Health Consultation

Groundwater Impacts

NORTHROP GRUMMAN/NAVAL WEAPONS INDUSTRIAL RESERVE PLANT FACILITIES

BETHPAGE, NASSAU COUNTY

AND

CALVERTON, SUFFOLK COUNTY, NEW YORK

EPA Facilities ID: NYD002047967 / NY1570024249

Prepared by the
New York State Department of Health

NOVEMBER 18, 2022

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Office of Capacity Development and Applied Prevention Science
Atlanta, Georgia, 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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The New York State Department of Health (NYSDOH) prepared this Health Consultation for the Northrop Grumman/Naval Weapons Industrial Reserve Plant Facilities, located in the towns of Bethpage, Nassau County and Calverton, Suffolk County, New York. This publication was made possible by a cooperative agreement (program #TS20-2001) with the federal Agency for Toxic Substances and Disease Registry (ATSDR). The NYSDOH evaluated data of known quality using approved methods, policies, and procedures existing at the date of publication. ATSDR reviewed this document and concurs with its findings based on the information presented by the NYSDOH. For copies of this document, or with other questions, you may contact the

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SUMMARY

INTRODUCTION

This health consultation was prepared in response to a June 30, 2012, petition letter sent to the Agency for Toxic Substances and Disease Registry (ATSDR) by a Patchogue, Long Island resident. The petitioner expressed concerns that local residents could be exposed to contaminants (primarily volatile organic compounds [VOCs]) in groundwater originating from Northrop Grumman/Naval Weapons Industrial Reserve Plant (NWIRP) facilities located in Bethpage, Great River, and Calverton, Long Island, New York. The top priority of this health consultation is to ensure that the community has the best information possible about how contaminants in groundwater from the facilities might affect their health.

Findings from environmental investigations that began in the 1980's led the New York State Department of Environmental Conservation (NYSDEC), in consultation with the New York State Department of Health (NYSDOH), to list the Northrop Grumman/NWIRP facilities in Bethpage and Calverton on the New York State Registry of Inactive Hazardous Waste Disposal Sites (also known as State Superfund list). Sites on the State Superfund list require further environmental investigation to confirm the presence of hazardous waste and evaluate the degree of risk posed by the site to public health or the environment. See Appendix B of this document for additional site history and investigation details of the Northrop Grumman/NWIRP facilities in Bethpage and Calverton.

The Northrop Grumman facility located in the hamlet of Great River, in the Town of Islip, Suffolk County was wholly owned by Northrop Grumman and never included on the New York State Superfund list or the United States Environmental Protection Agency's (EPA) National Priorities List (federal Superfund list). When in operation, the Northrop Grumman Great River facility was regulated by the EPA's Resource Conservation and Recovery Act. EPA's Detailed Facility Report indicates the Great River facility had no violations [EPA 2013]. The available data for the Great River facility provides no indication that groundwater has been impacted by contamination originating from the Northrop Grumman's former Great River facility, and therefore, this facility is not discussed further in this health consultation.

This health consultation provides information about historic and recent analytical data on public water supply wells, area monitoring, and irrigation wells. It describes how this information was evaluated to determine if ingestion (drinking), inhalation (breathing), or dermal (skin) contact exposures to contaminants in groundwater could have occurred in the past or could currently be occurring. An in-depth review of available information about potential exposures forms the basis for drawing conclusions about the public health implications. The evaluation of data for the Bethpage and Calverton facilities is the basis for the conclusions and recommendations presented in this health consultation.

The public was invited to review the health consultation during the public comment period, which ran from May 23, 2019, to July 22, 2019. The NYSDOH participated in a NYSDEC-sponsored public meeting in Bethpage, New York, on June 10, 2019, to discuss and receive comments on the draft health consultation. Comments received and the NYSDOH's responses to these comments can be found in Appendix H of this document.

CONCLUSION 1

The evaluation of VOCs included in this health consultation indicates that currently, drinking or other uses of water from public water supplies affected by the Northrop Grumman/NWIRP facility in Bethpage, Nassau County are unlikely to harm people's health.

BASIS FOR CONCLUSION

The public water supplies are monitored for chemical contaminants on a regular basis. Based on current drinking water standards, treatment to remove VOC contaminants from the public water supplies is being implemented, when necessary, prior to distribution to consumers.

CONCLUSION 2

Past use of drinking water contaminated with trichloroethene (TCE; also known as trichloroethylene) from Bethpage Water District Well 6-1 (prior to early December 1976) could have increased the risk for noncancer adverse health effects. Past use of drinking water contaminated with tetrachloroethene (PCE) and 1,1,1-trichloroethane (1,1,1-TCA) in Bethpage Well 6-1 is unlikely to have harmed people's health.

BASIS FOR CONCLUSION

The estimated ingestion and inhalation exposures to TCE (the primary contaminant in the water) in Well 6-1, occurring before early December 1976, approached exposures levels that could have resulted in immune or developmental toxicity. Regardless of the potential effects of previous exposures that could have increased the risks for health effects, preventive health recommendations for people who had drinking water and/or inhalation exposures to TCE from Well 6-1 prior to early December 1976 are similar to general recommendations for others: maintain a healthy lifestyle, have regular medical checkups, and discuss specific concerns with healthcare providers.

PCE was found in Well 6-1 at levels estimated to pose a very low[1] increased risk for cancer, and 1,1,1-TCA and PCE were at levels that posed a minimal[2] risk for noncancer health effects.

CONCLUSION 3

Past use of drinking water contaminated with TCE in the other public water supplies (i.e., other than Bethpage Water District Well 6-1) affected by Northrop Grumman/NWIRP facility in Bethpage is unlikely to harm people's health.

[1]The estimated exposure poses a cancer risk of less than one in one million.

[2]The estimated exposures are less than the contaminant's reference dose. The reference dose is defined by the EPA as an estimate (with uncertainty spanning perhaps an order of magnitude) of a chronic (up to a lifetime) contaminant exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

BASIS FOR CONCLUSION

TCE was found at levels in drinking water estimated to pose a very low[1] to low[3] increased risk for cancer and a minimal[2] risk for noncancer health effects. In Bethpage Water District Well 6-2 (taken out of service in 1988), the estimated past exposure to infants is slightly higher than the TCE reference dose but is still well below EPA's estimate of the human exposure that corresponds to a dose that causes immune toxicity in mice. This difference, or margin of exposure, is sufficient to conclude that the risk for immune toxicity from past exposure to TCE in Bethpage Water District Well 6-2 is low. Since then, water from both wells has been treated and routine monitoring is conducted to verify that the water meets New York State drinking water standards prior to distribution.

CONCLUSION 4

While exposures to facility-related contaminants through the use of unpermitted private wells were possible, such exposures are unlikely.

BASIS FOR CONCLUSION

Nassau County has not permitted the installation of private wells for drinking purposes in areas where public water is available since 1987. Since there are very limited historical and/or current data for private wells in the area of the Northrop Grumman/NWIRP facility in Bethpage, we do not know if or for how long people may have been exposed to contaminated water. Any private wells that might exist are unlikely to have been installed at depths that would intersect contaminated groundwater associated with the Northrop Grumman/NWIRP facility. Since the area is serviced by public water, any private wells that may exist in the area would likely only be used for irrigation purposes. Exposure to VOCs in irrigation wells does not constitute an exposure concern. Any VOCs in groundwater would volatilize into the air when the water was released during irrigation.

CONCLUSION 5

Currently, drinking or other uses of water from public water supplies in Calverton, Suffolk County, are unlikely to harm people's health.

BASIS FOR CONCLUSION

No public water supplies have been impacted by the Northrop Grumman/NWIRP facility in Calverton, Suffolk County.

CONCLUSION 6

Past use of drinking water from the Peconic River Sportsman Club private well (Suffolk County) is unlikely to harm people's health.

BASIS FOR CONCLUSION

The levels of VOCs detected in one Peconic River Sportsman's Club well did not exceed standards or available comparison values. The Club is currently connected to the Riverhead

[3]The estimated exposures pose a cancer risk between one in one million and one in ten thousand.

Water District public water supply and wells on the property were abandoned, grouted, cut, and capped and are no longer available for use.

NEXT STEPS

Recent data for one compound, the emerging contaminant identified as 1,4-dioxane, indicate it is present in public drinking water supplies, including those within the Northrop Grumman/NWIRP facility plume, and community concern has been voiced regarding this compound (see page 7 for additional information). The public health implications of the 1,4-dioxane data are not evaluated in this health consultation. NYSDOH and NYSDEC are committed to the evaluation and regulation of this compound in drinking water. A recently enacted statute requires public water systems in New York to test for 1,4-dioxane and other emerging contaminants in the future (Chapter 57 of the Laws of 2017). In December 2018, the New York State Drinking Water Quality Council recommended that the NYSDOH adopt a maximum contaminant level of 1 microgram per liter (mcg/L; equivalent to a part per billion) for 1,4-dioxane in public water systems. The NYSDOH accepted this recommendation, and in July 2019 began the formal rulemaking process to establish the recommended MCL as a standard for public water systems in New York State [DOH 2019, 2020a]. The NYSDOH responded to numerous public comments on the proposed MCL and published the Notice of Adoption for the 1,4-dioxane standard in the New York State Register on August 26, 2020 [DOH 2020b]. The NYSDOH will continue to work with the NYSDEC to identify and evaluate sources of 1,4-dioxane contamination, and to ensure that exposure to the chemical is mitigated when it is detected in public water systems in violation of the current MCL.

The requirements of Operable Units 2 and 3 (OU2 and OU3) Records of Decision (ROD) for the Northrop Grumman/NWIRP facility in Bethpage will continue to be enforced. Both RODs include a *Public Water Supply Protection* component that is designed to ensure that public water supply wells impacted or threatened by the Northrop Grumman/NWIRP facility groundwater contamination are able to deliver water to their customers that meet state and federal drinking water requirements [DEC 2001 and DEC 2013]. The NYSDOH will work with the NYSDEC and with the Nassau County Department of Health (NCDOH) to ensure that the stipulations set forth in the OU2 and OU3 RODs are met and that all impacted and threatened public water supply systems continue to comply with the New York State Part 5 Drinking Water Regulations (Part 5) and federal public drinking water standards.

In addition, the NYSDEC has completed a study on the feasibility of implementing remedial actions to fully contain the groundwater contamination originating at the Northrop Grumman/NWIRP facility. The findings of this feasibility study, and the specific remedial actions that have been identified as being capable of achieving full plume containment, were incorporated by the NYSDEC into a distinct Proposed Remedial Action Plan for containment and expedited cleanup of the Navy Grumman groundwater plume. The proposed Remedial Action Plan was presented at a NYSDEC sponsored public meeting in Bethpage on June 10, 2019. The Amended Record of Decision was issued in December 2019.

The NYSDOH will continue to work with the NYSDEC, County Health agencies, the EPA, and ATSDR to review information as it becomes available, evaluate the public health implications of any sampling results, and recommend public health actions as needed.

FOR MORE INFORMATION

If you have questions about the environmental investigation of the Northrop Grumman/NWIRP facilities on Long Island, please contact Jason Pelton of the NYSDEC at 518-402-9676. If you

have questions about this public health consultation or other health concerns related to the facilities, please contact Jim Sullivan of the NYSDOH at 518-402-7860.

BACKGROUND AND STATEMENT OF ISSUES

A health consultation is a verbal or written document response to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. This health consultation was prepared in response to a June 30, 2012 petition by a resident of Patchogue, Long Island, New York to the Agency for Toxic Substances and Disease Registry (ATSDR). The petition described concerns about contaminated groundwater originating from Northrop Grumman/Naval Weapons Industrial Reserve Plant (NWIRP) facilities in Bethpage and Calverton, and the Northrop Grumman facility in Great River, Long Island, New York. The petitioner expressed concern that local residents could be exposed to facility-related contaminants (primarily volatile organic compounds [VOCs]) if they relied on groundwater for household use or for irrigation. Evaluation of other potential pathways and/or contaminated media are not included in the petitioner's request and therefore outside of the scope of this health consultation.

This health consultation describes the evaluation of relevant information to find out whether the public is currently being exposed to groundwater impacted by contaminants originating from the Northrop Grumman/NWIRP facilities that exceed maximum contaminant levels established by the United States Environmental Protection Agency (EPA) and by New York State as well as to find out whether the public could have been exposed to these contaminants in the past. The nature of this evaluation, however, is broader than just comparisons to federal and state maximum contaminant levels (MCLs) and includes an assessment of health risks from exposure to contaminants in groundwater.

This evaluation includes:

- Review of results of raw, untreated water samples from public water supply wells and monitoring wells in areas that were impacted by facility-related groundwater contamination,
- Assessment of whether private and/or non-community water supply wells were, or are currently, in use in areas where facility-related groundwater contamination exists,
- Evaluation of whether there could have been past exposures to contaminants in drinking water; and
- Characterizing the risk for adverse health effects associated with past or current exposures to contaminated groundwater.

BACKGROUND

The New York State Department of Environmental Conservation (NYSDEC), New York State Department of Health (NYSDOH), United States Environmental Protection Agency (EPA), Nassau County Department of Health (NCDOH), and Suffolk County Department of Health Services (SCDHS) have been involved in the evaluation of environmental contamination associated with the Northrop Grumman/NWIRP Bethpage facility and the NWIRP Calverton facility since the 1980s. The Northrop Grumman/NWIRP Bethpage facility is located in the hamlet of Bethpage, in the Town of Oyster Bay, Nassau County, and the NWIRP Calverton facility is located in the hamlet of Calverton in the Town of Riverhead, Suffolk County (Appendix A, Figure A-1). Part of the Northrop Grumman/NWIRP facility, and all of the NWIRP Calverton facility were Naval Weapons Industrial Reserve Plants that were owned by the Navy and operated by Northrop Grumman (see Appendix B for more details on these sites). The NYSDEC and NYSDOH have no information indicating that groundwater has been impacted by

contamination originating from the Northrop Grumman's former Great River facility, and therefore, this facility is not discussed further in this health consultation.
The three principal groundwater aquifers on Long Island are the Upper Glacial Aquifer, the Magothy Aquifer, and the Lloyd Aquifer (see Appendix A, Figure A-2). The Upper Glacial Aquifer is an unconfined aquifer generally found around 30 to 50 feet below ground surface in the Bethpage area. The Magothy Aquifer attains a maximum thickness of approximately 1,100 feet and is the source of water for most of Nassau County and about half of Suffolk County. The Raritan Formation underlies the Magothy and consists of an upper clay member and a lower sand member (Lloyd Sand). The Lloyd Aquifer is the deepest and oldest of Long Island's aquifers. It is a sand and gravel formation ranging in thickness from zero to five hundred feet. [DEC 2014]. Long Island obtains its drinking water supply primarily from the Magothy and Lloyd Aquifers. EPA has designated the Long Island aquifer system as a sole source aquifer, which means that the aquifer is the sole or principal drinking water source for an area and, if contaminated, would create a significant hazard to public health [EPA 2014].

In the early 1970s, standard waste handling practices used by industry, including Northrop Grumman, were found to be contaminating groundwater throughout the United States. These practices included disposal of wastes directly to on-site surface impoundments or to sub-surface liquid waste handling systems, such as cesspools and septic tanks. These practices were common on Long Island and have resulted in extensive groundwater contamination in both Nassau and Suffolk Counties.

Due to an expanding understanding and concern about groundwater contamination and its impact on drinking water supplies, particularly on Long Island, the NYSDOH established interim drinking water guidelines in 1977. These interim guidelines required drinking water suppliers to sample their public water supply wells and restricted the concentration of any one organic chemical allowed in drinking water to no more than 50 micrograms per liter (mcg/L). The interim guidelines were in place until 1989, when New York State established regulations and allowable MCLs for public drinking water systems under 10 NYCRR Part 5, Subpart 5-1 (also known as Part 5) [DOH 2013]. The 1989 regulations lowered the MCLs for many VOCs, including Northrop Grumman facility-related contaminants, to 5 mcg/L. The Part 5 regulations require public water suppliers in New York State to conduct scheduled sampling of the untreated water supply (i.e., raw water) and the water that is distributed to customers. If a water supplier discovers that an MCL is being exceeded, or that one is about to be exceeded, subsection 1.12 of Part 5 requires that the supplier notify the State and take specific actions which include identifying the cause of the MCL exceedance, making modifications to or installation of treatment to meet Part 5 requirements, and submitting a written report to the State within 30 days documenting these actions. Since the implementation of Part 5 regulations, there have been no documented violations of MCLs of the volatile organic compounds of concern at the public water supplies discussed in this health consultation.

Northrop Grumman/NWIRP Bethpage Facility

Northrop Grumman has occupied the facility in Bethpage since the early 1930s, and the Naval Weapons Industrial Reserve Plant (NWIRP) in Bethpage since 1942. Activities conducted at these facilities included research, prototyping, testing, design engineering, fabrication, and primary assembly of military aircraft and spacecraft. Northrop Grumman/NWIRP ceased most manufacturing-related operations at the Bethpage facility in 1996.

The NYSDEC, in consultation with the NYSDOH, listed the Northrop Grumman Bethpage facility on the New York State Registry of Inactive Hazardous Waste Disposal Sites (also known as State Superfund) in 1983 and has segregated remedial activities into three distinct operable units. An operable unit (OU) is a portion of a remedial site that for technical or administrative

reasons can be more effectively addressed separately. OU1 addresses on-site soil contamination, OU2 includes off-site groundwater contamination, and OU3 includes disposal areas referred to as the former Grumman settling ponds that are now occupied by the Town of Oyster Bay Community Park. OU3 also includes off-site groundwater contamination that originated from the former Grumman settling ponds. The NWIRP was listed by the NYSDEC and NYSDOH in 1993. See Appendix B for more information about the history of the Bethpage facility and enforcement actions undertaken by the NYSDEC.

The primary groundwater contaminants of concern for the Northrop Grumman/NWIRP facility are the chlorinated volatile organic compounds (VOCs) tetrachloroethene (PCE), trichloroethene (TCE; also known as trichloroethylene), 1,1,1-trichloroethane (1,1,1-TCA), and associated degradation products. Vinyl chloride is also present in the groundwater but originates from an upgradient property (RUCO Polymer Corp. (Hooker Chem)) not related to the Northrop Grumman/NWIRP facility. These contaminants have been found at concentrations greater than Part 5 MCLs in public water supply wells. This health consultation evaluates the public health implications of exposures to Northrop Grumman/NWIRP facility contaminants detected in public water supply wells at concentrations exceeding New York State Part 5 and federal drinking water standards.

Public water systems serving more than 10,000 people are required by the Safe Drinking Water Act to also monitor their water supply for select unregulated contaminants. Once every five years, EPA is required to issue a list of unregulated contaminants to be monitored by public water systems. The third Unregulated Contaminant Monitoring Rule (UCMR 3) was published on May 2, 2012. UCMR 3 required monitoring for 30 contaminants (28 chemicals and two viruses) between 2013 and 2015. The UCMR provides a basis for possible future regulatory actions to protect public health. While not specifically indicated in the petitioner's request for evaluation, one chemical, 1,4-dioxane, is included in the UCMR 3 list and data indicate it is present in public drinking water supplies, including those within the Northrop Grumman/NWIRP facility plume. Community concern has been voiced regarding 1,4-dioxane. Summary information about 1,4-dioxane levels in public water supply wells within the Northrop Grumman/NWIRP facility plume is provided in Appendix C. This summary information indicates some Bethpage Water District supply wells are showing increasing levels of 1,4-dioxane over time. In response, the Bethpage Water District began installation of an advanced oxidation process (AOP) treatment system in 2017.

The public health implications of the 1,4-dioxane data are not evaluated in this health consultation. However, the NYSDOH and NYSDEC have committed to the evaluation and regulation of this compound in drinking water. A recently enacted statute requires public water systems in New York to test for 1,4-dioxane and other emerging contaminants in the future (Chapter 57 of the Laws of 2017). In December 2018, the New York State Drinking Water Quality Council recommended that the NYSDOH adopt a maximum contaminant level of 1 mcg/L for 1,4-dioxane. The NYSDOH accepted this recommendation, and in July 2019 began the formal rulemaking process to establish the recommended MCL as a standard for public water systems in New York State [DOH 2019, 2020a]. The NYSDOH responded to numerous public comments on the proposed MCL and published the Notice of Adoption for the 1,4-dioxane standard in the New York State Register on August 26, 2020 [DOH 2020b].

VOC contaminated groundwater originating at the Northrop Grumman/NWIRP facility moves rapidly down through the Upper Glacial Aquifer before coming in contact with the Magothy Aquifer. Impacted groundwater flows to the south, away from the Northrop Grumman/NWIRP facility, as three distinct plumes: a shallow plume, a deep western plume, and a deep eastern plume. The shallow plume is approximately 9,700 feet wide and at least 17,000 feet long (covering approximately 3,800 acres of area). The eastern and western deep plumes appear to

be relatively narrow (2,000 feet or less in width) and relatively continuous. The shallow plume generally occurs at depths between 100 and 300 feet below ground surface, and contains TCE, PCE, 1,1,1-TCA, and associated degradation products at concentrations typically less than 50 mcg/L. The deep western plume generally occurs between 300 and 750 feet below ground surface, and contains primarily TCE at concentrations typically greater than 50 mcg/L. The downgradient extent of this plume is approximately 12,000 feet south of what has been identified as the OU2 source areas (see Appendix B for additional information on OUs). The deep eastern plume originated from the former Grumman settling ponds area (present day Bethpage Community Park) which is being administered as OU3. This plume is understood to be 300 to 650 feet below ground surface, and contains TCE, PCE, 1,1,1-TCA, and degradation products at concentrations typically greater than 50 mcg/L [NFEC 2012]. At least eight public water supply well fields are located within the path of the contaminated groundwater plumes and are either impacted or threatened (likely to become impacted) by the Northrop Grumman/NWIRP facility-related contamination. (See the following section for information on specific well fields). In addition to three existing groundwater extraction and treatment systems, both the Navy and Grumman are currently designing and constructing groundwater extraction and treatment systems to address groundwater contamination hot spots in both the western and eastern plumes. Grumman and the Navy are also conducting additional OU2 and OU3 investigations to continue to refine the nature and extent of the off-site groundwater contamination.

The March 2001 and March 2013 NYSDEC Records of Decision (RODs) for OU2 and OU3 respectively address the bulk of off-site groundwater contamination associated with the Northrop Grumman/NWIRP facility. A ROD presents the remedial action plan for an inactive hazardous waste disposal site and documents the information and rationale used to arrive at the decision. Both RODs call for the implementation of a Public Water Supply Protection Program. This program includes procedures to ensure that appropriate wellhead treatment is put in place that will enable the public water suppliers to deliver water to customers that meet drinking water standards in accordance with New York State Part 5 Drinking Water Regulations and federal drinking water standards [DEC 2001]. Both RODs require Northrop Grumman and/or the Navy to fund the installation of appropriate wellhead treatment systems at impacted public water supply wells. The Public Water Supply Protection Program also includes long-term monitoring of the groundwater upgradient of public water supply well fields to ensure that wellhead treatment facilities can be constructed and be made operational prior to wells being impacted.

In 2017, the NYSDEC began a comprehensive reassessment of the remedies set forth in the OU2 and OU3 RODs and completed a study on the feasibility of implementing remedial actions to fully contain and expedite the groundwater contamination originating at the Northrop Grumman/NWIRP facility. The findings of this feasibility study, and the specific remedial actions that have been identified as being capable of achieving full plume containment, were incorporated by the NYSDEC into a Proposed Remedial Action Plan (PRAP). A PRAP is a document that the NYSDEC uses to present alternatives to the public and interested parties on how inactive hazardous waste sites can be remediated. The public and interested parties then have an opportunity to comment on the proposed remedial actions presented in the PRAP. Once comments are considered, the final remedy is documented by the NYSDEC in a Record of Decision (ROD). For the Navy and Northrop Grumman sites, an Amended ROD was issued in 2019 to supplement the existing remedies and to comprehensively address the Navy Grumman groundwater plume. Immediately following issuance of the Amended ROD, the NYSDEC began negotiations with both the Navy and Northrop Grumman to begin implementing elements of the selected remedy. With remedy implementation, full containment would ensure that additional public supply wells south of the identified groundwater contamination area can avoid the need for treatment for facility-related contaminants. Full containment would not only provide significant future protections for public health, it also would avoid long term-costs

associated with treatment of additional public supply wells. As stated above, no matter which remedies are ultimately implemented, the appropriate wellhead treatment systems will be installed at any impacted public water supply wells. The Proposed Remedial Action Plan was presented at a NYSDEC sponsored public meeting in Bethpage on June 10, 2019. The Amended Record of Decision was issued in December 2019.

