REMEDIAL OPTIONS REPORT

GRUMMAN AEROSPACE-BETHPAGE FACILITY

(NYSDEC Site Number 130003)

NYSDEC STANDBY ENGINEERING CONTRACT

Work Assignment #D007625-23

PREPARED FOR

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

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1,1-DCA	1,1-Dichloroethane
1,1-DCE	1,1-Dichloroethene
1,1,2-TCA	1,1,2-Trichloroethane
1,2-DCE	cis-1,2-Dichloroethene
1,2-DCA	1,2-Dichloroethane
6 NYCRR	Title 6 of the New York Code of Rules and Regulations
ARAR	Applicable or Relevant and Appropriate Requirements
AS	Air Sparging
BCP	Bethpage Community Park
bgs	below ground surface
BNR	Biological Nutrient Removal
BWD	Bethpage Water District
CCWPCP	Cedar Creek Water Pollution Control Plant
CERCLA	Superfund or Comprehensive Environmental Response, Compensation, and Liability Act of 1980
cfs	cubic feet per second
CHP	Catalyzed Hydrogen Perioxide
CVOCs	Chlorinated Volatile Organic Compounds
DER	Division of Environmental Remediation
DNAPL	Dense Non-Aqueous Phase Liquids
ERD	Enhanced Reductive Dechlorination
ERH	Enhanced Resistive Heating
FRTR	Federal Remediation Technology Roundtable
FS	Feasibility Study
ft/d	feet per day
GABF	Grumman Aerospace-Bethpage Facility
GAC	Granulated Activated Carbon
gpd	gallons per day
gpm	gallons per minute
GRA	General Response Actions
GWQS	Groundwater Quality Standards
HDPE	High Density Polyethylene
HDR	Henningson, Durham, and Richardson Architecture and Engineering P.C.
IC	Institutional Control
IRM	Interim Remedial Measure
ISCO	In-Situ Chemical Oxidation
ISTD	In-Situ Thermal Desorption
LTM	Long Term Monitoring
LWD	Levittown Water District
MCL	Maximum Contaminent Level

List of Acronyms (continued)

MGD	Million Gallons per Day
mg/l	milligrams per liter
MNA	Monitored Natural Attenuation
msl	Mean Sea Level
MWD	Massapequa Water District
NASA	National Aeronatics and Space Administration
NAPL	Non-Aqueous Phase Liquid
NGBF	Northrop Grumman Bethpage Facilities
NGSLP	Northrop Grumman Steel Los Plant 2
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NWIRP	Naval Weapons Industrial Reserve Plant
NYAW	New York American Water
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
O&M	Operation and Maintenance
ONCT	Onsite Containment System
OU	Operable Unit
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethene also known as Perchloroethylene
PDI	Pre-Design Investigation
POTW	Publicly Owned Treatment Works
ppm	parts per million
PRAP	Proposed Remedial Action Plan
PRB	Permeable Reaction Barrier
PVC	Polyvinyl chloride
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
SEAR	Surfactant-Enhanced Aquifer Remediation
ROR	Remedial Options Report
SEE	Steam Enhanced Extraction
SFWD	South Farmingdale Water District
SSP	Southern State Parkway
SPDES	State Pollutant Discharge Elimination System
SVE	Soil Vapor Extraction
SVOCs	Semi-Volatile Organic Compounds
TBC	To Be Considered
TCE	Trichloroethene

List of Acronyms (continued)

TCH	Thermal Conductive Heating
TDS	Total Dissolved Solids
TSDF	Treatment, Storage and Disposal Facility
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOCs	Volatile Organic Compounds
WA	Work Assignment
ZVI	Zero-Valent Ion

EXECUTIVE SUMMARY

Under Chapter 543 of the Laws of 2014, Navy Grumman Plume Review, the New York State Department of Environmental Conservation is required to prepare a report delineating options for intercepting and remediating the groundwater plume associated with the Grumman Aerospace – Bethpage Facility located in the Town of Oyster Bay, Nassau County, New York. In support of this effort Henningson, Durham & Richardson Architecture and Engineering, P.C. has prepared this Remedial Options Report to evaluate potential remedial options, costs, and timetables for implementation. The Grumman Aerospace –Bethpage Facility is currently listed on the New York State Registry of Inactive Waste Disposal Sites and includes the Northrop Grumman Bethpage Facilities, the Naval Weapons Industrial Reserve Plant, and the Northrop Grumman-Steel Los Plant 2 (NYSDEC Site #130003A/B/C).

Groundwater that emanated from Northrop Grumman Bethpage Facilities, the Naval Weapons Industrial Reserve Plant, the Northrop Grumman-Steel Los Plant 2, and the Bethpage Community Park-Former Grumman Settling Ponds contains hazardous chemicals above the maximum contaminant level. This groundwater is migrating to the south-southeast impacting local water supplies, and potentially impacting additional public water supply wells and other natural resources in its path.

Numerous technologies can be used to intercept or remediate this groundwater. Many remedial technologies (e.g., chemical oxidation, air sparging, or enhanced reductive dechlorination) can not be practically implemented given the extremely large area (i.e., roughly 5 square miles), the large depths (i.e., greater than 800 feet below ground surface) of groundwater containing hazardous chemicals, and the sub-urban area/population density.

Hydraulic capture is one of the few remedial technologies that can be implemented to capture or intercept groundwater over a large area and depth in these hydrogeologic conditions. Hydraulic capture is successfully used to intercept groundwater with hazardous chemicals at many Inactive Waste Disposal Sites in Nassau County. Therefore, it has a high level of scientific and engineering surety.

One of the greatest challenges with implementing a hydraulic capture remedy in Nassau County is identifying the land to build the groundwater extraction and treatment facility and determining how and where to dispose of the treated water. In addition there are challenges associated with disrupting the roads to excavate for pipelines to convey the water from the extraction point, to treatment plant(s), and finally to the discharge location. These are significant stakeholder challenges and a successful project of this magnitude and complexity will require the cooperation of many stakeholders.

Three hydraulic containment remedial options have been developed in this document. Each Remedial Option[1] is described below.

- Remedial Option 1: A series of extraction wells installed along the right-of-way of Southern State Parkway would be pumped to capture the groundwater plume, a new centralized treatment plant would be built, and the water would be treated to surface water standards prior to discharge to Massapequa Creek.

- Remedial Option 2: A series of extraction wells positioned in or near existing Nassau Country stormwater recharge basins would capture the groundwater plume, the Cedar Creek Water Pollution Control Plant would be upgraded to receive the additional flow, and the water treated to meet the wastewater treatment plants discharge limits prior to being discharged to the plants outfall (3 miles off-shore in the Atlantic Ocean).

- Remedial Option 3: A series of extraction wells installed in or near existing Nassau Country recharge basins along with three existing Public Water Supply Wells would be pumped to capture the groundwater plume, the Cedar Creek Water Pollution Control

[1] Each option also assumes certain common elements that include a Long Term Monitoring Plan (LTMP) and Institutional Controls (ICs) as appropriate. The LTMP specifically outlines the monitoring and data collection efforts to evaluate the performance of the option. ICs are legal and administrative mechanisms to restrict or control the site. Commonly a groundwater use restriction would be included as an IC within the boundaries of the site.

Plant would be upgraded to receive additional flow, and the water treated to meet the wastewater treatment plants discharge limits prior to being discharged to the plants outfall (3 miles off-shore). This option would require the replacement of three Public Water Supply Wells.

All three remedial options could be effectively constructed to achieve the Remedial Action Objectives and protect the Massapequa and other Public Water Supply Wells; however, all three of the remedial options will result in the loss of hundreds of billions of gallons of freshwater from a sole source aquifer.

Recharging treated groundwater from the hydraulic containment system comes with challenges. Even though the treated water could be recharged to the aquifer using recharge basins or injection wells, the use of these technologies comes with challenges associated with the scale or magnitude of the amount of water. For example, recharging a few million gallons per day of water with recharge basin or injections is feasible and has been successfully completed at many projects on Long Island. However, 10-20 million gallons per day can become impracticable requiring 30-60 acres of recharge basins and 20-50 injection wells.

Direct reuse of the water after wellhead treatment has been proven to be an effective approach to achieve the Remedial Action Objectives and protect the health and welfare of the public and the environment. The treatment of this water would be no different than what has been done by many water purveyors in Nassau County for many decades. This approach would be safe and effective but would require considerable planning and cooperation between stakeholders and water providers to implement. The primary advantage of this option would be the elimination of the need to 'dispose' of the treated water that after treatment would be suitable for drinking. This option although not within Chapter 543 of the Laws of 2014 would provide a long-term manageable solution, reduce the overall costs, and not result in a loss of Nassau County's precious water resources.

1.0 INTRODUCTION

Henningson, Durham & Richardson Architecture and Engineering, P.C. (HDR) prepared this Remedial Options Report (ROR) to evaluate remedial options for intercepting and remediating a groundwater plume of contaminants emanating from the former Naval Weapons Industrial Plant (NWIRP) and the Grumman Aircraft Engineering Corporation facilities (GABF)located in the Town of Oyster Bay, Nassau County, New York (Figure 1-1). The GABF is currently listed on the New York State Registry of Inactive Waste Disposal Sites as a Class 2 Site and includes the Northrop Grumman Bethpage Facilities (NGBF), the Naval Weapons Industrial Reserve Plant (NWIRP), and the Northrop Grumman-Steel Los Plant 2 (NYSDEC Site #130003A/B/C). As a Class 2 Registry Site, these sites pose a significant threat to the public health or environment and additional action is required.

Under Chapter 543 of the Laws of 2014, Grumman Plume Review, the New York State Department of Environmental Conservation's (NYSDEC) is required to prepare a report delineating options for intercepting and remediating the groundwater plume in this area. In support of this directive from the Legislature, the NYSDEC Division of Environmental Remediation (DER) has issued this Work Assignment (WA# 23) to HDR under contract D007625 to prepare the ROR for the GABF. HDR has prepared this ROR in substantial conformance with HDRs approved scope of work for this Work Assignment. The ROR evaluates state of the art remediation practices, including hydraulic containment, that are capable of removing site-related hazardous chemicals from the groundwater, primarily chlorinated volatile organic compounds (CVOCs) that are found above the NYS drinking water standards.

The GABF was originally listed on the Registry in 1983 and significant progress has been made towards removing the various sources of the contamination. This ROR assumes that the previously established remedial goals for what would generally be referred to as the "source areas" will be achieved and this report focuses on using hydraulic containment to halt and remediate the deep groundwater plume that is currently impacting or potentially impacting local water supplies. Although the ROR provides a comprehensive overview of the remedial options, potential costs, and timetable for implementation it is beyond the scope of the work assignment to evaluate each option to the level that would allow the NYSDEC to propose a remedial action plan (or PRAP) to design and implement the preferred remedy.

1.1 General Site Description

The former GABF, including the NGBF and the NWIRP was situated on 605 acres in the Town of Oyster Bay, Bethpage, N.Y. The Northrop Grumman Corporation was established in the early 1930s, and NWIRP was established in 1941. Activities conducted at these facilities included engineering, administrative, research and development, and testing operations, as well as manufacturing operations for the Navy and the National Aeronautics and Space Administration (NASA). The facility also had an active airfield to support the testing and manufacturing of various aircraft. The manufacturing portion of the NGBF and the NWIRP are now closed. The facility is surrounded by industrial and commercial facilities along with several residential communities.

Formerly known as the Grumman Site (Site No. 130003), the NGBF consisting of roughly 600 acres was listed on the Registry of Inactive Hazardous Waste Disposal Sites in New York State in 1983 (Site No. 130003 as defined did not include the Bethpage Community Park). Subsequently on March 10, 1993, the NGBF (130003) was divided into the NGBF (130003A) and the NWIRP (130003B). During the early 1990s many portions of the NGBF (130003A) were delisted as the investigation of areas was completed. The NGBF (130003A) was further divided on March 3, 2000 with 26 acres becoming the NGSLP (130003C). Currently the NGBF (130003A) is 9 acres. In June 2004, a portion of the NWIRP (130003B) was delisted reducing the NWIRP to 8.7 acres.

1.2 Operable Units

An operable unit represents a portion of a remedial program for a site that for technical or administrative reasons can be addressed separately to investigate, eliminate or mitigate a release, threat of release or exposure pathway resulting from contamination. The GABF site is divided into three operable units. The former NGBF and NWIRP manufacturing plant areas are designated as Operable Unit 1 (OU1). Operable Unit 2 (OU2) consists of the groundwater contamination plume and is a joint operable unit for both the NGBF and NWIRP sites. Operable

Unit 3 (OU3) consists of the Former Grumman Settling Ponds, adjacent areas of the Bethpage Community Park (BCP), and the Grumman Access Road. The disposal at OU3 has also resulted in impacts to some adjacent off-site properties as well as to the down gradient groundwater. The Town of Oyster Bay also completed an Interim Remedial Measure (IRM) on an area within the BCP, which was originally, but is not currently, included in the OU3 area. The following Records of Decision (RODs) have been issued by the NYSDEC for the NGBF and the NWIRP:

- 130003A, Operable Unit 1 On-Site Soils Source Area, 1995;
- 130003B, Operable Unit 1 On-Site Soils Source Areas, 1995;
- 130003A and 130003B, Operable Unit 2 Groundwater, 2001 and 2003; and
- 130003A, Operable Unit 3 Former Grumman Settling Ponds and Adjacent Areas On-Site Soils and Groundwater, 2013.

1.2.1 Operable Unit 1

1.2.1.1 Northrop Grumman Bethpage Facility

The NGBF is a part of the former GABF. It is located on Hicksville Road in an urbanized area of Bethpage. The NGBF was established in the early 1930s. The main activities of this facility have been the engineering, manufacturing, primary assembly, and research/development/testing of a variety of military and aerospace crafts. A remedial investigation (RI) was conducted by Northrop Grumman between 1991 and 1994. The RI included the investigation of chemical and waste storage and disposal areas. Historically, the main source of wastes was the metal finishing process lines, including degreasing, conversion coating, anodizing, and painting. A ROD for source areas (i.e., soil) was issued in March 1995. The 1995 ROD required the remediation, via soil vapor extraction (SVE), at the Plant 15 area and the former TCE tank area at Plant 2. Remediation of the Plant 2 and 15 areas has been completed.

1.2.1.2 Naval Weapons Industrial Reserve Plant

The NWIRP was established within the Northrop Grumman property during the early 1930s. Historically, this facility was a government-owned, contractor operated facility with the mission of design engineering, research prototyping, testing, fabrication, and primary and subassembly of various naval aircraft. The waste source areas that were studied during the remedial investigation/feasibility study (RI/FS) (Halliburton NUS, 1994) included Site 1: Former Drum Marshaling Area, Site 2: Recharge Basin Area, Site 3: Salvage Storage Area, and the HN-24 area.

The RI for the NWIRP was completed in May 1992, and a ROD for source areas (i.e., soil) was issued in May 1995. The 1995 ROD required excavation of inorganic-contaminated soils, the excavation of polychlorinated biphenyl (PCB)-contaminated soil above 10 parts per million (ppm), the remediation of VOC-contaminated soils via air sparging (AS), and the implementation of deed restrictions for certain areas of the NWIRP (Arcadis Geraghty & Miller, 2000).

1.2.2 Operable Unit 2

The Navy and Northrop Grumman have been implementing a remedy identified in the NYSDEC 2001 ROD and the Navy 2003 ROD for OU-2. The RODs call for on-site containment of impacted groundwater from source areas, groundwater extraction and treatment for hotspots in the plume, a wellhead contingency plan for treating downgradient water supplies as needed, and off-site monitoring of the impacted groundwater plume. Since the success of these remedies is critical to the overall strategy to contain and remediate the existing groundwater plume specific details on these efforts are outlined below:

- On-site containment of VOC-impacted groundwater at the southern (down gradient) edge of the OU-2 source areas. Northrop Grumman has been operating the OU-2 on-site containment (ONCT) system since 1998. The ONCT consists of five extraction wells (GP3 Well 3, GP-1 Well 1, Well 17, Well 18, and Well 19). The water is treated at an on-site treatment system and discharge to the on-site recharge basins. The location of the ONCT is shown on Figure 1-2.

- Under an agreement with the NYSDEC, the Navy designed, installed, and operates a groundwater extraction, treatment, and injection system (GM-38 Hot Spot) capable of remediating groundwater containing CVOCs greater than 1 mg/l since 2009. The location of the GM-38 Hot Spot groundwater remediation is shown on Figure 1-2.

1.2.3 Operable Unit 3

Operable Unit 3 includes Bethpage Community Park-Former Grumman Settling Ponds and adjacent areas of the NGBF. OU3 includes on-site source areas and on-site and off-site groundwater. The RI was completed in 2011 and the ROD signed in 2013. Details of the OU3 ROD specific to the groundwater include:

- The existing groundwater extraction and treatment IRM will continue to be operated and upgraded as necessary, based on a review of its effectiveness, to assure the capture/containment of the full depth and area of contaminated groundwater leaving the Site. The location of the Bethpage Community Park (BCP) IRM is shown on Figure 1-2.
- Areas of groundwater containing CVOCs greater than 1 mg/l were detected during the off-site groundwater monitoring completed as part of OU2.

