** | | | | | | |
| Has access to OU 2 Area 2 been maintained (have security procedures for base entry served to maintain a restricted access)? | Yes | Yes | Yes | Yes | Yes | – |
| Have activities that involved digging and construction within OU 2 Area 2 been controlled by the base excavation/dig permit procedure and other pertinent base instructions? | Yes | NA/Yes | NA | Yes | Yes | – |
| If activities requiring an excavation/dig permit were conducted within OU 2 Area 2, were there any instances in which the permit requirements were not effective in maintaining the requirements of the Institutional Controls Plan? | No | NA/No | NA | No | No | – |
| Have water wells been installed at OU 2 Area 2, except those for monitoring or remedial actions? | No | No | No | No | No | – |
| Has residential development occurred in OU 2 Area 2? | No | No | No | No | No | – |
| ***OU 2 Area 8 – Plating Shop Waste/Oil Spill Area*** | | | | | | |
| Has access to OU 2 Area 8 been maintained (have security procedures for base entry served to maintain a restricted access)? | Yes | Yes | Yes | Yes | Yes | – |
| Have activities that involved digging and construction within OU 2 Area 8 been controlled by the base excavation/dig permit procedure and other pertinent base instructions? | Yes | NA/Yes | Yes | Yes | Yes | – |

**Table 4-6 (continued). Summary of Annual IC Inspections at NBK Keyport**

| Inspector's Checklist | Response (Yes/No) | | | | | Findings/Comments |
|---|---|---|---|---|---|---|
| | 2015 | 2016 | 2017 | 2018 | 2019 | |
| If activities requiring an excavation/dig permit were conducted within OU 2 Area 8, were there any instances in which the permit requirements were not effective in maintaining the requirements of the Institutional Controls Plan? | No | NA/No | No | No | No | – |
| Have water wells been installed at OU 2 Area 8, except those for monitoring or remedial actions? | No | No | No | No | No | – |
| Has residential development occurred in OU 2 Area 8? | No | No | No | No | No | – |

(a) LUC areas within OU 1 are depicted in Figure 2-1.
– Indicates that question was not asked that year or site was not inspected that year.
NA Not applicable.

# 5.0 TECHNICAL ASSESSMENT

In accordance with the *Comprehensive Five-Year Review Guidance* (EPA, 2001), the technical assessment for NBK Keyport answers three questions:

- Question A: Is the remedy functioning as intended by the decision documents?
- Question B: Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid?
- Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

Table 5-1 summarizes the responses to Questions A, B, and C based on the technical assessment discussion provided in the following subsections for OU 1 and OU 2 at NBK Keyport.

**Table 5-1. Summary of the Technical Assessment for NBK Keyport**

| **OU** | **Area/Site** | **Question A:** Is the remedy functioning as intended by the decision documents? | **Question B:** Are the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy still valid? | **Question C:** Has any other information come to light that could call into question the protectiveness of the remedy? |
|---|---|---|---|---|
| OU 1 | Area 1 | No | No | No |
| OU 2 | Area 2 | Yes | No | No |
| | Area 8 | No | No | No |

## 5.1 Answers to Questions A, B, and C for OU 1

The following section provides a summary response to Questions A, B, and C for OU 1.

**Question A:** For OU 1, the remedy is not functioning as intended by the OU 1 ROD (U.S. Navy, EPA, and Ecology, 1998); therefore, the answer to Question A is "no." During this FYR period, the understanding of the CSM, as depicted in the ROD has changed completely. cVOCs have been found at deeper depths in both soil and groundwater than understood at the time of the ROD; cVOC concentrations discharging to surface water are more widespread and at substantially higher concentrations than known at the time of the ROD; and a PCB source area has been identified within the northern area of the landfill that may be re-contaminating an area of the wetland that was previously remediated. Based on this information, investigations in support of focused feasibility study for hotspot treatment and human health and ecological risk assessments to ensure risk assumptions have not changed based on the changed CSM have been initiated.

Phase I and Phase II Site Characterizations recommended in the fourth FYR (U.S. Navy, 2015e), along with source area investigations, have been conducted during this FYR period, providing new data to refine the CSM for the South Plantation, Central Landfill, and North Planation at OU 1 (see Section 4.2.1). These investigations are on-going and include verifying exposure assumptions, conducting supplemental human health and ecological risk assessments, and re-evaluating points of compliance, ARARs, RAOs, and cleanup levels to ensure protectiveness in the future. To date, these investigations have documented subsurface geology and contaminant distribution that differs significantly from the CSM understanding at the time of the ROD (U.S. Navy, EPA, and Ecology, 1998). For example, cVOCs have been found at deeper depths in both soil and groundwater; cVOC concentrations discharging to surface water are more widespread and at substantially higher concentrations than known at the time of the ROD; and a PCB source area has been identified within the area north of the north plantation that may be re-contaminating an area of the wetland that was previously remediated. LUCs are implemented and maintained to prevent all currently known exposures.

**Question B:** For OU 1, the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy are currently being re-evaluated based on data obtained during this FYR period, therefore, the answer to Question B is “no” for the following reasons:

1. Exposure point cVOC concentrations for ecological receptors in surface water in the wetland south of the south plantation are orders of magnitude higher than known at the time of the ROD, so this exposure assumption is no longer valid
2. Ecological cVOC exposures in sediment porewater occur over a much larger portion of the marsh than understood at the time of the ROD, so again this exposure assumption is no longer valid
3. PCB sediment data indicate the potential for adverse risk/effects to human health and the benthic community, and PCBs did not pose a risk at the time of the ROD.

ARARs used to establish cleanup levels in the OU 1 ROD (U.S. Navy, EPA, and Ecology, 1998) are evaluated in Section 5.5.1 and summarized in Table 5-2. The changes to the toxicity risk assumptions are discussed in Section 5.5.2. At the time of this FYR, there are no verified changes to the risk assessment exposure assumptions and LUCs are implemented and maintained to prevent all currently known exposures.

However, additional human health and ecological risk assessments are underway and the recent results of PCB samples in the wetland, as well as the exposure area and exposure point concentrations of cVOCs, will be used to assess whether risk conclusions in the ROD should be revised. For human health risk, the 2017 PCB sediment data were compared to natural background for marine sediment and indicated the potential for adverse risk at all sediment sampling locations. In the interim, the tide flats are currently closed by the Washington State Department of Health (WDOH) to harvesting and consuming shellfish by recreational or subsistence fishers; therefore, the remedy is protective in the short term. Note that the Suquamish Tribe has treaty reserved rights to harvest and maintain the authority to determine harvest practices for tribal members. For ecological risk, because the highest current PCB concentrations are not higher than those found at the time of the ROD and are limited to the immediate vicinity of station MA-09, the remedy is protective in the short term. Although initial risk evaluation of sample results near sediment station MA09 indicate minor adverse effects to the benthic community, and the ROD anticipated that post remedy concentrations would be lower and any adverse effects would have been eliminated by remedial action, these effects will be more thoroughly evaluated during the ongoing HHRA/ERA. Regarding ecological exposure to cVOCs, the area of these exposures is substantially larger than known at the time of the ROD, and the concentrations are orders of magnitude higher than understood at the time of the ROD.

Groundwater samples were collected and analyzed for PFAS compounds in 2017 and 2019 to determine if these chemicals of emerging concern were present at the site. PFAS compounds were detected in groundwater during these monitoring events; however, neither PFOS, PFOA, nor total PFOS plus PFOA concentrations were detected above the Lifetime Health Advisory (LHA) of 70 ng/L (see Appendix D). PFBS was also analyzed in 10 groundwater samples collected in 2017 and was not detected in any of the samples with the highest reporting limit achieved of 0.37 ng/L. Additionally, there have been no new pathways identified for exposure to occur as long as LUCs restricting groundwater use for drinking water are maintained.

**Question C:** For OU 1, no other information has come to light (i.e., other than information discussed in previous sections of this FYR report regarding preliminary data) that could call into question the protectiveness of the remedy; therefore, the answer to Question C is “no.”

The U.S. Navy recognizes PFAS compounds as chemicals of emerging concern and is in the process of completing a Preliminary Assessment (PA) (and will begin a Site Inspection [SI]) at NBK Keyport. The results of the PFAS PA/SI will be addressed in the next FYR for NBK Keyport. During this FYR period, PFAS and 1,4-dioxane were analyzed in select groundwater samples to assess whether the planned remedial alternative evaluation for hotspot treatment should account for additional contaminants. As stated previously, neither PFOS, PFOA, nor total PFOS plus PFOA concentrations were detected above the LHA of 70 ng/L in 2017 or 2019. Therefore, PFAS does not currently affect protectiveness.

Sea level rise caused by climate change effects and weather pattern changes caused by climate change may significantly impact the magnitude and duration of both tidal forces and storms, thereby increasing erosive forces along shorelines. At OU 1, the sill/causeway that separates Dogfish Bay from the tidal flats and the presence of the tide gate significantly lessen any effects of climate change that would cause tidal flooding of the marsh and erosion of the landfill in the short term. Therefore, climate change issues do not affect protectiveness.

## 5.2 Answers to Questions A, B, and C for OU 2 Area 2

The following section provides a summary response to Questions A, B, and C for OU 2 Area 2.

**Question A:** For OU 2 Area 2, the remedy (i.e., LTM and LUCs) is functioning as intended by the OU 2 ROD (U.S. Navy, EPA, and Ecology, 1994); therefore, the answer to Question A is “yes.” Contaminant concentrations have trended down or been steady and LUCs are implemented and maintained to prevent all currently known exposures.

However, As discussed in Section 4.2.2, the consistent vinyl chloride detections above the RG in well 2MW-6 (and a recent increased concentration) may indicate that cVOC mass detected in the shallow zone (i.e., wells 2MW-1, 2MW-3, and MW2-10) during the RI has migrated to deeper and further downgradient than can be evaluated by the current monitoring well network. As such, the monitoring network may not be providing a current understanding of the nature and extent of groundwater contamination at OU 2 Area 2. Notwithstanding, annual LUC inspections and the FYR site inspection demonstrate that LUCs have been adequately implemented and maintained during this FYR period, preventing all currently known exposures. However, to reduce restoration timeframe and ensure the protection of downgradient receptors, additional investigation is recommended at OU 2 Area 2.

**Question B:** For OU 2 Area 2, the cleanup level for vinyl chloride used at the time of the remedy is no longer valid; therefore, the answer to Question B is “no.”