Public Water Supplies Impacted or Threatened by the Northrop Grumman/NWIRP Bethpage Facility

Data from sampling conducted by public water suppliers (as required by Part 5 regulations) and groundwater monitoring data collected (as required by the OU2 and OU3 RODs) show that six public water supply well fields are impacted by the Northrop Grumman/NWIRP facility groundwater contamination (Appendix A, Figure A-3). One purpose of the OU2 and OU3 RODs groundwater monitoring requirements is to ensure that appropriate treatment systems are installed at currently contaminated public water supply wells, and at those that might become impacted in the future. The OU2 and OU3 RODs also stipulate that Northrop Grumman and the Navy will fund construction and operating costs associated with the treatment systems. A description of the impacted or threatened public water supplies follows.

1) South Farmingdale Water District

South Farmingdale Water District wells at the Langdon Road and Hicksville-Massapequa Road well fields contain Northrop Grumman/NWIRP facility-related VOCs but at levels below the New York State drinking water standards. Prior to the detection of VOCs, treatment systems were installed at the Langdon Road well field in 2011 and at the Hicksville-Massapequa Road well field in August of 2013 [Dennis Kelleher, H2M Architects and Engineers, personal communication, June 25, 2013], as precautionary measures. The treatment systems were approved by the NCDOH and have operated since 2011 and 2013, respectively. A condition of that approval is that both systems must treat the raw water for both wells even if contamination is not detected in the water. No other South Farmingdale Water District public water supply wells are threatened or impacted by contamination from the Bethpage Facility.

2) New York American Water Company – Merrick Operations

Two New York American Water Company - Merrick Operations supply wells (Well Number 3 and Well Number 4) at the Seaman's Neck Road well field have been contaminated by Northrop Grumman/NWIRP facility-related VOCs, but measured concentrations in raw, untreated water are all below Part 5 MCLs. The Part 5 MCL for TCE is 5 mcg/L. In 2006, TCE was detected at a concentration of 0.6 mcg/L in Well Number 3 (Appendix D, Table D-1). Subsequently, TCE concentrations slowly increased to a maximum of 3.3 mcg/L on October 18, 2011. TCE was detected at low levels (0.5 mcg/L) in the New York American Water Company's Well Number 4 in early 2008. The highest TCE level of 0.9 mcg/L was detected in Well Number 4 in February of 2011 (Appendix D, Table D-1).

In response to the contamination, the Navy installed an interim (i.e., temporary) VOC treatment system at the Seaman's Neck Road Water Plant in July 2012. A permanent, full scale VOC wellhead treatment system for the Seaman's Neck Road wells went on-line in February of 2015. No other New York American Water Company public water supply wells have been threatened or impacted by contamination from the Bethpage facility.

3) Bethpage Water District

Three Bethpage Water District well fields are located within the boundary of the plumes of contaminated groundwater that originate at the Bethpage facility. The Bethpage Water District provides treatment at all of its wells prior to distribution of water to customers.

Bethpage Water District Plant 6

The wells at Bethpage Water District Plant 6 were sampled three times between November and December of 1976 by the NCDOH. TCE was detected in the raw, untreated water samples collected from Well 6-1 at concentrations of 28, 26 and 60 mcg/L during these three sampling events. In December 1976, PCE and 1,1,1-TCA were detected at concentrations of 17 mcg/L and 15 mcg/L, respectively (Appendix D, Table D-2). These detections predated the establishment of the NYSDOH interim drinking water guideline for individual VOCs of 50 mcg/L and the current drinking water standards. The District took Well 6-1 out of service in December 1976 when 60 mcg/L of TCE was detected in the well water.

In February 1985, sampling first detected TCE in raw, untreated water from Well Number 6-2 at a concentration of 1 mcg/L. In February 1987, the TCE concentration reached as high as 5 mcg/L in the raw, untreated water (Appendix D, Table D-3). Well 6-2 was taken out of service in November 1988.

A VOC treatment system was installed at the Bethpage Water District Plant 6 in 1990. The District returned Well 6-1 into service in June of 1990 and returned Well 6-2 into service in December 1990. Since then, water from both wells has been treated and routine monitoring is conducted to verify that the water meets New York State drinking water standards prior to distribution.

Bethpage Water District Plant 4

TCE was detected in raw, untreated water from Bethpage Water District Plant 4 Well 4-1 between September 7, 1988 and July 30, 1990 (range 0.5 to 2.6 mcg/L). Contamination from the Northrop Grumman/NWIRP facility was not detected in routine monitoring samples again until October of 1992 (1.2 mcg/L) (Appendix D, Table D-4). After October 1992, TCE was detected in Well 4-1 at or above the reporting limit during four sampling events between 1993 and 1995.TCE was detected occasionally at low levels in Well 4-2 between January 7, 1993 and October 3, 1994 (Appendix D, Table D-5). VOC treatment equipment (air stripper) was installed on wells at the Bethpage Water District Plant 4 (Wells 4-1 and 4-2) in 1995 to treat the raw water prior to its distribution to customers. Routine monitoring is conducted to verify that the water meets New York State drinking water standards prior to distribution. Bethpage Water District removed Well 4-1 from service in February 2013.

Bethpage Water District Plant 5

A VOC treatment system was installed at the Bethpage Water District Plant 5 (Well 5-1) in October of 1995. The first VOC detection in the raw, untreated water at this well did not occur until 2007, when TCE was detected at 0.6 mcg/L. This water was never distributed to customers.

No other Bethpage Water District public water supply wells have been affected by contamination from the Northrop Grumman/NWIRP facility. Blending of raw water within the Bethpage Water District occurs depending on seasonal need, however, all District plant sites treat raw water prior to distribution to customers. The Bethpage Water District routinely monitors

the drinking water in accordance with Part 5 regulations to assess if the water quality meets state and federal drinking water standards.

Private Wells in the Bethpage Area

The NYSDOH reviewed NYSDEC Region 1 well completion reports[4] for permitted private irrigation and cooling wells in the area downgradient of the Northrop Grumman/NWIRP facility dating back to the 1940s to evaluate whether wells other than those associated with public water suppliers could have been impacted by groundwater contamination from the Northrop Grumman/NWIRP facility. Overall, a limited number of well completion reports indicated that past or current exposure to Northrop Grumman/NWIRP facility site contaminants through the use of permitted non-public water supply wells is unlikely.

The available well completion reports show that an irrigation well was located at a farm near the Northrop Grumman/NWIRP facility. However, current satellite imagery for the address on the well completion report shows that the area is heavily developed, and that there is no farm currently at this location. The NYSDOH has no documentation showing that the well was abandoned. However, due to the availability of public water in the area, continued use of a farm well is unlikely.

The well completion reports also show two irrigation wells installed at the Island Trees public school campus on Owl Place in Levittown, a location that is downgradient (in terms of groundwater flow direction) of the Northrop Grumman/NWIRP facility. The reports indicate that the wells were installed to depths of 61 feet and 108 feet. One irrigation well has been decommissioned. A groundwater sample collected in 2007 from the remaining irrigation well (as part of an environmental investigation of a nearby drycleaner) did not detect contaminants. Data from vertical profile boring sampling conducted in this general area show that facility-related groundwater contamination is greater than 140 feet below ground surface, and therefore these wells will not likely be impacted [NFEC 2012].

Two additional wells were identified near the Northrop Grumman/NWIRP facility. Well completion reports indicate that the wells were installed to the same depth as contaminated groundwater associated with the Northrop Grumman/NWIRP facility. The NYSDEC reports that one of these wells, installed at 100 Lauman Lane (immediately west of the Northrop Grumman/NWIRP facility across Hicksville Road) for the Lauman Company in 1967 has been abandoned [Bill Spitz, NYSDEC Region 1, personal communication, July 3, 2012], although the date of abandonment is unknown. The well completion report only noted that this well was a replacement for a previously installed well. The report did not specify the use of this well. There are no known exposures resulting from the use of this well. The second nearby well was installed in 1953. The completion report for this well noted that it was used to cool a restaurant located near the Northrop Grumman/NWIRP facility. The type of cooling system used in conjunction with this well is not known. However, cooling systems in this part of Long Island are typically closed (i.e., the water is circulated through the system and not exposed to the air). The well is no longer in use, but the date of abandonment is unknown. If the water from this well was used in a closed system for cooling, it is unlikely that past exposures occurred.

Nassau County has not permitted the installation of private wells for potable purposes in areas that are served by public water supplies since 1987. However, there are no prohibitions on the

[4] The New York State Environmental Conservation Law requires that a well completion report be completed by the well driller and filed with the NYSDEC for each well drilled within the State of New York that has the ability to pump greater than 45 gallons per minute.

installation of irrigation wells having a pumping capacity no greater than 45 gallons per minute. Any new well installed with a pumping capacity greater than 45 gallons per minute requires permitting by the NYSDEC. There is no program in place to identify whether private wells are in use in Nassau County [John Lovejoy, NCDOH, personal communication, March 11, 2014]. Consequently, the NYSDOH cannot determine whether anyone is being exposed to site-related contaminants through the use of private wells. However, data from vertical profile borings and monitoring well sampling show that groundwater contamination associated with the Northrop Grumman/NWIRP facility is generally located at depths greater than 140 feet below ground [NFEC 2012]. Any private wells are unlikely to have been installed at depths that would intersect contaminated groundwater associated with the Northrop Grumman/NWIRP facility. Since the area is served by public water, these wells are probably used only for irrigation and are unlikely to be used for drinking purposes. VOCs in irrigation wells does not constitute an exposure concern. Any VOCs in groundwater would volatilize into the air when the water was released during irrigation.

NWIRP Calverton Facility

The Naval Weapons Industrial Reserve Plant in Calverton (Appendix A, Figure A-4) was operated by Northrop Grumman from the early 1950s until 1996. More detailed information about the Northrop Grumman facility in Calverton can be found in Appendix B.

The NWIRP facility is a New York State Superfund site. Contaminants of concern in groundwater include the chlorinated solvent 1,1,1-TCA and its associated breakdown products 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE), and chloroethane. Contaminated groundwater has migrated off-site in a southerly direction and has impacted an area of approximately 93 acres [NWIRP 2012a].

Drinking water needs of the area are met by three municipal water supply systems (Riverhead Water District, Shorewood Water Company, and Suffolk Water Company), private wells, and wells on two government-owned facilities (Town of Riverhead and Brookhaven National Laboratory). These wells are located far outside the area of groundwater contamination associated with the NWIRP Calverton site and are not impacted [NFEC 2006].

Two former Northrop Grumman production wells are located on the NWIRP site. These wells are located on land that is now owned by the Town of Riverhead and are controlled by the Riverhead Water District. These wells are not currently permitted by the NYSDEC and cannot be used by the Riverhead Water District as part of its public water supply system or for any other purpose without the approval of the Office of Water Resources in the Suffolk County Department of Health Services.

Water Supplies Impacted or Threatened by the NWIRP Calverton Facility

The only wells impacted by contamination originating at the NWIRP Calverton site that were used for drinking water are on the privately owned Peconic River Sportsman's Club property (Appendix A, Figure A-4).

1) Peconic River Sportsman's Club

The Peconic River Sportsman's Club (Club) is situated on 400 acres south of the NWIRP site (see Appendix A, Figure A-4). The Main Lodge, an activity center, a private residence, and a shooting range on the Club's property were supplied drinking water from on-site wells until 2012, prior to the property being connected to a public water supply.

Beginning in 1983, the SCDHS regulated the well at the Main Lodge (Well Number 1) as a non-community public water supply. A non-community water system is a public water system, such as a private well serving a restaurant, that serves the public, but does not generally serve the same people year-round [DOH 2007]. Routine sampling of Well Number 1 by the SCDHS between 1988 and 2007 detected the site-related volatile organic compounds 1,1-DCA at 0.7 mcg/L and in 1996 detected 1,1-DCE at 0.5 mcg/L [SCDHS 2007]. Both detections were below the New York State drinking water standard of 5 mcg/L.

Wells installed at the activity center (Well Number 2) in 2001 and at the shooting range (Well Number 3) in 2007 were also considered non-community public water supply wells. A water sample from the activity center well (Well Number 2) on October 24, 2001 (collected immediately after the well was installed) showed 1,1-DCA at a concentration of 11 mcg/L. Since this level exceeded the New York State MCL of 5 mcg/L for 1,1-DCA, the SCDHS advised the Club that the water supplied by this well should not be used for drinking or cooking until a permanent solution to the contamination could be found [SCDHS 2002]. The Club did not use the activity center well for potable purposes until 2007, when a point-of-entry granular activated carbon treatment system was installed.

In January of 2008, the Navy began quarterly sampling of all four wells on the Club property (lodge, activity center, private residence and shooting range), including pre- and post-treatment samples of the activity center well. During this time, the lodge well was not used for drinking purposes due to VOC detections, and the well supplying the activity center was treated with a liquid-phase granular activated carbon system prior to use. Data do not indicate that the supply well at the shooting range (Well Number 3) and the private well at the residence on the property have ever been impacted by site-related contamination. Analysis of the post-treatment samples for the activity center system did not detect site-related contaminants [NWIRP 2012b].

In June of 2012, the Navy completed installation of a water line that connected the Club to the Riverhead Water District public water supply. All Club wells were then abandoned, grouted, cut and capped [NWIRP 2012c], and quarterly sampling of the wells ended.

DISCUSSION

Exposure Pathways

An exposure pathway is the process by which a person can come into contact with a hazardous substance. People were exposed in the past to Northrop Grumman/NWIRP Bethpage facility groundwater contamination in public drinking water supplies. Homeowners with contaminated water were exposed in several ways to the chemicals in their water. These include:

- ingestion - consuming the water by drinking it and cooking with it,
- inhalation - chemicals evaporating into the air may be breathed in during bathing, showering, or using water in household chores; and,
- direct contact with the skin.

Because historical sampling data for the public supply wells are limited, we do not know for exactly how long consumers of the public water supply had been using contaminated drinking water. The duration of contaminant exposure was generally assumed to be the length of time between when the contaminant was first detected in a given well to the time of the last detection and people were known to still be drinking water from that well. The exception to this was the assumed exposure duration in Bethpage Water District Well 6-1. This well was shown to be

contaminated at the first sampling event in 1976, and was assumed to be contaminated for 24 years, from the time the well was put into service in 1952. No other well showed contamination at the first sampling event. This indicates the contamination in the other wells began at later dates.

Nassau County has not permitted the installation of private wells for drinking purposes in areas where public water is available since 1987. Since no historical or current data for private wells in the area of the Northrop Grumman/NWIRP Bethpage facility are available, we do not know if and for how long people may have been exposed to contaminated water. Data from vertical profile borings and monitoring well sampling show that groundwater contamination associated with the Northrop Grumman/NWIRP facility is generally located at depths greater than 140 feet below ground [NFEC 2012]. Any private wells are unlikely to have been installed at depths that would intersect contaminated groundwater associated with the Northrop Grumman/NWIRP facility. As mentioned previously, due to data limitations, this pathway was not evaluated.

A summary of the exposure pathways related to the Northrop Grumman/NWIRP facility in Bethpage and NWIRP facility in Calverton is presented in Table 1.

Table 1: Exposure Pathway Evaluation for Drinking Water Supply Wells Impacted by Northrop Grumman Facilities.

Source	Environmental Medium	Exposure Point	Exposure Route	Exposed Population	Pathway Classification
Northrop Grumman/NWIRP facility Bethpage Release	Groundwater	Private wells	Ingestion Inhalation Dermal	Residents (adults and children)	Past, Current, Future - Potential
		South Farmingdale Water District	Ingestion Inhalation Dermal	Residents (adults and children)	Past, Current, Future - Eliminated
		NYAWC Well 3 & Well 4	Ingestion Inhalation Dermal	Residents (adults and children)	Past –Complete Current and Future– Eliminated
		BWD Plant 6 Well 6-1	Ingestion Inhalation Dermal	Residents (adults and children)	Past – Complete Current and Future- Eliminated
		BWD Plant 6 Well 6-2	Ingestion Inhalation Dermal	Residents (adults and children)	Past – Complete Current and Future- Eliminated
		BWD Plant 4 Well 4-1	Ingestion Inhalation Dermal	Residents (adults and children)	Past – Complete Current and Future - Eliminated
		BWD Plant 4 Well 4-2	Ingestion Inhalation Dermal	Residents (adults and children)	Past – Complete Current and Future - Eliminated
NWIRP facility Calverton Release	Groundwater	PRSC	Ingestion Inhalation Dermal	Residents (adults and children)	Past – Complete Current and Future - Eliminated

NYAWC: New York American Water Company – Merrick Operations; BWD: Bethpage Water District
PRSC: Peconic River Sportsman's Club

Selection of Contaminants for Further Evaluation

Contaminants were selected for further evaluation by comparing the highest contaminant level (concentration) for each well to its New York State public drinking water standard [DOH 2013] and the ATSDR's drinking water comparison value [ATSDR 2005, 2017]. Both the standards and the comparison values are water concentrations at which adverse health effects are not

expected to occur. Exceeding a drinking water standard or comparison value does not mean that an adverse health effect will occur, but that further evaluation of the contaminant is needed. The comparison values are based solely on health-based criteria, while the water standards are enforceable regulatory values that consider other factors in addition to health (e.g., the cost of compliance and the ability to reliably detect the chemical). Contaminants exceeding either of these values (Table 2) included PCE (Bethpage Water District Well 6-1), 1,1,1-TCA (Bethpage Water District Well 6-1), and TCE (New York American Water Company Wells 3 and 4, and Bethpage Water District Wells 4-1, 4-2, 6-1 and 6-2). The risks for cancer and noncancer health effects for exposures to these chemicals in these wells were further evaluated and are presented in this document. Potential health effects of site-related chemicals selected for further evaluation are discussed in Appendix E.

The levels of 1,1-DCA and 1,1-DCE in the Peconic River Sportsman's Club well do not exceed the New York State drinking water standards or available ATSDR comparison values (Table 2) and are therefore not evaluated further.

Table 2. Comparison of Highest Contaminant Concentrations in Public Water Supply Wells Impacted by Northrop Grumman Facilities to NYS Drinking Water Standards and ATSDR Drinking Water Comparison Values.
(all values in micrograms per liter)

Chemical	Well	Highest Detected Level	Contaminant Selected for Further Evaluation	New York State Drinking Water Standard[1]	ATSDR Drinking Water Comparison Value
1,1-DCA	PRSC 1	0.7	No	5	not available
1,1-DCE	PRSC 1	0.5	No	5	63(EMEG)
PCE	BWD 6-1	17	Yes	5	12 (CREG)
1,1,1-TCA	BWD 6-1	15	Yes	5	14,000 (RMEG)
TCE	NYAWC 3	3.3	Yes	5	0.43 (CREG)
	NYAWC 4	0.9	Yes		
	BWD 4-1	2.6	Yes		
	BWD 4-2	1	Yes		
	BWD 6-1	60	Yes		
	BWD 6-2	5	Yes		

[1]Some of the samples were taken prior to promulgation of the New York State drinking water standards in 1989.
1,1-DCA = 1,1-dichloroethane; 1,1-DCE = 1,1-dichloroethene; PCE = tetrachloroethene; 1,1,1-TCA = 1,1,1-trichloroethane; TCE = trichloroethene; PRSC = Peconic River Sportsman's Club; BWD = Bethpage Water District; NYAWD = New York American Water Company – Merrick Operations; CREG = Cancer Risk Evaluation Guide; EMEG = chronic Environmental Media Evaluation Guide; RMEG = intermediate Reference Dose Media Evaluation Guide for a child.

Public Health Implications of Completed Pathways

The following sections summarize an assessment of health risks for exposure to contaminants in public water supply wells impacted by the Northrop Grumman Facilities. This process uses a standard approach that combines assumptions about the frequency and magnitude of the exposures with information about the toxicity of the chemical to draw conclusions about the risk for human health effects [ATSDR 2005; EPA 2018]. The results of these assessments are used to evaluate potential exposures. They cannot be used to predict actual health outcomes, nor can they determine if health effects occurred in the past. The information is one of several considerations in the development risk management decisions about reducing exposures to environmental chemicals.

The increased risk for developing cancer (above the background lifetime cancer rate for humans[5]) for people who drank and used water containing TCE and PCE is evaluated by estimating exposure for each drinking water contaminant and then applying the chemical's cancer potency factor (1,1,1-TCA has not been classified as a carcinogen). The cancer potency factor is a numerical estimate of the carcinogenic strength (potency) of a chemical. In cases when exposure to contaminated water was for periods less than lifetime, the cancer risks were calculated from birth to when the exposure was assumed to end, which included the early stages of life when contaminant exposure and vulnerability may be higher compared to adults. Noncancer health risks are evaluated by comparing the exposure estimates for each chemical to its reference dose, which represents a lifetime exposure at which noncancer health effects are unlikely to occur. The cancer and noncancer health risks from drinking water are evaluated using ATSDR guidance [ATSDR 2014a].

Since exposure to VOCs such as TCE, PCE, and 1,1,1-TCA in drinking water is possible not only by ingestion, but also by dermal contact and inhalation from water uses such as showering and bathing, exposure through the inhalation and dermal routes together is assumed to be equal to that of the ingestion route. Thus, we doubled the water concentration used in our calculations to estimate the dose of the chemical in drinking water.[6] An additional evaluation of non-ingestion exposures to drinking water contaminants using ATSDR's Shower and Indoor Water Use Model is presented in Appendix G.

Bethpage Water District Well 6-1

Well 6-1 in the Bethpage Water District had the highest contaminant levels of the wells influenced by Northrop Grumman facilities. In 1976, Well 6-1 contained TCE as high as 60 mcg/L, and also had elevated levels of PCE (maximum = 17 mcg/L) and 1,1,1-TCA (maximum = 15 mcg/L) (see Appendix D, Table D-2). The District installed the well in 1952 [DEC 1952], and the first sampling in 1976 showed contamination. The District took the well out of service shortly thereafter.

The average water concentrations during November and December 1976, when the well was known to be contaminated and in service, are used to estimate the cancer risk. It is also assumed that people drank water at the average concentration for 24 years (the estimated number of years the well was in operation and used for drinking water). Based on the available sampling information, our exposure estimates, and the cancer potency factor, past long-term exposure (i.e., 24 years) to drinking water containing TCE at the average concentration[7] found in Well 6-1 (38 mcg/L) while it was in service posed an increased lifetime risk for cancer

[5] The lifetime risk of developing cancer in the United States (background lifetime cancer risk) is about 1 in 2 for men and 1 in 3 for women [ACS 2020].

[6] The basis for the assumption is the weight of evidence from several investigations that evaluate the contribution of inhalation and dermal exposure pathways during showering to the total exposure from VOCs in drinking water (McKone 1987, 1989; Maxwell et al. 1991; Chinery and Gleason 1993; Weisel and Jo 1996). These studies use modeling approaches and experimental measurements to conclude that indoor inhalation exposures from tap water containing VOCs can range from 1.5 to 6 times the exposure attributable to the consumption of 2 liters of water per day, and that the ratio of dermal VOC exposure to ingestion exposure is in the range of 0.3 to 1.8. The consideration of non-ingestion exposure pathways is consistent with past ATSDR guidance for considering inhalation and dermal exposures in conjunction with ingestion exposures, when assessing VOC contamination in drinking water (ATSDR 2005).

[7] The average values for TCE and PCE were calculated using the sampling results from November 29, December 2, and December 6, 1976, which represent the only sampling dates during the time the well was in service (see Table D-2, Appendix D). A value of one-half the detection limit (0.25 mcg/L) was used for non-detects.

between 3 in one hundred thousand and 8 in one hundred thousand.[8] This increase in cancer risk is characterized as low[3]. The estimated increased cancer risk for exposure to the average level of PCE (5.8 mcg/L) in Well 6-1 was between 1 in ten million and 4 in ten million, which is considered to be very low[1]. See Appendix F for additional detail on the cancer risk calculations for TCE and PCE.

To evaluate noncancer risks, children and adult exposure estimates for PCE, 1,1,1-TCA, and TCE are compared to each chemical's EPA reference dose [EPA 2007; 2011b; 2012]. For PCE and 1,1,1-TCA, children and adult exposure estimates based on the contaminant levels in Well 6-1 were below the reference dose. Therefore, the risk for noncancer health effects from these exposures is minimal (see Appendix F for additional details on the noncancer risk calculations).

