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FINAL REMEDIAL ALTERNATIVES ANALYSIS OFF-SITE LOCATIONS NSB NEW LONDON
CT
8/27/2012
RESOLUTION CONSULTANTS

August 27, 2012

Mr. James Tarr
Remedial Project Manager (Code OPTE3-5)
Naval Facilities Engineering Command – Mid-Atlantic
Environmental Restoration
Building Z-144
9742 Maryland Avenue
Norfolk, VA 23511-3095

Subject: Final Remedial Alternatives Analysis
Off-site Locations
NSB New London, CT
Contract No. N62470-11-8013, CTO WE17

Dear Mr. Tarr:

Resolution Consultants has prepared the enclosed Remedial Alternatives Analysis (RAA) for Soil and Groundwater Sampling at the Naval Submarine Base, New London, CT (NSB NLON). This final RAA addresses review comments from NAVFAC Atlantic dated July 20, 2012. Specifically, the following changes to the RAA were made to address the reviewer's comments:

- **Comments #1 through #3.** No changes were required to address these comments.
- **Comment #4:** *"Dolphin Mart and Arrowwood Housing. The "Size" subsection indicates that horizontal and vertical extent of contamination have not been determined. What are target treatment zones in Figures 2 and 3 based on? How do these areas compare with annual groundwater monitoring reports?"*

The RAA was revised to clarify that although the horizontal and vertical extents have not been fully delineated, based on the release details and the constituents of concern, contamination is not believed to extend significantly beyond the release area. As such, the target treatment zones are shown to extend slightly beyond the existing monitoring network. This data gap does not significantly affect the ability to evaluate remedial alternatives.

- **Comment #5:** *"Remove Route 12 from figure as it does not pass by Dolphin Mart."*

Figures 1 and 2 were revised to remove the incorrect reference to Route 12.

- **Comment #6:** *"If groundwater monitoring shows compliance with clean-up criteria, no target treatment zone should be indicated. "*

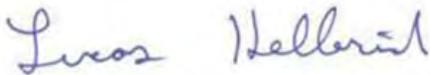
Figure 4 was revised to remove the indicated target treatment zone.

During the preparation of the RAA, we noted that the groundwater monitoring being conducted at the sites should be modified to obtain data necessary for site closure. Below are some suggestions to minimize cost and maximize efficiency:

- **Heron Avenue:** We recommend that the Navy discontinue sampling the original monitoring well for extractable petroleum hydrocarbons (ETPH). The Connecticut Department of Energy and Environmental Protection (CTDEEP) recently issued new draft criteria for ETPH. The former Groundwater Protection Criteria (GWPC) for ETPH (100 parts per billion (ppb)) is no longer approved for statewide use. The new draft GWPC, Surface Water Protection Criteria (SWPC) and Groundwater Volatilization Criteria (GWVC) are all 250 ppb for ETPH. The ETPH concentration at the original Heron Avenue monitoring well has been below 250 ppb for the past five years. A letter indicating completion of monitoring and remedial activities should be submitted to DEEP. It is our understanding that the new wells that were recently installed have been sampled and the data should be incorporated into the letter to confirm the down-gradient extent of impacts.
- **Dolphin Mart:** We recommend that total petroleum hydrocarbon (TPH) analysis be discontinued. The analytical method that the TPH cleanup criteria were based on is no longer conducted. Based on the fact that TPH concentrations present in groundwater at the site are over 1,000 ppb, the ETPH concentrations at the Dolphin Mart likely exceed the new draft criteria for ETPH. We recommend that groundwater be analyzed for both ETPH and volatile and extractable petroleum hydrocarbons (VPH/EPH). Depending upon which carbon chains are present, and in what proportion, there is a possibility that concentrations are below the new draft VPH/EPH criteria. Following a review of the data, a decision can be made to either request use of the new draft ETPH criteria or the VPH/EPH criteria.
- **Arrowwood:** ETPH concentrations at the Arrowwood sites are above the new draft ETPH criteria of 250 ppb. We recommend that groundwater be analyzed for volatile and extractable petroleum hydrocarbons (VPH/EPH). Depending upon which carbon chains are present, and in what proportion, there is a possibility that concentrations are below the new draft VPH/EPH criteria. Following a review of the data, a decision can be made as to which analytical method to use for the Site.

Any questions regarding this correspondence should be directed to Ms. Michelle Snyder, Task Order Manager, at 978-905-2409, or Mr. Lucas Hellerich, Activity Coordinator, at 860-263-5783. Thank you.

Sincerely,



Lucas Hellerich, PhD, PE, LEP
Activity Coordinator, NSB NLON

cc: Thomas Spriggs, NAVFAC, LANT
Michelle Snyder, Resolution Consultants

Remedial Alternatives Analysis (RAA)

**CTO WE17 - Dolphin Mart, Arrowwood and Heron Avenue Family Housing
Off-Site Locations, Naval Submarine Base, New London, Connecticut**

Indicate which remedy evaluation document this RAA supports.