1.3 Physical Setting

1.3.1 Topography

The topography in the vicinity of the Site is relatively flat, resulting mainly from the advance and retreat of the ice sheets of the Wisconsin aged glacier during the Pleistocene, which last retreated about 15,000 years ago. The roughly east-west trending ridge that forms the spine of Long Island, located to the north of the Site, is an accumulation of glacial deposits that represents the southernmost terminus of the glacier and represents the highest elevations in this area (Buxton and Shernoff, 1999). South of the moraine, in the vicinity of the Site, the ground surface dips gently southward from the moraine to the Atlantic Ocean.

1.3.2 Surface Water

Massapequa Creek, and its associated ponds, the Massapequa Park and Massapequa Preserve, and other areas that surround it comprise a mix of woodland, freshwater wetland, tidal wetland, and aquatic environments (Cashin Associates Inc., 2009). The watershed is located in the south-central portion of the Town of Oyster Bay. The Massapequa Creek Watershed is located on the south shore of Long Island and is the largest watershed basin in the Town of Oyster Bay. The current surface water runoff area of the watershed covers an estimated 6.67 square miles and is a major surface water contributor to South Oyster Bay. The watershed extends from the southern end of Bethpage State Park and includes portions of the Incorporated Villages of Farmingdale and Massapequa Park and the neighborhoods and communities of Bethpage, South Farmingdale, North Massapequa, Massapequa, and Biltmore Shores before ending at South Oyster Bay.

The Creek and surrounding riparian area contain a variety of habitats consisting of coastal streams, ponds, lakes/reservoirs, freshwater and tidal wetlands, and upland wooded areas that support diverse vegetation and wildlife. The majority of Massapequa Creek and the surrounding riparian area are located within the Massapequa Preserve and the boundaries of the South Shore Estuary Reserve. The Creek and it tributaries eventually empty in the Great South Bay. Below are stream flow statistics for Massapequa Creek based on a 68 year period of record (http://waterdata.usgs.gov/usa/nwis/uv?01309500).

Table 1-1

Massapequa Creek Stream Flow Statistics

Minimum Stream Flow (1995)	25th Percentile Stream Flow	Median Stream Flow	Mean Stream Flow	75th Percentile Stream Flow	Maximum Stream Flow (1959)
0.83 cfs	2.6 cfs	6.2 cfs	8.4 cfs	9.5 cfs	57 cfs

cfs: cubic feet per second

1.3.3 Geology

This section presents the geology and hydrogeology in the area to put the local conditions into perspective within the larger regional geologic and hydrogeologic framework. The data in this

Section is based on the published data from Cartwright (2002), Misut and Feldman (1996), Smolensky and Feldman (1995), Isbister (1966), Perlmutter and Geraghty (1963), Fuller (1914), Fenneman (1938), various USGS reports and Site-specific data collected during remedial investigations at the GABF.

The NGBF, NWIRP, and BCP are located in the Atlantic Coastal Plain physiographic province. This region is bordered to the south and east by the Atlantic Ocean and to the north and west by the Piedmont and New England physiographic provinces (Fenneman, 1938). Four distinct geologic units lie beneath the NGBF, NWIRP, and BCP, including glacial deposits composed of the Ronkonkoma and/or Harbor Hill glacial outwash (upper glacial), the Magothy Formation and Matawan Group (Magothy), a clay member of the Raritan Formation (Raritan Clay), and the Lloyd Sand Member of the Raritan Formation (Lloyd). A stratigraphic column of the geology of Nassau County is shown on Figure 1-3. A generalized hydrogeologic cross-section is shown on Figure 1-4.

The Ronkonkoma ice sheet deposited a mantle of glacial drift on the Cretaceous, Pliocene, and early Pleistocene deposits. The drift ranges from unstratified till to stratified outwash and mainly occurs in three forms; basal drift, terminal moraine, and an outwash plain. South of the Ronkonkoma moraine is a relatively flat outwash plain that generally extends from the center of Long Island to the south shore. It is composed of well-rounded coarse-grained sand and gravel.

The Harbor Hill drift covers most of northern Nassau County and consists of outwash and till. Outwash deposits of the Harbor Hill ice sheet often thinly cover and are generally indistinguishable from the Ronkonkoma outwash from the Ronkonkoma moraine to the south shore of Long Island. Its surface is generally irregular and it includes numerous kettles, depressions, and small hills.

Glacial outwash from the Ronkonkoma and/or Harbor Hill glacial advances were likely encountered at the NGBF, NWIRP, and BCP. The material is predominantly brown, medium to coarse-grained sand with minor amounts of fine sand and silt. The glacial outwash extends from ground surface to an unknown depth as the transition between the upper glacial and Magothy is not distinct but presumed to occur before 75 feet bgs based on published literature (Isbister

1966). A surficial geologic map of the area showing the geologic units at land surface is presented as Figure 1-5.

The Magothy deposits are undifferentiated and lie unconformably on the Raritan Clay. The Magothy, like the Lloyd Sands and Raritan Clay, are early Cretaceous deposits of continental origin and are mostly deltaic quartzose very fine to coarse-grained sand and silty sand with interbedded silt and clay. The Magothy ranges in thickness from zero at its northern limit to more than 800 feet in southeastern Nassau County. The Magothy's upper surface slopes to the southeast and ranges from 200 feet above mean sea level (msl) to more than 350 feet below msl. The Magothy commonly has a 25- to 50-foot thick coarse sand and gravel layer at its base (Isbister, 1966).

1.3.4 Hydrogeology

Regional groundwater recharge occurs most prominently along the moraine north of the Site which serves as not only a deep recharge zone but also as a groundwater divide. Although the moraine area is the most important regional recharge feature, groundwater recharge takes place across most of the land surface of Long Island. In general, groundwater moves away from the recharge area along the central spine of the island toward the coastal areas. The regional groundwater flow direction in the Magothy aquifer can be inferred from the 2010 potentiometric surface map provided by the US Geological Survey (Monti et al., 2013) presented as Figure 1-6. Based on the potentiometric surface of the Magothy aquifer as presented on this figure, the groundwater flow direction at and down-gradient of the NGBF, NWIRP, and BCP is to the south to southeast.

Groundwater in the shallow portions of the Magothy Aquifer in the vicinity of the NGBF, NWIRP, and BCP occurs as an unconfined aquifer. However, lenses of silt and clay, whose overlapping arrangement produces anisotropy ranging from approximately 36:1 to 120:1, cause a confining effect with depth (Isbister, 1966 and Reilly et al., 1983). The storativity of the Magothy ranges from water table conditions (0.25) to confined conditions (0.0006) depending on the location and depth (Reilly et al. 1983). Hydraulic conductivity estimates for the Magothy Formation based on aquifer tests of permeable portions of the aquifer range from approximately

200 gallons per day per square foot (gpd/ft^2) to as much as 1,100 gpd/ft^2 with an average of approximately 500 gpd/ft^2, or approximately 27 feet per day (ft/d) to 150 ft/d with an average of approximately 67 ft/d (Isbister, 1966). Variations in the horizontal and vertical hydraulic conductivity can occur locally due to the presence of lower or higher permeability materials such as silts, clays, or gravels. More recent studies have generally assumed average values of hydraulic conductivity for the Magothy Formation to be in the range of 35 to 90 ft/d (Cartwright, 2002; Misut and Feldman, 1996; Smolensky and Feldman, 1995). The horizontal hydraulic gradient in shallow portions of the Magothy can range from 0.0001 to 0.001 feet per foot; however, the hydraulic gradient can be affected by hydraulic stresses such as local pumping, recharge basins, and remediation systems (Busciolano et al, 1998).

1.4 NATURE & EXTENT OF GROUNDWATER CONTAMINATION

Numerous remedial investigations have been completed by Northrup Grumman (Geraghty & Miller and Arcadis) and the Navy (TetraTech) over the last few decades. These data have been used to define the nature and extent of groundwater containing hazardous chemicals. These remedial investigations have identified three groundwater plumes to the south-southeast of the GABF. These plumes include the shallow plume and the deep eastern and western plumes. The maps for these plumes were developed by Arcadis and TetraTech by interpreting vertical profile boring groundwater quality screening data and monitoring well groundwater quality data. The nature and extent of groundwater containing site-related CVOCs as depicted on Figures 1-7, 1-8, and 1-9. The data from these reports, as shown on these figures, were combined with recently completed vertical profile borings that were drilled north and south of the Southern State Parkway to further define the distal end of groundwater containing site-related contamination. Groundwater containing CVOCs above the MCLs has been interpreted to be roughly at the Southern State Parkway (VPB-151 and VPB-153) as shown on Figure 1-10. The horizontal and vertical limits of CVOCs in groundwater should be further defined during a pre-design investigation (PDI).

1.5 POTENTIAL RECEPTORS

Groundwater containing VOCs from the NGBF, NWIRP, and BCP migrates to the south-southeast. As the groundwater migrates to the south-southeast, the groundwater also migrates through deeper and deeper portions of the aquifer. This is conceptually shown on Figure 1-4. Based on the data collected to date, it does not appear that groundwater containing VOCs from the NGBF, NWIRP, and BCP discharges to Massapequa Creek. Groundwater from NGBF, NWIRP, and BCP migrates to the south-southeast and through deeper and deeper portion of the aquifer as it migrates towards and may potentially discharge to either the South Oyster Bay or the Atlantic Ocean. Municipal and industrial wells (receptors) that extract groundwater from these portions of the aquifer have been impacted by VOCs, and have had appropriate treatment implemented under the Public Water Supply Contingency Plan to ensure that water meeting Department of Health Maximum Contaminant Levels is delivered to customers. Other potential public water supply well receptors are listed in Table 1-2 and shown on Figure 1-11.

2.0 REMEDIAL ACTION OBJECTIVES AND ARARS

2.1 Remedial Action Objectives

Remedial Action Objectives (RAOs) are developed to define Site-specific concerns that must be addressed and to what levels to protect human health and the environment. The RAOs for this project are presented below.

<u>Groundwater RAOs for Public Health Protection</u>

- Prevent ingestion of groundwater with contaminant levels exceeding drinking water standards.
- Prevent contact with contaminated groundwater.

<u>Groundwater RAOs for Environmental Protection</u>

- Restore groundwater to pre-disposal/pre-release conditions.
- Prevent the discharge of contaminants to surface water.

The T.O.G.S. 1.1.1: Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, contains promulgated water quality standards and groundwater effluent limitations for discharges to Class GA waters to be used for the restoration of the groundwater aquifer to pre-disposal/pre-release conditions. The Nassau-Suffolk Aquifer is designated as a sole source aquifer and used as a source of drinking water by communities in Nassau County. Therefore, contaminated groundwater in the Nassau-Suffolk Aquifer that continues to migrate to the south-southeast towards existing public water supply wells is a potential public health exposure pathway, if no action is taken.

2.2 Applicable Relevant and Appropriate Requirements

Remedial actions must comply with Applicable Relevant and Appropriate Requirements (ARARs). ARARs consist of two sets of requirements: those that are applicable and those that are relevant and appropriate. Applicable requirements are those substantive standards that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at Inactive Hazardous Waste Disposal Sites and National Priorities List (NPL) sites.

The second set of requirements consists of relevant and appropriate requirements. The relevance and appropriateness of a requirement may be judged by comparing a number of factors, including the characteristics of the remedial action, the hazardous substances in question, or the physical characteristics of the site, with those addressed in the requirement. A requirement that is judged to be relevant and appropriate must be complied with to the same degree as if it were applicable.

Many federal and state environmental and public health agencies develop criteria, advisories, guidance, and proposed standards that are not legally enforceable, but contain information that would be helpful in carrying out, or in determining the level of protectiveness of, selected remedies. To be considered (TBC) materials are meant to complement the use of ARARs, not compete with or replace them. Because TBCs are not ARARs, their identification and use are not mandatory. Where no ARARs exist to address a particular situation, the TBCs may be used to set cleanup targets (in conjunction with a baseline risk assessment).

Chemical-Specific ARARs are either health- or risk-based numerical values or methodologies that establish the acceptable amount or concentration of a chemical that may remain in or be discharged to the environment. Where more than one requirement addressing a contaminant is determined to be an ARAR, the most stringent requirement should be applied.

ARARs include relevant standards derived from the Safe Drinking Water Act Maximum Contaminant Levels (MCLs) (40 CFR 141), the NYSDEC Water State Quality Standards (6 NYCRR Part 703), NYSDEC Water and Technical and Operational Guidance Series (TOGS 1.1.1), and the New York State Department of Health (NYSDOH Part 5, Subpart 5-1). These ARARs are summarized on Table 2-1. The lowest chemical-specific ARARs was used to define the portion of the groundwater containing CVOCs above the ARARs that is the focus of this Remedial Options Report (Under Chapter 543 of the Laws of 2014, Grumman Plume Review) (Table 2-2).

3.0 EVALUATION AND SCREENING OF GENERAL RESPONSE ACTIONS AND REMEDIAL ACTION TECHNOLOGIES

3.1 Technology Identification and Technical Implementability

The following sub-sections describe the general response actions, technology classes, and process options evaluated in this document. The major factors that influence the technical feasibility of general response actions, technology classes, and process options are the geologic complexity, aquifer heterogeneity, depth of contamination, and the residential and commercial density of the area. Table 3-1 lists the technologies and process options and summarizes the outcome of the technical implementability screening. A detailed description of the general response actions, technology classes, and process options are provided in Appendix A. Below are the general response actions, technology classes, and process options that have been retained.

3.1.1 Institutional Controls and Long-Term Monitoring

The remedial technology identified under the Institutional Controls and Long-Term Monitoring General Response Action (GRA) consists of administrative restrictions focused on minimizing potential contact with contaminated groundwater. This GRA also includes long-term monitoring of groundwater to demonstrate the effectiveness of groundwater remediation and compliance with the institutional controls. This process option could be combined with other GRAs to achieve the goals of Chapter 543 of the Laws of 2014, Grumman Plume Review.

3.1.2 Hydraulic Control

Hydraulic control may be achieved by controlling the direction of groundwater flow with capture zones, which are low points of hydraulic head (level) to which all of the groundwater within a specific area flows. When groundwater is pumped from extraction wells, the groundwater level (or potentiometric surface) in the vicinity of the well is modified from its existing surface creating flow towards the well. By optimizing the locations of the extraction wells and adjusting the groundwater pumping rates, a potentiometric surface can be artificially modified to prevent groundwater carrying contaminants from migrating beyond the capture zone of the well to distant receptors. This technology has been used at many sites and is technically feasible. The water that is extracted typically requires treatment and disposal. Hydraulic control using groundwater extraction wells will be retained for further evaluation.

3.1.3 Ex Situ Treatment

Ex situ treatment may be required when the selected remedy involves groundwater extraction, and when the groundwater requires treatment prior to discharge. Although the technologies used for treating extracted groundwater are important aspects of a remedy, they have little influence on reducing contaminant levels in the aquifer or minimizing contaminant migration. Therefore, the technologies presented in USEPA's *Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites* (1996) are evaluated.

These presumptive (or proven) *ex situ* treatment technologies are well-understood methods that have been used for many years in the treatment of drinking water and/or municipal or industrial wastewater. The presumptive technologies presented below are the technologies retained for the development of remedial alternatives. The presumptive response guidance document serves as the technology screening step for the *ex situ* treatment component of a potential remedial option.

The presumptive technologies for treatment of extracted groundwater containing dissolved organic contaminants include the following:

- Air stripping
- Granular activated carbon

3.1.4 Groundwater Disposal Options

Groundwater discharge or disposal would be required if the potential remedial option involved groundwater extraction. The primary options for groundwater disposal include treatment followed by discharge to surface water, or transport to an off-site location (e.g., POTW) for treatment and disposal. These options are described and evaluated below.

Publicly Owned Treatment Works (POTW): This process option involves the direct discharge of untreated extracted groundwater to a local POTW for treatment. The extracted water is assumed to be directed to the existing wastewater treatment facility operated by the Cedar Creek Water Pollution Control Plant (CCWPCP). The discharge of untreated groundwater to a POTW will be retained as a process option.

Discharge to Surface Water: This process option involves the discharge of treated groundwater to Massapequa Creek. Selected portions of Massapequa Creek have been designated by the NYSDEC as Class A surface water. The discharge of treated groundwater to Massapequa Creek will be retained for further evaluation.

The evaluation and screening of the groundwater disposal options resulted in the two previously outlined options which result in the treated water being discharged to surface water. Since the disposal of the treated water is one of the major challenges and cost drivers the other disposal options that were not retained are outlined below including potentially using infiltration basins, well injection, and irrigation.