The EPA reference dose for TCE[9] is based on studies reporting immune toxicity in mice [Keil *et al*. 2009; Peden-Adams *et al*. 2006] and developmental toxicity (fetal heart defects) in rats [Johnson *et al*. 2003]. The average TCE concentration in the drinking water from Well 6-1 (38 mcg/L), which was assumed to represent long-term past daily exposure, was used to evaluate risks to the immune system. The estimated TCE exposures of children (based on the average TCE concentration) are up to 22 times higher than the reference dose, and the estimated exposures of adults are up to 6 times higher than the reference dose. Since these exposures exceed the reference dose, the margin of exposure was evaluated. For this evaluation, the margin of exposure is a measure of how many times lower the TCE drinking water exposure is when compared to the TCE exposure that is associated with effects on the immune system. The TCE exposures in drinking water for children and adults were 4 and 16 times lower, respectively, than the EPA's estimate of the human exposure that corresponds to a dose that causes immune toxicity in mice [EPA 2011b]. This margin of exposure is considered to be too small to be adequately protective of public health. Stated another way, the estimated TCE exposure from using water from Bethpage Water District Well 6-1 approaches exposures that might cause immune system effects in humans.

The highest TCE water concentration was used to evaluate the risk for developmental effects because these effects may occur after relatively short periods of exposure (e.g., early pregnancy). Using the highest TCE water concentration (60 mcg/L), a pregnant woman (used to evaluate the risk to the fetus) is estimated to receive an exposure that is about 8 times higher than the reference dose. Since the exposures exceed the reference dose, the margin of exposure was again evaluated. For this evaluation, the margin of exposure is a measure of how many times lower the TCE drinking water exposure is when compared to the TCE exposure that is associated with effects on development. The estimated TCE exposure at 60 mcg/L is only 1.2 times lower than the EPA's estimated human TCE exposure that corresponds to a dose associated with fetal heart malformations in rats [EPA 2011b], and therefore this exposure could have posed an increased risk for developmental toxicity. This margin of exposure is considered too small to be adequately protective of public health. Stated another way, the estimated TCE exposure from using water from Bethpage Water District Well 6-1 approached exposures that could result in fetal heart defects in humans. Additional details on our calculation of noncancer hazard quotients and margins of exposure are found in Appendix F.

[8] The calculation of estimated cancer risks for TCE uses age-dependent adjustment factors to account for the potential increased vulnerability in early life stages for those exposed to chemicals such as TCE that cause cancer by a mutagenic mode of action [EPA 2011a,b].

[9] For TCE, ATSDR has adopted the EPA reference dose of 0.0005 mg/kg/day as its chronic oral minimal risk level [ATSDR 2014b]. The chronic minimal risk level is virtually identical to a reference dose and is defined as an estimate of a daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects for exposures up to a lifetime.

Bethpage Water District Wells 4-1, 4-2, 6-2 and New York American Water Company Wells 3 and 4

Exposures, cancer risks, and noncancer health risks for TCE in the other wells influenced by the Northrop Grumman facilities (New York American Water Company Wells 3 and 4, and Bethpage Water District Wells 4-1, 4-2, and 6-2) were evaluated using the same general methods as for Bethpage Water District Well 6-1. For each well, the cancer risk estimates reflected the period of time that persons might have been using TCE-contaminated water from that well. In each case, the exposure duration was assumed to be the length of time between when TCE was first detected in a given well, to the time of the last detection when people were known to still be drinking water from that well. All the TCE exposures in these wells are estimated to have posed a very low to low increased lifetime cancer risk (ranging from about 9 in 100 million to 2 in one million). The exposures are also estimated to have posed a minimal risk for noncancer health effects, since they do not exceed each chemical's reference dose, with the exception of exposure to the average level of 2 mcg/L TCE in Bethpage Water District Well 6-2. The estimated TCE infant exposure at this water level is slightly higher than the TCE reference dose but is 84 times lower than the EPA's estimate of the human exposure that corresponds to a dose that causes immune toxicity in mice [EPA 2011b]. This difference, or margin of exposure, is sufficient to conclude that the risk for immune toxicity from past exposure to the average TCE level in Bethpage Water District Well 6-2 (2 mcg/L) is low. A summary of the evaluation of TCE cancer and noncancer risks is provided in Table 3. See Appendix F for additional details on our risk calculations for these wells.

Table 3: Water Concentrations, Exposure Durations, Cancer Risks and Hazard Quotients for TCE in Public Water Supply Wells Impacted by Northrop Grumman Facilities

Chemical	Well	Maximum Water Concentration (mcg/L)	Average Water Concentration[1] (mcg/L)	Exposure Duration (years)[2]	Cancer Risk[3]	Noncancer Hazard Quotient[4]
TCE	BWD 6-2	5	2.0	4	2 in 1,000,000	1.1
	BWD 4-1	2.6	0.49	7	6 in 1,000,000	0.36
	BWD 4-2	1	0.48	3	4 in 10,000,000	0.27
	NYAWC 3	3.3	1.12	6	1 in 1,000,000	0.64
	NYAWC 4	1	0.37	4	3 in 10,000,000	0.21

TCE= trichloroethene; mcg/L = micrograms per liter; BWD = Bethpage Water District; NYAWC = New York American Water Company.

[1]The water concentrations were averaged over the time between when the contaminant was first detected to the time of the last detection when people were known to still be drinking water from that well, using one-half the detection limit for any non-detects over the exposure duration. Average water concentrations were used to evaluate cancer and non-cancer risks except for TCE developmental toxicity, for which the highest detected water concentration was used. Water concentrations were doubled to account for non-ingestion exposures. See Appendix F for additional detail and calculations.

[2]The duration of contaminant exposure was assumed to be the length of time between when the contaminant was first detected in a given well to the time of the last detection and people were known to still be drinking water from that well.

[3]Highest cancer risk is shown of those calculated for several age groups. See Appendix F for additional detail and calculations.

[4]Highest hazard quotient is shown of those calculated for several age groups and for pregnant women. For all wells the highest hazard quotient was for infants exposed to the average TCE level (used to evaluate immune toxicity), except for the hazard quotient for Well 4-1, which was based on pregnant women exposed to the highest TCE level (used to evaluate developmental toxicity). The hazard quotient is calculated by dividing the estimated contaminant exposure by the chemical's reference dose. Hazard quotients less than 1 indicate that the exposure is less than the reference dose and there is minimal risk for noncancer health effects. See Appendix F for additional detail and calculations.

UNCERTAINTIES AND LIMITATIONS

There are several sources of uncertainty with respect to the assumptions used to generate the quantitative estimates of risks for exposure to contaminants in drinking water influenced by the Northrop Grumman facilities. The primary areas of uncertainty are discussed below.

- Limited Sampling Data: Only three drinking water samples were available from Bethpage Water District Well 6-1 and these were all taken within a limited time frame (i.e., over one week in late 1976). While Well 6-1 was intermittently in service and likely contaminated prior to the time the samples were taken, we do not know if the levels of contamination prior to sampling were lower or higher. This represents a substantial uncertainty regarding the estimates of cancer risk and noncancer effects on the immune system from potential long-term exposure. However, since the evaluation of developmental health effects is based on short term exposure, the limited sampling data present less uncertainty to the conclusion of a potential increased health risk. Consistent with ATSDR guidance, and in the absence of definitive evidence that individuals were not exposed during this time, the highest known TCE concentration was used to evaluate the risk for developmental health effects.

- Exposure Assumptions: The assessment of health risks used standard drinking water consumption rates and body weights according to guidance developed by ATSDR to estimate contaminant exposures. These are based on survey data and considered by ATSDR to be within the ranges that could occur for these parameters. The degree to which the assumed exposure parameters do not represent the actual exposures that may have taken place constitutes a source of uncertainty in the quantitative estimates of risk.

- Use Patterns of Well 6-1: While preparing the public comment version of the health consultation, the NYSDOH did not have information on the pumping history for Well 6-1, where TCE concentrations were the highest. This can have important implications with respect to the assumptions made about the exposure duration, long-term water concentrations, and resulting exposure estimates. If Well 6-1 was not pumped (used) continuously, or if the contaminated water from Well 6-1 was blended with uncontaminated water from other wells over the time period of interest, then the actual long-term exposures may have been lower than those assumed by this evaluation. This appears to be likely, as pumping records for Bethpage Water District wells provided during the public comment period indicated, that the pumped volume of Well 6-1 varied substantially between 1952 and 1976. This new information is not sufficient to allow us to make meaningful revised quantitative estimates of long-term exposures in the absence of specific knowledge of when the water was blended and at what ratios and for what time periods. Even so, the associated lifetime cancer risk estimate (assuming the average TCE concentration in Well 6-1 and an exposure duration of 24 years) is qualitatively characterized as “low” since it is between one and one million and one in ten thousand. Assuming a shorter exposure duration (e.g., 1 year) based on pumping history would have not changed the qualitative descriptor applied to the increased cancer risk. The uncertainties related to the use patterns of Well 6-1 are less significant in the estimates of short-term exposure used to evaluate developmental toxicity, which led to the conclusion of a potential increased risk.

- Potential Differences Between Contaminant Concentrations in Finished and Raw Water: Sampling data were available only for raw, untreated water, not for finished water delivered to homes. The simplest and most reasonably conservative approach without

specific knowledge of how treatments such as chlorination and corrosion control may have influenced the raw water concentrations is to assume the detected concentrations in raw water could have been consumed. If these treatments reduced the levels, the exposures and resulting health risks may have been lower than those reported in the health consultation.

There are also uncertainties regarding possible exposure to water contaminants in private wells. Since there are limited historic private well data or a program in place to identify whether private wells are still in use in Nassau County, it is not possible to determine past, current, or future public health implications of exposures to contaminants in private water supplies in the area of the Northrop Grumman/NWIRP facility. The area is served by public water, and therefore any such private wells are unlikely to be used for drinking and probably used only for irrigation. Exposure to VOCs in irrigation wells does not constitute an exposure concern since any VOCs in groundwater would volatilize into the air when the water was released during irrigation. In addition, private wells are unlikely to have been installed at depths that would intersect contaminated groundwater associated with the Northrop Grumman/NWIRP facility.

CONCLUSIONS

The evaluation of VOCs included in this health consultation indicates that currently, drinking or other uses of water from public water supplies affected by the Northrop Grumman/NWIRP facility in Bethpage, Nassau County are unlikely to harm people's health. This is because the public water supplies are monitored for chemical contaminants on a regular basis based on current drinking water standards, and because treatment to remove VOC contaminants included in this evaluation from the public water supplies is being implemented when necessary prior to distribution.

Past use of drinking water contaminated with TCE from Bethpage Water District Well 6-1 in the past (before early December 1976) could have increased the risk for adverse noncancer health effects. This is because some people were likely exposed to VOCs, including TCE, in drinking water prior to the time when water treatment systems were installed on certain supply wells. The estimated ingestion and inhalation exposures to TCE (the primary contaminant in the water) in Well 6-1, occurring before early December 1976, approached exposures levels that could have resulted in immune or developmental toxicity. Preventive health recommendations for people who had drinking water and/or inhalation exposures to TCE from Well 6-1 prior to early December 1976 are similar to general recommendations for others: maintain a healthy lifestyle, have regular medical checkups, and discuss specific concerns with healthcare providers.

Past use of drinking water contaminated with PCE and 1,1,1-TCA in Bethpage Well 6-1 is unlikely to harm people's health because PCE was found in Well 6-1 at levels estimated to pose a very low increased risk for cancer, and 1,1,1-TCA and PCE were at levels that posed a minimal risk for noncancer health effects.

Past long-term ingestion and inhalation exposure to TCE in the other public water supplies (i.e., other than Bethpage Water District Well 6-1) affected by Northrop Grumman/NWIRP facility in Bethpage is unlikely to harm people's health. This is because TCE was found at levels in drinking water estimated to pose a very low to low increased risk for cancer and a minimal risk for noncancer health effects. In Bethpage Water District Well 6-2 (taken out of service in 1988), the estimated past exposure to infants is slightly higher than the TCE reference dose but is still well below EPA's estimate of the human exposure that corresponds to a dose that causes

immune toxicity in mice. This difference, or margin of exposure, is sufficient to conclude that the risk for immune toxicity from past exposure to TCE in Bethpage Water District Well 6-2 is low. Since then, water from both wells has been treated and routine monitoring is conducted to verify that the water meets New York State drinking water standards prior to distribution.

While exposures to facility-related contaminants through the use of unpermitted private wells were possible, such exposures are unlikely. Nassau County has not permitted the installation of private wells for drinking purposes in areas where public water is available since 1987. Since there are very limited historical and/or current data for private wells in the area of the Northrop Grumman/NWIRP facility in Bethpage, we do not know if and for how long people may have been exposed to contaminated water. Data from vertical profile borings and monitoring well sampling show that groundwater contamination associated with the Northrop Grumman/NWIRP facility is generally located at depths greater than 140 feet below ground [NFEC 2012]. Any private wells that might exist are unlikely to have been installed at depths that would intersect contaminated groundwater associated with the Northrop Grumman/NWIRP facility. Since the area is served by public water, any such private wells are probably used only for irrigation and are unlikely to be used for drinking. Exposure to VOCs in irrigation wells does not constitute an exposure concern. Any VOCs in groundwater would volatilize into the air when the water was released during irrigation.

Currently, drinking or other uses of water from public water supplies in Calverton, Suffolk County, are unlikely to harm people's health. This is because no public water supplies have been impacted by the Northrop Grumman/NWIRP facility in Calverton, Suffolk County.

Past use of drinking water from the Peconic River Sportsman Club private well (Suffolk County) is unlikely to harm people's health. This is because the levels of VOCs detected in one Peconic River Sportsman's Club well did not exceed standards or available comparison values. The Club is currently connected to the Riverhead Water District public water supply. The Club's private wells were abandoned, grouted, cut and capped and are no longer available for use.

RECOMMENDATIONS

The NYSDOH and NYSDEC should ensure that the requirements of the OU2 and OU3 RODs, along with the Amended ROD for the Northrop Grumman/NWIRP facility in Bethpage continue to be enforced. These RODs/Amended ROD include a Public Water Supply Protection component that is designed to ensure that public water supply wells impacted or threatened by the Northrop Grumman/NWIRP facility groundwater contamination are able to deliver water to their customers that meet state and federal drinking water requirements [DEC 2001].

The NYSDEC has completed a study on the feasibility of implementing additional remedial actions to fully contain the groundwater contamination originating at the Northrop Grumman/NWIRP facility. The findings of this feasibility study, and the specific remedial actions that have been identified as being capable of achieving full plume containment, were incorporated by the NYSDEC into a Proposed Remedial Action Plan (PRAP). Any additional remedial actions identified by the NYSDEC should continue to similarly ensure that any public water supply wells impacted or threatened would be treated to deliver water to customers that meets all applicable standards.

Preventive health recommendations for people who had drinking water and/or inhalation exposures to TCE from Well 6-1 prior to early December 1976 are similar to general recommendations for others: maintain a healthy lifestyle, have regular medical checkups, and discuss specific concerns with healthcare providers.

The NYSDOH should work with ATSDR, NYSDEC, EPA and County Health agencies to evaluate 1,4-dioxane data collected by public water supply systems to determine whether further public health actions are needed.

PUBLIC HEALTH ACTION PLAN

The NYSDOH will work with the NYSDEC and with the Nassau County Department of Health to ensure that the stipulations set forth in the OU2 and OU3 RODs for the Northrop Grumman/NWIRP are met and that all impacted and threatened public water supply systems continue to comply with the New York State Drinking Water Regulations and federal public drinking water standards. The program is designed to ensure that appropriate wellhead treatment is put in place that will enable the public water suppliers to meet drinking water standards.

The NYSDOH will continue to work with the NYSDEC, County Health agencies, EPA, and ATSDR to review information as it becomes available, evaluate the public health implications of any sampling results, and recommend public health actions as needed.

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REPORT PREPARATION

The New York State Department of Health (NYSDOH) prepared this Health Consultation for the Northrop Grumman/Naval Weapons Industrial Reserve Plant Facilities, located in the towns of Bethpage, Nassau County and Calverton, Suffolk County, New York. This publication was made possible by a cooperative agreement (program #TS20-2001) with the federal Agency for Toxic Substances and Disease Registry (ATSDR). The NYSDOH evaluated data of known quality using approved methods, policies, and procedures existing at the date of publication. ATSDR reviewed this document and concurs with its findings based on the information presented by the NYSDOH.