Check one: FS EE/CA CMS CAP (LUST)

Conceptual Site Model (CSM)	CSM - General	<p>This Remedial Alternatives Analysis (RAA) has been prepared under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Atlantic Contract No. N62470-11-D-8013, Contract Task Order (CTO) WE17. CTO WE17 directs the development of a proposed remedial strategy to expedite closure of the Dolphin Mart, Arrowwood and Heron Avenue locations (See Figure 1, Site Location Map). These locations are off-site of Naval Submarine Base (NSB) New London in Groton, Connecticut, and are regulated under the Connecticut Department of Energy and Environmental Protection (CTDEEP) Underground Storage Tank (UST) Petroleum Clean-up Program. The contaminants of concern for these sites are benzene (at Dolphin Mart only) and Extractable Total Petroleum Hydrocarbons (ETPH) at all sites. Total Petroleum Hydrocarbons – Diesel Range Organics (TPH-DRO) analyzed via EPA Method 8100 was also detected above an action level, but the analytical method that the cleanup criteria were based on (EPA Method 418.1) is no longer conducted; therefore the criteria is no longer applicable. ETPH or volatile and extractable petroleum hydrocarbons (VPH/EPH) data will need to be obtained for compliance where TPH-DRO exceeded action levels.</p> <p>Cleanup criteria for Connecticut's ETPH have recently changed and the old criterion (100 parts per billion (ppb) for the Groundwater Protection Criteria (GWPC)) is no longer approved for statewide use. Based on communication with CTDEEP, an application can be submitted to obtain site-specific approval of new draft criteria (250 ppb) for ETPH or other draft criteria for VPH/EPH (see Table 1). Pending this approval, it would not be necessary to perform remediation at one of the sites (Heron Avenue) to meet the applicable cleanup standards, since concentrations of ETPH have been below 250 ppb since 2005. However, the new draft criteria include a Groundwater Volatilization Criteria (GWVC) value for ETPH, indicating that potential vapor concerns may need to be evaluated as part of the remedial process at two of the sites (Arrowwood and Dolphin Mart).</p>
	Previous Site Use	<p><u>Dolphin Mart</u></p> <p>The site was a gasoline/diesel service station until 1985. At that time, releases from historical operations were identified and reported to CTDEEP. The site no longer sells or stores petroleum products and currently operates as a convenience store.</p>

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Off-Site Locations, Naval Submarine Base, New London, Connecticut**

		<p><u>Arrowwood Family Housing</u> Several duplex residential dwellings for NSB personnel were historically located on the properties. Remediation was performed in 1996. Following remediation, the structures were demolished as part of the redevelopment of the area, and new townhomes were constructed in the vicinity of the demolished structures.</p> <p><u>Heron Avenue Family Housing</u> The Heron Avenue Site historically and currently serves as housing for base personnel.</p>
Size		<p><u>Dolphin Mart (Figure 2).</u> The site is approximately one acre. The vertical and horizontal extent of contamination has not been determined; however, due to the relatively low concentrations of constituents in groundwater and the nature of the materials released, contamination is not believed to extend significantly beyond the release area. Based on the current monitoring well network, the impacted area is estimated to be approximately ½-acre, slightly larger than the area covered by existing monitoring wells.</p> <p><u>Arrowwood Family Housing (Figure 3)</u> There are four sites associated with Arrowwood Family Housing. Each site is approximately one acre. The vertical and horizontal extent of contamination has not been determined; however, due to the relatively low concentrations of constituents in groundwater, contamination is not believed to extend significantly beyond the release area. Based on the current monitoring well network, the impacted area is estimated to be approximately 3 acres per site, slightly larger than the area covered by existing monitoring wells.</p> <p><u>Heron Avenue Family Housing (Figure 4)</u> The site is approximately ¼-acre. The vertical and horizontal extent of contamination has not been determined; however, due to the relatively low concentrations of constituents in groundwater and the nature of the materials released, contamination is not believed to extend significantly beyond the release area. The impacted area is estimated to be approximately ½-acre.</p>
Previous Investigations and Remedial Actions		<p><u>Dolphin Mart</u> Releases were identified in 1985, and tightness testing at that time indicated potential releases from each of the four existing 10,000-gallon USTs and/or associated piping. The USTs and surrounding impacted soil were removed between 1985 and 1987. A soil-vapor extraction/air sparge (SVE/AS) system operated at the site from 1996 to 1999, when it was deactivated with CTDEEP approval due to decreasing concentrations.</p>

