USN STRATEGIC WORK PLAN
OPERABLE UNIT NO. 2 GROUNDWATER
NWIRP BETHPAGE, NY

The Navy is addressing volatile organic compounds- (VOC) impacted groundwater associated with Northrop Grumman's (NG's) operations at the former Naval Weapons Industrial Reserve Plant (NWIRP) Bethpage under the 2003 Operable Unit 2 (OU2) Record of Decision (ROD) (Figure 1). NG's operations at the NG-owned manufacturing facilities in Bethpage have also contributed to this contamination (Figure 2). The evidence also suggests that the former Grumman Settling Ponds Site (Bethpage Community Park), the Occidental-Hooker-RUCO Site, and possibly other upgradient disposal sites in the area are contributors to this contamination.

The VOC-impacted groundwater results from multiple plumes or plume fingers and is bounded by an area that is over three miles long, 1.5 miles wide, and a maximum depth of approximately 750 feet (Figure 3). The plumes are not continuous throughout this area or depth. The fingers are present at variable depths and locations and result from multiple releases over several decades and move throughout the aquifer at variable rates and directions in response to the geology, natural hydraulic gradients, and stresses imposed by pumping wells and recharge basins. Regional groundwater flow is normally to the south and southeast, but can be affected locally by extraction wells as well as recharge basins and water supply wells. Brief conceptual descriptions of the Bethpage Plumes are provided below:

- The shallow plume is approximately 9,700 feet wide and at least 17,000 feet long (covering approximately 3,800 acres of area). The shallow plume generally occurs at depths between 50 and 300 feet below ground surface (bgs), and consists of a mixture of trichloroethylene (TCE), tetrachloroethene (PCE), 1,1,1-trichloroethane (TCA) and degradation products. VOC concentrations in the shallow plume are typically less than 50 micrograms per liter (µg/L). Other sources have shallow plumes that are within or extend into the Bethpage Plume footprint.
- The deep western plume generally occurs between 300 and 750 feet bgs, and consists primarily of TCE. TCE concentrations are typically greater than 50 µg/L. Other VOCs are present, but their concentrations are typically less than 10 µg/L. This plume is believed to have originated from OU-2 source areas. Vertically, the plume is not uniform; it consists of one or more bands of high-VOC-concentration groundwater within a broader aquifer cross-section that has little or no VOC impacts. The downgradient extent of this plume is approximately 12,000 feet south of the OU-2 source areas. An isolated PCE plume was identified within this part of the Bethpage Plume and has potentially originated from non-OU-2 sources. In addition, more pockets of contamination may be present.
- The deep eastern plume is believed to have originated from the Former Grumman Settling Ponds Site (also known as Bethpage Community Park and OU-3). This plume is currently reported to be 300 to 650 feet bgs, and consists of a mixture of TCE, PCE, TCA, and degradation products. VOC concentrations in this plume are typically greater than 50 µg/L. Vertically, the

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plume is not uniform and consists of one or more bands of high-VOC-concentration groundwater within a broader aquifer cross-section that has little or no VOC impacts. The downgradient extent of this plume is not well defined. One or two isolated PCE plumes from other sources (non-OU-2 and non-OU-3 sources) are also present in this portion of the aquifer.

Since the 1990s, the Navy has been working with NYSDEC and the water districts to respond to impacts to the groundwater that may be migrating from the former NWIRP-Bethpage property. Primary elements of the Navy's response actions are as follows:

- Installation and/or funding of Wellhead Treatment systems on five water supply plants;
- Installation and testing of Vertical Profile Borings and Outpost Monitoring Wells;
- Operation of a "Hot Spot" (defined in the 2003 ROD as an area of groundwater with total VOCs above one part per million) Treatment System (GM-38) for mass removal; and
- Ongoing regional monitoring of VOC-impacted groundwater migration; and
- Evaluating the remedy through the Optimization Study, Alternatives Report and Hydraulic Capture Zone Analysis.
- Contracting USGS to evaluate the hydraulic capture zone of GM-38 Treatment Plant by developing a groundwater flow model and continuing work with the Navy to develop groundwater flow model at three additional supply well fields (New York American Water and South Farmingdale Water Districts Plants 3 and 6) in the southwest portion of the Bethpage Plume.