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Appendix A: Figures

Figure A-1. Overview Map of Northrop Grumman Facility Locations

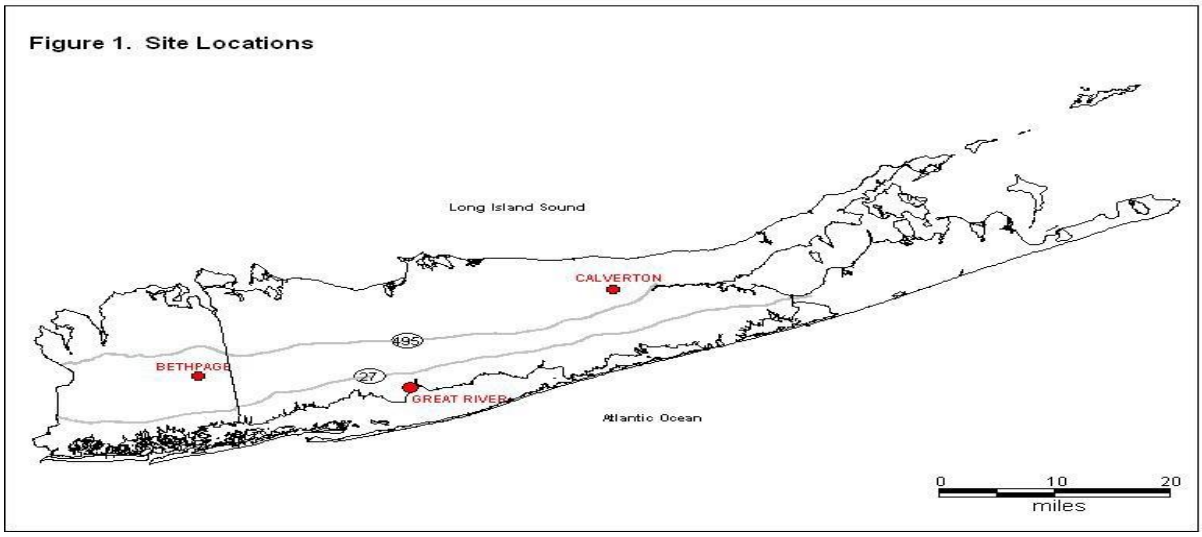


Figure A-2. Units of the Long Island Aquifer

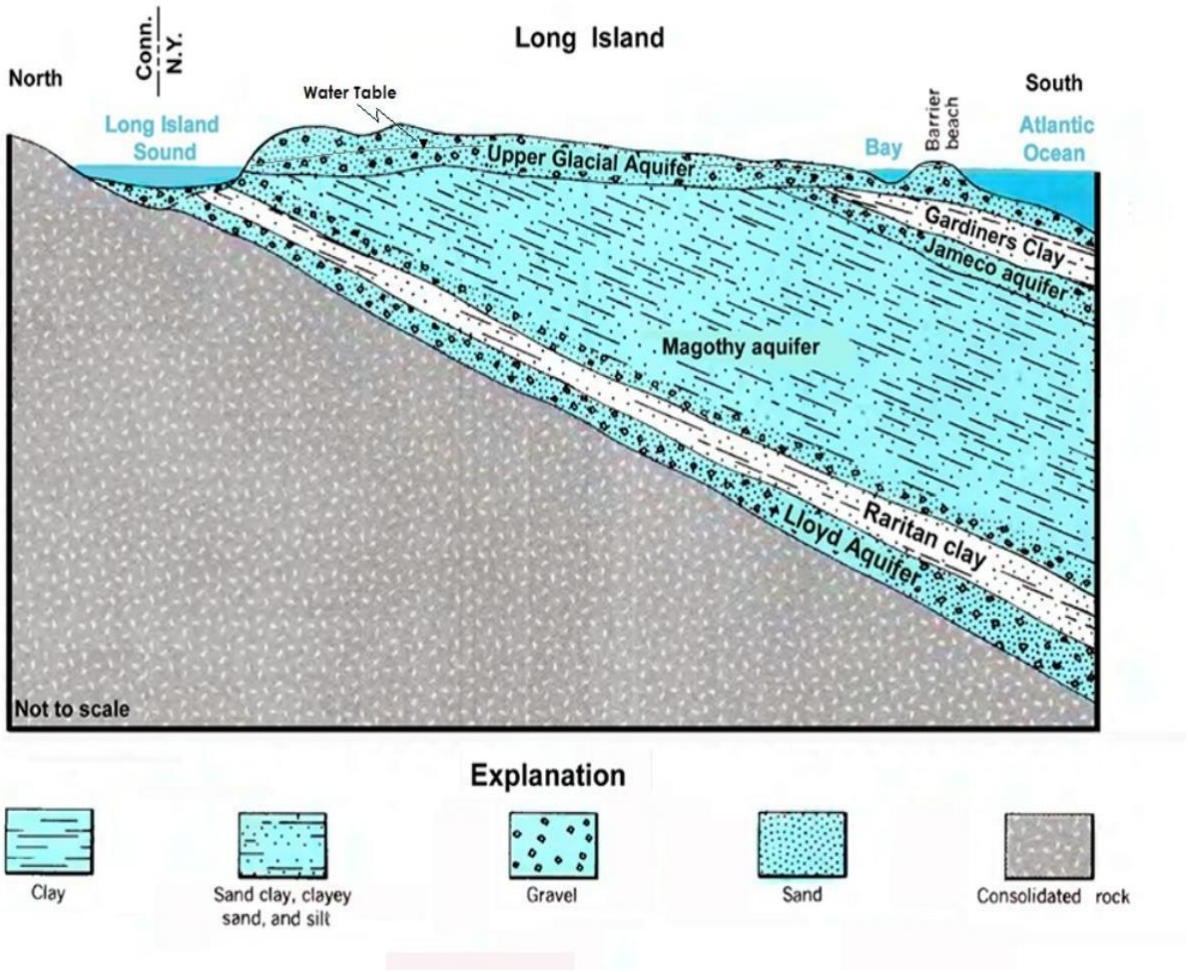


Figure A-3. Northrop Grumman/NWIRP facility and Public Water Supply Wells

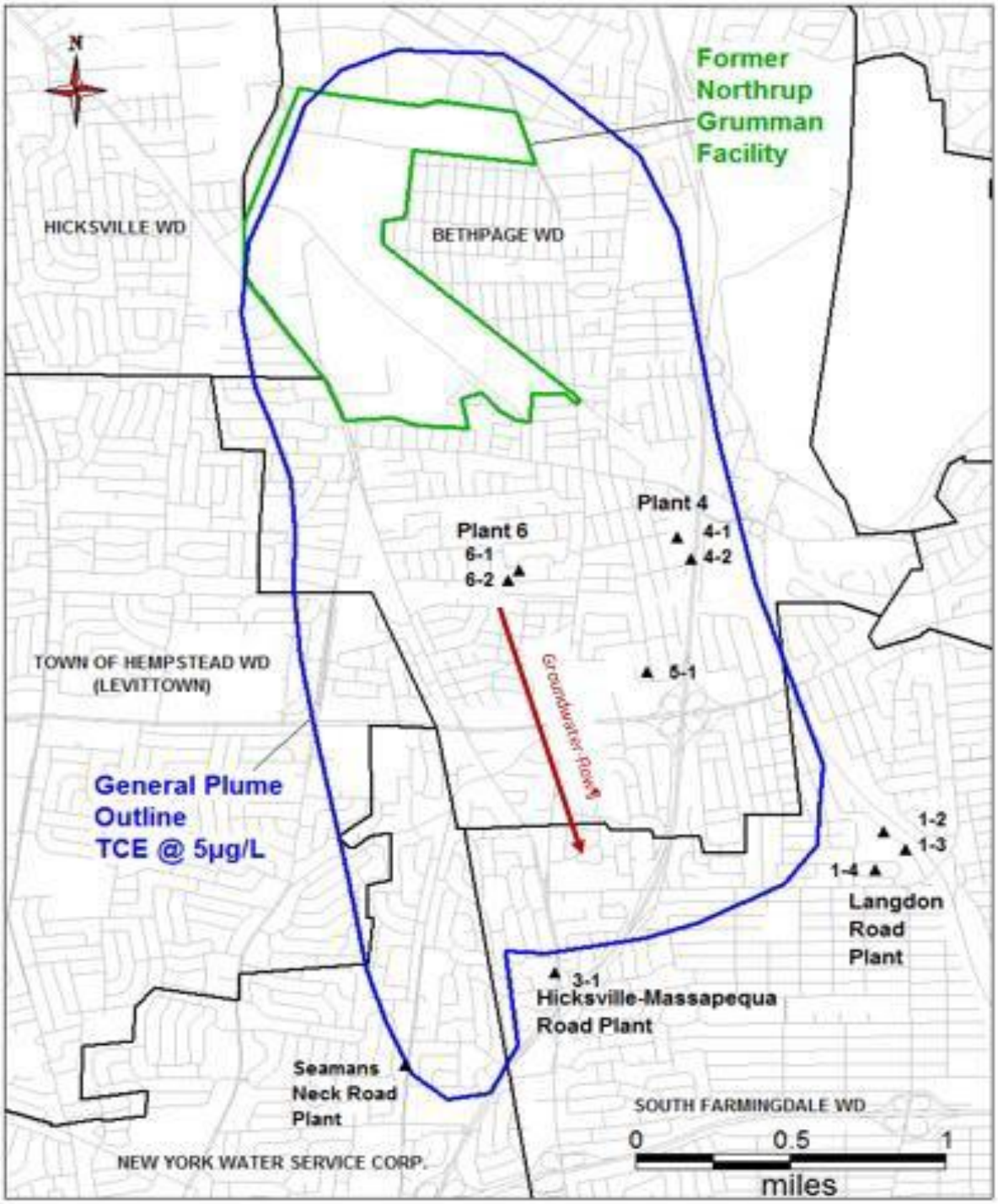
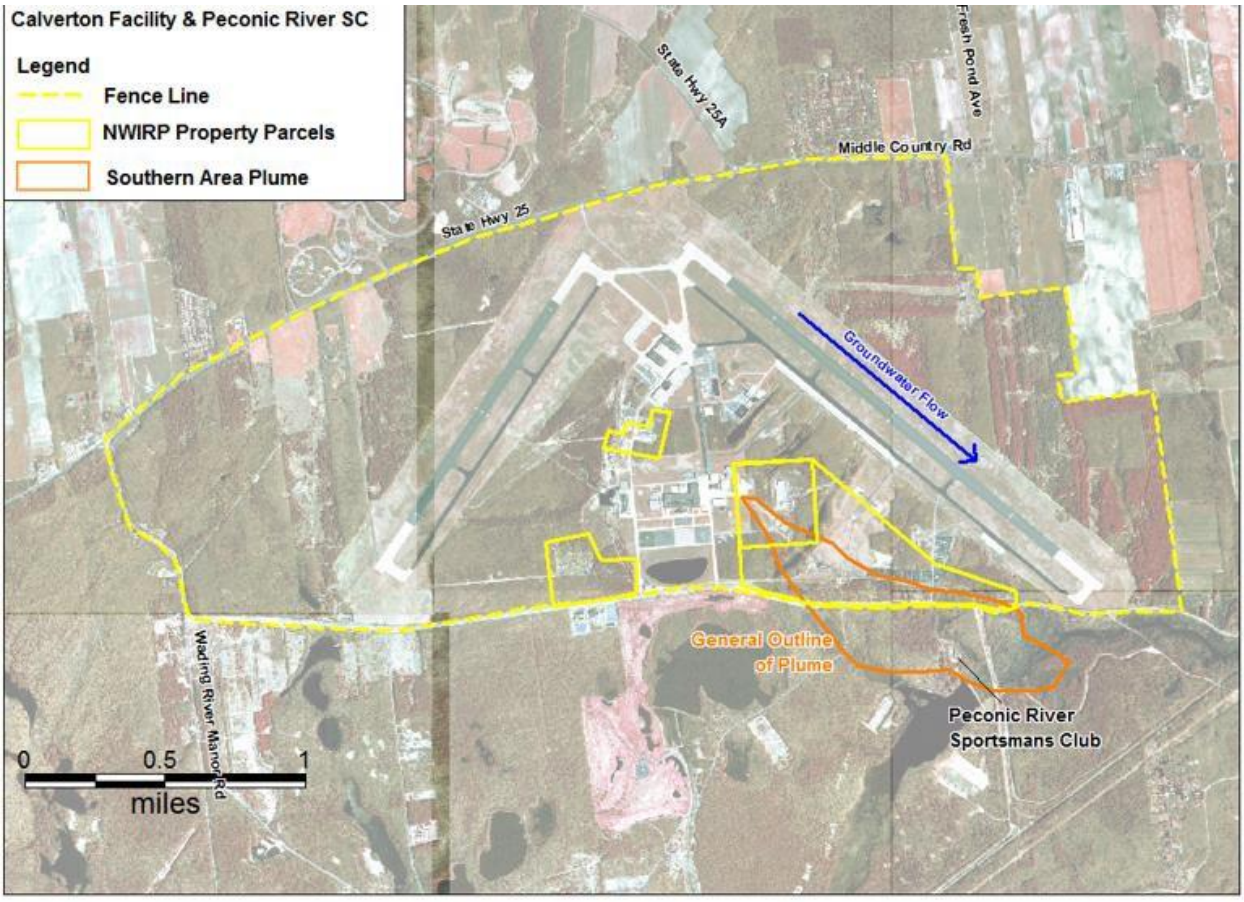


Figure A-4. Calverton Facility



Appendix B: Site Details

Northrop Grumman/Naval Weapons Industrial Reserve Plant (NWIRP)

Northrop Grumman/NWIRP Bethpage facility

Northrop Grumman (formerly Grumman Aircraft Engineering Corporation, later Grumman Aerospace Corporation) first occupied the Northrop Grumman facility in Bethpage in the early 1930s and by the 1990s the property covered approximately 500 acres. Activities conducted at the facility included research, prototyping, testing, design engineering, fabrication and primary assembly of various military aircraft and spacecraft. The United States Navy established the Naval Weapons Industrial Reserve Plant in Bethpage in 1942, which occupied approximately 109 acres within the Northrop Grumman facility. The Naval Weapons Industrial Reserve Plant was a Government-Owned Contractor Operated facility that was run by Northrop Grumman. Northrop Grumman ceased most manufacturing related operations at the Northrop Grumman/NWIRP facility in 1996.

The activities that took place at the Northrop Grumman Northrop Grumman/NWIRP facility generated significant amounts of inorganic and volatile organic wastes. During the first 40 or so years that the Northrop Grumman/NWIRP facility was in operation, the accepted waste handling procedures typically called for disposal directly to on-site surface impoundments or to on-site sub-surface liquid waste handling systems such as cesspools and septic tanks. These disposal practices were eventually discontinued as the impacts to drinking water supplies became apparent.

Taste and odor issues associated with Northrop Grumman's on-site water supply wells used for drinking led to investigations by the NCDOH, the EPA, and the NYSDOH in the mid-1970s. These investigations found vinyl chloride, trichloroethene (TCE) and tetrachloroethene (PCE) in the Northrop Grumman water supply wells. In 1976, Northrop Grumman connected its Northrop Grumman/NWIRP facility to the Bethpage Water District for supply of potable water. Thereafter, Northrop Grumman used the on-site supply wells only for industrial and cooling purposes. While Northrop Grumman used TCE and PCE on site, it was determined that the source of vinyl chloride was from another industrial site located northeast of the Bethpage Complex.

The NYSDEC, in consultation with the NYSDOH, listed the Northrop Grumman Northrop Grumman/NWIRP facility on the New York State Registry of Inactive Hazardous Waste Sites (also known as State Superfund) in 1983. Findings from investigations conducted between 1989 and 1994 led the NYSDEC to divide the remedial programs for the Northrop Grumman/NWIRP facility into distinct operable units. An operable unit is a portion of a remedial site that for technical or administrative reasons can be more effectively addressed separately. NYSDEC created operable units (OU) to address on-site soil contamination (OU1), groundwater contamination that was migrating off the site (OU2), and disposal areas now occupied by the Town of Oyster Bay Community Park (OU3).

The NYSDEC issued a Record of Decision for OU1 in 1995. The company remediated OU1 soil contamination at Plant 2 and a small area of PCE contamination at Plant 15 using a soil vapor extraction method. Northrop Grumman addressed other areas of contamination at their Northrop Grumman facility by separate removal actions and by deed restrictions that require maintenance of a cap or cover system.

Investigations conducted between 1991 and 1995 identified soil contamination at three areas within the Naval Weapons Industrial Reserve Plant portion of the Northrop Grumman Bethpage

Complex. In 1993 the NYSDEC, in consultation with the NYSDOH, listed the Naval Weapons Industrial Reserve Plant separately. In 1995, the NYSDEC issued the OU1 Record of Decision for the Naval Weapons Industrial Reserve Plant that called for excavation of polychlorinated biphenyls (PCBs) and VOC contaminated soil, and implementation of a system to remediate shallow on-site groundwater contamination.

Northrop Grumman and the Navy continued to investigate the nature and extent of groundwater contamination associated with the Northrop Grumman/NWIRP facility throughout the 1990s. The information from these investigations showed that actions were needed to prevent further migration of contaminants off the site. In 1997, Northrop Grumman implemented an interim remedial measure in the form of groundwater containment known as the On-Site Containment System, which consists of five wells that extract groundwater at the southern site boundary and treats the extracted water to remove VOC contaminants. The treated water is then discharged to on-site recharge basins or used by a nearby power plant. The On-Site Containment System continues to operate.

In March 2001, the NYSDEC issued a Record of Decision (ROD) for Northrop Grumman OU2 to address the regional groundwater contamination plume. At that time NYSDEC and NYSDOH estimated the groundwater plume to have extended over an area of more than 2,000 acres and to a depth of approximately 700 feet below ground surface. The agencies identified the primary groundwater contaminants to be the chlorinated VOCs PCE, TCE, 1,1-dichloroethene (1,1-DCE), vinyl chloride, and 1,1,1-trichloroethane (1,1,1-TCA). As previously noted, the vinyl chloride groundwater contamination is not associated with the Northrop Grumman/NWIRP facility but resulted from improper waste disposal at an upgradient site northeast of the property.

The Groundwater Remedial Program, as specified in the OU2 ROD included 1) continued operation of the On-Site Containment groundwater extraction and treatment system, 2) evaluation of the On-Site Containment system to confirm that it is performing effectively, 3) implementation of an off-site groundwater extraction and treatment system in an area known as GM 38 monitoring well cluster, 4) long-term operation and maintenance of the On-Site Containment and GM 38 area remedy, 5) continued investigation to better define the extent of groundwater contamination and to determine whether additional groundwater remediation systems are required, 6) long-term monitoring of the groundwater including a comprehensive monitoring of plume attenuation, 7) the formation of a technical advisory committee as deemed necessary by the NYSDEC, to be comprised at a minimum, of the involved Agencies, participating local water districts, Northrop Grumman and the Department of the Navy, and 7) establishment of a Public Water Supply Protection Program.

The Public Water Supply Protection Program is the primary mechanism that ensures public water suppliers do not deliver water to customers that contains site-related contamination at concentrations greater than state or federal drinking water standards. The standards are established by the NYSDOH and included in New York State's Part 5, Subpart 5-1 Public Water Systems Regulations [DOH 2013] and by the EPA as federal drinking water standards. The Public Water Supply Protection Program implements procedures to ensure that appropriate wellhead treatment is put in place that will enable the public water suppliers to meet drinking water standards, with costs of the treatment systems funded by Northrop Grumman and/or the Navy. The Public Water Supply Protection Program also includes long-term monitoring of the groundwater upgradient of public water supply well fields to ensure that wellhead treatment facilities can be constructed and be made operational prior to wells being impacted.

In 2014 the State of New York passed Assembly Bill 9492 calling for the NYSDEC to create and deliver to the state legislature a report detailing the options for intercepting and remediating the groundwater plume of contaminants emanating from the Northrop Grumman and NWIRP

facilities in Bethpage. In response, the NYSDEC worked with a State Engineering Contractor (HDR, Inc.) and prepared and released a Remedial Options Report in August 2016. This report provided a big picture view of the remedial options and identified three potential hydraulic containment remedies. This Remedial Options Report was not designed to support development of a Proposed Remedial Action Plan (PRAP). In February 2017, the Executive Branch directed NYSDEC to undertake an investigation and engineering analysis to further evaluate options for managing of the groundwater plume. A NYSDEC standby contractor was tasked to complete this detailed analysis of remedial alternatives as part of a Feasibility Study. The findings of this Feasibility Study, and the specific remedial actions that have been identified as being capable of achieving full plume containment, were incorporated by the NYSDEC into a Proposed Remedial Action Plan was presented to the public for review and comment.

As of December 2017, Northrop Grumman and the Navy continue to design and construct extraction and treatment systems to address groundwater contamination that has migrated from the facility through implementation of two additional systems to extract contaminated groundwater from specific areas identified as hot spots. These hot spots have been targeted as a result of the on-going investigations that the Navy and Northrop Grumman have been conducting. The extracted groundwater will be treated to remove contaminants and the treated water returned to the aquifer.

NWIRP Calverton Facility

The Naval Weapons Industrial Reserve Plant in Calverton was a Government-Owned Contractor Operated facility that originally occupied 6,000 acres (Appendix A, Figure A-4). Northrop Grumman operated the facility from its construction in the early 1950s until 1996, when operations ceased, and the land was returned to Navy control. The company transferred most of the land within the site to the Town of Riverhead for economic redevelopment, to NYSDEC for conservation and public recreation, or to the Veterans Administration.

The Navy retained three non-contiguous parcels of land totaling approximately 209 acres to continue Environmental Restoration Program activities. One of these areas was the source of groundwater contamination that migrated off-site, creating what is referred to as the Southern Area Plume (see Appendix A, Figure A-4). The Navy's Environmental Restoration Program is responsible for ensuring that appropriate remedial actions are developed and implemented as necessary to protect public health and the environment.

The Calverton facility is a NYSDEC State Superfund site, and chlorinated VOC groundwater contamination has migrated off the southern boundary of the site. The contaminated groundwater encompasses an area of approximately 118 acres, with 25 acres on Naval Weapons Industrial Reserve Plant Calverton property and 93 acres off the property [NWIRP 2012].

References for Appendix B

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Appendix C: Water Districts Reports: 1,4-Dioxane Summary Information Concentrations of 1,4 Dioxane in Water Supply Wells within the Northrop Grumman/NWIRP Facility Plume

Water District	Date	Range of 1,4-Dioxane Concentrations (micrograms per liter)
South Farmingdale Water District		
-	03-02-2014	ND – 1.0
-	12-18-2017	ND – 1.4
New York American Water Company, Merrick Operations		
-	2014	ND – 1.35
-	2017	ND – 1.35
Bethpage Water District		
-	12-11-2013	0.3 - 8.6
-	04-15-2016	2.1 - 12.0
-	11-30-2017	0.37 – 15.4

Data provided here are from Water Quality Reports:
http://sfwater.com/news/water-quality-reports/
http://www.amwater.com/ccr/merrick.pdf
http://bethpagewater.com/Water-Quality

Appendix D: Health Consultation Tables

Table D-1. Trichloroethene Concentrations in Raw, Untreated Water Samples from the New York American Water Company Seaman's Neck Well Field.

(all values in micrograms per liter)

Sampling Date	Concentration	
	Well 3 (N-8480)	Well 4 (N-9338)
2003	ND	NS
2004	ND	NS
2005	ND	NS
September 11, 2006	0.6	NS
September 26, 2006	NS	ND
October 2, 2006	0.5	NS
February 2, 2007	NS	ND
March 27, 2007	NS	ND
April 10, 2007	0.4	NS
April 25, 2007	0.5	ND
May 14, 2007	0.6	ND
June 5, 2007	0.6	ND
July 19, 2007	0.8	ND
August 7, 2007	0.6	ND
September 7, 2007	0.8	ND
October 4, 2007	0.8	ND
November 2, 2007	0.6	ND
December 5, 2007	NS	ND
December 10, 2007	0.5	NS
January 7, 2008	NS	ND
January 9, 2008	0.7	NS
February 4, 2008	0.5	ND
March 6, 2008	0.6	0.5
March 14, 2008	NS	0.5
March 19, 2008	NS	0.5
March 24, 2008	NS	< 0.5
April 2, 2008	< 0.5	< 0.5
May 1, 2008	0.6	NS
May 15, 2008	NS	< 0.5
June 5, 2008	NS	< 0.5
June 16, 2008	1.0	NS
July 15, 2008	1.2	< 0.5
August 15, 2008	1.1	< 0.5
September 3, 2008	1.4	< 0.5
October 6, 2008	0.9	NS
October 7, 2008	NS	< 0.5
November 7, 2008	0.7	NS
November 10, 2008	NS	< 0.5
December 2, 2008	0.8	< 0.5
January 6, 2009	NS	0.5
January 7, 2009	0.8	NS
February 13, 2009	0.8	< 0.5
March 4, 2009	0.9	< 0.5

Sampling Date	Concentration	
	Well 3 (N-8480)	Well 4 (N-9338)
April 6, 2009	NS	< 0.5
April 20, 2009	0.9	NS
May 13, 2009	0.9	0.5
July 14, 2009	NS	< 0.5
July 16, 2009	1.2	NS
August 11, 2009	1.2	< 0.5
September 11, 2009	1.6	< 0.5
October 8, 2009	0.9	< 0.5
December 8, 2009	NS	0.6
January 28, 2010	1.1	NS
March 8, 2010	NS	0.7
March 9, 2010	1.4	NS
June 2, 2010	1.9	NS
June 8, 2010	NS	< 0.5
July 28, 2010	2	< 0.5
October 5, 2010	2.1	< 0.5
February 12, 2011	2.4	NS
February 17, 2011	NS	0.9
June 17, 2011	2.3	ND
July 19, 2011	1.4	NS
July 20, 2011	NS	ND
July 22, 2011	NS	ND
October 13, 2011	NS	0.8
October 18, 2011	3.3	NS
October 28, 2011	2.6	NS
February 7, 2012	NS	1
April 10, 2012*	2.4	NS

*Temporary treatment operational.

NS = Well not sampled

ND = not detected, detection limit not available. Results beginning with "<" indicate that the chemical was not detected, followed by the analytical detection limit.

Table D-2. Trichloroethene (TCE), Tetrachloroethene (PCE), and 1,1,1-Trichloroethane (1,1,1-TCA) Concentrations for Raw, Untreated Water Samples from Bethpage Water District Well 6-1.

(all values in micrograms per liter)

Date of Sampling	Source	Trichloroethene (TCE) Concentration	Tetrachloroethene (PCE) Concentration	1,1,1-Trichloroethane (1,1,1-TCA) Concentration
November 29, 1976	raw water	28	ND	2
December 2, 1976	raw water	26	ND	3
December 6, 1976*	raw water	60	17	15

*Well taken out of service after collection of this sample.
ND = not detected, detection limit not available.

Table D-3. Trichloroethene (TCE), Tetrachloroethene (PCE), and 1,1,1-Trichloroethane (1,1,1-TCA) Concentrations for Raw, Untreated Water Samples from Bethpage Water District Well 6-2.

(all values in micrograms per liter)

Date of Sampling	Source	Trichloroethene (TCE) Concentration	Tetrachloroethene (PCE) Concentration	1,1,1-Trichloroethane (1,1,1-TCA) Concentration
February 1, 1985	raw water	1	ND	ND
July 24, 1985	raw water	1	ND	ND
October 8, 1985	raw water	ND	ND	ND
May 14, 1986	raw water	2	ND	ND
July 24, 1986	raw water	2	ND	ND
July 29, 1986	raw water	3	ND	ND
November 21, 1986	raw water	4	ND	ND
February 6, 1987	raw water	5	ND	ND
May 12, 1987	raw water	4	ND	ND
September 28,1987	raw water	4	ND	ND
March 29, 1988	raw water	0.8	ND	ND
April 26,1988	raw water	ND	ND	ND
September 22,1988	raw water	0.8	ND	ND
October 19, 1988	raw water	ND	ND	ND

ND = not detected, detection limit not available.

Table D-4. Trichloroethene (TCE) Concentrations for Raw, Untreated Water Samples from Bethpage Water District Well 4-1.

(all values in micrograms per liter)

Date of Sampling	Trichloroethene (TCE) Concentration
September 7, 1988	1.1
August 22, 1989	0.5
November 7, 1989	0.7
February 20, 1990	0.5
May 15, 1990	0.6
July 27, 1990	1
July 30, 1990	2.6
October 5, 1992	1.2
June 3, 1993	0.5
August 3, 1993	0.5
October 4, 1993	0.5
March 13, 1995	2.2

In accordance with New York State Part 5 drinking water regulations, routine monitoring of supply well water has been conducted. TCE was not detected (except as noted above) in 52 samples from 1976 to 1995.

Table D-5. Trichloroethene Concentrations for Raw, Untreated Water Samples from Bethpage Water District Well 4-2.

(all values in micrograms per liter)

Date of Sampling	Trichloroethene (TCE) Concentration
January 7, 1993	0.8
January 12, 1993	0.6
January 13, 1993	<0.5
February 8, 1993	0.5
March 2, 1993	0.5
April 6, 1993	<0.5
May 6, 1993	0.5
June 3, 1993	0.6
July 7, 1993	0.6
August 3, 1993	<0.5
September 2, 1993	<0.5
October 4, 1993	0.7
June 14, 1994	<0.5
July 13, 1994	0.5
August 2, 1994	0.5
October 3, 1994	1
March 13, 1995	<0.5
May 2, 1995	<0.5

Results beginning with "<" indicate that the chemical was not detected, followed by the analytical detection limit.

In accordance with New York State Part 5 drinking water regulations, routine monitoring of supply well water has been conducted. TCE was not detected except as noted above from 1993 to 1995.

Appendix E: Health Effects of Site-Related Chemicals

Health Effects of Trichloroethene (TCE), Tetrachloroethene (PCE) and 1,1,1-Trichloroethane (1,1,1-TCA)

All chemicals can cause health effects. The risk for adverse health effects from any chemical depends on the chemical's toxicity, the amount of the chemical to which a person is exposed, and how long and how often the exposure occurs. Below is some general information about the kinds of health effects that are associated with exposure to chemicals associated with the Northrop Grumman/Naval Weapons Industrial Reserve Plant Facilities.

The EPA classifies TCE as carcinogenic to humans by all routes of exposure [EPA 2011a,b]. The types of cancer most strongly associated with human TCE exposure are non-Hodgkin's lymphoma and cancer of the liver and kidney. The EPA identifies TCE as a chemical that causes kidney cancer by a mutagenic mode of action and recommends the use of age-dependent adjustment factors to account for the greater vulnerability of cancer in early life stages when evaluating cancer risks from TCE exposure [EPA 2005, 2006, 2011a]. PCE is classified by EPA as likely to be carcinogenic to humans by all routes of exposure [EPA 2012a,b]. There is inadequate information to assess the carcinogenic potential of 1,1,1-TCA [EPA 2007a,b].

Exposure to TCE, PCE and 1,1,1-TCA at levels higher than typical environmental exposures can cause noncancer health effects, primarily on the nervous system and liver [ATSDR 2006; DOH 2006; EPA 2011a; 2012a]. Exposure to 1,1,1-TCA causes body weight changes and can damage the cardiovascular system in laboratory animals [ATSDR 2006]. Exposure to TCE affects the immune system of laboratory animals and can cause fetal heart malformations in their offspring [EPA 2011a]. Some studies report an increased risk for adverse effects on human fetal heart development in the offspring of women who lived in areas with elevated levels of TCE in air or drinking water [Goldberg et al. 1990; Forand et al. 2012]. Due to the limitations of the studies, including poor or no quantitative exposure estimates, it is not known if the observed effects on fetal development in humans were caused by TCE or some other factor. Studies of people exposed to mixtures of chlorinated solvents (including PCE) in drinking water during pregnancy suggest an increased risk for birth defects, but there are uncertainties about how much contaminated water the women drank during pregnancy and about how much PCE was in that water [EPA 2012a]. Some studies show a slightly increased risk for some types of reproductive effects among workers (including dry-cleaning workers) exposed to PCE and other chemicals [DOH 2013]. In each of these PCE studies, the role of other factors in causing these effects is not fully known, and they therefore suggest, but do not prove, that PCE can cause reproductive toxicity and effects on the developing fetus.

