NORTHROP GRUMMAN

Northrop Grumman Corporation
Aerospace Systems

Military Aircraft Systems
925 South Oyster Bay Road
Bethpage, New York 11714-3582

September 9, 2016

James B. Harrington
Director Remedial Bureau A
New York State Department of Environmental Conservation
625 Broadway
Albany, New York, 12233-7012

Re: Northrop Grumman Comments on Bethpage Remedial Options Report

Dear Mr. Harrington:

Northrop Grumman Systems Corporation (Northrop Grumman) hereby submits its comments on the Remedial Options Report for the Grumman Aerospace-Bethpage Facility (Options Report), pursuant to the Department's invitation to submit comments, dated August 10, 2016.

Northrop Grumman has worked closely with the Department to address groundwater issues associated with the operations of the former Navy/Grumman Bethpage facility. Those ongoing efforts are achieving favorable results. We understand the Department's legislative mandate to evaluate "full plume containment" of the Bethpage groundwater plume and have had a team of experts examine the Options Report. As set forth in the attached comments, we believe that the remedial options described in the Options Report would not effectively or efficiently remedy the groundwater issues, but rather would harm the groundwater resource and other natural resources.

Our comments are consistent with the Department's prior two reasoned decisions that reject full plume containment as an inappropriate remedy for the Bethpage plume. In fact, the Options Report recognizes that such a remedy would not be able to return the extracted and treated groundwater to the aquifer. As a result "all three of the remedial options will result in the loss of hundreds of billions of gallons of freshwater from a sole source aquifer." (See Options Report at page 3.)

Our comments demonstrate that the proposed remedies in the Options Report would:

- Induce further salt water intrusion;
- Harm estuarine and other natural resources;
- Potentially increase contamination in supply wells;
- Deplete water supplies below a sustainable level; and
- Still likely require wellhead treatment.

Moreover, the remedial options are inconsistent with the National Contingency Plan and 6 NYCRR Part 375.

Thus, although the Options Report is intended to set out remedial options that would contain the plume without the need for wellhead treatment, the options will not meet that goal. In fact, the Options Report implicitly recognizes the merits of the Department's ongoing remedial plans that utilize wellhead treatment: "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 RAOs and protect human health and the environment." (See Option Report at page 41.)

We understand the interest in exploring other options, but we believe the continued implementation of the remedies adopted in the Department's Records of Decision is the most responsible way to address the contaminant plume for protection of both public health and the environment. We remain committed to continuing to work with the Department, the U.S. Navy and other interested parties in achieving that goal.

Sincerely,

Edward Hannon

Edward J. Hannon
Manager ESH&M
Northrop Grumman

Comments on Remedial Options Report Regarding the Bethpage Plume

Prepared for:

NORTHROP GRUMMAN

Northrop Grumman Systems Corporation
Bethpage Facility

September 9, 2016

Prepared by:

EMAGIN
Creative Environmental Solutions

Environmental Management & Global Innovations, Inc.
15711 Mapledale Blvd, Suite B
Tampa, Florida 33624
(813) 968-7722

and

RAMBOLL ENVIRON

Ramboll Environ
10150 Highland Manor Drive, Suite 440
Tampa, FL 33610

Introduction

These comments have been prepared for Northrop Grumman Systems Corporation ("Northrop Grumman") to respond to the New York State Department of Environmental Conservation's ("Department") request for comments on the document entitled "Remedial Options Report, Grumman Aerospace-Bethpage Facility" ("Options Report") prepared for the Department by Henningson, Durham & Richardson Architecture and Engineering, P.C. (HDR). The Options Report was prepared in response to Chapter 543 of the Laws of 2014, which requires the Department to prepare a report delineating options for intercepting and remediating a regional plume, which consist primarily of volatile organic compounds ("VOCs").

Complete plume containment would purportedly be accomplished by installing paired shallow and deep remedial wells along a transect south of the leading edge of the plume, extracting groundwater at a rate of 19 million gallons per day (MGD), treating the water at either an existing treatment plant or a newly constructed treatment plant, and discharging the treated water to surface water.

The three remedial options evaluated in the Options Report are:

- Option 1 - a series of extraction wells installed along the Southern State Parkway right-of-way would be pumped at 19 MGD and the extracted water would be treated in a newly constructed treatment plant, followed by conveyance and discharge of the treated water to Massapequa Creek.

- Option 2 - a series of extraction wells installed near existing Nassau Country recharge basins would be pumped at 19 MGD and the extracted water would be treated at the Cedar Creek Water Pollution Control Plant (upgraded to receive additional flow), followed by discharge of the treated water from the plant's outfall three miles off-shore in the Atlantic Ocean.

- Option 3 - a series of extraction wells installed near existing Nassau Country recharge basins, plus three existing South Farmingdale Water District public supply wells, would be pumped at 19 MGD and the extracted water would be treated at the Cedar Creek Water Pollution Control Plant (upgraded to receive additional flow), followed by discharge of the treated water from the plant's outfall three miles off-shore in the Atlantic Ocean.

Summary of responses to Options Report

The remedies evaluated in the Options Report for full plume containment would not appreciably improve on the remedial options already being implemented or planned and would likely create adverse impacts to the aquifer, water districts, natural resources, and the public. In addition, full plume containment has been determined to not be feasible by multiple parties, including the Department. These concepts are addressed in the following sections of this document.

1. The remedies in the Options Report would induce saltwater intrusion into public water supplies.
2. The remedies in the Options Report would harm natural resources.
3. The remedies in the Options Report would deplete available water to water districts to below a sustainable level.
4. The remedies in the Options Report are contrary to prior Department decisions.
5. The remedies in the Options Report are contrary to conclusions of prior studies.
6. The remedies in the Options Report would not improve on the current plume remediation effort and may increase VOC impacts on local water supplies.
7. The remedies in the Options Report would not reliably contain the plume to eliminate the need for wellhead treatment.
8. The current Department-approved remedy being implemented is protective of public health.
9. The remedies in the Options Report do not satisfy key regulatory requirements for selecting an appropriate remedy.
10. Substantial technical and administrative difficulties would impede construction of the remedies in the Options Report.

Detailed Responses to the Options Report

Northrop Grumman assembled a team of technical experts, including engineers and scientists, to review the Remedial Options Report and its conclusions. One of the tools used by the team is an updated and expanded version of the regional groundwater model to evaluate the impacts of the remedies proposed in the Options Report. Properly applied tools, such as three-dimensional groundwater models, are used to assist regional planners, water suppliers, engineers, and scientists in assessing the impacts of proposed groundwater stresses both regionally and locally. The groundwater model, extending from the regional groundwater divide to the south shore of Long Island, was recently modified and extended from earlier models and used to evaluate the overall effects of implementing the full plume containment options in southern Nassau County. The modeling report (Arcadis, 2016; **Attachment 1**) is attached.

A peer review of the updated groundwater model and the analytical model used in the Options Report was conducted by Peter Shanahan, Ph.D., P.E., the principal of Hydro Analysis, Inc. (Shanahan, 2016; **Attachment 2**). Dr. Shanahan has extensive experience in groundwater modeling, including the development of computer codes for the groundwater model developed for Nassau County. Dr. Shanahan's peer review included a review of the model used in the Options Report and the model developed by Arcadis. He reviewed the history of the development of the Arcadis model, including the additions and calibrations undertaken for the current effort. Dr. Shanahan's review found that the "simple analytical model" used in the Options Report to design a capture-well remediation system for plume containment resulted in "an incomplete evaluation of the potential effects" of the Report's proposed remedial systems. In contrast, he found that "the digital computer model developed by Arcadis has been constructed and calibrated appropriately and consistent with conventional groundwater modeling practice." He concluded that the Options Report "has proposed a hydraulic capture system with extensive potential impact on the Long Island aquifer using a simple analytical model that arrives at incorrect results. Given the complexities of the aquifer system and vast quantities of pumping proposed, a sophisticated three-dimensional digital computer model is required to do justice to the analysis of the proposed full-plume remediation."

The overall simulated groundwater flow system (in terms of a water budget) changes from one of surplus to one of deficit under the remedial options presented in the Options Report. Under current conditions, groundwater recharge from precipitation over the model domain exceeds the total amount pumped (current pumping) by approximately 18 percent. However, pumping under the proposed remedial scenario would result in a water balance deficit in which groundwater extraction would exceed recharge from precipitation by approximately 13 percent. As detailed in the responses to the Options Report below, such a deficit would result in a rebalancing of the modeled groundwater system and a redistribution of sources and discharges of groundwater. Undesirable impacts include increased saltwater intrusion, depletion of available water to water districts, reduced fresh water outflow to surface waters and the associated ecological damages, and changes in the movement of VOC-impacted groundwater.

1. The remedies in the Options Report would induce saltwater intrusion into public water supplies.

Saltwater intrusion in Nassau County is well documented (Barlow, 2003) and has been recognized as a major threat to Nassau County water supplies. However, the Options Report does not acknowledge the very real likelihood of the proposed remedies overwhelming the freshwater aquifer that keeps the saltwater wedge at bay and the impact that the options present regarding saltwater intrusion into public supply wells. The modeling performed in connection with these comments demonstrates the documented existing salt water intrusion problems will be significantly aggravated by implementation of any of the three options.

Groundwater extraction near coastal areas such as South Oyster Bay has been the primary cause of saltwater intrusion. The inland extent and depth of freshwater/saltwater interface is controlled by the higher pressure of the freshwater column due to its higher elevation. Under natural conditions, the interface is described as a saltwater wedge that extends inland underneath the freshwater because of its greater density. When groundwater extraction lowers the water level, it reduces the pressure exerted by the freshwater column and allows the denser saltwater wedge to move upward and laterally inland. Supply wells located over or near the saltwater wedge can draw the saltwater upward, creating a saltwater cone beneath the well that can enter and contaminate the well. Saltwater intrusion, which is already an issue for public water suppliers in coastal zones of Nassau County, is expected to become a more serious problem over time as a result of climate changes such as sea-level rise that increase the risks of saltwater intrusion.

Saltwater intrusion in Nassau County has been caused by many years of over-pumping of the primary drinking water aquifers (Bartolino and Cunningham, 2003). More recently, the effects of over-pumping were conveyed by the USGS at the Long Island Water Conference's 2014 Groundwater Symposium. It was reported that the extent of saltwater intrusion near coastal communities is worse than previously estimated, which means that saltwater could impact supply wells sooner than expected and at greater salinities.

USGS (Buxton and Smolensky, 1998) stated "[t]he response of the ground-water system to stress takes the form of changes in ground-water levels, and in the pattern and distribution of ground-water flow. Declines in the water table decrease discharge to streams and the shore: declines in head in the confined aquifers decrease subsea discharge and accelerate landward movement of the saltwater/freshwater interface. The pattern of water-level declines determines which areas are affected most severely." Pumping an additional 19 MGD under any of the remedies in the Options Report would accelerate the rate of saltwater intrusion, particularly in the Magothy aquifer (the main producing aquifer in this area and regionally) under the southern coastal areas.

Drawdown in the Upper Glacial and Magothy aquifers, caused by the proposed 19 MGD withdrawal would be extreme. Based on modeling results, drawdown in the vicinity of the proposed extraction wells would lower water levels by over 30 feet. In key areas between the remedial wells and the shoreline of Oyster Bay, water levels would be lowered to levels ranging from 10 feet above sea level to below sea level (**Figures 1 and 2**).

Such low and continuous water levels produced by the upgradient groundwater withdrawal at the proposed extraction wells and the existing supply wells would result in extensive landward migration of saltwater in the Magothy aquifer and potential upconing of saltwater to supply wells, resulting in the likelihood of saltwater damage to the aquifer and water supplies in the affected area. As indicated in **Figures 1 and 2**, wells lying within the 5-foot contour, such as Massapequa Water District wells, are considered to be particularly vulnerable to saltwater intrusion. In most cases, aquifers impacted by salt water are lost to beneficial use and supply wells impacted by saltwater are abandoned or used sparingly. The affected water districts would then be forced to meet the needs of its customers by providing water from other sources.

2. The remedies in the Options Report would harm natural resources.

The Options Report contains little or no analysis regarding detrimental impacts to south shore streams, wetlands, estuaries, and the salt water environment as a result of the implementation of any of the three remedial options. Nevertheless, the Options Report incorrectly concludes "[s]ince 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" (Page 40). To the contrary, attempting full plume containment under the Options Report would likely have adverse impacts on natural resources in both riverine and estuarine areas because of the rebalancing of freshwater in these systems.

The remedies included in the Options Report would remove 19 MGD of groundwater and discharge this as treated water to Massapequa Creek under Remedial Option 1 or to the Atlantic Ocean under Remedial Options 2 and 3. This loss of groundwater from the aquifer under all three remedial options and the discharge of water in Massapequa Creek under Option 1 are features of the remedies that would increase risk to natural resources.

The streams on Long Island are termed "gaining streams" because the stream channels are lower in elevation than the water table and, as a result, groundwater flows into the streams and contributes to the stream flow. As the water table rises and falls seasonally, the amount of stream flow increases and decreases correspondingly. This seasonal cycling and the mixture of groundwater and surface water inputs is a characteristic of Massapequa Creek and the other stream systems along the south shore and shapes how and which plant and animal species make use of the habitat. The removal of 19 MGD from the aquifer would lower the water table elevation and substantially reduce the normal input of groundwater to the streams throughout the area.

Based on the current groundwater modeling evaluation, pumping 19 MGD under Options 2 and 3 would result in an approximately 55 percent reduction in stream flow in the streams within the model domain including Massapequa Creek, Newbridge Creek, Bellmore Canal, Cedar Creek, Seaford Creek, Carman Creek, and Narraskatuck Creek. Changes in the groundwater recharge to the streams on this scale will alter both the recreational quality of the streams and their ecological value. Further, reductions in stream flows will affect the salinity levels in the brackish estuaries where the creeks discharge fresh water to coastal marshes and saltwater bodies.

The pumping associated with the proposed options would impact the coastal and wetland areas by reducing the freshwater inputs via groundwater. Thus, the coastal areas would receive less groundwater directly reaching the surface in this area while simultaneously receiving less stream flow from the creeks. Accordingly, adverse impacts of the pumping would be expected in the coastal marshes and adjacent bay areas in addition to direct impacts on the freshwater streams from loss of water.

The expected impacts on Massapequa Creek and Massapequa Preserve as freshwater systems and Massapequa Cove and South Oyster Bay as coastal estuary systems are illustrative of the damage that would be expected from the proposed options. Those water bodies are near the center of the area of expected stream flow loss and are prime examples of natural, preserved lands in the area.

Massapequa Creek and Massapequa Preserve

Massapequa Creek and Massapequa Preserve are important natural resources that are the focus of conservation management (Cashin Associates, 2009). The Massapequa Creek watershed catchment is approximately 6.7 square miles, representing one of the largest natural areas remaining in southern

Nassau County. The creek and the associated preserve (**Figures 3A, 3B, and 3C**) provide habitat for a variety of plant and animal species. The damage from the proposed remedies would impact both the recreational qualities of the creek and preserve and the ecological benefits they provide.

Under Option 1, the 19 MGD of extracted groundwater released from the proposed treatment plant into Massapequa Creek would increase its average flow approximately five-fold compared to United States Geological Survey flow data (approximately 5.5 cubic feet per second (cfs) on average over the last 10 years), even accounting for the decreased discharge of groundwater into the creek previously discussed. This substantial increase in flow down Massapequa Creek under Option 1 would change conditions not only within the stream, but also in the surrounding preserved wetlands. The impacts of implementing Option 1 on Massapequa Creek and its ecology would include:

- Creation of a large, fast-flowing stream channel and resulting increased erosion and sedimentation downstream.
- Increased flow velocity may be too great for some freshwater fish species in Massapequa Creek to continue to inhabit and breed in the creek.
- Erosion and sediment transport would impact and could eliminate local populations of rare species. There are documented instances of New York State threatened and endangered plants along Massapequa Creek and in Massapequa Preserve.
- Erosional scour could physically remove wet pine barrens habitat. The wet pine barrens in the Massapequa Preserve support several state listed endangered plant species, including the only New York State occurrence of false china root, the largest state occurrence of button sedge, exemplary occurrences of Barratt's sedge, and smaller populations of whip nutrush and St. Andrew's cross.
- Changes in recreational fishing quality could be expected for Massapequa Creek as freshwater fish species are displaced by increased flow in the creek or their normal food sources are disrupted.
- Changes in the nature of the stream system and preserve from a seasonally variable system influenced by the pattern of mixing between groundwater recharge and rainfall/surface water inputs to something analogous to a constant-temperature spring-like system flowing rapidly throughout the year would alter its ecology. This would disrupt the normal seasonal changes in the preserve, degrading the cycles of stream rise and fall and temperature changes that would damage habitat. Option 1 would turn the natural stream and preserve system into a steady-flow industrial discharge channel.

Under Options 2 and 3, the 19 MGD of extracted groundwater would be discharged to the Atlantic Ocean via the Cedar Creek Water Pollution Control Plant outfall. Because no water would be returned to Massapequa Creek (or the other streams in the area) under those two options, the average flow in

Massapequa Creek would be substantially reduced (average 55 percent across all streams) due to water table changes from pumping the proposed extraction wells. The impacts of implementing Options 2 or 3 on Massapequa Creek and its ecology would include:

- Reduce average creek flow in Massapequa Creek to approximately 1.9 MGD (3.0 cfs), which would also reduce the area of the surrounding wetlands, resulting in detrimental effects on freshwater plant and animal communities throughout the creek and preserve.
- Reduced freshwater input to Massapequa Creek would alter the extent of the wet pine barrens habitat and could eliminate this habitat from certain areas. Drier habitat types will not support the same plant populations, and this transition could make it too dry for rare plants to survive where they are currently found in the preserve. In contrast to the expected effects of Option 1, where accelerated flow and scouring would threaten habitat for rare species, the effect of Options 2 and 3 would be to dry out one of the few wet pine barrens habitats in Nassau County and threaten the same rare species. The lower flow conditions could have adverse effects on populations of state-listed threatened and endangered species.
- Low flow conditions could have adverse effects on recreational fishing as freshwater fish habitat is reduced in Massapequa Creek and other creeks. The loss of wetlands that support food sources for freshwater fish is another factor that could adversely affect fishing.
- The current recreational qualities of the preserve are related to the presence of both the flowing stream and the wetland floodplains areas surrounding the stream. Usability of the preserve could be substantially altered for activities such as bird watching, hiking, and general enjoyment of the types of vegetative cover and landscape qualities if the water input were reduced to the extent expected from Options 2 and 3.

Massapequa Cove and South Oyster Bay

Massapequa Creek discharges into South Oyster Bay via Massapequa Cove, currently a highly regarded fishing area along the south shore of Nassau County (Melton, 2016). The habitat features and recreational qualities of the cove relate to the balance and seasonal fluctuations in fresh water entering from Massapequa Creek and salt water carried by the tides. The brackish water balance in the cove and surrounding bay would be affected by Option 1, which would greatly increase the freshwater flow in this area and scour the bottom along the mouth of the creek, and by Options 2 and 3, which would have the opposite effect by reducing stream flow. With any of the options, the pumping would reduce the groundwater discharge to the coastal marshlands that are critical to estuary function.

The connections among Massapequa Creek, Massapequa Cove, and South Oyster Bay are illustrated on **Figures 4A and 4B**. These figures also show the locations of seagrass beds and clam and shellfish beds in South Oyster Bay. Seagrasses in the area (particularly marine eelgrass) are the focus of New York State Seagrass Task Force because they stabilize sediments, reduce wave turbulence/storm surge, improve water quality by reducing nutrients and contaminants, and provide an oxygen source (NYS Seagrass Taskforce 2009).

Under Option 1, the increase in stream flow down Massapequa Creek and erosion of the stream channel will increase turbidity (reducing light penetration), transport coliform bacteria from upstream areas used by wildlife, and will increase sedimentation in the delta area of the creek and Massapequa Cove. The impacts expected from implementing Option 1 on Massapequa Cove and South Oyster Bay would include:

- Impacts from sedimentation on clams and shellfish in the area of Massapequa Cove and the proximate areas of South Oyster Bay.
  - Clam bed and shellfish areas protected by the State of New York (as mapped by Long Island South Shore Estuary Reserve Comprehensive Management Plan, 2001) include South Oyster Bay. Major shellfish species in the area include soft clam, northern quahog, bay scallop, and ribbed mussel. These are important to both the ecology and recreational uses of South Oyster Bay.
  - Filter feeding shellfish are particularly vulnerable to effects from sedimentation due to their limited (clams, scallops) or non-existent (mussel) ability to move out of degraded environments. Sedimentation can foul their gills, cause feeding difficulty (or failure), and reduce the population of phytoplankton that they feed on, or smother them entirely in areas of significant deposition.
- Sediment transport down Massapequa Creek would reduce water transparency and block sunlight. Light attenuation, as well as sedimentation on the leaf surfaces can have profound effects on seagrass survival (NYS Seagrass Taskforce 2009). Deposited sediments may be finer and have more organic matter compared to the largely sandy sediments of the bay. Both characteristics reduce oxygen penetration into sediments and the organic material can consume oxygen, potentially leading to sulfide poisoning of the seagrass root systems (rhizomes) (NYS Seagrass Taskforce 2009).
- Adverse effects to seagrass could damage other species in the estuary because seagrass is important habitat for many organisms (e.g., shrimp, juvenile fish) and the seagrass and those organisms that live within the seagrass are important food sources for fish and shellfish that are harvested by anglers. Fish and invertebrates use seagrasses for refuge and reproduction. The grasses also provide protection for the two largest shell fisheries in New York, the bay scallop and the hard clam.
- Increased stream flow into Massapequa Cove would decrease the local salinity. The average salinity in Massapequa Cove and South Oyster Bay is 26 to 28 parts per thousand (USACE 2004, Submerged Aquatic Vegetation Bed Characterization Report.) Treated groundwater discharges

of 19 MGD would result in a substantial reduction in salinity in Massapequa Cove and also reduce the tidal transport of salt water into the lower reaches of the creek. Reduced salinity can alter the presence and distribution of estuarine organisms.

