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Study Area Feasibility Study

Operable Unit 3 (Former Grumman Settling Ponds),

Bethpage, New York

NYSDEC Site # 1-30-003A

November 10, 2010, Revised April 7, 2011

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Study Area Feasibility Study
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York
NYSDEC Site # 1-30-003A

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Table of Contents

Certification **viii**

Acronyms and Abbreviations **ix**

EXECUTIVE SUMMARY **xii**

1. Purpose **1**

2. Study Area Description **1**

2.1 Study Area 1

2.2 Groundwater Use 2

3. Summary of RI and Current Remedial Operations **3**

3.1 Previous/Other Investigations 3

3.2 Study Area Geology 3

3.3 Study Area Hydrogeology 4

3.4 Nature and Extent of Groundwater Contamination in Study Area 4

3.5 Study Area Conceptual Site Model 5

3.6 Impacted Groundwater 5

3.7 Current Remedial Operations 6

4. Remedial Goals and Remedial Action Objectives **7**

4.1 Standards, Criteria, and Guidance 7

4.2 Remedial Goals 8

4.3 Remedial Action Objectives 8

5. Identification and Screening of Remedial Technologies **9**

6. Development and Analysis of Remedial Alternatives **9**

6.1 Modeling 9

6.2 Description and Analysis of Alternatives 11

6.3 Preliminary Assessment of Remedial Process Closure Requirements 13

7. Recommended Remedy for Study Area **13**

7.1 Summary of Recommended Remedy for Study Area 13

7.2 Sustainable Practices for the Recommended Alternative 15

8. Summary of Comprehensive Recommended Remedy **16**

9. References **20**

Tables

Table 4-1 Potential Chemical-, Action-, and Location-Specific Standards, Criteria, and Guidelines (SCGs) Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Table 5-1 Screening of Remedial Technologies: Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Table 6-1 Evaluation Criteria for Remedial Alternatives, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Table 6-2 Detailed Evaluation of Remedial Alternatives, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Table 8-1 Summary of Comprehensive Recommended Remedy for Site and Study Areas, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Figures

Figure 2-1 Study Area Showing Well and Vertical Profile Boring Locations and Line of Section A-A', Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Figure 3-1 Study Area Conceptual Site Model, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Figure 3-2 Concentrations of TVOCs in Regional Area Groundwater - Plan View, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Figure 3-3 Concentrations of TVOCs in Groundwater (Cross Section A-A'), Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Figure 6-1 Alternative 2 – Baseline/Continued Action Conceptual Site Layout, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Figure 6-2 Alternative 3 – Alternative 2 Plus One New Remedial Well Conceptual Site Layout, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Figure 6-3 Alternative 4 – Alternative 2 Plus Two New Remedial Wells Conceptual Site Layout, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Figure 6-4 Alternative 5 – Alternative 2 Plus One New Remedial Well and BWD Plant 4 as a Remediation System Conceptual Site Layout, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Figure 6-5 Alternative 6 – Alternative 2 Plus Five New Remedial Wells Conceptual Site Layout, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds) Bethpage, New York.

Figure 6-6 Comparison of Model-Predicted TVOC Concentrations at BWD Well 4-1 by Remedial Alternative, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3, Bethpage, New York.

Figure 6-7 Comparison of Model-Predicted TVOC Concentrations at BWD Well 4-2 by Remedial Alternative, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3, Bethpage, New York.

Figure 6-8 Comparison of Model Predicted TVOC Concentrations at BWD Well 5-1 by Remedial Alternative, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3, Bethpage, New York.