The Navy OU-2 ROD recognized the importance of NG's continued operation of an On-Site Groundwater Containment (ONCT) System to prevent further migration of contaminants off property to the extent practicable and removal of contamination prior to being recharged back into the aquifer via on-property recharge basins in the immediate vicinity of NG's former manufacturing facilities, known as the "On-Site" area. The ONCT System has been in operation since 1998 and as discussed below, its operation is anticipated to reduce the magnitude and duration of potential impacts to downgradient water users.

The Navy is continuing to monitor the VOC-impacted groundwater that may have migrated from the former NWIRP property, by focusing additional studies in three separate areas, as follows:

1. Upgradient Plume Area: Navy is conducting an ongoing investigation of the area upgradient of Bethpage Water District (BWD) Plant 6 to determine whether On-Site OU2 sources of VOCs are being adequately contained by NG's ONCT system or if these sources or other non-OU2 source areas are somehow bypassing the ONCT or underflowing the ONCT and continuing to contribute to the plumes downgradient of the NWIRP. Without containment, there could be long-term impacts to BWD Plant 6 and other downgradient receptors;

2. Mid-Plume Area. This area is the hot spot near BWD Plant 6. In 2014, an ongoing field investigation in this area confirmed the presence of the hot spot in groundwater. This hot spot is now being referred to as the RE108 Hot Spot. The areal and vertical extents of the hot spot are being determined by an ongoing field investigation and are currently estimated to be approximately 200 acres at a depth of 655 to 755 feet below ground surface; and

3. Downgradient Plume Area. This area is near the downgradient edge of the deep western finger plume and beyond. The Navy is extending the Outpost Monitoring Well Program to the south as an early measure to monitor any future impacts to water districts from this plume.

Specific objectives and the associated activities for each of the areas are described below.

Upgradient Plume Area Evaluation

Objective 1 – Evaluate the Source of Impacts to BWD 6 and RE108 Hot Spot

NG's ONCT is located at the southern boundary of the NG property and is owned and operated by NG since 1998. The continued operation of the ONCT by NG is critical to its containment of contamination migrating from source areas at its former manufacturing facilities. NG has reported that a recent evaluation of the ONCT effectiveness carried out by NG indicated it is operating properly. However, the presence of the RE108 Hot Spot near BWD Plant 6 and south of the ONCT may indicate that: 1) some VOCs originating from the NWIRP, the NG property, or some other nearby property could be migrating around, between or underneath the ONCT recovery wells; or 2) the RE108 Hot Spot represents contamination that migrated off property prior to operation of the ONCT. In order to better understand the source of the hot spot, the Navy is installing vertical profile borings (VPBs) and monitoring wells north and west of BWD Plant 6. Figure 4 presented the Navy's drilling priorities, the results of which will be used to further evaluate the ONCT's effectiveness. Using outpost wells and monitoring wells, trend analysis of groundwater sampling results from Navy and NG will be used by the Navy in a supplemental evaluation of the ONCT's effectiveness. The Navy will install water level data loggers in monitoring wells around ONCT Wells 17 and 18. The Navy believes that it is essential to verify that NG's ONCT is effectively containing the VOC source and upgradient plume because based on its location in relation to the RE108 Hot Spot; NG's ONCT should be a primary element of the RE108 Hot Spot containment efforts around BWD Plant 6.

It is anticipated that the Upgradient Plume Area evaluation will be an ongoing effort over several years with an initial evaluation completed around the time of the RE108 Hot Spot delineation (anticipated to be December 2016). As outlined below, steps to be taken include: installation of 4 to 6 additional VPBs around the ONCT wells; installation of approximately 6 to 12 monitoring wells; and performance and evaluation of the ONCT system. Generally it takes six to eight weeks to install a VPB and four to six weeks to install a monitoring well.