- The increased stream flow will also change the water temperature pattern in Massapequa Cove, leading to cooler water in the summer and warmer water in the winter than natural conditions. This will change the distribution of fish species making use of the cove and impact the life cycle/reproductive cycle for sediment-dwelling species and shellfish.

- South Oyster Bay has been under EPA restrictions for coliform bacteria and polychlorinated biphenyls (PCBs) in the past decade. Increasing sediment transport from upland areas around Massapequa Creek may increase bacteria loading from pet and wildlife waste. Material and bacteria that would normally be trapped in the wetlands of Massapequa Preserve will be transported directly to the cove with the accelerated flow under Option 1.

Under Options 2 and 3, the primary effects on Massapequa Cove would be from the approximately 55 percent reduction in stream flow from Massapequa Creek. An effect in South Oyster Bay would be reduced discharge of fresh groundwater throughout the coastal marshlands from Bellmore to Amityville; the groundwater modeling estimated the reduction in discharge to be about 14 percent. Freshwater decreases on this scale could change the characteristics of the near shore estuaries. The impacts expected from implementing either Option 2 or 3 on Massapequa Cove and South Oyster Bay would include:

- Increased salinity in Massapequa Cove and increase in the upstream movement of salt water under tidal influence, potentially affecting freshwater fish and food sources in the lower creek.

- Changes in the conditions influencing marsh grasses along the shoreline of South Oyster Bay as the normal cycle of freshwater flushing and alternating directions of saltwater movement with the tides is changed.

In summary, all of the proposed options may substantially alter areas recognized to be sensitive habitat for threatened and endangered species and highly valued as a coastal estuary and fishery. Massapequa Creek and Massapequa Preserve represent key areas of important and limited natural habitat along the developed south shore in Nassau County. Massapequa Cove and the bay have been prized for shellfish and fishing for decades due to the natural balance between fresh and salt water supporting juvenile and bait fish along with good growth conditions for shellfish. All of the options would disrupt these conditions, with Option 1 potentially turning the creek and cove into an industrial channel transporting sediments that likely will impact bottom-dwelling organisms in the cove, while Options 2 and 3 would leave the cove and coastal marshes for miles of shoreline deficient in freshwater inputs. Given such changes, the statement in the Options Report that all of the options would be protective of natural resources (Page 40) is not supported by an evaluation and understanding of the ecological and recreational importance of the largest preserve of natural habitat in the area, or the balance of saltwater and fresh water in the cove and bay that has supported commercial and recreational uses for decades.

3. The remedies in the Options Report would deplete water currently available to water districts to below a sustainable level.

The Options Report acknowledges "all of the remedial options [described in the report] 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." (Page 41). Extracting an additional 19 MGD of groundwater beyond what is currently withdrawn by public supply wells would cause additional aquifer depletion (Konikow 2013) and thereby reduce the availability of water to the water districts. Recharge due to rainfall in the Bethpage area is around 16.2 MGD (23 inches of rain per year over an area 5.5 miles long by 2.7 miles wide) (Tetra Tech 2012), and since the total withdrawal in the Bethpage area would be around 33.5 MGD, there would be a local annual groundwater deficit that would grow by approximately 17.3 MGD (33.5 minus 16.2 MGD) or 6.3 billion gallons per year, year after year.

Excessive groundwater pumping ("over-pumping") has been debated in Nassau County for over a decade because it leads to depletion of the aquifer. The "safe yield" for Nassau County, traditionally defined as the amount of water that can be withdrawn without producing an undesired effect, is reported to be 185 MGD, a benchmark that was exceeded nine times between 1990 and 2003 (Nassau County Department of Public Works, 2005). The average annual groundwater demand now consistently exceeds the safe yield (Nassau County Growth Management Department, 2013). Compounding this problem is the current understanding that "sustainable yield" rather than "safe yield" should be the objective of prudent water supply planning (Alley et. al., 1999, Alley and Leak, 2004, and Bartolino and Cunningham 2003), which necessitates less withdrawal than the "safe yield", as traditionally defined (http://ponce.sdsu.edu/groundwater_sustainable_yield.html):

> "The traditional concept of safe yield, which equates safe yield with natural recharge, is flawed and has been widely discredited. It has now been replaced with sustainable yield. Sustainable yield depends on the amount of capture, and whether this amount can be accepted as a reasonable compromise between a policy of little or no use, on one extreme, and the sequestration of all natural discharge, on the other extreme. …Sustainable yield may also be expressed as a percentage of recharge. Limited experience suggests that average percentages may be around 40%, with the least conservative around 70%, and reasonably conservative around 10%."

Repeatedly exceeding the sustainable yield would substantially reduce the water currently available to public supply wells, particularly those nearest the proposed extraction wells (i.e., South Farmingdale Water District Plants 4 and 6 and New York American Water Seaman's Neck Plant). Magothy aquifer drawdown in the zone of influence of the proposed extraction wells would increase 20 feet or more near South Farmingdale Plants 4 and 6 and over 30 feet at the containment wells (**Figure 5**). This drawdown may necessitate modifying the supply wells and pump elevations or possibly installing new wells to extract water deeper in the aquifer. These well modification options would be viable only if the quality of water at lower depths in the aquifer is not impacted by saltwater intrusion (see previous discussion of saltwater intrusion).

Inability to Comply with the Long Island Well Permit Requirements

Prior to installing the proposed extraction wells under the Options Report, the State or a responsible party acting under the authority of the Department would need to obtain a Long Island Well Permit and/or comply with all "substantive technical requirements applicable to like activity conducted pursuant to a permit…" issued pursuant to the Long Island Well Permit Statute, ECL §15-1527. Certain statutory criteria for obtaining a Water Withdrawal Permit under the recently enacted provisions are specifically incorporated into the Long Island Well Permit Statute, and thus the Department must consider those criteria. As such, issuance of a permit and or compliance with the technical requirements would be unlikely because Section 601.16(a)(2), consistent with the statutory purpose, provides that the Department "…may deny an application for a water withdrawal permit if the department determines that… the water withdrawal will exceed or cause to be exceeded the safe yield or sustainable supply of the water source". Department approval of a permit that would violate this criterion would not be supportable. Moreover, an applicant implementing any of the options could not demonstrate (Section 601.10(k)) that:

- "the project is just and equitable to all affected municipalities and their inhabitants with regard to their present and future needs for sources of potable water supply" (ECL §15-1527.4 and ECL §15-1503.2.c); and
- "… the proposed water withdrawal will be implemented in a manner to ensure it will result in no significant individual or cumulative adverse impacts on the quantity or quality of the water source and water dependent natural resources." (ECL §15-1503.2.f).

Thus, the harmful effects associated with the three options proposed in the Options Report would mean that neither the state nor an applicant implementing any of the proposed options could obtain a Long Island Well Permit or comply with the substantive technical requirements applicable to such a permit.

4. The remedies in the Options Report are contrary to prior Department decisions.

The Department has previously rejected full plume containment as a remedy for the Bethpage plume. The Options Report does not propose to improve the technology associated with the groundwater extraction process, and therefore the prior Department decisions and prior studies indicating that the extraction process will not reliably prevent contaminants reaching down gradient supply wells remain valid.

Full plume containment was first evaluated in the Department's 2001 Record of Decision for OU-2 ("OU-2 ROD") for consistency with the National Contingency Plan ("NCP"), 40 CFR Part 300, and 6 NYCRR Part 375, each of which mandates that a remedy protect human health and the environment as the primary objective, and balance tradeoffs among viable alternatives. The Department did not select full plume containment because of the "…technical infeasibility of implementing such a program in the extensive and diffuse offsite plume." The Department explained that "[t]his is based on the sheer width, depth, and overall area of the plume and on comparison of this plume information with ONCT [On-site Containment] extraction system data and data from other sites on Long Island where groundwater extraction and treatment is being implemented." The Department concluded "[i]n addition, the area is densely developed and finding the necessary locations to implement total plume containment would be difficult at best and more likely, infeasible to implement." (NYSDEC, 2001, OU-2 ROD page 58).

In the OU-2 ROD Responsiveness Summary, the Department answered a July 27, 2001, request by the Massapequa Water District Commissioner that the Bethpage plume be contained by stating "… full plume containment is not a feasible option… it is clear that full plume containment would be too extensive in nature, and is just not feasible." (ROD response 60, page 55).

Twelve years after the OU-2 ROD, the Department expressed again, this time in the 2013 ROD for OU-3, that full plume containment was not feasible and, moreover, was even less realistic than in 2001, when the plume was characterized as less extensive and diffuse (NYSDEC, 2013, OU-3 ROD Responsiveness Summary, introduction, page A-2):

> "Full containment of the OU-2 groundwater contamination plume was evaluated as part of the OU-2 remedy and was not selected. This decision, set forth in the OU-2 ROD, has recently been reviewed independently by a number of organizations including the United States Environmental Protection Agency (USEPA), the United States Geological Survey (USGS), the United States Army Corps of Engineers (USACOE) and the Battelle Institute. The Naval Facilities Engineering Command (NAVFAC) finalized this review into the Remedy Optimization Team Report (06/2011). While these four reviewing groups have offered suggestions regarding the need for further evaluation, none have suggested that the selected remedy for OU-2 was not appropriate."

The Department also concluded that the expanded pump and treatment system evaluated in the OU-3 ROD would be even more difficult to implement than the full containment system evaluated in the OU-2 ROD (NYSDEC 2013, OU-3 ROD Exhibit D, page 15):

> "There is a greater degree of difficulty of implementation for the off-site groundwater remedial program the larger the given pump and treatment system is. This includes the number of groundwater extraction wells, pipelines, treatment system(s) and points of discharge. The off-site full plume containment groundwater system would be constructed in a densely populated area with significant implementability due to the greater difficulty of siting and constructing the off-site groundwater remedial elements for this huge pump and treatment system. All this

construction would be occurring within highly developed residential areas or highway rights of way both of which will present significant implementability issues associated with the access and siting of the large pump stations, treatment systems and required pipe lines connecting all the facilities."

Although the Options Report acknowledges the difficulty of implementing a full plume containment remedy, its failure to adhere to the Department's decisions has produced options that are not only infeasible but would result in significant harm.

5. The remedies in the Options Report are contrary to conclusions of prior studies.

The Options Report incorrectly concludes that hydraulic capture is being successfully used to intercept groundwater with hazardous chemicals at many Inactive Waste Disposal Sites in Nassau County and, therefore, it has a high level of scientific and engineering surety. Those conclusions are not supported with site-specific examples of success or detailed discussions of why hydraulic capture would have a high level of surety in remediating a plume the size, depth, and complexity of the Bethpage plume.

The proposed remedial options are variants of full plume containment alternatives that have been intensively evaluated over the past 15 years by the Department, the U.S. Geological Survey ("USGS"), the U.S. Navy, Northrop Grumman, and nationally recognized technical experts. Full plume containment was found to be not feasible in those evaluations within the meaning of "feasible" in 6 NYCRR Part 375-1.2 as "…suitable to site conditions, capable of being successfully carried out with available technology, implementable, and cost effective." Specifically, the feasibility of implementing full plume containment has been evaluated on four occasions since 2000.

2000 OU-2 Groundwater Feasibility Study

Full plume containment alternatives were first discounted in the Department's 2001 OU-2 ROD following the conclusion of a public process, and based on the findings of the October 2000 "Groundwater Feasibility Study Grumman Aerospace-Bethpage, NY Site #130003A and Naval Weapons Industrial Reserve Plant, Bethpage, NY Site #130003B" ("OU-2 Feasibility Study", Arcadis 2000). At that time, the plume was reportedly 9,600 feet wide, 12,100 feet long and extended to a depth of 580 feet. Several full plume containment alternatives were evaluated in the OU-2 Feasibility Study, each of which included six off-site extraction wells withdrawing a total of 5.2 MGD followed by treatment of extracted groundwater and discharge to existing storm sewers. Full plume containment was not recommended in the OU-2 Feasibility Study because of implementation difficulties, high costs, and negligible improvements in contaminant mass removal and groundwater cleanup time compared to the recommended alternative.

2001 OU-2 Record of Decision

The findings of the OU-2 Feasibility Study were reflected in the Department's alternatives evaluation in the OU-2 ROD. The selected remedy consisted of focused groundwater remediation to address VOC source areas, on-going wellhead treatment to protect public water supplies, and contingency planning for potential future wellhead treatment. The OU-2 ROD stated "[t]he selected remedy is protective of human health and the environment, complies with State and Federal requirements that are legally applicable or relevant and appropriate to the remedial action to the extent practicable, and is cost effective. This remedy utilizes permanent solutions and alternative treatment or resource recovery technologies, to the maximum extent practicable, and satisfies the preference for remedies that reduce toxicity, mobility, or volume as a principal element." (OU-2 ROD, Declaration, NYSDEC, 2001). The Department further stated that the remedy (Alternative 3) was selected "…based on the fact that it is not economically or technically feasible to contain and treat all the contaminated groundwater that has migrated from the Northrop Grumman and NWIRP sites to groundwater quality standards." (OU-2 ROD, page 28, NYSDEC, 2001).

2011 Optimization Study

The Department's conclusion that wellhead treatment is a necessary component of an effective remedy was validated in 2011 when the Navy assembled a technical team to revisit full plume containment. The technical team included experts in chlorinated solvent impacts from the Navy, USGS, academia, and private sector. The technical team concluded in the June 2011 "Remedy Optimization Team Report for the Bethpage Groundwater Plume Remedy" ("Optimization Report", The Technical Team for Optimization of the Bethpage plume Remedy, 2011) that:

- "The sheer size of the TCE plume footprint … renders complete aquifer cleanup unachievable within a reasonable timeframe, even with the benefit of unlimited economic resources." (page 10); and

- "Experience at other sites shows that geologic heterogeneities, plume migration, and matrix diffusion are significant technical constraints that will likely make large-scale, rapid restoration of groundwater in the downgradient plume to pre-plume conditions impossible. Therefore, impacts to public water supply wells are unavoidable." (page 10)

2012 Alternatives Report

The full plume containment alternative was again dismissed in the Navy's January 2012 "Study of Alternatives for Management of Impacted Groundwater at Bethpage" ("Alternatives Report", TetraTech, 2012). By then, the plume that the Options Report purports to address was better defined, revealing an even more extensive and diffuse plume than what was believed to exist in 2001, making full plume containment even more difficult and less reliable. The Navy characterized the plume as having shallow and deep components, with the shallow plume (generally 100-300 feet deep) reported to be approximately 9,700 feet wide and at least 17,000 feet long. The deep western plume occurred between 300 and 750 feet below land surface and extended downgradient over 12,000 ft. The deep eastern plume was reported to be 300 to 650 feet below land surface and vertically discontinuous. Full plume containment was not recommended in the Alternatives Report because it would present negative short-term and long-term impacts, would be difficult to implement, would not be cost effective, and would require wellhead treatment. The Alternatives Report was widely circulated, and did not receive any publicly recorded criticism from the Massapequa Water District nor the Department.

6. The remedies in the Options Report would not improve on the current plume remediation effort and may increase VOC impacts on local water supplies.

By the Remedial Option Report's own admission, extracting an additional 19 MGD of groundwater beyond what is currently withdrawn by public supply wells would "overpower" the aquifer system. This proposed "overpowering" of the aquifer would likely result in little to no benefit to the progress of the regional plume remediation and may increase VOC impacts on local water supply wells and capture contamination outside of the proposed capture zone:

- The existing and planned remedial systems approved by the Department, together with natural attenuation processes, are effective remedies that are functioning without the harmful impacts that would be associated with full plume containment. Eventually, some contamination will be drawn south to the line of extraction wells under the pumping conditions proposed in the Options Report (**Figures 6 and 7**). This occurrence would be unlikely or very minimal under the current remedial approach to the plume. Based on modeling results, no measurable VOCs are projected to arrive at the line of proposed extraction wells within the next 30 years under the current remedial approach to the plume (except an estimated 2 parts per billion of total VOCs in one shallow well; **Figures 6 and 7**). Similarly, only four of the proposed extraction wells (of 16 total) under Option 1 are projected to remove any VOCs in groundwater at concentrations above the VOC detection limits.

- However, as discussed in Sections 5, 7 and 8, there will remain some risk of breakthrough within the capture zone or bypass around the capture zone due to complexities in the geology, size and depth of the plume, and other known and unknown areas of contamination within and outside the containment system capture zone necessitating the option of well head treatment to achieve the non-detect standard.

- South Farmingdale Plants 1, 3, and 6 and New York American Water Seaman's Neck Road Plant are located between the proposed groundwater extraction wells and high VOC concentrations in the regional plume (**Figure 8**). The additional groundwater extraction would increase the hydraulic gradient and approximately double the rate of the southerly migration of contaminants toward those wells. Operating the containment system may necessitate adding or modifying wellhead treatment systems to handle greater VOC concentrations. The capture zones for the Massapequa Water District supply wells would expand into areas to the east and west and capture water that may be impacted by unknown sources of contamination.

- Pumping 19 MGD of groundwater would produce a much larger overall capture zone for the proposed extraction wells than was estimated in the Options Report. The Report did not consider that the capture zones of the proposed extraction wells would have a cumulative effect (i.e., they would not overlap as shown in the report), which means a much larger capture zone than estimated would be produced (**Figure 8**). Because nearby supply wells south of the proposed extraction wells would have to compete for water with the new extraction wells, the capture zones of the supply wells would be redirected to new areas and possibly induce migration of contamination toward these supply wells from other VOC sources (e.g., Liberty

Finishing Site, Old Bethpage Landfill, drycleaners) that would otherwise have been outside the capture zone of those wells (**Figure 8**).

7. The remedies in the Options Report would not reliably contain the plume to eliminate the need for wellhead treatment.

The Options Report assumes "[b]y 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." (Page16). The support for this assumption is the unsubstantiated statement: "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" (Page 25). This may be true for small scale projects; however, the Options Report does not provide any support that this remedial approach would work for much larger and more complex sites.

There are no identified examples in Nassau County, or elsewhere, of a containment system as extensive in scope and complexity as those described in the Options Report. Contrary to the assumptions in the Options Report, the OU-2 Feasibility Study, OU-2 ROD, Optimization Report, and Alternatives Report have all concluded that even an aggressive attempt at full plume containment would not reliably protect the downgradient public supply wells because VOCs would likely migrate past the remedial system. This point was underscored in the Alternatives Report's conclusion that downgradient wellhead protection must be retained as part of any groundwater remediation alternative to achieve the threshold criterion of protecting human health and the environment (Alternatives Report, page 3-1).

A similar conclusion was reached by Dr. Paul Misut, a USGS scientist who reviewed the Alternatives Report and commented "[m]odeled outcomes that evince plume capture do not mean that the plume will be completely captured; therefore, wellhead protection is retained in all alternatives evaluated. Given the complexity and heterogeneity of the Magothy aquifer and top of the Raritan confining unit, it is probable that breakthrough (contaminants moving beyond recovery wells) will occur and contamination will eventually reach downgradient supply wells" (Misut, 2012).

The conclusion that full plume containment would not be effective in protecting downgradient supply wells is supported by a review in the Alternatives Report of remedial programs at eight Superfund sites with a history of managing deep VOC plumes. Based on the information drawn from those sites, the Alternatives Report found that monitoring and remediation was slow, difficult, expensive, and ineffective beyond a depth of 100 feet. Significantly, none of the sites reviewed had VOC impacts as widespread or deep as the plume in Bethpage. Reviews of remedial performance at deep plume sites showed hydraulic containment needs grew over time as breakthrough occurred. In some cases, (e.g., Otis Air Force Base from 1999 to 2007 and Aerojet Site from 1983 to 2009), additional extraction wells had to be repeatedly added to the initial remedy to address breakthrough. A similar lack of containment would be expected if one of the remedial options in the Options Report is implemented in the deeper and more extensive and complex Bethpage plume: "As aquifer depth and plume length increase, the plume encounters increasingly complex geology and undergoes more complex dispersion patterns (reflecting the increasingly complex source distribution upgradient and the geologic heterogeneities encountered along the flow path)." (Alternatives Report, page 2-15).

The plume is characterized in the Alternatives Report as diluting while migrating vertically and horizontally into numerous fingers that flow through alternating layers of clay, sand, and gravel. Further, "the plume is not uniform: it consists of one or more bands of high concentration groundwater within a broader aquifer cross-section that has little or no impacts." (Alternatives Report, Page 1-4). Full plume containment would be greatly hindered by the presence of the clay lenses and other heterogeneities that were observed to increase with depth in this complex aquifer. This difficulty would arise from trying to extract impacted groundwater from between narrowly spaced clay layers and from multiple plume fingers produced by complex dispersion patterns.

Groundwater containment systems rely on extraction wells to induce groundwater flow towards the wells by lowering the water table (or potentiometric surface) and producing cones of depression (i.e., depression of the water level) around the wells. Even in well-designed systems, where the cones of depression for the extraction wells overlap, bands of high permeability in a complex aquifer, like the downgradient perimeter of the Bethpage plume, can allow contaminated groundwater to bypass the containment system. The problems associated with plume containment because of plume depth and complex geology are magnified by the large size of the Bethpage plume. As described in the Alternatives Report, the shallow plume is about 9,700 feet wide and 17,000 feet long, with the deep western plume extending downgradient (southeasterly) over 12,000 feet. There are no technical precedents for containing such a widespread and deep plume in a hydrogeological setting as complex as that in Bethpage.