Infiltration Basin or Gallery: An infiltration basin allows treated water to seep through the ground surface in a controller area. An infiltration gallery includes a subsurface network of perforated pipes in trenches that return the treated water below the surface, but above the water table. This process option is likely not feasible as a sole disposal method because of the very large groundwater disposal rates; however, it could be part of an overall disposal strategy evaluated during a remedial design.

Well Injection: This process option involves the use of injection wells to push treated water into geologic formations. This process option is likely not feasible as a sole disposal method because of the very large groundwater disposal rates and the high O&M costs associated with injection wells; however, it could be part of an overall disposal strategy evaluated during a remedial design.

Irrigation: Irrigation allows treated water to be discharge through the land application or irrigation of vegetation. Given the high disposal rates the average growing season is eight months, and land surface is often frozen or covered by snow during the winter, this process option is not feasible and will not be retained for further evaluation.

4.0 ASSEMBLY OF REMEDIAL OPTIONS

In this section, the remedial technologies and process options retained are used to assemble remedial options for achieving the RAOs. The options developed and screened are conceptual. All characteristics of these options should be considered to be approximate for the purposes of a comparison only. Specific details would be finalized during a PDI and remedial design.

4.1 Rationale for Assembly of Options

For the purposes of cost estimates only, it is assumed that all of the remedial options have a time frame of 30 years, in accordance with CERCLA guidance for costing procedures. The actual duration of the proposed remedies would be based on performance monitoring results. However, results indicate that the time for these types of contaminated groundwater sites to become 'clean' is many decades or longer, due to long time scales associated with pore-volume flushing, and several orders of magnitude differences between initial concentrations and MCLs. The 30 year technical analyses and cost evaluations are also presented for consistency between alternatives.

4.2 Development of Options

Based on the rationale presented above, and the technology and process options that have been retained after screening, the following remedial options are proposed for the groundwater:

- Remedial Option 1: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (wells along Southern State Parkway), Ex-situ Treatment, and Discharge to Massapequa Creek (includes LTM and ICs);

- Remedial Option 2: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (wells at Nassau County Recharge Basins and available land), and Discharge to POTW (includes LTM and ICs); and

- Remedial Option 3: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (combination of existing municipal wells and new wells at Nassau County Recharge Basins), and Discharge to POTW (includes LTM and ICs).

4.2.1 Remedial Option 1: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS using Wells along Southern State Parkway, Ex-situ Treatment, and Discharge to Massapequa Creek (includes LTM and ICs);

Remedial Option 1 consists of a groundwater extraction system to capture groundwater containing CVOCs greater than the MCLs at the down gradient extent of groundwater contamination. The groundwater will be conveyed to a centralized treatment system. The water will be treated to NYS Class A Water Quality standards before it is discharged to Massapequa Creek. Institutional Controls including long-term monitoring will be used to monitor the effectiveness of the remediation and compliance with State and local permits and regulations. In addition, new water supply well permits should not be issued for this area of Nassau County.

4.2.1.1 Groundwater Extraction System

Hydraulic control of the groundwater containing CVOCs above the MCLs will be achieved by installing an array of wells at two depths along the Southern State Parkway right-of-way. One array of wells will be installed to capture the shallow groundwater containing CVOCs above the MCLs. The array will include eight 550 foot deep wells screened from 250 to 550 feet bgs. The second array of wells will be installed to capture the deep groundwater containing CVOCs above the MCLs. The array will include eight 800 foot deep wells screened from 550 to 800 feet bgs. Each array of wells is described below.

4.2.1.1.1 *Shallow Groundwater Plume*

The plume of shallow groundwater containing CVOCs above the MCLs has been interpreted to be roughly 10,000 feet wide and 350 feet thick at the Southern State Parkway. Based on the analytical model, using a hydraulic conductivity of 100 ft/day and a hydraulic gradient of 0.002, a single well extracting groundwater at 950 gpm from a 350 foot thickness of the aquifer would create a capture zone that is roughly 1,300 feet wide at each extraction well (Grubb, 1993). A conservatively high hydraulic conductivity (average hydraulic conductivity = 67 feet/day for the Magothy Aquifer) was used in this calculation to account for the variability in aquifer hydraulic conductivity, the aquifer heterogeneity, and the use of a simplified 2-D analytical model that does not account for recharge. Eight extraction wells (1,300 ft x 8 = 10,400 feet at 7,600 gpm or about 11 mgd) will be necessary to create a capture zone that is capable of extracting the 10,000 foot wide CVOCs that are greater than the MCLs as shown on Figures 4-1 and Figure 4-2. These capture zones overlap to achieve capture at the line of extraction wells that also coincides with the extent of VOCs.

4.2.1.1.2 *Deep Groundwater Plume*

The plume of deep groundwater containing CVOCs above the MCLs has been interpreted to be roughly 10,000 feet wide and 250 feet thick at the Southern State Parkway. Based on an analytical model (Grubb, 1993), using a hydraulic conductivity of 100 ft/day and a hydraulic gradient of 0.002, a single well extracting groundwater pumping 700 gpm from a 250 foot thickness of the aquifer and would create a capture zone that is roughly 1,300 feet wide at each extraction well. A conservatively high hydraulic conductivity (average hydraulic conductivity = 67 feet/day for the Magothy Aquifer) was used in this calculation to account for the variability in aquifer hydraulic conductivity, the aquifer heterogeneity, and the use of a simplified 2-D analytical model that does not account for recharge. Eight extraction wells (1,300 ft x 8 = 10,400 feet @ 5,600 gpm or about 8 mgd) will be necessary to create a capture zone that is capable of extracting the 10,000 foot wide CVOCs that are greater than the MCLs as shown on Figure 4-1 and 4-2. These capture zones over lap to achieve capture at the line of extraction wells that also coincides with the extent of VOCs.

4.2.1.1.3 *Summary*

Based on the above calculations, 11 million gallons per day (mgd) plus 8 mgd will need to be extracted to capture groundwater impacted with VOCs as shown on Figure 4-1. These extraction rates should be sufficient to overpower the complexity and heterogeneous nature of the Magothy aquifer and overpower the uncertainty associated with connecting the capture zones of numerous wells. Additional plume delineation and hydraulic capture calculations/modeling should be completed during a PDI to further define the nature and extent of groundwater containing CVOCs above the MCLs and additional modeling should be completed to further evaluate the screen depth/length, extraction rate, and capture zone.

4.2.1.2 Conveyance System

Groundwater extracted from each well will be pumped with an in-well vertical turbine to a centralized treatment system through 10-inch diameter double wall high density polyethylene (HDPE) pipe. The maximum distance the water will be conveyed is 10,000 feet.

4.2.1.3 Groundwater Treatment System

A centralized treatment plant will be constructed along the Southern State Parkway near Massapequa Creek (Figure 4-1). The centralized treatment plant will be capable of treating 19 mgd of groundwater containing an average of 35 µg/l VOCs (based on a standard mass flux analysis using the concentration of VOCs along a cross-section perpendicular to groundwater flow and the hydraulic properties of the aquifer) to NYS Class A Surface Water Standards using the following treatment components:

- Equalization Tank (5 million gallon);
- Shallow Tray Air Strippers (13 units); and
- Bag Filters (13, @ 1,200 gpm units);
- Liquid Phase and Vapor Phase Granular Activated Carbon Canisters (13 vapor phase units and 26 liquid phase units).

An approximately one acre in size groundwater treatment plant is proposed west of Massapequa Creek along the SSP as shown on Figure 4-1. The actual location will be confirmed during the design phase. Groundwater will initially be pumped into an equalization tank. The groundwater from the equalization tank will be pumped through air strippers to remove the VOCs. Water from the air strippers will be pumped through bag filters and then through liquid phase GAC to remove any remaining VOCs and to assure the water does not contain any VOCs before it is discharged. The VOCs will be removed from the air coming out of the stripper towers using vapor phase carbon. A schematic of the proposed treatment process is shown on Figure 4-3.

4.2.1.4 Groundwater Discharge

Approximately thirty-one cfs (19 mgd) of treated water will be discharged to Massapequa Creek. This amount of flow is roughly four times greater than the mean stream flow of 8.4 cfs (Table 1-1). When combined with the mean stream flow will bring the mean stream flow to 39.4 cfs. This represents 70 percent of the maximum stream flow on a daily basis. The system will be equipped with a level sensor installed in the Creek that will be temporarily shut down the extraction wells during major storm events and prevent flooding of downstream areas. A more detailed evaluation of the potential impact to Massapequa Creek and the Massapequa Creek Preserve will need to be completed during a PDI. Measurable differences from the increased stream flow would include variations in creek water temperature due to discharge of colder groundwater, possible reductions in salinity as the creek reaches brackish areas, potentially lowered capacity to convey stormwater, and possible alterations to wetland areas and biota associated with the creek. The discharged effluent will be subject to the NYS Class A surface water effluent limitations and will be detailed in a SPDES permit or permit equivalent issued by the NYSDEC.

4.2.1.5 Period of Performance

The period of performance of a hydraulic containment remedy was estimated to be up to 200 years. This calculation assumes that the source areas have been hydraulically contained, the GM-38 IRM and the BCP IRM effectively captures groundwater greater than 0.5 mg/l in the eastern plume, and that any other hot spots with groundwater containing CVOCs greater than 0.5 mg/l are identified and effectively remediated. This is based on a calculation of the pore volume of the plume (20,000 feet long, 10,000 feet wide, 600 feet thick, 0.3 effective porosity) and the number of pore flushes (5) that could potentially be required to reduce the concentration of CVOCs (500 µg/l maximum) to the MCLs (5 µg/l) based on the physical (k-100 ft/day, and i=0.002) and solute transport (K_{oc}=94, f_{oc}= 0.001, bulk density 1.80, and porosity 0.3) properties of the aquifer and the extraction rate (19 mgd).

4.2.1.6 Implementation

It will take 1 year to complete the remedial design and permitting of this hydraulic control remedy. It will take 3 years to complete construction of 18 large diameter wells, 10,000 feet of conveyance piping, a centralized treatment plant, and an outfall on Massapequa Creek. Due to the number of wells and complexity of the entire remedy, it is anticipated it will take roughly 1 year of startup/functionality operations.

Design & Permitting		Start Up	Operation Maintenance & Performance Monitoring	
1 Year	3 Years	1 Year		Up to 200 years >
	Construction		Periodic Reviews	

4.2.1.7 Performance Monitoring Plan

A performance monitoring program will be implemented to confirm that the groundwater extraction and treatment system is achieving remedial objectives. This performance monitoring plan will include:

- Monthly process sampling (Liquid and vapor) and analysis for compliance with applicable permits
- Installation of ten 4-inch diameter PVC monitoring wells (five 400 feet deep & five 700 feet deep);
- Collection of synoptic water level measurements and groundwater samples from 25 existing monitoring wells and ten newly installed monitoring wells;
- Collection of water levels and groundwater samples quarterly for first three years, semi-annually for next two years, and annually thereafter;
- Analysis of groundwater samples for CVOCs; and
- Preparation of an annual report.

The results of these analyses will be used to determine whether remedial action objectives are being achieved, and whether changes are required in the system design, configuration, and operation.

Operation and maintenance (O&M) costs associated with treatment system include the collection of monthly process samples to verify the system is operating within the permit limits. Water samples would be collected from the influent and effluent of the treatment system and analyzed for VOCs, pH, TDS, total iron, total manganese and total zinc likely stipulated in a NPDES permit. Air measurements will be collected at the influent and effluent of the vapor phase granular activated carbon (GAC) for laboratory analysis, and between the GAC vessels, or (adsorbent media) using a photoionization detector. The treatment system was assumed to be decommissioned in 200 years.

4.2.1.8 Evaluation of Remedial Alternative

4.2.1.8.1 *Effectiveness*

This remedial option will be effective at achieving the RAOs. Hydraulic control is used at numerous sites in Nassau County, New York and proven to be effective at stopping the migration of aqueous phase CVOCs in groundwater. The treatment technologies that will be used in this remedial option have also been proven to be effective at reducing the concentration of aqueous phase CVOCs to surface water standards.

4.2.1.8.2 *Implementability*

While this remedial option is technically implementable, given the size and depth of the groundwater containing VOCs and given the high density residential and commercial nature of the area, it would be extremely difficult. Groundwater extraction is a commonly used technology and would be implementable using readily available technologies. Additional evaluation and possible pilot testing may be required to refine the groundwater treatment train. The components of the proposed treatment trains are commonly used and are readily available. A NPDES permit equivalent will be required for the surface water discharge and a permit from the New State Parks Recreation & Historic Preservation will be required to access the land along the Southern State Parkway to install the extraction wells and water main. The monitoring with ICs would be implemented by applicable local authorities. Finding a suitable location for treatment facilities, and the disruption caused during construction of the conveyance piping, will also present a significant challenge.

4.2.1.8.3 *Costs*

Detailed costs are shown in Tables 4-1 and 4-2. Capital costs are estimated to be $89 million. Total O&M costs are estimated to be $173 million, with a first year annual O&M cost of $7.6 million. The annual O&M cost for subsequent years will also increase based on inflation (costing assumes increase of 3% annually). Total periodic costs (including pump rehabilitation, well redevelopment, and pump replacement) are estimated to be $6 million. The Total Present Value are estimated to be $268 million.

4.2.1.8.4 *Summary*

- Pros
    - Construction using proven, standard construction methods.
    - Land available along South State Parkway
    - Water main(s) can be excavated in land along SSP and directional drilling can be used to pass beneath roads and highways.
    - Minimal disruption to surrounding residential and commercial area.
    - Improve water quality and flow in Massapequa Creek
- Cons
    - Disruption to Massapequa Preserve during construction of treatment plant and discharge infrastructure
    - Massapequa Creek may need improvements to effectively convey an additional 19 mgd.
    - 19 mgd of freshwater from a sole-source aquifer will be discharged to Ocean. Over the projected 200 year period of performance of this remedy, that equates to

over 730 billion gallons of freshwater extracted from a sole-source aquifer that would be discharged to Ocean.

- Potential permanent changes to Massapequa Creek such as measurable differences in water temperature and salinity, reduced ability to convey stormwater, and possible alterations to the current creek biota.

4.2.2 Option 2: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS using wells at Nassau County Recharge Basins, Available Land, and the Southern State Parkway, and Discharge to POTW (includes LTM and ICs)

Remedial Option 2 consists of a groundwater extraction system to capture groundwater containing CVOCs greater than the MCLs. The groundwater will be conveyed to the sanitary sewer and treated at the Cedar Creek Water Pollution Control Plant. Institutional Controls including long-term monitoring will be used to monitoring the effectiveness of the remediation and compliance with State and local permits and regulations.

4.2.2.1 Groundwater Extraction System

Hydraulic control of the groundwater containing CVOCs above the MCLs will be achieved by installing an array of wells at two depths at selected Nassau County Recharge Basins, available land, and along the Southern State Parkway. One array of wells will be installed to capture the shallow groundwater containing CVOCs above the MCLs. The array will include six 550 foot shallow wells screened from 200 to 550 feet bgs. The second array of wells will be installed to capture the deep groundwater containing CVOCs above the MCLs. The array will include six 800 foot deep wells screened from 550 to 800 feet bgs. Each array of wells is described below.

4.2.2.1.1 *Shallow Groundwater Plume*

The plume of shallow groundwater containing CVOCs above the MCLs has been interpreted to be roughly 10,000 feet wide and 350 feet thick at the southern end of the plume near the Southern State Parkway. Based on an analytical model (Grubb, 1993), using a hydraulic conductivity of 100 ft/day and a hydraulic gradient of 0.002, a single well extracting groundwater at 1,250 gpm from a 350 foot thickness of the aquifer would create a capture zone that is roughly 1,700 feet wide at each extraction well. A conservatively high hydraulic conductivity (average hydraulic conductivity = 67 feet/day for the Magothy Aquifer) was used in this calculation to account for the variability in aquifer hydraulic conductivity, the aquifer heterogeneity, and the use of a simplified 2-D analytical model that does not account for recharge. Six extraction wells (1,700 ft x 6 = 10,200 feet @7,500 gpm or 11 mgd) will be necessary to create a capture zone that is capable of extracting the 10,200 foot wide CVOCs that are greater than the MCLs as shown on Figures 4-4 and 4-2. These capture zones over lap to achieve capture at the line of extraction wells that also coincides with the extent of VOCs.

4.2.2.1.2 *Deep Groundwater Plume*

The plume of deep groundwater containing CVOCs above the MCLs has been interpreted to be roughly 10,000 feet wide and 250 feet thick at the Southern State Parkway. Based on an analytical model (Grubb, 1993), using a hydraulic conductivity of 100 ft/day and a hydraulic gradient of 0.002, a single well extracting groundwater pumping 930 gpm from a 250 foot thickness of the aquifer and would create a capture zone that is roughly 1,800 feet wide at each extraction well. A conservatively high hydraulic conductivity (average hydraulic conductivity = 67 feet/day for the Magothy Aquifer) was used in this calculation to account for the variability in aquifer hydraulic conductivity, the aquifer heterogeneity, and the use of a simplified 2-D analytical model that does not account for recharge. Six extraction wells (1,800 ft x 6 = 10,800 feet @ 5,600 gpm or 8 mgd) will be necessary to create a capture zone that is capable of extracting the 10,000 foot wide CVOCs that are greater than the MCLs as shown on Figures 4-4 and 4-2. These capture zones over lap to achieve capture at the line of extraction wells that also coincides with the extent of VOCs.