Mid-Plume Area Evaluation

Objective 2 – Additional Characterization and Treatment of the Recently Discovered VOC Hot Spot in the Groundwater near Bethpage Water District Plant 6

The Navy's 2003 ROD for OU2 defines a "hot spot" as an area of groundwater with VOC concentrations greater than 1 part per million (ppm), and confirmed by three consecutive sampling events in any one well. For groundwater with 1 ppm or above of VOCs sustained over this period of time, substantial VOC

mass removal is possible, leading to a tangible impact on control of plume migration that may not otherwise be technically feasible. The purpose of the VOC mass removal is to reduce the magnitude and/or duration of potential impacts to downgradient receptors.

In 2014, the vertical profile boring and monitoring well program confirmed the presence of a hot spot of VOCs north of Hempstead Turnpike and south of the NG's ONCT system. Figure 5 provides the results of the Navy's groundwater sampling performed over the last four quarters, with TCE (the dominant VOC in the OU2 plume fingers) concentrations listed for each quarter. As can be seen from the location of the monitoring wells and the lack of data around these wells, the horizontal and vertical extent of the hot spot as yet is undefined. The existing delineation is not sufficient to allow a containment system to be designed. Navy is conducting additional drilling to fully delineate the hot spot and provide the time frame necessary to design an effective mass removal system.

Figure 4 shows the drilling priorities for this hot spot delineation. This figure also shows the rationale for each drilling location as part of the overall strategy to address the hot spot. Besides performing additional delineation, the Navy is continuing the quarterly and/or annual sampling of wells within the RE108 Hot Spot to determine concentration trends over time. Provided no delays with weather or logistics, the best projected schedule to complete this additional delineation is provided in Table 1:

Table 1: Schedule for Completion of Additional Delineation

VPB	VPB Installation	Well Installation
158	3/13/2015	10/2/2015
157	5/8/2015	7/3/2015
141	7/3/2015	8/28/2015
159	8/28/2015	10/23/2015
155	10/2/2015	11/27/2015
160	10/25/2015	12/18/2015

Figure 5 also shows the location of BWD Plant 6 wells. From 1990 to 2010, NG funded the installation, upgrade and operation of a treatment system at BWD Plant 6 to protect the water supply from VOC contamination. When BWD determined the need for a further upgrade to the treatment system, NG refused to provide further funding, and BWD sought funding from the Navy. The Navy concurred that an upgraded treatment system was necessary and thus, has invested further in installing, upgrading and maintaining the treatment system at BWD Plant 6 to continue to protect the water supply wells from VOC contamination.

In the meantime, the Navy is working with BWD to determine the possibility of using one of the Plant 6 wells as a recovery well to capture a significant portion of the VOC hot spot. Because the hot spot is not fully delineated, the effectiveness of using this system is as yet uncertain, so, as described below, the Navy has suggested a pilot study to test this option. A capture zone analysis performed by the Navy

indicated that operation of one of the BWD Plant 6 wells (Well 6-2) could effectively capture a majority of the known RE108 Hot Spot. Also, the hydrologic connection between the BWD Plant 6 well and the RE108 Hot Spot is confirmed by the sustained VOC concentrations in the BWD well when it is operating. When BWD Plant 6 is not pumping, the VOCs in this well decrease 200-fold, indicating that the BWD Well 6-2 is not normally within the RE108 Hot Spot, but intercepts the hot spot with its wide capture zone during operation. In cooperation with BWD, the Navy will implement a pilot study to evaluate the effectiveness of operating Well 6-2 continually to minimize contamination migration to other downgradient water districts. It is expected that start-up of BWD 6-2 as a recovery well would begin in May 2015. Based on the initial findings, the evaluation may continue beyond 2015 and may require additional VPBs and monitoring wells to be installed in this area.

Depending on the results of the ongoing field investigation regarding the effectiveness of using BWD Well 6-2 in capturing the RE108 Hot Spot, it is possible that an additional recovery well and treatment system might be required to capture any remaining portion of the RE108 Hot Spot not captured by BWD Well 6-2. Several methods will be used to evaluate the hot spot capture by BWD Plant 6, including pumping tests and groundwater modeling, effectiveness of NG's ONCT, spatial evaluation of the RE108 Hot Spot, and trend analysis of concentrations within the hot spot. In furtherance of the potential need to design and construct a supplemental hot spot treatment system, the Navy is investigating properties that could potentially be used to site this system.