ARARs used to establish cleanup levels in the OU 2 ROD (U.S. Navy, EPA, and Ecology, 1994) are evaluated in Section 5.5.1 and summarized in Table 5-3. The changes to the toxicity risk assumptions are

discussed in Section 5.5.2. Although the ARAR value supporting the ROD RG for vinyl chloride is no longer valid, LUCs are implemented and maintained to prevent all currently known exposures.
**Question C:** For OU 2 Area 2, no other information has come to light (i.e., other than information discussed in previous sections of this FYR report regarding preliminary data) that could call into question the protectiveness of the remedy (i.e., LTM and LUCs); therefore, the answer to Question C is "no."

The Navy recognizes PFAS compounds as chemicals of emerging concern and is in the process of completing a PA (and will begin a SI) at NBK Keyport. The results of the PFAS PA/SI will be addressed in the next FYR for NBK Keyport. At this time, there are no recommendations or analytical data from OU 2 Area 2 to assess; therefore, the presence/effects of PFAS have not been evaluated. Also, there are no shoreline remedies in place at OU 2 Area 2; therefore, climate change effects do not call into question the protectiveness of the remedy.

## 5.3 Answers to Questions A, B, and C for OU 2 Area 8

The following section provides a summary response to Questions A, B, and C for OU 2 Area 8.

**Question A:** For OU 2 Area 8, the remedy is not functioning as intended by the OU 2 ROD (U.S. Navy, EPA, and Ecology, 1994); therefore, the answer to Question A is "no."

The LTM program for OU 2 Area 8 includes groundwater, seep water, surface water, and sediment sampling for VOCs and metals and has been conducted in accordance with the regulator-approved LTM Work Plans (U.S. Navy, 2012h and 2017c) during this FYR period. The results of the annual LUC inspections demonstrate that LUCs have been adequately implemented and maintained; thus, preventing human exposure to groundwater as drinking water. In addition to LTM and LUCs, other components of the selected remedy for OU 2 Area 8 (U.S. Navy, EPA, and Ecology, 1994) include:

- Assess risks to human health and the environment using sediment and tissue monitoring data from the Area 8 beach.
- Implement contingent groundwater controls if OU 2 Area 8 groundwater is demonstrated to present a risk to human health or the environment based on a completed risk assessment.

As part of the selected remedy and recommendations in previous FYRs, human health and ecological risk assessments were completed during this FYR period. The human health risk assessment concluded that despite the presence of several COCs in Area 8 beach sediment and clam tissue samples at concentrations exceeding background and reference area concentrations, the incremental site risk over reference area risk for Suquamish subsistence and recreational receptors met target health goals, so no risk to human health was identified. The ecological risk assessment concluded that acute and chronic exposure to accumulated contaminants in sediment pose a current potential hazard to benthic organisms based on the bioassay results/endpoints, but did not identify risk to higher trophic level biota. Therefore, the risk assessments found that contingent groundwater control actions are not needed to protect human health or higher trophic level biota, but contingent groundwater control actions (to be conducted as part of the selected remedy) are needed to protect the benthic community.

Results of the VI soil gas study performed at OU 2 Area 8 in 2016 indicated the presence of contaminants in an area not previously identified. The highest soil gas concentrations were detected west of the Area 8 plume, adjacent to Building 82. Results of the VI study indicate that the presence of this contamination does not present a risk to human health via the VI pathway. In addition, there is no direct contact pathway, since the entire area is paved, and LUCs are maintained restricting groundwater use for drinking

water. Therefore, the presence of this additional contamination does not affect protectiveness. However, these results will be investigated during the upcoming 2021 supplemental remedial investigation.
**Question B:** For OU 2 Area 8, the exposure assumptions, toxicity data, cleanup levels, and RAOs used at the time of the remedy are still valid for the terrestrial environment. The human health and ecological risk assessments for the marine environment (required by the OU 2 ROD and recommended in previous FYRs) were completed during this FYR period, constituting a revision to the risk assessment assumption in the OU 2 ROD; therefore, the answer to Question B is “no.”

ARARs used to establish cleanup levels in the ROD are evaluated in Section 5.5.1 and summarized in Table 5-3. The changes to the toxicity risk assumptions are discussed in Section 5.5.2.

As stated previously, the human health risk assessment conducted in the Area 8 beach intertidal zone during this FYR period concluded that despite the presence of several COCs in beach sediment and clam tissue samples at concentrations exceeding background and reference area concentrations, the incremental site risk over reference area risk for Suquamish subsistence and recreational receptors met target health goals. Therefore, the project team agreed that no additional investigation or contingent actions, such as groundwater controls, were necessary to protect human health.

The ecological risk assessment identified no risk to higher trophic level biota, but concluded that acute and chronic exposure to accumulated contaminants in sediment pose a current potential hazard to benthic organisms based on the bioassay results/endpoints. The area of exposure with unacceptable risk is well delineated and of limited extent within the Area 8 beach intertidal zone. However, based on the OU 2 ROD, contingent groundwater control actions, to be conducted as part of the selected remedy, are required to protect the benthic community.

Groundwater samples were collected and analyzed for PFAS compounds in 2018 and 2019 to assess these chemicals of concern in all existing monitoring wells at the site. PFAS compounds were detected in groundwater during these monitoring events. The total concentration of PFOA plus PFOS was detected above the LHA of 70 ng/L in two monitoring wells (i.e., MW8-11 at 74 ng/L and MW8-12 at 77 M ng/L) in 2018. PFBS was detected in five of seven samples at concentrations (0.77 to 4.7 ng/L) well below the EPA RSL of 400,000 ng/L. PFAS concentrations were below the LHA in all monitoring wells in 2019. Using the EPA RSL Calculator and maximum detected concentration (of 77 M ng/L), the estimated screening level non-cancer hazard quotient (HQ) is 0.2, less than EPA’s acceptable target HQ of 1 for non-carcinogens, indicating no non-cancer effects associated with daily consumption of groundwater. Additionally, there have been no new pathways identified for exposure to occur as long as LUCs restricting groundwater use for drinking water are maintained.

**Question C:** For OU 2 Area 8, no other information has come to light (i.e., other than information discussed in previous sections of this FYR report related to preliminary data) that could call into question the protectiveness of the remedy; therefore, the answer to Question C is “no.”

The U.S. Navy recognizes PFAS as chemicals of emerging concern and is in the process of completing a PA (and will begin a SI) at NBK Keyport. The results of the PFAS PA/SI will be addressed in the next FYR for NBK Keyport. PFAS were added to the analyte list for OU 2 Area 8 in 2018 to determine the presence or absence of these contaminants in groundwater at the site. PFAS concentrations in 2018 and 2019 indicate no non-cancer effects associated with daily consumption of groundwater; therefore, the detection of PFAS does not currently impact protectiveness.

Climate change effects may significantly impact the magnitude and duration of saltwater intrusion at OU 2 Area 8, thus causing changes to groundwater geochemistry and the attenuation capacity of the aquifer. Based on the HHRA, groundwater COCs have not impacted sediments and surface water quality offshore to cause unacceptable human health risks, indicating that groundwater geochemistry and attenuation capacity have not yet been adversely impacted by saltwater intrusion. Therefore, climate change issues do not currently affect protectiveness.

## 5.4 Continued Validity of ROD Assumptions (Question B)

This section reviews the validity of the ROD cleanup levels by assessing: 1) any changes to standards identified as ARARs; 2) any changes in underlying assumptions used to calculate risk-based concentrations identified as cleanup levels in the RODs; and 3) newly promulgated standards for COCs since the RODs were signed to evaluate the protectiveness of the remedy.

### *5.4.1 Changes in Standards and TBCs*

For this FYR, all sources of ARARs identified in the RODs (U.S. Navy, EPA, and Ecology, 1998 and 1994) were reviewed for changes that could affect the assessment of remedy protectiveness. Based on this review, it was concluded that the following regulations listed as ARARs have changed:

- EPA's National Recommended Water Quality Criteria (304[a]) – aquatic life and human health criteria.
- EPA's 2016 "Revision of Certain Federal Water Quality Criteria Applicable to Washington" (40 Code of Federal Regulations [CFR] 131.45; formerly the Washington criteria were in 40 CFR 131.36, referred to as the National Toxics Rule [NTR]).
- Water Quality Standards for Surface Waters of the State of Washington (as provided in 173-201A WAC, Table 240 Toxics Substances Criteria, last updated 1/23/2019) – aquatic life and human health criteria.
- Washington State Sediment Management Standards (Chapter 173-204 WAC)
- Washington State MTCA Cleanup Regulations (Chapter 173-340 WAC), in particular, the use of background levels or the laboratory PQL as a cleanup level when the MTCA cleanup level is lower than these values. As such, this FYR includes an assessment of current PQLs used for LTM and a comparison of the current ARARs with the RGs based on background levels or the PQLs.
- Although the Washington State MTCA regulations have not changed since 2013, the risk-based criteria in the associated Cleanup Levels and Risk Calculation (CLARC) tables were updated in May 2019 to align with EPA's RSL toxicity. The CLARC tables were consulted for this FYR to compare ROD MTCA Method B RGs to current MTCA Method B values, where applicable.

**OU 1**

OU 1 RGs were established for groundwater, surface water, sediment, and clam tissue. The basis for the RGs was the protection of human health, if groundwater was used for drinking, if surface water contained a food source, or if clams were harvested by a subsistence population (U.S. Navy, EPA, and Ecology, 1998). No specific numeric RG was established for sediment. Instead, the ROD indicated that bioassays would be conducted if sediment concentrations exceeded SQS. No numeric RG was established for the landfill soil. Instead, the ROD indicated that LUCs would be maintained to prevent contact with landfill soil and vapor. The following subsections discuss the RGs for groundwater, surface water, sediment, and clam tissue established in the ROD compared to current ARARs (as of February 2020) and those ARARs with lower values that may impact the protectiveness of the remedy.

**Groundwater.** Table 5-2 compares modified standards (as of February 2020) with the RGs presented in the OU 1 ROD (U.S. Navy, EPA, and Ecology, 1998; Table 11-4). The RGs were based on the use of groundwater as drinking water. There have been no changes to the groundwater ARARs during this FYR period. As discussed in the fourth FYR (U.S. Navy, 2015b), although lower drinking water ARARs were noted for 1,1-DCA, 1,2-DCA, cis-1,2-DCE, TCE, and vinyl chloride, the RGs remain protective because the calculated risks associated with the RGs are either within EPA's acceptable excess cancer risk range of $10^{-4}$ to $10^{-6}$ (or MTCA's acceptable excess cancer risk range of $10^{-5}$ to $10^{-6}$), or if the calculated risk is above that risk range, LUCs are in place, and the remedy remains protective for the groundwater COCs. As noted in the fourth FYR (U.S. Navy, 2015b), 1,1-DCE is no longer considered a carcinogen. The current MCL is approximately an order of magnitude greater than the RG and the MTCA Method B value is approximately three orders of magnitude greater than the RG (i.e., 0.5 µg/L).