8. The current Department-approved remedy being implemented is protective of public health.

The current remedy, selected by the Department under the OU2 and OU3 RODs, consists of groundwater remedial measures that treat VOCs in on-site and off-site areas of elevated VOCs and that protect public health through wellhead treatment. These remedial measures are comprised of the following components:

- Containment and treatment of the on-site portion of the VOC plume by operation of the ONCT system and Bethpage Park Groundwater Containment System ("BPGWCS"). The ONCT system, which began operating in September 1998, and the BPGWCS, which began operating in July

2009, consist of extraction wells, water treatment systems, and discharge of treated water to surface impoundments. These systems contain the portion of the plume(s) that are on-site, thereby preventing off-site movement of VOCs in groundwater from the former Navy/Grumman facility and Bethpage Community Park and reducing future contaminant loads to the downgradient public water supplies.

- Additional containment and treatment of the off-site plume is being provided by the off-site GM-38 area treatment system and, in the future, the OU-3 RW-21 Area remedial system. These systems are designed to capture and remove substantial VOC mass from the aquifer and further reduce future contaminant loading to downgradient public well fields.

- Implementation of a Public Water Supply Protection Program consisting of operation and maintenance of treatment systems at impacted well fields and a contingency plan for wellhead treatment at public supply wells that may become affected in the future. The State's maximum contaminant levels, or MCLs, are being met for treated water at each of the affected public supply well fields in the area. This is being accomplished using VOC-removal treatment systems that are operating at the wellheads.

- Groundwater monitoring to give potential downgradient water supplies advanced warning of changes in contaminant concentrations to allow time to implement contingency plans or modify existing treatment systems.

The current remedy under the OU2 and OU3 RODs was determined, pursuant to a public review process, to be protective of public health. Furthermore, the RODs found that these remedial measures comply with the chemical- and action-specific requirements, achieve substantial VOC mass removal, use reliable technologies, are implementable in a shorter timeframe than other alternatives, and are cost effective. These determinations were made by developing and evaluating a full and appropriate range of remedial alternatives in the OU2 and OU3 feasibility studies in accordance with the NCP and 6 NYCRR Part 375.

An important aspect of the current remedy relates to protection of water quality of downgradient water supply wells. A key element of this protection has been wellhead treatment, which has consistently produced safe potable water. Wellhead treatment is not only a key component of the Bethpage groundwater remediation, but is a key component of numerous other groundwater remediation projects throughout Nassau County and Long Island. The Alternatives Report describes the ongoing effectiveness of the current remedy as follows:

- "[The current remedy] … already incorporates a substantial degree of protection [to water supply wells] because of the considerable plume capture already ongoing ..." (page 3-2)

- "Between the upgradient source areas and the leading edge of the plume, the plume is subject to mitigating influences including on-site containment wells, hot spot containment, and (fortuitously) impacted supply wells with wellhead treatment. The plume that emerges past all these influences is a much weakened plume … consisting of isolated, dispersed fingers of low concentration, especially in the deeper aquifer, where most of the downgradient supply wells are screened." (page 3-8)

The Magothy aquifer from which Massapequa Water District draws its water supply is not a pristine aquifer, either in the Bethpage area or elsewhere in Nassau County. Nevertheless, residents throughout the County have enjoyed safe drinking water for decades as a result of wellhead treatment methods despite the presence of VOCs and other contaminants in groundwater. This fact is recognized in the Options Report, which affirms:

"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 …" (Page 41)

- "This option [use of the treated water for drinking water] 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." (Page 41).

Wellhead treatment systems are relatively simple to design and install, and routine monitoring by the water districts and the New York State Department of Health ensures the continued safety of the treated drinking water. Those facts were made clear during a March 9, 2012, presentation to the U.S. EPA on the Fulton Avenue Superfund Site in Garden City, in which H2M (Massapequa Water District's consultant) introduced a map showing 185 municipal supply wells throughout Nassau County that are currently being treated at the wellhead for VOCs. H2M's presentation offered:

- The "evolving realities" of delivering potable water on Long Island include use of public water supply wells to restore aquifers contaminated with VOCs and at the same time delivering safe drinking water to customers.

- "Water suppliers cannot and will not rely on remedies [e.g., plume remediation technologies] to provide wellhead protection" and that "wellhead protection [is] required regardless".

- Community disturbance during construction of a groundwater remedy is a major concern. Removal of mass using public supply wells and providing safe drinking water was characterized as outweighing the community impacts of constructing and operating a groundwater remediation system.

In a January 21, 2015, Massapequa Observer article, Assemblyman Joseph Saladino, the sponsor of the Chapter 543 bill relating to the regional plume, stressed to local residents that "by the DEC treating the water at the well head, it is made safe at the tap". Further, Stan Carey, Massapequa Water District

Superintendent, stated during an interview by the Long Island affiliate of News 12 on December 2, 2015, that "Bethpage [Water District] wells have been impacted and have treatment in place, making the water safe to drink…"

Given that wellhead treatment would be required under all remedial scenarios to protect public health, attempting to implement both full plume containment and wellhead treatment would substantially exceed the cost of the current source control approach plus wellhead treatment yet, as acknowledged by Massapequa Water District's consultant and Assemblyman Saladino, wellhead treatment currently being employed is protecting public health.

9. The remedies in the Options Report do not satisfy key regulatory requirements for selecting an appropriate remedy.

Proposed remedies under state and federal regulations must be evaluated for consistency with 6 NYCRR Part 375 and the NCP, which mandate that a remedy protect human health and the environment as the primary objective, balance tradeoffs between other viable alternatives, and also consider remedy implementation, cost effectiveness, and community concerns. This process for evaluating remedy feasibility must be followed because circumventing that process by a particular stakeholder would be inconsistent with federal and state law and could be at the expense of other stakeholders and the environment. The Options Report admits "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 [sic] consistency with the National Contingency Plan." (Page 39).

Department regulations at 6 NYCRR 375-1.8(f) set forth criteria for selecting an appropriate remedy; these mirror the remedy selection criteria listed in the NCP. The remedies proposed in the Options Report do not satisfy the following criteria for selecting an appropriate remedy:

<u>Long-term Effectiveness and Permanence (f)(3).</u> The proposed remedies would not prevent the groundwater plume from reaching downgradient public supply wells with sufficient certainty to eliminate the need for wellhead treatment; therefore, full plume containment would not be effective over the long term. Factors for evaluating long-term effectiveness include the extent of remaining contamination and the reliability of controls to accomplish the cleanup objective, which militate against selecting hydraulic containment alone for the plume. See DER-10, page 132; 40 CFR § 300.430(e)(9)(iii)(C).

<u>Short-term Impacts and Effectiveness (f)(5)</u>. The proposed remedies would not mitigate short-term adverse impacts. The proposed remedial options would take many years to implement and would have significant adverse impacts on the community and the environment associated with constructing the expansive off-site groundwater remedial systems (e.g., noise, dust, disruption of traffic and commerce). Following construction, operating the remedial system would result in a net loss of groundwater in the local aquifer near public water supply wellfields, thereby worsening an already recognized saltwater

intrusion problem. See DER-10 at 133; 40 CFR § 300.430(e)(9)(iii)(E); U.S. EPA, A Guide to Selecting Superfund Remedial Actions (1990).

Implementability (f)(6). Substantial technical and administrative difficulties, including land acquisition for treatment systems, access agreements for drilling wells and installing piping, and construction in dense, highly-developed neighborhoods, would occur when implementing a full plume containment remedy. See, e.g., NYSDEC, Record of Decision for the Unisys Corporation Site: Operable Unit Number 02: Offsite Groundwater (December 2014) (finding that certain alternatives considered faced difficulty in implementability due to challenges in gaining access to multiple off-site properties that would be required for construction of remediation systems). See DER-10 at 133; 40 CFR § 300.430(e)(9)(iii)(F).

Cost Effectiveness (f)(7). The Department is required to select the most cost effective remedy from amongst equally effective remedial actions. Even if the proposed full plume containment would protect water users to the same extent as current OU-2 ROD and OU-3 remedies, it would fail the cost-effectiveness test because other less costly remedies would be at least as effective. See DER-10 at 133; 40 CFR § 300.430(e)(9(iii)(G)). Cost effectiveness is a statutory requirement for all Superfund remedies and is determined by comparing the cost of the remedy to its "overall effectiveness." Accordingly, a cost-effective remedy is one whose "costs are proportional to its overall effectiveness" (NCP §300.430(f)(1)(ii)(D)). The overall effectiveness of a remedial alternative is determined by evaluating the following criteria:

- Long-term Effectiveness. The current ROD remedies (source remediation and wellhead protection) would achieve long-term effectiveness by treating all impacted drinking water to meet health-based standards, thereby eliminating long-term risk. Long-term risk would occur with attempted full plume containment because the possibility of impacts to downgradient supply wells above health-based standards would not be eliminated.

- Reduction in toxicity, mobility, or volume (TMV). Substantial reductions of TMV in the plume would continue to occur under the current ROD remedy through groundwater extraction and treatment in VOC source areas (ONCT, BPGWCS, GM-38, and RW-21 Area remedies) and incidental extraction by supply wells with wellhead treatment. Only small additional reductions of TMV would be realized under the remedies proposed in Options Report through extracting large quantities of mostly clean groundwater beyond the leading edge of the plume in an attempt to contain the leading edge.

- Short-term Effectiveness. The current ROD remedies would achieve short-term effectiveness by implementing necessary wellhead treatment systems in about one year and, because construction would occur on the existing water plant properties, short-term risks to the community and environment are not anticipated. Construction of any of the full plume containment systems described in the Options Report would take many years to implement because of difficulties associated with acquiring necessary access and property, and construction in a densely populated area and would present short-term risks to the community during construction including increased dust, noise, and traffic.

The remedies in the Options Report would not be consistent with either the Department's or the U.S. EPA's green policies, which require consideration of green remediation principles when selecting remedial alternatives. In particular, the Department's policy, DER-31/Green Remediation, calls for "considering all environmental effects of remedy implementation and incorporating options to minimize the environmental footprint of cleanup actions" including:

- Considering the environmental impacts of remedy stewardship over the long term;
- Reducing direct and indirect greenhouse gas and other emissions;
- Increasing energy efficiency and minimizing use of non-renewable energy; and
- Conserving and efficiently managing resources and materials.

The proposed removal of 19 MGD of water from the aquifer would increase impacts on natural resources resulting in: 1) reduced water availability to streams, wetlands, and public supply wells, 2) changes in localized groundwater flow, and 3) increased likelihood for further salt water intrusion. Also, significant energy would be consumed as a result of pumping billions of gallons of mostly clean groundwater and to treat, transport, and dispose it into surface waters. Large-scale construction of a full plume containment system would consume more fuel and natural resources and would result in substantially greater impacts to air quality and disruption to communities than wellhead treatment. Moreover, the long-term maintenance and monitoring of the proposed full plume containment system would result in additional fuel and resource consumption and disruptions to the local community.

10. Substantial technical and administrative difficulties would impede construction of the remedies in the Options Report.

The feasibility of using the Cedar Creek Water Pollution Control Plant to treat 19MGD of extracted groundwater (an element of Options 2 and 3 in the Options Report) was evaluated (**Attachment 3).** The findings of that evaluation indicate a number of technical feasibility and associated issues would work against the use of the Cedar Creek plant to treat the extracted groundwater, including:

- The current treatment capacity of the plant (72MGD) is inadequate to handle the additional 19 MGD of groundwater flow. The use of all remaining plant capacity could:
  - Severely limit development and restrict growth in Nassau County; and
  - Increase the likelihood of untreated waste releases during storm events.
- The ability to expand the treatment plant capacity to handle the additional flow, as specified in the Options Report, would be severely limited by a lack of available space.

- Pretreatment requirements would require expensive groundwater treatment for VOCs prior to discharge into the treatment plant.

- Discharge of dilute treated groundwater into the treatment plant would likely upset the biological treatment processes in the plant, which would be a violation of pretreatment regulations and the local sewer ordinance.

Implementability is a key remedy selection criterion under the NCP and 6NYCRR Part 375-1.8(f)(6) and must address both the technical and administrative feasibility of carrying out a remedy. Technical feasibility refers to the ability to construct the remedy, reliability of the approach, and ease of undertaking any necessary additional remedial action, such as adding additional extraction wells or wellhead treatment to supply wells. Administrative feasibility covers issues related to coordinating with government agencies, such as required permitting, public noticing, and/or local approvals.

Technical Feasibility

The technical feasibility of full plume containment was first evaluated in the October 2000 OU2 Feasibility Study. The full plume containment alternative was not recommended in the OU-2 Feasibility Study because of implementation problems and high costs even though the remedial system evaluated was considerably smaller and less complex than any of the options evaluated in the Options Report; i.e., fewer extraction wells, shorter piping runs, and use of existing storm sewers and recharge basins. The OU2 Feasibility Study, concluded that “Alternatives 5 through 8 [those including full plume containment] would require property acquisition, building demolition and construction, zoning changes, and tie-ins to existing utilities.” (OU2 Feasibility Study, page 5-9)

Consistent with the findings of the OU-2 Feasibility Study, the subsequent 2001 OU-2 ROD described the technical feasibility constraints of this alternative: “full plume containment would be difficult or infeasible to implement because of the multiple difficulties associated with purchasing private property for system construction; zoning and permitting requirements; and finding the necessary locations to implement total plume containment in a densely populated area.” (OU-2 ROD, page 58).

The implementability of full plume containment was reviewed again in the 2012 Alternatives Report, which included an additional 14 extraction wells and associated conveyance piping compared to the OU-2 Feasibility Study design. This change in design (from 6 to 20 extraction wells) is consistent with the containment approach described in the OU-2 ROD because the Navy applied the same scientific and engineering principals for remedy design. The additional wells in the Navy’s design address deeper portions of plume not characterized prior to the OU-2 ROD.

Construction of the any of the Options Report remedies would be more difficult and intrusive than in previous conceptual designs due to the added complexity presented by many more extraction wells, longer piping runs, and relocating the treated water discharge miles away from the extraction wells. All of the remedies would include installing miles of underground transmission piping and electrical conduits, which would require slow, surgical efforts to protect business patrons, residents, and existing utilities. Construction activities would disturb residential properties, produce traffic detours, generate noise, disrupt commerce, place heavy trucks and construction equipment in neighborhoods, and likely damage trees, fences, and other features on public and private property.

Administrative Feasibility

The Options Report does not address the administrative difficulties and delays related to securing property access agreements and applicable approvals from local, state, and federal agencies for installing the transmission piping, wells, and treatment systems. Design and construction of any of the remedies under the Options Report would entail two sequential phases of access agreements:

<u>Phase 1, Pre-Design Investigation.</u> The first phase of access agreements could require several years of effort. The 2011 Optimization Report concluded that "…off-site monitoring well network needs to be augmented with vertical profile borings and multi-level monitoring wells … in order to … [b]etter quantify hydrogeologic parameters critical for improved groundwater flow modeling…" (Optimization Report page iv). The flow model would be integral to the design effort and is necessary to design the extraction system and treatment equipment. The flow model would also help estimate the magnitude of the impacts on the local aquifer generated by the additional pumping, including reducing the water supply to drinking water wells and accelerating the rate of salt-water intrusion.

Although the Navy continues to advance borings and install monitoring wells, sufficient plume delineation and aquifer characterization associated with groundwater flow and fate and transport simulations are not complete. A work plan would be needed to address these inadequacies and identify appropriate locations where soil borings and/or monitoring wells could be installed to help fill some of the data gaps, and access agreements would be needed for those properties selected for drilling. At another location within the Bethpage Plume, an access agreement for a single boring and well location took many months to negotiate before drilling could begin.

<u>Phase 2, Construction.</u> Access agreements or acquisition of property for construction would require years of additional legal and engineering effort. Assuming the remedial design is completed, a second round of access agreements or property acquisitions would be needed to install remedial wells, conveyance piping, and groundwater treatment, as appropriate. The conveyance piping would need to be installed on contiguous properties, so the inability to obtain access or acquire even a single property may necessitate rerouting of the piping and restarting the process with other property owner(s).

Substantial legal and engineering effort would be needed to negotiate terms and prepare long-term response/contingency plans to protect the public and utility workers from leakage by conveyance piping. Road Opening Permit*s* and Sidewalk Permits would be required from Nassau County for pipeline construction in public ROWs. Those permits would require extensive, time-consuming surveying and engineering plans for the affected parcels, and require performance and maintenance bonds that would likely carry onerous liability provisions and contingencies to account for leakage or releases of contaminated groundwater. Because transmission pipelines would convey millions of gallons of groundwater per day, a pipeline rupture could release a large volume of potentially contaminated groundwater in residential or commercial areas.

Conclusions

Removing 19 MGD from an already stressed aquifer and discharging to surface waters will create a very high potential for saltwater intrusion into the aquifer system and existing supply wells, and result in much greater damage to water suppliers than easily treatable VOCs. The loss of freshwater to some coastal systems and the increase to others, particularly Massapequa Creek and its associated estuary, will cause harm to those systems due to high flow rates and or changes in salinity of the impacted water bodies. In addition, with the purposeful relocation of the capture areas of the Massapequa Water District's existing supply wells south of the containment system, it is very possible that the supply wells will be exposed to greater VOC concentrations from sources outside of both the current treatment systems and the proposed containment system.

Full plume containment has been evaluated over the last 15 years by technical and regulatory experts and dismissed as a feasible option for addressing the plume. The Options Report does not contain adequate modeling or other technical studies to refute those scientific opinions and Department decisions and offers on new technical approach. Moreover, the Options Report has proposed a variation on past remedies, which have a potential to create significant harm to the water districts and natural resources.

Further, error (by omission) is introduced into the Options Report by failing to consider the effectiveness of the existing remedial program mandated by the Department and being implemented by Northrop Grumman and the U.S. Navy. The existing remedial program, which attacks the plume's sources and provides for well head treatment, has provided and will continue to provide safe drinking water. Indeed, an irony of the Options Report is its repeated assertion that well head treatment provides a tested, safe, and efficient method of assuring the delivery of potable water.

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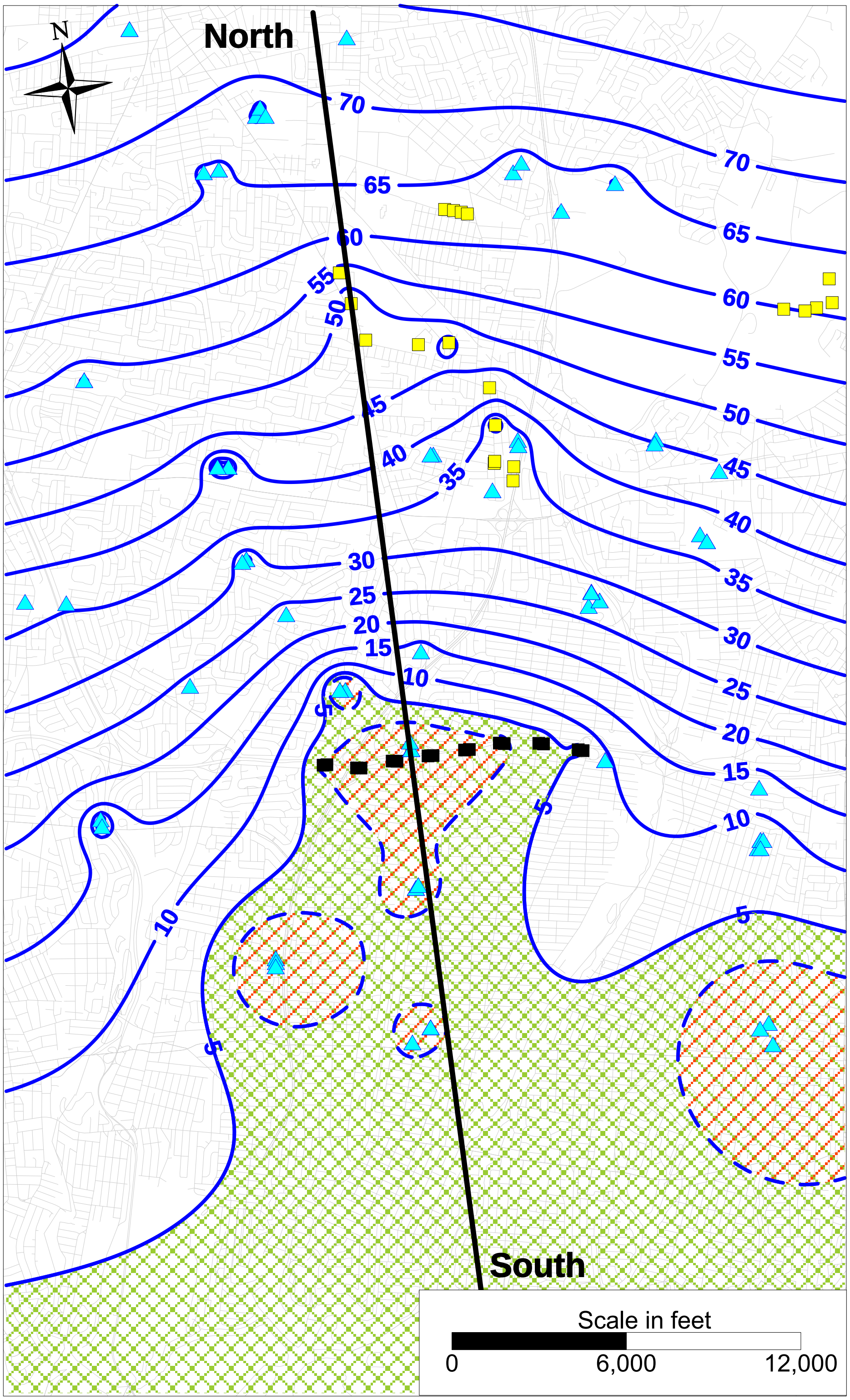
FIGURES



MODEL LAYER 10
(approximately 620-680 ft bls)

LEGEND

- 10 SIMULATED GROUNDWATER ELEVATION (FT NAVD 88)
- NORTH-SOUTH CROSS-SECTION (see Figure 2)
- SIMULATED GROUNDWATER ELEVATION BELOW AVERAGE SEA LEVEL (0.75 FT NAVD 88)
- AREA VULNERABLE TO SALT WATER INTRUSION
- WATER SUPPLY WELL
- CURRENT/PLANNED REMEDIATION WELL
- PROPOSED EXTRACTION WELL (OPTION 1)*

*Option 2 and 3 effects on groundwater elevations similar to Option 1.

