On-Site Containment System Hydraulic Effectiveness Work Plan

Northrop Grumman Systems Corporation, Bethpage, New York
NYSDEC Site 1-30-003A
December 6, 2011

1.0 Introduction

This Work Plan has been prepared by ARCADIS of New York, Inc. (ARCADIS) on behalf of the Northrop Grumman Systems Corporation (Northrop Grumman) and describes the approach for drilling vertical profile borings (VP) VP-3-1, VP-73R and VP- 33 (VP-74 is included as a contingency location) and for installing Monitoring Wells MW-3-1 and GM-73D3 at the Northrop Grumman facility in Bethpage, New York. This work is being conducted to further evaluate the effectiveness of the On-Site Containment (ONCT) System in preventing the off-site movement of volatile organic compound (VOC) impacted groundwater**.** Regional groundwater flow in the area of the Northrop Grumman facility is to the south/southeast, with a downward component, and is locally modified by pumping of public supply and remediation wells and discharge of water to recharge basins.

1.1 Background

The Northrop Grumman facility is located in the hamlet of Bethpage, Town of Oyster Bay in east-central Nassau County, Long Island, New York approximately 30 miles east of New York City (**Figure 1**). The facility at one time consisted of slightly more than 600 acres, of which 110 acres were owned by the US Navy (Navy) – a government owned-company operated (GOCO) facility. Beginning in the 1930s the Northrop Grumman facility (originally Grumman Aircraft Corporation) designed, tested, and built military aircraft, primarily for the Navy. Although the Navy owned a portion of the property, Northrop Grumman carried out site operations. Much of the facility has been sold and redeveloped over the ensuing years (**Figure 2).**

Because of the existence of on-site groundwater contamination and pursuant to the Operable Unit (OU) 2 Record of Decision (ROD) issued by the New York State Department of Environmental Conservation (NYSDEC), Northrop Grumman designed, constructed, and operates the ONCT system that consists of 5 deep remedial wells (Wells 1, 3, 17, 18, and 19-see **Figure 2**) that pump continuously at a rate of 3,800 gallons per minute (gpm; 5.5 million gallons per day [MGD]). Water from the wells is treated by two air strippers and then discharged primarily to the Northrop Grumman south basins with anywhere from 100 to 400 gpm going to the adjacent Calpine Energy generating facility for energy generation and up to 700 gpm going to the Northrop Grumman west basins. The purpose of the ONCT system is to prevent on-site groundwater, impacted with VOCs, from moving off-site. Data collected and evaluated (multiple lines of evidence) since early 1999, during quarterly and annual sampling and reporting rounds, indicate that the ONCT system is meeting its objective of preventing off-site movement of VOC-impacted groundwater. Furthermore, a study required by the NYSDEC OU 2 ROD and carried out by Navy and Northrop Grumman resulted in a report entitled “Operable Unit 2 Groundwater Remedial System Hydraulic Effectiveness Evaluation” (2003) which came to the same conclusion on the ONCT system as the quarterly and annual reports.

Although all data analyses to date have concluded that the ONCT system is working as designed, it is recognized that the monitoring well network (that provides much of the data upon which conclusions about the ONCT system effectiveness in meeting remedial goals are based) can be enhanced to allow more confident conclusions to be reached.

1.2 Objectives

The objective of the work outlined in this Work Plan is to provide additional monitoring points to help in assessing the effectiveness of the ONCT system in containing on-site VOC- impacted groundwater. The work discussed herein is a first phase and additional VPs and wells will be proposed through an addendum(s) to this Work Plan. The Navy is also planning deep VPs near the southern boundary of the Northrop Grumman facility and the work defined in this plan will be coordinated with the Navy to ensure consistency of approach to this deep drilling and to avoid duplication of efforts.

1.3 Scope

The scope of work consists of drilling, sampling of soil and groundwater, and analysis of groundwater samples for VOCs from 3 VPs (VP-3-1, VP-33 or VP-74 [if VP-33 is not accessible] and VP-73R) and the installing, developing, and sampling of two monitoring wells (MW-3-1 and GM-73D3) (**Figure 2**). VP-74 is not a replacement location for VP-33, as the 2 locations are separated by over 2,000 feet. Instead, VP-74 would be drilled as the next prioritized VP to keep the field work progressing if the VP-33 location is not immediately available due to access issues. VP drilling will extend into the Raritan confining unit (RCU) to ensure that all transmissive zones, through which VOC-impacted groundwater could migrate, have been identified. The RCU identification protocol (Appendix A) will be followed to ensure a standardized approach to identifying this unit.