Appendices

A Groundwater Model Results

1. Introduction

2. Modeling Approach

2.1 Model Updates

2.1.1 Pumping and Recharge Rates

2.1.2 Contaminant Mass Distribution

2.1.3 Dual Domain Mass Transport

2.2 Particle Tracking Analysis

2.2.1 Potentially Impacted Wells

2.3 Solute Transport

3. Simulation of Remedial Alternatives

4. Modeling Results

4.1 Alternative 2 – Baseline/Continued Action

4.2 Alternative 3 – Alternative 2, Plus One New Remedial Well

4.3 Alternative 4 – Alternative 2, Plus Two New Remedial Wells

4.4 Alternative 5 – Alternative 2, Plus Operate BWD Plant 4 as Remediation System, plus One New Remedial Well (RW-20)

4.5 Alternative 6 – Alternative 2, Plus Five New Remedial Wells

5. References

Tables

Table A-1 Comparison of Remedial Well Pumpage/Recharge by Alternative Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Table A-2 Summary of Model-Predicted TVOC Mass Removed from Groundwater at the End of the 30 Year Period of Operation, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Table A-3 Proposed Remedial Well Details, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figures

Figure A-1 Groundwater Model Domain, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-2 Model Layers, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A3 Current Extent of Regional TVOC Plume and Area of Interest, Study Area Feasiblity Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-4 Particle Tracking, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-5 Maximum Extent of TVOCs in Study Area Groundwater, Initial Conditions, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-6 Alternative 2- Baseline/Continued Action Maximum Extent of TVOCs in Study Area Groundwater After 30 Years, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-7 Alternative 3- Maximum Extent of TVOCs in Study Area Groundwater After 30 Years, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-8 Alternative 4- Maximum Extent of TVOCs in Study Area Groundwater After 30 Years, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-9 Alternative 5- Maximum Extent of TVOCs in Study Area Groundwater After 30 Years, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-10 Alternative 6- Maximum Extent of TVOCs in Study Area Groundwater After 30 Years, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-11 Model Predicted TVOC Concentrations in Existing Northrop Grumman Remedial Well under Alternative 2, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3, Bethpage, New York.

Figure A-12 Model Predicted TVOC Concentrations in Existing and Proposed Northrop Grumman Remedial Wells under Alternative 3, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3, Bethpage, New York.

Figure A-13 Model Predicted TVOC Concentrations in Existing and Proposed Northrop Grumman Remedial Wells under Alternative 4 Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3, Bethpage, New York.

Figure A-14 Model Predicted TVOC Concentrations in Existing and Proposed Northrop Grumman Remedial Wells under

Alternative 5 Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3, Bethpage, New York.

Figure A-15 Model Predicted TVOC Concentrations in Existing and Proposed Northrop Grumman Remedial Wells under Alternative 6, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3, Bethpage, New York.

Figure A-16 Comparison of Model-Predicted TVOC Concentrations at BWD Well 4-1 by Remedial Alternative, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3, Bethpage, New York.

Figure A-17 Comparison of Model-Predicted TVOC Concentrations at BWD Well 4-2 by Remedial Alternative, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3, Bethpage, New York.

Figure A-18 Comparison of Model Predicted TVOC Concentrations at BWD Well 5-1 by Remedial Alternative, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3, Bethpage, New York.

Figure A-19 Alternative 2- Baseline/Continued Action Conceptual Site Layout, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-20 Alternative 3- Alternative 2 Plus One New Remedial Well Conceptual Site Layout, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-21 Alternative 4- Alternative 2 Plus Two New Remedial Wells Conceptual Site Layout, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-22 Alternative 5- Alternative 2 Plus One New Remedial Well and BWD Plant 4 as a Remedial System Conceptual Site Layout, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Figure A-23 Alternative 6- Alternative 2 Plus Five New Remedial Wells Conceptual Site Layout, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

B Remedial Alternatives Detailed Cost Estimates

Table B-1 Summary of Systems Operation Periods, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Table B-2 Detailed Costs of Remedial Alternatives: Study Area Groundwater Alternative 3, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Table B-3 Detailed Costs of Remedial Alternatives: Study Area Groundwater Alternative 3, Present Worth Calculations, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Table B-4 Detailed Costs of Remedial Alternatives: Study Area Groundwater Alternative 4, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Table B-5 Detailed Costs of Remedial Alternatives: Study Area Groundwater Alternative 4, Present Worth Calculations, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Table B-6 Detailed Costs of Remedial Alternatives: Study Area Groundwater Alternative 5, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Table B-7 Detailed Costs of Remedial Alternatives: Study Area Groundwater Alternative 5, Present Worth Calculations, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Table B-8 Detailed Costs of Remedial Alternatives: Study Area Groundwater Alternative 6, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Table B-9 Detailed Costs of Remedial Alternatives: Study Area Groundwater Alternative 6, Present Worth Calculations, Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Certification

I, Kenneth Zegel, certify that I am currently a New York State registered professional engineer and that this Feasibility Study Report was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER-10 Technical Guidance for Site Investigation and Remediation (NYSDEC 2010).