Massapequa Water District Wells are operating at 40% of reported capacity (2010-2015 rates).

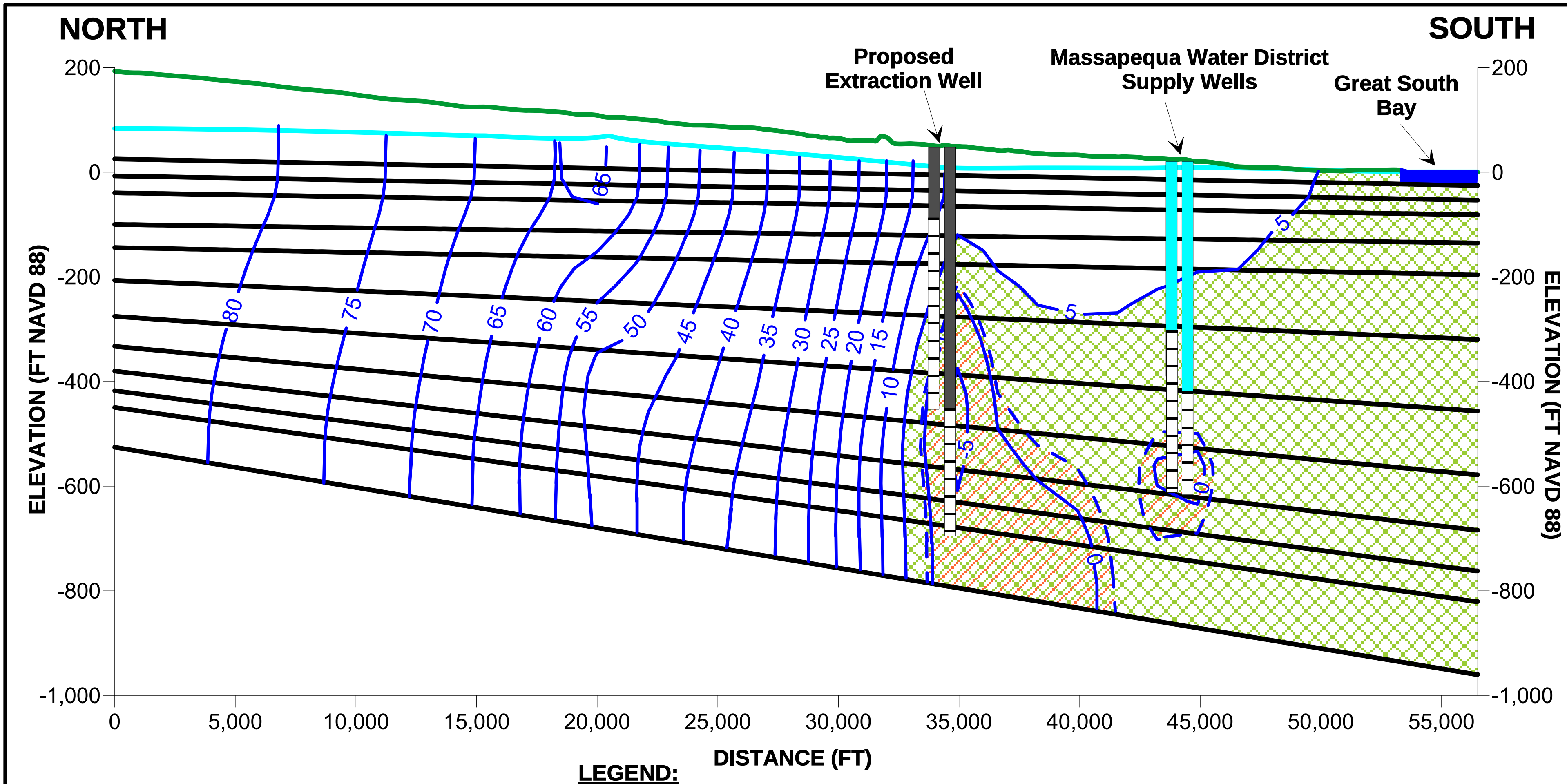
Northrop Grumman
Bethpage, New York

Groundwater Model Update

SIMULATED GROUNDWATER ELEVATIONS PRODUCED BY REMEDIAL OPTION 1 AND AREA VULNERABLE TO SALTWATER INTRUSION

ARCADIS Design & Consultancy for natural and built assets

FIGURE
1

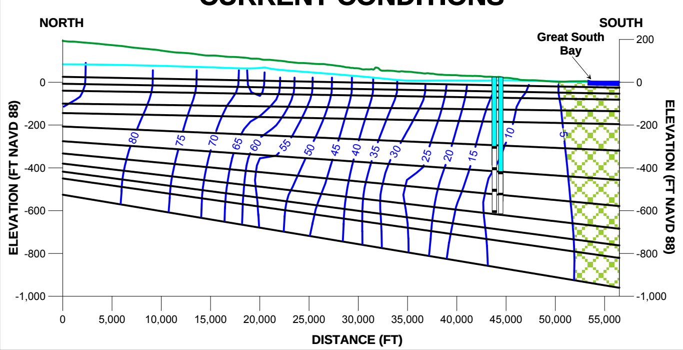


LEGEND:

- 10 — SIMULATED GROUNDWATER ELEVATION (FT NAVD 88)
- MODEL LAYER CONTACT
- LAND SURFACE
- SIMULATED WATER TABLE
- MASSAPEQUA PUBLIC SUPPLY WELL
- PROPOSED EXTRACTION WELL (OPTION 1)*
- SIMULATED GROUNDWATER ELEVATION BELOW AVERAGE SEA LEVEL (0.75 FT NAVD 88)
- AREA VULNERABLE TO SALT WATER INTRUSION

*Option 2 and 3 effects on groundwater elevations similar to Option 1.

CURRENT CONDITIONS

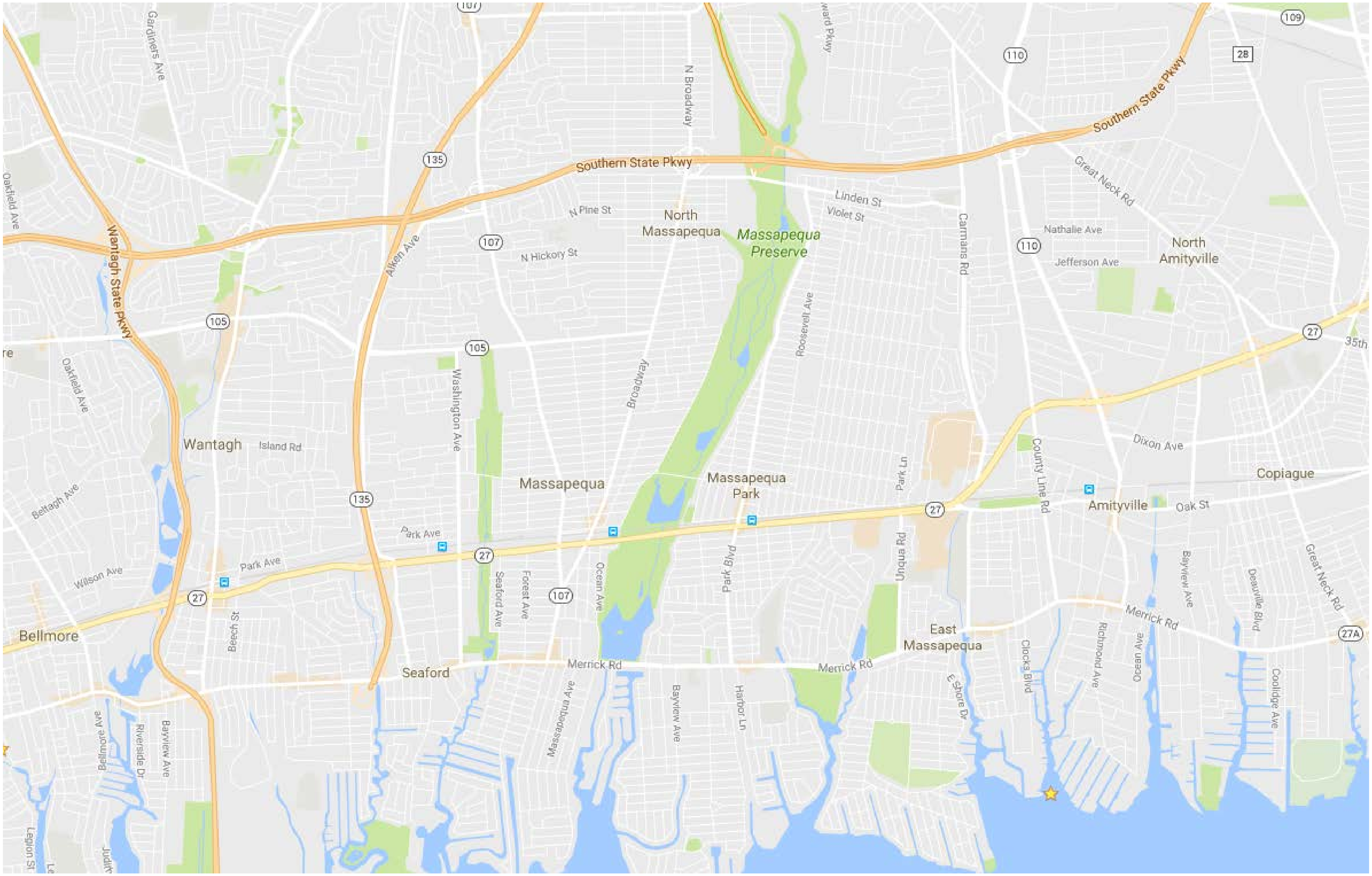


Northrop Grumman
Bethpage, New York
Groundwater Model Update

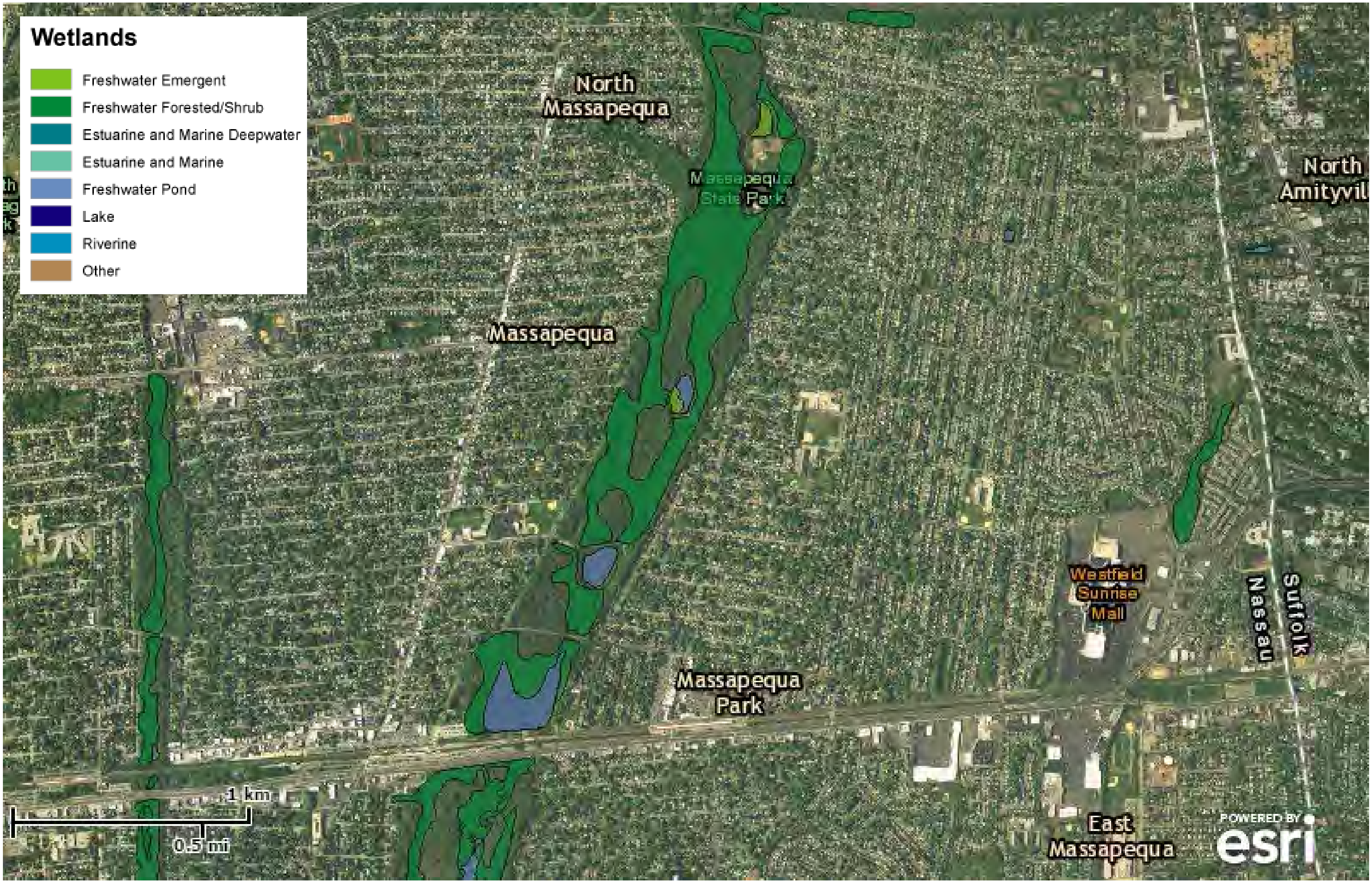
SIMULATED GROUNDWATER ELEVATIONS (IN CROSS-SECTION) PRODUCED BY REMEDIAL OPTION 1 AND AREA VULNERABLE TO SALT WATER INTRUSION

ARCADIS Design & Consultancy for natural and built assets

FIGURE 2



RAMBOLL ENVIRON	MASSAPEQUA PRESERVE	FIGURE 3A
DRAFTED BY: PAL — DATE: 5/22/2013		



RAMBOLL ENVIRON

MASSAPEQUA WETLANDS
(USFWS 2016 NATIONAL WETLANDS INVENTORY

FIGURE
3B

DRAFTED BY: PAL

DATE: 5/22/2013

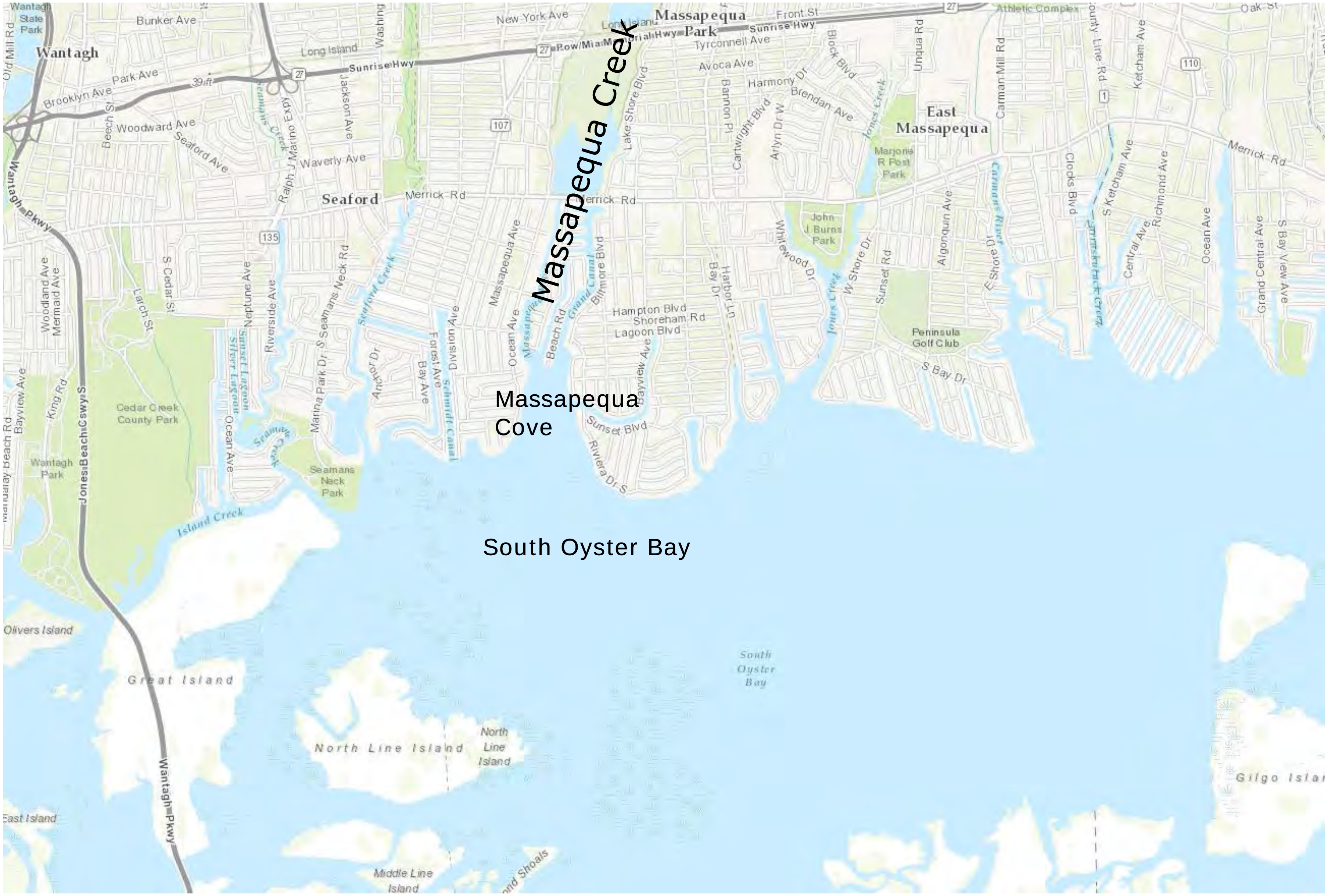
RAMBOLL ENVIRON

DRAFTED BY: PAL

DATE: 5/22/2013

LOCAL WETLANDS
(USFWS 2016 NATIONAL WETLANDS INVENTORY

FIGURE
3C

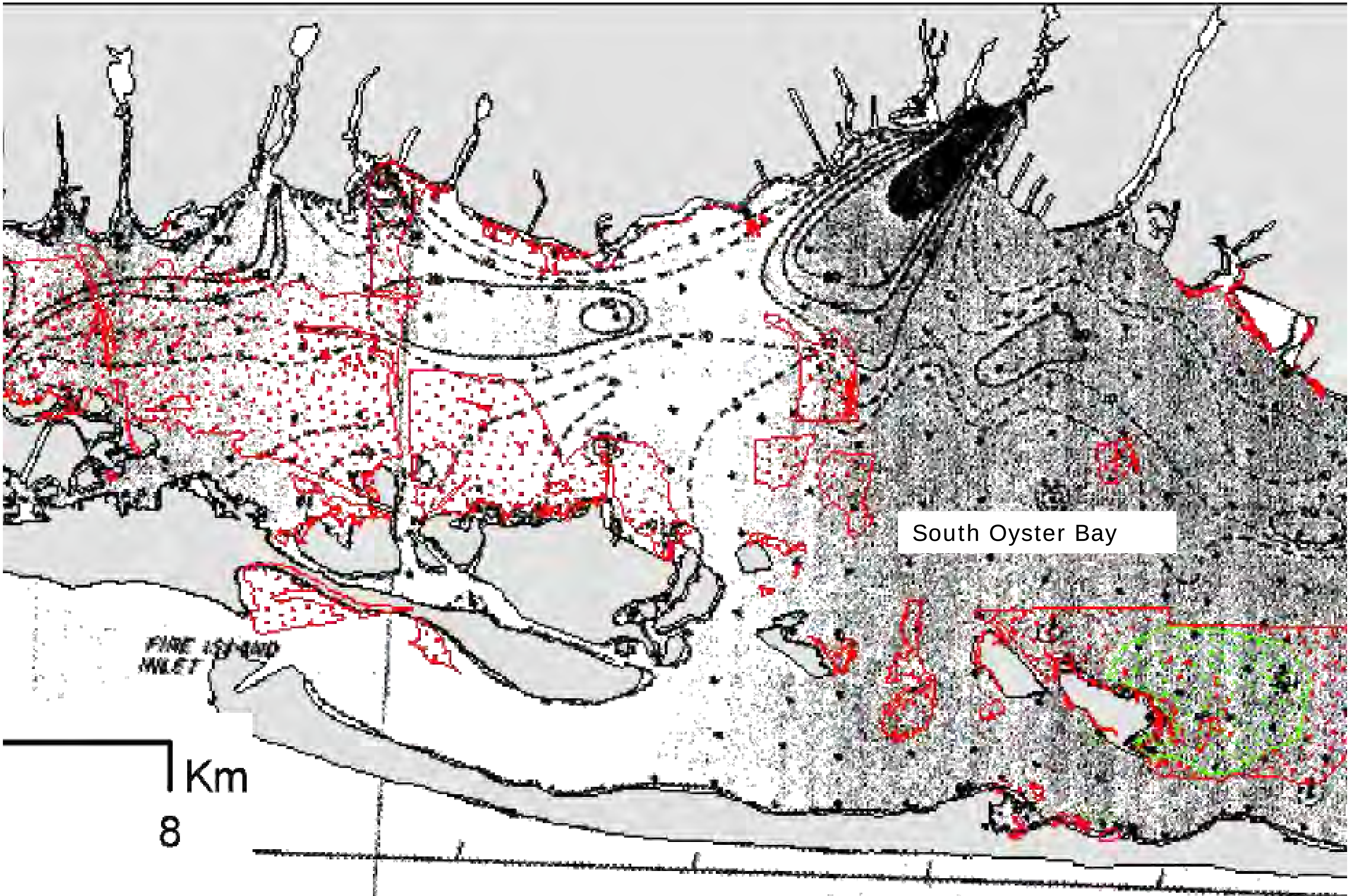


RAMBOLL ENVIRON

SEAGRASS BEDS NEAR MASSAPEQUA CREEK
(USFWS IPAC SYSTEM, 2016)