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Appendix F: Sample Calculations

ATSDR-Recommended Exposure Parameters for Drinking Water

Age Group	Reasonable Maximum Exposure			Central Tendency Exposure		
	Drinking Water Daily Intake (mL/day)	Body Weight (kg)	Drinking Water Daily Dose (L/kg/day)	Drinking Water Daily Intake (mL/day)	Body Weight (kg)	Drinking Water Daily Dose (L/kg/day)
Birth to < 1 year	1113	7.8	0.1427	504	7.8	0.0646
1 to < 2 years	893	11.4	0.0783	308	11.4	0.0270
2 to < 6 years	977	17.4	0.0561	376	17.4	0.0216
6 to < 11 years	1404	31.8	0.0442	511	31.8	0.0161
11 to < 16 years	1976	56.8	0.0348	637	56.8	0.0112
16 to < 21 years	2444	71.6	0.0341	770	71.6	0.0108
≥ 21 years	3092	80	0.0387	1227	80	0.0153
Pregnant women	2589	73	0.0355	872	73	0.0119

mL/day = milliliters per day; kg = kilograms; L/kg/day = liters per kilogram per day
ATSDR 2016; EPA 2011c

All sample calculations are done using the maximum drinking water concentration of trichloroethene or tetrachloroethene in the 6-1 well. All calculations are done using ATSDR's Exposure Dose Guidance for Drinking Water Ingestion [ATSDR 2016].

1. **Calculation of Noncancer Exposure Estimates and Hazard Quotients:**

   A. Noncancer Ingestion Exposure Dose:

$$\mathrm{D} = 2(C) \times IR$$

D = exposure dose (mg/kg/day)
C = Contaminant concentration in drinking water, doubled to account for exposure via non-ingestion pathways (mg/L)
IR = Age-specific water ingestion rate (L/kg/day)

   B. Hazard Quotient:

$$\mathrm{HQ} = \frac{D}{RfD}$$

D = exposure dose (mg/kg/day)
RfD = reference dose (mg/kg/day)

Northrop Grumman Groundwater Contamination Area
Noncancer Exposure Estimates and Hazard Quotients

Trichloroethene - Bethpage Water District Well 6-1 (average concentration = 38 mcg/L; maximum concentration = 60 mcg/L)

Group	Water Concentration (mg/L)	Double Water Concentration (mg/L)	Drinking Water Consumption Rate[1] (L/kg/day)		Exposure Dose (mg/kg/day)		Reference Dose[2] (mg/kg/day)	Hazard Quotient[3]	
			RME	CTE	RME	CTE		RME	CTE
0 to < 1	0.038	0.076	0.143	0.065	1.08E-02	4.91E-03	5.0E-04	21.7	9.8
1 to < 2	0.038	0.076	0.078	0.027	5.95E-03	2.05E-03	5.0E-04	11.9	4.1
2 to < 6	0.038	0.076	0.056	0.022	4.27E-03	1.64E-03	5.0E-04	8.5	3.3
6 to < 11	0.038	0.076	0.044	0.016	3.36E-03	1.22E-03	5.0E-04	6.7	2.4
11 to < 16	0.038	0.076	0.035	0.011	2.64E-03	8.52E-04	5.0E-04	5.3	1.7
16 to < 21	0.038	0.076	0.034	0.011	2.59E-03	8.17E-04	5.0E-04	5.2	1.6
≥ 21	0.038	0.076	0.039	0.015	2.94E-03	1.17E-03	5.0E-04	5.9	2.3
Pregnant Women	0.060	0.120	0.035	0.012	4.20E-03	1.44E-03	5.0E-04	8.4	2.9

[1]Drinking water consumption rates are from the Exposure Factors Handbook (EPA 2011c) and applied as recommended by ATSDR (ATSDR 2016).

[2]Reference dose derived by the United States Environmental Protection Agency (EPA 2011b).

[3]Hazard quotient = contaminant dose/reference dose.

mcg/L: micrograms per liter; mg/L: milligrams per liter; L/kg-day: liters per kilogram per day; mg/kg/day: milligrams per kilogram per day; RME = reasonable maximum exposure; CTE= central tendency exposure

C. Calculation of Margins of Exposure:

$$\mathrm{MOE} = \frac{Effect\ Level}{Estimated\ Exposure\ Dose}$$

Effect level: For TCE, a lowest observe effect level (LOEL) for decreased thymus weights in mice for immune toxicity of 0.048 mg/kg/day or a 1% increased risk for fetal malformations in rats ($BMDL_{01}$, see EPA 2011b) of 0.0051 mg/kg/day

Trichloroethene - Bethpage Water District Well 6-1
Calculation of Margins of Exposure for Immune and Developmental Toxicity

Contaminant	Water District	Well	Contaminant Concentration[1] (mcg/L)	Reference Dose[2] (mg/kg/day)	Adult			Child		
					Dose (mg/kg/day)	Hazard Quotient[3]	Margin of Exposure[4]	Dose (mg/kg/day)	Hazard Quotient[3]	Margin of Exposure[4]
TCE	Bethpage	6-1	38.0	5E-04	2.94E-03	5.87	16	1.08E-02	21.7	4.4
	Bethpage	6-1	60.0	5E-04	4.20E-03	8.40	1.2	-	-	-

[1]The average TCE concentration is used to evaluate immunotoxicity for children and adults, the maximum TCE concentration and the maternal dose are used to evaluate developmental toxicity.
[2]Reference dose derived by the United States Environmental Protection Agency (EPA 2011b).
[3]Hazard quotient = contaminant dose/reference dose.
[4]The margin of exposure for immune toxicity is the dose that corresponds to a lowest observe effect level (LOEL) for decreased thymus weights in mice (see EPA 2011b) divided by the estimated adult or child contaminant exposure at the average TCE water concentration. The dose at the LOEL for decreased thymus weights is 0.048 mg/kg/day. Margin of exposure for immune toxicity = (0.048 mg/kg/day)/dose. The margin of exposure for developmental toxicity is the dose that corresponds to a 1% increased risk for fetal malformations in rats (BMDL01, see EPA 2011b) divided by the estimated contaminant exposure for a pregnant woman at the highest TCE water concentration. The $BMDL_{01}$ for fetal heart malformations is 0.0051 mg/kg/day. Margin of exposure for developmental toxicity = (0.0051 mg/kg/day)/dose.
TCE = trichloroethene; mcg/L: micrograms per liter; mg/kg/day: milligrams per kilogram per day

2. Calculation of Cancer Risk:

A. Cancer Ingestion Exposure Dose

$$\mathrm{D} = 2(C)\ \times (\frac{ED}{AT})\ \times\ IR$$

D = Exposure dose (mg/kg/day)
C = Contaminant concentration in drinking water, doubled to account for exposure via non-ingestion pathways (mg/L)
ED = Exposure duration, specific to how long each well was in use (years)
AT = Averaging time (78 years)
IR = Age-specific water ingestion rate (L/kg/day)

B. Cancer risk:

Cancer risk = exposure dose x cancer slope factor

C. Lifetime RME cancer risk:

Lifetime cancer risk = sum of cancer risk for each age group

Bethpage Water District Well 6-1
Calculation of Tetrachloroethene Cancer Risk in Drinking Water
(Average Drinking Water Concentration = 5.8 mcg/L; Exposure Duration = 24 years)

Age Group	Exposure Duration (years)	Fraction of Lifetime	Drinking Water Concentration (mg/L)	Drinking Water Concentration Doubled (mg/L)	Drinking Water Consumption Rate (L/kg/day)		Exposure Dose (mg/kg/day)		Cancer Risk	
					RME	CTE	RME	CTE	RME	CTE
0 to < 1	1	0.0128	0.0058	0.0116	0.143	0.065	0.002	0.001	4.5E-08	2.0E-08
1 to < 2	1	0.0128	0.0058	0.0116	0.078	0.027	0.001	0.000	2.4E-08	8.4E-09
2 to < 6	4	0.0513	0.0058	0.0116	0.056	0.022	0.001	0.000	7.0E-08	2.7E-08
6 to < 11	5	0.0641	0.0058	0.0116	0.044	0.016	0.001	0.000	6.9E-08	2.5E-08
11 to < 16	5	0.0641	0.0058	0.0116	0.035	0.011	0.000	0.000	5.4E-08	1.8E-08
16 to < 21	5	0.0641	0.0058	0.0116	0.034	0.011	0.000	0.000	5.3E-08	1.7E-08
21 to < 24	3	0.0385	0.0058	0.0116	0.039	0.015	0.000	0.000	3.6E-08	1.4E-08
					Total Cancer Risk for 24 Year Exposure:				3.5E-07	1.3E-07

mcg/L = micrograms per liter; mg/L = milligrams per liter, RME = reasonable maximum exposure; CTE = central tendency exposure
Cancer risk calculated according to ATSDR guidance (ATSDR 2016). Cancer potency factor = 0.0021 $(mg/kg/day)^{-1}$ (EPA 2012b).
Drinking water consumption rates are from the Exposure Factors Handbook (US EPA, 2011c) and applied as recommended by ATSDR (ATSDR 2016).

3. Calculation of Trichloroethene Cancer Risk using Age Dependent Adjustment Factors:

A. Kidney cancer risk adjusted with ADAFs for mutagenic mode of action:

$$\text{Kidney cancer risk} = 2(C) \times \left(\frac{ED}{AT}\right) x\ IR\ x\ ADAF\ x\ CPF$$

C = Contaminant concentration in drinking water, doubled to account for exposure via non-ingestion pathways (mg/L)
ED = Exposure duration, specific to how long each well was in use (years)
AT = Averaging time (78 years)
IR = Age-specific water ingestion rate (L/kg/day)
ADAF = Age-dependent adjustment factor
CPF = Unadjusted lifetime kidney cancer potency factor $(mg/kg/day)^{-1}$

B. Non-Hodgkin's Lymphoma and liver cancer risk:

$$\text{NHL and liver cancer risk} = 2(C) \times \left(\frac{ED}{AT}\right) x\ IR\ x\ CPF$$

C = Contaminant concentration in drinking water, doubled to account for exposure via non-ingestion pathways (mg/L)
ED = Exposure duration, specific to how long each well was in use (years)
AT = Averaging time (78 years)
IR = Age-specific water ingestion rate (L/kg/day)
CPF = Unadjusted lifetime Non-Hodgkin's Lymphoma and liver cancer potency factor $(mg/kg/day)^{-1}$

C. TCE cancer risk:

$$\text{TCE cancer risk} = \text{Kidney cancer risk} + [\text{Non Hodgkin's Lymphoma and liver cancer risk}]$$

D. Total TCE lifetime cancer risk:

$$\text{Lifetime TCE cancer risk} = \text{sum of TCE cancer risk for each age group}$$

Bethpage Water District Well 6-1

Calculation of Trichloroethene Cancer Risk in Drinking Water Using Age Dependent Adjustment Factors

(Average Drinking Water Concentration = 38 mcg/L; Exposure Duration = 24 years)

ATSDR Recommended 95th Percentile Ingestion Rates (RME)

EXPOSURE PARAMETERS						DOSE RESPONSE ASSESSMENT CALCULATIONS						
Age Group	Drinking Water Consumption Rate (L/kg/day)	Drinking Water Concentration (mg/L)	Drinking Water Concentration Doubled (mg/L)	Years	Fraction of Lifetime	Kidney Unadjusted Potency Factor $(mg/kg/day)^{-1}$	ADAFs	Kidney ADAF Adjusted Partial Risk	Kidney + NHL + Liver Unadjusted Potency Factor $(mg/kg/day)^{-1}$	NHL + Liver Unadjusted Potency Factor $(mg/kg/day)^{-1}$	NHL and Liver Partial Risk	Total Risk
0 to < 1	0.1427	0.038	0.076	1	0.0128	9.30E-03	10	1.29E-05	4.60E-02	3.67E-02	5.10E-06	1.80E-05
1 to < 2	0.0783	0.038	0.076	1	0.0128	9.30E-03	10	7.10E-06	4.60E-02	3.67E-02	2.80E-06	9.90E-06
2 to < 6	0.0561	0.038	0.076	4	0.0513	9.30E-03	3	6.11E-06	4.60E-02	3.67E-02	8.03E-06	1.41E-05
6 to < 11	0.0442	0.038	0.076	5	0.0641	9.30E-03	3	6.00E-06	4.60E-02	3.67E-02	7.89E-06	1.39E-05
11 to < 16	0.0348	0.038	0.076	5	0.0641	9.30E-03	3	4.73E-06	4.60E-02	3.67E-02	6.22E-06	1.09E-05
16 to < 21	0.0341	0.038	0.076	5	0.0641	9.30E-03	1	1.55E-06	4.60E-02	3.67E-02	6.10E-06	7.65E-06
21 to < 24	0.0387	0.038	0.076	3	0.0385	9.30E-03	1	1.05E-06	4.60E-02	3.67E-02	4.15E-06	5.20E-06
										Total Risk for 24 Year Exposure:		**7.98E-05**

RME = reasonable maximum exposure; CTE = central tendency exposure; mcg/L: micrograms per liter; mg/L: milligrams per liter; L/kg-day: liters per kilogram per day; mg/kg/day: milligrams per kilogram per day;

NHL: non-Hodgkin's lymphoma; ADAF = age-dependent adjustment factor.

Drinking water consumption rates are from the Exposure Factors Handbook (US EPA, 2011c) and applied as recommended by ATSDR (ATSDR 2016). Age-Dependent Adjustment Factors (ADAFs) are recommended by US EPA (2005, 2006) for chemicals such as TCE that cause cancer by a mutagenic mode of action and are applied as recommended by ATSDR (ATSDR 2016).

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Appendix G: Evaluation of Inhalation Exposures Using ATSDR's Shower and Household Water Use (SHOWER) Model

Introduction

Exposure to volatile organic compounds (VOCs) in drinking water is possible not only by ingestion, but also by inhalation and dermal absorption from water uses such as showering and bathing. In the draft public comment release of the Northrop Grumman/Naval Weapons Industrial Reserve Plant Facilities Groundwater Impacts Health Consultation (dated May 23, 2019), the NYSDOH doubled the contaminant drinking water concentrations to account for inhalation and dermal exposures that could have occurred through showering and other non-drinking uses. Since the time the health consultation was prepared, ATSDR has released the Shower and Household Water Use Exposure (SHOWER) Model [ATSDR 2020]. The SHOWER model provides health assessors with an alternative way to evaluate inhalation and dermal exposures from VOCs in household water. This appendix summarizes the estimated risks for inhalation exposures to site-related VOCs obtained with the SHOWER model and compares them to the risk estimates in the original Health Consultation.[10]

SHOWER Model Parameters

The SHOWER model predicts average daily air exposure concentrations based on the concentrations of the contaminants in the drinking water and several exposure parameters. The NYSDOH ran the model using the following parameters and assumptions:

- Each person in a four-person household takes an 8-minute shower, followed by a 5-minute bathroom stay (13-minute total bathroom stay)
- The showers occur sequentially in the morning
- The bathroom fan is off during each shower

Results (average daily exposure concentrations) are provided for the most exposed person, who showers last and stays home all day.

Methods for Evaluation of Inhalation Exposures

The NYSDOH used the daily indoor air concentrations predicted by the SHOWER model to evaluate cancer and noncancer risks for inhalation exposures for trichloroethene (TCE), tetrachloroethene (PCE), and 1,1,1-trichloroethane (1,1,1-TCA; noncancer risk only) in water. The inhalation lifetime cancer risks were calculated by multiplying the daily contaminant air concentration by the contaminant's inhalation unit risk with applicable time-weighting. An inhalation unit risk is a numerical estimate of a contaminant's carcinogenic strength (potency). Noncancer risks for inhalation exposure were evaluated by comparing the daily indoor air concentrations to the contaminant's reference concentration[11]. A reference concentration is an air concentration at which noncancer health effects are unlikely to occur, assuming exposures of up to a lifetime.

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[10] The NYSDOH also evaluated dermal exposures using the SHOWER model by comparing the dermal exposure estimates to each contaminant's reference dose or minimal risk level, and by estimating the cancer risks using the contaminant's cancer potency factor and applicable time-weighting. The risk for noncancer health effects for contaminants in all wells via dermal exposure is minimal because all dermal exposure estimates were well below the corresponding reference doses, and the estimated cancer risks from dermal exposure were well below one in one million.

[11] Agencies use different terms for the reference concentration, including chronic reference exposure level, tolerable concentration in air, and chronic inhalation minimal risk level.

Evaluation of Cancer Risks for TCE and PCE

The NYSDOH used the SHOWER model to calculate an average daily air concentration based on the average contaminant concentration in the drinking water. The average daily air exposure concentration is then time-weighted for the length of time that the corresponding well was known or estimated to be contaminated and people were using the water. For TCE, the cancer risks are calculated using age-dependent adjustment factors to account for the potential increased vulnerability in early life stages for those exposed to chemicals such as TCE that cause cancer by a mutagenic mode of action [USEPA 2005, 2006, 2011].

The inhalation cancer risks (from showering) for TCE and PCE are added to the oral cancer risks (from drinking the water) to calculate a combined lifetime cancer risk that reflects exposure from both pathways (Table G-1). The oral cancer risks in Table G-1 were calculated using the same methods as in the original Public Health Consultation, except that the water concentrations for each well were not doubled.

Table G-1. Cancer Risks for Combined Oral and Inhalation Exposure to TCE and PCE

Chemical	Public Water Supply Well	Average Water Concentration[1] (mcg/L)	Average Daily Air Exposure Concentration[2] (mcg/m^3)	Exposure Duration[3] (years)	Cancer Risk for Oral Exposure[4]	Cancer Risk from Inhalation Exposure[5]	Combined Cancer Risk[6]
TCE	BWD 6-1	38	13	24	4.0E-05	2.4E-05	6.4E-05
	BWD 6-2	2	0.7	4	9.2E-07	3.5E-07	1.3E-06
	BWD 4-1	0.49	0.17	7	2.9E-07	1.2E-07	4.1E-07
	BWD 4-2	0.48	0.16	3	2.0E-07	6.6E-08	2.7E-07
	NYAWC 3	1.1	0.39	6	6.2E-07	2.5E-07	8.7E-07
	NYAWC 4	0.37	0.13	4	1.7E-07	6.4E-08	2.3E-07
PCE	BWD 6-1	5.8	1.5	24	1.8E-07	1.2E-07	3.0E-07

[1] The average water concentration is used to calculate lifetime cancer risks for oral exposure.

[2] The average daily air exposure concentration is calculated using ATSDR's SHOWER model [ATSDR 2020].

[3] The duration of contaminant exposure was generally assumed to be the length of time between when the contaminant was first detected in each well to the time of the last detection and when people were known to still be drinking water from that well. The exception to this was Well 6-1 where the duration of contaminant exposure was assumed to be 24 years (see Exposure Pathways in the Discussion section of Public Health Consultation)

[4] The TCE oral cancer risk was calculated using the USEPA cancer potency factor of 0.046 (mg/kg/day)$^{-1}$, according to guidance for chemicals such as TCE that are considered to cause cancer by a mutagenic mode of action [USEPA 2005, 2006, 2011]. The PCE oral cancer risk was calculated by multiplying the estimated contaminant dose by the USEPA cancer potency factor of 0.0021 (mg/kg/day)$^{-1}$ [USEPA 2012].

[5] The TCE inhalation cancer risk was calculated by using the USEPA inhalation TCE unit risk of 4.1E-06 (mcg/m^3)$^{-1}$, according to guidance for chemicals such as TCE that are considered to cause cancer by a mutagenic mode of action [USEPA 2005, 2006, 2011]. The PCE inhalation cancer risk was calculated by multiplying the estimated contaminant air concentration by the USEPA inhalation unit risk of 2.6E-07 (mcg/m^3)$^{-1}$ [USEPA 2012].

[6] The combined cancer risk is the sum of the cancer risks for oral exposure and inhalation exposure.

mcg/L = micrograms per liter; mcg/m^3 = micrograms per cubic meter; BWD = Bethpage Water District; NYAWC = New York American Water Company.

The combined cancer risks from oral and inhalation exposure (with the inhalation portion obtained from the SHOWER model) are reported in Table G-1 and are compared in Table G-2 to the cancer risk estimates from the original Public Health Consultation. When the SHOWER model was used to estimate the inhalation contribution to the cancer risk, the estimated increased lifetime cancer risks posed by past oral and inhalation exposures to TCE ranged from two in ten million to six in one hundred thousand. When the average water concentration was simply doubled to take inhalation exposures into account, the cancer risks ranged from three in ten million to eight in one hundred thousand. For PCE in Well 6-1, the combined oral and inhalation cancer risk using the SHOWER model was three in ten million and the cancer risk when the average water concentration was doubled was four in ten million. Overall, the two methods produced similar estimated cancer risks for TCE and PCE and use of the SHOWER model would not alter the conclusions of the Public Health Consultation nor the NYSDOH qualitative characterization of the cancer risks for either contaminant (either very low to low).

Table G-2. Comparison of Estimated Lifetime Cancer Risks Using the SHOWER Model and Doubled Water Concentrations

Chemical	Public Water Supply Well	Combined Oral and Inhalation Cancer Risk Using SHOWER Model[1]	Cancer Risk from Doubling Average Water Concentration[2]
TCE	BWD 6-1	6 in 100,000	8 in 100,000
	BWD 6-2	1 in 1,000,000	2 in 1,000,000
	BWD 4-1	4 in 10,000,000	6 in 10,000,000
	BWD 4-2	3 in 10,000,000	4 in 10,000,000
	NYAWC 3	9 in 10,000,000	1 in 1,000,000
	NYAWC 4	2 in 10,000,000	3 in 10,000,000
PCE	BWD 6-1	3 in 10,000,000	4 in 10,000,000

[1] The SHOWER model was used to calculate the daily indoor air concentrations of TCE and PCE that people could have been exposed to from showering and household water use. The daily indoor air concentrations are used to calculate the inhalation component of the combined cancer risk.

[2] These cancer risks are from the Public Health Implications section of the original Public Health Consultation. The average drinking water concentration was doubled to account for inhalation exposures.

BWD= Bethpage Water District; NYAWC = New York American Water Company.

Evaluation of Noncancer Risks for TCE, PCE and 1,1,1-TCA

TCE

To evaluate the noncancer risks from exposure to TCE, the hazard quotients from oral exposure and inhalation exposure were calculated. The hazard quotient is the ratio of the oral or inhalation exposure to the contaminant's reference dose or reference concentration, respectively. The hazard quotients for the oral and inhalation pathways are then added to obtain the hazard index[12]. Direct addition of the ingestion and inhalation TCE hazard quotients is possible because both the USEPA reference dose and reference concentration (used to

[12] A hazard index is the sum of hazard quotients for contaminants that affect the same target organ or organ system.

evaluate ingestion and inhalation exposure separately) are based on identical studies, toxicological endpoints (immune toxicity in mice and developmental toxicity in rats), internal doses, pharmacokinetic models, points of departure, and uncertainty factors. As with hazard quotients, a hazard index less than one indicates a minimal risk for adverse noncancer health effects. A hazard index of greater than one does not necessarily mean adverse effects are likely, but that further evaluation of the exposure is needed. For water supply wells where the TCE hazard index was greater than one, the margin of exposure was evaluated. The margin of exposure is the ratio of the exposure associated with TCE health effects from animal studies (i.e., immune or developmental toxicity) to the combined ingestion and inhalation exposure from drinking water and showering.

TCE Immune Toxicity

To evaluate risks to the immune system from TCE exposure, the NYSDOH used the SHOWER model to calculate a daily air concentration based on the average water concentration. The inhalation hazard quotients for TCE were added to the oral hazard quotients. The oral hazard quotients were calculated using the same method as in the original Public Health Consultation, except the average water concentrations for each well were not doubled. The margin of exposure was calculated for any well where the TCE concentrations resulted in a hazard index greater than 1. Hazard quotients, hazard indices, and margins of exposure for immune toxicity are presented in Table G-3. These indicators of the noncancer risk for immune toxicity calculated using the SHOWER model are compared in Table G-4 to those from the original Public Health Consultation.

Table G-3. Oral and Inhalation Hazard Quotients, Hazard Indices, and Margins of Exposure for TCE Immune Toxicity

Public Water Supply Well	Average Water Concentration[1] (mcg/L)	Average Daily Air Exposure Concentration[2] (mcg/m^3)	Hazard Quotient for Oral Exposure[3]	Hazard Quotient for Inhalation Exposure[4]	Hazard Index for Immune Toxicity[5]	Margin of Exposure for Immune Toxicity[6]
BWD 6-1	38	13	11	6.5	17.5	5.7
BWD 6-2	2	0.70	0.57	0.35	0.92	na
BWD 4-1	0.49	0.17	0.14	0.08	0.22	na
BWD 4-2	0.48	0.16	0.14	0.08	0.22	na
NYAWC 3	1.1	0.39	0.32	0.19	0.51	na
NYAWC 4	0.37	0.13	0.11	0.06	0.17	na

[1] The average water concentration is used to evaluate immune toxicity risks resulting from long term exposure.