The steps to be taken to address the RE108 Hot Spot consist of installation of 2 to 4 additional VPBs and installation of approximately 6 to 12 monitoring wells south and west of the hot spot, and performance and evaluation of the BWD Well 6-2. Generally it takes six to eight weeks to install a VPB and four to six weeks to install a monitoring well. The BWD Well 6-2 evaluation, which is estimated to take one year, will include: the Navy working with BWD to conduct a long term pumping test. Transducer/data logger probes will be used to collect various parameters (i.e. water level data and temperature) from nearby groundwater wells. This data in conjunction with groundwater quality data will be evaluated to determine the capture zone extents of BWD Well 6-2 and more specifically whether BWD Well 6-2 area groundwater is being captured. If a determination is made that a standalone mass removal system is needed then the follow action will be taken: develop a preliminary design to establish extraction well (one year), locate properties to build a treatment plant in close proximity to a discharge basin (one year); negotiate property acquisition through lease or eminent domain (assume a minimum of two years); detailed design construction (one year); and startup.

Objective 3 – Evaluation of Additional (Non-Navy Property) Sources Contributing to the OU2 Plume and Surrounding Groundwater Commonly Referred to as the "Bethpage Plume"

The drilling priorities provided in Figure 4 will allow an evaluation of potential additional sources migrating from the north-northwest into the RE108 Hot Spot area. Potential additional sources include the Hooker/Ruco Superfund site, the New Cassel/Hicksville Groundwater Contamination Superfund site, and Bethpage Community Park (OU3 Plume). Specifically, VPB location 158 is expected to provide insight into the possibility of other sources and is expected to be completed in March 2015, weather

permitting. Subsequently, the Navy will continue to investigate additional potential (non-Navy property) sources near GM-38 (near BWD Plants 4 and 5) and near recently installed VPB-153.

The Navy can only take response actions for VOCs that are associated with the NWIRP. During the Navy's groundwater monitoring program, VOCs were periodically detected in Navy borings that were not associated with the NWIRP. This determination was based on the type of chemical, concentration, relative percentage of each chemical, location, and/or depth. Two common examples of these other VOCs are petroleum products and dry cleaning chemicals.

Downgradient Plume Area Evaluation

Objective 4 – Protection of South Farmingdale and Massapequa Water District Wells

The purpose of Objective 4 is to provide a strategy and mechanism for early warning in the event sampling indicates VOCs are migrating towards certain South Farmingdale Water District (SFWD) or Massapequa Water District (MWD) supply wells. This overall strategy of protecting water supply wells has been in place for several years and has included installation of outpost wells, which are situated at locations upgradient of certain public water supply wells. This strategy has enabled early installation of wellhead treatment at supply wells, such as SFWD Plants 1 and 3. The Outpost Monitoring Well Program is continuing to the south with the installation of new wells and groundwater quality monitoring.

Figure 6 provides the location of the current outpost wells. In the 2003 Public Water Supply Contingency Plan (PWSCP), trigger values, or values at which a response action is anticipated to be required to protect a water supply well through treatment, were developed through analytical groundwater modeling for nine wells. These trigger values are designed to provide enough early warning (5 years) in order to prepare the water supply well for appropriate treatment, taking into account expected groundwater travel velocity. Based on sampling performed over the last five years by the Navy, the SFWD Plant 6 and MWD wells are downgradient of the potential flow field of OU2 groundwater; therefore, outpost wells are currently being installed to address these water supply wells in advance of plume migration. Trigger values will be developed for these wells using methodology consistent with that developed in the PWSCP. All existing outpost wells are sampled on a quarterly basis; the SFWD and MWD outpost wells will be included in this sampling program once they are installed.

Figure 7 provides the location of the SFWD and MWD outpost wells currently being installed, including wells at VPB locations 151, 152, ,and 153 (to protect SFWD Plant 6 well 8864 and 8865), and VPB locations 145, 146, and 147 (to protect MWD-6442 and MWD-6443). Additional wells may also be needed in the future for enhanced protection of SFWD Plant 1 well 7377, located east of Oyster Bay State Parkway (Hwy 135) and south of Hempstead Turnpike.