The RG for vinyl chloride was based on the PQL of 0.5 µg/L, which was achievable in 1998. As noted in the fourth FYR (U.S. Navy, 2015b), most laboratories can now achieve PQLs of 0.02 µg/L for vinyl chloride and a recommendation was made in the fourth FYR to adopt the lower PQLs. However, based on the LTM reports, the achievable lower PQL was not used during this FYR period. The PQL used over the last 5 years for vinyl chloride is equal to the ROD RG of 0.5 µg/L which is associated with a risk of $2 \times 10^{-5}$ (i.e., exceeding the ROD target risk goals, but within EPA's target range). LUCs are in place to prevent groundwater use as drinking water; therefore, the remedy remains protective with ROD RGs for the groundwater COCs.

The second FYR recommended the addition of 1,4-dioxane to the groundwater analyte list because of its potential to be present in chlorinated solvent plumes. There is no RG established in the ROD for 1,4-dioxane. The 2012 CRA Plan (U.S. Navy, 2012i) reported the MTCA Method B value of 0.44 µg/L as a screening level and provided a trigger action matrix for detections of 1,4-dioxane. The current MTCA Method B value, as shown in Table 5-2, remains unchanged.

**Surface Water.** Table 5-2 also compares modified standards for surface water (as of February 2020) with those in the OU 1 ROD (U.S. Navy, EPA, and Ecology, 1998; Table 11-5). Based on the current MTCA Method B values, the RG for TCE would decrease from 56 to 13 µg/L. MTCA Method B values for the other COCs have either remained the same or increased.

Since the fourth FYR (U.S. Navy, 2015b), Washington State published water quality criteria protective of human health in WAC 173-201A. EPA approved of some of these Washington criteria and promulgated them in the Federal water quality criteria applicable to Washington State in 40 CFR 131.45. The Washington State criteria for the COCs listed in Table 5-2 were not approved by EPA and therefore, the modified standard would be the Federal water quality criteria listed under 40 CFR 131.45 in Table 5-2. EPA is currently in the process of proposing to amend the federal regulations to withdraw certain human health criteria applicable to waters in Washington State. If these Federal water quality criteria are withdrawn, then the State criteria take precedence. The outcome of this pending action will be reviewed during the next FYR period.

**Table 5-2. Groundwater and Surface Water ARARs for OU 1**

| | Drinking Water (µg/L) | | | | | | Surface Water Protection (Marine) (µg/L) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Current Values | | | | | Current Values[e] | | | | | |
| Chemical | ROD RG[a] | Basis of ROD RG | MTCA Method B[b] | Federal and State MCL | PQL | Change in RG if Established Today? | ROD RG Based on MTCA Method B Surface Water[a] | MTCA Method B[b] | National WQC CWA §304 | State WQC 173-201A WAC[c] | Federal WQC 40 CFR 131.45[d] | PQL | Change in RG if Established Today? |
| 1,1-DCA | 800 | MTCA B | 7.7 | None | NA | Yes, lower (MTCA) | NA | NA | NA | NA | NA | NA | NA |
| 1,2-DCA | 5 | MCL | 0.48 | 5 | NA | No (MCL); Yes, lower (MTCA) | 59 | 59 | 650 | 120 | 73 | NA | No (MTCA) |
| 1,1-DCE | 0.5 | PQL | 400 | 7 | 0.02 | Yes, higher (MCL) | 1.9 | 23,000 | 20,000 | 4,100 | 4,000 | NA | Yes, higher |
| cis-1,2-DCE[f] | 70 | MCL | 16 | 70 | NA | No (MCL); Yes, lower (MTCA) | NA | NA | NA | NA | NA | NA | NA |
| trans-1,2-DCE | 100 | MCL | 160 | 100 | NA | No (MCL) | 33,000 | 33,000 | 4,000 | 5,800 | 1,000 | NA | Yes, lower (federal WQC) |
| PCE[g] | 5 | MCL | 5 | 5 | NA | No (MCL) | 4.2 | 100 | 29 | 7.1 | 2.9 | NA | Yes, lower (federal WQC) |
| 1,1,1-TCA | 200 | MCL | 16,000 | 200 | NA | No (MCL) | 41,700 | 930,000 | 200,000 | 160,000 | 50,000 | NA | Yes, higher |
| TCE[h] | 5 | MCL | 4 | 5 | NA | No (MCL); Yes, lower (MTCA) | 56 | 13 | 7 | 0.86 | 0.70 | NA | Yes, lower (federal WQC) |
| Vinyl chloride | 0.5 | PQL | 0.029 | 2 | 0.02 | Yes, lower (MTCA/PQL) | 2.9 | 3.7 | 1.6 | 0.26 | 0.18 | NA | Yes, lower (federal WQC) |
| PCBs | 0.04 | PQL | 0.044 | 0.5 | 0.01-0.005 | Yes (MTCA/PQL) | PQL: 0.04 | 0.0001 | 0.000064 | 0.00017 | 0.000007 | 0.01-0.005 | Yes (PQL) |
| 1,4-Dioxane[i] | None | NA | 0.44 | None | NA | NA | NA | NA | NA | NA | NA | NA | NA |

a. Source: ROD Table 11-4 for groundwater and Table 11-5 for surface water (U.S. Navy, EPA, and Ecology, 1998).
b. MTCA Method A levels as reported in the Cleanup Levels and Risk Calculation (CLARC) Master Table dated June 26, 2019. CLARC cleanup levels for hazardous waste sites comply with the Model Toxics Control Act (MTCA) Cleanup Regulation, chapter 173-340 WAC as provided in Ecology, 2013.
c. 173-201A WAC, Table 240. Permanent ruling in August 2016 and last updated January 2019. Based on a much higher consumption rate of 175 g/day compared to a MTCA Method B consumption rate of 54 g/day: https://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-240.
d. Because EPA approved the corresponding water quality criteria adopted by Washington that meet the requirements of the CWA and EPA's implementing regulations at 40 CFR part 131, the EPA is now proposing a rulemaking to withdraw these corresponding federal criteria applicable to Washington. The withdrawal, once finalized, will enable Washington to implement its EPA-approved human health criteria, submitted on August 1, 2016, and approved on May 10, 2019, as applicable criteria for CWA purposes.
e. Derived for human health for the consumption of organism only.
f. In accordance with WAC 173-340-720(3)(a) and 173-340-720(7)(b), the MCL for cis-1,2-DCE is not sufficiently protective when compared to the current MTCA B drinking water values. Therefore, the MCL would no longer be acceptable if cleanup levels were to be established today, i.e., the non-cancer hazard level of the MCL would exceed hazard index of 1.
g. Because the MCL does not exceed a hazard quotient of 1 or a cancer risk of 1 x $10^{-5}$, the MCL can be selected as the Method B ground water cleanup level [WAC 173-340-720 (7) (b)]. Thus, the MTCA groundwater cleanup levels are based on the MCL for PCE of 5 µg/L.
h. Normally, under MTCA, Ecology would use the MCL of 5 µg/L for TCE as the Method B cleanup level. However, in this case, the new toxicity information indicates the MCL exceeds a hazard quotient of 1. Therefore, under WAC 173-340-720 (7)(b), the MCL must be adjusted downward to 4 ug/L, so that the Method B cleanup level will not exceed a hazard quotient of 1. Thus, 4 ug/L is selected as the Method B groundwater cleanup level instead of the standard risk-based MTCA Method B value of 0.54 µg/L (Ecology, 2019b).
i. The chemical was identified as a potential chemical of concern in the second FYR; therefore, no ROD RG was established.

Notes:
WQC – water quality criteria
DCA – dichloroethane
DCE – dichloroethene
MCL – maximum contaminant level
µg/L – microgram per liter
MTCA – Model Toxics Control Act
PCBs – polychlorinated biphenyls
PCE – tetrachloroethene
PQL –- practical quantitation limit
RG – remedial goal
ROD – Record of Decision
TCA – trichloroethane
TCE – trichloroethene

The RGs for trans-1,2-DCE, PCE, TCE, and vinyl chloride are based on MTCA Method B values for consumption of organisms from surface water. The other surface water ARARs shown in Table 5-2, also are based on consumption of organisms from water. Values differ across regulatory programs based on the values of the exposure input parameters, in particular, the consumption rate. Differences in consumption rates are discussed in Section 5.4.2.2.

As shown in Table 5-2, trans-1,2-DCE, PCE, TCE, and vinyl chloride would have lower or more stringent surface water ARARs if selected today. Based on the most recent surface water sampling results from 2017 (U.S. Navy, 2018b):

- The maximum concentration of trans-1,2-DCE detected (at 47.2 JD μg/L) is significantly less than the RG of 33,000 μg/L and federal water quality criteria of 1,000 μg/L; therefore, the lower ARAR does not impact the protectiveness of the remedy with regard to trans-1,2-DCE.
- PCE concentrations were not detected above the LOD; thus, the lower ARAR does not impact the protectiveness of the remedy with regard to PCE.
- Concentrations of TCE detected in five of the 12 surface water samples exceeded the RG of 56 μg/L, and concentrations of TCE in all surface water samples were greater than the federal water quality criterion of 0.70 μg/L.
- Concentrations of vinyl chloride detected in nine of the 12 surface water samples exceeded the RG of 2.9 μg/L, and concentrations of vinyl chloride in all surface water samples were greater than the federal water quality criterion of 0.18 μg/L.

For PCBs, the surface water RG is based on the PQL (i.e., 0.04 μg/L), not a MTCA or water quality criterion, which are both orders of magnitude lower. The maximum detected value remains above the RG (see Appendices C and D). Therefore, using a method to achieve a lower PQL is premature at this time. However, once concentrations reduce below the PQL, a revised method should be evaluated for future sampling to meet a human health risk-based value.