FIGURE 4A

DRAFTED BY: PAL | DATE: 5/22/2013



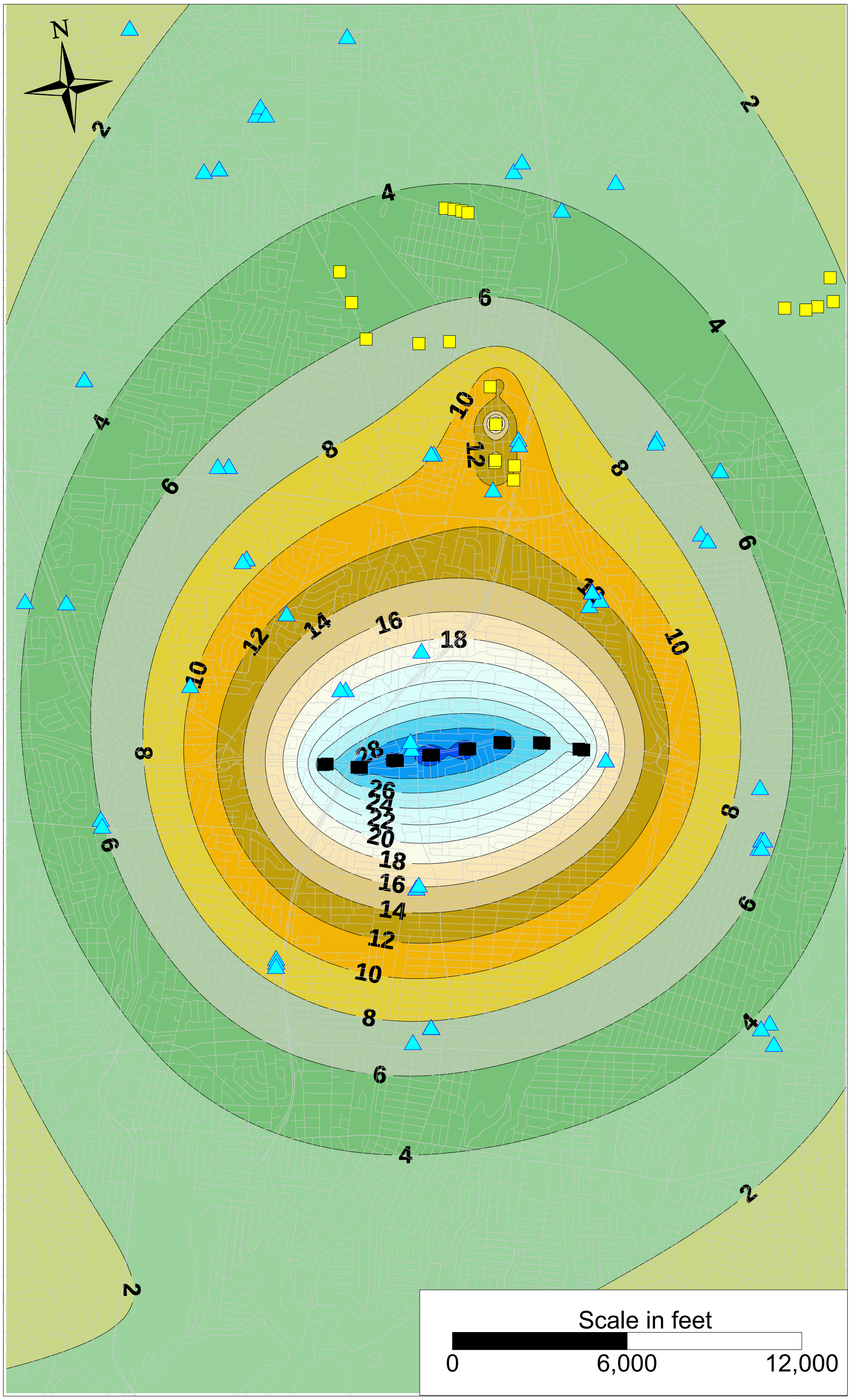
RAMBOLL ENVIRON

DRAFTED BY: PAL

DATE: 5/22/2013

SEAGRASS BEDS NEAR MASSAPEQUA CREEK
(USFWS 2004 SAV BED CHARACTERIZATION REPORT)

FIGURE 4B



LEGEND

WATER SUPPLY WELL

CURRENT/PLANNED REMEDIATION WELL

PROPOSED EXTRACTION WELL (OPTION 1)*

*Option 2 and 3 effects on groundwater drawdown similar to Option 1.

SIMULATED DRAWDOWN (FT)

30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0

MODEL LAYER 10
(approximately 620-680 ft bls)

Northrop Grumman
Bethpage, New York

Groundwater Model Update

SIMULATED GROUNDWATER DRAWDOWN PRODUCED BY REMEDIAL OPTION 1

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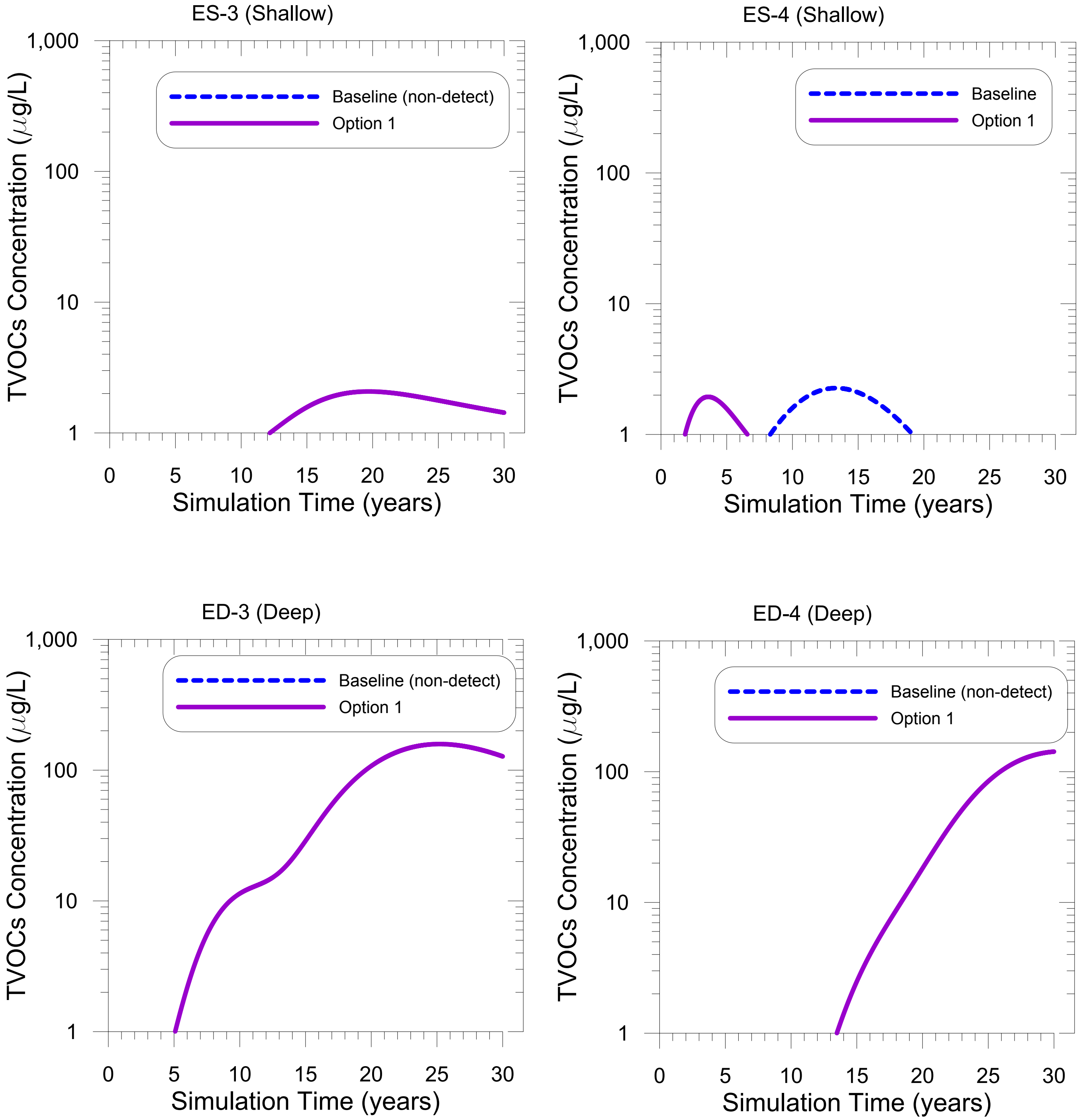
FIGURE
5



TVOC concentrations are simulated at proposed extraction well locations that would be impacted under Option 1 (see Figure 6 for well locations).

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Bethpage, New York
GROUNDWATER MODEL UPDATE

SIMULATED TVOC CONCENTRATIONS OVER TIME UNDER BASELINE CONDITIONS AND PRODUCED BY REMEDIAL OPTION 1

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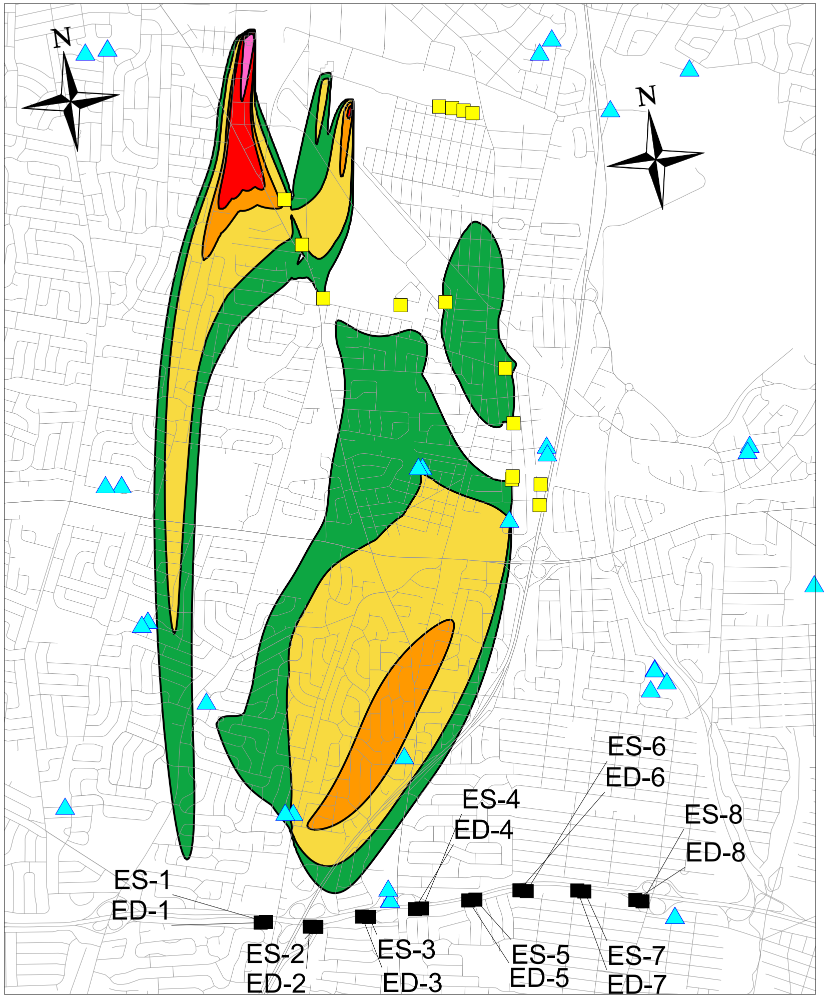
FIGURE 6

BASELINE

YEAR 30

REMEDIAL OPTION 1



LEGEND

PROPOSED EXTRACTION WELL (OPTION 1)*

WATER SUPPLY WELL

CURRENT/PLANNED REMEDIATION WELL

*TVOC impacts for Options 2 and 3 are similar to Option 1.

ES-3, ED-3, ES-4, and ED-4 are the only extraction wells that would extract groundwater with detectable TVOCs in a 30 year simulation.

Proposed well locations in baseline scenario are for reference only.

TVOC Concentration (μg/L)

5 | 50 | 500 | 1,000 | 5,000

Scale in feet

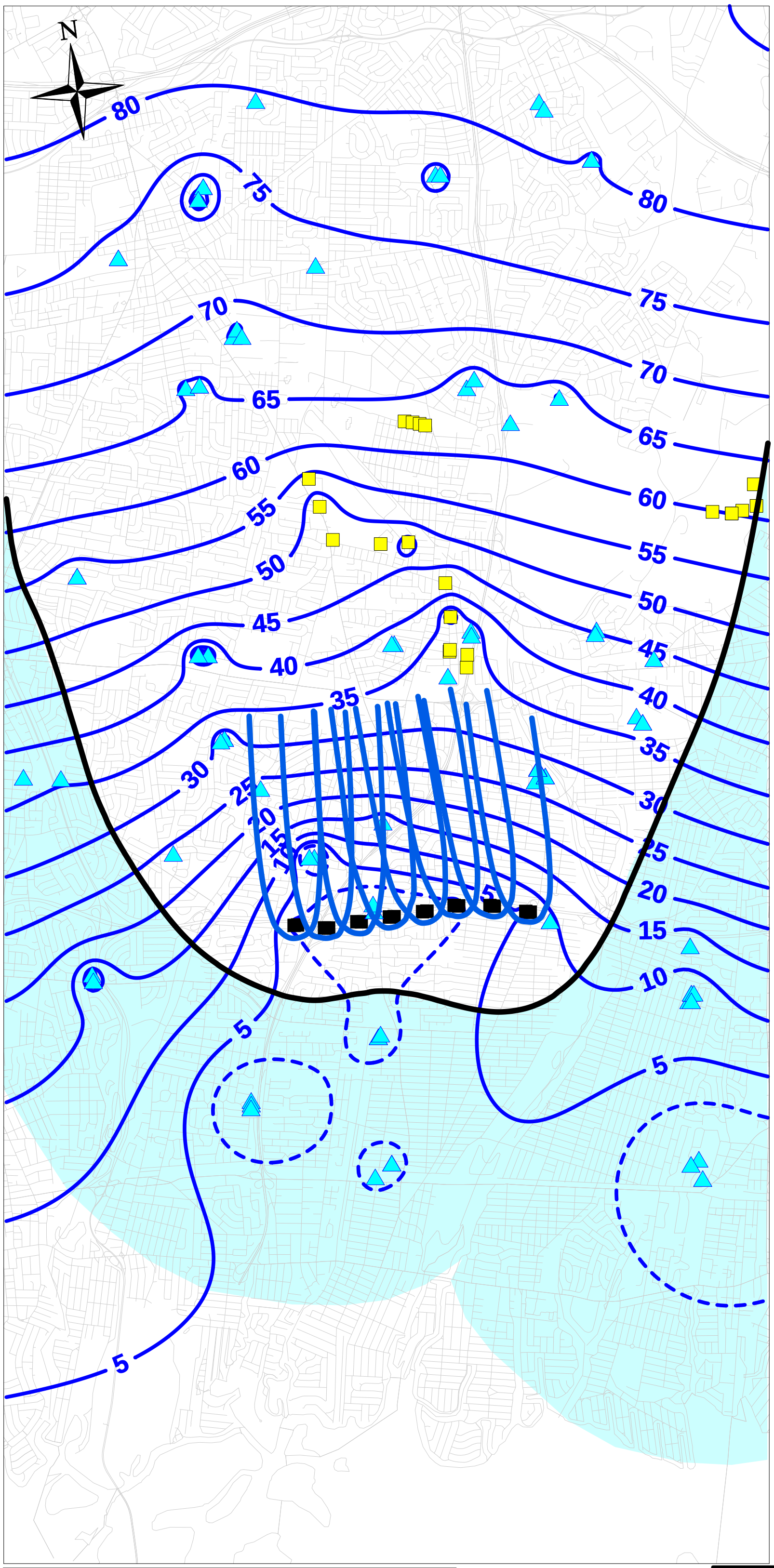
0 | 4,500 | 9,000

Northrop Grumman
Bethpage, New York
Groundwater Model Update

SIMULATED DISTRIBUTION OF VOC PLUME UNDER BASELINE CONDITIONS AND PRODUCED BY REMEDIAL OPTION 1 IN 30 YEARS

ARCADIS Design & Consultancy for natural and built assets

FIGURE
7



LEGEND

- 10 — SIMULATED GROUNDWATER ELEVATION (FT NAVD 88)
- SIMULATED GROUNDWATER ELEVATION BELOW AVERAGE SEA LEVEL (0.75 FT NAVD 88)
- WATER SUPPLY WELL
- CURRENT/PLANNED REMEDIATION WELL
- PROPOSED EXTRACTION WELL (OPTION 1)
- EXTRACTION WELL CAPTURE ZONES FROM OPTIONS REPORT (HDR, 2016)
- SIMULATED EXPANDED CAPTURE ZONE FOR WATER SUPPLY WELLS
- SIMULATED MAXIMUM CAPTURE ZONE EXTENT*

*Option 2 and 3 effects on groundwater capture similar to Option 1.

Massapequa Water District Wells are operating at 40% of reported capacity (2010-2015 rates).

Scale in feet

0 7,000 14,000

MODEL LAYER 10
(approximately 620-680 ft bls)

Northrop Grumman
Bethpage, New York

Groundwater Model Update

SIMULATED GROUNDWATER CAPTURE PRODUCED BY REMEDIAL OPTION 1

ARCADIS Design & Consultancy for natural and built assets

FIGURE
8

ATTACHMENT 1

Groundwater Flow and Solvent Transport Model Update, Northrop Grumman, Bethpage, New York

(Large file that will be submitted separately)

ATTACHMENT 2

Peer Review of Groundwater Modeling to Evaluate Full Plume Containment at Grumman Bethpage Facility, Bethpage, New York

PEER REVIEW OF GROUNDWATER MODELING TO EVALUATE FULL PLUME CONTAINMENT AT GRUMMAN AEROSPACE BETHPAGE FACILITY, BETHPAGE, NEW YORK

SEPTEMBER 9, 2016

Prepared by:

Peter Shanahan, Ph.D., P.E.

HydroAnalysis

481 Great Road, Suite 3
Acton, Massachusetts 01720
(978) 263-1092

1. SUMMARY

This report summarizes the results of my peer review of the groundwater modeling performed by Arcadis, Inc. with regard to the proposed "Full Plume Containment" remedial alternative for contaminated groundwater associated with the former Grumman Aerospace Bethpage Facility (Bethpage Facility) in Bethpage, New York described in the "Remedial Options Report, Grumman Aerospace-Bethpage Facility" prepared by HDR (2016) (Options Report). I have been requested by Northrop Grumman Systems Corporation (Northrop Grumman) to conduct this peer review. I have not previously been retained by Northrop Grumman or its predecessor entities in any matter. Based on my review of the Arcadis model as well as the Options Report, I conclude that:

1. The simple analytical model used by HDR to design a capture-well remediation system for plume containment results in an incomplete evaluation of the potential effects of the system.

2. The digital computer model developed by Arcadis has been constructed and calibrated appropriately and consistent with conventional groundwater modeling practice. The model incorporates reasonable and appropriate representations of the vertical hydrostratigraphy, aquifer hydraulic properties, and system boundaries.

3. To ensure that the current version of the Arcadis model had been appropriately developed and calibrated, I obtained and reviewed the actual model inputs and conferred with Arcadis to obtain information in addition to that contained in memoranda that describe the changes to the model over time (Arcadis, 2002, 2003, 2009, 2010, 2016).

4. The digital computer model used by Arcadis is a more appropriate, accurate, and complete model for assessment of the capture-well remediation system and its consequences than the model used in the Options Report.

2. QUALIFICATIONS

I am a consulting hydrologist and environmental engineer. My business is incorporated in Massachusetts as HydroAnalysis, Incorporated. HydroAnalysis is located at 481 Great Road, Suite 3, Acton, Massachusetts. I founded HydroAnalysis in January 1988 and this business was my primary employment until September 2004. Between September 2004 and June 2013, I divided my working time more or less equally between HydroAnalysis and an academic position at the Massachusetts Institute of Technology (MIT) in Cambridge, Massachusetts. Since June 2013, HydroAnalysis is again my primary employer.

I am retired from a position as Senior Lecturer in the Department of Civil and Environmental Engineering at MIT. I was appointed a part-time Lecturer at MIT in September 1996 and was appointed a Senior Lecturer with full-time academic-year duties beginning in September 2004. At MIT, I taught graduate and undergraduate courses on the fate and transport of chemicals in the environment, waste characterization and remediation, and environmental engineering. I also supervised research projects completed by environmental engineering graduate students. I formally retired from MIT in September 2013 but have continued to work on a part-time basis conducting research and advising graduate students.