4.2.2.1.1 *Summary*

Based on the above calculations, 11 million gallons per day (mgd) plus 8 mgd will need to be extracted to capture groundwater impacted with VOCs as shown on Figure 4-3. These extraction rates should be sufficient to over power the complexity and heterogeneous nature of the Magothy aquifer and over power the uncertainty associated with connecting the capture zones of numerous wells. Additional plume delineation and hydraulic capture calculations/modeling should be completed during a PDI to further define the nature and extent of groundwater containing CVOCs above the MCLs and additional modeling should be completed to further evaluate the screen depth/length, extraction rate, and capture zone.

4.2.2.2 Conveyance System

A new 10-inch diameter double walled HDPE will be installed in the streets to convey water from each well to the nearest trunk sanitary sewer main where the water will be carried by gravity to the Cedar Creek Water Pollution Control Plant. It is assumed that the nearest trunk sewer main would have the capacity to accommodate the additional water. Based on the location of the extraction wells and the trunk sanitary sewer pipes, approximately 12,000 feet of new sewer pipes will be constructed as part of this Remedial Option.

4.2.2.3 Groundwater Treatment

The Cedar Creek Water Pollution Control Plant will be upgraded to be capable of treating an additional 19 mgd of wastewater to meet the wastewater treatment plants discharge limits prior to being discharged to the plants outfall (3 miles off-shore in the Atlantic Ocean). The upgrades to the Cedar Creek Water Pollution Control Plant will include pumping stations, the forced vortex grit chamber, the primary and secondary clarifiers, the biological nutrient removal (BNR) activated sludge system, the air supply system, the chlorine contact basin and chemical feed systems, the anaerobic digestion, and the dewatering processes.

4.2.2.4 Period of Performance

The period of performance of a hydraulic containment remedy was estimated to be up to 200 years. This calculation assumes that the source areas have been hydraulically contained, the GM-38 IRM effectively captures groundwater greater than 0.5 mg/l in the eastern plume, and there are not other hot spots with groundwater containing CVOCs greater than 0.5 mg/l. This is based on a calculation of the pore volume of the plume (20,000 feet long, 10,000 feet wide, 600 feet thick, 0.3 effective porosity) and the number of potential pore flushes (5) that could be required to reduce the concentration of CVOCs (500 µg/l maximum) to the MCLs (5 µg/l) based on the physical (k-100 ft/day, and i=0.002) and solute transport (K_{oc}=94, f_{oc}= 0.001, bulk density 1.80, and porosity 0.3) properties of the aquifer and the extraction rate (20 mgd).

4.2.2.5 Implementation

It will take 1 year to complete the remedial design and permitting of this hydraulic control remedy. It will take 3-5 years to complete construction of ten large diameter wells, thousands of feet of sanitary sewer lines, and design and complete any potential upgrades needed at the Cedar Creek Water Pollution Control Plant. The length of construction is mainly driven by any needed upgrades to the Cedar Creek Water Pollution Control Plant. It is anticipated it will take roughly 6 months to complete startup/functionality operations.

Design		Start Up	Operation Maintenance & Performance Monitoring	
1 Year	3-5 Years	6 Months	Up to 200 years	>
	Construction		Periodic Reviews	

4.2.2.6 Performance Monitoring Plan

A performance monitoring program will be implemented to confirm that the groundwater extraction and treatment system is achieving remedial objectives. This performance monitoring plan will include:

- Installation of ten 4-inch diameter PVC monitoring wells (five 400 feet deep & five 700 feet deep);
- Collection of synoptic water level measurements and groundwater samples from 25 existing monitoring wells and ten newly installed monitoring wells;
- Collection of water levels and groundwater samples quarterly for first three years, semi-annually for next two years, and annually thereafter;
- Analysis of groundwater samples for CVOCs; and

- Preparation of an annual report.

The results of these analyses will be used to determine whether remedial action objectives are being achieved, and whether changes are required in the system design, configuration, and operation.

4.2.2.7 **Evaluation of Remedial Alternative**

4.2.2.7.1 *Effectiveness*

This remedial option will be effective at achieving the RAOs. Hydraulic control is used at numerous sites in Nassau County New York and proven to be effective at stopping the migration of aqueous phase CVOCs in groundwater.

4.2.2.7.2 *Implementability*

This remedial option can be implemented given the size and depth of the groundwater containing CVOCs and given the high density residential and commercial nature of the area. Groundwater extraction and treatment is a commonly used technology and would be implementable using readily available technologies.

4.2.2.7.3 *Costs*

Detailed costs are shown in Tables 4-1 and 4-3. Capital costs are estimated to be $283 million. Total O&M costs are estimated to be $266 million, with a first year annual O&M cost of $11.8 million. The annual O&M cost for subsequent years will also increase based on inflation (costing assumes increase of 3% annually). Total periodic costs (including pump rehabilitation, well redevelopment, and pump replacement) are estimated to be $3 million. The Total Present Value are estimated to be $552 million.

4.2.2.7.4 *Summary*

- Pros
  - Constructed using standard construction methods.
  - Available land at Nassau County Recharge Basins and Southern State Parkway.

- New discharge lines can be installed in streets without disrupting existing sanitary sewers until they reach interceptor sewers.

- Cons
  - Some disruption to roads during the excavation the installation of the new discharge lines.
  - 19 mgd upgrade to Cedar Creek Water Pollution Control Plant.
  - 19 mgd of freshwater from a sole-source aquifer will be discharged to Ocean. Over the projected 200 year period of performance of this remedy, that equates to over 730 billion gallons of freshwater extracted from a sole-source aquifer that would be discharged to Ocean.

4.2.3 Remedial Option 3: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (combination of existing municipal wells and new wells at Nassau County Recharge Basins and Southern State Parkway), and Discharge to POTW (includes LTM and ICs).

Remedial Option 3 consists of a groundwater extraction system to capture groundwater containing VOCs greater than the MCLs at the down gradient extent of groundwater contamination. The groundwater will be conveyed to the sanitary sewer and treated at the Cedar Creek Water Pollution Control Plant. Institutional Controls including long-term monitoring will be used to monitoring the effectiveness of the remediation and compliance with State and local permits and regulations.

4.2.3.1 Groundwater Extraction System

Hydraulic control of the groundwater containing VOCs above the MCLs will be achieved by installing an array of wells at two depths using selected municipal water supply wells and newly installed wells at Nassau County Recharge Basins and at the Southern State Parkway. One array of wells will be installed to capture the shallow groundwater containing VOCs above the MCLs. This array will be composed of six 550 foot deep wells screened from 200 to 550 feet bgs, two of the six are existing water supply wells. The existing water supply wells at the locations identified below will be disconnected from the municipal water supply systems and evaluated to determine the portion of the existing infrastructure that can be used for this project. It is anticipated for the purposes of this remedial option that the well pumps will be removed, the well screens removed, the borehole will be drilled to the proper depth, and the well screen will be installed to the proper depth.

- South Farmingdale Plant 6 (SFWD-8665); and
- South Farmingdale Plant 4 Wellfield (SFWD-6148).

The second array of wells will be installed to capture the deep groundwater containing CVOCs above the MCLs. The array will be composed of six 800 foot deep wells screened from 550 to 800 feet bgs, one of the six is an existing water supply well. This existing water supply well at the location identified below will be disconnected from the municipal water supply systems and evaluated to determine the portion of the existing infrastructure that can be used for this project. It is anticipated for the purposes of this remedial option that the well pump will be removed, the well screen removed, the borehole will be drilled to the proper depth, and the well screen will be installed to the proper depth.

- South Farmingdale Plant 6 Wellfield (SFWD-8664).

The groundwater that these wells would have generated for the South Farmingdale Water District will be replaced by either installing new wells outside of the limits of the plume or by neighboring water districts using inter-connections between water distribution systems. Costs for the installation of three new water supply wells have been included within this estimate.

4.2.3.1.1 *Shallow Groundwater Plume*

The plume of shallow groundwater containing CVOCs above the MCLs has been interpreted to be roughly 10,000 feet wide and 350 feet thick near the Southern State Parkway. Based on an analytical model (Grubb, 1993), using a hydraulic conductivity of 100 ft/day and a hydraulic gradient of 0.002, a single well extracting groundwater at 1,250 gpm from a 350 foot thickness of the aquifer would create a capture zone that is roughly 1,700 feet wide at each extraction well. A conservatively high hydraulic conductivity (average hydraulic conductivity = 67 feet/day for the Magothy Aquifer) was used in this calculation to account for the variability in aquifer hydraulic conductivity, the aquifer heterogeneity, and the use of a simplified 2-D analytical model that does not account for recharge. Six extraction wells (1,700 ft x 6 = 10,200 feet @7,500 gpm or 11 mgd) will be used to create a capture zone that is capable of extracting the 10,200 foot wide CVOCs that are greater than the MCLs as shown on Figures 4-5 and 4-2. These capture zones over lap to achieve capture at the line of extraction wells that also coincides with the extent of VOCs.

4.2.3.1.2 *Deep Groundwater Plume*

The plume of deep groundwater containing CVOCs above the MCLs has been interpreted to be roughly 10,000 feet wide and 250 feet thick at the Southern State Parkway. Based on an analytical model (Grubb, 1993), using a hydraulic conductivity of 100 ft/day and a hydraulic gradient of 0.002, a single well extracting groundwater pumping 930 gpm from a 250 foot thickness of the aquifer and would create a capture zone that is roughly 1,300 feet wide at each extraction well. A conservatively high hydraulic conductivity (average hydraulic conductivity = 67 feet/day for the Magothy Aquifer) was used in this calculation to account for the variability in aquifer hydraulic conductivity, the aquifer heterogeneity, and the use of a simplified 2-D analytical model that does not account for recharge. Six extraction wells (1,800 ft x 6 = 10,800 feet @ 5,600 gpm) will be used to create a capture zone that is capable of extracting the 10,000 foot wide CVOCs that are greater than the MCLs as shown on Figures 4-5 and 4-2. These capture zones over lap to achieve capture at the line of extraction wells that also coincides with the extent of VOCs.

4.2.3.2 Conveyance System

A new 10-inch diameter double walled HDPE will be installed in the streets to convey water from each well to the nearest trunk sanitary sewer main where the water will be carried by gravity to the Cedar Creek Water Pollution Control Plant. It is assumed that the nearest trunk sewer main would have the capacity to accommodate the additional water. Based on the location of the extraction wells and the trunk sanitary sewer pipes, approximately 12,000 feet of new sewer pipes will be constructed as part of this Remedial Option.

4.2.3.3 Groundwater Treatment System

The Cedar Creek Water Pollution Control Plant will be upgraded to be capable of treating an additional 19 mgd of wastewater to meet the wastewater treatment plants discharge limits prior to being discharged to the plants outfall (3 miles off-shore in the Atlantic Ocean). The upgrades to the Cedar Creek Water Pollution Control Plant will include pumping stations, the forced vortex grit chamber, the primary and secondary clarifiers, the BNR activated sludge system, the air supply system, the chlorine contact basin and chemical feed systems, the anaerobic digestion, and the dewatering processes.

4.2.3.4 Period of Performance

The period of performance of a hydraulic containment remedy was estimated to be up to 200 years. This calculation assumes that the source areas have been hydraulically contained, the GM-38 IRM effectively captures groundwater greater than 0.5 mg/l in the eastern plume, and there are not other hot spots with groundwater containing CVOCs greater than 0.5 mg/l. This is based on a calculation of the pore volume of the plume (20,000 feet long, 10,000 feet wide, 600 feet thick, 0.3 effective porosity) and the number of potential pore flushes (5) that could be required to reduce the concentration of CVOCs (500 µg/l maximum) to the MCLs (5 µg/l) based on the physical (k-100 ft/day, and i=0.002) and solute transport (K_{oc}=94, f_{oc}= 0.001, bulk density 1.80, and porosity 0.3) properties of the aquifer and the extraction rate (20 mgd).

4.2.3.5 Implementation

It will take 1 year to complete the remedial design and permitting of this hydraulic control remedy. It will take 3-5 years to complete construction of twelve large diameter wells, the retrofitting of three existing wells, thousands of feet of sanitary sewer lines, and design and complete any potential upgrades needed at the Cedar Creek Water Pollution Control Plant. The length of construction is mainly driven by any needed upgrades to the Cedar Creek Water Pollution Control Plant. It is anticipated it will take roughly 6 months to complete startup operations.

Design		Start Up	Operation Maintenance & Performance Monitoring
1 Year	3-5 Years	1 Year	Up to 200 years >
	Construction		Periodic Reviews

4.2.3.6 **Performance Monitoring Plan**

A performance monitoring program will be implemented to confirm that the groundwater extraction and treatment system is achieving remedial objectives. This performance monitoring plan will include:

- Installation of ten 4-inch diameter PVC monitoring wells (five 400 feet deep & five 700 feet deep);
- Collection of synoptic water level measurements and groundwater samples from 25 existing monitoring wells and ten newly installed monitoring wells;
- Collection of water levels and groundwater samples quarterly for first three years, semi-annually for next two years, and annually thereafter;
- Analysis of groundwater samples for CVOCs; and
- Preparation of an annual report.

The results of these analyses will be used to determine whether remedial action objectives are being achieved, and whether changes are required in the system design, configuration, and operation.

4.2.3.7 **Evaluation of Remedial Alternative**

4.2.3.7.1 *Effectiveness*

This remedial option will be effective at achieving the RAOs. Hydraulic control is used at numerous sites in Nassau County New York and proven to be effective at stopping the migration of aqueous phase CVOCs in groundwater. The treatment technologies that will be used at the

Cedar Creek Water Pollution Control Plant have also been proven to be effective at reducing the concentration of aqueous phase CVOCs to surface water standards.

4.2.3.7.2 *Implementability*

This remedial option can be implemented given the size and depth of the groundwater containing CVOCs and given the high density residential and commercial nature of the area. Groundwater extraction is a commonly used technology and would be implementable using readily available technologies.

4.2.3.7.3 *Costs*

Detailed costs are shown in Tables 4-1 and 4-4. Capital costs are estimated to be $308 million. Total O&M costs are estimated to be $276 million, with a first year annual O&M cost of $12.2 million. The annual O&M cost for subsequent years will also increase based on inflation (costing assumes increase of 3% annually). Total periodic costs (including pump rehabilitation, well redevelopment, and pump replacement) are estimated to be $3 million. The Total Present Value are estimated to be $587 million.

4.2.3.7.4 *Summary*

- Pros
    - Constructed using standard construction methods.
    - Available land at Nassau County Recharge Basins and Southern State Parkway.
    - New Sanitary sewer lines can be installed in streets without disrupting existing sanitary sewers.
- Cons
    - Purchase selected existing water supply wells.
    - Must arrange for alternative water source to make up lost water capacity.
    - Some disruption to roads during the excavation of sanitary sewers.
    - 19 mgd upgrade to Cedar Creek Water Pollution Control Plant.

- 19 mgd of freshwater from a sole-source aquifer will be discharged to Ocean. Over the projected 200 year period of performance of this remedy, that equates to over 730 billion gallons of freshwater extracted from a sole-source aquifer that would be discharged to Ocean.

5.0 CONCLUSIONS

Groundwater that emanated from Northrop Grumman Bethpage Facilities, the Naval Weapons Industrial Reserve Plant, the Northrop Grumman-Steel Los Plant 2, and the Bethpage Community Park- Former Grumman Settling Ponds contains hazardous chemicals above the maximum contaminant level. This groundwater is migrating to the south-southeast impacting public supply wells, with the potential to impact additional public water supply wells and other natural resources in its path. Further action is required to remediate the existing groundwater plume and the overall RAO would be to restore the groundwater to its pre-existing (pre-release) quality. Once this objective is achieved it would eliminate potential pathways to those residents of Nassau County who solely rely on the groundwater as a source of drinking water. Restoration would also serve to eliminate potential impacts to municipal wells down-gradient of the plume and other natural resources within and down-gradient of the plume. During the time required to meet the RAO continued wellhead treatment would be necessary to eliminate the groundwater pathway at the drinking water wells that already exhibit elevated concentrations of hazardous chemicals.

In order to evaluate potential remedial options to meet the stated goal of restoration, the existing site data was evaluated to define the current extent of the plume (Figure 1-10). Based on this a review and screening of the current state of the remediation practices was conducted that concluded the only options that could be implemented in this very large plume area in a highly urbanized location would be hydraulic control by extracting and capturing the contaminated groundwater. Once this was determined, three possible remedial options were formulated and evaluated in detail including the development of costs and a timetable for implementation. However, a more detailed evaluation, (considering all of the remedy selection criteria) would be required to change the remedy selected in the 2001 ROD to insure consistency with the National Contingency Plan.