2.0 Field Activities-Vertical Profile Borings/Monitoring Well

Table 1 contains the rationale for the proposed VP drilling and well installation. **Table 2** provides the details of the proposed VP drilling and sampling. **Table 3** summarizes the details of well construction and development and **Figure 3** is a generalized monitoring well construction diagram.

2.1 Sampling and Analysis

Sampling and laboratory protocols for the collection and analysis of water samples collected as part of this Work Plan and any subsequent addendum(s) will follow procedures detailed in the NYSDEC-approved OU2 Groundwater Monitoring Plan (ARCADIS 2001; 2006). Groundwater samples collected from VPs and monitoring wells will be submitted for laboratory analysis for the Target Compound List VOCs.

2.2 Health and Safety Plan

The health and safety procedures, detailed in the Site-Specific Health and Safety Plan (ARCADIS 2011), will be followed for work carried out according to this Work Plan and any subsequent addendum(s) to it.

2.3 Pumping Test Protocol

A protocol for conducting a pumping test(s) will be developed in a future Work Plan addendum and the test(s) will be conducted once all VPs and wells have been completed. The purpose of the pumping test(s) will be to obtain hydraulic information to use to further evaluate the effectiveness of the ONCT system in preventing the off-site movement of VOC-impacted groundwater. The test(s) will likely involve using pressure transducers to measure water-levels in select monitoring wells while turning one or more of the ONCT wells off and/or on.

2.4 Investigation Derived Waste

Investigation derived waste (IDW) produced during drilling and well development activities will be collected, containerized in 55-gallon drums, and temporarily stored at the Northrop Grumman facility before being characterized (as required by the disposal facility) and disposed off-site at an approved facility.

2.5 Decontamination

A decontamination pad will be located on Northrop Grumman property that will be used for the collection of all decontamination-generated fluids. These fluids will be collected and stored in drums, pending characterization sampling, and either discharged to the local Publically Owned Treatment works (POTW) or sent off-site for disposal.

2.6 Surveying

The locations of all VPs and wells will be surveyed to the North American Datum (NAD) 1983 to the nearest 0.1 foot by a New York State (NYS) licensed surveyor along with the measuring point elevation of the wells to the nearest 0.01 foot.

2.7 Reporting

Following the drilling/sampling of the VPs, the installing/developing/sampling of the monitoring wells, and data validation, the basic data will be submitted to the NYSDEC. An addendum describing the rationale and details for any additional VPs and monitoring wells will be submitted to the NYSDEC after the basic data report. An interpretative report will be prepared after all work proposed in this Work Plan and any subsequent addendum(s) is completed.

3.0 References

ARCADIS 2011. Site Specific Health and Safety Plan, Northrop Grumman Systems Corporation, October 2011.

ARCADIS G&M, Inc. 2006. Petition for Recommended Modifications to the Operable Unit 2 Groundwater Monitoring Plan, Northrop Grumman Corporation, Bethpage, New York. June 2006.

ARCADIS Geraghty & Miller, Inc. 2001. Operable Unit 2 Groundwater Monitoring Plan. Northrop Grumman Corporation, Bethpage, New York. May 11, 2001.

Tables

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Table 1. Rationale for Proposed Well and Vertical Profile Borings, ONCT System Hydraulic Effectiveness Evaluation, Operable Unit 2, Northrop Grumman Systems Corporation, Bethpage, New York.

Location	Action Planned	Intermediate Monitoring Well	Deep Monitoring Well	Deep 2 Monitoring Well	Deep 3 Monitoring Well	Rationale
Proposed VP/Wells						
VP3-1	Drill/sample new VP3-1	--	--	***PROPOSED Well MW3-1***	--	1.) Objective of VP3-1 is to collect additional geologic information and groundwater quality data that will provide additional horizontal and vertical characterization/delineation of VOCs in groundwater at the western boundary of the NG site, near the Well 3, to the base of the Magothy aquifer. 2.) Based on the results of VP3-1, Monitoring Well MW3-1 will be installed to monitor groundwater quality and water levels at the western boundary of the NG site. Table 2 provides proposed groundwater and split-spoon sampling intervals.
VP-33	Drill/sample new VPB-33	--	--	EXISTING Well GM-33D2	--	Objective of VP-33 is to collect additional geologic information and groundwater quality data near existing Monitoring Well GM-33D2 that will provide additional horizontal and vertical characterization/delineation of VOCs in groundwater at the southwestern boundary of the NG site, near the on-site containment system, to the base of the Magothy aquifer. Table 2 provides proposed groundwater and split-spoon sampling intervals.
VP-73R/ GM-73D3	Drill/sample new VPB-73R. Install new Monitoring Well GM-73D3	--	EXISTING Well GM-73D	EXISTING Well GM-73D2	***PROPOSED Well GM-73D3***	1.) Objective of VP-73R is to collect additional geologic information and groundwater quality data near former VP-73 and existing Monitoring Well Cluster GM-73 that will provide additional horizontal and vertical characterization/ delineation of VOCs in groundwater at the southern boundary of the NG site, near the on-site containment system, to the base of the Magothy aquifer. 2.) Based on the results of VP-73R, Monitoring Well GM-73D3 will be installed at existing GM-73 well cluster to monitor groundwater quality and water levels at the southern boundary of the NG site. Table 2 provides proposed groundwater and split-spoon sampling intervals. Table 3 provides proposed well construction details.
Contingency VP						
VP-74	Drill/sample new VP-74	EXISTING Well GM-74I	EXISTING Well GM-74D	EXISTING Well GM-74D2	--	Objective of VP-74 (if drilled) is to collect additional geologic information and groundwater quality data that will provide additional horizontal and vertical characterization/delineation of VOCs in groundwater at the southern boundary of the NG site, near the on-site containment system, to the base of the Magothy aquifer. Table 2 provides groundwater and split-spoon sampling intervals.