The following paragraphs summarize my background and experience, which are presented in greater detail in Attachment 1, my current curriculum vitae.

I hold four academic degrees in engineering and earth sciences. These include two Bachelor of Science degrees from MIT, one in Civil Engineering and one in Earth and Planetary Sciences, both awarded in 1973. I hold a Master of Science degree in Applied Earth Sciences with a designation in Environmental Earth Sciences from Stanford University in Stanford, California, awarded in 1974. My graduate research at Stanford University entailed the modification and application of a groundwater flow model. I also hold a Doctor of Philosophy in Environmental Engineering, awarded by MIT in 1982. My doctoral research at MIT addressed the development of computer models of water quality in lakes and reservoirs.

I have over 40 years of experience in consulting and academic research. At HydroAnalysis, Inc., I specialize in the analysis of problems in hydrology and water quality. Specific areas of practice include groundwater flow and contamination; surface-water hydrology and water quality; hazardous waste site investigation and remediation; and computer modeling. My work experience includes participation in the investigation, remediation, and/or litigation of over fifty federal Superfund hazardous substance sites and a larger number of state-listed hazardous substance sites. I have worked on sites in thirty-five states and Puerto Rico. My past projects include working as the task manager for the groundwater remedial design/remedial action at the Wildwood Parcel portion of the Woburn Wells G&H Superfund Site, the site featured in the book and movie, *A Civil Action*. As a subcontractor to Camp Dresser & McKee (now CDM-Smith) I developed computer codes for their groundwater model of Nassau County, New York.

Prior to forming my own consulting firm, I was employed for seven years by ENSR Corporation (formerly Environmental Research and Technology, Inc. and now part of AECOM). At ENSR I practiced in areas similar to those in which I practice today, including hydrology, water quality, hydraulics, and computer modeling. Pertinent work at ENSR included analysis of groundwater flow and contamination at several major federal Superfund sites including the Stringfellow Acid Pits in Fontana, California; the Reilly Tar & Chemical Site in St. Louis Park, Minnesota; and the Twin Cities Army Ammunition Plant in New Brighton/Arden Hills, Minnesota. I also consulted on issues of water-quality control and groundwater contamination at manufacturing operations in a variety of industries.

Employers prior to ENSR include CDM and Bechtel Corporation. I was also employed by MIT and the International Institute for Applied Systems Analysis in Laxenburg, Austria during the course of my doctoral studies.

I am a registered Professional Engineer in Massachusetts and Maine. I serve or have served on the technical committees of several professional organizations, including the American Society of Civil Engineers, the Water Environment Federation, and the International Water Association. I am a past member of the editorial board of the Journal of Groundwater. I am a member of several other professional organizations, including the American Geophysical Union, and am a Life Member of the American Society of Civil Engineers.

I have published over sixty refereed journal articles, conference papers, and book chapters on the subjects of hydrology, water quality, and computer modeling. A complete list of publications is included as part of my curriculum vitae.

3. REVIEW OF HDR MODEL

In the Options Report, HDR puts forward three remedial options for intercepting and remediating the groundwater plume using hydraulic capture—that is, pumping groundwater at a location downgradient of the plume so as to capture the contaminated groundwater. The three alternatives are similar in concept and scale: all entail pumping from two arrays of wells near the Southern State Parkway. The first, shallow array would pump approximately 11 million gallons per day (mgd) from eight extraction wells screened between 250 and 550 feet below ground surface (feet bgs). The second, deep array would pump an additional 8 mgd from eight extraction wells screened between 550 and 800 feet bgs.

HDR uses an analytical capture-zone model to design the extraction well arrays. This model, by Grubb (1993), computes the width of groundwater flow captured by a single well in an idealized confined aquifer with uniform properties and perfectly regular flow that does not vary over time (i.e., it is a steady-state model). This is an inappropriate model for the heterogeneous multi-layer aquifer on Long Island. Moreover, the pumping rates specified for the extraction well system (19 mgd in total) are vast and would have cumulative impacts well beyond simply creating the capture zones predicted by the analytical model. The analytical model does not account for interference between the multiple extraction wells and nearby existing pumping wells. Because the model does not account for the cumulative effect of the multiple wells, the capture-zone predictions are incorrect. As well, the model assumes steady-state conditions. Thus, the HDR presentation implies that the capture zones would come to exist essentially immediately whereas the capture zone would in fact require considerable time to develop in an aquifer this large.

In the final analysis, HDR has proposed a hydraulic capture system with extensive potential impact on the Long Island aquifer using a simple analytical model that arrives at incorrect results. Given the complexities of the aquifer system and vast quantities of pumping proposed, a sophisticated three-dimensional digital computer model is required to do justice to the analysis of the proposed full-plume remediation.

4. REVIEW OF ARCADIS MODEL

Arcadis (2016) uses an appropriate tool to evaluate HDR's proposals. They employ a three-dimensional groundwater flow model based on the U.S. Geological Survey MODFLOW computer code (McDonald and Harbaugh, 1988). The Bethpage area model was first created and calibrated in 1997 to model the area including and proximate to the Bethpage Facility (G&M, 1997) and was subsequently expanded in 2002, 2010, and 2016 to model progressively larger areas of Long Island (Arcadis, 2002, 2003, 2009, 2010, 2016).

Documentation of the current version of the model is limited. G&M (1997) report on the model construction and calibration in detail, but subsequent versions of the model are less completely documented in a series of short memos and letter reports. This was of concern as subsequent versions of the model include some significant changes, including reconfigured model layers and a substantially expanded area. To assure myself about model construction, including the changes in the model's hydraulic parameters, and to assess the model calibration in the expanded areas, I requested and received a copy of the model input files and an informal report on recent calibration checks. Based on this information, I am satisfied that the model has been constructed in conformance with accepted standards of practice for groundwater modeling and constitutes a reasonable representation of the Long Island groundwater system. As such, the Arcadis model is far superior to HDR's analytical model for evaluating the effects of the proposed full-plume remediation system.

The current version of the Arcadis model now extends from the regional groundwater divide on the north to the shoreline on the south. These are natural hydrologic boundaries and thus are an improvement over previous versions of the model in which the north and south boundaries were internal to the natural groundwater flow system. On the east and west, the model is bounded by general-head boundaries, a replacement of what was set as constant-head boundaries in the 1997 version of the model and no-flow boundaries in more recent versions. These lateral boundaries are not natural hydrologic boundaries, a necessary trade-off in representing a system as large as the Long Island aquifer with ample detail in the study area. The character of the lateral boundaries is discussed further below. The model also includes drain boundaries to represent the surface-water drainages on the south coast. This is an appropriate representation of those surface-water features.

Aquifer stratigraphy in the model is appropriately based on field data and according to Arcadis (2003, 2016) has been updated with new data acquired since the model's original construction. The model is bounded below by the Raritan Clay formation; the underlying Lloyd Aquifer is not included in the model. This is a sensible approach given the low hydraulic conductivity and considerable thickness of the Raritan Clay. This approach allows the model to focus only on those aquifers directly affected by the contaminant plume by reducing the computational burden of modeling the deeper unaffected aquifer. Although the U.S. Geological Survey (Misut, 2010, 2011) has pointed out that contaminant diffusion into and out of the Raritan Clay may affect the contaminant plume, this type of interaction would have no effect on the hydraulic performance of the proposed capture system and only secondary effect on contaminant migration and persistence.

Recharge is set at roughly 50% of the annual precipitation, a reasonable fraction for a sandy glacial outwash deposit like Long Island. As a comparison point, the same 50% proportion is used by Walter and LeBlanc (2008) in models of the similar Cape Cod aquifer. Recharge in the Arcadis model is augmented to account for leakage from sewerage and water-supply systems, which is also reasonable.

Values used for aquifer hydraulic properties in the model are based on prior hydrologic studies of Long Island published by the U.S. Geological Survey (USGS). Typically, USGS data are the best available and it is prudent and accepted practice to rely on such data. Additionally, Arcadis (2003) reports that local areas within the Bethpage Facility are assigned hydraulic conductivity values based on on-site tests. This is also appropriate although these local variations, which are limited to a small area, are unlikely to affect significantly the performance of the proposed hydraulic capture systems which operate on a much larger spatial scale. Other than these small areas, the Arcadis model uses an appropriately parsimonious approach to specifying hydraulic conductivity, with most of the model layers employing only one or two values of hydraulic conductivity throughout the modeled area. A parsimonious approach is desirable if it results in an adequate representation of the aquifer, which it does in this instance. This is shown by the similarity between the hydraulic head distribution predicted by the model (Arcadis, 2016, Figure 6, Layer 1) and that observed in the field by the USGS (Arcadis, 2016, Figure 1).

As indicated above, the lateral boundaries of the model are not natural hydrologic boundaries. A superior formulation would be to place no-flow boundaries along groundwater flow streamlines well distant from the area of interest. According to Arcadis (2016), this was how these boundaries were formulated in recent prior versions of the model. That approach was no longer practical with the addition of extensive pumping at the remediation extraction wells—the lateral boundaries would have needed to be much further to the east and west. Such distant lateral boundaries would have created a model of such large area that model simulation times would be impractically long. Thus, use of general-head lateral boundaries represents an acceptable compromise between practicality and technical rigor. The general-head boundaries create an appropriate representation of flow entering the modeled area from lateral areas outside the model.

Not surprisingly given the proposed volume of remediation pumping, Arcadis' model simulations of the proposed remediation systems show those systems create drawdown at the model's lateral boundaries. Ideally, the model boundaries would be sufficiently distant to show only minimal such drawdown. This concern is addressed by the use of general-head lateral boundaries as a means to represent lateral inflow as discussed above. The occurrence of drawdown at the model's lateral boundaries has a ready explanation; Arcadis sized their model so as to amply fit the 10,000-foot wide plume. The model is in fact roughly 29,000-feet wide, more than adequate to represent the plume and a comparably wide capture zone as well as accompanying drawdown outside the capture zone. However, the vast quantities of water proposed to be extracted in the Options Report create impacts far beyond 10,000 feet, including drawdown at the model boundaries. These far-reaching impacts are not addressed by the HDR model, but the Arcadis model properly represents the combined effects of the multiple wells and correctly predicts more distant impacts, albeit with some drawdown at the model's lateral boundaries.

Arcadis (2016) used the current version of the model to simulate the effects of the proposed full-plume remediation system. As indicated above, the Arcadis model is a more appropriate means to evaluate that system and the consequences of the pumping of 19 mgd than the simple analytical model used in the Options Report. The predictions made by the Arcadis model more accurately reflect the combined capture zone that would be created by the proposed extraction system alternatives. The Arcadis model also accounts for existing water-supply wells and how those would be affected by the large volume of water proposed to be pumped from the proposed extraction system alternatives. The Arcadis model predicts an increase in the drawdown at existing water-supply wells in the southern area of the model. This is an unsurprising result given the large quantities of additional water proposed to be withdrawn from the aquifer and these particular model results are both reasonable and qualitatively predictable.

In summary, based on my review of the written documentation of the Arcadis model, a review of the model itself, and discussions with the model developers, I find the model to have been constructed consistently with accepted groundwater modeling practice and to be a reasonable representation of the Long Island aquifer. It is superior to the simple analytical model used in the Options Report by HDR and is a far more reliable means to evaluate the potential effects of the proposed full-plume remediation alternatives.

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ATTACHMENT 1

PETER SHANAHAN

EDUCATION

1982	Ph.D.	Environmental Engineering	Massachusetts Institute of Technology
1974	M.S.	Environmental Earth Sciences	Stanford University
1973	B.S.	Civil Engineering	Massachusetts Institute of Technology
1973	B.S.	Earth and Planetary Sciences	Massachusetts Institute of Technology

PROFESSIONAL HISTORY

1988-date	HydroAnalysis, Inc.
2004	Tufts University
1996-date	Massachusetts Institute of Technology
1981-1988	ERT, Inc. (now ENSR Corporation)
1980	International Institute for Applied Systems Analysis, Laxenburg, Austria
1978-1981	Massachusetts Institute of Technology
1976-1979	Resource Analysis/Camp Dresser & McKee Inc.
1974-1976	Bechtel, Inc.

AFFILIATIONS

Fellow, American Society of Civil Engineers (Committee on Hydrologic Transport and Dispersion, 1988-1993, Chairman 1989-1990)
International Water Association (Task Group on River Water Quality Modeling, 1996-2002; Specialist Group on Systems Analysis and Integrated Assessment, 2000-2013)
Water Environment Federation (Committee on Research, 1986-1992)
Association of Ground Water Scientists and Engineers (Editorial Board, Journal of Ground Water, 1990-1992)
American Geophysical Union
American Water Resources Association
Conservation Commission, Acton, Massachusetts, 1990-1996

REGISTRATION

Professional Engineer (Civil), Massachusetts
Professional Engineer, Maine

REPRESENTATIVE EXPERIENCE

Dr. Shanahan has directed or been a major contributor to a wide variety of projects involving analysis and computer modeling of environmental water quality, hydrology, and hydraulics. These studies have included engineering analysis and design of water-pollution controls, hazardous waste site remedial actions, flooding and drainage controls, and water-resources development. Dr. Shanahan is an experienced expert witness and has represented clients in courtroom testimony, administrative hearings, negotiations with regulatory agencies, and public meetings. Dr. Shanahan recently retired from a position as Senior Lecturer in the Department of Civil and Environmental Engineering at the Massachusetts Institute of Technology where he taught both graduate and undergraduate subjects in environmental engineering. As a Research Affiliate at MIT, he continues to conduct research and supervise environmental engineering graduate students.

Hydrology and Hydraulics

Dr. Shanahan has completed technical analyses and developed and applied models to a wide variety of hydrologic and hydraulic problems. Past projects include:

Lake Balaton, Hungary	Developed MITLAKE model for three-dimensional wind-driven circulation in shallow lakes
Cumberland River, Kentucky and Tennessee	Developed computer code to model rainfall runoff, reservoir operation, and flood flow
Oahe Dam, South Dakota	Modeled hydropower plant hydraulic transients
Fitchburg, Massachusetts	Developed stormwater management model for combined sewer system
Henrico County, Virginia	Managed comprehensive drainage and flooding model development project
Development sites in Massachusetts	Applied the SCS TR-20 model for stormwater analysis and design
Nuclear waste repository, Texas	Served as principal investigator for water resources site study

Dr. Shanahan is also a co-author of the U.S. Army Corps of Engineers generalized model for hydraulic transients in hydropower systems, WHAMO (Water Hammer and Mass Oscillation).

Water Quality

Dr. Shanahan's water-quality experience includes academic research to develop modeling approaches and engineering experience analyzing information and using models in practical applications. Project experience includes a wide range of contaminants in rivers, lakes, and coastal environments. Representative examples include:

Lake Balaton, Hungary	Eutrophication model development
Mississippi River, Mississippi	Model of dissolved solids plume
Wateree River, South Carolina	Permit application for paper mill discharge
Conowingo Reservoir, Pennsylvania	Model of power plant thermal plume
Fishkill Creek, New York	Permit application for industrial discharge
East Machias River, Maine	Model of fish hatchery discharge
Westfield River, Massachusetts	Model of paper mill discharge
Ohio River, West Virginia	Model of phenol and ammonia plume
Strait of Malacca, Indonesia	Analysis of LNG plant thermal discharge
Fort Point Channel, Boston, Massachusetts	Model of cooling water discharge
Lake Galena, Pennsylvania	Model of lake eutrophication
Lake North Anna, Virginia	Model of cooling lake
Snake River, Idaho and Washington	Model of temperature and dissolved oxygen
Worcester, Massachusetts	Model of nonpoint source pollution and runoff

Dr. Shanahan has also served as a consultant to the U.S. Environmental Protection Agency advising on wasteload allocation, total maximum daily loads, effects of climate change, and other topics in water quality.

Ground-Water Hydrology

Dr. Shanahan's experience includes a wide variety of projects involving the assessment and modeling of ground-water hydrology and quality, as well as using models to design remediation measures for contaminated ground water. Example projects include:

Reilly Tar & Chemical Superfund Site, St. Louis Park, Minnesota	Modeled ground-water flow in multiple aquifers affected by coal-tar compounds; developed model for design of gradient and source control wells.
Burkeville, Alabama	Modeled the hydrologic impacts of planned industrial supply well
Baltimore, Maryland	Modified USGS MOC ground-water contaminant transport model to assess DNAPL transport from manufactured gas plant site
Brainerd, Minnesota	Modeled contaminant transport to design ground-water remedy at Superfund site
More than twenty Massachusetts municipalities	Employed ground-water flow models to delineate Massachusetts aquifer protection Zone II

Dr. Shanahan also authored the section on modeling inactive hazardous waste sites in the Handbook on Manufactured Gas Plant Sites published by the Edison Electric Institute.

Hazardous Waste Site Consultation

Dr. Shanahan has served as a consultant on the investigation, remediation, and regulation of Superfund, RCRA, and other hazardous waste sites. Typical assignments include critical review of RI/FS documents, technical evaluation of hydrogeologic and modeling studies, and oversight of technical contractors. Representative past projects include:

Low-Level Radioactive Waste Site, Clark County, Illinois	Served as principal hydrologist for characterization of proposed waste disposal site
Stringfellow Acid Pits, California	Participated on technical committee as representative of one of the named site generators
Wells G&H, Woburn, Massachusetts	Managed ground-water remediation task for site Remedial Design/Remedial Action program
Slatersville and Forestdale Reservoirs, Rhode Island	Evaluated potential impact of Superfund sites on proposed water-supply development
Koppers Superfund Site, Galesburg, Illinois	Managed ground-water remediation task for site Remedial Design/Remedial Action program
Los Alamos National Laboratory, New Mexico	Assessed ground-water contamination by radionuclides, organic chemicals, and explosives as part of a comprehensive site-wide risk assessment and model
Massachusetts Military Reservation	Completed studies of effects of contaminated ground-water inflow on Ashumet and Johns Ponds on behalf of citizen’s group

In other project assignments, Dr. Shanahan has assisted industrial groups and trade associations in critically reviewing and submitting comments to government agencies on proposed regulations governing Natural Resource Damage Assessments under CERCLA and Hazardous Waste Characterization under RCRA.

Contaminated Sediments

Dr. Shanahan has consulted on a number of sites at which sediments contaminated by PCBs, metals, and other chemicals have been an issue. Example projects include:

Fox River, Wisconsin	Modeled the fate and transport of sediments and PCBs as influenced by river flow and lake seiche
Newark Bay, New Jersey	For an industrial client, oversaw a team of technical specialists assessing patterns of organic chemical contamination
Passaic River, New Jersey	For an industrial client analyzed patterns of mercury contamination and potential for contribution to contaminated sediments
Paoli Rail Yard Superfund Site, Paoli, Pennsylvania	Retained as expert witness and provided analysis of the extent and causes of soil and stream sediment contamination at PCB-contaminated site
Pompton Lakes Works, Pompton, NJ	Developed and applied stream flooding model to determine extent of past flooding as cause of sediment contamination by lead and mercury

Peer Review

Dr. Shanahan has provided expert peer review to a variety of governmental and other clients. Selected assignments include:

Housatonic River, Massachusetts	Served on EPA panel providing peer review of the modeling framework design for a two-dimensional hydrodynamic, sediment transport, and water-quality model of PCBs
Massachusetts Estuaries Program	Served on panel conducting an independent, scientific review of the MEP Linked Watershed Embayment Model, a key component of a large number of nutrient TMDLs in the Cape Cod and Buzzards Bay region
Review of EPA Silver Study	Provided a formal peer review of the draft report "Silver Waste Stream: Management Practices, Risks and Economics" for the U.S. EPA

Expert Testimony and Agency Negotiation

Dr. Shanahan has represented clients in courtroom testimony, public meetings, agency negotiations, a press conference, and other forums on a variety of technical issues associated with hazardous waste, ground water, and surface water. Dr. Shanahan has provided expert testimony at ten trails, twelve adjudicatory hearings, and thirty-six depositions. Dr. Shanahan has provided expert testimony on ground-water contamination and transport, surface-water flooding, surface-water quality, and hazardous waste site remediation.

PUBLICATIONS

Shanahan, P., “A Groundwater Model Used to Sense Subsurface Geology in an Alluvial Basin near Tombstone, Arizona,” M.S. Report, Department of Applied Earth Sciences, Stanford University, Stanford, California. June 1974.

Harleman, D.R.F., E. E. Adams and P. Shanahan, “Field Verification of a Stratified Cooling Pond Model,” Proceedings of the VXIII Congress, International Association for Hydraulic Research, Cagliari, Italy, Volume 4, pages 309-316. September 1979.

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Somlyódy, L., M. Henze, L. Koncsos, W. Rauch, P. Reichert, P. Shanahan, and P. Vanrolleghem, "River Water Quality Modelling: III. Future of The Art," *Water Science and Technology*, Volume 38, Number 11, pages 253-260. December 15, 1998.

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Chapter 1, Section 5B, "Mixing and Transport of Pollutants in Surface Water" by P. Shanahan and S.C. Gaudet.

Chapter 24, Section 3, "Sensitive Environmental Systems, Alpine Lakes" by P. Shanahan.

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Shanahan, P., “Modelling advance for river quality.” *Water21, Magazine of the International Water Association*. Pp. 38-41. April 2002.

Oates, P.M., P. Shanahan, and M.F. Polz, “Solar Disinfection (SODIS) for Point-of-Use Water Treatment in Haiti and Simulation of Solar Radiation Global for Global SODIS Assessment.” *Water Research*. Vol. 37, No. 1, Pp. 47-54. January 2003.