The three remedial options that are outlined in detail in this report include:

Remedial Option No. 1: includes installation of 16 groundwater extraction wells along the Southern State Parkway pumped at a total of 19 mgd to capture groundwater containing chlorinated volatile organic compounds greater than 5 µg/l. Water extracted from these wells would be conveyed to a centralized treatment plant capable of removing contaminants to the NYS Class A Surface Water Standards. Approximately, 31 cubic feet per second (cfs) or treated water would be discharged to Massapequa Creek. Given the length and depth of CVOCs greater than 5 µg/l and resulting pore-volume of groundwater containing CVOCs greater than 5 µg/l, this remedial option could operate for over 200 years. The total present value of this remedial option is $268 million.

Remedial Option No. 2: includes the drilling and installation of 10 groundwater extraction wells at Nassau County Recharge basins and the Southern State Parkway pumped at a total of 19 mgd could effectively capture groundwater containing CVOCs greater than 5 µg/l. Water extracted from these wells would be discharge to the sanitary sewer and treated at the Cedar Creek Water Pollution Control Plant. This Remedial Option includes the installation of up to 12,000 feet of new sanitary sewer lines and a major upgrade to the Cedar Creek Water Pollution Control Plant. Given the length and depth of CVOCs greater than 5 µg/l this remedial option could operate for over 200 years. The total present value of this remedial option is $552 million.

Remedial Option No. 3: includes the use of three South Farmingdale Water District wells and the installation of up to seven new groundwater extraction wells at Nassau County Recharge Basins and the Southern State Parkway pumped at a total of 19 mgd could effectively capture groundwater containing CVOCs greater than 5 µg/l. The water supply wells would be disconnected from water mains and connected to the sanitary sewers. The water from the newly installed extraction wells would be discharged to the sanitary sewers. This Remedial Option includes the installation of up to 12,000 feet of new sanitary sewer lines and a major upgrade to the Cedar Creek Water Pollution Control Plant. Given the length and depth of CVOCs greater than 5 µg/l this remedial option could operate for over 200 years. The total present value of this remedial option is $587 million.

All three remedial options could be effectively constructed to achieve the RAOs and protect the Massapequa and other Public Water Supply Wells in the area. Since all three options effectively capture and contain the plume they would be protective of other natural resources including freshwater wetlands and the salt water environment. The cost of implementing any of these remedial options will be in excess of $268 million and any of these remedial options will operate for up to a century. Finally, all of the remedial options will result in a loss of 730 billions of gallons of water resource from a sole source aquifer that supply the residents of Nassau County with drinking water for the next century especially given the unknown effects of climate change.

Direct use of the water after wellhead treatment has been proven to be an effective approach in other areas of the United States to achieve the RAOs and protect human health and the environment. The treatment of this water would be no different to what has been done by many water purveyors for many decades, including many water purveyors in Nassau County. This approach would be safe and effective but would require considerable planning and cooperation between the stakeholders and water providers to implement. The primary advantage of this option would be the elimination of the need to 'dispose' of the treated water that after treatment would be suitable for drinking. This option is not consistent with Chapter 543 of the Laws of 2014 but would provide a long-term manageable solution, reduce the overall costs, and not result in a loss of Nassau County's precious water resources.

6.0 REFERENCES

Arcadis, 2011, Remedial Investigation Report (Study Area Groundwater) Operable Unit 3, (Former Grumman Settling Ponds), Bethpage, New York, 189 p.

Arcadis Geraghty & Miller, 2000, Groundwater Feasibility Study, Grumman Aerospace-Bethpage, NY Site #130003A and Naval Weapons Industrial Reserve Plant Bethpage, NY Site #130003B, October.

Busciolano, R., Monti, J. Jr., and Chu, A., 1998, Water-table and Potentiometric-surface Altitudes of the Upper Glacial, Magothy, and Lloyd Aquifers on Long Island, New York, in March-April 1997, with a Summary of Hydrogeologic Conditions: U.S. Geological Survey Water-Resources Investigations Report 98-4019, 17 p.

Buxton, H, T., Shernoff, P. K., 1999, Ground-water Resources of Kings and Queens Counties, Long Island, New York: U.S. Geological Survey- Water supply Paper 2498, 113 p.

Cartwright, R. A., 2002, History and Hydrologic Effects of Ground-water Use in Kings, Queens and Western Nassau Counties, Long Island, New York, 1800's through 1997: U.S. Geological Survey Water-Resources Investigations Report 01-4096, 79 p.

Cashin Associates Inc., 2009, Massapequa Creek Watershed Management and Corridor Restoration Plan, Town of Oyster Bay, December.

Environmental Security Technology Certification Program (ESTCP), 2010, Critical Evaluation of State-of-the-Art In Situ Thermal Treatment Technologies for DNAPL Source Zone Treatment, ESTCP Project ER-0314, 1270 p.

Fenneman, N. M., 1938, Physiography of Eastern United States, Journal of Geology, Vol. 47, No. 1, 105 – 107 p.

Fuller, M. L., 1914, The Geology of Long Island, New York: U.S. Geological Survey Professional Paper 82, 231 p.

Grubb, S., 1993, Analytical Model for Estimation of Steady-State Capture Zones of Pumping Wells in Confined and Unconfined Aquifers, Groundwater, Vol. 31, Issue 1, 27-32 p.

Halliburton NUS Corporation, 1994, Feasibility Study Report for Naval Weapons Industrial Reserve Plant, Bethpage, NY, March.

Interstate Technology and Regulatory Council (ITRC), 2002, DNAPL Source Reduction: Facing the Challenge.

Isbister, J., 1966, Geology and Hydrology of Northeastern Nassau County, Long Island, New York: U.S. Geological Survey Water-Supply Paper 1825, 89 p.

Misut, P. E.; Feldman, S. M., 1996, Delineation of areas contributing recharge to wells in central Long Island, New York, by particle tracking: U.S. Geological Survey, Open-File Report 95-703, vi, 47 p.

Monti, J Jr., Como, M., Busciolano, R., 2013, Water-table and Potentiometric-surface Altitudes in the Upper Glacial, Magothy, and Lloyd Aquifers Beneath Long Island, New York, April-May 2010: U.S. Geological Survey, Scientific Investigations Map 3270, 4 sheets, scale 1:125,000, http://dx.doi.org/10.3133/sim3270

New York State Assembly, B. 9492, Chapter 543, Navy Grumman Plume Review (2014)

New York State Department of Environmental Conservation (NYSDEC), 1998, Technical and Operational Guidance Series Memorandum 1.1.1

New York State Department of Environmental Conservation (NYSDEC), 1999, Part 703 Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations

New York State Department of Health (NYSDOH), 2011, Part 5, Subpart 5-1 Public Water Systems, Revised November 2011.

Perlmutter, N. M., Geraghty, J. J., 1963, Geology and Ground-water Conditions in Southern Nassau and Southeastern Queens Counties, Long Island, NY: U.S. Geological Survey Water-Supply Paper 1613-A, 205 p.

Resolution Consultants, 2015a, 2014 OU2 Groundwater Investigation, VPB 158, Bethpage, NY, prepared for Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic, 232 p.

Resolution Consultants, 2015b, 2014 OU2 Groundwater Investigation, VPB 153, Bethpage, NY, prepared for Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic, 272 p.

Resolution Consultants, 2015c, 2014 OU2 Groundwater Investigation, VPB 152, Bethpage, NY, prepared for Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic, 280 p.

Resolution Consultants, 2015d, 2014 OU2 Groundwater Investigation, VPB 151, Bethpage, NY, prepared for Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic, 327 p.

Resolution Consultants, 2015e, 2014 OU2 Groundwater Investigation, VPB 147, Bethpage, NY, prepared for Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic, 336 p.

Resolution Consultants, 2015f, 2014 OU2 Groundwater Investigation, VPB 146, Bethpage, NY, prepared for Department of the Navy, Naval Facilities Engineering Command, Mid-Atlantic, 291 p.

Reilly, T. E., Buxton, H. T., Franke, O. L., Wait, R. L., 1983, Effects of Sanitary Sewers on Ground-water Levels and Streams in Nassau and Suffolk Counties, New York, Part 1, Geohydrology, Modeling Strategy, and Regional Evaluation: U.S. Geological Survey Water-Resources Investigations Report 82-4045, 45 p.

Smolenksy, D.A., and Feldman, S.M., 1995, Three-dimensional advection transport of volatile organic compounds in ground water beneath an industrial/residential area of Nassau County, New York: U.S. Geological Survey Water-Resources Investigations Report 92–4148, 53 p.

Tetra Tech, 2012, Study of Alternatives for Management of Impacted Groundwater at Bethpage, Naval Facilities Engineering Command Mid-Atlantic, 188 p.

United States Environmental Protection Agency (USEPA), 2011, 40 CFR Part 141 – National Primary Drinking Water Regulations, 40 FR 59570

United States Environmental Protection Agency (USEPA), 1996, Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites, Final Guidance; EPA Document No. 540-R-96-023.

TABLES

Table 1-2

Potential Muncipal Well Receptors

NYSDEC Well ID	Well Supplier	Well No.	Plant Site	Rated Well Capacity (gpm)	Depth (ft)
8480	New York American Water	3S	Seaman's Neck	2,100	680
9338	New York American Water	4S	Seaman's Neck	2,100	650
5767	New York American Water	4D	Demott	1,935	385
8837	New York American Water	5D	Demott	1,154	680
9910	New York American Water	6D	Demott	1,667	780
7414	New York American Water	6M	Sunrise Mall	1,667	530
8603	New York American Water	7M	Sunrise Mall	1,607	893
10863	New York American Water	8M	Sunrise Mall	1,879	685
BWD-6915	Bethpage	4-1	Plant 4	1,400	608
BWD-6916	Bethpage	4-2	Plant 4	1,400	611
BWD-8004	Bethpage	5-1	Plant 5	1,400	740
BWD-3876	Bethpage	6-1	Plant 6	1,400	386
BWD-8941	Bethpage	6-2	Plant 6	1,200	775
5303	Levittown (Town of Hempstead)	NS	Wantagh Ave	1,236	714
7523	Levittown (Town of Hempstead)	NS	NS	NS	684
8279	Levittown (Town of Hempstead)	NS	NS	NS	547
MWD-6442	Massapequa	4	Northwest	1,400	618
MWD-6443	Massapequa	5	Northwest	1,400	825
MWD-6866	Massapequa	6	New York Ave	1,400	626
MWD-6867	Massapequa	7	New York Ave	1,400	492
MWD-13,338	Massapequa	9	Sunrise Highway	1,400	645
NS	Massapequa	1	Northeast	NS	NS
NS	Massapequa	2R	Northeast	NS	NS
NS	Massapequa	3	Northeast	NS	NS
NS	Massapequa	8	Northeast	NS	NS
SFWD-4043	South Farmingdale	1-2	Plant 1	1,200	382
SFWD-5148	South Farmingdale	1-3	Plant 1	1,200	369
SFWD-7377	South Farmingdale	1-4	Plant 1	1,400	758
NS	South Farmingdale	2-2	Plant 2	NS	NS
NS	South Farmingdale	2-3	Plant 2	NS	NS
SFWD-6150	South Farmingdale	3-1	Plant 3	1,400	612
SFWD-6148	South Farmingdale	4-1	Plant 4	1,200	566
SFWD-8664	South Farmingdale	6-1	Plant 6	1,400	610
SFWD-8665	South Farmingdale	6-2	Plant 6	1,400	560

NS: Not Specified

Source:

ARCADIS Geraghty & Miller, 2000, Groundwater Feasibility Study, Grumman Aerospace-Bethpage, NY Site #130003A and Naval Weapons Industrial Reserve Plant, Bethpage, NY, Site #130003B

Massapequa Water District Case In Opposition to NYSDEC NAVY ROD OU-2, February 2011.

Tetra Tech, 2012, Study of Alternatives for Management of Impacted Groundwater at Bethpage, Naval Facilities Engineering Command Mid-Atlantic.

Table 2-1

Applicable or Relevant and Appropriate Requirements

Title	Citation	Description	ARAR or TBC	Comments
Federal				
Safe Drinking Water Act	40 CFR Part 141	Drinking water standards, expressed as maximum containment levels (MCLs), which apply to specific contaminants that have been determined to have an adverse impact on human health.	ARAR	Contaminant concentrations exceeding MCL in drinking water may warrant corrective actions.
State of New York				
New York State Department of Environmental Conservation Water Quality Standards	6 CRR-NY 703	Water Quality Standards are the basis for programs to protect the state waters. Standards set forth are the MCL of chemical pollutants and are used as the regulatory targets for permitting, compliance, enforcement, and monitoring and assessing the quality of the state's waters.	ARAR	Contaminant concentrations exceeding MCL in drinking water may warrant corrective actions.
New York State Department of Environmental Conservation Water and Technical and Opertional Guidance Series	TOGS 1.1.1	Compilation of ambient water quality standards and guidance values and groundwater effluent limitations for use where there are no standards or regulatory effluent limitations.	ARAR	Contaminant concentrations exceeding MCL in drinking water may warrant corrective actions.
New York State Department of Health	NYSDOH Part 5, Subpart 5-1	Rules that are promulgated to protect present or future source of water supply.	ARAR	Contaminant concentrations exceeding MCL in drinking water may warrant corrective actions.

Table 2-2
Chemical-Specific ARAR

Contaminant of Concern	CAS #	NYSDEC Part 703.5 Class GA (ug/l)	NYSDEC TOGS 1.1.1 (ug/l)	NYSDOH Part 5, Subpart 5-1 (ug/l)	Federal MCLs (ug/l)	Lowest ARAR
1,1,1-Trichloroethane	71-55-6	5	5	5	200	5
1,1,2,2-Tetrachloroethane	79-34-5	5	5	5	NS	5
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	5	5	NS	NS	5
1,1,2-Trichloroethane	79-00-5	1	1	5	5	1
1,1-Dichloroethane	75-34-3	5	5	5	NS	5
1,1-Dichloroethene	75-35-4	5	5	5	7	5
1,2,3-Trichlorobenzene	87-61-6	5	5	5	NS	5
1,2,4-Trichlorobenzene	120-82-1	5	5	5	70	5
1,2-Dibromo-3-chloropropane	96-12-8	0.04	0.04	NS	NS	0.04
1,2-Dibromoethane	106-93-4	0.0006	0.0006	NS	NS	0.0006
1,2-Dichlorobenzene	95-50-1	3	3	5	NS	3
1,2-Dichloroethane	107-06-2	0.6	0.6	5	5	0.6
1,2-Dichloropropane	78-87-5	1	1	5	5	1
1,3-Dichlorobenzene	541-73-1	3	3	5	NS	3
1,4-Dichlorobenzene	106-46-7	3	3	5	NS	3
1,4-Dioxane	123-91-1	NS	NS	NS	NS	0
2-Butanone	78-93-3	NS	50	NS	NS	50
2-Hexanone	591-78-6	NS	50	NS	NS	50
4-Methyl-2-pentanone	108-10-1	NS	NS	NS	NS	0
Acetone	67-64-1	NS	50	NS	NS	50
Benzene	71-43-2	1	1	5	5	1
Bromochloromethane	74-97-5	5	5	5	NS	5
Bromodichloromethane	75-27-4	NS	50	NS	NS	50
Bromoform	75-25-2	NS	50	NS	NS	50
Bromomethane	74-83-9	5	5	5	NS	5
Carbon disulfide	75-15-0	60	NS	NS	NS	60
Carbon tetrachloride	56-23-5	5	5	5	5	5
Chlorobenzene	108-90-7	5	5	5	100	5
Chloroethane	75-00-3	5	5	5	NS	5
Chloroform	67-66-3	7	7	NS	NS	7
Chloromethane	74-87-3	5	5	5	NS	5
cis-1,2-Dichloroethene	156-59-2	5	5	5	70	5
cis-1,3-Dichloropropene	10061-01-5	0.4*	0.4*	5	NS	5
Cyclohexane	110-82-7	NS	NS	NS	NS	0
Dibromochloromethane	124-48-1	NS	50	NS	NS	50
Dichlorodifluoromethane	75-71-8	5	5	5	NS	5
Ethylbenzene	100-41-4	5	5	5	700	5
Isopropylbenzene	98-82-8	5	5	5	NS	5
m&p-Xylenes	136777612	NS	NS	5	NS	5
Methyl Acetate	79-20-9	NS	NS	NS	NS	0
Methylcyclohexane	108-87-2	NS	NS	NS	NS	0
Methylene chloride	75-09-2	5	5	5	NS	5
Methyl-t-butyl ether	1634-04-4	NS	NS	NS	NS	0
o-Xylene	95-47-6	5	5	5	NS	5
Styrene	100-42-5	5	5	5	100	5
Tetrachloroethene	127-18-4	5	5	5	NS	5
Toluene	108-88-3	5	5	5	1000	5
trans-1,2-Dichloroethene	156-60-5	5	5	5	70	5
trans-1,3-Dichloropropene	10061-02-6	0.4*	0.4*	5	NS	5
Trichloroethene	79-01-6	5	5	5	5	5
Trichlorofluoromethane	75-69-4	5	5	5	NS	5
Vinyl chloride	75-01-4	2	2	NS	2	2
Xylenes (Total)	1330-20-7	5	5	NS	10	5