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		<p>Quarterly groundwater monitoring was conducted from 1999 to 2003, when the sampling was reduced to an annual basis. Methyl tert butyl ether (MBTE) was dropped from the compound of concern (COC) list in 2003. Benzene is the only remaining volatile organic compound (VOC) COC and is currently in single digit ranges (2-3 ppb). Concentrations of TPH-DRO have generally trended downward but several wells have exhibited periodic exceedances of the current GWPC (500 ppb) and the new draft Connecticut Remediation Standard Regulation (RSR) Criteria for ETPH (250 ppb). Note that for TPH-DRO the analytical method that the cleanup criteria were based on is no longer conducted. ETPH or EPH and VPH data will need to be obtained for compliance.</p> <p><u>Arrowwood Family Housing</u></p> <p>Investigation and remediation began at #122/124 Arrowwood Drive in 2002. Upon discovery of a release at this property, the UST and approximately 250 tons of impacted soil were removed. Several soil and groundwater investigations were performed later in 2002, which identified continuing impacts in groundwater. Denitrification-based bioremediation (DBB) was implemented at this property between November 2003 and July 2004.</p> <p>In 2006, the Navy excavated petroleum impacted soil from 11 properties located on Arrowwood Drive that were impacted by releases of fuel oil from USTs. Post excavation samples were collected by the Navy, and soil remediation is presumed to be complete, although the results of confirmatory soil sampling could not be located for the properties.</p> <p>Four of the properties on Arrowwood Drive (#47/49, #109/113, #122/124 & #191/195) continue to be impacted by releases to groundwater. Concentrations of ETPH in groundwater range from below detection limits to 1,480 ppb during the 2010 monitoring period and continue to persist above the new draft GWPC, surface water protection criteria (SWPC), and GWVC of 250 ppb. VOCs were not detected during the 2010-2011 monitoring period. Benzene was the only remaining VOC COC and was last detected in 2008 in single digit range (1-2 ppb).</p> <p><u>Heron Avenue Family Housing</u></p> <p>In 2001, a UST was removed and associated petroleum-impacted soil was excavated. At that time, one monitoring well was installed to monitor groundwater quality. During a recent site inspection in June 2012, it appears that this monitoring well was also constructed and used as a product recovery well. This well has been monitored on a quarterly basis since 2004. Concentrations of ETPH have ranged from 510 ppb in 2004 to 126 ppb in 2010, and have been trending</p>
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		<p>downward. There have been no exceedances of the current draft ETPH RSR GWPC, GWVC, or SWPC (all 250 ppb) since 2005. VOCs do not appear to have been evaluated, although significant VOC impacts are not expected from a fuel oil release.</p> <p>Two additional monitoring wells were installed in May 2012 and one groundwater monitoring well, replacing the original well, was installed in June 2012. These wells have not been sampled as of the date of this report.</p>
	<p>Current and Potential Future Land and Resource (e.g. Groundwater) Uses</p>	<p><u>Current land uses are as follows:</u></p> <ul style="list-style-type: none"> • <u>Dolphin Mart</u> - convenience store that does not sell or store petroleum products. • <u>Arrowwood Family Housing</u> - townhomes for NSB personnel. • <u>Heron Avenue Family Housing</u> - a single-family home for NSB personnel. <p>Groundwater in the vicinity of the sites is classified as GA by the CTDEEP, indicating that it is presumed to be suitable for drinking water without treatment. Future uses of the sites are expected to remain the same.</p>
	<p>Affected Media</p>	<p>Soil remediation is presumed to be complete at each site. Groundwater impacts are summarized as follows:</p> <ul style="list-style-type: none"> • <u>Dolphin Mart</u> - Concentrations of benzene and TPH-DRO remain slightly above the GWPC in groundwater beneath the site. The TPH-DRO concentrations also exceed the new draft GWVC and SWPC for ETPH. • <u>Arrowwood Family Housing</u> - Concentrations of ETPH remain slightly above the new draft GWPC, GWVC, and SWPC (all 250 ppb) in groundwater beneath the site. • <u>Heron Avenue Family Housing</u> - There have been no exceedances of the current draft ETPH RSR GWPC, GWVC, or SWPC (all 250 ppb) since 2005. <p>Groundwater geochemical conditions are generally consistent with what would be expected at petroleum release sites (relatively low dissolved oxygen with slightly reducing to slightly oxidizing potential).</p>
	<p>Geology/Hydrogeology</p>	<p>Surficial materials consist of sand (glacial outwash) and till (ground moraine). In some locations, sand overlies the glacial till. Bedrock in this area consists of gneiss and granitic gneiss. Excavations were backfilled with bank-run gravel.</p> <p>Boring logs for the sites indicate the presence of sand, silty sand, and cobbles. A buried silt and peat layer was encountered at an approximate depth of 6-7 ft bgs at Arrowwood Drive.</p> <p>Groundwater at all three locations is relatively shallow,</p>

Remedial Alternatives Analysis (RAA)

**CTO WE17 - Dolphin Mart, Arrowwood and Heron Avenue Family Housing
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		<p>and was encountered in remedial excavations performed at these sites.</p> <p><u>Dolphin Mart</u></p> <p>Groundwater flow at the site is to the south toward the Beaverdam Brook wetlands, which are within 100 hundred feet south of the site. Based on monitoring well data, the down-gradient extent of groundwater impacts has not been determined.</p> <p><u>Arrowwood Family Housing</u></p> <p>In general, the topography of the Arrowwood Drive area slopes downward from a high along Gungywamp Road toward the Beaverdam Brook wetlands located within 100 hundred feet south and southeast. Groundwater flow is to the southeast toward the Beaverdam Brook wetlands. Based on monitoring well data, the down-gradient extent of groundwater impacts has not been determined.</p> <p><u>Heron Avenue Family Housing</u></p> <p>The site is located in a level to low-lying area northwest of Hempstead Brook and other low lying wooded areas. Groundwater flow direction has not been determined since there has historically only been one well. It is assumed that groundwater flows southeastward toward Hempstead Brook wetlands located several hundred feet southeast. Groundwater data has been recently collected from the newly installed wells and can presumably be used to infer groundwater direction.</p>
	<p>Nature and Extent of Contamination</p>	<p>Gasoline and diesel were released from USTs at the Dolphin Mart site. No. 2 heating oil was released from USTs at each of the Arrowwood Drive and Heron Avenue sites. Soil remediation is presumed to be complete at each site; however, as previously noted, documentation of confirmatory sampling has not been located. At all sites, groundwater flow directions are assumed and the hydraulic conductivity, groundwater flow velocity, down-gradient extent of the groundwater plumes and vertical extent of contamination has not been defined.</p>
	<p>Receptors/Exposure Pathway</p>	<p><u>Soil:</u> presumed to be remediated at all sites, no exposure potential.</p> <p><u>Impacted Groundwater:</u></p> <ul style="list-style-type: none"> • The properties are connected to the municipal water supply; therefore ingestion is not an exposure route. • Volatilization to indoor air and subsequent inhalation is considered a potential exposure pathway to residents at Heron Avenue and Arrowwood Drive and workers at Dolphin Mart based on new draft GWVC values for ETPH. However, the impacted groundwater flows away from the buildings and does not appear to be situated directly beneath any buildings. Site specific approval of these draft values is required under the current regulations.