The remedy remains protective in the short term for human receptors while the source area investigations of the elevated VOCs, 1,4-dioxane, and PCBs concentrations continue, because the tide flats are currently closed by WDOH to harvesting and consuming shellfish by recreational and subsistence fishers. Note that the Suquamish Tribe has treaty reserved rights to harvest and maintain the authority to determine harvest practices for tribal members. For ecological receptors, exposures to PCBs in surface water are limited to the immediate vicinity of station MA-09, and as discussed below for sediment, the remedy is protective in the short term while source area investigations continue. For ecological exposures to VOCs in surface water, adverse impacts to organisms are expected to be minimal because VOCs are more likely to volatilize to the atmosphere, and because VOCs are not bioaccumulative (WAC 173-333-310), so adverse impacts through the food chain will not occur. Therefore, the remedy is protective in the short term while source area investigations continue. An update of the human health and ecological risk assessments is being conducted and will incorporate the results of the source area investigations. If ongoing investigations or the planned update of the HHRA and ERA identify a current or future unacceptable human health or ecological risk, then the existing CSM will be updated and alternative remedial actions to address contamination will be evaluated.

**Sediment.** The OU 1 ROD established RGs for the nine VOCs identified as COCs and for PCBs (U.S. Navy, EPA, and Ecology, 1998; Table 11-6). The RGs were based on the Washington State 1995 SMS, which include SQS criteria for the protection of the benthic community and performance of bioassays if the chemical result failed the SQS criterion. The OU 1 ROD also identified pesticides, SVOCs, and metals as sediment contaminants of interest (COIs) to be included in the LTM program to monitor ecological risks posed by potential migration of landfill contaminants. Although RGs were not established in the OU 1 ROD for COIs, COI data have been historically compared to current SMS criteria.

As addressed in the fourth FYR (U.S. Navy, 2015b), the Sediment Management Standard (SMS) was revised in September 2013, including an updated cleanup decision framework to address bioaccumulative chemicals (e.g., PCBs) that pose risks to human health and higher trophic level species. The risks to humans and higher trophic levels occur primarily through consumption of fish/shellfish. Under the revised SMS, the SQS criterion protective of the benthic community for PCBs remains 12 mg/kg. For the protection of human health and higher trophic level species, the revised SMS offers options of back calculating risk-based sediment criteria from tissue concentrations. Alternatively, for sites where it is expected that risk-based sediment concentrations would be below background, which is the case for most bioaccumulative carcinogenic chemicals, cleanup levels can be established at background (natural or regional, respectively) or the PQL, whichever value is higher.

To assess whether exposure to PCBs in sediment samples may be associated with adverse health effects, the Sediment Cleanup User’s Manual II (SCUM II) guidance (Ecology, 2019a), which is the guidance document for implementing the cleanup provisions of the SMS (Chapter 173-204 WAC), provides different approaches, depending on available data. For instance, under Option 1, it is assumed that risk-based sediment concentrations based on the consumption of fish/shellfish exposure pathway by humans are below background concentrations and because it is not feasible to clean up below background concentrations, Option 1, Part 1, represents a simpler, more practical, and protective approach (Ecology, 2019a). Although there is not an established regional background data set for Liberty Bay, the measured PCB concentrations can be compared to the BOLD data set as Ecology has determined it to be appropriate to establish natural background for marine sediment (Ecology, 2019a).

To support review of ROD risk assumptions in light of the 2013 promulgation of Ecology's revised SMS and recommendations provided in the fourth FYR (U.S. Navy, 2015b), sediment samples were collected in the vicinity of seep SP1-1 during the Phase II investigation. The data are used to assess whether expanded, ongoing PCB monitoring should be initiated, and risk assumptions reviewed. For human health risk, the 2017 sediment data were compared to natural background for marine sediment and indicated the potential for adverse risk at all sediment sampling locations (i.e., sediment concentrations exceeded background). Source investigation data will be used in the ongoing HHRA/ERA to conduct a more detailed risk evaluation for exposure to sediment at these locations. In the interim, the tide flats are not currently open by WDOH for harvesting and consuming shellfish by recreational and subsistence fishers; therefore, the remedy remains protective in the short term. Note that the Suquamish Tribe has treaty reserved rights to harvest and maintain the authority to determine harvest practices for tribal members.

For ecological risk based on the PCB sediment results, the 2017 and 2019 data indicated a limited area of sediments where minor adverse effects to the benthic community could occur in the vicinity of station MA-09, but no adverse effects are predicted for the rest of the area. To assess bioaccumulative exposures, sediment concentrations observed in Marsh Creek sediment were averaged on an area-weighted basis for comparison to the natural background value following the evaluation options provided in the SCUM II. The area-weighted dioxin-like PCB congener toxicity equivalence (TEQ) exceeded the natural background upper tolerance limit of 0.2 ng/kg for marine sediment in Washington State (Ecology, 2019a). These findings are consistent with those of the ROD, which identified station MA-09 as exhibiting the highest PCB concentrations, and the only concentrations exceeding the SQS at the time. The 2017 PCB concentrations at station MA-09 are nearly equal to the pre-ROD concentrations at this station, prior to the sediment removal action. The measured concentrations could be residual pre-ROD concentrations, given the selective nature of the sediment removal to protect root systems. Because the highest current PCB concentrations are not higher than those found at the time of the ROD and are limited to the immediate vicinity of station MA-09, the remedy remains protective in the short term. Source investigation data will be used to conduct a more detailed ERA.

**Clam Tissue.** Clam tissue RGs were established for the nine VOCs identified as COCs and for PCBs. Because VOCs were never detected in clam tissue, VOCs were removed from the analyte list and their RGs are no longer included for review. The RG for PCBs of 0.015 mg/kg was a site-specific risk-based level protective of subsistence consumption of clams. PCBs were not detected in clam tissue above the RG of 0.015 mg/kg in the 2004 and 2009 monitoring events; therefore, tissue analysis was discontinued after 2009 based on regulator-approved recommendations in the third FYR.

During this FYR period, clam samples were collected from a single monitoring station (i.e., TF21) within the tide flats as reported in the 2017 LTM Report (U.S. Navy, 2018d). No PCB Aroclors were detected in TF21 marine (clam) tissue above the respective PQLs for each Aroclor. The PQLs ranged from 10 μg/kg to 15 μg/kg, all below or equal to the RG of 0.015 mg/kg (i.e., for the seafood ingestion pathway).

The PCB RG for clam tissue was established as a risk-based level protective of subsistence harvesters using a consumption rate of 92 grams per day (g/day). This consumption rate is much lower than what is expected today for the Suquamish Tribe consumption rate. In consultation with the Suquamish Tribe and stakeholders, it was decided that a shellfish consumption rate of 498.4 g/day better represents tribal members consumption of shellfish. If this higher consumption rate better reflects the Suquamish population potentially at risk, a revised site-specific RG if calculated today using the original exposure assumptions included in Appendix B, Table B-1 of the OU 1 ROD (along with the higher Suquamish-specific consumption rate) would be much lower at 0.0028 mg/kg. This revised RG cannot be compared to the historical clam data, as the PQLs are higher. Source investigation data and Suquamish-specific shellfish consumption rate will be used in the ongoing HHRA to evaluate the risk to subsistence fishers from consumption of shellfish. In the interim, the tide flats are currently not open by WDOH for harvesting or consuming shellfish; therefore, the remedy remains protective in the short term. Note that the Suquamish Tribe has treaty reserved rights to harvest and maintain the authority to determine harvest practices for tribal members.

Additional information regarding exposure assumptions (shellfish consumption rate) are reviewed in Section 5.4.2.2.

**OU 2 Area 2**

ARARs used to establish cleanup levels in the OU 2 ROD (U.S. Navy, EPA, and Ecology, 1994) and comparison to current ARARs are provided in Table 5-3. OU 2 Area 2 COCs are TCE and vinyl chloride in groundwater only, and RGs are based on human consumption of groundwater for potable water purposes. There have been no changes to the groundwater ARARs during this FYR period. As shown in Table 5-3, the RG for TCE was established as the MCL (i.e., 5 μg/L), and there has been no change. For vinyl chloride, the RG was established as the MTCA Method B cleanup level of 0.023 μg/L, which at the time, was below the PQL of standard EPA methods for drinking water. In such a case, the MTCA B cleanup level was based on the PQL (per WAC 173-340-700[6]) and the expected PQL was 0.1 μg/L. In 2012, the RG for vinyl chloride was updated to 0.029 μg/L based on the calculated MTCA B cleanup level using the current oral slope factor. Using improved analytical techniques (e.g., EPA Method 8260C-SIM), the PQL has been below this updated RG of 0.029 μg/L since June 2012. From 1995 through 2019, vinyl chloride concentrations in monitoring well 2MW-6 have consistently been above the RG of 0.029 μg/L. Although the RG continues to be exceeded for vinyl chloride in groundwater, LUCs are implemented and maintained, restricting groundwater use for potable water purposes. Therefore, the remedy remains protective in the short term.

**OU 2 Area 8**

The OU 2 ROD (U.S. Navy, EPA, and Ecology, 1994) identified three COCs in OU 2 Area 8 soil based on residential land use: arsenic, cadmium (if ingested in homegrown produce), and chromium. However, arsenic concentrations were considered at or below background for soil and groundwater. In OU 2 Area 8 groundwater, the risk assessment identified cadmium, chromium, and TCE as COCs with HQs greater than 1 and five additional COCs (i.e., carbon tetrachloride, chloroform, 1,2-DCA, 1,1-DCE, and 1,1,2-TCA) with cancer risks exceeding $1 \times 10^{-5}$, if shallow groundwater was used for drinking water. The current analyte list for ongoing LTM includes selected metals and VOCs related to TCE and its breakdown products. A comparison of the ROD RGs with current ARARs and changes to values that may impact the protectiveness of the remedy are discussed by media in the sections below.

**Soil.** Cadmium and chromium (total chromium concentrations were assumed to be 100 percent hexavalent chromium per the OU 2 Area 8 Explanation of Significant Differences ESD) RGs of 80 and 400 mg/kg, respectively, were based on MTCA Method B (U.S. Navy, EPA, and Ecology, 1994). The current MTCA Method B soil values are 80 mg/kg for cadmium (i.e., remains the same) and 240 mg/kg for hexavalent chromium (i.e., lower). As demonstrated in the fourth FYR (U.S. Navy, 2015b), the lower hexavalent chromium value called into question the protectiveness of the remedy. However, LUCs are in place that restrict residential land use; therefore, the remedy remains protective in the short term. Action would be required in the future if the land is converted to residential land use, and a process is in place through LUC management to trigger such action.