* Applies to the sum of cis- and trans-1,3-dichloropropene, CAS Nos. 10061-01-5 and 10061-02-6,respectively.
NS - No Standard

Table 3-1

Initial Technology Screening for Technical Implementability

General Response Actions	Technology Class	Process Option	Brief Description	Screening Action		Screening Comments
				Retain	Reject	
No Action	None	Not Applicable	No Action		X	Does not fulfill goals of chapter 543 of the Laws of 2014, Grumman Plume Review
Institutional Controls and Monitoring	Administrative Restrictions	Groundwater use restrictions and monitoring to verify plume configuration	Restrictions placed on installation of new supply wells and usage of existing groundwater supply wells.	X		Technically feasible
Monitored Natural Attenuation	Natural Attenuation via Dilution, Adsorption, Dispersion, Biodegradation	Groundwater monitoring with analysis of biological and chemical indicators of attenuation processes	Establish a monitoring network and monitor contaminant concentrations and indicators of attenuation processes		X	Does not fulfill goals of chapter 543 of the Laws of 2014, Grumman Plume Review
In Situ Treatment	Thermal Treatment	Steam Enhanced Extraction (SEE)	Combination of steam injection and vacuum extraction		X	Groundwater contamination is too deep, the aquifer is too hetergeneous, and the high density commercial/residental nature of this area will prevent an effective implemention of this technology
		Electrical Resistance Heating (ERH)	Uses application of 3- or 6-phase electrical power and resistivity of soil particles to heat subsurface		X	Not technically feasibile. This technology is most effective at remediating fine-grained silts and clays. Depth and extent of contamination is also prohibitive.
		Thermal Conduction Heating (TCH), also known as In Situ Thermal Desorption (ISTD)	Install heater wells that have operating temperatures as high as 800 degrees C and extract vapor.		X	Not technically feasibile. This technology is most effective at remediating fine-grained silts and clays. Depth and extent of contamination is also prohibitive.
	Biological Treatment	Enhanced Reductive Dechlorination (biostimulation only)	Injection of carbon substrate to promote anaerobic conditions and foster growth of dechlorinating bacteria.		X	Does not fulfill goals of chapter 543 of the Laws of 2014, Grumman Plume Review
		Enhanced Reductive Dechlorination (biostimulation and bioaugmentation)	Injection of a microbial culture known to perform complete dechlorination of targeted compounds		X	Does not fulfill goals of chapter 543 of the Laws of 2014, Grumman Plume Review
	In Situ Chemical Oxidation	Permanganate	Injection of sodium permanganate or potassium permanganate.		X	Not technically feasible. Depth and implementation issues.
		Catalyzed hydrogen peroxide (CHP)	Injection of hydrogen peroxide and a catalyst (typically ferrous sulfate) to produce hydroxyl free radicals.		X	Not technically feasible. Depth and implementation issues.
		Activated persulfate	Injection of persulfate into subsurface. The persulfate is activated via addition of a base, addition of a ferrous salt, or addition of heat to produce the sulfate free radical.		X	Not technically feasible. Depth and implementation issues.
	Permeable Reactive Barriers	Zero-Valent Iron	Emplace zero-valent iron into the aquifer perpendicular to groundwater flow		X	Not technically feasible. Depth and implementation issues.
		Nano-Scale Iron	Inject nano-scale iron into aquifer		X	Not technically feasible. Depth and implementation issues.

Table 3-1
Initial Technology Screening for Technical Implementability

General Response Actions	Technology Class	Process Option	Brief Description	Screening Action		Screening Comments
				Retain	Reject	
In Situ Treatment- Cont.	Enhanced Desorption and Treatment	Surfactant Enhanced Aquifer Remediation (SEAR)	Inject surfactant solution to solubilize and/or mobilize DNAPL. Typically followed by a water flush.		X	Not technically feasibile. DNAPL not detected at site.
		Co-Solvent Flooding	Injection and extraction of cosolvents, such as alcohol, to solubilize and or mobilize DNAPL. Similar to SEAR in design and implementation.		X	Not technically feasibile. DNAPL not detected at site.
		Air sparging	Inject air into aquifer to gasify contaminants and mobilize gas phase from groundwater to surface. May need additional gas phase treatment at surface.		X	Not technically feasible. Depth and implementation issues.
Containment	Hydraulic Control	Extraction wells	Single or multiple vertical wells to extract groundwater using pumps	X		Technically feasible
		Interceptor trenches	Groundwater collection in a closed, permeable trench from which groundwater is extracted using pumps		X	Not technically feasible. Depth of contamination is greater than maximum depth of trenches.
	Vertical barrier	Slurry wall	Trench around areas of contamination and backfill with a low permeability soil bentonite or cementbentonite slurry		X	Not technically feasible. Depth of contamination is greater than maximum depth of slurry walls.
		Grout Curtain	Injection of a variety of fluids or particulate grouts into soil matrix to form a vertical barrier.			Not technically feasible. Depth of contamination is greater than maximum depth of trenches.
		Sheet piling	Drive steel sheet pile around areas of contamination		X	Not technically feasible. Depth of contamination is greater than maximum depth of sheet piling.
	Capping	Multimedia cap	Low-permeability clay and synthetic membrane covered by soil over areas of contamination to minimize groundwater recharge		X	Not technically feasibile. Will not achieve RAOs.
		Asphalt or concrete cap	Installation of a layer of asphalt or installation of a concrete slab over areas of contamination to minimize groundwater recharge		X	Not technically feasibile. Will not achieve RAOs.
Ex Situ Treatment	Biological Treatment	Aerobic bioreactor	Degradation of organics using microorganisms in an aerobic environment		X	Not technically feasible. Implementability Issues.
	Physical /Chemical Treatment	Carbon adsorption	Adsorption of contaminants onto activated carbon by passing water through carbon column	X		Technically feasible
		Chemical / UV oxidation	Chemical oxidation with or without enhancement with ultraviolet radiation		X	Not technically feasible. Implementability Issues.
		Ion Exchange	Water is passed through a resin bed where ions are exchanged between resin and water		X	Not technically feasibile. Typically used for metals treatment.
		Precipitation / Co-Precipitation	Use of pH adjustment, addition of a chemical precipitant, and flocculation to alter chemical equilibria to reduce solubility of contaminants		X	Not applicable for VOCs
		Air stripping	Aerate water to induce volatilization of contaminants in a packed column	X		Technically feasible
		Filtration (reverse osmosis, microfiltration, media filtration)	Separation processes to remove particles from solution		X	Not applicable for VOCs

Table 3-1
Initial Technology Screening for Technical Implementability

General Response Actions	Technology Class	Process Option	Brief Description	Screening Action		Screening Comments
				Retain	Reject	
Groundwater Disposal	Off-Site Treatment	POTW	Extracted groundwater discharged to local POTW for treatment	X		Technically feasible
		RCRA TSDF	Extracted groundwater transported to licensed RCRA facility for treatment and/or disposal		X	Not technically feasible. Volume of extracted groundwater is prohibitive.
	Discharge of treated water	Discharge to surface water	Discharge to nearby stream	X		Technically feasible
		Discharge to POTW	Treated water discharged to local POTW	X		Technically feasible
		Infiltration Basin or Gallery	Treated water discharged to infiltration basin or gallery		X	Not technically feasible. Large groundwater disposal rates prohibit use of existing basins.
		Well injection	Injection of treated water at the site via deep injection wells		X	Would require very large number of injection wells; require a lot of land; shallow depth to water could affect successful operation; and high O&M costs.
		Irrigation	Allows treated water to be discharged through land application or irrigation of vegetation.		X	Not technically feasible. Difficult to implement due to 8-10 month growth season and frozen or snow covered land surface during winter.

Table 4-1 Comparison of Total Cost of Remedial Options

Site:	Grumman Aerospace-Bethpage Facility	**Base Year:**	2016
Location:	Nassau County, New York	**Date:**	January 12, 2016
Phase:	Feasibility (-30% - +50%)		

Description	**Option 1** **Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (wells along Southern State Parkway), Ex-situ Treatment, and Discharge to Massapequa Creek (includes LTM and ICs).**	**Option 2** **Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (wells at Nassau County Recharge Basins and available land), and Discharge to POTW (includes LTM and ICs).**	**Option 3** **Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (combination of existing municipal wells and new wells at Nassau County Recharge Basins), and Discharge to POTW (includes LTM and ICs).**
Estimated Project Duration (Years)	30	30	30
Capital Cost	$ 89,371,295	$ 282,985,671	$ 308,381,137
Total O&M Cost	$ 173,421,405	$ 266,347,901	$ 276,320,968
Total Periodic Cost	$ 5,893,460	$ 3,050,002	$ 3,050,002
Total Present Value of Options	**$ 268,690,000**	**$ 552,390,000**	**$ 587,760,000**

Table 4-2 Cost Estimate for Option 1

Option 1
Hydraulic Control - Discharge to Massapequa Creek

COST ESTIMATE SUMMARY

Site: Grumman Aerospace-Bethpage Facility
Location: Nassau County, New York
Phase: Feasibility (-30% - +50%)
Base Year: 2016
Date: January 12, 2016

Description: Option 1: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (wells along Southern State Parkway), Ex-situ Treatment, and Discharge to Massapequa Creek (includes LTM and ICs).

Item No.		Description	Quantity	Unit	Unit Cost	Total	Notes
CAPITAL COSTS:							
1	**Well Installation**						
	1.1	Mobilization	1	LS	$ 100,000	$ 100,000	Delta Estimate
	1.2	Soil Erosion and Sediment Control	16	EA	$ 2,500	$ 40,000	
	1.3	Drilling Costs - Deep Extraction Well (800 ft. bgs)	8	EA	$ 325,000	$ 2,600,000	Delta Estimate
	1.4	Well Construction Costs - Deep Extraction Well (800 ft. bgs)	8	EA	$ 175,000	$ 1,400,000	Delta Estimate - 24" dia steel casing, 200' SS wire wrapped screen, concrete, grout, sand pack
	1.5	Drilling Costs - Shallow Extraction Well (550 ft. bgs)	8	EA	$ 275,000	$ 2,200,000	Delta Estimate
	1.6	Well Construction Costs - Shallow Extraction Well (550 ft. bgs)	8	EA	$ 170,000	$ 1,360,000	Delta Estimate - 24" dia steel casing, 350' SS wire wrapped screen, concrete, grout, sand pack
	1.7	Extraction Pump (700-950 GPM)	16	EA	$ 75,000	$ 1,200,000	Delta Estimate, waiting on Grundfos Pump Supplier
	1.8	IDW - Non-Haz Soil Disposal	3,600	Ton	$ 100	$ 360,000	~1.5 ton/ cy with each well:175 CY for the deep well, 125 CY for the shallow. $100/ ton- need basis for cost
	1.9	IDW - Non-Haz Water Disposal	1,933,172	Gal	$ 1.50	$ 2,899,758	Estimated 75,000 gallons per well for drilling and 3 well volume for development.
	1.10	Extraction Well Housing (20' x 20')	16	EA	$ 250,000	$ 4,000,000	Concrete block construction, glass block windows with steel doors. Well housing consists of extraction well control panel, well head, well head protection.
	1.11	Site Civil	16	EA	$ 50,000	$ 800,000	
	1.12	Heating System	16	EA	$ 10,000	$ 160,000	
	1.13	Fans	16	EA	$ 5,000	$ 80,000	
	1.14	Backup generator system (diesel)	16	EA	$ 150,000	$ 2,400,000	150Kw LPG Backup Generator with Switchover
	1.15	Electrical Control	16	EA	$ 100,000	$ 1,600,000	
	1.16	Power Drop for extraction wells	8	EA	$ 120,000	$ 960,000	
	1.17	Performance Well Installation and Materials (800 ft. bgs)	5	EA	$ 75,000	$ 375,000	
	1.18	Performance Well Installation and Materials (550 ft. bgs)	5	EA	$ 50,000	$ 250,000	
	1.19	Performance Well Transducers	10	EA	$ 5,000	$ 50,000	
	1.20	Well Permitting and As-Built Records	26	EA	$ 1,500	$ 39,000	
	1.21	As-Built Survey	5	Day	$ 2,500	$ 12,500	Assume day rate of $2,500 and 1 week to complete survey of all wells
		Sub-Total				**$ 22,886,258**	
2	**Conveyance Piping**						
	2.1	Mobilization	1	LS	$ 1,113,046	$ 1,113,046	Assumed 10% of total conveyance cost
	2.2	Soil Erosion and Sediment Control	11,657	LF	$ 3	$ 34,971	
	2.3	Trenching	17,350	CY	$ 30	$ 520,508	
	2.4	Pipe Install	57,545	LF	$ 150	$ 8,631,750	
	2.5	Utility Marking Tape	11,657	LF	$ 0.29	$ 3,381	
	2.6	Bedding	9,783	CY	$ 50.00	$ 489,143	
	2.7	Backfill and compaction	84,307	SF	$ 10.00	$ 843,069	
	2.8	Hydroseed	79,720	SF	$ 0.18	$ 14,350	
	2.9	Vaults and Junctions	22	EA	$ 5,000	$ 108,987	
	2.10	Road Crossings & Road Repair	510	CY	$ 200	$ 101,933	
	2.11	Road Closure (Police presence)	9	EA	$ 4,000	$ 36,000	
	2.12	Pipe (10" HDPE Double Walled)	11,657	LF	$ 5.71	$ 66,550	10" double walled HDPE
	2.13	Pipe (4" HDPE conduit)	11,657	LF	$ 0.75	$ 8,743	
	2.14	Pipe (36" HDPE Effluent Discharge)	530	LF	$ 40.00	$ 21,200	
	2.15	Effluent Trenching	687	CY	$ 30.00	$ 20,611	
	2.16	Effluent Pipe Install	530	LF	$ 150.00	$ 79,500	
	2.17	Outfall Structure	1	LS	$ 50,000.00	$ 50,000	
	2.18	Asphalt/ Concrete Disposal	998	Ton	$ 100.00	$ 99,767	
		Sub-Total				**$ 12,243,508**	
3	**Treatment Plant**						
	3.1	Mobilization	1	LS	$ 1,237,412	$ 1,237,412	Assumed 10% of total treatment plant cost
	3.2	Soil Erosion and Sediment Control	1	LS	$ 15,000	$ 15,000	
	3.3	Reinforced Concrete Foundation	7,500	CY	$ 65	$ 487,500	
	3.4	Steel Building	20,000	SF	$ 20	$ 400,000	
	3.5	HVAC System	1	LS	$ 75,000	$ 75,000	
	3.6	Windows and Doors	1	LS	$ 50,000	$ 50,000	
	3.7	Site Civil - Landscaping Costs	1	LS	$ 102,750	$ 102,750	Assumed 10% of building costs.
	3.8	Electrical Power and Lighting	1	LS	$ 200,000	$ 200,000	
	3.9	Equalization Tank	1	EA	$ 5,000,000	$ 5,000,000	5MM gallon storage, assume $1/ gallon
	3.10	Secondary Containment EQ Tanks	3,574	CY	$ 65	$ 232,324	Concrete containment
	3.11	Bag Filter (1,200 gpm)	13	EA	$ 21,920	$ 284,960	Cost from 2014-2015 USA Bluebook
	3.12	Air Stripper (Carbonair Model STAT 720)	13	EA	$ 153,215	$ 1,991,795	low profile air strippers (Equipment install and delivery)
	3.13	Air Stripper PLC	1	EA	$ 375,782	$ 375,782	Allen-Bradley Compact Logix - Carbonair
	3.14	Process Air Heaters and Vapor Phase Carbon Adsorber Package	13	EA	$ 46,270	$ 601,510	Carbonair quote - includes shipment and installation oversight (40hrs)
	3.15	Liquid Phase Carbon Adsorbers (Polish after Airstripper)	26	EA	$ 76,346	$ 1,984,996	
	3.16	Interconnection Piping and Valves	1	LS	$ 250,000	$ 250,000	
	3.17	Meters and Instrumentation	1	LS	$ 100,000	$ 100,000	
	3.18	Power Drop for Treatment Plant	1	LS	$ 200,000	$ 200,000	
	3.19	Technical Training	96	Hour	$ 250	$ 24,000	
	3.20	System Start-up	1	LS	$ 13,500	$ 13,500	
		Sub-Total				**$ 13,626,529**	
4	**Pre-Design Investigation**						
	4.1	Pre-Design Investigation	1	LS	$ 5,000,000.00	$ 5,000,000	
		Sub-Total				**$ 5,000,000**	
	Sub-Total					**$ 53,756,295**	Sub-Total All Construction Costs.
		Contingency	25%			$ 13,439,000	10% scope + 15% bid.