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		<ul style="list-style-type: none"> • Dermal contact with groundwater during excavation is a potential exposure pathway to workers at all sites. • Groundwater discharge to surface water and ecological effects are a concern based on new draft SWPC values for ETPH. Site specific approval of these draft values is required under the current regulations. 																					
	Other Site Constraints	No other constraints are expected for the sites.																					
Risk Summary	Human Health Risk	A human health risk assessment has not been conducted and is not anticipated. The response actions at these sites will follow CTDEEP guidance to achieve the relevant regulatory criteria.																					
	Ecological Risk	An ecological assessment has not been conducted and is not anticipated. The response actions at these sites will follow CTDEEP guidance to achieve the relevant regulatory criteria.																					
COCs	Surface Soil	Soil remediation is presumed to be complete at all sites.																					
	Subsurface Soil	Soil remediation is presumed to be complete at all sites.																					
	Groundwater	<p>The average and maximum detected concentrations presented below are from the most recent year of monitoring data currently available.</p> <p><u>Dolphin Mart</u></p> <table border="0"> <thead> <tr> <th><u>COC</u></th> <th><u>Average Conc.</u></th> <th><u>Max Detect</u></th> </tr> </thead> <tbody> <tr> <td>Benzene</td> <td>1.01 ppb</td> <td>2.3 ppb</td> </tr> <tr> <td>TPH-DRO</td> <td>585 ppb</td> <td>2,320 ppb</td> </tr> </tbody> </table> <p>(Note that for TPH-DRO the analytical method that the cleanup criteria were based on is no longer conducted. ETPH or EPH and VPH data will need to be obtained for compliance)</p> <p><u>Arrowwood Family Housing</u></p> <table border="0"> <thead> <tr> <th><u>COC</u></th> <th><u>Average Conc.</u></th> <th><u>Max Detect</u></th> </tr> </thead> <tbody> <tr> <td>ETPH</td> <td>270 ppb</td> <td>1480 ppb</td> </tr> </tbody> </table> <p><u>Heron Avenue Family Housing</u></p> <table border="0"> <thead> <tr> <th><u>COCs</u></th> <th><u>Average Conc.</u></th> <th><u>Max Detect</u></th> </tr> </thead> <tbody> <tr> <td>ETPH</td> <td>94 ppb</td> <td>148 ppb</td> </tr> </tbody> </table>	<u>COC</u>	<u>Average Conc.</u>	<u>Max Detect</u>	Benzene	1.01 ppb	2.3 ppb	TPH-DRO	585 ppb	2,320 ppb	<u>COC</u>	<u>Average Conc.</u>	<u>Max Detect</u>	ETPH	270 ppb	1480 ppb	<u>COCs</u>	<u>Average Conc.</u>	<u>Max Detect</u>	ETPH	94 ppb	148 ppb
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ETPH	265 ppb	749 ppb																					
Indoor Air	Not applicable.																						
RAOs	Remedial Action Objectives	<p>The remedial action objectives (RAOs) for the sites consist of applicable numeric cleanup criteria in the Connecticut RSRs:</p> <ul style="list-style-type: none"> • the Groundwater Protection Criteria (GWPC) since 																					

Remedial Alternatives Analysis (RAA)