[2] The average daily air exposure concentration is calculated using ATSDR's SHOWER model.

[3] The hazard quotient for oral exposure is calculated by dividing the estimated contaminant exposure by the US EPA reference dose of 0.0005 mg/kg/day [USEPA 2011].

[4] The hazard quotient for inhalation exposure is calculated by dividing the estimated contaminant exposure by the US EPA reference concentration of 2 mcg/m^3 [USEPA 2011].

[5] The hazard index is the sum of the ingestion and inhalation hazard quotients for TCE. As with hazard quotients, a hazard index less than one indicates a minimal risk for adverse noncancer health effects and a hazard index greater than one indicates a need for further evaluation of the exposure.

[6] The margin of exposure is calculated by dividing the uncertainty factor (100; see USEPA [2011]) used to derive the TCE reference dose and reference concentration for immune system toxicity by the hazard index. A margin of exposure was not calculated if the hazard index was less than one.

mcg/L = micrograms per liter; mcg/m^3 = micrograms per cubic meter; BWD = Bethpage Water District; NYAWC = New York American Water Company; na = not applicable.

As indicated in Table G-4, the SHOWER model and doubling the water concentration to account for the inhalation exposure component for TCE in drinking water resulted in similar measures of noncancer risks when evaluating immune toxicity (as indicated by the hazard quotients, hazard indices, and margins of exposure). Consequently, using the SHOWER model to evaluate non-ingestion exposures would not change any of the risk characterizations or conclusions for immune toxicity in the original Public Health Consultation, including the conclusion that past exposure to TCE in Bethpage Well 6-1 could have increased the risk for effects on the immune system.

Table G-4. Comparison of Hazard Indices, Hazard Quotients and Margins of Exposure for TCE Immune Toxicity Using the SHOWER Model and Doubled Water Concentrations

Public Water Supply Well	Hazard Index for Immune Toxicity with SHOWER Model[1]	Margin of Exposure for Immune Toxicity with SHOWER Model	Hazard Quotient Doubling Water Concentration[2]	Margin of Exposure for Immune Toxicity with Doubling Water Concentration
BWD 6-1	17.5	5.7	22	4.5
BWD 6-2	0.92	na	1.1	84
BWD 4-1	0.22	na	0.28	na
BWD 4-2	0.22	na	0.27	na
NYAWC 3	0.51	na	0.64	na
NYAWC 4	0.17	na	0.21	na

[1] The SHOWER model was used to calculate the average daily air concentrations of TCE that people could have been exposed to from showering and household water use. The air concentrations are used to calculate the inhalation component of the combined noncancer risk. The oral hazard quotients are added to the inhalation hazard quotients to calculate the hazard index shown.

[2] The hazard quotients are from the Public Health Implications section of the original Public Health Consultation. The average drinking water concentration was doubled to account for inhalation exposures.

BWD = Bethpage Water District; NYAWC = New York American Water Company; na = not applicable, margins of exposure are generally not calculated when the hazard index or hazard quotient is less than 1.

TCE Developmental Toxicity

The NYSDOH used the highest TCE water concentrations, and exposure parameters for a pregnant woman to evaluate the risk for developmental effects because these effects could occur after relatively short periods of exposure (e.g., early pregnancy). The SHOWER model calculates a daily air concentration of TCE based on the highest water concentrations in each well. To estimate noncancer risks, the resulting hazard quotient for developmental toxicity for TCE inhalation exposure is then added to the hazard quotient for oral TCE exposure. The oral hazard quotients were calculated using the same method as in the original Public Health Consultation, except the water concentrations for each well were not doubled. Hazard quotients, hazard indices and margins of exposure are shown in Table G-5. Table G-6 compares these indicators of the risk for developmental toxicity calculated using the SHOWER model to those from the original Public Health Consultation.

Table G-5. Oral and Inhalation Hazard Quotients, Hazard Indices, and Margins of Exposure for TCE Developmental Toxicity

Public Water Supply Well	Highest Water Concentration (mcg/L) [1]	Average Daily Air Concentration[2] (mcg/m^3)	Hazard Quotient for Oral Exposure[3]	Hazard Quotient for Inhalation Exposure[4]	Hazard Index for Developmental Toxicity[5]	Margin of Exposure for Developmental Toxicity[6]
BWD 6-1	60	21	4.3	11	15.3	0.7
BWD 6-2	5	1.8	0.35	0.90	1.3	7.7
BWD 4-1	2.6	0.92	0.18	0.46	0.64	na
BWD 4-2	1	0.35	0.07	0.18	0.25	na
NYAWC 3	3.3	1.2	0.23	0.60	0.83	na
NYAWC 4	1	0.34	0.07	0.18	0.25	na

[1] The highest TCE water concentrations are used as the exposure point concentrations for evaluating developmental toxicity to account for the possibility that developmental effects could occur after relatively short periods of exposure during pregnancy.
[2] The average daily air concentration is calculated using ATSDR's SHOWER model [ATSDR 2020].
[3] The hazard quotient for ingestion exposure is calculated by dividing the estimated contaminant exposure by the USEPA TCE reference dose of 0.0005 mg/kg/day [USEPA 2011].
[4] The hazard quotient for inhalation exposure is calculated by dividing the estimated contaminant exposure by the USEPA TCE reference concentration of 2 mcg/m^3 [USEPA 2011].
[5] The hazard index is the sum of the ingestion and inhalation hazard quotients for TCE. As with hazard quotients, a hazard index less than one indicates a minimal risk for adverse noncancer health effects and a hazard index greater than one indicates a need for further evaluation of the exposure.
[6] The margin of exposure is calculated by dividing the uncertainty factor (10; see USEPA [2011]) used to derive the TCE reference dose and reference concentration for developmental toxicity by the hazard index. A margin of exposure was not calculated if the hazard index was less than one.
mcg/L = micrograms per liter; mcg/m^3 = micrograms per cubic meter; BWD = Bethpage Water District; NYAWC = New York American Water Company; na = not applicable.

For the evaluation of TCE developmental toxicity (Table G-6), using the SHOWER model to account for the inhalation exposure component results in hazard indices that are almost twice the hazard quotients obtained by doubling the water concentrations, and the corresponding margins of exposure are about halved. For Bethpage Well 6-1, the estimated combined exposure using the SHOWER model exceeds the TCE exposure associated with developmental toxicity (hazard index 15.3), indicating that the exposure could result in an increased risk for developmental health effects. This conclusion is consistent with that reached by the NYSDOH for the highest TCE concentration in Bethpage Well 6-1 in the original Public Health Consultation. For Bethpage Well 6-2, the combined oral and inhalation exposure using the SHOWER model results in a margin of exposure of 7.7, compared to 14.3 obtained by doubling the water concentration. The NYSDOH concludes that this margin of exposure indicates a low risk for developmental health effects, based on the degree of the margin of protection, the conservative assumptions used by the SHOWER model to predict the inhalation exposure, and the conservative parameters used to derive the US EPA TCE reference dose and reference concentrations (i.e., the point of departure is based on a modeled 1% response for the 99th percentile exposure). Thus, use of the SHOWER model to evaluate the inhalation component of the TCE water exposure does not change any of the overall conclusions or risk characterizations of the Public Health Consultation with respect to developmental toxicity.

Table G-6. Comparison of Hazard Indices, Hazard Quotients and Margins of Exposure for TCE Developmental Toxicity Using the SHOWER Model and Doubled Water Concentrations

Public Water Supply Well	Hazard Index for Developmental Toxicity with SHOWER Model[1]	Margin of Exposure for Developmental Toxicity with SHOWER Model	Hazard Quotient Doubling Water Concentration[3]	Margin of Exposure for Developmental Toxicity with Doubling Water Concentration
BWD 6-1	15.3	0.7	8.5	1.2
BWD 6-2	1.3	7.7	0.71	14.1
BWD 4-1	0.64	na	0.37	na
BWD 4-2	0.25	na	0.14	na
NYAWC 3	0.83	na	0.16	na
NYAWC 4	0.25	na	0.14	na

[1] The SHOWER model was used to calculate the average daily air exposure concentrations of TCE that people could have been exposed to from showering and household water use. The air concentrations are used to calculate the inhalation component of the combined noncancer risk. The oral hazard quotients are added to the inhalation hazard quotients to calculate the hazard index shown.

[2] The hazard quotients are from the Public Health Implications section of the original Public Health Consultation. The highest drinking water concentration was doubled to account for inhalation exposures.

BWD= Bethpage Water District; NYAWC = New York American Water Company; na = not applicable, margins of exposure are generally not calculated when the hazard index or hazard quotient is less than 1.

PCE and 1,1,1-TCA

The NYSDOH also used the SHOWER model to evaluate the noncancer inhalation risks for exposure to PCE and 1,1,1-TCA in Bethpage Well 6-1. The hazard quotients for the inhalation pathway for both chemicals are well below 1 (see Table G-7), meaning that the exposure is far less than their reference concentrations, and that there is minimal risk for noncancer health effects. The inhalation exposures for PCE and 1,1,1-TCA also contribute insignificantly to the oral exposures for these contaminants, which were both far less than the PCE and 1,1,1-TCA reference doses. Thus, use of the SHOWER model does not change the conclusion from the original Public Health Consultation, that past ingestion and inhalation exposures to PCE and 1,1,1-TCA in Bethpage Well 6-1 were unlikely to harm people's health.

Table G-7. SHOWER Model Air Concentrations and Noncancer Inhalation Hazard Quotients for PCE and 1,1,1-TCA

Chemical	Well	Average Water Concentration[1] (mcg/L)	Average Daily Air Exposure Concentration[2] (mcg/m^3)	Reference Concentration[3] (mcg/m^3)	Inhalation Hazard Quotient[4]
PCE	BWD 6-1	5.8	1.5	40	0.04
1,1,1-TCA	BWD 6-1	6.7	1.8	5000	0.0004

[1] The average water concentration is used to evaluate the noncancer risks resulting from long term exposure.

[2] The average daily air exposure concentration is calculated using ATSDR's SHOWER model [ATSDR 2020].

[3] A reference concentration is an air concentration at which noncancer health effects are unlikely to occur, assuming exposures of up to a lifetime. The USEPA reference concentration of 40 mcg/m^3 was used for PCE [USEPA 2012] and the USEPA reference concentration of 5,000 mcg/m^3 was used for 1,1,1-TCA [USEPA 2007].

[4] The hazard quotient for inhalation exposure is calculated by dividing the estimated contaminant exposure by the reference concentration.

mcg/L = micrograms per liter; mcg/m^3 = micrograms per cubic meter; PCE = tetrachloroethene; 1,1,1-TCA = 1,1,1-trichloroethane; BWD = Bethpage Water District.

Conclusion

Prior to the release of ATSDR's SHOWER model, the NYSDOH doubled the drinking water concentrations to account for inhalation exposures to VOCs in the public water supply wells impacted by the Northrop Grumman facilities. The current evaluation in this appendix compared risk estimates obtained using the SHOWER model to those obtained in the original Public Health Consultation. This evaluation indicates that using the SHOWER model to estimate the inhalation component of the total VOC exposure results in nearly identical estimates of cancer risks and in most cases, similar indicators of noncancer risk as does doubling the water concentrations. Although some of the quantitative estimates of risk differed, none of these differences resulted in any changes in the overall risk characterizations and conclusions of the original Public Health Consultation.

References for Appendix G

[ATSDR] Agency for Toxic Substances and Disease Registry. 2020. Shower and Household Water-use Exposure (SHOWER) Model v2.0. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

[USEPA] United States Environmental Protection Agency. 2005. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. Risk Assessment Forum. EPA/630/R-03/003F. Last accessed (03/20/2020) at http://www.epa.gov/ttn/atw/childrens_supplement_final.pdf.

[USEPA] United States Environmental Protection Agency. 2006. Implementation of the Cancer Guidelines and Accompanying Supplemental Guidance - Science Policy Council Cancer Guidelines Implementation Workgroup Communication II: Performing Risk Assessments that Include Carcinogens Described in the Supplemental Guidance as Having a Mutagenic Mode of Action. Memo from William H. Farland to Science Policy Council.

[USEPA] United States Environmental Protection Agency. 2007. Integrated Risk Information System: 1,1,1-Trichloroethane (CASRN 71-55-6). Last accessed (03/20/2020) at http://www.epa.gov/iris/.

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Appendix H: Summary of Public Comments and Responses

Northrop Grumman/Naval Weapons Industrial Reserve Plant
Groundwater Contamination
Health Consultation
Summary of Public Comments and Responses

The NYSDOH prepared this summary to address comments and questions on the public comment draft of the Northrop Grumman/Naval Weapons Industrial Reserve Plant Groundwater Contamination Health Consultation dated May 23, 2019. The NYSDOH invited the public to review the draft health consultation during the public comment period, which ran from May 23, 2019 to July 22, 2019. The NYSDOH participated in a NYSDEC sponsored public meeting on June 10, 2019 to discuss and receive comments on the draft health consultation. Written comments were received through e-mail. Comments covering similar issues were consolidated and some comments were reworded for clarity and brevity.

Comment 1. The Health Consultation relied primarily on United States Environmental Protection Agency (US EPA) and Agency for Toxic Substances and Disease Registry (ATSDR) evaluations of trichloroethylene (TCE) toxicity and did not make note of or use evaluations done by other authoritative bodies, specifically the National Academy of Sciences (NAS). The NAS differs in their analyses and conclusions about the strength of the evidence for various aspects of TCE toxicity, and this should be included in the document for completeness and transparency. The Health Consultation also did not acknowledge that the US EPA TCE toxicity values have been criticized based on the relevance of the toxicological endpoints to humans, the methods used to derive the values, and study quality issues.

Response 1: The New York State Department of Health (NYSDOH) is aware of the NAS assessment for TCE and differing opinions in the scientific community regarding the US EPA TCE health assessment and toxicity values. Including details about the NAS assessment is beyond the scope of this health consultation, as is providing a comparison of various scientific opinions about the toxicity of TCE. The health consultation was prepared under a cooperative agreement between the NYSDOH and the ATSDR as a focused response to a citizen petition. The purpose of the health consultation is to evaluate exposures and characterize risks according to guidance provided and approved by the ATSDR. This guidance included acceptance and endorsement of the 2011 TCE health assessment prepared by the US EPA and the use of US EPA TCE toxicity values [US EPA 2011a][13].

Comment 2: The chemical name “trichloroethylene” should be added to the Health Consultation to avoid confusion.

Response 2: “Trichloroethylene” was added to the document’s list of commonly used names for TCE.

Comment 3: The health consultation states that there is an 80-fold difference between exposures that may cause developmental toxicity and those that may cause immune effects. The more stringent toxicity values for developmental effects should not be used for populations for which pregnancy is impossible (i.e., males and pre-pubescent or post-menopausal females).

Response 3: The comment does not accurately represent what was stated in the document. The section of the document the commenter refers to is the evaluation of the average level of 2

[13] The ATSDR has adopted the US EPA TCE reference dose and reference concentration as its chronic TCE minimal risk levels for oral and inhalation exposure, respectively.

micrograms per liter (mcg/L) TCE in Well 6-2 of the Bethpage Water District. The document states the estimated TCE exposure from this well "is slightly higher than the TCE reference dose but is 84 times lower than the EPA's estimate of the human exposure that corresponds to a dose that causes immune toxicity in mice." This margin of exposure calculation is the basis for the conclusion that the risk for immune toxicity was low. The "80-fold" was not comparing "exposures that may cause developmental toxicity and those that may cause immune effects," but rather it refers to the margin of exposure calculated as the ratio between the exposure that causes immune effects and the exposure estimate corresponding to 2 mcg/L in Well 6-2. Lastly, the health consultation did not use "the more stringent toxicity values for developmental effects" for "populations for which pregnancy is impossible." The hazard quotients and margins of exposure for developmental toxicity were based on exposure estimates for pregnant women. This was indicated in the document text (see description of methods in the Public Health Implication section for Well 6-1, also used for Well 6-2), and sample calculations provided in Appendix F.

Comment 4: The stated purpose in the Introduction of the Health Consultation is to compare exposures to EPA's regulatory maximum contaminant levels (MCLs). However, the document contains comparisons to non-regulatory US EPA Integrated Risk Information System (IRIS) and ATSDR screening values. The text should clearly identify whether MCLs or guidance values are being used, since the differences are significant with respect to levels of potential concern.

Response 4: In this health consultation, both MCLs and ATSDR comparison values were used to select contaminants for further evaluation. This process is explained in the Public Health Implications section, under "Selection of Contaminants for Further Evaluation" where the text states that the highest detected level of each contaminant was compared to both the MCL and the health based ATSDR comparison values. If either the MCL or comparison value was exceeded, the contaminant was further evaluated. The Background and Statement of Issues Section has been updated to indicate that the nature of this review is broader than just a comparison to MCLs, but also includes an assessment of health risks. Thus, although the MCLs were used as one of the screening values to select which chemicals to evaluate, the quantitative assessment of health risks was done using ATSDR-approved exposure parameters and toxicity values.

Comment 5: The TCE reference dose was used as an effect level and the margins of exposure were incorrectly calculated.

Response 5: The reference doses were not used as effect levels at any point in the document and the margins of exposure were correctly calculated in accordance with ATSDR guidance. Specifically, the margins of exposure were calculated as the ratio of the TCE effect level to the estimated exposure from drinking water and were calculated only when the estimated exposure exceeded the reference dose. The calculations were presented in detail in Appendix F of the document. Clarifying language on the margin of exposure calculation was added to the document text.

Comment 6: Considering this document is intended for the public, it is very confusing to track which location/facility is being discussed throughout the report. The document should provide clearer topic headings, particularly in the early sections, so the reader can more easily track which text relates to Bethpage and which discussion relates to NWIRP Calverton. These additions/changes should be made to the report.

Response 6: Comment noted. Changes have been made to the document headings so the reader can more easily track site discussions.

Comment 7: The petitioner request that spurred this consultation "expressed concerns that local residents could be exposed to contaminants…in groundwater…originating from" Grumman facilities in Bethpage, Great River, & Calverton properties. However, rather than focusing on identifying complete exposure to contaminants from these facilities, the document seems focused on making tenuous conclusions regarding potential health effects. The health consultation should be refocused, so it more clearly addresses the petitioner's concern. Potentially linking any complete exposure to health effects should be an additional section or even appendix in the document. To make the consultation clearer, the summary conclusions should be restructured, so they directly link to exposure and a facility.

Response 7: The Department believes that this health consultation is responsive to the petitioner request because it characterizes the potential for historic and current exposures from contaminants in groundwater spatially associated with particular facilities. The health consultation characterizes potential pathways of exposure according to prescribed guidelines from ATSDR. This health consultation describes where and when potential exposures to site related contaminants present in drinking water supply wells could have occurred, evaluates the risks posed by those exposures, and describes actions taken to mitigate the exposures.

Comment 8: It is unclear to the reader if there is exposure to raw water. Since, the primary concern of the petitioner was exposure, it is important to describe the water that users were exposed to rather than raw, untreated water. If finished water was not considered in this assessment, it needs to be clearly stated that the assessment of potential health impacts is theoretical and not based on water that was provided to consumers. If the intent of using raw water is to reflect any users with private wells, this does not seem consistent with the many conclusions regarding the lack of potential private drinking water wells. Please be specific regarding what consumers were exposed to, particularly for public drinking water since that represents the vast majority of potential exposure.

Response 8: The health assessment process relies heavily on information and environmental data already collected as part of the regulatory investigation. An important task in the process is to determine whether people could be exposed to contamination at levels above standards and health protective comparison values. Thus, based on the available information before treatment systems were initiated, the NYSDOH assumed individuals could have been exposed to facility-related contaminants in raw, unblended water drawn from any one of the impacted public supply wells. The uncertainty associated with this assumption is further discussed in response to Comment 11 and in the Uncertainties and Limitations section of the revised report. For this health consultation, information on the existence/use of private wells and related data was not available for evaluation.

Comment 9: The health consultation reached appropriate conclusions that consumption of current water supplies is not expected to harm people's health and past exposures to water from New York American Water and Bethpage Water District wells other than Well 6-1 were not expected to harm people's health. These conclusions have factual support and the health consultation's assumptions provide confidence that the conclusions are accurate.

Response 9: Comment noted.

Comment 10: "The top priority of this health consultation is to ensure that the community has the best information possible about how contamination in groundwater from the facilities might affect their health." As our focus is on the facility in Bethpage, how is it possible that the assessment and report is completely silent regarding possible exposure from the NWIRP facility itself? As you must be aware, for over 40 years until 1976, the NGC/NWIRP facility provided drinking water to its approximately 25,000 employees every day through its several on-property

supply wells. The pool of employees who drank water every day at the facility made up a majority of the demographic in the Bethpage and surrounding communities. When Northrop Grumman came to the Bethpage Water District in 1976 asking to be provided drinking water from the District, it was because the onsite Grumman drinking water wells were contaminated, there were taste and odor complaints, and employees were reportedly becoming ill from drinking the water. From the perspective of historic potential exposure due to groundwater impacts, this condition would far and away be the most significant. The absence of any assessment whatsoever of 25,000 employees drinking water from contaminated Grumman wells for decades underscores the weak and superficial nature of the health consultation report. In the interests of report credibility, if nothing else, this report must have a focus on the exposure potential from the NGC/NWIRP itself."

Response 10: The petitioners request is specific to residents' exposure to facility-related contaminants (primarily volatile organic compounds) in groundwater through the public drinking water supply. The water supplied to employees of Northrop Grumman prior to early December 1976 was not a public drinking water supply, and therefore does not fall under the scope of potential exposures this health consultation was tasked with evaluating.

Comment 11: The conclusion that past use of drinking water contaminated with trichloroethene (TCE) from Bethpage Water District Well 6-1 (prior to early December 1976) could have harmed people's health is not valid because assumptions used to develop the quantitative estimates of risk likely overestimated people's actual exposure. Specifically, the exposures were based on limited data (three drinking water samples from Well 6-1), and people were assumed to have been exposed to raw, untreated water. Further, the assumptions did not reflect real world conditions, did not take into account the noncontinuous use of Well 6-1 (based on pumping history[1]), and the water was often mixed with water from uncontaminated wells which could have diluted the contamination. These uncertainties and limitations regarding the exposure assumptions were inadequately addressed in the Health Consultation.

Response 11: The New York State Department of Health agrees that there are several sources of uncertainty with respect to the assessment of health risks and the assumptions used to obtain the risk estimates. These comments indicate a need to provide a more extensive discussion of the specific sources of uncertainty in the health consultation. Consequently, a discussion of the major sources of uncertainty is being added to the Uncertainties and Limitations section of the revised document.

Comment 12: The use of current drinking water standards in Table 2 for comparison with contaminant levels found in 1976 is misleading and lacks any explanation as to the relevance of the drinking water standards. It implies that the Bethpage Water District exceeded drinking water standards, which is patently untrue. The table should be clarified by either removing the drinking water standard column or explaining the dates of the samples versus the date MCLs were set at 50 ppb, and versus the date the MCLs were set at 5 ppb.

Response 12: The purpose of using the current drinking water standards as comparison values to select contaminants for further evaluation is explained in the paragraph preceding Table 2, under "Selection of Contaminants for Further Evaluation." In response to the comment, a footnote was added to Table 2 to note that the standards were promulgated in 1989, while some of the samples in the table were collected prior to this date.

[1] The New York State Department of Health did not have information on the monthly pumping history of Well 6-1 during the preparation of the Health Consultation.

Comment 13: The completed exposure pathways are insufficiently, and inconsistently documented, and sufficient justification was not provided for how they were estimated. The Summary states that exposure to VOCs could occur by ingestion and inhalation, but later states that exposure could occur by ingestion, dermal contact and inhalation during showering. The document should clarify and explain the specific studies that relate to VOC exposures through a showering scenario and how the decision to double the water concentrations to account for these exposures is justified. The health consultation should include the approximate contributions from dermal contact and inhalation indicated by each of the studies.