Continued on next page.

Table 4-2 Cost Estimate for Option 1

Option 1
Hydraulic Control - Discharge to Massapequa Creek

COST ESTIMATE SUMMARY

Site: Grumman Aerospace-Bethpage Facility
Location: Nassau County, New York
Phase: Feasibility (-30% - +50%)
Base Year: 2016
Date: January 12, 2016

Description: Option 1: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (wells along Southern State Parkway), Ex-situ Treatment, and Discharge to Massapequa Creek (includes LTM and ICs).

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
	Sub-Total				**$ 67,195,295**	
	Project Management	5%			$ 3,360,000	
	Remedial Design	10%			$ 6,720,000	
	Construction Management	8%			$ 5,376,000	
	Construction Oversight	10%			$ 6,720,000	
	TOTAL CAPITAL COST				**$ 89,371,295**	

O&M COST:

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
1	**Operation**					
1.1	Plant Operators Staff	4	EA	$ 208,000	$ 832,000	Assume 4 full time (2,080hr/ yr) staff billing at $100/ hr.
1.2	Electrical Usage - Extraction Well Pumps	13,803,948	KW-Hr	$ 0.12	$ 1,656,474	
1.3	Electrical Usage - Treatment Plant Equipment	20,475,458	KW-Hr	$ 0.12	$ 2,457,055	
1.4	Permitting for Discharging to Creek	1	yearly	$ 15,500.00	$ 15,500	Based on NYSDEC SPDES Permit for municipal user.
	Sub-Total				**$ 4,961,029**	
	Project Management	10%			$ 496,000	
	Technical Support	8%			$ 397,000	
	Contingency	15%			$ 744,000	5% scope + 10% bid.
	Sub-Total				**$ 6,598,029**	
2	**Maintenance**					
2.1	Extraction Well Maintenance	16	EA	$ 2,000	$ 32,000	
2.2	Extraction Pump Maintenance	16	EA	$ 1,875	$ 30,000	Assume 2.5% cost per pump
2.3	Filter bag replacement	4,056	EA	$ 7.19	$ 29,163	Unit cost from USA BlueBook. 6 bags per housing, 13 units, assume 1 change out/ week
2.4	VGAC Regeneration - Off gas Treatment	114,063	Lb	$ 1.50	$ 171,094	
2.5	LGAC Regeneration - Polishing	260,000	Lb	$ 1.20	$ 312,000	
	Sub-Total				**$ 574,256**	
	Project Management	10%			$ 57,000	
	Technical Support	8%			$ 46,000	
	Contingency	15%			$ 86,000	5% scope + 10% bid.
	Sub-Total				**$ 763,256**	
3	**Performance Monitoring**					
3.1	Site Management Plan	1	LS	$ 30,000	$ 30,000	
3.2	Groundwater Sampling	35	EA	$ 950	$ 33,250	25 existing wells + 10 new wells sampled annually
3.3	Groundwater Sample Laboratory Analysis	38	EA	$ 550	$ 20,900	Sampling 35 wells annually for Total VOCs analysis + QA/QC.
3.4	Data Reduction, Evaluation and Reporting	1	EA	$ 25,000	$ 25,000	
3.5	Field Labor and Expenses	1	LS	$ 13,983	$ 13,983	
	Sub-Total				**$ 123,133**	
	Project Management	10%			$ 12,000	
	Field Staff - Scientist/ Geologist/ Engineer	8%			$ 10,000	
	Contingency	15%			$ 18,000	5% scope + 10% bid.
	Sub-Total				**$ 163,133**	
4	**Performance Sampling**					
4.1	Monthly Performance Sampling - Air (Effluent)	12	EA	$ 1,500	$ 18,000	
4.2	Quarterly Performance Sampling - Air (Effluent)	4	EA	$ 2,500	$ 10,000	
4.3	Monthly Performance Sampling - Water (Effluent)	12	EA	$ 1,500	$ 18,000	
4.4	Quarterly Performance Sampling - Water (Effluent)	4	EA	$ 2,500	$ 10,000	
4.5	Monthly, Quarterly, and Annual Reporting	1	LS	$ 61,950.00	$ 61,950	
	Sub-Total				**$ 117,950**	
	Project Management	10%			$ 12,000	
	Technical Support	8%			$ 9,000	
	Contingency	15%			$ 18,000	5% scope + 10% bid.
	Sub-Total				**$ 156,950**	

PERIODIC COSTS:

Item No.	Description	Year	Quantity	Unit	Unit Cost	Total	Notes
1	**Periodic Review Report**						
1.1	Annual PRR	1	5	LS	$ 20,000	$ 100,000	
1.2	Update Institutional Controls (every 5 years)	5	1	LS	$ 25,000	$ 25,000	
	Sub-Total					**$ 125,000**	
	Project Management		5%			$ 6,000	
	Construction Oversight		8%			$ 10,000	
	Contingency		15%			$ 19,000	5% scope + 10% bid.
	Sub-Total					**$ 160,000**	
2	**Extraction Pump Replacement**						
2.1	Extraction Pump Replacement (every 15 years)	15, 30	16	EA	$ 75,000	$ 1,200,000	
	Sub-Total					**$ 1,200,000**	
	Project Management		5%			$ 60,000	
	Construction Oversight		8%			$ 96,000	
	Contingency		15%			$ 180,000	
	Sub-Total					**$ 1,536,000**	

Continued on next page.

Table 4-2 Cost Estimate for Option 1

Option 1
Hydraulic Control - Discharge to Massapequa Creek

COST ESTIMATE SUMMARY

Site: Grumman Aerospace-Bethpage Facility
Location: Nassau County, New York
Phase: Feasibility (-30% - +50%)
Base Year: 2016
Date: January 12, 2016

Description: Option 1: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (wells along Southern State Parkway), Ex-situ Treatment, and Discharge to Massapequa Creek (includes LTM and ICs).

Item No.		Description		Quantity	Unit	Unit Cost	Total	Notes
3	**Extraction Pump Rehab**							
	3.1	Extraction Pump Rehab (year 5, 10, 20, & 25)	5, 10, 20, 25	4	EA	$ 15,000	$ 60,000	Assume 25% rehab costs 20% replacement costs on
		Sub-Total					**$ 60,000**	
	Project Management			5%			$ 3,000	
	Construction Oversight			8%			$ 5,000	
		Contingency		15%			$ 9,000	
	Sub-Total						**$ 77,000**	
4	**Extraction Well Redevelopment**							
	4.1	Extraction Well Redevelopment (every 5 years)	5	16	EA	$ 25,000	$ 400,000	Assumed 25k per well for redevelopment
		Sub-Total					**$ 400,000**	
	Project Management			5%			$ 20,000	
	Construction Oversight			8%			$ 32,000	
		Contingency		15%			$ 60,000	
	Sub-Total						**$ 512,000**	
5	**Treatment Plant**							
	5.1	Bag Filter Pump Replacement (every 5 years)	5	3	EA	$ 21,920	$ 71,240	Assumed replacement of 25%
	5.2	Air Stripper Cleaning (every 5 years)	5	1	LS	$ 53,000	$ 53,000	
	5.3	Replace Interconnection Piping and Valves	5	1	LS	$ 6,250	$ 6,250	Assume 2.5% replacement
		Sub-Total					**$ 130,490**	
	Project Management			5%			$ 7,000	
	Construction Oversight			8%			$ 10,000	
		Contingency		15%			$ 20,000	5% scope + 10% bid.
	Sub-Total						**$ 167,490**	

PRESENT VALUE ANALYSIS: Rate of Return: 5% Interest Rate: 3%

Item No.		Cost Type	Year	Total Cost	Present Value	Notes
1	**Capital Cost**		0	$ 89,371,295	**$ 89,371,295**	
2	**O & M**					
	2.1	Operation		$ 6,598,029	*	Annual cost for the life of the system
	2.2	Maintenance		$ 763,256	*	Annual cost for the life of the system
	2.3	Performance Monitoring		$ 163,133	*	Annual cost for the life of the system
	2.4	Performance Sampling		$ 156,950	*	Annual cost for the life of the system
		Sub-Total			**$ 173,421,405**	**NPV Assuming 5% Return and 3% Inflation**
3	**Periodic Costs**					
	3.1	Periodic Review Report		$ 160,000	*	Every 5 years
	3.2	Extraction Pump Replacement		$ 1,536,000	*	Every 15 years
	3.3	Extraction Pump Rehab		$ 77,000	*	Every 5 years, except 15 and 30 year marks
	3.4	Extraction Well Redevelopment		$ 512,000	*	Every 5 years
	3.5	Treatment Plant		$ 167,490	*	Every 5 years
		Sub-Total			**$ 5,893,460**	**NPV Assuming 5% Return and 3% Inflation**
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$ 268,690,000**	

***** The annual and periodic costs over the life of the system changes on an annual basis as noted. For simplicity, the total O&M and periodic costs over the 30 years are presented.

Table 4-3 Cost Estimate for Option 2

Option 2
Hydraulic Control - Discharge to POTW

COST ESTIMATE SUMMARY

Site:	Grumman Aerospace-Bethpage Facility
Location:	Nassau County, New York
Phase:	Feasibility (-30% - +50%)
Base Year:	2016
Date:	January 12, 2016

Description: Option 2: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (wells at Nassau County Recharge Basins and available land), and Discharge to POTW (includes LTM and ICs).

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
CAPITAL COSTS:						
1	**Extraction Well Installation**					
	Well Installation					
1.1	Mobilization	1	LS	$ 100,000	$ 100,000	Delta Estimate
1.2	Soil Erosion and Sediment Control	12	EA	$ 2,500	$ 30,000	
1.3	Site Preparation - Clearing & Grubbing	12	EA	$ 2,500	$ 30,000	
1.4	Drilling Costs - Deep Extraction Well (800 ft. bgs)	6	EA	$ 325,000	$ 1,950,000	Delta Estimate
1.5	Well Construction Costs - Deep Extraction Well (800 ft. bgs)	6	EA	$ 175,000	$ 1,050,000	Delta Estimate - 24" dia steel casing, 200' SS wire wrapped screen, concrete, grout, sand pack
1.6	Drilling Costs - Shallow Extraction Well (550 ft. bgs)	6	EA	$ 275,000	$ 1,650,000	Delta Estimate
1.7	Well Construction Costs - Shallow Extraction Well (550 ft. bgs)	6	EA	$ 170,000	$ 1,020,000	Delta Estimate - 24" dia steel casing, 350' SS wire wrapped screen, concrete, grout, sand pack
1.8	Extraction Pump (700-950 GPM)	12	EA	$ 75,000	$ 900,000	Delta Estimate, waiting on Grundfos Pump Supplier
1.9	IDW - Non-Haz Soil Disposal	2,700	Ton	$ 100	$ 270,000	~1.5 ton/ cy with each well:175 CY for the deep well, 125 CY for the shallow. $100/ ton- need basis for cost
1.10	IDW - Non-Haz Water Disposal	1,449,879	Gal	$ 1.50	$ 2,174,819	Estimated 75k per well for drilling and 3 well volume for development.
1.11	Extraction Well Housing	12	EA	$ 250,000	$ 3,000,000	Concrete block construction, glass block windows with steel doors. Well housing consists of extraction well control panel, well head, well head protection.
1.12	Site Civil	12	EA	$ 50,000	$ 600,000	
1.13	Heating System	12	EA	$ 10,000	$ 120,000	
1.14	Fans	12	EA	$ 5,000	$ 60,000	
1.15	Backup generator system	12	EA	$ 75,000	$ 900,000	150Kw LPG Backup Generator with Switchover
1.16	Electrical Control	12	EA	$ 100,000	$ 1,200,000	
1.17	Power Drop for extraction wells	6	EA	$ 120,000	$ 720,000	
1.18	Performance Well Installation and Materials (800 ft. bgs)	5	EA	$ 75,000	$ 375,000	
1.19	Performance Well Installation and Materials (550 ft. bgs)	5	EA	$ 50,000	$ 250,000	
1.20	Performance Well Transducers	10	EA	$ 2,000	$ 20,000	
1.21	Well Permitting and As-Built Records	22	EA	$ 1,500	$ 33,000	
1.22	As-Built Survey	5	Day	$ 2,500	$ 12,500	Assume day rate of $2,500 and 1 week to complete survey of all wells
	Sub-Total				**$ 16,465,319**	
2	**Conveyance Piping**					
2.1	Mobilization	1	LS	$ 886,487	$ 886,487	Assumed 10% of total conveyance cost
2.2	Soil Erosion and Sediment Control	16,717	LF	$ 3	$ 50,151	
2.3	Trenching	9,510	CY	$ 30	$ 285,303	
2.4	Pipe Install	16,717	LF	$ 150	$ 2,507,550	
2.5	Utility Marking Tape	16,717	LF	$ 0.29	$ 4,848	
2.6	Bedding	96,290	CY	$ 50.00	$ 4,814,496	
2.7	Backfill and compaction	53,494	SF	$ 10.00	$ 534,944	
2.8	Hydroseed	20,000	SF	$ 0.18	$ 3,600	
2.9	Vaults and Junctions	8	EA	$ 5,000	$ 38,545	
2.10	Road Crossings & Road Repair	1,238	CY	$ 200	$ 247,659	
2.11	Road Closure (Police presence)	33	Day	$ 4,000	$ 133,736	
2.12	Pipe (10" HDPE Double Walled)	16,717	LF	$ 5.71	$ 95,437	10" double walled HDPE
2.13	Asphalt/ Concrete Disposal	1,857	Ton	$ 80.00	$ 148,596	Disposal as debris
	Sub-Total				**$ 9,751,353**	
3	**Capital Improvements to Cedar Creek**					
3.1	Capital Improvements to Cedar Creek (20 MGD Upgrade)	1	LS	$ 139,000,000	$ 139,000,000	Based on HDR Water Cost estimate of 20 MGD upgrade. This cost is understood to be a planning level, 50% design cost.
	Sub-Total				**$ 139,000,000**	
4	**Pre-Design Investigation**					
4.1	Pre-Design Investigation	1	LS	$ 5,000,000	$ 5,000,000	
	Sub-Total				**$ 5,000,000**	
	Sub-Total				**$ 170,216,671**	Sub-Total All Construction Costs.
	Sub-Total					
	Contingency	25%			$ 42,554,000	10% scope + 15% bid.
	Sub-Total				**$ 212,770,671**	
	Project Management	5%			$ 10,639,000	
	Remedial Design	10%			$ 21,277,000	
	Construction Management	8%			$ 17,022,000	
	Construction Oversight	10%			$ 21,277,000	
	TOTAL CAPITAL COST				**$ 282,985,671**	

O&M COST:

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
1	**Operation**					
1.1	System Operators	0	yearly	$ 249,600	$ -	
1.2	Electrical Usage - Extraction Well Pumps	13,803,948	KW-Hr	$ 0.12	$ 1,656,474	

Continued on next page.

Table 4-3 Cost Estimate for Option 2

Option 2
Hydraulic Control - Discharge to POTW

COST ESTIMATE SUMMARY

Site: Grumman Aerospace-Bethpage Facility
Location: Nassau County, New York
Phase: Feasibility (-30% - +50%)
Base Year: 2016
Date: January 12, 2016

Description: Option 2: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (wells at Nassau County Recharge Basins and available land), and Discharge to POTW (includes LTM and ICs).