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		<p>the sites are located in a GA classified area, groundwater is presumed to be usable for drinking water;</p> <ul style="list-style-type: none"> the Groundwater Volatilization Criteria (GWVC), determining the potential for volatilization from groundwater into structures; and, the Surface Water Protection Criteria (SWPC), determining potential impacts to surface water bodies due to groundwater discharge.
Remediation Goals	Preliminary/Final Remediation Goals	<p>Soil remediation is presumed to be complete at all sites. The groundwater remediation goals for all three sites are as follows:</p> <p>ETPH = 250 ppb (pending site specific approval)</p> <p>Benzene = 1 ppb</p> <p>There is no remedial goal for TPH-DRO because the analytical method that the cleanup criteria were based on is no longer conducted. ETPH or EPH and VPH data will need to be obtained for compliance. If EPH and VPH are selected in place of ETPH, refer to Table 1 for the Remedial Goals.</p>
TTZs	Target Treatment Zones	Please refer to Figures 2 through 3 for the Target Treatment Zone (TTZ) locations for each site. A TTZ is not needed for Figure 4.
Remedy Status	Interim or Final Remedy	The alternatives presented are intended to be the final remedy.
Unrestricted Land Use	Was an UU/UE Remedial Alternative Evaluated?	All of the remedial alternatives evaluated would allow unrestricted use/unrestricted exposure.
Data Gaps	Identify Any Remaining Data Gaps	<p>The following data is needed to refine the remedial design:</p> <ul style="list-style-type: none"> Confirmation that soil remediation is complete Post-excavation/remediation soil data Delineation of the down-gradient extent of the dissolved plume. Vertical delineation of impacts Groundwater velocity information <p>These data gaps will not significantly affect the ability to evaluate alternatives</p>
Applicable Documents		<p>Additional Site Evaluations, Arrowwood, 21 Heron Avenue, and Dolphin Mart, Tetra Tech, 2011.</p> <p>Annual Groundwater Monitoring Reports for the Navy Exchange Service Station and Dolphin Mart, Naval Submarine Base, EA Engineering, 2002.</p> <p>Corrective Action Plan, 122/124 Arrowwood Drive, EA Engineering, 2003.</p> <p>Draft Groundwater Monitoring Report, 122-124 Arrowwood Drive, HRP Associates, 2006.</p>

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	<p>Draft Sampling and Analysis Plan, Additional Well Installation Activities, Heron Avenue Base Housing Site. Tetra Tech NUS, 2012.</p> <p>Final Arrowwood Housing Sites 2011 Groundwater Monitoring Report for Quarterly Events, H&S Environmental, 2012.</p> <p>Final Year 7 Annual Groundwater Monitoring Report for 21 Heron Avenue, H&S, 2011.</p> <p>Final 2010 Annual Groundwater Monitoring Report, Dolphin Mart, H&S Environmental, 2011.</p> <p>Groundwater Permitting – ISCO-ORC Options at Various Locations, Resolution Consultants, 2012.</p> <p>Groundwater Sampling Work Plan for Arrowwood Housing Sites, Tetra Tech NUS, 2007.</p> <p>January 17, 2012 Meeting Notes, Naval Submarine Base – New London Off Base Sites Strategy Meeting at CTDEEP, unsigned.</p> <p>Monthly Operations Summary for the Naval Exchange and Dolphin Mart Air Sparging/Soil Vapor Extraction OHM Emergency Discharge Permit Application, Dolphin Mart, OHM Remediation Services, 1996.</p> <p>Site Evaluation and Status Update, Polaris Park, Arrowwood Housing, 21 Heron Avenue & Dolphin Mart Sites, NAVFAC – CTDEEP Meeting, January 17, 2012.</p> <p>Soil and Groundwater Sampling Work Plan, Off-Site Locations, Resolution Consultants, 2012.</p> <p>Startup Report for Sparge and Vent Remediation Systems, Dolphin Mart and Naval Exchange, OHM Remediation Services, 1996.</p> <p>Systems and OT-8 Passive Free Product Recovery System, Fluor Daniel GTI, 1997.</p>
<p>Additional Comments</p>	<p>As previously noted, cleanup criteria for ETPH have recently changed and the old criterion (100 ppb for the GWPC) is no longer approved for statewide use. Site-specific approval of 250 ppb as a cleanup criterion is required under the current regulations. Pending this approval and confirmation from CT DEEP that the site has been remediated, it would not be necessary to perform remediation or further sampling at one of the sites (Heron Avenue) since concentrations of ETPH are below 250 ppb. The new draft criteria include a GWVC value for ETPH, indicating that potential vapor concerns may need to be evaluated as part of the remedial process. Tables and figures are attached.</p>

Remedial Alternatives Analysis (RAA)

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Description of Feasibility Study Alternatives

Alternative Number	Alternative Description
Alternative #1 No Action	No action would be taken to address groundwater impacts.
Alternative #1A No Action while Applying for New Criteria	<p>Based on communication with CTDEEP, it should be possible to apply for site-specific approval of new draft criteria (250 ppb) for ETPH (see Table 1). Pending this approval, it would not be necessary to perform remediation at Heron Avenue Family Housing to meet the applicable cleanup standards, since concentrations of ETPH have been below 250 ppb since 2005.</p> <p>The other sites will be evaluated in a similar manner. The TPH-DRO concentrations at the Dolphin Mart and ETPH concentrations at the Arrowwood Sites are above the draft EPH Criteria; however, analysis of EPH and VPH could demonstrate compliance with RSR Criteria depending upon the concentrations of the various carbon fractions. Retaining the No Action alternative is also consistent with Navy guidance.</p>
Alternative #2 Passive Oxygenation	<p>Passive oxygenation through the use of an oxygen release compound (ORC) or in-situ oxygen curtain (ISOC) can create a passive oxygen barrier along the contaminant migration pathway. As the contaminants pass through the zone of elevated dissolved oxygen, the contaminants are oxidized via aerobic biodegradation. To be effective, the oxygen barrier must be maintained until the dissolved-phase hydrocarbon concentrations within the plume area are reduced below the applicable standards.</p> <p>Site conditions lend themselves to passive oxygenation based on relatively low current concentrations of dissolved oxygen (DO) and receptive geology. Passive Oxygenation has proven effective for low-level hydrocarbon remediation in groundwater at similar sites. Additionally, this approach lends itself to a phased approach in combination with other remedial alternatives including monitored natural attenuation (MNA). CTDEEP has developed a streamlined General Permit for Enhanced Aerobic Biodegradation that covers many of the available methods of passive oxygenation.</p> <p>During implementation, performance groundwater monitoring is used to monitor progress and determine re-application and/or remediation exit points. Passive oxygenation may be followed by MNA. It is anticipated that one year of quarterly groundwater compliance monitoring will be required, follow by three years of groundwater monitoring for compliance with the GWPC. Alternative monitoring approaches are allowable under the regulations.</p>