Notes

VP and monitoring wells will be drilled by mud rotary methodology

NG Northrop Grumman Systems Corporation
VP vertical profile boring
-- No proposed/existing well located at this depth.
VOCs volatile organic compounds

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Table 2. Proposed Vertical Profile Boring Drilling/Sampling Details, ONCT System Hydraulic Effectiveness Evaluation, Operable Unit 2, Northrop Grumman Systems Corporation, Bethpage, New York.

Sample Location	Sampling Intervals (ft bls)	Split-Spoon Sampling Frequency (ft)	Hydropunch Groundwater Sampling Frequency (ft)	Groundwater Laboratory Analysis [5]	Borehole Geophysical Logging
Proposed VPs					
VP-3-1	Water Table[2] to 300	20	50	TCL VOC	Gamma/ Spontaneous Potential/Resistivity
	300 - 430	20	20	TCL VOC	
	430 - 570	5	10	TCL VOC	
	570 - 630	10	20	TCL VOC	
	630 - Raritan Clay[3]	5	20	TCL VOC	
	Raritan Clay - End of Boring[4]	Continuous	Sand Units Only	TCL VOC	
VP-33	Water Table[2] to 400	50	50	TCL VOC	Gamma/ Spontaneous Potential/Resistivity
	400 - 630	20	20	TCL VOC	
	630 - Raritan Clay[3]	5	20	TCL VOC	
	Raritan Clay - End of Boring[4]	Continuous	Sand Units Only	TCL VOC	
VP-73R[1]	Water Table[2] to 400	50	0		Gamma/ Spontaneous Potential/Resistivity
	400 - 630	20	20	TCL VOC	
	630 - Raritan Clay[3]	5	20	TCL VOC	
	Raritan Clay - End of Boring[4]	Continuous	Sand Units Only	TCL VOC	
Contingency VP					
VP-74 [6]	Water Table[2] to 400	50	50	TCL VOC	Gamma/ Spontaneous Potential/Resistivity
	400 - 630	20	20	TCL VOC	
	630 - Raritan Clay[3]	5	20	TCL VOC	
	Raritan Clay - End of Boring[4]	Continuous	Sand Units Only	TCL VOC	

Footnotes:

(1) VP-73R will be drilled next to VP-73 drilled by Navy in 2002; VOC exceedences detected in VP-73 were at approximately 400 ft bls.

(2) Water table is approximately 50 ft bls.

(3) The Raritan Confining Unit is estimated to be in the range of 650 to 700 ft bls.

(4) Split-spoon sampling/Hydropunch groundwater sampling frequency near the anticipated depth of the Raritan and the decision to terminate drilling of VPBs will be based on the Raritan Identification Protocol (Appendix A).

(5) Laboratory analysis of groundwater samples will be performed for the TCL List of VOCs using NYSDEC ASP 2000 Method OLM 4.2. Results will be obtained on a 24 hour TAT.

(6) VP-74 is provided as an alternate location if access is not granted at VP-33 in a timely manner.

Definitions:

ONCT	On-Site Containment
ft bls	feet below land surface
VP	vertical profile boring
TAT	turnaround time
TCL	target compound list
VOC	volatile organic compound
NYSDEC	New York State Department of Environmental Conservation
ASP	Analytical Services Protocol

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Table 3. Summary of Proposed Monitoring Well Constuction Details, ONCT System Hydraulic Effectiveness Evaluation, Operable Unit 2, Northrop Grumman Systems Corporation, Bethpage, New York.