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Bras, R. L., F. Chagnon, E. E. Adams, J. Atkinson, O. Madsen, S. Murcott, U. Shamir, P. Shanahan, and L. Thatcher, “Donald R. F. Harleman: A Life of Excellence and an Excellent Life.” *Journal of Hydraulic Engineering, ASCE*. Vol. 133, No. 11, Pg. 1187-1191. November 2007.

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Shanahan, P., "Adaption of the USGS 3-D Ground Water Flow Model for Simplified Mass Transport Analysis," presented at the Eastern Regional Ground Water Conference, National Water Well Association, Newton, Massachusetts, July 1984.

Shanahan, P., "Directions in Superfund Response Actions: Investigation, Treatment Alternatives and Cleanup Standards," lecture at the 1986 Environmental Law Institute, Minnesota Institute for Legal Education, Minneapolis, Minnesota, March 20, 1986.

Shanahan, P., "Type B Natural Resource Damage Assessment: Overview" and "Surface Water and Geologic Resources," presented at the 1986 Washington Conference on Damages to Natural Resources, The Center for Energy and Environmental Management, Alexandria, Virginia, November 18, 1986.

Shanahan, P. and R.J. Fine, "Trends in Superfund Response Actions," Paper No. 87-17.2, presented by P. Shanahan at the 80th Annual Meeting and Exhibition, Air Pollution Control Association, New York, New York, June 22, 1987.

Shanahan, P., "Ground-water Remediation at Coal-Tar Contamination Sites," presented at Seminar on Implications of SARA and RCRA Closure/Continuing Release Provisions on the Iron and Steel Industry, American Iron and Steel Institute, Pittsburgh, Pennsylvania, October 7, 1987.

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Shanahan, P., "Drainage: Basic Functions," workshop presented at the Massachusetts Association of Conservation Commissions 1991 Annual Meeting, Worcester, Massachusetts, March 2, 1991.

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ATTACHMENT 3

Analysis of the Cedar Creek Water Pollution Control Plant's Ability to Treat or Process 19MGD of Groundwater, Grumman Aerospace-Bethpage Facility

September 8, 2016

ANALYSIS OF THE CEDAR CREEK WATER POLLUTION CONTROL PLANT'S ABILITY TO TREAT OR PROCESS 19 MGD OF GROUNDWATER

Grumman Aerospace - Bethpage Facility
NYSDEC Site Number 130003

Prepared for:

NORTHROP GRUMMAN SYSTEMS CORPORATION AND NORTHROP GRUMMAN CORPORATION

ROUX ASSOCIATES, INC.

Environmental Consulting & Management

ROUX

and REMEDIAL ENGINEERING, P.C.

209 Shafter Street, Islandia, New York 11749 ♦ 631-232-2600

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FIGURE

APPENDIX

LIST OF ACRONYMS

BOD	Biochemical Oxygen Demand
FT-BGS	Feet Below Grade Surface
HDR	Henningson, Durham & Richardson Architecture and Engineering, P.C.
MGD	Million Gallons Per Day
NCDPW	Nassau County Department of Public Works
NYSDEC	New York State Department of Environmental Protection
SPDES	State Pollutant Discharge Elimination System
VOC	Volatile Organic Compound
WPCP	Water Pollution Control Plant

1.0 INTRODUCTION

Roux Associates, Inc. and Remedial Engineering, P.C. (collectively "Roux Associates") have prepared this report of the feasibility for the utilization of the Cedar Creek Water Pollution Control Plant (WPCP) as part of Remedial Options 2 and 3 presented in the *Remedial Options Report* prepared by Henningson, Durham & Richardson Architecture and Engineering, P.C. (hereby referred as "Remedial Options Report")[1]. Roux Associates undertook this evaluation to provide additional information to aid Northrop Grumman Systems Corporation and Northrop Grumman Corporation in their comments on the Remedial Options Report pursuant to the New York State Department of Environmental Conservation's (NYSDEC's) August 8, 2016 invitation to submit comments.

In an effort to evaluate the feasibility of Remedial Options 2 and 3, Roux Associates obtained and reviewed the following:

- Publicly availably documents from the Nassau County Department of Public Works (NCDPW), Nassau County Department of Assessment, NYSDEC, and the Environmental Protection Agency;
- Documents provided by United Water Long Island (a subsidiary of "Suez Environnement"), the private management company overseeing the Cedar Creek WPCP;
- Documents developed by not-for-profit organizations such as Citizens Campaign for the Environment; and
- Video and print articles from news outlets including, but not limited to, Long Island Herald, Newsday, and Massapequa Observer.

In addition, Roux Associates communicated with Assistant to Commissioner Mr. Ken Arnold and Sanitary Engineer Mr. Pasquale Assalone, P.E. from the NCDPW, and Chief Sanitary Engineer Mr. Joseph Davenport, P.E. from the Cedar Creek WPCP to obtain information on the existing plant infrastructure, capacity, and pre-treatment program. The relevant information obtained from these various sources is discussed below.

[1] Attached as Appendix A are the professional profiles of the principle Roux Associates drafters of this report.

2.0 REMEDIAL OPTIONS REPORT SUMMARY

On behalf of the NYSDEC, Henningson, Durham & Richardson Architecture and Engineering, P.C. (HDR) prepared a *Remedial Options Report* (July, 2016) summarizing the proposed 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. HDR selected hydraulic capture as the viable remedial technology. One of the largest challenges associated with pump and treat technology is identifying/designing the treatment system location and specifications, and determining where to discharge the treated effluent. HDR developed three remedial options to resolve these challenges.

2.1 Remedial Option 1

A groundwater extraction system consisting of eight shallow recovery wells (550 feet below grade surface [ft-bgs]) and eight deep groundwater recovery wells (800 ft-bgs) to be installed along the Southern State Parkway to capture approximately 19 million gallons per day (MGD) of groundwater. The extracted groundwater will be conveyed to a treatment plant to be built in a centralized location. Groundwater will be treated to New York State Class GA Water Quality standards prior to discharge to Massapequa Creek.

2.2 Remedial Option 2

A groundwater extraction system consisting of six shallow recovery wells (550 ft-bgs) and six deep groundwater recovery wells (800 ft-bgs) will be installed at select areas within Nassau County Recharge Basins, adjacent available land, and along the Southern State Parkway. The estimated 19 MGD of extracted groundwater will be conveyed via new sewer lines to nearby existing trunk sewer mains; the estimated length of new piping required is 12,000 feet. The extracted groundwater will then be conveyed via gravity to the Cedar Creek WPCP to be treated to the plant's discharge limits and discharged to the outfall located three miles off-shore in the Atlantic Ocean.

2.3 Remedial Option 3

A groundwater extraction system consisting of four shallow recovery wells (550 ft-bgs) and five deep groundwater recovery wells (800 ft-bgs) will be installed at select areas within Nassau County Recharge Basins and along the Southern State Parkway. In addition, three municipal water supply wells in the targeted area will be converted into recovery wells (two shallow and one deep). Replacement municipal wells will either be installed outside of the contamination plume, or the infrastructure will be reconnected such that neighboring water districts will supply the affected water district with additional water supply. The estimated 19 MGD of extracted groundwater will be conveyed via new sewer lines to nearby existing trunk sewer mains; the estimated length of new piping required is 12,000 feet. The extracted groundwater will then be conveyed via gravity to the Cedar Creek WPCP to be treated to the plant's discharge limits and discharged to the outfall located three miles off-shore in the Atlantic Ocean.

3.0 CEDAR CREEK WPCP HISTORY AND DESCRIPTION

The Cedar Creek WPCP receives and treats 40 percent of Nassau County's sewage wastewater, making it a critical component of the Nassau County Public Works system. The WPCP was constructed in 1974 to treat up to 45 MGD of domestic, commercial, and industrial wastewater via physical, chemical, and biological processes. The multi-stage treatment process is discussed further below.

Since its construction in 1974, the WPCP has undergone significant expansions and upgrades to meet the growth needs of Nassau County. In the 1980's, capacity of the WPCP was increased by constructing three aeration tanks, six settling tanks, and a polymer feed system, and by upgrading or modifying the air diffusers, flotation thickeners, digester gas collection and pumping system, and ancillary equipment. In addition, maintenance was conducted to clean and rehabilitate the sludge digesters. In the 1990's, an additional grit chamber was installed, four new primary tanks were constructed, eight sedimentation tanks were demolished and replaced with six new tanks, four new mechanical bar screens installed, and the sludge handling facilities were expanded to include three new digesters, two new sludge storage tanks, and four new sludge thickening tanks. In 2003, covers were constructed and installed for the six aeration tanks to mitigate odors in the neighboring community. These expansions, modifications, upgrades, and maintenance activities completed over the past 30 years increased the wastewater treatment capacity at the WPCP to 72 MGD from its previous capacity of 45 MGD. On average, the WPCP receives and treats approximately 53 MGD of sewage wastewater. Storm sewers are segregated from sanitary sewers in Nassau County. Nevertheless, the WPCP does experience extra flow during major storm events mostly due to flood water entering manholes from the street.

The approximate 53 MGD of influent is conveyed through several treatment stages. Each stage of the treatment process is briefly described below and depicted in the attached treatment flow diagram.

- Screening chambers with mechanically-cleaned bar screens remove large objects such as rags, paper, plastics, and metals. The waste collected is compacted, dewatered, and disposed off-site.

- Aerated grit chambers remove heavy solid materials such as sand, gravel, cinder, and large organic particulates (e.g., food waste). The waste collected is compacted, dewatered, and disposed off-site.

- Sodium hypochlorite (i.e., bleach) is added for pre-chlorination of the waste stream to control odors, aquatic growth, reduce biochemical oxygen demand (BOD) (i.e., degree of organic pollution), and aid in coagulation and settling.

- Primary settling tanks remove approximately 45 to 55 percent of the total suspended solids as sludge and reduce the BOD. The sludge removed is conveyed to the primary digesters.

- Activated sludge aeration tanks introduce a biological floc composed of microorganisms that reduce the amount of organic materials within the wastewater.

- Secondary settling tanks remove the biomass and any remaining solids. A portion of sludge/biomass is returned to the activated sludge aeration tanks for recycling and the rest is conveyed to the sludge digesters.

- Final screening and chlorination facilities remove the remaining solids and disinfect the effluent.

- Sludge removed from the process is conveyed to sludge thickening units prior to transport to covered sludge digesters (five primary units and two secondary units). Digested sludge is dewatered and transferred off-site for disposal and/or recycling.

4.0 FEASIBILITY EVALUATION

4.1 Sewer Network Infrastructure

Remedial Options 2 and 3 assume the installed and converted recovery wells will be connected to the nearest sewer trunk mains to convey the extracted groundwater to the Cedar Creek WPCP. The work required to complete the new connections to the existing sewer network is estimated to involve trenching and installing approximately 12,000 feet of 10-inch diameter piping. The proposed trenching areas extend along residential roads and right-of-way sections of the Southern State Parkway. The work would likely need to be planned around commuter rush-hours to seek to minimize impacts on traffic, while also maintaining compliance with residential noise and other construction ordinances. Therefore, the trenching required for Remedial Options 2 and 3 presents issues with respect to the feasibility of these plans.

In addition to the difficulties of executing the proposed sewer connection strategy, the Remedial Options Report states in Sections 4.2.2.2 and 4.2.3.2 that "[i]t is assumed that the nearest trunk sewer main would have the capacity to accommodate the additional water." This is a critical assumption that should have been verified in the Report because of the significant potential consequences to overall construction costs and the feasibility of Remedial Options 2 and 3 in relation to the sewer network infrastructure if insufficient capacity is available. Absent such capacity, additional piping and trenching may be required to connect to other trunk sewer mains that have the available capacity, if present, or new trunk sewer mains may need to be constructed, if feasible; both alternatives would increase construction costs and may be time-consuming.

4.2 Hydraulic Capacity of Cedar Creek WPCP

The hydraulic load placed on Cedar Creek WPCP has been relatively consistent over the past few years (approximately 53 MGD) due to a slowdown in new residential, commercial, and industrial developments in Nassau County. An additional three to five MGD of wastewater is anticipated as a result of a new pump station to be installed in Hempstead, and additional flow is expected to be directed from future developments in the neighborhood surrounding the Nassau Veterans Memorial Coliseum in Uniondale.

With the anticipated additional flow from Hempstead, and even without allowing for additional flow capacity for future normal development in Nassau County, the current available excess capacity of the WPCP is inadequate to accept an additional 19 MGD. While there are currently no large developments planned, there would be negative impacts on future county developments if excess capacity is exhausted due to the input of large quantities of water from the groundwater remediation program. This would remove the additional capacity required for community development project discharges, and storm events. Removing all of the available capacity of the WPCP has the potential to:

- Stress the existing sewer district/network infrastructure;
- Stress other NCDPW and private treatment facilities in Nassau County if portions of flow need to be redirected;
- Eliminate the possibility of redeveloping or closing smaller treatment plants and redirecting flow to Cedar Creek WPCP, as was proposed by past municipal administrations;
- Restrict future growth of the community; and
- Increase the likelihood of untreated sewage releases due to capacity exceedances during storm events and/or periods of above-average sewage flow.

In addition to the infrastructure challenges, the relationship between the Cedar Creek WPCP and community is sensitive and must also be considered. According to Citizen's Campaign for the Environment, the Cedar Creek WPCP ranked first in violations in the period 2005-2010 (128 violations), in a comparison of ten large sewage treatment plants in Long Island. There have been numerous complaints by the surrounding community of odors emanating from the facility. Violations and odor complaints will likely increase if the treatment process is adversely affected by the additional 19 MGD of influent, as discussed below. However, the Remedial Options Report contains no analysis of whether the WPCP could obtain the necessary State Pollutant Discharge Elimination System (SPDES) permit for renewal or expansion to accommodate the additional flow.

4.3 Impacts on Treatment Process

Based on the location of the extraction wells (plume boundary), pumping rates, and radii of influence, it is anticipated that the extracted groundwater will initially have low concentrations of volatile organic compounds (VOCs) and low organic content. Pre-treatment is expected to be mandated because the concentrations of VOCs, while low, are anticipated to be higher than typically allowed in accordance with the federal Pretreatment Standards and Requirements. Therefore, the pre-treatment of 19 MGD will require a separate treatment facility to remove VOCs, and would result in an influent to the WPCP that will likely meet potable drinking water standards. The Nassau County Sewer Ordinance, Section 4.2, titled "Discharge of Unpolluted Wastes to Sanitary Sewer Prohibited" explicitly prohibits this type of flow to the WPCP without obtaining a "special agreement". Therefore, it would be impractical to send such a large volume of clean water to a sewage treatment facility simply for the purpose of discharging it to the WPCP outfall, as discussed below.

The reason for such restrictions is that the addition of 19 MGD of relatively clean water to the existing influent into Cedar Creek WPCP would reduce the biomass concentration and upset the activated sludge process. This biological process is critical to provide efficient treatment and is dependent on timely development of an adequate biomass of diverse organic matter. This biomass serves as the food supply for the treatment plant's microorganisms, which drive the degradation of the BOD (organic pollution) and also are useful in removal of fine solids from the wastewater. The addition of large quantities of relatively clean water would slow the formation of floc particles and decrease the settleability of organic material. Operational changes, such as the continuous addition of nutrients and biologic materials could help offset the addition of relatively clean water, but would add substantial complexity and may lead to upset conditions and subsequent SPDES discharge violations due to the discharge of insufficiently treated sewage.

4.4 Cedar Creek WPCP Infrastructure

The Remedial Options Report assumes that the Cedar Creek WPCP will be upgraded to handle the additional 19 MGD load. The Remedial Options Report states that the "upgrades to the Cedar Creek [WPCP] 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, and the chlorine contact basin and chemical feed systems, the anaerobic digestion, and the dewatering process." However, the Remedial Options Report is deficient, because it does not discuss the technical difficulties of expanding/upgrading every treatment component.

During the past 30 years the facility has undergone major upgrades. During that time, the facility was expanded and now covers almost all of the available property acreage. To expand the capacity of the WPCP further, additional tanks, equipment, and piping will be required. The WPCP's lack of available space and the necessity of adding tanks and piping in specific locations, since the plant is gravity fed, present significant feasibility issues. An attempt to utilize the limited space within the property would require additional pumps. However, another issue not discussed in the Remedial Options report is that it may be impracticable and too costly to add pumps to convey the magnitude of flow that is proposed. In addition, pumps add higher maintenance costs and have an increased chance of failing as opposed to a gravity fed system.

4.5 Pre-Treatment Requirements

The NCDPW and Cedar Creek WPCP personnel that were contacted indicated that all waste streams from groundwater remediation systems that are directed to the WPCP are required to receive pre-treatment prior to discharge into the sewer network. A pre-treatment system was not proposed for Remedial Options 2 and 3, and would greatly increase the cost due to the additional piping/trenching necessary and the construction of a treatment system that can process 19 MGD flow rates. As discussed previously, it is anticipated that the treated groundwater concentrations will achieve levels below New York State Class GA Water Quality standards. It will likely be considered an impractical, excessive, and redundant effort to redirect the treated groundwater to the Cedar Creek WPCP once it has been pre-treated, simply for the purpose of discharge.

The input of 19 MGD to the WPCP would also violate federal Pretreatment Standards and Requirements, in that it would constitute "interference." "Interference" is defined as:

> "A discharge that, alone or in conjunction with a discharge or discharges from other sources, both (1) inhibits or disrupts the [publicly owned treatment works], its treatment processes or operations, or its sludge processes, use, or disposal….[2]"

[2] https://www.epa.gov/npdes/pretreatment-standards-and-requirements#general

Roux Associates trusts that the above discussion has analyzed the difficulties inherent in the groundwater treatment strategy proposed in Remedial Options 2 and 3 of the Remedial Options Report.

Respectfully submitted,

ROUX ASSOCIATES, INC./REMEDIAL ENGINEERING, P.C.

Brian P. Morrissey, P.E.
Principal Engineer

FIGURE

1. Cedar Creek Water Pollution Control Plant Treatment Flow Diagram

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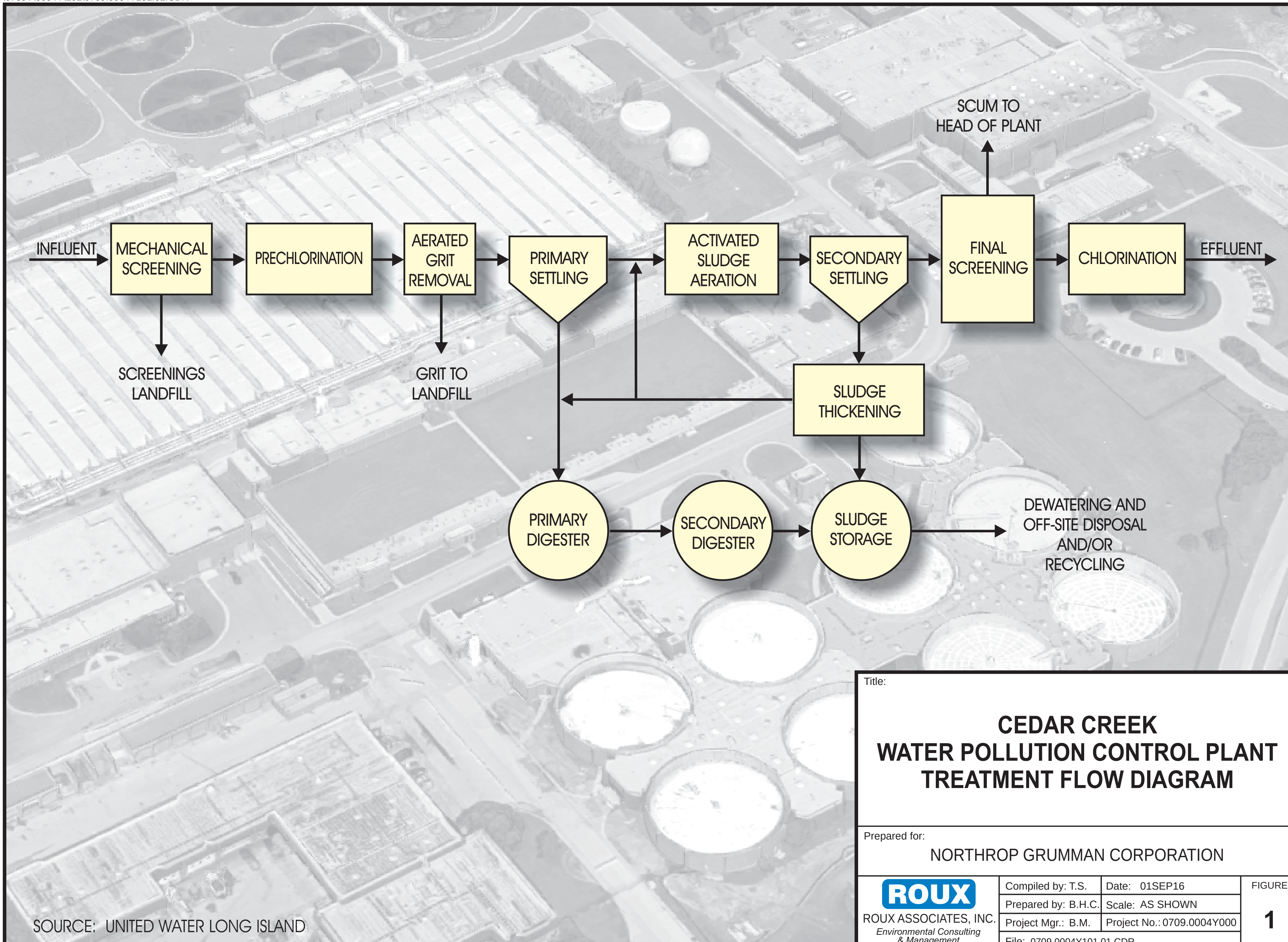

SOURCE: UNITED WATER LONG ISLAND

Title:

CEDAR CREEK WATER POLLUTION CONTROL PLANT TREATMENT FLOW DIAGRAM

Prepared for:

NORTHROP GRUMMAN CORPORATION

ROUX ROUX ASSOCIATES, INC. *Environmental Consulting & Management*	Compiled by: T.S.	Date: 01SEP16	FIGURE
	Prepared by: B.H.C.	Scale: AS SHOWN	1
	Project Mgr.: B.M.	Project No.: 0709.0004Y000	
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APPENDIX A

Professional Profiles

Brian P. Morrissey, P.E., BCEE
Principal Engineer

Technical Specialties:
Preparation of feasibility studies, engineer's reports, design drawings, specifications, contract documents, cost estimates, operations and maintenance plans for the following:

- Ground water pumping and treatment facilities
- Industrial and sanitary wastewater treatment systems
- Floating product recovery systems
- Potable water supply, treatment and distribution
- Underground storage tank systems
- *In situ* groundwater remedial technologies
- Air sparging, soil vapor extraction and vapor treatment systems
- Hazardous waste soils removal, transportation, and disposal procedures

Experience Summary:
More than 30 years of experience: Principal Engineer and Office Manager at Roux Associates, Inc./Remedial Engineering, P.C.; Senior Engineer and Senior Project Manager at ERM; Project Engineer at the former Jamaica Water Supply Company.