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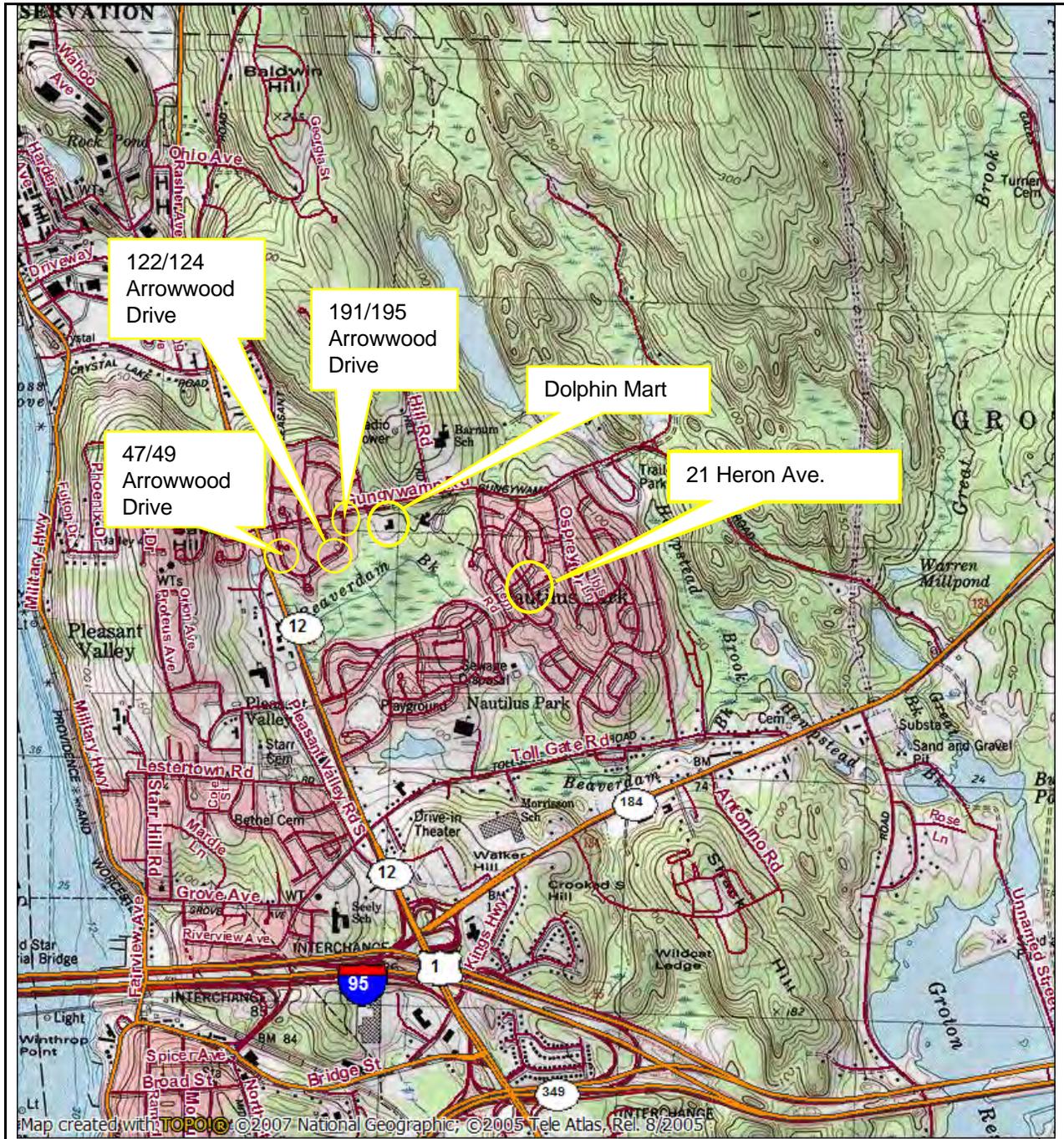
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Off-Site Locations, Naval Submarine Base, New London, Connecticut**