Item No.		Description	Quantity	Unit	Unit Cost	Total	Notes
	1.3	Monthly Reporting	12	Month	$ 7,500	$ 90,000	
	1.4	Permitting for Discharging to POTW	1	yearly	$ 15,500	$ 15,500	
	1.5	Discharge Fee to Cedar Creek POTW	7,300,000	$/1000 gal	$ 1.00	$ 7,300,000	Per year cost (~75MM for 30 year life). $1/1,000 gallons is comparable to the O&M cost for the 20MGD plant outlined in Option. 1.
		Sub-Total				**$ 9,061,974**	
	Project Management		5%			$ 453,000	
	Technical Support		8%			$ 725,000	
		Contingency	15%			$ 1,359,000	5% scope + 10% bid.
	Sub-Total					**$ 11,598,974**	
2	**Maintenance**						
	2.1	Extraction Well Maintenance	1	LS	$ 10,000	$ 10,000	
	2.2	Extraction Pump Maintenance	12	EA	$ 1,875	$ 22,500	Assume 2.5% cost per pump
		Sub-Total				**$ 32,500**	
	Project Management		5%			$ 2,000	
	Technical Support		8%			$ 3,000	
		Contingency	15%			$ 5,000	5% scope + 10% bid.
	Sub-Total					**$ 42,500**	
3	**Performance Monitoring**						
	3.1	Site Management Plan	1	LS	$ 30,000	$ 30,000	
	3.2	Groundwater Sampling	35	EA	$ 950	$ 33,250	25 existing wells + 10 new wells sampled annually
	3.3	Groundwater Sample Laboratory Analysis	38	EA	$ 550	$ 20,900	Sampling 35 wells annually for Total VOCs analysis + QA/QC.
	3.4	Data Reduction, Evaluation and Reporting	1	EA	$ 25,000	$ 25,000	
	3.5	Field Labor and Expenses	1	LS	$ 13,983	$ 13,983	
		Sub-Total				**$ 123,133**	
	Project Management		5%			$ 6,000	
	Technical Support		8%			$ 10,000	
		Contingency	15%			$ 18,000	5% scope + 10% bid.
	Sub-Total					**$ 157,133**	

PERIODIC COSTS:

Item No.		Description	Year	Quantity	Unit	Unit Cost	Total	Notes
1	**Periodic Review Report**							
	1.1	Annual PRR	1	5	EA	$ 20,000	$ 100,000	
	1.2	Update Institutional Controls (every 5 years)	5	1	EA	$ 25,000	$ 25,000	
		Sub-Total					**$ 125,000**	
	Project Management			5%			$ 6,000	
	Construction Oversight			8%			$ 10,000	
		Contingency		15%			$ 19,000	5% scope + 10% bid.
	Sub-Total						**$ 160,000**	
2	**Extraction Pump Replacement**							
	2.1	Extraction Pump Replacement (every 15 years)	15	12	EA	$ 75,000	$ 900,000	
		Sub-Total					**$ 900,000**	
	Project Management			5%			$ 45,000	
	Construction Oversight			8%			$ 72,000	
		Contingency		15%			$ 135,000	5% scope + 10% bid.
	Sub-Total						**$ 1,152,000**	
3	**Extraction Pump Rehab**							
	3.1	Extraction Pump Rehab (every 5 years)	5	3	EA	$ 15,000	$ 45,000	Assume rehab costs 20% replacement costs on 25% of the pumps.
		Sub-Total					**$ 45,000**	
	Project Management			5%			$ 2,000	
	Construction Oversight			8%			$ 4,000	
		Contingency		15%			$ 7,000	
	Sub-Total						**$ 58,000**	
4	**Extraction Well Redevelopment**							
	4.1	Extraction Well Redevelopment (every 5 years)	5	12	EA	$ 10,000	$ 120,000	
		Sub-Total					**$ 120,000**	
	Project Management			5%			$ 6,000	
	Construction Oversight			8%			$ 10,000	
		Contingency		15%			$ 18,000	
	Sub-Total						**$ 154,000**	

PRESENT VALUE ANALYSIS: Rate of Return: 5% Interest Rate: 3%

Item No.		Cost Type	Year	Total Cost	Present Value	Notes
1	**Capital Cost**		0	$ 282,985,671	**$ 282,985,671**	
2	**O & M**					
	2.1	Operation		$ 11,598,974	*	Annual cost for the life of the system
	2.2	Maintenance		$ 42,500	*	Annual cost for the life of the system
	2.3	Performance Monitoring		$ 157,133	*	Annual cost for the life of the system
		Sub-Total			**$ 266,347,901**	**NPV Assuming 5% Return and 3% Inflation**

Continued on next page.

Table 4-3 Cost Estimate for Option 2

Option 2
Hydraulic Control - Discharge to POTW

COST ESTIMATE SUMMARY

Site: Grumman Aerospace-Bethpage Facility
Location: Nassau County, New York
Phase: Feasibility (-30% - +50%)
Base Year: 2016
Date: January 12, 2016

Description: Option 2: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (wells at Nassau County Recharge Basins and available land), and Discharge to POTW (includes LTM and ICs).

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
3	**Periodic Costs**					
3.1	Periodic Review Report	$ 160,000			*	Every 5 years
3.2	Extraction Pump Replacement	$ 1,152,000			*	Every 15 years
3.3	Extraction Pump Rehab	$ 58,000			*	Every 5 years, except 15 and 30 year marks
3.4	Extraction Well Redevelopment	$ 154,000			*	Every 5 years
	Sub-Total				**$ 3,050,002**	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$ 552,390,000**	**NPV Assuming 5% Return and 3% Inflation**

* The annual and periodic costs over the life of the system changes on an annual basis as noted. For simplicity, the total O&M and periodic costs over the 30 years are presented.

Table 4-4 Cost Estimate for Option 3

Option 3
Hydraulic Control – Groundwater Containment to NYS Class GA GWQS

COST ESTIMATE SUMMARY

Site: Grumman Aerospace-Bethpage Facility
Location: Nassau County, New York
Phase: Feasibility (-30% - +50%)
Base Year: 2016
Date: January 12, 2016

Description: Option 3: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (combination of existing municipal wells and new wells at Nassau County Recharge Basins), and Discharge to POTW (includes LTM and ICs).

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
CAPITAL COSTS:						
1	**Extraction Well Installation**					
	Well Installation					
1.1	Mobilization	1	LS	$ 100,000	$ 100,000	Delta Estimate
1.2	Soil Erosion and Sediment Control	12	EA	$ 2,500	$ 30,000	
1.3	Site Preparation - Clearing & Grubbing	12	EA	$ 2,500	$ 30,000	
1.4	Drilling Costs - Deep Extraction Well (800 ft. bgs)	5	EA	$ 325,000	$ 1,625,000	Delta Estimate
1.5	Well Construction Costs - Deep Extraction Well (800 ft. bgs)	5	EA	$ 175,000	$ 875,000	Delta Estimate - 24" dia steel casing, 200' SS wire wrapped screen, concrete, grout, sand pack
1.6	Drilling Costs - Shallow Extraction Well (550 ft. bgs)	4	EA	$ 275,000	$ 1,100,000	Delta Estimate
1.7	Well Construction Costs - Shallow Extraction Well (550 ft. bgs)	4	EA	$ 170,000	$ 680,000	Delta Estimate - 24" dia steel casing, 350' SS wire wrapped screen, concrete, grout, sand pack
1.8	Public Water Supply Well Retrofit	3	EA	$ 100,000	$ 300,000	
1.9	Extraction Pump (700-950 GPM)	12	EA	$ 75,000	$ 900,000	Delta Estimate, waiting on Grundfos Pump Supplier
1.10	IDW - Non-Haz Soil Disposal	2,288	Ton	$ 100	$ 228,750	~1.5 ton/ cy with each well:175 CY for the deep well, 125 CY for the shallow and 50 CY for the retrofit.
1.11	IDW - Non-Haz Water Disposal	1,314,879	Gal	$ 1.50	$ 1,972,319	Estimated 75,000 gallons per new well for drilling, 30,000 gallons per retrofit well, and 3 well volume for development.
1.12	Extraction Well Housing (20' x 20')	12	EA	$ 250,000	$ 3,000,000	Concrete block construction, glass block windows with steel doors. Well housing consists of extraction well control panel, well head, well head protection.
1.13	Site Civil	12	EA	$ 50,000	$ 600,000	
1.14	Heating System	12	EA	$ 10,000	$ 120,000	
1.15	Fans	12	EA	$ 5,000	$ 60,000	
1.16	Backup generator system	12	EA	$ 75,000	$ 900,000	150Kw LPG Backup Generator with Switchover
1.17	Electrical Control	12	EA	$ 100,000	$ 1,200,000	
1.18	Power Drop for extraction wells	6	EA	$ 120,000	$ 720,000	
1.19	Performance Well Installation and Materials (800 ft. bgs)	6	EA	$ 75,000	$ 450,000	
1.20	Performance Well Installation and Materials (550 ft. bgs)	6	EA	$ 50,000	$ 300,000	
1.21	Performance Well Transducers	10	EA	$ 2,000	$ 20,000	
1.22	Well Permitting and As-Built Records	22	EA	$ 1,500	$ 33,000	
1.23	As-Built Survey	5	Day	$ 2,500	$ 12,500	Assume day rate of $2,500 and 1 week to complete survey of all wells
	Sub-Total				**$ 15,256,569**	
2	**Conveyance Piping**					
2.1	Mobilization	1	LS	$ 975,961	$ 975,961	Assumed 10% of total conveyance cost
2.2	Soil Erosion and Sediment Control	27,875	LF	$ 3	$ 83,625	
2.3	Trenching	15,858	CY	$ 30	$ 475,733	
2.4	Pipe Install	16,717	LF	$ 150	$ 2,507,550	
2.5	Utility Marking Tape	16,717	LF	$ 0.29	$ 4,848	
2.6	Bedding	96,290	CY	$ 50.00	$ 4,814,496	
2.7	Backfill and compaction	53,494	SF	$ 10.00	$ 534,944	
2.8	Hydroseed	20,000	SF	$ 0.18	$ 3,600	
2.9	Vaults and Junctions	11	EA	$ 5,000	$ 52,794	
2.10	Road Crossings - Road Repair	2,753	CY	$ 200	$ 550,617	
2.11	Road Crossings - Road Closure (Police presence)	56	Day	$ 4,000	$ 223,000	
2.12	Pipe (10" HDPE Double Walled)	16,717	LF	$ 5.71	$ 95,437	10" double walled HDPE
2.13	Asphalt/ Concrete Disposal	4,130	Ton	$ 100.00	$ 412,963	Disposal as debris
	Sub-Total				**$ 10,735,568**	
3	**Drinking Water Replacement**					
3.1	Water Supply Well Replacement	3	EA	$ 3,500,000	$ 10,500,000	Estimate to replace each water supply well
3.2	Water Main Improvements	5	Mi	$ 1,000,000	$ 5,000,000	Assume 5 miles of water main improvements at ~$1MM/ mile
	Sub-Total				**$ 15,500,000**	
4	**Capital Improvements to Cedar Creek**					
4.1	Capital Improvements to Cedar Crek (20 MGD Upgrade)	1	LS	$ 139,000,000	$ 139,000,000	Based on HDR Water Cost estimate of 20 MGD upgrade. This cost is understood to be a planning level, 50% design cost.
	Sub-Total				**$ 139,000,000**	
5	**Pre-Design Investigation**					
5.1	Pre-Design Investigation	1	LS	$ 5,000,000	$ 5,000,000	
	Sub-Total				**$ 5,000,000**	
	Sub-Total				**$ 185,492,137**	Sub-Total All Construction Costs.
	Contingency	25%			$ 46,373,000	10% scope + 15% bid.
	Sub-Total				**$ 231,865,137**	
	Project Management	5%			$ 11,593,000	
	Remedial Design	10%			$ 23,187,000	
	Construction Management	8%			$ 18,549,000	
	Construction Oversight	10%			$ 23,187,000	
	TOTAL CAPITAL COST				**$ 308,381,137**	

O&M COST:

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes

Continued on next page.

Table 4-4 Cost Estimate for Option 3

Option 3
Hydraulic Control – Groundwater Containment to NYS Class GA GWQS

COST ESTIMATE SUMMARY

Site: Grumman Aerospace-Bethpage Facility
Location: Nassau County, New York
Phase: Feasibility (-30% - +50%)
Base Year: 2016
Date: January 12, 2016

Description: Option 3: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (combination of existing municipal wells and new wells at Nassau County Recharge Basins), and Discharge to POTW (includes LTM and ICs).

Item No.		Description	Quantity	Unit	Unit Cost	Total	Notes
1	**Operation**						
	1.1	System Operators	0	yearly	$ 249,600	$ -	
	1.2	Electrical Usage - Extraction Well Pumps	13,803,948	KW-Hr	$ 0.12	$ 1,656,474	
	1.3	Monthly Reporting	12	Month	$ 7,500	$ 90,000	
	1.4	Permitting for Discharging to POTW	1	yearly		$ -	
	1.5	Discharge Fee to Cedar Creek POTW	7,300,000	$/1,000 gal	$ 1.00	$ 7,300,000	Per year cost (~75MM for 30 year life). $1/1,000 gallons is comparable to the O&M cost for the 20MGD plant outlined in Option. 1.
		Sub-Total				**$ 9,046,474**	
	Project Management		10%			$ 905,000	
	Technical Support		8%			$ 724,000	
		Contingency	15%			$ 1,357,000	5% scope + 10% bid.
	Sub-Total					**$ 12,032,474**	
2	**Maintenance**						
	2.1	Extraction Well Maintenance	1	LS	$ 10,000	$ 10,000	
	2.2	Extraction Pump Maintenance	12	EA	$ 1,875	$ 22,500	Assume 2.5% cost per pump
		Sub-Total				**$ 32,500**	
	Project Management		10%			$ 3,000	
	Technical Support		8%			$ 3,000	
		Contingency	15%			$ 5,000	5% scope + 10% bid.
	Sub-Total					**$ 43,500**	
3	**Performance Monitoring**						
	3.1	Site Management Plan	1	LS	$ 30,000	$ 30,000	
	3.2	Groundwater Sampling	35	EA	$ 950	$ 33,250	25 existing wells + 10 new wells sampled annually
	3.3	Groundwater Sample Laboratory Analysis	38	EA	$ 550	$ 20,900	Sampling 35 wells annually for Total VOCs analysis + QA/QC.
	3.4	Data Reduction, Evaluation and Reporting	1	EA	$ 25,000	$ 25,000	
	3.5	Field Labor and Expenses	1	LS	$ 13,983	$ 13,983	
		Sub-Total				**$ 123,133**	
	Project Management		10%			$ 12,000	
	Technical Support		8%			$ 10,000	
		Contingency	15%			$ 18,000	5% scope + 10% bid.
	Sub-Total					**$ 163,133**	

PERIODIC COSTS:

Item No.		Description	Year	Quantity	Unit	Unit Cost	Total	Notes
1	**Periodic Review Report**							
	1.1	Annual PRR	1	5	EA	$ 20,000	$ 100,000	
	1.2	Update Institutional Controls (every 5 years)	5	1	EA	$ 25,000	$ 25,000	
		Sub-Total					**$ 125,000**	
	Project Management			5%			$ 6,000	
	Construction Oversight			8%			$ 10,000	
		Contingency		15%			$ 19,000	5% scope + 10% bid.
	Sub-Total						**$ 160,000**	
2	**Extraction Pump Replacement**							
	2.1	Extraction Pump Replacement (every 15 years)	15	12	EA	$ 75,000	$ 900,000	
		Sub-Total					**$ 900,000**	
	Project Management			5%			$ 45,000	
	Construction Oversight			8%			$ 72,000	
		Contingency		15%			$ 135,000	5% scope + 10% bid.
	Sub-Total						**$ 1,152,000**	
3	**Extraction Pump Rehab**							
	3.1	Extraction Pump Rehab (every 5 years)	5	3	EA	$ 15,000	$ 45,000	Assume rehab costs 20% replacement costs on 25% of the pumps.
		Sub-Total					**$ 45,000**	
	Project Management			5%			$ 2,000	
	Construction Oversight			8%			$ 4,000	
		Contingency		15%			$ 7,000	
	Sub-Total						**$ 58,000**	
4	**Extraction Well Redevelopment**							
	4.1	Extraction Well Redevelopment (every 5 years)	5	12	EA	$ 10,000	$ 120,000	
		Sub-Total					**$ 120,000**	
	Project Management			5%			$ 6,000	
	Construction Oversight			8%			$ 10,000	
		Contingency		15%			$ 18,000	
	Sub-Total						**$ 154,000**	

PRESENT VALUE ANALYSIS: Rate of Return: 5% Interest Rate: 3%

Item No.		Cost Type	Year	Total Cost	Present Value	Notes
1	**Capital Cost**		0	$ 308,381,137	**$ 308,381,137**	
2	**O & M**					
	2.1	Operation		$ 12,032,474	*	Annual cost for the life of the system
	2.2	Maintenance		$ 43,500	*	Annual cost for the life of the system
	2.3	Performance Monitoring		$ 163,133	*	Annual cost for the life of the system
		Sub-Total			**$ 276,320,968**	**NPV Assuming 5% Return and 3% Inflation**

Continued on next page.

Table 4-4 Cost Estimate for Option 3

Option 3
Hydraulic Control – Groundwater Containment to NYS Class GA GWQS

COST ESTIMATE SUMMARY

Site: Grumman Aerospace-Bethpage Facility
Location: Nassau County, New York
Phase: Feasibility (-30% - +50%)
Base Year: 2016
Date: January 12, 2016

Description: Option 3: Hydraulic Control – Groundwater Containment to NYS Class GA GWQS (combination of existing municipal wells and new wells at Nassau County Recharge Basins), and Discharge to POTW (includes LTM and ICs).

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
3	**Periodic Costs**					
3.1	Periodic Review Report	$ 160,000			*	Every 5 years
3.2	Extraction Pump Replacement	$ 1,152,000			*	Every 15 years
3.3	Extraction Pump Rehab	$ 58,000			*	Every 5 years, except 15 and 30 year marks
3.4	Extraction Well Redevelopment	$ 154,000			*	Every 5 years
	Sub-Total				**$ 3,050,002**	**NPV Assuming 5% Return and 3% Inflation**
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$ 587,760,000**	

* The annual and periodic costs over the life of the system changes on an annual basis as noted. For simplicity, the total O&M and periodic costs over the 30 years are presented.