**Groundwater.** Table 5-3 compares current groundwater ARARs with those presented in the OU 2 ROD (U.S. Navy, EPA, and Ecology, 1994; Table 10-12). The modified standards have not changed during this FYR period. As discussed in the fourth FYR (U.S. Navy, 2015b), lower drinking water ARARs were noted for hexavalent chromium, cis-1,2-DCE, and TCE. Although no cleanup level was established in the ROD for 1,4-dioxane, it was added to the LTM program in 2011. At the time of initial sampling in 2007, the MTCA Method B value was 4 µg/L – it is currently 0.44 µg/L. During this FYR period, concentrations of TCE, PCE, and 1,4-dioxane were detected above the RG and MTCA Method B cleanup levels (U.S. Navy, 2019b). However, LUCs are in place that prevent groundwater use as drinking water; therefore, the remedy remains protective in the short term.

**Surface Water.** Because OU 2 Area 8 groundwater discharges into Port Orchard Bay, there is a potential for chemical migration from groundwater to the marine environment. Therefore, Table 5-3 also compares modified standards for surface water (as of February 2020) with those selected in the OU 2 ROD (U.S. Navy, EPA, and Ecology, 1994; Table 10-12). The RGs for trivalent chromium and 1,1,1-TCA are based on MTCA Method B values for consumption of organisms from surface water. Current MTCA B values are greater than the RGs. The RGs for cadmium and hexavalent chromium are based on the National water quality criterion (WQC) for aquatic life and these values have not changed since the ROD. For the remaining COCs (i.e., 1,1-DCE, PCE, and TCE), the surface water RGs were based on the National WQC for protection of human health. The National WQC for human health for TCE was the only criterion to decrease since the ROD. The other two values have increased since the ROD RGs were selected.

**Table 5-3. Groundwater ARARs for OU 2**

| | Drinking Water (µg/L) | | | | | | Surface Water (Marine) (µg/L) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Current Values | | | | | | Current Values | | | | |
| **Chemical** | **ROD Drinking Water Cleanup Level** | **Basis of Cleanup Level** | **MTCA B[a]** | **Federal MCL** | **State MCL** | **Change in Cleanup Level if Established Today?** | **ROD Surface Water Cleanup Level** | **Basis of Cleanup Level** | **MTCA B[a]** | **National WQC CWA §304** | **State WQC 173-201A WAC** | **Federal WQC 40 CFR 131.45[e]** | **Change in Cleanup Level if Established Today?** |
| ***Area 2*** | | | | | | | | | | | | | |
| TCE[b] | 5 | MCL | 4 | 5 | 5 | No (MCL); Yes, lower (MTCA) | NA | NA | NA | NA | NA | NA | NA |
| Vinyl chloride | 1 | PQL | 0.029 | 2 | 2 | Yes, lower (MTCA) | NA | NA | NA | NA | NA | NA | NA |
| ***Area 8*** | | | | | | | | | | | | | |
| Cadmium | 5 | Federal MCL | 8 | 5 | 5 | No | 8 | National WQC (Aquatic Life) | 41 | 7.9 (Aquatic Life) | 9.3 (Aquatic Life) | None | Yes, higher |
| Trivalent chromium | 16,000 | MTCA B | 24,000 | None | None | Yes, higher | 160,000 | MTCA B | 240,000 | None | None | None | Yes, higher |
| Hexavalent chromium | 80 | MTCA B | 48 | None | None | Yes, lower | 50 | National WQC (Aquatic Life) | 490 | 50 (Aquatic Life) | 50 (Aquatic Life) | None | No |
| Chromium (total) | 50 | State MCL | None | 100 | 100 | Yes, higher | NA | NA | NA | NA | NA | NA | NA |
| 1,1-DCE | 7 | MCL | 400 | 7 | 7 | No | 3.2 | National WQC (HH) | 23,000 | 20,000 (HH) | 4100 (HH) | 4,000 (HH) | Yes, higher |
| cis-1,2-DCE[c] | 70 | MCL | 16 | 70 | 70 | No (MCL); Yes, lower (MTCA) | NA | NA | NA | NA | NA | NA | NA |
| PCE[d] | 5 | MCL | 21 | 5 | 5 | No | 8.9 | National WQC (HH) | 100 | 29 (HH) | 7.1 (HH) | 2.9 (HH) | Yes, lower |
| 1,1,1-TCA | 200 | MCL | 16,000 | 200 | 200 | No | 42,000 | MTCA B | 930,000 | 200,000 (HH) | 160,000 (HH) | 50,000 (HH) | Yes, higher |
| TCE[b] | 5 | MCL | 4 | 5 | 5 | No (MCL); Yes, lower (MTCA) | 81 | National WQC (HH) | 13 (HH) | 7 (HH) | 0.86 (HH) | 0.70 (HH) | Yes, lower |

a. MTCA Method A levels as reported in the Cleanup Levels and Risk Calculation (CLARC) Master Table dated June 26, 2019. CLARC cleanup levels for hazardous waste sites comply with the Model Toxics Control Act (MTCA) Cleanup Regulation, chapter 173-340 WAC as provided in Ecology, 2013.
b. Normally, under MTCA, Ecology would use the MCL of 5 µg/L for TCE as the Method B cleanup level. However, in this case, the new toxicity information indicates the MCL exceeds a hazard quotient of 1. Therefore, under WAC 173-340-720 (7)(b), the MCL must be adjusted downward to 4 ug/L, so that the Method B cleanup level will not exceed a hazard quotient of 1. Thus, 4 ug/L is selected as the Method B groundwater cleanup level instead of the standard risk-based MTCA Method B value of 0.54 µg/L (Ecology, 2019b).
c. In accordance with WAC 173-340-720(3)(a) and 173-340-720(7)(b), the MCL for cis-1,2-DCE is not sufficiently protective when compared to the current MTCA B drinking water values. Therefore, the MCL would no longer be acceptable if cleanup levels were to be established today, i.e., the non-cancer hazard level of the MCL would exceed hazard index of 1.
d. Because the MCL does not exceed a hazard quotient of 1 or a cancer risk of $1 \times 10^{-5}$, the MCL can be selected as the Method B ground water cleanup level [WAC 173-340-720 (7) (b)]. Thus, the MTCA groundwater cleanup levels are based on the MCL for PCE of 5 µg/L.
e. Because EPA approved the corresponding water quality criteria adopted by Washington that meet the requirements of the CWA and EPA's implementing regulations at 40 CFR part 131, the EPA is now proposing a rulemaking to withdraw these corresponding federal criteria applicable to Washington. The withdrawal, once finalized, will enable Washington to implement its EPA-approved human health criteria, submitted on August 1, 2016, and approved on May 10, 2019, as applicable criteria for CWA purposes.

Notes:
WQC – water quality criteria
DCE – dichloroethene
HH – the WQC based on human ingestion of fish in the water body
MCL – maximum contaminant level
µg/L – microgram per liter
MC – marine chronic
MTCA – Model Toxics Control Act
PCE – tetrachloroethene
ROD – Record of Decision
TCA – trichloroethane
TCE – trichloroethene
NA – not applicable
WQC – water quality criteria

Since the fourth FYR, Washington State published WQC protective of human health in WAC 173-201A. EPA approved of some of these Washington State criteria and promulgated them in the Federal WQC applicable to Washington State in 40 CFR 131.45. The Washington State criteria for the COCs listed in Table 5-3 were not approved by EPA and therefore, the modified standard would be the Federal WQC listed under 40 CFR 131.45 in Table 5-3. EPA is currently in the process of proposing to amend the federal regulations to withdraw certain human health criteria applicable to waters in Washington State and, if these Federal WQC are withdrawn then the State criteria take precedence. The outcome of this pending action should be reviewed during the next FYR.

In summary, if selected today, the RGs would be higher for 1,1-DCE (4,000 µg/L) and 1,1,1-TCA (50,000 µg/L), and would be lower for PCE (2.9 µg/L) and TCE (0.70 µg/L). Surface water ARARs based on consumption of organisms from water differ across regulatory programs based on the values of the exposure input parameters, in particular, the consumption rate. Differences in consumption rates are discussed below in Section 5.5.2.2. Concentrations of PCE and TCE observed in groundwater monitoring wells and seep water samples collected during this FYR period are below their RGs (U.S. Navy, 2019b). However, concentrations of TCE in groundwater and seep water samples were above the current Federal WQC in samples collected during this FYR period. Clam tissue samples were collected in 2015 and 2016 but were not analyzed for the VOC COCs because these VOCs are not listed as bioaccumulative contaminants in WAC 173-333-310 or have log octanol-water partitioning coefficients greater than 3.5 (log $K_{ow} > 3.5$). Although TCE exceeds the current Federal WQC, this does not necessarily indicate there is a potential risk associated with consumption of clams. Nevertheless, current WDOH restrictions prohibit the harvesting of shellfish from Port Orchard Bay; therefore, the remedy remains protective. Note that the Suquamish Tribe has treaty reserved rights to harvest and maintain the authority to determine harvest practices for tribal members.

**Sediment.** As discussed previously, the SMS was revised in September 2013, with an expanded emphasis on assessing human health risks. No numerical sediment RGs were established in the ROD. The results of the LTM sediment and tissue sampling have been used to assess human health and ecological risks from exposure to marine sediment and tissue. Based on LTM sediment concentrations exceeding risk-based screening levels and recommendations in the third and fourth FYRs, an HHRA/ERA was conducted in 2018 utilizing sediment and clam tissue data obtained in 2015 and 2016. The HHRA/ERA (U.S. Navy, 2018a) was developed in collaboration with the EPA, Ecology and Suquamish Tribe project managers and performed in accordance with an approved HHRA/ERA Work Plan (U.S. Navy, 2016c). The HHRA concluded that despite the presence of several COCs in Area 8 beach sediment and clam tissue samples at concentrations exceeding background and reference area concentrations, the incremental site risk over reference area risk for Suquamish subsistence and recreational receptors met target health goals. As such, the project team agreed that no additional investigation or contingent actions, such as groundwater controls, were necessary to protect human health.

Likewise, the ERA found no significant hazards to free-swimming aquatic life, semi-aquatic birds, or mammals; therefore, contingent actions, such as groundwater controls, are not necessary to protect these higher trophic receptor groups. Existing lines of evidence suggested that the hazards to benthic organisms were likely low, despite localized elevated concentrations of selected metals (i.e., cadmium, mercury, and silver) in seeps and sediment. Ecology's SMS regulation and the ROD allow the use of bioassay analysis in cases where chemical concentrations in sediment samples exceed the published numeric standards, To ensure OU 2 Area 8 COCs do not pose a hazard to benthic organisms on the Area 8 beach, additional seep and sediment bioassay data were collected in 2019. As reported in the ERA Addendum (U.S. Navy, 2019d), the additional bioassay data collected at Seep C using mussels as an indicator species demonstrate that seep water COCs do not pose a hazard to benthic organisms. However, acute exposure to accumulated contaminants in sediment pose a potential hazard to benthic organisms based on the bioassay results for larval mussels at two locations. In addition, chronic exposure to accumulated contaminants in sediment pose a potential hazard to benthic organisms based on the bioassay endpoints of both reduced survival and growth for juvenile polychaetes at two locations.