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Acronyms and Abbreviations

Access Road	Former Grumman Plant 24 Access Road
ARCADIS	ARCADIS of New York. Inc.
Bethpage Community Park	The entire area that constitutes the present day Bethpage Community Park property
bls	below land surface
BWD	Bethpage Water District
COPCs	Constituents of Potential Concern
CSM	Conceptual site model
DCA	Dichloroethane
DCE	Dichloroethene
Freon 12	Dichlorodifluoromethane
FS	Feasibility Study
ft	feet
ft/day	feet per day
GAC	Granular activated carbon
gpm	gallons per minute
Grumman	Grumman Aerospace Corporation
HHRA	Human Health Risk Assessment
IRM	Interim Remedial Measure
ISTD	In-situ thermal desorption
LEED	Leadership in Energy and Environmental Design
Main Facility	Northrop Grumman Main Facility, used to refer to current remedial systems associated with OU2 (Tower 96 and Tower 102)

ft msl	feet above mean sea level
Navy	United States Navy
Northrop Grumman	Northrop Grumman Systems Corporation
NWIRP	Naval Weapons Industrial Reserve Plant
NYCRR	New York Code of Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OCC	Occidental Chemical Corporation
OM&M	Operation, maintenance, and monitoring
OU2	Operable Unit 2
OU3	Operable Unit 3
Park	Portion of the Bethpage Community Park not subject to soil removal during Town redevelopment activities
PCE	Tetrachloroethene (a/k/a perchloroethene)
ppm	parts per million
RAO	Remedial action objective
RI	Remedial Investigation
ROD	Record of Decision
RSE	Remedial System Evaluation
SCGs	Standards, Criteria and Guidance Values
SCO	Soil Cleanup Objective

Site Area	Portion of the Bethpage Community Park not subject to soil removal during Town of Oyster Bay (Town) redevelopment activities plus the Former Grumman Plant 24 Access Road. For the media soil gas and groundwater, the Site Area includes the entire Bethpage Community Park and the Former Grumman Plant 24 Access Road.
Study Area	The area of Volatile Organic Compound (VOC)-impacted groundwater hydraulically downgradient (i.e., south and southeast) of and impacted by the Site Area, plus the peripheral area (i.e., an area of significantly lower to non-detect concentrations of VOCs) that was used to delineate the impacted groundwater
TCA	Trichloroethane
TCE	Trichloroethene
Town	Town of Oyster Bay
TVOCs	Total volatile organic compounds
USGS	United States Geological Survey
µg/L	micrograms per liter
USEPA	United States Environmental Protection Agency
VC	Vinyl chloride
VOCs	Volatile organic compounds
VPB	Vertical profile boring

EXECUTIVE SUMMARY

This Study Area Feasibility Study (FS) was prepared by the Northrop Grumman Systems Corporation (Northrop Grumman) to identify and screen remedial technologies and evaluate remedial alternatives for constituents in groundwater in the Study Area, located in Bethpage, New York. This FS also presents a summary of the Comprehensive Remedy for OU3, which includes both the Site Area FS (ARCADIS of New York, Inc. 2011) recommended remedy and the Study Area recommended remedy.

The term "Study Area" hereinafter refers to the area of volatile organic compound (VOC)-impacted groundwater hydraulically downgradient (i.e., south and southeast) of and impacted by the Site Area, plus the peripheral area (i.e., an area of significantly lower to non-detect concentrations of VOCs) that was used to delineate the impacted groundwater. The term "Site Area" hereinafter refers to the portion of the Bethpage Community Park not subject to soil removal during Town of Oyster Bay (Town) redevelopment activities plus the Former Grumman Plant 24 Access Road.