Well Identification	Nominal Borehole/ Well Diameter (in)	Casing/ Screen Material	Screen Slot Size (in)	Screen Length (ft)	Well Development Method	Protective Casing Diameter/Type	Proposed Groundwater Sampling [3]
Proposed Wells							
MW3-1[1]	10 / 4	Sch. 80 PVC/SS	0.02	20	AL/PS	8" FM	TCL VOCs
GM-73D3[2]	10 / 4	Sch. 80 PVC/SS	0.02	20	AL/PS	8" FM	TCL VOCs

Footnotes

(1) Total depth and screened interval of the monitoring well will be determined upon completion of Vertical Profile Boring VP3-1. Well specifications may be modified in the field based on site conditions.

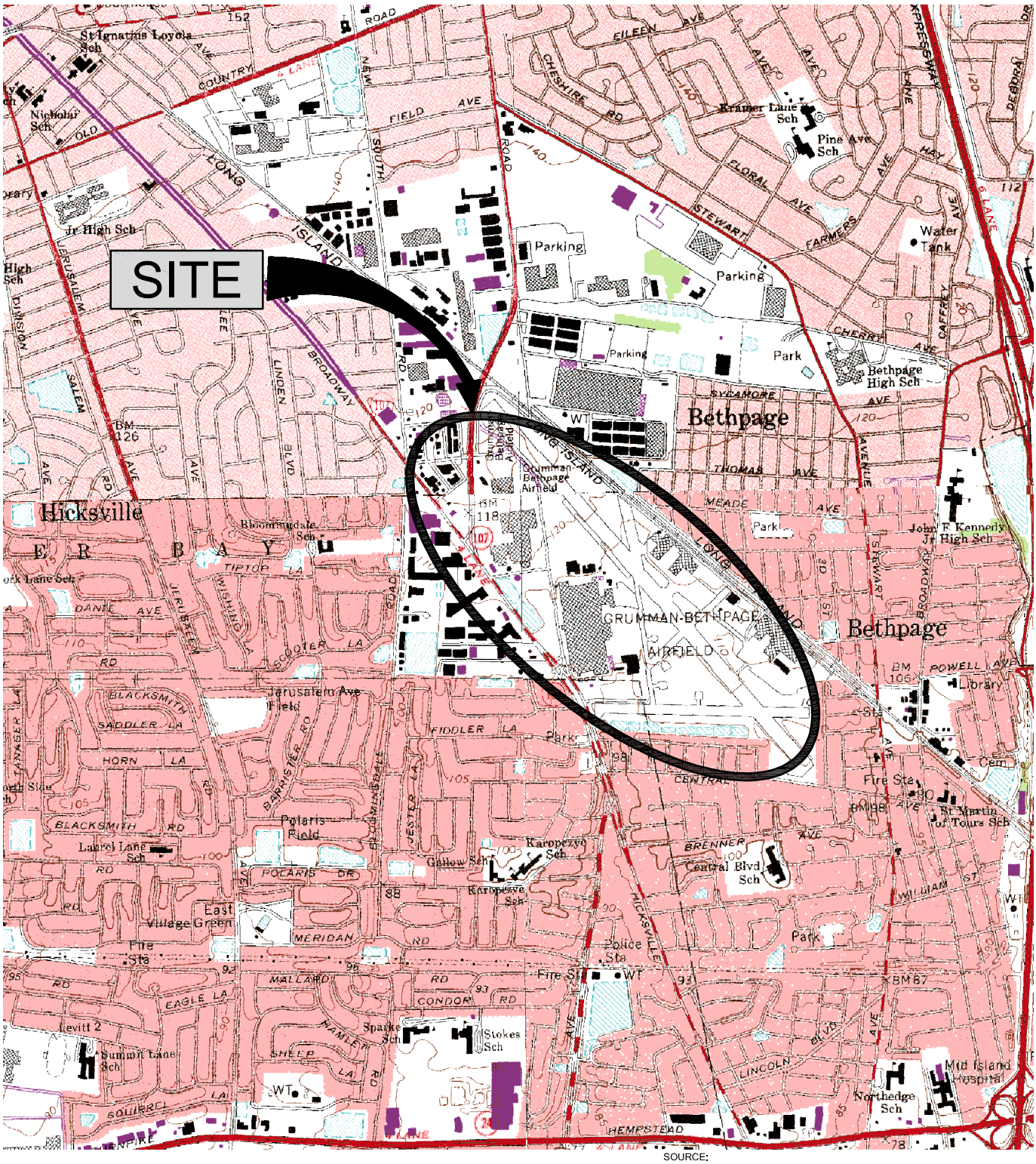
(2) Total depth and screened interval of the monitoring well will be determined upon completion of Vertical Profile Boring VP-73R. Well specifications may be modified in the field based on site conditions.