Therefore, elevated cadmium concentrations occur in sediment, and because acute and chronic exposure to accumulated contaminants in sediment pose a potential hazard to benthic organisms based on the bioassay results/endpoints, additional or contingent actions (to be conducted as part of the selected remedy) are planned and will be performed to ensure protectiveness.

### *5.4.2 Review of Human Health Risk Assessment Assumptions*

Risk assessment assumptions were also reviewed as part of the requirement to assess protectiveness of the remedy. For human health, there are potentially four areas where changes could have occurred since the signing of the RODs: 1) COC toxicity or contaminant characteristics; 2) risk assessment methodology, including exposure assumptions; 3) changes in exposure pathways; and 4) new contaminants or contaminant sources. The following subsection discuss how these changes affect the protectiveness of the remedy.

#### *5.4.2.1 Changes in Toxicity and Other Contaminant Characteristics*

There have been changes in oral cancer and non-cancer toxicity criteria since the RODs were signed; however, these changes were captured during the completion of the fourth FYR (U.S. Navy, 2015b) and highlighted as reasons for differences between ROD and current MTCA Method B values. There have been no changes to oral cancer and non-cancer toxicity criteria associated with site COCs during this FYR period.

Cancer and non-cancer inhalation toxicity criteria for COCs in OU 2 Area 8 undergoing VI evaluation have not changed based on an evaluation of the MTCA Method C air criteria selected as PALs in the 2017 and 2019 VI SAPs (U.S. Navy, 2017c, 2019e, and 2019f) to current MTCA Method C air criteria provided in the May 2019 CLARC tables (Ecology, 2019b). Note however, that the current CLARC tables are rounded to two significant figures compared to earlier versions of the CLARC tables.

#### *5.4.2.2 Changes in Risk Assessment Methods*

For OU 1, the RG for PCBs in tissue was calculated during ROD preparation as a site-specific, risk-based level protective of subsistence-level ingestion of clams, using a subsistence shellfish consumption rate of 92 g/day. More recently however, a subsistence shellfish consumption rate was determined specifically for the Suquamish Tribe and used in the recently completed risk assessment for OU 2 Area 8. A fish consumption study conducted by the Suquamish Tribe for its members presented seafood consumption rates for all the species that tribal members reported they consume, which included over 45 different species in seven broad seafood groups (Suquamish Tribe, 2000; Table T-3). In consultation with the Suquamish Tribe and stakeholders, it was decided that the 95th percentile consumption rates for adults and children from this study for shellfish Groups E and G would be used in the OU 2 Area 8 HHRA. For adults, EPA modified the 95th percentile shellfish consumption rate from the rate in the Suquamish Tribe's report (615.4 grams per day [g/day]) to include only species harvested from Puget Sound. Therefore, the EPA-modified value, 498.4 g/day (65 percent of total consumed seafood) from the EPA Framework document (EPA, 2007b, Appendix B, Table B-2), was used in the HHRA as the appropriate adult seafood consumption rate for a Puget Sound location. For children, the 95th percentile shellfish ingestion rate of 83.9 g/day was calculated using the all-shellfish tribal consumption rate of 4.994 grams per kilogram day (g/kg-day) and the tribe-specific body weight of 16.8 kilograms (kg) (Suquamish Tribe, 2000; Table C-6) was used.

If the OU 1 RGs for tissue are revised based on the planned upcoming HHRA (which would require a ROD Amendment or ESD), other exposure parameters used in the development of the OU 1 RGs will be updated to be consistent with the following exposure parameters used in the OU 2 Area 8 HHRA shellfish consumption exposure scenario:

| Parameter | OU 1 ROD RG Value | OU 2 Area 8 HHRA Value |
|---|---|---|
| Fraction ingested from contaminated source | 0.25 (unitless) | 1 (unitless) |
| Exposure duration | 70 years | 64 years (adult)<br>6 years (child) |
| Body weight | 70 kilogram (adult) | 79 kilogram (adult)<br>16.8 kilogram (child) |

Updates to the exposure parameters would result in a lower RG for PCBs at OU 1; however, there are currently WDOH restrictions in place that prohibit the harvesting of shellfish; therefore, the remedy remains protective in the short term. Note that the Suquamish Tribe has treaty reserved rights to harvest and maintain the authority to determine harvest practices for tribal members.

Currently, additional data are being collected for the OU 1 source area investigations that will be used in the ongoing HHRA and ERA. As the HHRA/ERA work plan was developed for OU 2 Area 8 in collaboration with the project team, this work plan should be followed for OU 1 to the extent practical, such that evaluations are performed consistently across OUs at NBK Keyport.

#### *5.4.2.3 Changes in Exposure Pathways*

Evaluations of the VI pathway were performed at the former landfill area along Bradley road in the late 1980s and early 1990s as part of the OU 1 RI. The VI pathway was reassessed for the former landfill area as part of the fourth FYR using historical indoor air, soil gas, and groundwater data collected in 1990 and 1991. Based on review of the historical indoor air, soil gas, and groundwater data, the COC concentrations would exceed today’s screening levels. However, because LUCs are in place that prevent occupied building on the former landfill, there are no human receptors. Therefore, the VI pathway above the landfill and along Bradley Road is incomplete.

A VI evaluation had not been previously conducted in the buildings east of Bradley Road, even though historically high soil gas concentrations were found at a location near Building 883. Therefore, an evaluation of the VI pathway east of Bradley road was recommended in the fourth FYR (U.S. Navy, 2015b) because the protectiveness of the remedy with regard to building occupancy in this area could be impacted.

This VI study was conducted in March and July 2018 at buildings east and northeast of Bradley Road (U.S. Navy, 2019a).

The results of the OU 1 VI study indicated that contaminants associated with the former landfill do not present an unacceptable risk to industrial workers via the VI pathway in the buildings east and northeast of Bradley Road, based on current industrial use. Therefore, the remedy remains protective.

#### *5.4.2.4 New Contaminants or Contaminant Sources*

Although PFAS has been detected in groundwater at OU 1 and OU 2 Area 8 during this FYR period, there have been no new human health pathways identified for exposure to occur as long as LUCs restricting groundwater use for drinking water are maintained. The Navy is currently progressing through the CERCLA process for this COC, and data are still being collected to assess:

- The nature and extent of PFAS at NBK Keyport
- Potential/new migration pathways
- Potential effects of PFAS on ecological receptors
- Potential risks to human health via a seafood ingestion pathway
- The cumulative risk of PFAS and other COCs present at the OUs

For OU 1, PFAS compounds were detected in 2017 and 2019 (see Appendix D). However, individual PFAS concentrations and PFOA plus PFOS concentrations were less than the LHA of 70 ng/L in all monitoring wells in 2017 and 2019.

For OU 2 Area 8, groundwater samples were collected and analyzed for PFAS compounds from seven monitoring wells in 2018 and 2019 (see Appendix G). PFOA plus PFOS concentrations were detected above the LHA of 70 ng/L in two monitoring wells (i.e., MW8-11 at 74 ng/L and MW8-12 at 77 M ng/L) in 2018. Individual PFAS and PFOA plus PFOS concentrations were below the LHA in all monitoring wells in 2019. PFBS was detected in five of the seven groundwater samples at concentrations between 0.77 and 4.7 ng/L, which are well below the EPA RSL of 400,000 ng/L.

An estimated screening level non-cancer HQ is provided as part of this FYR for informational purposes to preliminarily assess remedy protectiveness as it relates to the recently discovered presence of PFAS in groundwater. The estimate of the non-cancer HQ was calculated using a risk ratio comparison wherein the maximum PFOA plus PFOS concentration detected of 77 ng/L was divided by the EPA risk-based screening value of 400 ng/L. This risk-based screening value was derived using EPA RSL Calculator (available at https://epa-prgs.ornl.gov/cgibin/chemicals/csl_search) based on a standard residential tap water use scenario for an adult and child. The RSL calculator includes the toxicity value used in the derivation of the 2016 LHA (i.e., the chronic oral reference dose of 0.00002 mg/kg-day). The estimated HQ is 0.2, less than EPA's acceptable target HQ of 1 for noncarcinogens, indicating no non-cancer effects associated with daily consumption of groundwater. PFAS will be evaluated further as part of a U.S. Navy-wide program to assess its installations for areas where PFAS-containing materials, such as aqueous film forming foam (AFFF), are suspected to have been stored, used or released to the environment. As such, the U.S. Navy is in the process of completing a PA (and will begin a SI) at NBK Keyport.

### *5.4.3 Review of Ecological Risk Assessment Assumptions*

The recent ERA conducted for OU 2 Area 8 (U.S. Navy, 2019d) did not utilize the exposure factors from the original baseline risk assessments (as stipulated by the OU 2 ROD) because new information and activities completed at the Area 8 beach affected how the current risk assessment evaluated tissue and sediment results and quantified risk. Information and revised methods of evaluating environmental media contained in the 2013 revised SMS and in the SCUM II manual were incorporated into the recent ERA for OU 2 Area 8 (since these rules are ARARs in the ROD), in addition to updates that have occurred to federal and state ERA guidance, guidelines, and policy since the OU 2 ROD. A risk assessment work plan was developed for OU 2 Area 8 in collaboration with site stakeholders; therefore, any future ERAs conducted at NBK Keyport will utilize this work plan to the extent practical, such that risk assessments are performed consistently across OUs.

## 5.5 Any Other Information That Could Call into Question the Protectiveness of the Remedy (Question C)

### *5.5.1 Chemicals of Emerging Concern*

The U.S. Navy recognizes PFAS compounds as chemicals of emerging concern. These substances may be present in the soil and/or groundwater at U.S. Navy sites as a result of historical firefighting activities using AFFF, in additional to other common industrial uses. AFFF was used for plane crashes, equipment testing, and training, as well as in other operations such as hangars where AFFF was used in the fire suppression system and plating shops were AAAF was used as a vapor suppressant on plating baths. As such, the U.S. Navy is in the process of completing a PA (and will begin a SI) at NBK Keyport, as part of the U.S. Navy-wide program to assess its installations for areas where PFAS is suspected to have been stored, used, or released to the environment. The results of the PFAS PA/SI will be addressed in the next FYR for NBK Keyport. PFAS concentrations detected in OU 1 and OU 2 Area 8 pose no non-cancer effects associated with daily consumption of groundwater; therefore, does not impact protectiveness.