<p>Alternative #3 In-Situ Chemical Oxidation</p>	<p>In-situ chemical oxidation (ISCO) is a method by which organic contaminants are degraded in place by an oxidant (potassium permanganate, persulfate, or hydrogen peroxide are commonly used). Chemical oxidant usage with remediation relies heavily on the mass balance of contaminant remaining in the contaminated media, and the existence of other naturally occurring reducing agents (e.g. organic matter).</p> <p>Site conditions lend themselves to ISCO, and this method has been proven effective for hydrocarbon remediation in groundwater. Additionally, ISCO may be combined in a phased approach with passive oxygenation and/or monitored natural attenuation. Application of ISCO would require permitting through CTDEEP. Additionally, evaluation of buried peat layers at some of the sites would need to be performed prior to implementing ISCO as a remedial option.</p> <p>During implementation, performance groundwater monitoring is used to monitor progress and determine re-application and/or remediation exit points. It is anticipated that one year of quarterly groundwater compliance monitoring will be required, follow by three years of groundwater monitoring for compliance with the GWPC. Alternative approaches are allowable under the regulations.</p>
<p>Alternative #4 In-Situ Aerobic Bioremediation</p>	<p>The process of enhanced in-situ aerobic bioremediation consists of indigenous or inoculated microorganisms (i.e. fungi, bacteria, and other microbes) degrading contamination in groundwater under aerobic conditions into byproducts such as carbon dioxide and water. Enhanced aerobic bioremediation techniques have been successfully used to remediate groundwater contaminated with petroleum hydrocarbons.</p> <p>In order to implement in-situ aerobic bioremediation at the sites, it may be necessary to combine this alternative with oxygen enhancement (Alternative #2) in select areas to achieve adequate concentrations of dissolved oxygen. CTDEEP has developed a streamlined General Permit for Enhanced Aerobic Biodegradation that covers application of biological amendments.</p> <p>During implementation, performance groundwater monitoring is used to monitor progress and determine re-application and/or remediation exit points. It is anticipated that one year of quarterly groundwater compliance monitoring will be required, follow by three years of groundwater monitoring for compliance with the GWPC. Alternative approaches are allowable under the regulations.</p>

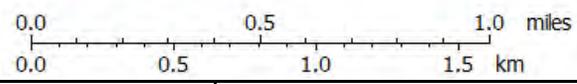
Remedial Alternatives Analysis (RAA)

**CTO WE17 - Dolphin Mart, Arrowwood and Heron Avenue Family Housing
Off-Site Locations, Naval Submarine Base, New London, Connecticut**

<p>Alternative #5 In-Situ Anaerobic Denitrification- Based Bioremediation</p>	<p>The process of anaerobic denitrification-based bioremediation (DBB) consists of indigenous or inoculated microorganisms degrading contamination in groundwater under anaerobic conditions into carbon dioxide, water, and inert nitrogen gas. DBB relies on a biodegradation process that uses nitrogen-based compounds as alternative electron acceptors. DBB bioremediation was successfully used to remediate soil and groundwater at #122/124 Arrowwood Drive in 2002.</p> <p>Application of DBB methods are limited to remediation areas with low dissolved oxygen concentrations (typically found in the central portions of petroleum groundwater plumes). As such, it may be necessary to combine this alternative with another approach to fully treat all release areas at the sites. Application of remedial amendments would require a permit or temporary authorization from CTDEEP.</p> <p>During implementation, performance groundwater monitoring is used to monitor progress and determine re-application and/or remediation exit points. It is anticipated that one year of quarterly groundwater compliance monitoring will be required, follow by three years of groundwater monitoring for compliance with the GWPC. Alternative approaches are allowable under the regulations.</p>
<p>Alternative #6 Monitored Natural Attenuation</p>	<p>Natural attenuation is a reduction in the concentration of contaminants through natural processes including biodegradation, volatilization, dilution, adsorption, and chemical reactions with other materials. Natural attenuation processes are occurring, at some degree, at most contaminated sites. The amount of contamination and varying physical, chemical and biological properties of the subsurface will determine the rate at which natural attenuation will occur.</p> <p>The processes of degrading petroleum by natural processes produce heavier petroleum hydrocarbons of low solubility and volatility.</p> <p>Monitored natural attenuation has been performed at the sites for several years, without achieving compliance with the RSRs within a reasonable timeframe. It is expected that natural attenuation processes will ultimately contribute to the cleanup of these sites in combination with other alternatives</p>
<p>Other Alternatives Considered</p>	<p>Alternatives that were not retained for additional consideration:</p> <p><u>Groundwater Pump and Treat</u>: Not retained due to cost, degree of site disturbance, and long timeframes required to achieve compliance.</p> <p><u>Air Sparge/Soil Vapor Extraction</u>: Not retained due to cost and low concentrations of VOCs at the sites.</p> <p><u>Groundwater Reclassification</u>: Not retained due to regulatory infeasibility.</p>



Map created with TOPOIC © 2007 National Geographic; © 2005 Tele Atlas. Rel. 8/2005



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**Naval Submarine Base
New London
Groton, Connecticut**

Site Location Map

21 Heron Avenue
47/49, 122/124 & 191/195 Arrowwood Drive
Dolphin Mart - 591 Route 12
Groton, Connecticut

Project # 60249706

Figure 1

File: G:\Projects\Navy CLEAN AECOM-EnSafe JV\New London\CADD\Reference&Tbk\60249706-C01.dwg Layout: Fig-2 User: vershonb Plotted: Aug 01, 2012 - 3:03pm Xref's:

GUNGYWAMP ROAD

SAILFISH DRIVE

BEVERDAM
BROOK
WETLANDS

WE-1
WE-1A
DM-5

BLDG #1002

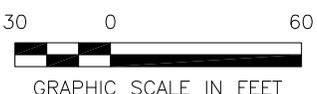
DOLPHIN MART SERVICE CENTER

NAVY FEDERAL
CREDIT UNION

ESTIMATED
GROUNDWATER
FLOW DIRECTION

LEGEND

-  DESTROYED MONITORING WELL
-  EXISTING MONITORING WELL LOCATION
-  SOIL BORING
-  MANHOLE
-  LIGHT
-  TARGET TREATMENT ZONES