(3) Wells will be sampled a minimum of 2 weeks after installation. Laboratory analysis of groundwater samples will be performed for the TCL List of VOCs using NYSDEC ASP 2000 Method OLM 4.2. Results will be obtained on a 2-week TAT.

Definitions

ONCT	On-Site Containment System
SS	Stainless Steel wire-wrapped
PVC	Polyvinyl chloride
in	inches
ft	feet
FM	Flush Mount
AL/PS	Air Lift/Pump and Surge
TAT	turnaround time
TCL VOCs	Target Compound List of Volatile Organic Compounds

Figures



SOURCE:
USGS 7.5 MIN. AMITYVILLE QUADRANGLE, AMITYVILLE, N.Y., 1994,
FREEPORT QUADRANGLE, FREEPORT, N.Y., 1994,
HICKSVILLE QUADRANGLE, HICKSVILLE, N.Y., 1967, PHOTOREVISED 1979,
HUNTINGTON QUADRANGLE, HUNTINGTON , N.Y., 1967, PHOTOREVISED 1979

0 2000' 4000'

SCALE IN FEET

NORTHROP GRUMMAN SYSTEMS CORPORATION
BETHPAGE, NEW YORK
OPERABLE UNIT 2

SITE LOCATION

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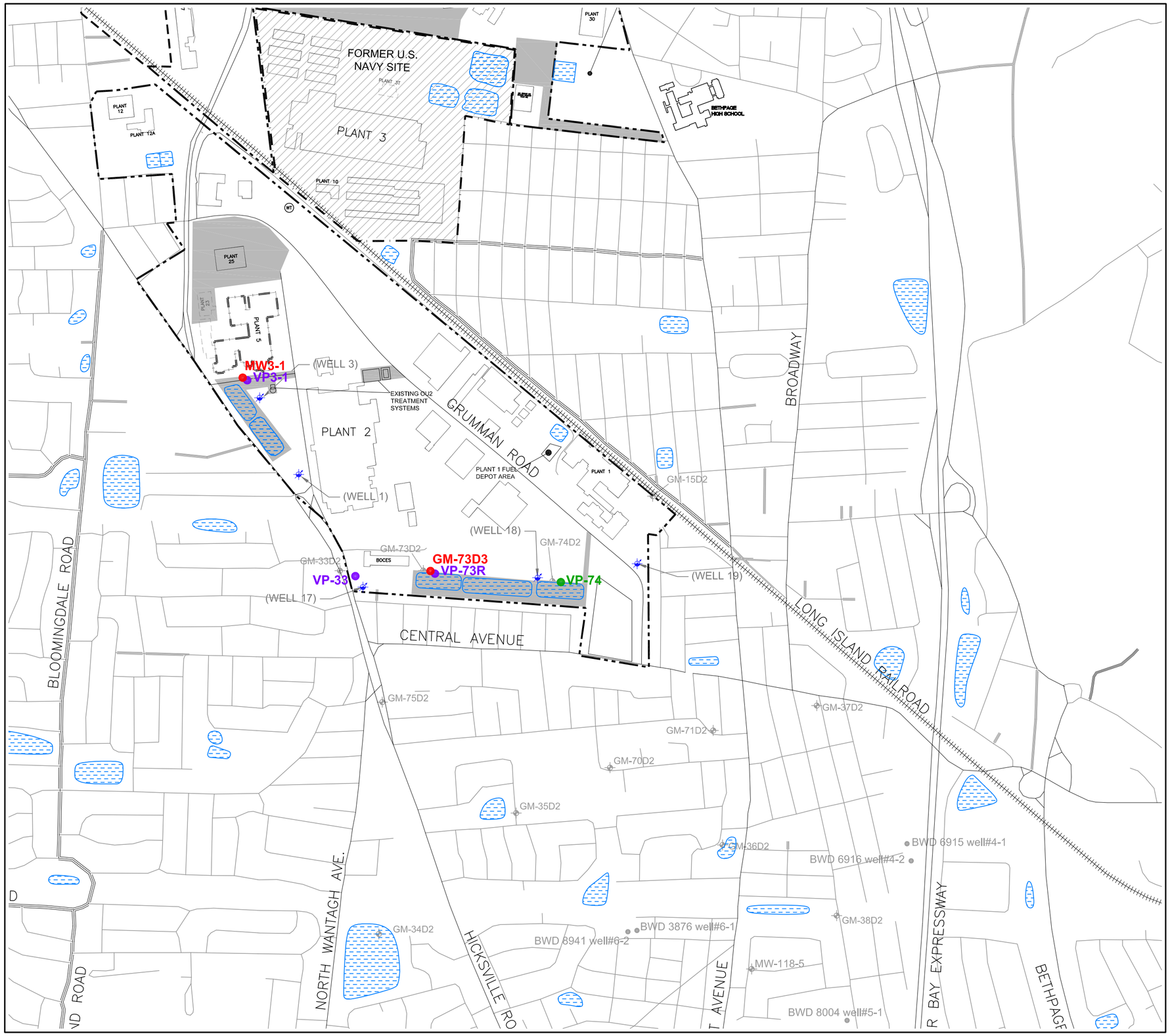
FIGURE
1