### *5.5.2 Climate Change*

Climate change research indicates that any shoreline remedies (e.g., tide gate, cutoff walls, shoreline armoring) may be vulnerable to climate change impacts, including sea level rise and weather pattern changes, not apparent during remedy selection. These aspects of climate change increase the possibility of flooding/inundation or significant saltwater intrusion of the shoreline areas and can increase the energy of storm events and thus, their erosive force.

There are no shoreline remedies implemented at OU 2 Area 2; however, based on its low elevation and proximity to the shallow lagoon, potential sea level rise attributable to climate change may call into question the protectiveness of the remedies at this site in the future and should be monitored during future FYRs.

At OU 1, the sill/causeway that separates Dogfish Bay from the tidal flats and the presence of the tide gate significantly lessen any effects of climate change that would cause tidal flooding of the marsh and erosion of the landfill. Therefore, climate change issues do not currently affect protectiveness of the remedy at OU 1.

At OU 2 Area 8, climate change effects may significantly impact the magnitude and duration of saltwater intrusion, thus causing changes to groundwater geochemistry and the attenuation capacity of the aquifer. Based on the HHRA, groundwater COCs have not impacted sediments and surface water quality offshore significantly enough to cause unacceptable human health risks, indicating that groundwater geochemistry and attenuation capacity has not yet been adversely impacted by saltwater intrusion. Therefore, climate change issues do not currently affect protectiveness of the remedy at OU 2 Area 8.

# 6.0 ISSUES/RECOMMENDATIONS

This section presents the issues and recommendations identified as a result of this FYR process for NBK Keyport. Table 6-1 summarizes the issues (and subsequent recommendations) that affect current and/or future protectiveness of the remedy. There were no issues (or recommendations) identified for OU 2 Area 2.

**Table 6-1. Issues and Recommendations Identified in the Five-Year Review**

<table>
<tr><th colspan="5">Issues/Recommendations</th></tr>
<tr><td rowspan="3">OUs: 1</td><td colspan="4">Issue Category: Remedy Performance</td></tr>
<tr><td colspan="4">Issue: Investigations pursuant to recommendations from the fourth FYR (U.S. Navy, 2015b) have documented subsurface geology and contaminant distribution that differs significantly from the CSM understanding at the time of the ROD (U.S. Navy, EPA, and Ecology, 1998).</td></tr>
<tr><td colspan="4">Recommendation:<br>1. Complete the on-going investigations to update the CSM.<br>2. Complete the planned updates to the human health and ecological risk assessments using the updated CSM and incorporating the latest guidance and ARARs.<br>3. In collaboration with the project team, review and revise (as appropriate) the points of compliance and RAOs.<br>4. Based on the results of items 1 through 3, evaluate the need for any early remedial actions and/or a focused FS leading to an optimized remedy.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Party Responsible</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>Yes</td><td>U.S. Navy</td><td>Ecology</td><td>December 2023</td></tr>
<tr><td rowspan="3">OUs: 1</td><td colspan="4">Issue Category: Remedy Performance</td></tr>
<tr><td colspan="4">Issue: Investigations pursuant to recommendations from the fourth FYR (U.S. Navy, 2015b) have documented an area of the landfill north of the north phytoremediation plantation with elevated PCB concentrations in soil that may represent a discrete source of the PCBs consistently detected in water from seep SP1-1, and a potential source of recontamination to an area of the wetland previously remediated.</td></tr>
<tr><td colspan="4">Recommendation:<br>1. Conduct an investigation to delineate and characterize the potential PCB source in soil.<br>2. In collaboration with the project team, evaluate the need for a removal action to address the PCB source.</td></tr>
<tr><td>Affect Current Protectiveness</td><td>Affect Future Protectiveness</td><td>Party Responsible</td><td>Oversight Party</td><td>Milestone Date</td></tr>
<tr><td>No</td><td>Yes</td><td>U.S. Navy</td><td>Ecology</td><td>December 2022</td></tr>
</table>

### Table 6-1 (continued). Issues and Recommendations Identified in the FYR

| Issues/Recommendations | | | | |
|---|---|---|---|---|
| **OUs: 2, Area 2** | **Issue Category:** Remedy Performance | | | |
| | **Issue:** The consistent vinyl chloride detections above the RG and recent increased concentration in well 2MW-6 may be an indication that cVOC mass detected in shallow groundwater (i.e., wells 2MW-1, 2MW-3, and MW2-10) during the RI may have since migrated deeper and further downgradient than revealed by the monitoring network. | | | |
| | **Recommendation:** Conduct a limited data gap investigation to refine the CSM and verify the leading edge of the cVOC plume, both laterally and vertically, at OU 2 Area 2. | | | |
| **Affect Current Protectiveness** | **Affect Future Protectiveness** | **Party Responsible** | **Oversight Party** | **Milestone Date** |
| No | Yes | U.S. Navy | Ecology | December 2022 |
| **OUs: 2, Area 8** | **Issue Category:** Remedy Performance | | | |
| | **Issue:** During this FYR period, the HHRA concluded that no contingency/additional actions are necessary to protect human health. However, the ERA concluded that acute and chronic exposure to accumulated contaminants in sediment poses a current potential hazard to benthic organisms based on the bioassay results/endpoints. This area of exposure with unacceptable risk is well delineated and of limited extent within the intertidal zone. | | | |
| | **Recommendation:** Implement a contingent groundwater control action as required by the selected remedy (U.S. Navy, EPA, and Ecology, 1994). To identify a feasible contingent action, perform a supplemental RI and focused FS. Once identified and agreed upon by regulators and stakeholders, perform remedial design, implement the remedial action, and potentially conduct a shoreline repair to address elevated COC concentrations in intertidal sediment and on-going discharge of these COCs in seep water. Prepare a ROD amendment or Explanation of Significant Differences (ESD) to document the contingent action taken. Prepare a ROD amendment or Explanation of Significant Differences (ESD) to document the contingent action taken. | | | |
| **Affect Current Protectiveness** | **Affect Future Protectiveness** | **Party Responsible** | **Oversight Party** | **Milestone Date** |
| Yes | Yes | U.S. Navy | Ecology | December 2024 |

## 6.1 Other Findings/Recommendations

This section presents other findings and recommendations identified through this FYR process that may improve performance of the remedy, reduce costs, improve management of O&M, accelerate site closeout, conserve energy, and/or promote sustainability, but do not affect the current and/or future protectiveness of the remedy. Table 6-2 summarizes these other findings and subsequent recommendations.

**Table 6-2. Other Findings and Recommendations Not Affecting Protectiveness**

| Other Finding/Recommendation | |
|---|---|
| **OUs: Sitewide** | **Finding Category:** Monitoring |
| | **Finding:** During this FYR period, the PQL used for vinyl chloride is equal to the ROD RG which is associated with a risk of 2 x $10^{-5}$. This risk exceeds the ROD target risk goals and MTCA allowable risk but is within EPA's target range. |
| | **Recommendation:** Adopt lower reporting limits as measured concentrations decrease to near the current PQL, and before any decision-making regarding unrestricted use of the sites. |
| | **Finding Category:** Changed Site Conditions |
| | **Finding**: PFAS compounds have been detected in groundwater samples from existing monitoring wells at OU 1 and OU 2. |
| | **Recommendation:** Include PFAS in the supplemental remedial investigations currently underway at OU 1 and OU 2 Area 8. |
| **OUs: 1** | **Finding Category:** Monitoring |
| | **Finding:** The OU 1 LTM reports continue to use ½ the highest "U" value when generating trend graphs, which appears not to conform to the recommendations of the fourth FYR. |
| | **Recommendation:** In accordance with Ecology's comments on the recent LTM reports, present a statistical evaluation of contaminant concentration trends over time in each LTM report, |
| **OUs: 1** | **Finding Category:** Monitoring |
| | **Finding:** The ROD RG for vinyl chloride was based on the PQL achievable at the time of the ROD; however, SIM analysis is now available that can achieve lower reporting limits. |
| | **Recommendation:** Compare vinyl chloride results to current ARARs, including analyzing surface water samples for vinyl chloride using SIM analysis to achieve a lower reporting limit. |
| **OUs: 1** | **Finding Category:** Monitoring |
| | **Finding:** Currently, the surface water PCB data are not compared to ARARs for the protection of human health. |
| | **Recommendation:** Compare future surface water PCB data to the current ARAR for human health exposure pathways (including incidental ingestion and fin-fish and shellfish consumption), given that the concentration can now be achieved by the laboratories using congener analysis. |
| **OUs: 1** | **Finding Category:** Remedy Performance |
| | **Finding:** Information and revised methods of evaluating environmental media contained in the 2013 revised SMS and in the SCUM II manual were incorporated into the recent ERA for OU 2 Area 8, in addition to updates that have occurred to federal and state ERA guidance, guidelines, and policy since the OU 2 ROD. |

**Table 6-2 (continued). Other Findings and Recommendations Not Affecting Protectiveness**

| Other Finding/Recommendation | |
|---|---|
| | **Recommendation:** Utilize the OU 2 Area 8 ERA Work Plan to the extent practical for any future ERAs conducted at NBK Keyport, in particular the upcoming planned ERA for OU 1, such that risk assessments are performed consistently across OUs. |
| **OUs: 1** | **Finding Category:** Institutional Controls |
| | **Finding:** During annual LUC inspections and the FYR site inspection, several cracks were observed in the asphalt pavement of the Central Landfill. Also, alder trees and other brush are growing up through penetrations in the asphalt pavement near old foundations in the southern portion of the Central Landfill. |
| | **Recommendation:** Conduct landfill venting and cover upgrades, as planned in FY 2021, to address potential risks from methane migration beyond the landfill boundaries and prevent direct contact with the underlying soils in the future, respectively. |
| **OUs: 2, Area 2** | **Finding Category:** Monitoring |
| | **Finding:** During this FYR period (i.e., total of three monitoring events), all 1,4-dioxane results were either non-detect or below the MTCA B cleanup level of 0.44 μg/L. |
| | **Recommendation:** Discontinue monitoring for 1,4-dioxane at OU 2 Area 2, it is not present at levels which pose unacceptable risk. |
| **OUs: 2, Area 8** | **Finding Category:** Monitoring/Remedy Performance |
| | **Finding:** During this FYR period, several COCs (including 1,1-DCE, 1,1,1-TCA, arsenic, lead, mercury, thallium, and zinc) in groundwater, seep water, and surface water samples were consistently, or more frequently than not, detected below their RGs. In addition, no RG was established in the ROD for vinyl chloride, which is a breakdown product of the chlorinated solvent COCs present at the site. |
| | **Recommendation:** As part of the contingent actions for OU 2 Area 8 (including a ROD amendment), update the list of COCs to reflect current conditions in groundwater, seep water, and surface water. |
| **OUs: 2, Area 8** | **Finding Category:** Monitoring |
| | **Finding:** Although vinyl chloride is not a COC established by the ROD, it is a breakdown compound of other chlorinated solvent COCs and should be included in the LTM analyte list to provide a comprehensive understanding of COC fate and transport over time. |
| | **Recommendation:** Add vinyl chloride to the LTM analyte list and compare results to current ARARs to evaluate the magnitude and extent of this contaminant at the site. |
| **OUs: 2, Area 8** | **Finding Category:** Remedy Performance/Institutional Controls |
| | **Finding:** During the 2018 VI investigation, cVOC concentrations in sub-slab vapor exceeded PALs underneath Buildings 82, 85, and 98; however, the vapor intrusion pathway was found to be incomplete. |