Response 13: The Department acknowledges that greater clarification regarding non-ingestion exposure pathways is needed. The basis for doubling the water concentrations to account for non-ingestion exposures, along with the relevant studies from the scientific literature, is added to the revised document in footnote 6 of the Public Health Implications of Completed Pathways section. In the time since this health consultation was completed, the ATSDR has developed a Shower and Indoor Water Use Model, which estimates exposure to VOCs via non-ingestion pathways based on numerous input parameters chosen by the user (e.g., shower/bathroom time, number of showers, presence of fans, and activity patterns). The range of exposures for TCE and other VOCs predicted by the model supports that the approach taken in the health consultation is reasonable and conservative. A summary of this additional evaluation of non-ingestion exposures is added to the revised document and presented in Appendix G, and the results of the Shower and Indoor Water Use Model are compared with those of the original health consultation. Use of the Shower and Indoor Water Use Model did not result in any changes in the overall risk characterizations and conclusions of the original Public Health Consultation.

Comment 14: The daily consumption rate on which the doses and exposure rates are based is missing. The consumption rate per day should be provided.

Response 14: The daily water consumption rates used to estimate exposures were provided in Appendix F of the health consultation. The main text notes several times that additional details on the risk calculations can be found in this section of the document.

Comment 15: The health consultation looks almost exclusively at drinking water as a potential toxic exposure pathway for Bethpage area residents and concludes that, since its contaminated public supply wells were either shut down or treated at some point during their operations, people have not been adversely affected. No attempt is made to verify the data, account for the fact that applicable safety standards have changed over the years, or the fact that many contaminants were not tested and, therefore, not accounted for in the past. The report also completely ignores other significant exposure pathways, including soil, air, and soil vapor, and use of contaminated groundwater for irrigation and agriculture. At the very least, existing data should be carefully analyzed to determine the likelihood of these impacts, and, since gaps in the data are known to exist, additional testing should be conducted before they can be dismissed as potential exposure routes.

Response 15: A health consultation is a verbal or written document response to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. This health consultation was prepared in response to a petition by a resident of Patchogue, Long Island, who expressed concern that area residents could be exposed to Northrop Grumman/NWIRP facility-related contaminants (primarily volatile organic compounds) if they relied on groundwater for household uses or irrigation. The revised health consultation now states in the Background and Statement of Issues section that the evaluation of other potential exposure pathways and contaminated media is not within the scope of this

health consultation. However, to further address this comment, the Department provides the following information.

Regarding the comment about changing safety standards, the health consultation describes the evolution of applicable drinking water standards (MCLs) in New York State under the section entitled 'Background'. As part of these standards, if a water supplier discovers that an MCL is being exceeded, or that one is about to be exceeded, Subsection 1.12 of Part 5 requires that the supplier notify the State and take specific actions which include identifying the cause of the MCL exceedance, making modifications to or installation of treatment to meet Part 5 requirements, and submittal of a written report to the State within 30 days that documents these actions. This health consultation evaluated data made available through this reporting process.

Concerning "other significant exposure pathways", the groundwater contamination associated with the Navy Grumman Plume is at a significant depth below the ground surface and is covered with clean water from precipitation that infiltrates from the surface. This condition ensures that structures located over impacted groundwater are separated and buffered from being impacted by conditions that could result in soil vapor intrusion from the deeper groundwater contamination. However, several properties directly adjacent to the site were found to be impacted by soil vapor intrusion, which did result in exposures. The Navy has mitigated the impacts to these homes, and in response to concerns about these known exposures, the Department of Health conducted an "Evaluation of Cancer Incidence and Environmental Exposures in the Area of the Naval Weapons Industrial Reserve Plant and Grumman Aerospace Site" in 2013. The cancer evaluation reviewed available information for evidence of unusual cancer patterns in the area of concern. This information gave no evidence of unusual patterns of cancer occurrence unique to the area of concern.

Also, Northrop Grumman conducted soil removal at several off-site properties located directly adjacent to one area of the site that were found to be slightly impacted by contaminants associated with the site. The impacts to soil at these properties were at concentrations just slightly above those that New York State deems acceptable for residential properties, and it is not expected that residents would have been exposed to concentrations that would have posed a significant risk for adverse health effects. These impacts likely occurred when site-related soil was redistributed to the properties prior to construction of the residential buildings. There is no information available to indicate that soil at other off-site properties has been impacted by the Navy Grumman related contaminants because contamination source areas are only found at on-site areas.

Comment 16: There is no analysis of cumulative impacts of low-level contamination over long term water use, as is the case with many residents, and no consideration given to children drinking and metabolizing those contaminants at a different rate than adults, and who therefore may have a greater exposure and vulnerability than adults.

Response 16: The health consultation's evaluation of cancer risks assumes cumulative exposure to drinking water contaminants for long periods of time (i.e., every day for 24 years for Well 6-1). Regarding children, the health consultation specifically considered the unique vulnerabilities of those in early life stages. The drinking water exposures for all contaminants were estimated with high end exposure values (e.g., reasonable maximum exposure values for drinking water ingestion rates), including those specific for infants, young children, and pregnant women. For TCE (the primary contaminant of concern), noncancer risks were evaluated based on effects to the developing fetus (i.e., fetal heart malformations). Finally, consistent with US EPA guidance [EPA 2005, 2006, 2011b] and as explained in footnote 8 and Appendix E, cancer risks for TCE were evaluated assuming that TCE causes cancer by a mutagenic mode of action,

which results in a higher vulnerability (compared to adults) of people in early life stages to the cancer effects of TCE.

Comment 17: NYSDOH should, jointly with the DEC, conduct comprehensive independent testing of all environmental media at private properties in the area of the plume. Only after a comprehensive sampling program of soil, soil vapor, indoor and outdoor air, drinking water and groundwater at any private properties whose owners' consent to such testing, can the NYSDOH begin to assess whether toxic hazards are present. If they are, interim remedial measures should be implemented immediately to mitigate the harm, and the Department should conduct a study of resulting health impacts. Furthermore, recognizing that current testing only gives a snapshot of present conditions, analysis of past concentrations of contaminants in and under residential neighborhoods should be conducted to determine past exposure levels, accounting for attenuation and the changing contours of the plume.

Response 17: As noted previously, the scope of this health consultation is limited to the petitioner's request. NYSDOH will continue to work with the NYSDEC, County Health agencies, the US EPA and ATSDR to review information as it becomes available, evaluate the public health implications of any sampling results, and recommend public health actions as needed.

Comment 18: The role of the Health Department is to look at people's health. The Health Consultation, inexplicably, does not do that. The site itself was and continues to be highly contaminated. Bethpage Community Park, Grumman's "present" to the Town of Oyster Bay, was, for decades, Grumman's dumping ground for toxic sludge, waste oil, and other hazardous wastes. Community residents worked for Grumman, used the Park, and sent their children to the schools immediately adjacent to the Site. They have and continue to live in homes which are located on top of the contaminated groundwater plume, which was never cleaned up. Many have expressed concern about the high rate of cancer incidence and other serious illnesses in families (and even pets) in the vicinity of the Site and the groundwater plume. Surely, all of this is enough to justify a health study. A very limited "cancer study" was conducted by the NYSDOH in 2009 (and took another 4 years to publish), looking, quite superficially, at a small 20-block area immediately adjacent to the Site. Today, given the amount of data that can be gathered and analyzed with modern techniques, the information already available through the New York State Cancer Registry, the latest information on Site-related contaminants and their potential harm, and the ability to survey residents directly through on-line platforms, a new community-wide study should be conducted. It is the only way to provide affected residents, the public, and responsible government officials with objective measures of the health impacts from the Site and to render any DOH conclusions on the subject plausible and useful.

Response 18: The New York State Department of Health conducts a wide range of studies that bear on the health of the population. The goal of the present health consultation was to determine whether people are currently being exposed to groundwater impacted by contaminants from the Northrop Grumman and NWIRP facilities in Bethpage and other locations at levels exceeding those set to protect human health, and whether they could have been exposed to these contaminants in the past. Evaluating the potential for exposure is important because without exposure, there can be no increased risk for health effects. The health consultation concluded that people are not currently being exposed to volatile organic chemicals (VOCs) from the facilities at levels that could harm their health, but that exposures to the chemical trichloroethene (TCE) in water from one well in the Bethpage Water District prior to early December 1976 could have increased health risks.

The aim of the cancer study released in 2013 was to assess the incidence of cancer among people living in a very limited area where there had either been documented or possible exposures to high levels of VOCs that had entered homes through the process of soil vapor

intrusion. Soil vapor intrusion occurs when volatile substances dissolved in groundwater enter the air spaces surrounding soil particles and from there people's homes. The study did not document any unusual patterns of cancer in this area.

A community-wide health study cannot determine whether any specific individual had health effects from a past exposure, or whether anyone will experience health effects in the future. One of the most challenging tasks of a health study is to determine the likelihood of past exposure to chemicals. Additionally, individual consumption of water during a specific period of time is variable and not easily determined. Finally, the movement of individuals into and out of the area of concern over many years introduces uncertainties and limits data on which to base any conclusions. Therefore, a health study of communities near the Northrop Grumman and NWIRP facilities is unlikely to provide meaningful information toward addressing possible health impacts from past exposures to contaminants in the water supply.

Comment 19: In conducting the above study, NYSDOH should pay special attention to health impacts on children. Many of them attended schools in close proximity to the Site which also used the school ball fields and playing areas at Bethpage Community Park. There, they came into direct contact with the contaminated soils, dust, air and surface water from the Site, which would been over and above their exposure at home. In general, children are at greater risk than adults from certain kinds of exposure to hazardous substances. Since they are ·shorter than adults, they breathe more dust, soil, and heavy vapors close to the ground. Children are also smaller, resulting in higher doses of chemical exposure per body weight. The Agency for Toxic Substances and Disease Registry recognizes the unique vulnerabilities of children exposed to environmental contamination and hazards. Chemical exposures are often unequally distributed over a lifetime, and there are critical periods of susceptibility at varying times, especially during pregnancy and childhood. Children may be especially susceptible during periods of rapid tissue growth and development and have a longer time in which to develop adverse health effects. A significant portion of lifetime risk may, therefore, be accumulated in a relatively short time. Furthermore, children are typically exposed to higher doses of toxins per unit of body weight and may be able to absorb higher doses of some contaminants than adults. For these reasons, a dedicated portion of the study should address health impacts on children and residents who grew up near the Site.

Response 19: The Department is aware of the increased vulnerability of children to the effects of hazardous substances, and the health consultation took this into account. No children are currently being exposed to levels of contaminants in the drinking water above those set to be protective of human health, and no children were exposed after 1976. Although cancer effects may not show up for decades after first exposure to a contaminant, it would not be possible to track down all the people who grew up in the area, especially those who moved away. A complete accounting of all persons who had been or may have been exposed to a substance is important for the accurate assessment of health effects in a population, and due to the time elapsed, this type of study of persons exposed as children would not be possible.

Comment 20: The health consultation focuses on just three of the Site-related chemicals, TCE, PCE and 1,1,1-TCA, and advises that at least two are classified by the EPA as human carcinogens. They can also harm the nervous system, liver, immune system and fetal development. The health impacts of the chemical, 1,4-dioxane, which led to the shutdown of two Bethpage Water District wells in 2018, were not evaluated. The other 21 "contaminants of concern" identified in the Grumman plume and cited in the DEC remediation plan are not addressed by the DOH.

Response 20: While not specifically indicated in the petitioner's request for evaluation, 1,4-dioxane data indicate it is present in the Bethpage drinking water supplies, including those

within the Northrop Grumman/NWIRP facility plume in Bethpage. The Department understands that the community has voiced their concerns regarding this chemical. In August 2020, the NYSDOH adopted a public drinking water standard (maximum contaminant level) of 1 microgram per liter (mcg/L) for 1,4-dioxane. This action requires that corrective measures be taken to reduce 1,4-dioxane levels in public water systems found to be in violation of the standard. The NYSDOH will continue to work with the NYSDEC to identify and evaluate sources of 1,4-dioxane contamination, and to ensure that exposure to the chemical is mitigated when it is detected in public water systems in violation of the current MCL.

Although other contaminants have been identified in the Grumman plume, the scope of the health consultation was specific to the citizen's petition and therefore addressed the volatile organic chemicals that had been detected in public water supplies at concentrations exceeding health comparison values. As a point of clarification to what is stated in the comment, the only chemical evaluated that is characterized by the US EPA as "carcinogenic to humans" is trichloroethene.

Comment 21: The health consultation did not consider impacts from radioactive substances in the groundwater (ex. Radium) and indoor air (ex. Radon). This is a serious oversight, given what we already know. Grumman's operations at the Site involved the use of radioactive materials. Many questions remain about the decommissioning of those parts of the facility. The Bethpage Water District had to shut down one of its wells due to excessive radium levels. Recent testing conducted by the Bethpage Water District, the Bethpage School District and the U.S. Navy shows that radium is present in on-site and off-site groundwater. Radon was found in at least one of the local schools. The Navy's data have recently been called into question due to illegal cover ups by its consultant at another Superfund Site. Radioactive substances can kill and are known human carcinogens. Yet, not one reference to these concerns is made in the DOH report. This issue alone requires additional study and amendment.

Response 21: The health consultation does not address radioactive substances because it is beyond the scope of the original petitioner's request. However, to address this comment the following information is provided. New York State has information that shows Northrop Grumman did use radiological compounds in testing equipment at some locations, and that these facilities were found to be properly decommissioned by the New York State Department of Health. New York State has evaluated soil and groundwater data in and around the Bethpage area and has determined that the radium found is naturally occurring and not attributable to activities that took place at the site.

Comment 22: The scope of the health consultation is too limited with respect to the contaminants evaluated. Specifically, PFOA, PFOS, and other chemicals identified in the Grumman plume should be evaluated.

Response 22: The scope of the health consultation was specific to the citizen's petition, which was to address concerns about volatile organic chemicals in drinking water impacted by the Grumman plume. Consequently, the chemicals evaluated in the Health Consultation were limited to those volatile organic chemicals that had been detected in public water supplies at concentrations exceeding health comparison values.

Comment 23: What year did treatment systems to remove volatile organic compounds from the Bethpage Water District Well 6-1 begin?

Response 23: Contamination of Well 6-1 was discovered in November/December 1976, the well was taken out of service in December 1976, and it was returned to service after a treatment system installed to remove the site-related contamination in June 1990.

Comment 24: What ill health impacts have occurred prior to treatment commencement?

Response 24: As described in the health consultation, there is an increased health risk for developmental and immune effects from consumption of water from Well 6-1 prior to early December 1976 when that well was taken out of service. However, this is a theoretical risk associated with numerous uncertainties as now more fully described in the revised final health consultation. The health consultation does not predict health risks at the individual level and cannot provide conclusions on what impacts "have occurred". The assessment of health risks is used to draw conclusions about the level of risk on a population basis posed by assumed exposures to environmental contaminants and is used to inform risk management decisions for addressing the exposures.

Comment 25: I am concerned because I grew up in Bethpage and from what I can see on the maps, our house was right in the middle of the plume. I lived there from 1956 to 1976. What concerns me is that my mother had two types of cancer—breast cancer and non-Hodgkins lymphoma. I have been diagnosed and treated for breast cancer and fortunately I am now an almost two-year survivor. I also have been diagnosed with systemic lupus and both my sister and I have auto-immune issues. Please forward any information that would be helpful to me.

Response 25: Living in the plume area prior to early December 1976, it is possible that you and your family may have received water from Bethpage Water District Well 6-1 that was contaminated with TCE. However, as detailed in the public comment draft health consultation, the cancer risk levels associated with the detected chlorinated solvent concentrations represent only minimal to very low risk for cancer. Further, as discussed above and further elaborated upon in the revised final health consultation, there are factors which may have reduced historic exposures such as the fact that water in a distribution system on Long Island typically is a mixture of water from different source wells. The health consultation does not have enough information to know how blending may have decreased exposures. With respect to autoimmune concerns, the highest TCE level detected in Well 6-1 corresponds to an exposure that is lower than the TCE exposure estimated to cause immune toxicity in humans. Breast cancer is not known to be associated with exposure to TCE, rather, genetic inheritance and various other host factors are known to contribute to a woman's risk. Non-Hodgkin lymphoma is one of the cancers that has been associated with exposure to TCE in studies of workers exposed to relatively high levels. Evaluations in the health consultation show that people exposed for 24 years to drinking water containing TCE at the average level found in water from Well 6-1 in 1976 would have an increased risk of all cancers over their lifetime that ranged from 3 in one hundred thousand to 8 in one hundred thousand, or 0.003% to 0.008%. This increased risk would not be detectable given the lifetime risks of developing cancer for the general population – 39.3% for males and 37.7% for females for all cancers, and 2.4% for males and 1.9% for females for non-Hodgkin lymphoma. It is therefore not possible to know whether the illnesses experienced by you and your family members could have been related to possible exposures to contaminants in the drinking water. Our best advice would be the same as the advice we would give to the general population – maintain a healthy lifestyle, have regular medical checkups, and discuss your specific concerns with your healthcare provider.

Comment 26: I live on North 2nd Street in Bethpage I really feel cementing Bethpage Community Park and the road adjacent to it is the only way to keep us safe! Let's face it, it's in the air, the dirt, the water, and every time one agency examine the plume everyone else needs their own levels. Punching holes in it so it's going to spread! I am sick. I have Lupus. Most of my friends are sick or died from living here. New wells yes! We need them but fixing the Community park will only hurt the people more!

Response 26: The comment is noted. An evaluation of work being proposed at the Bethpage Community Park is not within the scope of this health consultation. Questions regarding the investigation at the park should be directed to New York State Department of Environmental Conservation.

Comment 27: Attenuation at sites like the Grumman/Naval Industrial Reserve Plants on Long Island should never be considered. The timeframe for natural decontamination is too long (ie., hundreds to thousands of years). DOH and all other agencies responsible for the health of the public cannot allow any more superfunds on Long Island. Long Island is already contaminated from one end of the island to the other. Prevention can be the only answer, going forward.

Response 27: Regarding mitigation of existing contamination, the health consultation points out that the NYSDEC have been actively pursuing a long-term groundwater plume containment strategy as it is recognized that attenuation will have limited effect over the near term. Regarding prevention, many environmental laws have passed since the Grumman plume developed. These laws have helped decrease the amount of new contamination entering the environment.

Comment 28: Cancer risk estimates as high as one in ten thousand falls within the "acceptable risk range". Consequently, considering the protective assumptions incorporated into the risk calculations, the text characterizing the cancer risk as low or very low should be re-worded to say that the contaminant levels of TCE and PCE in Well 6 did not present an unacceptable cancer risk. The risks are consistent with a range that the US EPA considers acceptable and some reference to the US EPA's opinion should be added to the document as a reference point for the public.

Response 28: The comment is noted. When cancer risks are between one in one million and one in ten thousand, risk management decisions must be made on a case-by-case basis whether to pursue risk reduction measures. The National Contingency Plan [US EPA 2015] and the US EPA [1991] stated a preference for managing cancer risks at the protective end of this risk range with consideration being given to the practicality of implementing measures to reduce exposures. NYSDOH practice for ATSDR health consultations and assessments has been to provide qualitative descriptors of cancer risk (e.g., "low", "very low") based on the quantitative risk estimates. The NYSDOH prefers to avoid making statements about the acceptability of cancer risks simply because the quantitative estimates fall into a certain range.

Comment 29: It is unclear how "Preventive health recommendations" can apply to exposures prior to 1976, especially potential developmental toxicity. Recommend that sentence be changed to read something like, "Regardless of the potential effects of previous exposures or activities that might affect health, general recommendations for maintaining good health include: maintain a healthy lifestyle, have regular medical checkups, and discuss specific concerns with healthcare providers."

Response 29: The comment is noted and a modification to this section of the text was made.

Comment 30: The health consultation confused TCE exposure to infants with *in utero* exposure. Infants would not be affected by the developmental effects from *in utero* exposures that are the basis for the reference dose. The wording should be changed to "past exposure to embryos or fetuses" or "past exposures in utero".

Response 30: Infant exposures were not compared to effect levels for developmental toxicity. The statement referred to in the comment has to do with the comparison of infant exposures first to the TCE reference dose (which was exceeded resulting in a hazard quotient greater than

1), and then to the human equivalent dose at the effect level for immune toxicity in mice. Several different age groups (including infants) were evaluated, and sample calculations were provided in the appendices. Infants had the highest TCE exposure, and hence had the highest risk for immune effects. For evaluation of developmental endpoints, maternal exposures were compared first to the reference dose, and then a margin of exposure was calculated using the estimated maternal exposures and the human equivalent dose at the maternal effect level for developmental toxicity in rats. Again, sample calculations were provided in the appendices.
Comment 31: If the NYSDOH believes the potential immune toxic effects from TCE exposure are reversible, it should be mentioned since it would be useful to the public to know, since the exposure has decreased.

Response 31: The NYSDOH does not wish to speculate on this in the health consultation, because there is insufficient information about the reversibility of TCE-related effects on the immune system in humans.

Comment 32: The basis for concluding that exposure was unlikely from unpermitted, private wells appears to be based on an absence of information. While the installation of private drinking water wells was not permitted after 1987, private wells may have been constructed before then, and people may have been exposed, and may continue to be exposed, to water obtained from private wells. Under the section “Private Wells in the Bethpage Area” it is stated, “There is no program in place to identify whether private wells are in use in Nassau County [John Lovejoy, NCDOH, personal communication, March 11, 2014]. Consequently, the NYSDOH cannot determine whether anyone is being exposed to site-related contaminants through the use of private wells.” Also, the document states, “Any private wells are unlikely to have been installed at depths that would intersect contaminated groundwater associated with the Northrop Grumman/NWIRP facility.” If this is the rationale for the statement in the previous paragraph, it should be mentioned there. Also, in the same paragraph: “Exposure to VOCs in irrigation wells does not constitute an exposure concern.” If the logic here is also that the wells are not expected to be at a depth to have the contaminants, the suggested changes should explain this conclusion as well. Otherwise, for clarity and transparency, it is important to provide additional information, as use of contaminated water could pose a risk by dermal contact or inhalation of vapors. If those potential exposures were deemed de Minimis, e.g., because of infrequency, that should be stated. If accurate based on the information provided, suggest changing the conclusion to read something like: “Because private wells constructed prior to 1987 were not likely to have been installed at depths that would have encountered the contamination considered in this evaluation, exposure to contaminants through the use of unpermitted private wells are considered unlikely.” These additions/changes should be made to the report.

Response 32: The comment is noted. The health consultation text was modified in the conclusion sections from “…use of unpermitted private wells” to “through the use of private wells.” Although installation of private wells for potable purposes is not permitted, irrigation wells of a certain pumping capacity may be permitted by the NYSDEC. As stated in the health consultation and as alluded to in this comment, it is unlikely for any private wells to intersect facility-related groundwater contamination nor be used for drinking water purposes. The discussion of irrigation wells in the health consultation also points out that these are unlikely to intersect the plume based upon drilling depth logs for those for which the Department has records.

Comment 33: There was a modification or transition of the approach used in the health consultation, since exposures first were compared to maximum contaminant levels, and then to health-based values and reference doses. The text should be altered to state this.

Response 33: The approach used in the health consultation to evaluate the exposures is explained in the sections entitled “Selection of Contaminants for Further Evaluation” and “Public Health Implications of Completed Pathways”. At no point were the maximum contaminant levels used to generate the quantitative estimates of risk. They were used, along with ATSDR comparison values, to select which chemicals to evaluate. Once the contaminants were selected for evaluation, the risks were further evaluated using standard procedures provided in guidance issued by ATSDR. This general paradigm is followed for all public health consultations and assessments involving drinking water conducted under the cooperative agreement with ATSDR.

Comment 34: The health consultation says that Long Island obtains its drinking water supply primarily from the Magothy and Lloyd aquifers. Given that there are private wells, the document should provide a date when this became true, assuming that all households were on public water from that date and that the “water supply” in the citation is for publicly supplied water. A clause should be added that states the approximate date when this became true.

Response 34: Specific information about the dates for use of the Magothy and Lloyd aquifers, and the dates various residents were connected to public water is not available. This information is not directly relevant to the focus of the health consultation, which was to respond to a citizen’s concerns about exposure to volatile organic chemicals in public water supplies.

Comment 35: The document states that “Since suppliers must meet Part 5 requirements, it is unlikely exposures to contaminant levels above MCLs have occurred from public water supplies since implementation of Part 5 regulations in 1989.” Assuming that the Part 5 records would be available to the authors of this evaluation, it might be useful to review those records to see if the statement could be that there were no, or only a few, exceedances of the MCLs. Otherwise, this may be read as an inference, and facts would be preferable. Recommend reviewing and referencing Part 5 records required by New York, as demonstrating that contaminant exposures have not exceeded the applicable MCLs would be preferable.