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\Melville-NY\ACTIVITY\001496\0411\WorkPlan\WorkPlan_01&03.dwg LAYOUT: 1 SAVED: 11/9/2011 11:21 AM ACADVER: 18.0S (LMS TECH) PAGESETUP: --- PLOTSTYLETABLE: --- PLOTTED: 11/9/2011 12:16 PM BY: SANCHEZ, ADRIAN
XREFS: IMAGES: PROJECTNAME: ---
AMITYVILLE.TIF
FREEPORT.TIF
HICKSVILLE.TIF
HUNTINGTON.TIF



0 800' 1600'

SCALE IN FEET

N

EXPLANATION

- PROPERTY BOUNDARY OF THE FORMER GRUMMAN AEROSPACE SITE
- PROPERTY BOUNDARY OF THE FORMER U.S. NAVY SITE
- LONG ISLAND RAILROAD
- NORTHROP GRUMMAN OWNED PROPERTY (AS OF 2003)
- FORMER U.S. NAVY OWNED PROPERTY
- RECHARGE BASIN
- OU-2 OPERABLE UNIT 2
- PUBLIC SUPPLY WELL
- OU-2 REMEDIAL WELL
- MONITORING WELL INCLUDED IN THE OU-2 MONITORING NETWORK

NOTES:

1. NORTHROP GRUMMAN REMEDIAL WELLS 1, 3, 17, 18, AND 19 SCREENED IN DEEP 2 ZONE.
2. BETHPAGE WATER DISTRICT WELL 3876 SCREENED IN DEEP ZONE.
3. BETHPAGE WATER DISTRICT WELLS 6915, AND 8004 SCREENED IN DEEP 2 ZONE. BETHPAGE WATER DISTRICT WELLS 6916 AND 8941 SCREENED IN DEEP 3 ZONE.

PROPOSED ACTIVITIES

- VERTICAL PROFILE BORING (VPB)
- PROPOSED MONITORING WELL
- CONTINGENCY WELL/ VPB

NORTHROP GRUMMAN SYSTEMS CORPORATION
BETHPAGE, NEW YORK
OPERABLE UNIT 2

PROPOSED AND EXISTING MONITORING WELLS AND PROPOSED VPB LOCATIONS DEEP 2 AND DEEP 3 ZONE

ALL COORDINATES REFERENCED TO NORTH AMERICAN DATUM 1983

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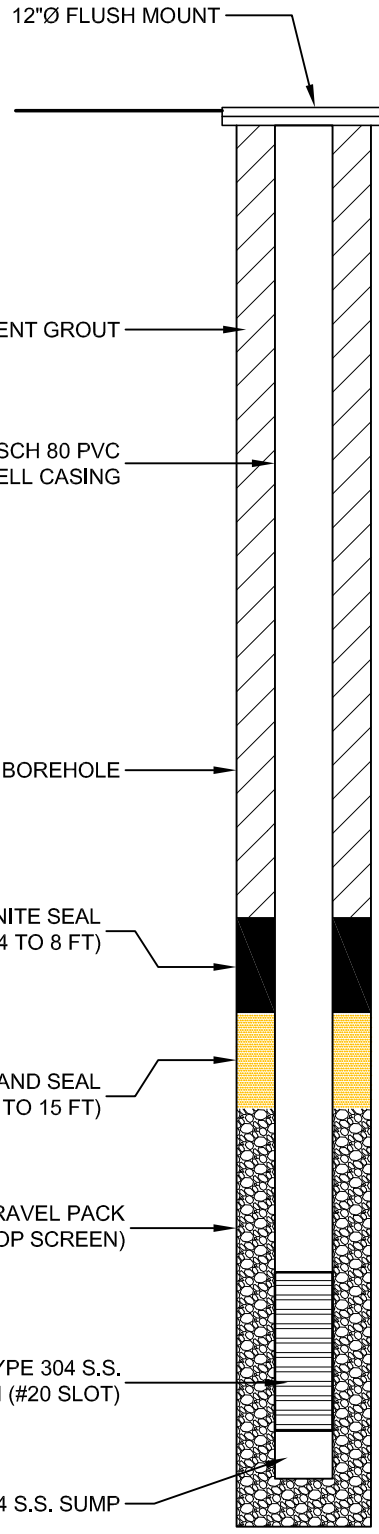
FIGURE 2



NOTES:

1. WELL CONSTRUCTION DEPTHS AND RELATED WELL CONSTRUCTION ITEMS (i.e., SCREEN LENGTHS/SLOT SIZE, GRAVEL PACK) ARE APPROXIMATE. WELL DESIGN WILL BE FINALIZED BASED ON VERTICAL PROFILE BORING RESULTS.