Credentials:
B.E., Civil Engineering, Cooper Union, 1980
M.S., Civil and Environmental Engineering, Polytechnic University, 1985
Professional Engineer, New York, 1986
Professional Engineer, New Jersey, 2003
OSHA 40-hour Health and Safety Training
Board Certified Environmental Engineer (BCEE) of the American Academy of Environmental Engineers and Scientists; Specialty Certification in Hazardous Waste Management, 1995

Professional Affiliations:
Water Environment Federation

Key Projects

- Project Manager for the design of wastewater treatment plant (WWTP) upgrades at three (3) separate facilities under the program to protect New York City's public water supply and watershed areas. The work included preparing conceptual upgrade plans, facility plans, detailed cost estimates, design drawings and specifications, startup plans, O&M plans and oversight of construction. Design at one facility included replacement of secondary treatment components and the addition of re-circulating sand filters, microfiltration units, emergency generator and telemetry systems.

- Project Manager for evaluation of water supply, treatment and distribution system for village in Barrington, New Hampshire. USEPA had proposed a costly solution to rehabilitate the existing treatment system. Reviewed available information and developed an alternative that satisfied all federal and state regulations and complied with The Recommended Standards for Water Works (Ten State Standards). The recommended alternative was implemented at a cost significantly lower than that estimated for the original plan.

- Project Manager for the planning and design of irrigation system using treated wastewater in the Catskills area. Conducted study on acceptable uses of wastewater treated by tertiary methods in accordance with federal and New York State guidance.

- Project Manager for evaluation of wellhead treatment alternative for 1,100-gpm public water supply well in Mineola, NY. Conducted well efficiency tests and investigated existing conditions and future requirements. After engineer's report was approved, prepared design of activated carbon treatment system including building modifications and requirements for well development and pump replacement.

- Project Manager for remediation of industrial airport site in Millville, New Jersey under ECRA/ISRA. Managed testing, design and permitting activities required to replace 1,000-gpm public water supply well impacted by extensive chlorinated solvent plume. Also designed and conducted oversight of temporary activated carbon treatment system. Also managed final design of 200-gpm groundwater recovery, treatment, and recharge system that includes ultraviolet light/hydrogen peroxide system controlled by PLC. This project won a national Honor Award from the American Academy of Environmental Engineers.

- Principal Engineer for evaluation of remedial options for VOC-contaminated groundwater at former electronics manufacturing plant in Taiwan. Prepared cost estimates for site remediation alternatives. Prepared Pilot Study Plan and presentation for Taiwanese regulatory officials on use of the *in situ* technologies of enhanced reductive dechlorination and chemical oxidation.

Brian P. Morrissey, P.E., BCEE
Principal Engineer

- Principal Engineer for the remediation and monitoring of over 100 sites in New York City. The remediation systems at the various sites include multi-phase extraction, soil vapor extraction, air sparging, groundwater recovery and treatment, and product-only recovery systems. Priorities on this multi-year contract include expediting remedial progress, increasing the effectiveness of operating systems, achieving NFA status, and reducing overall program costs. The work also included conducting a soil vapor study at nine sites to assess vapor intrusion concerns. *In situ* injections were conducted at 14 sites to cost-effectively achieve site closure. The *in situ* injections involve chemical oxidation and bioremediation products including sodium percarbonate, oxygen generating compounds, hydrogen peroxide, petroleum-degrading bacteria, and nutrient/enzyme complexes.

- Project Manager, remedial design and construction oversight at federal Superfund site in Elmira, New York. The 33-acre site included several areas of concern where soil/groundwater were contaminated by different types of hazardous wastes. Managed preparation of design submittals to EPA Region II in accordance with CERCLA guidelines. The soil-sediment remediation design included requirements for materials handling, dewatering and disposal. PCB wastes were segregated and disposed of at TSCA-permitted facility. The design required stabilization of wastes and installation of a RCRA cap. Groundwater remediation system includes 12 recovery wells, filtration units and two air strippers.

- Principal Engineer for design upgrades of the groundwater depression and separate phase product recovery systems at former petroleum refinery in Brooklyn, New York. Recent system expansion and upgrades include adding recovery wells, providing additional groundwater treatment and enhancement of the automated controls.

- Design Manager for groundwater recovery and treatment system at manufactured gas plant (MGP) in Atlantic Highlands, New Jersey. Implemented directional drilling under state highway to expand groundwater recovery system to capture off-site contamination. Treatment system includes PLC-based control software that significantly reduced on-site staffing requirements. Managed construction phase, negotiated/reduced change orders and worked with several subcontractors to meet tight schedule for system start-up. The system removes cyanide, metals, VOCs, and free-phase product.

- Project Manager for design and construction oversight of new 12,000-foot sewer system for the collection of sanitary and industrial wastewater in Melville, New York. Sewer design included route selection, sizing of gravity sewers, provisions for utility crossings, solar-powered flow meters, grease interceptor, pump station for one branch line, and proper abandonment of leaching facilities. Project also included installation of two 20,000-gallon underground storage tanks and a tanker truck fill area with secondary containment. Final phase of the project consisted of the addition of an industrial waste pretreatment system utilizing pH adjustment and bioreactor tank. This project provided a safe and reliable wastewater disposal system and eliminated a 40,000-gallon per day hold and haul system.

- Project Engineer, prepared feasibility study for state Superfund site in Glen Cove, New York. Evaluated groundwater and soil remediation technologies. After approval of FS by NYSDEC, managed final design, construction oversight, and startup phases of the project. Remedial system includes 30 variable speed controlled recovery pumps, filtration, iron sequestration, tray aeration, soil vapor extraction, and vapor treatment via catalytic oxidation.

- Principal Engineer for development of innovative approach for remediation and reuse of federal Superfund site in Plaistow, New Hampshire. Prepared cost estimates for approaches aimed at reducing project costs by utilizing alternate treatment technologies and maximizing efficiency of existing system. Phased approach for site includes hot spot soil removal, enhancements of existing remedial system, implementing air sparging with SVE and follow with polishing step of *in situ* bioremediation. This alternative plan will achieve environmental restoration of site and is tailored to anticipated re-development of land.

- Project Engineer for public water supply utility. Performed design and construction inspection duties for projects including replacement of contaminated supply well, cleaning and cement relining of existing water mains, rehabilitation of stationhouses, and overhauling iron removal treatment plant. Also conducted study on corrosion control of water system. Supervised testing, collected data and prepared report that evaluated corrosion inhibitors and sequestering agents.

Professional Profile

Nathan A. Epler, Ph.D.
Principal Hydrogeologist

Technical Specialties:
Quantitative Hydrogeology / Geochemistry / Environmental Forensics / Regulatory Advocate / Environmental Project Management. Expert witness / litigation support. Project Manager for remedial investigations, feasibility studies, and remedial actions. Re-development of Brownfield, petroleum spill and MGP Sites. Specialties include analytical and numerical groundwater flow and contaminant transport modeling for hazardous waste sites, landfills, remedial design and litigation support. Specialist in computerized mapping, 3D graphics, and Geographic Information Systems.

Experience Summary:
Twenty-three years of experience: Hydrogeologist at Roux Associates, Hydrogeologist at United States Geological Survey.

Credentials:
Licensed Environmental Professional in the State of Connecticut, 2011.
Ph.D. in Hydrogeology, State University of New York at Stony Brook, 1991.
M.S. in Geology, State University of New York at Stony Brook, 1986.
B.S. in Geology, Queens College, City University of New York, 1983.

Publications and Presentations:
2012 Served on Faculty for American Bar Association Environmental Litigation Conference Faculty, Washington DC.
2011 "Environmental Science and General Hydrogeologic Principles for Lawyers", in Environmental Issues in Real Estate Business Transactions, Lawrence Schnapf Editor, Published by American Bar Association.
2011 Served on Faculty for American Bar Association Environmental Litigation Conference Faculty, Washington DC.
2011 DC Building Industry Association meeting. Vapor Intrusion and Other Environmental Issues During Redevelopment.
2011 Guest Lecturer, New York Law School Seminar on hydrogeologic principles, NPL and Superfund processes.
2010 Guest Lecturer, New York Law School Seminar on hydrogeologic principles, NPL and Superfund processes.
2009 American Bar Association Dispute Resolution Section Annual Conference, in New York. Served on panel discussion.
2009 Guest Lecturer, Columbia Law School. Seminar for second year law class on interpretation of environmental data.
Epler, N. et al., 2005, Use of Graphics in Environmental Litigation Support. Manuscript and presentation at National Ground Water Association Environmental Law Conference, Baltimore, MD.
Epler, N. et al., 1993, Retardation of ^{238}U and ^{232}Th decay chain radionuclides in Long Island and Connecticut aquifers. Geochemica et Cosmochimica Acta, v 57, 597-603.
Epler, N, 1991, A Multiple Tracer Study of Ground Water From A Shallow, Unconfined Aquifer, Long Island, New York, Ph.D. Dissertation, State University of New York at Stony Brook, 156pp. The research included contaminant transport modeling and groundwater dating.
Epler, N, 1990 Dating Shallow Ground Water, Groundwater, V28.

<u>Investigation and Remediation Projects</u>

- Project Manager of groundwater Remedial Investigation at an ISRA Site in New Jersey. Project included installation of over 120 monitoring wells to delineate off-site plume of chloroform and pesticides in groundwater; installation and testing of a 1,500-gallon per minute interceptor/recharge system to capture the plume; applying for and acquiring Discharge-to-Groundwater and Water Allocation permits; and, quarterly monitoring.
- Project Manager, Site investigation and remediation at a NYS Superfund Site in Glen Cove, New York. Project included performing Remedial Investigation to identify the nature and extent of impacts to soil and groundwater and developing a remedial action plan.
- Project Manager, Site investigation and remediation at a bulk petroleum storage terminal in New York. Project included soil borings and installation of wells to delineate free-product plume. Successfully negotiated with NYSDEC regarding scope and design of active free-product recovery system.
- Project Manager Remedial Investigation at a New York State Superfund Site. Site was a former dye and pigment manufacturing facility for over 100 years. Extensive soil and groundwater contamination was delineated and remediated under a series of IRMs designed to be coordinated with the future re-development of the Site into a newsprint recycling facility.
- Project Manager remedial investigation under the New York State Voluntary Cleanup Program of a Closed Industrial Landfill. Site was contaminated with numerous compounds and contained drums and construction debris. Site was evaluated using electromagnetic surveys, trenching and borings. Remedial Action Work Plan using phyto-technology to address leachate control is being prepared.
- Project Manager remedial investigation under the New York State Voluntary Cleanup Program of an undeveloped area associated with an industrial parcel, where arsenic-contaminated fill was placed. Successfully demonstrated efficacy of using field-screening techniques for arsenic delineation.
- Project Manager of remediation of industrial landfill in Newburgh, New York. Project includes evaluated pre-treatment options for waste impacted by high concentrations of metals, including cadmium and lead, and VOCs, including MEK and MIBK.
- Project Manager of Site investigation and re-development project for 10 parcels in Manhattan. Sites are impacted by MGP waste and petroleum hydrocarbons. Site remedies include installation of sheet-piling containment barrier, and incorporation of vapor barrier and active venting systems into building construction.
- Project Manager of soil Remedial Investigation at an ISRA Site in New Jersey. Project included delineation of pesticides in soil at a 28-acre facility. Higher delineation limits and cleanup levels were successfully negotiated with the NJDEP to reduce the volume of soil to be remediated.
- Project Manager of Remedial Investigation at Delaware City PVC Site. Project includes well installation, water-level measurements and groundwater sampling to determine whether PVC Site could be source of VOCs beneath petroleum refinery.
- Project Manager of Performance Monitoring at the Delaware City PVC Superfund Site. Project includes sampling of over 100 monitoring wells to assess the performance of a 12-well groundwater interceptor and treatment system. Due to large reductions in plume volume, recommendations were accepted by the USEPA to reduce the number of pumping wells and the total pumping rate.
- Project Manager, installation of a 2,000-gallon per minute supply well for a New Jersey utility. Project included startup testing, 72-hour aquifer test and preparation of Water Allocation Permit.
- Project Manager of soil remediation at an ISRA Site in New Jersey. Implemented excavation and on-site consolidation and capping of pesticide-contaminated soil. Capped areas were designed to be incorporated into a Site re-development plan for use as a parking area.

Nathan A. Epler, Ph.D.
Principal Hydrogeologist

- Project Manager of lagoon remediation at a former dye manufacturing facility in New York. Project included separation and cleaning of 3,000 cubic yards of contaminated riprap for reuse onsite.
- Project Manager offsite soil gas and groundwater investigation in residential neighborhood adjacent to former dye manufacturing facility.
- Project Manager site investigation at a dry cleaner in Staten Island, New York where both soil and groundwater are impacted by tetrachloroethene. Site is adjacent to church and school, requiring significant community involvement.
- Directed research into the use of naturally-occurring radium isotopes, tritium and radiocarbon to date shallow groundwater for flow model calibration in the Upper Glacial aquifer on Long Island, New York.

Litigation Support Projects

- Testifying Expert for a case involving impacts to public supply wells on Long Island.
- Expert Witness for water district impacted by a Superfund Site on Long Island, New York. Provided opinions on source and timing of VOC plume and apportionment.
- Consulting Expert to provide opinions on impact of product release at a petroleum terminal relative to existing impacts.
- Consulting Expert to provide opinions on nature and timing of pipeline release.
- Expert Witness for former service station owners in Westchester, NY defending against claim of impact to adjacent private properties. Demonstrated that additional third party defendants were equally responsible for impact.
- Gross v. Pall Corporation. Expert Witness for Long Island industrial site. Successfully defended third party against claim that they contributed to offsite contamination of a public supply well. Case settled prior to trail.
- Expert Witness for upstate New York industrial site where residents were claiming indoor air impacts due to migration of chlorinated solvents in groundwater along sewer lines. Used historic release data and GIS interpretation of chemical signatures to demonstrate that additional responsible parties likely contributed to contamination, which were not named in the original complaint.
- Expert Witness for an insurance carriers' defense group. Provided expert report concerning the timing of ground-water contamination. Case settled prior to deposition.
- Major et al. and Green et al. v. AstraZeneca Inc., et al. Expert Witness for upstate New York industrial site. Provided litigation support on case involving a former industrial dump site where wastes were burned and whether migration from the site could have impacted surrounding domestic supply wells. Case settled prior to deposition.
- FMC Corporation v. The Vendo Company and Wier Floway, Inc. Consulting Expert for plaintiff. Reviewed groundwater fate and transport model created by defendants. Model was shown to be flawed, inaccurate and invalid according to generally-accepted modeling practices. Case settled prior to deposition.
- Consulting expert for New Jersey Industrial Site. Provided litigation support concerning the source, timing and extent of pesticides in soil and groundwater. Reviewed and analyzed consultant's reports, exhibits, and technical data. Client settled case prior to trial.
- Consulting expert for Delaware City Site. Provided litigation support concerning the source, timing, and extent of volatile organic compounds in soil and groundwater. Reviewed and analyzed consultant reports, exhibits and technical data. Client settled case prior to trial.

Groundwater Flow and Contaminant Transport Projects

- Principal Modeler, groundwater flow and contaminant transport at a former picture tube manufacturing facility in Taiwan.
- Principal Modeler, groundwater flow and remedial design for a 600-gpm groundwater extraction system to prevent off-site migration of petroleum hydrocarbons from an 850-acre former refinery in Rhode Island.
- Principal Modeler, LNAPL and groundwater flow and transport modeling to support risk assessment and remedial design for an 800,000-gallon LNAPL plume at a former refinery site in Rhode Island.
- Principal Modeler, surface-water flow, solute and sediment transport in a river adjacent to an 850-acre petroleum terminal. Dissolved phase hydrocarbon fluxes into the river were calculated based on a groundwater flow model. The fluxes were used as input into a 2D finite element river model. The river model was used to predict the maximum downstream transport of dissolved phase and sediment borne contaminants.
- Principal Modeler, LNAPL recovery simulations using finite-element modeling. Recovery simulations were performed to evaluate the feasibility of recovery of a benzene plume at an industrial facility in Brazil. The modeling results indicated that LNAPL recovery alone would be inadequate to remediate the plume. Air sparging and soil vapor extraction were proposed as alternatives.
- Principal Modeler, groundwater flow and solute transport at an industrial site on Long Island, New York, where groundwater is impacted by hexavalent chromium that threaten public water-supply wells downgradient of the site.
- Principal Modeler, groundwater and surface-water flow and contaminant transport at a Superfund Site in New Jersey. Groundwater contaminant fluxes based on a 3D groundwater flow model are used to provide input into a 2D finite element surface-water model of a tidally-influenced creek and wetlands system. The combined models are used to study the flux of contaminants through the groundwater/surface-water flow system.
- Principal Modeler, groundwater flow and remedial design at a Superfund site in Delaware impacted by volatile organic compounds. Performed DNAPL investigation. Designed remedial system consisting of 12 interceptor wells.
- Principal Modeler, groundwater flow and remedial design at an ISRA site in New Jersey where groundwater is impacted by pesticides that threaten public water-supply wells downgradient of the site. Prepared work plans and reports for the delineation of on-site and off-site groundwater plumes.
- Principal Modeler, groundwater flow at a Superfund site (No. 5 on NPL) in Massachusetts. This project involved modeling to determine the interaction between groundwater and surface water in a stratified drift aquifer.

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Professional Profile

Thalassa Sodre
Project Engineer

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Technical Specialties:
Environmental engineering services associated with report preparation for submission to regulatory agencies, and maintenance/management of LNAPL remediation systems and groundwater treatment systems.

Experience Summary:
Three years of experience: Staff Assistant, Staff, and Project Engineer with Roux Associates, Inc., Islandia, New York.

Credentials:
E.I.T. (Engineer-in-Training) Certification, 2013
B.S., Earth and Environmental Engineering, Columbia University, 2013
B.S., Physics, Muhlenberg College, 2010
First Aid and CPR Certified
Transportation Worker Identification Credential (TWIC) Certification
OSHA 40-Hour Health and Safety Course
OSHA 10-Hour Construction Course
Loss Prevention System (LPS) Awareness, 8-Hour Certified

Key Projects

- Prepared and developed Surfactant Work Plan for a major petroleum distributor for submission to the NYSDEC. Responsibilities include: research, vendor contact, meeting coordination and support, internal/third party/client comment resolution, additional document preparation (figures, tables, etc.), and final preparation.
- Project management for operation, maintenance, monitoring, design upgrades and reporting activities at three active petroleum and distribution terminals located in New York for a large petroleum company. Associated tasks include: scheduling and management of subcontractors; preparation of NYSDEC quarterly monitoring reports, discharge monitoring reports, and other regulatory deliverables; coordinating facility upgrades and routine equipment maintenance; organizing performance monitoring data to track the efficiency of the treatment systems; and preparing compliance monitoring data.
- Project Engineer and project manager for PCB remediation project, including, bid spec preparation, excavation design, regulatory research, client relations, subcontractor management, project team scheduling, and safety coordinator.
- Preparation of an Alternatives Analysis Report to help address the largest subsurface free-product plume in North America at a former petroleum refinery and terminal. Responsibilities include: preparation and development of a multimillion dollar cost analysis; meeting coordination and support; internal/third party/client comment resolution; additional document preparation (figures, tables, etc.), and final preparation.
- Site Safety Officer for various remedial investigation sites. Responsibilities include preparation of health and safety plans (HASPs), job safety analysis (JSA) documents development and review, on-site safety meeting management, safety document preparation (Lessons Learned, Near Loss, Field Audits, etc.), and planning/execution of corrective actions.
- Various construction oversight / field management activities for environmental subsurface investigations. Responsibilities include completion of soil borings, soil classification, collection of soil samples, managing subcontractors and providing health and safety oversight.
- Field Manager addressing the largest subsurface free-product plume in North America at a former petroleum refinery and terminal. Responsibilities include construction oversight of subcontractors in various tasks (electrical installation, well installation/development, well abandonment, soil trucking, and maintenance activities), soil sampling, groundwater sampling, groundwater gauging, and soil vapor sampling.
- Assisted field management for wetland restoration monitoring at a former telephone recycling facility in Staten Island, New York. Responsibilities include: cap inspection, subcontractor oversight for asphalt and geotextile repairs, and report preparation assistance.