Response 35: Part 5, Subpart 5-1, Public Water Systems, documents the requirements that public water suppliers in New York State must follow. These include the list of Maximum Contaminant Levels for organic and inorganic contaminants, sampling and reporting requirements, and the actions that public water suppliers must take if an MCL is exceeded, which includes potentially taking an impacted public water supply well out of service. Information pertaining to the detection of volatile organic compounds of concerns, MCL violations, and actions taken to mitigate exposure can be found in the section entitled “Public Water Supplies Impacted or Threatened by the Northrop Grumman/NWIRP Bethpage Facility” and in Appendix D. Since the implementation of the Part 5 regulation in 1989, no MCL violations have been documented. Therefore, the statement that “it is unlikely exposures to contaminant levels above MCLs have occurred for people who are served by a public water supply” is not an inference but is based on information provided by the water purveyors.

Comment 36: From the description of the shallow plume, a reader might conclude that there could be a vapor intrusion issue. NYSDOH has evaluated this issue (https://www.health.ny.gov/environmental/investigations/bethpage/questions_and_answers.htm) and has stated that “The NYSDOH conducted a comprehensive evaluation of cancer cases occurring in an area affected by soil vapor intrusion by contaminants from the NWIRP, and an area that might have been affected by soil vapor contaminants from the NWIRP or the Grumman site in the past. The evaluation provided no persuasive evidence that cancers occurring in this particular area were any different from cancers occurring in other communities, therefore no further cancer studies are planned for this area at this time.”

Recommend a comment that NYSDOH has evaluated vapor intrusion and concluded it is not a problem, as well as providing the website for the report.

Response 36: The soil vapor intrusion pathway was previously evaluated, and the results of that evaluation can be found at the link indicated in the above comment. Soil vapor is not the subject of the petitioner's request and therefore no changes in the document were made in response to this comment. This issue is further addressed under Comment 15.

Comment 37: The document discusses an evaluation by the NYSDEC regarding OU2 and OU3 remedies. The relevance of this statement in the context of this consultation (to identify potential exposures) is unclear. Recommend this paragraph be deleted since it is not clear how it informs the determination of potential exposure to groundwater contamination emanating from the aforementioned facilities.

Response 37: The comment is noted.

Comment 38: In the section entitled "Public Water Supplies Impacted", the lack of context for detections makes it difficult to interpret the data being presented. This applies to multiple sections, as noted by the multiple page numbers referenced. Recommend including more information so that the data being discussed have appropriate context. For example, on page 9 for Bethpage Water District Plant 6, it states, "In February 1985, sampling first detected TCE in the raw, untreated water from Well Number 6-2…" and "In February 1987, the TCE concentration reached as high as 5 mcg/L…" It is unclear if 1985 is the first-time sampling was performed for TCE, or if it is the first time TCE was detected. Provide sufficient context to interpret the data being reported. For example, summaries of data do not detail if these are all the data, or a subset.

Response 38: The section entitled Northup Grumman/NWIRP Bethpage Facility clearly explains the progression of requirements placed on public water suppliers by the NYSDOH to address contaminants in public water supply wells, including the requirement to sample these wells, and that these guidelines have been in place since 1977.

Comment 39: It is unclear if the drinking water standard referred to in the section describing the drinking water sampling data for the South Farmingdale Water District (page 8 of the Health Consultation) is a Federal or a State standard. This should be specified.

Response 39: Clarifying language was added to the text to make clear which standards were used for the initial evaluation of the sampling results.

Comment 40: Table 1 (Exposure Pathways Evaluation) provides little value to the report and should be deleted.

Response 40: Table 1 provides the reader with a simple description of how exposure pathways are evaluated and is a required component of the ATSDR health consultation process.

Comment 41: The first paragraph of the paragraph in the section "Selection of Contaminants for Further Evaluation" incorrectly refers to Table 1.

Response 41: The comment is noted, and the text was changed to correctly direct the reader to Table 2.

Comment 42: The ATSDR comparison values (Cancer Risk Evaluation Guide, Chronic Environmental Media Evaluation Guide, Child Intermediate Reference Dose Media Evaluation Guide) were introduced without enough context and definition. This could result in confusion and lead to the inference that any exceedance of these values could cause harm. These terms should be defined in the report.

Response 42: The ATSDR comparison values are defined in the text. Just above the table in which they are used (Table 2) the text states that that these values "are water concentrations at which adverse health effects are not expected to occur", and that "exceeding a drinking water standard or comparison value does not mean that an adverse health effect will occur, but that further evaluation of the contaminant is needed." The text also makes clear in this section that the comparison values are used, along with MCLs, only to screen and select contaminants for further evaluation, not to evaluate risk. In response to the comment, a reference to a detailed explanation of the comparison values was added.

Comment 43: It would be useful to specify that the lifetime cancer risk in the United States is between 1 in 2 and 1 in 3, according to the American Cancer Society.

Response 43: The background rate of cancer was added in footnote 5 to the section entitled "Public Health Implications of Completed Pathways".

Comment 44: The report provided no criteria or basis for the descriptors "low" and "very low", and that without such a basis the descriptors appear subjective.

Response 44: The meaning of each qualitative descriptor of risk used in the Health Consultation is provided in footnotes 1, 2 and 3 to the Summary section of the document.

Comment 45: Overall, dates and other specific information is lacking such that there is insufficient context for some of the analysis. For example, how many private wells were identified in the area? Also, what year were the private wells installed at the Island Trees public school campus? Clearly this report was written by professionals that are very familiar with all aspects of what was investigated and considered. However, all of that knowledge is not clearly reflected in the report. Recommend updating the next version to clearly explain the conceptual site model of the areas and not leave too many knowledge/detail gaps.

Response 45: There is no program in place to identify whether private wells are in use in Nassau County. Nassau County has not permitted the installation of private wells for potable purposes since 1987. The installation date of the irrigation wells at the Island Trees public school is not relevant because 1) Neither well was installed to a depth where they intersected the facility related groundwater contamination, 2) The wells were not used for water consumption, 3) One well has been decommissioned, and 4) Testing of the remaining well in 2007 in conjunction with another environmental investigation did not show contamination. No changes in the text were made in response to this comment.

Comment 46: The first paragraph incorrectly defines NWIRP as "National" rather than "Naval". Change "National" to "Naval."

Response 46: The comment is noted, and "National" was changed to "Naval."

Comment 47: The health consultation states that "Sites on the state Superfund list require further environmental investigation to confirm the presence of hazardous waste and determine the threat posed by the site to public health or the environment." The wording suggest all Superfund Sites present an unacceptable risk. Sites on the state Superfund list require further

environmental investigation to confirm the presence of hazardous waste and determine whether site constituents present an unacceptable risk to human health and the environment. Consider re-wording the introduction.

Response 47: Sites that are put on the New York State Registry of Inactive Hazardous Waste Disposal Sites are already known to be contaminated in some way, and therefore further evaluation of the site is necessary to determine the level of risk the site poses to public health and the environment. The sentence was modified to reflect this.

Comment 48: The average of three samples for Well 6-1 is highly uncertain, and this should be stated in the text. The use of one half the detection limit for non-detects in the other wells (for which there were more data) overestimates the average, and that overall, given the paucity of data, the language dealing with risk should be made more conditional.

Response 48: The comment is noted. Additional discussion was added to the Uncertainties and Limitations section to provide more perspective on the limitations of the data, particularly for Well 6-1. This was the only well for which it was concluded that the estimated exposures could have increased the risk for effects on development and the immune system. With respect to the other wells (New York American Water Company Wells 3 and 4, Bethpage Water District Wells 4-1, 4-2 and 6-2), for which more data were available, and the contamination was estimated to result in much lower risks, we agree that use of one half the detection limit for non- detects could result in higher exposure point concentrations compared to those calculated using other methods. Accordingly, the revised final health consultation recalculates the exposure point concentrations for these wells following recent draft guidance from ATSDR [ATSDR 2019]. This guidance involves using the US EPA's Pro UCL software to calculate the 95th percentile upper confidence limit on the mean and includes statistical alternatives to substituting half the detection limit for non-detects. Using this more robust method did not significantly change the exposure point concentrations nor the risk characterization conclusions for these wells.

Comment 49: The interpretation of the TCE reference dose for developmental effects ignores the 10-fold uncertainty factor that was applied to the rodent data.

Response 49: The 10-fold uncertainty factor was not ignored. The estimated TCE maternal exposure at the water concentration of 60 mcg/L exceeded the reference dose, thus reducing the margin of protection provided by the uncertainty factor. The margin of exposure was then calculated by comparing the maternal dose (0.0042 mg/kg/day) to the human equivalent dose at the effect level for fetal heart malformations (0.0051 mg/kg/day) in rats, resulting in a margin of exposure of 1.2. These calculations were presented in Appendix F of the health consultation.

Comment 50: The noncancer risks are presented as absolutes with two significant figure accuracy that is beyond the scope of the limited data.

Response 50: The hazard quotients are calculated as the ratio of the exposure of interest to the reference dose and are presented with two significant figures for the benefit of the reader who may want to repeat the calculations. This also allows for the reader to better gauge the relationship between the estimated exposure and the reference dose. It is not meant to imply they are "absolutes" or to convey an undue degree of accuracy or precision.

Comment 51: Applying the qualitative descriptor "minimal" to the risk for health effects for exposures lower than the reference dose was confusing. The precise definition of the reference dose should be used.

Response 51: The use of the term “minimal” as a qualitative descriptor to describe risks for exposures lower than the reference dose was chosen to make the concept more understandable for the lay reader. The exact meaning of the term was explained in footnote 2 of the Summary section, and this footnote also contained the more technical definition of the reference dose.

Comment 52: Limitations that would generally apply to all epidemiology studies should be mentioned in the description of epidemiology studies for both tetrachloroethene and trichloroethene, so as not to imply that certain limitations exist for the studies on one chemical and not the other.
Response 52: The comment is noted. In response to the comment, clarifying language was added to the description of the epidemiology studies for trichloroethene.

Comment 53: The trichloroethene reference dose was incorrectly applied to evaluate developmental toxicity for people who cannot become pregnant (e.g., infants, children), but who should be evaluated for immune toxicity endpoints. The tables showing the relevant sample calculations should be corrected.

Response 53: The trichloroethene (TCE) reference dose is based on both developmental toxicity and immune toxicity and is considered protective of both endpoints. Using the reference dose to evaluate exposures for all member populations is appropriate and consistent with the definition of the reference dose, which indicates it is an exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of adverse effects during a lifetime. In the health consultation, when estimated TCE exposures exceeded the reference dose, margins of exposure were calculated by comparing the exposure from drinking water to the human equivalent TCE dose corresponding to immune or developmental effects in animals. To evaluate immune toxicity, the infant dose (i.e., the highest dose for all the age groups evaluated) estimated from the average TCE water concentration was compared to the human equivalent dose for immune effects to obtain the margin of exposure. To evaluate developmental toxicity, the maternal dose estimated from the highest TCE water concentration was compared to the human equivalent dose for fetal heart malformations. Thus, the TCE reference dose was correctly used, the tables showing the calculations are correct as presented. These calculations were presented in Appendix F of the health consultation.

Comment 54: The margin of exposure is incorrectly defined in Footnote 4 (see the table of sample calculations in Appendix F), and the margins of exposure are incorrectly calculated. The result must be unitless, and the units in both the numerator and denominator should be in mg/kg/day. The table should be corrected.

Response 54: The definition of the margin of exposure in the footnote and in the table are both correct as presented. It says that “The margin of exposure for immune toxicity is the dose that corresponds to a lowest observed effect level (LOEL) for decreased thymus weights in mice (see EPA 2011b) *divided* by the estimated adult or child contaminant exposure at the average TCE water concentration” [italics added]. The footnote offers a similar description for the margin of exposure calculated to evaluate developmental toxicity. The margin of exposure calculations used the same dose units in both the numerator and denominator, which cancel out, and are correct as presented.

Comment 55: There can be no lifetime cancer potency factor for TCE (as indicated in the sample calculation table of Appendix F) because the kidney cancer risk depends on the age of exposure. The corresponding column of the table should be deleted.

Response 55: The TCE cancer risks were calculated using template spreadsheets provided by ATSDR and are correct as presented. The kidney cancer risk (which is assumed to have a mutagenic mode of action) is separated out and has age-dependent adjustment factors applied to account for possible increased early life vulnerability. This risk is then added to the estimated risk for non-Hodgkin's lymphoma and liver cancer to obtain the total risk for each age group. The total risk for each age group is then summed to obtain the lifetime cancer risk. For clarity, the descriptor "lifetime" was removed from the table headings describing the cancer potency factor.

Comment 56: The Health Consultation states that "Currently, drinking or other uses of water from public water supplies affected by the Northrop Grumman/NWIRP facility are not expected to harm people's health". This NYSDOH conclusion has substantial factual support. All potentially impacted public supply wells are monitored and equipped with state-of-the-art treatment systems that ensure drinking water standards are met. For example, BWD has affirmed that the "drinking water is safe and meets all Federal and State requirements." (Bethpage Water District 2017). In addition, the Public Water Supply Contingency Plan ("PWSCP") provides outpost monitoring wells that facilitate installation of wellhead treatment or comparable alternative measures at public supply wells if they are impacted in the future. The State's drinking water standards for VOCs are being met for treated water at each of the affected public supply wellfields. This is an appropriate scientific basis to support the NYSDOH conclusion that current use of public water supplies is not expected to harm people's health.

Response 56: The comment is noted.

Comment 57: Use of the maximum TCE water concentration in Well 6-1 to evaluate developmental toxicity results in an overestimate of exposure because the sample is from raw (not treated) water, and because the exposure period (eight days) is less than the period of development. Disinfection and corrosion control also could have reduced the TCE levels.

Response 57: The highest TCE water concentration from Well 6-1 was used to evaluate developmental toxicity. This is consistent with generally accepted practice for the assessment of health risks and recognizes that the target effects (fetal heart malformations) can occur from a short-term exposure during a critical period of fetal development during pregnancy. It also recognizes that the length of time needed for a gestational TCE exposure to produce developmental health effects in humans is unknown, as is the specific period during pregnancy at which the fetus is most vulnerable to the effects of TCE. The raw water sampling results were used to represent exposure because there were no available sampling data from points in the distribution system, and because we had no information to indicate that water from Well 6-1 was being treated at the time the samples were taken. The possibility that treatment (e.g., disinfection, corrosion control) could have reduced the TCE contaminant concentrations is discussed in the Uncertainties and Limitations section of the revised health consultation

Comment 58: Doubling the water concentrations combined with reasonable maximum exposure (RME) assumptions and using the US EPA's TCE reference dose (which is based on 99th percen**ti**le modeling assumptions) results in exposure and risk estimates that are unrealistically conservative and uncertain, as well as inconsistent with the US EPA's guidance for using RME approaches.

Response 58: The Health Consultation was prepared under a cooperative agreement with ATSDR. ATSDR provided guidance on the standard procedures and methods to be used to evaluate the health risks, which were followed. These included using central tendency and upper percentile (reasonable maximum exposure or RME) dose estimates, evaluating noncancer risks with the US EPA reference dose for TCE, and using methods to account for

exposures to volatile organic chemicals through pathways other than ingestion, such as showering and bathing. Risk calculations were developed with both central tendency and RME exposure assumptions, and examples for both were provided in the document. Since the RME parameters are based on survey data and considered by ATSDR and the US EPA to be within the range of exposures that could occur, the conclusion that the past potential exposures based on the upper percentile parameters could have increased the risk for health effects is valid.

The basis for assuming equal exposure to volatile organic contaminants (VOC) by ingestion and non-ingestion pathways is presented in footnote 6 of the Public Health Implications of Completed Pathways section. The practice of evaluating non-ingestion exposure to water contaminants is consistent with ATSDR direction for appropriately considering these exposures when assessing VOC contamination in drinking water [ATSDR 2005]. The assumption of equal exposure through ingestion and non-ingestion pathways is supported by several studies (see footnote 6) and also by the results of ATSDR's recently developed Shower and Indoor Water Use Model (see Appendix G of the revised health consultation). A discussion of the possibility that the assumptions used in the health consultation could overestimate exposures and risk was added to the Uncertainties and Limitations section of the document.

Comment 59: The health consultation did not disclose relevant data quality limitations or discuss their implications on the findings. This should have been done based on ATSDR guidance which indicates that public health assessments should acknowledge when environmental sampling data are of limited or unknown quality.

Response 59: A discussion of uncertainties related to data quality limitations and their implications on the health consultation findings was added to the Uncertainties and Limitations section of the document.

Comment 60: The approach used in the health consultation is protective with respect to forward-looking risks and managing site impacts but is not predictive with regard to the outcome of past exposures for individuals or groups of individuals. The safety factors and assumptions built into the US EPA toxicity values result in imprecision and uncertainty in attempting to predict risks from historical exposures. Therefore, findings suggesting potential increases in risk require more in-depth evaluation.

Response 60: The health consultation uses a standard procedure (provided in ATSDR guidance) that combines assumptions about the frequency and magnitude of exposures with information about the toxicity of the chemicals to draw conclusions about the risk for human health effects. This evaluation is one tool used to inform risk management decisions. The finding of an increased risk cannot be used to predict whether there will be actual adverse health outcomes for individuals, nor can it be used to determine if health effects occurred in the past. There is no indication in the health consultation that the assessment of risks is being used for this purpose. The comment appears to ascribe less confidence to the use of toxicity values and exposure assumptions to evaluate past exposures than for other purposes and indicates that further evaluation is needed when the process indicates a public health concern. This was in fact done in the health consultation. The reference dose for TCE was used as an initial tool for assessing noncancer risk, but when the estimated past TCE exposures in drinking water exceeded the reference dose, the margin of exposure was calculated for both immune and developmental toxicity, using child and maternal exposure estimates, respectively, and the appropriate estimated human effect levels (i.e., the points of departure for immune and developmental toxicity). The conclusions were then based on the margins of exposure, an evaluation of the potential for exposure to the measured TCE concentrations, and the weight of evidence and strength of the toxicological data for TCE.

Comment 61: The US EPA reference dose for TCE is based on a point of departure that corresponds to a 99th percentile exposure and a 1% response level for developmental toxicity. Use of this point of departure for margin of exposure calculations is overly conservative because it already incorporates a large margin of safety, but the NYSDOH characterized the margin of safety as limited in order to substantiate its conclusion.

Response 61: The health consultation was prepared under a cooperative agreement with ATSDR, using standard procedures contained in ATSDR guidance. These procedures included evaluating TCE exposures with the US EPA TCE reference dose, which was endorsed by ATSDR. When estimated exposures exceeded the reference dose, the margins of exposure were then evaluated, and the human health risks characterized, considering the magnitude of the margin of exposure, the potential for exposure to the measured contaminant levels, and the strength of the toxicological database for TCE. The NYSDOH did not apply a qualitative descriptor to the margin of exposure in order to substantiate a pre-conceived conclusion about the health risks for TCE exposure at the site.

The point of departure for the TCE reference dose is based on pharmacokinetic modeling to obtain an estimate of the human equivalent dose at the rodent effect level for developmental toxicity, which is used as a point of departure in the derivation. Pharmacokinetic modeling is preferred, not because of inherent conservatism, but because it is generally considered to provide a more robust and accurate estimate of the human equivalent dose than default uncertainty factors for interspecies extrapolation. While the choices of response level and upper percentile exposure from the modeling to represent the point of departure are conservative, they nonetheless constitute an effect level for exposures that could occur, and therefore this point of departure is appropriate for calculating margins of exposure for developmental toxicity.

Comment 62: The Health Consultation states that “Past long-term ingestion and inhalation exposure to TCE in the other water supply wells (i.e., other than Bethpage Water District Well 6-1) affected by Northrop Grumman/NWIPR facility in Bethpage is not expected to harm people’s health.” In summarizing the basis for Conclusion 3, pertaining to use of water from wells other than Well 6-1, the Report concluded that “TCE was found at levels in drinking water estimated to pose a very low to low increased risk for cancer and a minimal risk for noncancer health effects (p. 2).” We have reviewed the concentrations reported for the other wells and conclude that the Health Consultation reached an appropriate conclusion that consumption of corresponding water is not expected to harm people’s health, even under the Health Consultation’s assumptions.

Response 62: The comment is noted.

Comment 63: The Health Consultation acknowledges that residents whose drinking water was supplied from at least six drinking water wells (NYAWC Wells 3 and 4, BWD, Wells 6-1 and 6-2 and Wells 4-1 and 4-2) had a complete toxic exposure pathway in the past, in many cases lasting for decades. See Table 1. Despite this, only general conclusory statements are made about the health impacts on these people and no attempt is made to either quantify the exposure, look at the incidence of exposure related health conditions in those areas, or consider second generation impacts. A much more thorough review of the data, and then, actual field studies and epidemiological analysis is necessary to determine the nature and latent effects of the exposure. Only then can the report draw conclusions and make recommendations.

Response 63: Trichloroethene (TCE) was detected in New York American Water Company – Merrick Operations Wells 3 and 4, and Bethpage Water District Wells 6-2 and 4-1, but not at levels that exceeded the current New York State drinking water standard of 5 micrograms per liter. As described in the health consultation comparison of detected levels to current MCLs was

a key to prioritizing wells and contaminants for further evaluation. These low-level detections prompted the water suppliers to either install a water treatment system or remove a well from service. The Bethpage Water District Well 6-1 was removed from service in 1976 when TCE was detected above the interim drinking water guidance value of 50 micrograms per liter.

As described in the Health Consultation, contaminants having detected levels exceeding the MCLs and ATSDR comparison values were further evaluated according to ATSDR guidance. This evaluation included estimating the long-term contaminant exposure through drinking water, evaluating the estimated exposures with ATSDR-approved toxicity values, and then characterizing the estimated risks for health effects. As indicated in the response to comment 18, a health or epidemiological study cannot determine whether any specific individual has already experienced health effects from past exposure, or whether anyone will experience health effects in the future.

Comment 64: The Report discusses only three Well 6-1 samples; however, as described in the NCDOH 1977 chronology, another sample was collected and analyzed for TCE (NCDOH 1977, page 30). The TCE concentrations in these four Well 6-1 samples collected over an eight-day period (11/29/76 to 12/6/76) differed by more than several hundred percent, ranging from 10-15 µg/L on 11/30/76 to 60 µg/L on 12/6/76. The wide range of observed TCE concentrations would not be expected over a short sampling period in a continuously pumped supply well.

Response 64: The NYSDOH reviewed the previously unavailable referenced document "Chronological Record of the Bureau of Water Supply Pollution Control Relating to the Regulation of Industrial Wastes of the Grumman Aerospace Corporation Plant at Bethpage, NY" [NCHD1977]. While the commenter indicates the existence of one additional data point beyond the data evaluated in the health consultation, a review of the documentation on page 30 of the report indicates a range of TCE at 10-15 micrograms per liter rather than a single data point. Without a single data point or analytical quality control information, we would not include this range in estimating the long-term exposure point concentrations. A discussion of the uncertainties related to the limited sampling data for Well 6-1 was added to the Uncertainties and Limitations section of the health consultation.

Comment 65: The health consultation did not clearly distinguish in its conclusions that the increased health risk based on hypothetical exposures applies to noncancer health effects and not to cancer effects.

Response 65: The comment is noted, and clarifying language was added to say that Conclusion 2 is based on non-cancer health endpoints for TCE (i.e., developmental and immune toxicity) rather than cancer endpoints.

References for Appendix H

[ATSDR] Agency for Toxic Substances and Disease Registry. Public Health Assessment Guidance Manual (Update). US Department of Health and Human Services. Public Health Service. [accessed 2022 April 21]. Available from: https://www.atsdr.cdc.gov/pha-guidance/

[ATSDR] Agency for Toxic Substances and Disease Registry. 2019. Exposure Point Concentration Guidance for Discrete Sampling. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, July 12.

[EPA] United States Environmental Protection Agency. 2011b. Toxicological Review of Trichloroethylene. EPA/635/R-09/011F [updated 2011 September 28; accessed 2018 October 18]. Available from: https://cfpub.epa.gov/ncea/iris/search/index.cfm?keyword=

[NCDH] Nassau County Department of Health. 1977. Chronological Record of the Bureau of Water Supply Pollution Control Relating to the Regulation of Industrial Wastes of the Grumman Aerospace Corporation Plant at Bethpage, NY.