DRAWING NOT TO SCALE

NORTHROP GRUMMAN SYSTEMS CORPORATION
BETHPAGE, NEW YORK
OPERABLE UNIT 2

PROPOSED MONITORING WELL CONSTRUCTION DETAIL

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FIGURE
3

Appendix A

Raritan Confining Unit Field Identification Protocol

Introduction

The protocol described herein provides a standardized approach for field identification of the Raritan confining unit (RCU) (i.e., the hydrogeologic designation for the unnamed clay member of the Upper Cretaceous- age Raritan Formation on Long Island, New York). This protocol is intended as guidance for field geologists/scientists during oversight of drilling for selecting split-spoon sampling and Hydropunch groundwater sampling intervals and the depth to terminate borings. While this protocol was specifically prepared for field staff overseeing the drilling and sampling of deep boreholes that are part of the On-site Containment (ONCT) System evaluation program, this protocol will be useful to other investigators in confidently identifying this unit. This protocol is intended to be a flexible field guide that can be adjusted to fit site-specific field conditions based on the geologists/scientists experience. This protocol stresses the need to adequately identify the transmissive zones of the Magothy aquifer and to a lesser extent any that may exist in the upper portion of the RCU through which advective transport of impacted groundwater could occur as well as the vertical extent of volatile organic compound (VOC) contamination in those formations.

Raritan Confining Unit and Magothy Aquifer Lithology

According to Smolensky and others (1989), the RCU typically consists of solid and silty clay with a few lenses and layers of sand. Lignite and pyrite are commonly found in the unit and colors typically found are red, brownish-red, gray, pink, and white, commonly variegated (i.e., having discrete markings of different color). The overlying Magothy aquifer is, in general, an upward fining sequence that typically includes fine to medium sand which is clayey in part, interbedded with lenses and layers of coarse sand and sandy and solid clay. Gravel is common in the basal portions of the Magothy. Sand and gravel are quartzose; lignite, pyrite, and iron oxide concretions are common. Colors typically found are gray, with lesser amounts of white, red, brown, or yellow.

Procedures for Implementing the Protocol

The following are procedures for identification and characterization of the RCU and a framework for staff to make field decisions.

1. Review applicable literature

a. Review Smolensky and others (1989)-“Hydrologic Framework of Long Island, New York” and specifically Sheet 2 of 3- the map showing the “Altitude of the Upper Surface of the Raritan Confining Unit” to obtain an initial indication of the expected altitude of the top of the RCU at a planned drilling location(s) by locating the proposed borehole(s) to be drilled on this map. For convenience in the field during drilling oversight, use a topographic map of the area or a nearby surveyed elevation to convert the expected RCU altitude to a depth in feet below land surface.

b. Review Buxton and others (1989)-“Hydrogeologic Correlations for Selected Wells on Long Island, New York-A data base with retrieval program” which is the companion publication to the Smolensky report referenced above and contains the basic data on which that report was based. Look in the Buxton report for wells near the planned drilling location(s) to obtain more site specific information to refine the expected depth to the RCU.

2. Drilling and split-spoon sampling

a. Communicate the objective of the borehole to the driller before commencing drilling and maintain communication throughout the borehole drilling to obtain his observations on material being penetrated by the drill bit. Ask him to tell you when he is drilling in sand or gravel and when he believes the borehole is penetrating clay or silt. Periodically note the drilling fluid pressure (if using a fluid based drilling technique and the rig has such a gage) as pressure increases may indicate penetration of a low permeability layer such as silt or clay.

b. While drilling through the Magothy aquifer, examine and describe split-spoon samples for evidence of the RCU based on the general descriptions given in the above-referenced literature for these units. If drilling is carried out using drilling fluid, note any color changes in the fluid that might indicate that the RCU has been reached. Generally, the Magothy tends to be gray with some white, but the RCU tends to be red, brownish-red, and pink. The red to brownish-red RCU frequently contains very thin white layers, which collectively can produce a pinkish color in the drilling fluid once the RCU has been penetrated.

c. Be aware that the basal zone of the Magothy aquifer is typified by coarse sand and gravel, and small cobbles have even been encountered in this horizon. The basal Magothy coarse zone may be tens of feet thick and at some locations may be up to 75 to 100 feet thick. This horizon is reflective of a high energy environment and many times will stand in stark contrast to the fine sediment of the low energy environment of the underlying RCU.