Quarterly monitoring of outpost wells is scheduled to continue for one year. If no detections are reported then sampling frequencies will be reduced to semiannually and then to annually. In the event

that 0.5 ug/L is detected in an outpost well, sampling will be increased to quarterly. The Navy's best estimate of projected drilling schedule for outpost wells, providing no delays due to weather or logistics is included in Table 2.

Table 2. Drilling Schedule for MWD and SFWD VPBs and Outpost Wells

MWD	Status	Estimated Completion
VPBs	Completed	July 2014
Wells	In progress	March 2015
SFWD	**Status**	**Estimated Completion**
VPBs	Completed	December 2014
Wells	In progress	August 2015

Objective 5 – Evaluation of Southwestern Plume Finger near New York American Water (NYAW)

In 2007, Aqua New York (now NYAW) advised the New York State Department of Environmental Conservation, Navy and NG that VOCs had been detected in samples of raw water at their supply well without being detected in the outpost wells. Because the Aqua New York water supply well was directly affected, the Navy commenced design and construction of a treatment system for Aqua New York. An interim treatment system has been in place since April 2012, and full scale treatment started in January 2015. The monitoring well network for NYAW was completed in 2012. The monitoring well data will be used to provide information about potential future actions that may be required.

Recently, the Navy has been installing additional vertical profile borings and monitoring wells in the area of the aquifer near NYAW and SFWD Plants 3 and 6 to investigate VOCs in the groundwater. Although this area is not identified as a hot spot, if sufficient mass is present in this area, there may be benefit in extracting contaminant mass in this area, especially if existing infrastructure can be used. Next, the Navy plans to install water level data loggers in the monitoring wells in this area to evaluate the capture zones of the supply wells in this area. A pseudo-pump test that tracks the cycling on and off of the supply wells will be conducted in 2015. In 2016, the Navy expects to complete this investigation. USGS is assisting the Navy with groundwater modeling to help determine the fate of the VOCs in this area.

Schedule

The anticipated schedule of activities is presented in Table 3 and includes both short-term high priority tasks and long-term low- and medium-priority tasks. If a conflict for resources develops, high priority tasks will normally take precedence over lower priority tasks. The schedules presented in this plan are based on assumptions regarding the findings in each of the investigative areas.

The highest priority task for the Navy has been and will continue to be protection of the public's drinking water. Over the past several years, the Navy has installed VPBs and outpost monitoring wells for three water supply plants (SFWD Plants 1 and 3 and NYAW) and worked with and provided funding for three water supply plants that were potentially impacted by the VOCs (SFWD Plants 1 and 3 and BWD Plant 6). In addition, the Navy is or will be installing VPBs and outpost monitoring wells for SFWD Plant 6 and certain MWD wells which should be completed by September 2015. The monitoring wells are necessary to provide the information needed to determine if wellhead treatment may be required for these water supplies. Furthermore, the number of borings and wells required for delineation of the RE108 Hot Spot is dependent on the findings. Weather and logistics will play a role in execution of the schedule, but this table represents the Navy's best projection at this time.

Table 3 – Schedule

Area	Activity	Status	Dates
MWD Outpost Wells	Well Installation	In progress	Complete March2015
	Trigger Value Development	In progress	Preliminary Values complete in July 2015
	Well Sampling	Pending completion of wells	Start May 2015
SFWD Outpost Wells	Well Installation	In progress	Complete August 2015
	Trigger Value Development	In progress	Preliminary Values complete in July 2015
	Well Sampling	Pending completion of wells	Start October 2015
RE108 Hot Spot	Plume Delineation	In progress	Complete July 2016
	Interim Treatment (Well 6-2)	In planning phase	Start May 2015
	Effectiveness evaluation of BWD 6-2 in capturing RE108 Hot Spot	Pending completion of plume delineation	December 2016
	Design – Well Location	Dependent on pumping test and plume delineation	Complete June 2017
	Preliminary Treatment System Design, and Siting, if needed	Start January 2016	Complete December 2017
	Property Access/Lease Agreements	Start January 2018	December 2019 (assumed)
	Design	Pending Access/ Lease Agreements	December 2020
	Construction	Pending Town concurrence	May 2021
	Startup	Pending Town/ NYSDEC concurrence	June 2022