**Table 6-2 (continued). Other Findings and Recommendations Not Affecting Protectiveness**

| Other Finding/Recommendation | |
|---|---|
| | **Recommendation:** Prepare a building inspection and monitoring plan based on the recommendations of the VI study report to ensure that the VI pathway remains incomplete. Include annual foundation inspections for Buildings 82, 85, and 98 and paired indoor air and subslab vapor monitoring every five years for Buildings 82 and 98. Add paired indoor air and subslab vapor monitoring every five years for Building 85 if warranted based on future changes in building use or occupancy.. |
| **OUs: 1 and 2, Area 8** | **Finding Category:** Monitoring |
| | **Finding:** Climate change effects, particularly weather pattern changes (i.e., local atmospheric pressure and wind conditions) may significantly impact the magnitude and duration of saltwater intrusion and ultimately, the timeframe when best to sample groundwater for freshwater contaminants. |
| | **Recommendation:** Update the LTM Work Plan accordingly to use a downhole conductivity probe to identify the saltwater interface in each monitoring well (above which is the ideal/most representative depth for sampling groundwater) prior to sample collection. |
| **OUs: NA, Site 23** | **Finding Category:** Institutional Controls |
| | **Finding:** Site 23 was removed from the most recent IC Plan (U.S. Navy, 2017b). |
| | **Recommendation:** Add Site 23 back into the LUC Plan, along with the other LUC only sites (i.e., Sites 7 and 22), to ensure LUCs are adequately implemented and maintained, preventing exposure to contaminated soil and groundwater. |

# 7.0 PROTECTIVENESS STATEMENT

This section presents the protectiveness determinations and statements as a result of this fifth FYR for NBK Keyport. Table 7-1 lists the individual protectiveness determinations and statements for OU 1 and OU 2. Table 7-2 provides the sitewide protectiveness determination and statement for NBK Keyport for this FYR period. Ecology, EPA, and the Suquamish Tribe do not concur with the Navy's protectiveness determination for OU 1, and feel that a determination of 'protectiveness deferred' would be more appropriate.

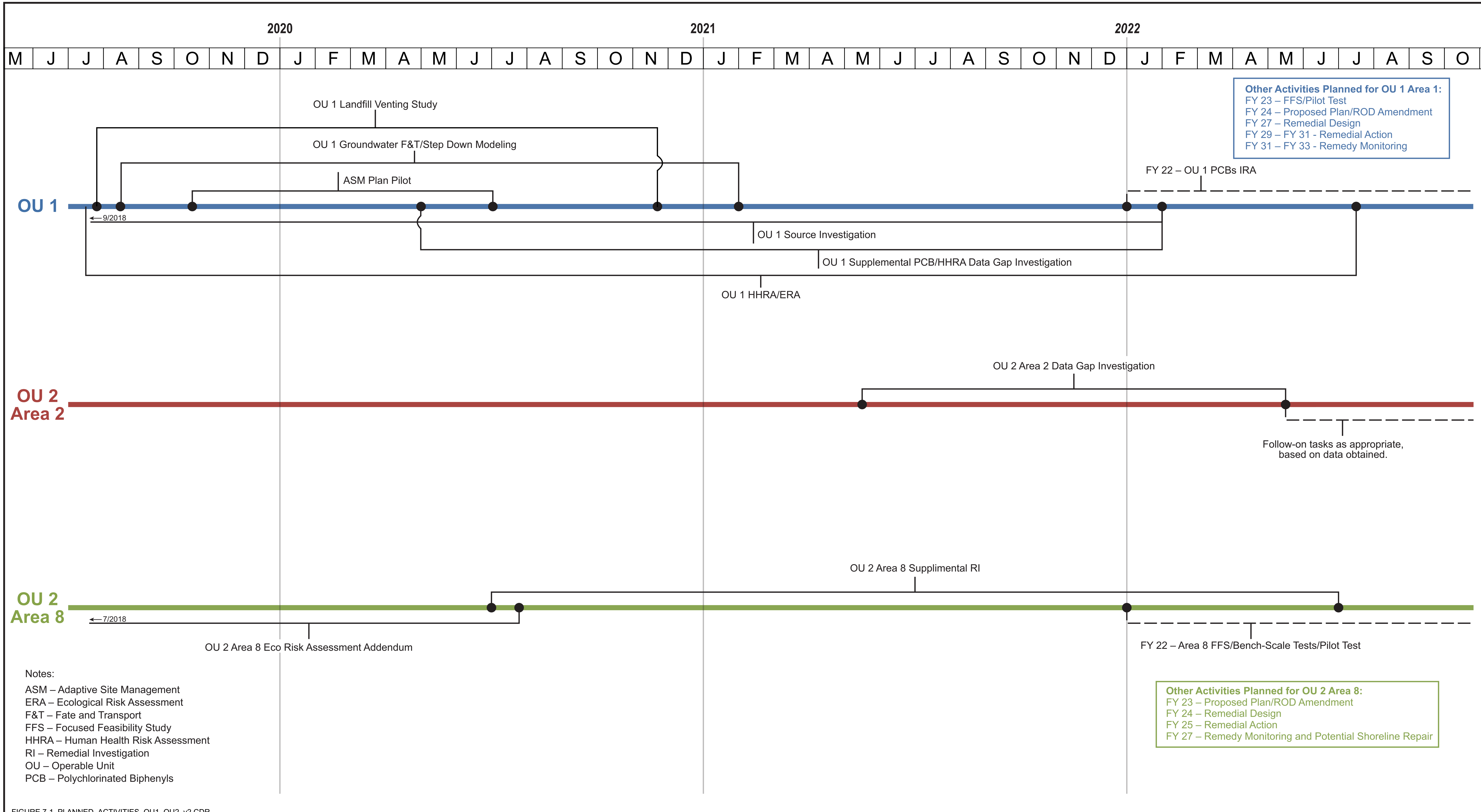
As detailed in Section 6.0, additional or contingent actions are being conducted and/or planned for OU 1 and OU 2 to ensure protection of human health and the environment. Figure 7-1 presents a timetable or schedule for these upcoming/planned actions at OU 1 and OU 2 to support their respective ‘Short-Term Protective’ and ‘Will Be Protective’ determinations (see Table 7-1).

**Table 7-1. Protectiveness Statements for OU 1 and OU 2 at NBK Keyport**

<table>
<tr><th colspan="2">Protectiveness Statement(s)</th></tr>
<tr><td>Operable Unit: 1</td><td>Protectiveness Determination: Short-Term Protective</td></tr>
<tr><td colspan="2">Protectiveness Statement:<br>The remedy at OU 1 is short-term protective. Exposure pathways that could result in unacceptable risks are being controlled and monitored via LUCs while further information is being obtained. Investigation work is ongoing to verify the risk conclusions in the OU 1 ROD, to allow evaluation of potential additional removal or remedial action(s) that could be taken to shorten the overall restoration timeframe, and to ensure the remedy is protective in the long term.</td></tr>
<tr><td>Operable Unit: 2 (Area 2 and Area 8)</td><td>Protectiveness Determination: Not Protective</td></tr>
<tr><td colspan="2">Protectiveness Statement:<br>The remedy at OU 2 Area 2 is short-term protective. Exposure pathways that could result in unacceptable risks are being controlled and monitored via LUCs; however, the consistent vinyl chloride detections above the RG and recent increased concentration in well 2MW-6 may be an indication that cVOC mass detected in shallow groundwater (i.e., wells 2MW-1, 2MW-3, and MW2-10) during the RI may have since migrated deeper and further downgradient than revealed by the monitoring network. The remedy at OU 2 Area 8 is protective of human health; however, it is not protective of ecological receptors based on a finding of unacceptable risk, for which a contingent remedial action has not yet been implemented, as required by the ROD. To identify a feasible contingent groundwater control action, the Navy will perform a supplemental RI and focused FS. Once identified, and agreed upon by regulators and stakeholders, the Navy will perform remedial design, implement remedial action, and potentially conduct a shoreline repair to address elevated COC concentrations in intertidal sediment and on-going discharge of these COCs in seep water. A ROD amendment or Explanation of Significant Differences (ESD) will be prepared to document the contingent groundwater control action taken. The human health risk assessment at the Area 8 beach intertidal zone concluded that, despite the presence of several COCs in the beach sediment and clam tissue at concentrations exceeding background and reference area concentrations, the incremental site risk over reference area risk for Suquamish subsistence and recreational receptors meets target health goals. The ecological risk assessment concluded that there was no risk to higher trophic level species, but acute and chronic exposure to accumulated contaminants in sediment pose a current potential hazard to benthic organisms based on the bioassay results/endpoints.</td></tr>
</table>

**Table 7-2. Sitewide Protectiveness Statement for NBK Keyport**

| **Sitewide Protectiveness Statement** |
| --- |
| **Protectiveness Determination:**<br>Not Protective |
| **Protectiveness Statement:** The remedies at NBK Keyport are not protective due to an uncontrolled risk and the contingent remedial action has not yet been implemented to address ecological risk at OU 2 Area 8. |




| U.S. NAVY | **Figure 7-1**<br>**Planned Remedial Activities at OU 1 and OU 2** | NBK KEYPORT<br>FIFTH<br>FIVE-YEAR REVIEW |
|---|---|---|

# 8.0 NEXT REVIEW

The next FYR is scheduled for 2025.