d. Once the borehole reaches a depth close (e.g., within 20 feet) to the anticipated depth of the surface of the RCU based on the literature, increase the split-spoon sampling frequency to every 5 feet. After the first spoon sample suggestive of the RCU is observed go to continuous split-spoon sampling over the following 10-foot interval. If this 10-foot interval is predominately clay diagnostic of the RCU, the borehole can be terminated pending further characterization as described below in 3b.

e. If during split-spoon sampling it is no longer possible to advance the split spoon (i.e., refusal is reached-decided in the field with driller input) then the driller will be instructed to complete drilling of the borehole to the full depth of what would have been the 10-foot split-spooned interval and then steps 2f through 3b will be carried out. If the geophysical logging indicates that the portion of the 10 foot interval that was not split-spooned is predominately clay then the borehole can be terminated. However, if the geophysical logging indicates that the portion of the 10 foot interval that was not split-spooned is not predominately clay then a decision should be made, with office project management staff, to either attempt to conduct split-spoon sampling over an additional 10 foot interval or terminate the borehole.

f. Once the drilling has been terminated, if using a fluid based drilling system, request the driller to slowly re-drill the last 10-foot interval to ensure that any swelling of the clay into the borehole is overcome and the borehole remains open to its full drilled diameter. Also, ask the driller to continue to circulate the drilling fluid until all entrained sediment has reached the fluid pit and settled out to the extent practical. The purpose of these procedures is to help ensure that the borehole remains open to its full drilled depth so that geophysical logging can be effectively carried out.

3. Geophysical logging

a. Have the driller pull the rods from the borehole and then proceed with geophysical logging of the borehole, including a gamma ray log.

b. Review the split-spoon geologic descriptions and compare to the gamma ray log to confirm that the RCU has been reached and is predominately clay and, if confirmed, then drilling can be considered terminated.

4. **VOC sampling**

a. If the 10-foot continuously split-spooned sample interval is predominately clay diagnostic of the RCU but contains sand zones of a foot or more in thickness then an attempt should be made to collect a water quality sample from each of those sand zones with a Hydropunch sampler or equivalent device. All water samples collected as part of this protocol will be analyzed for VOCs by a fixed location laboratory on a 24-hour turnaround basis. It is recognized that since each Hydropunch water quality sampling attempt will be made prior to collecting the next split-spoon sample, there is no guarantee that the Hydropunch sampling attempt will be in a sand zone. Therefore, the attempt may not be successful in obtaining water. Regardless, the attempt should be made. If a sample is obtained and is free of VOCs or multiple samples are obtained and all or the deepest sample is free of VOCs, then the borehole drilling will be terminated after the 10 feet of continuous sampling is complete, and above steps 2f through 3b should be carried out.

   If water quality samples cannot be obtained, then a decision should be made, with office project management staff, whether to split-spoon sample an additional 10 feet and attempt to collect water quality samples from any sand zones or to terminate the borehole. One logistical issue that will need to be resolved is that VOC results will not be immediately available and so decisions to temporarily suspend drilling or continue will have to be made based on when in the work day the water quality sample is collected, when the VOC results will be available, and what other tasks the driller may be able to do while waiting for analytical results so that standby time can be minimized.

b. If the water quality sampling and analysis of the only sand zone or the deepest sand zone in the RCU contains elevated levels of Total VOCs (i.e., 100 ug/l or greater) then continuous split-spoon sampling over a second 10-foot interval should be carried out. If this 10-foot interval is predominately clay, diagnostic of the RCU, then terminate drilling of the borehole and follow steps 2f through 3b above.

c. If the second 10-foot continuously split-spooned sample interval is predominately clay diagnostic of the RCU but contains sand zones of a foot or more in thickness then an attempt should be made to collect a water quality sample from each sand zone, with a Hydropunch sampler or equivalent device. If all samples or the deepest sample is free of VOCs then the borehole drilling will be terminated after the additional 10 feet of continuous sampling is complete and above steps 2f through 3b should then be carried out.

d. If the water quality sampling of the only or the deepest sand zone in the second split-spooned interval of the RCU contains elevated levels of VOCs, than a decision will be made, with office project management staff, on whether to continue drilling/sampling or to terminate the borehole. When the borehole is terminated the above steps 2f through 3b should be carried out.

The rationale for the VOC sampling protocol is that 10 feet (or more) of relatively solid clay or clay with sand layers with no VOC detections (or no detections in the deepest sample) are sufficient evidence that the bottom of the transmissive zones of the Magothy or similar zones in the RCU have been identified and penetrated.