BASEMAP SOURCE:
TertraTech CADD files

60249706		SITE PLAN DOLPHIN MART NAVAL SUBMARINE BASE NEW LONDON GROTON CONNECTICUT	
DATE: 7-2012	DRWN: BcV/C-MA		

WE-5

WE-3

MW-1

MW-3

SB-2

MW-2

WE-6

WE-2D

WE-2S

P3

P2

P4

P1

WE-4

OBG-8A

SB-1

OBG-8

HRP-10

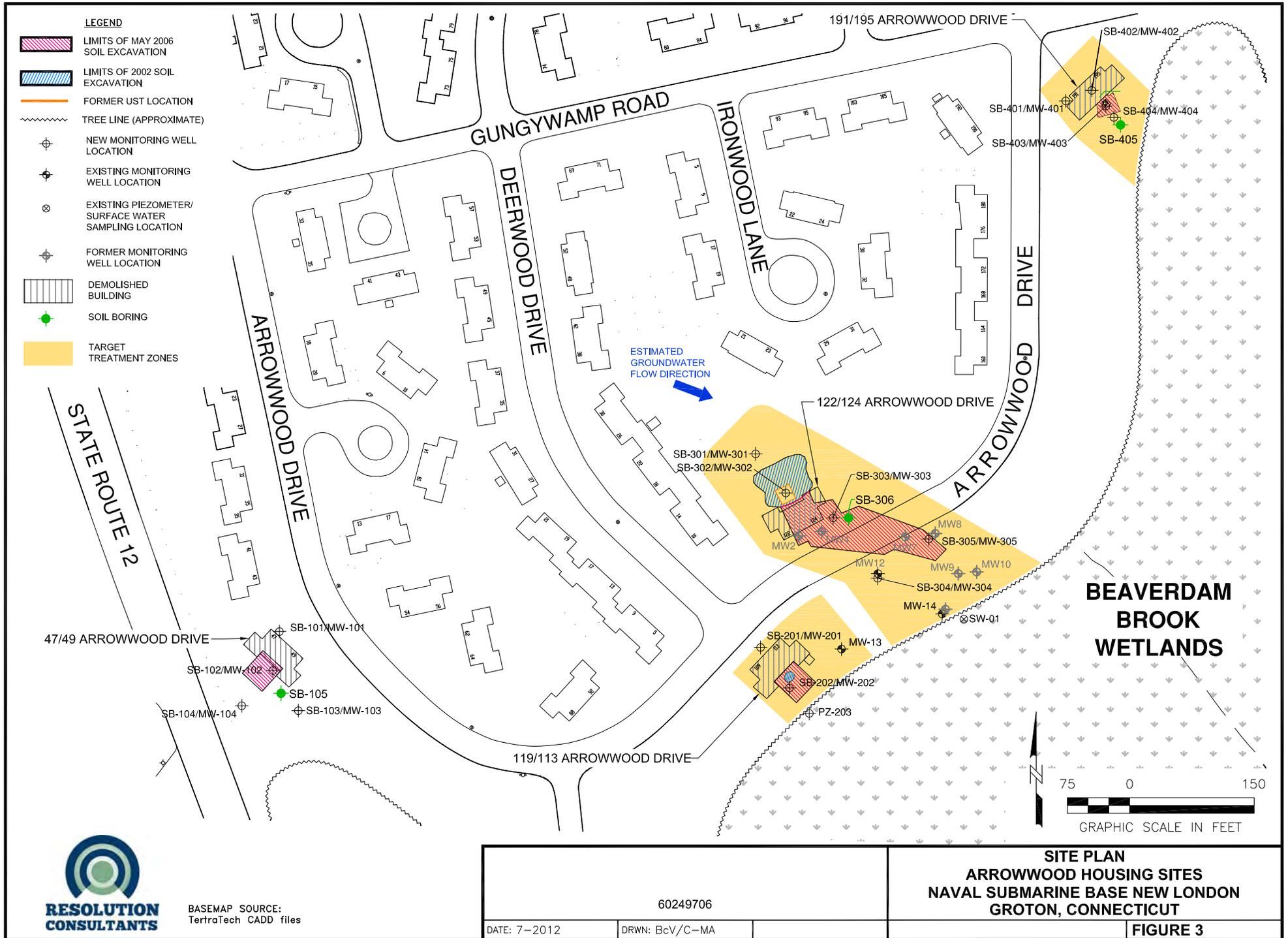
OBG-9A
OBG-9

DM-1

DM-2

DM-3

DM-4



BASEMAP SOURCE:
TetraTech CADD files

60249706

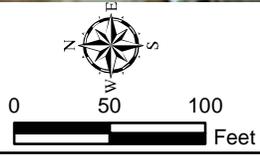
DATE: 7-2012

DRWN: BcV/C-MA

SITE PLAN
ARROWWOOD HOUSING SITES
NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT

FIGURE 3

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NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT

DATE: 05/10/12 | DRWN: J.E.B.

21 HERON AVENUE
SITE PLAN

SOURCE: BING MAPS AERIAL | FIGURE 4