Investigations conducted by Northrop Grumman within the Study Area and previous investigations conducted by others identified a regional area of VOC-impacted groundwater hydraulically downgradient of the Site Area, and the adjacent former Grumman Facility, the Naval Weapons Industrial Reserve Plant (NWIRP), and the Occidental Chemical Corporation (OCC) site, located west of the Site Area. The constituents of potential concern (COPCs) identified in the Study Area groundwater are VOCs.

This Study Area FS was developed consistent with New York State Department of Environmental Conservation (NYSDEC) requirements. Potential remedial technologies were screened using applicable Standards, Criteria, and Guidelines (SCGs). Remedial technologies that were retained after screening were assembled into remedial alternatives that were evaluated against the remedy selection criteria in Title 6 of the New York Code of Rules and Regulations (NYCRR), Part 375-1.8(f).

Study Area Recommended Remedy

Based on the evaluations conducted, the Study Area Recommended Remedy is presented in this FS and is summarized below:

Baseline Remedial Elements

- Remediate Site Area VOC source areas (i.e., total VOCs (TVOCs) greater than 10 parts per million (ppm) in soil and groundwater) using in-situ thermal desorption (ISTD) to reduce TVOC concentrations to 1 ppm or less.

- Continue operation, maintenance, and monitoring (OM&M) of the existing groundwater interim remedial measure (IRM) (four wells; total 210 gallons per minute (gpm)) to prevent groundwater from migrating off site. For cost estimating purposes, the Groundwater IRM is estimated to operate for 15 years.

- Continue to operate the following remedial systems to reduce VOC mass in the Study Area:

    - Main Facility Tower 102 remedial system (three wells; total 2,300 gpm) and

    - GM-38 Area Groundwater Remedy (two wells; total 1,100 gpm).

  The above remedial systems include ex-situ groundwater treatment via air stripping (with off-gas treatment) and discharge to local recharge basins and one injection well (GM-38 Area remedy only).

- Continue to operate the existing wellhead protection systems at Bethpage Water District (BWD) Plants 4 and 5.

New Remedial Elements

- Install one new remedial well (Well RW-21, pumping at 1,000 gpm) to reduce VOC mass in the Study Area groundwater and pipe the recovered water to the Northrop Grumman Main Facility for treatment. Upgrade the Main Facility Remedial System (Tower 102) with a new air stripper blower to treat water from RW-21 and to achieve groundwater effluent discharge limits at the increased hydraulic loading rate. Discharge treated water into the South Basins.

- Install new monitoring wells and use with existing wells to perform plume management, performance monitoring, and effectiveness monitoring.

- Develop and implement an OM&M plan or similar document, following remedial construction completion.

- Operate Remedial Well RW-21 full-time for 20 years, followed by 5 years of pulsed operation, followed by 5 years of post-remediation groundwater monitoring/natural attenuation for residual VOCs. Actual operating times, shut down criteria, and post-remediation monitoring requirements will be determined over time based on field data.

The new remedial elements, combined with the baseline remedial elements described above, represent the integral components of a comprehensive solution to VOCs in the regional groundwater.

Comprehensive Recommended Remedy

This FS discusses several remedial systems that are currently in place to address the regional area of VOC-impacted groundwater and recommends further groundwater remedies to provide a comprehensive solution to the regional area of VOC-impacted groundwater. Additionally, as detailed in the Site Area FS, remedies are also recommended to address impacted soils, soil gas, and source areas. Those remedies, in combination with the recommended groundwater remedies, create a comprehensive, integrated solution to contamination present in both the Site Area and Study Area. The various remedial elements of the Comprehensive Recommended Remedy are summarized below:

Soils

- Alternative S-P2: Excavate upper 2 feet (ft) of soil across Park where Site Area-related COPCs exceed restricted-residential soil cleanup objectives (SCOs) and replace with clean fill.

- Alternative S-AR2: Install gravel cap over Access Road soils where Site Area-related COPCs exceed restricted-residential SCOs.

Source Areas

- Alternative SA-3**:** Remediate VOC source areas in the Park (i.e., areas exceeding 10 ppm TVOCs) using ISTD to minimize potential migration of VOCs to groundwater and soil gas.

Soil Gas

- Alternative SG-2: Operate Soil Gas IRM to prevent off-site migration of soil gas until shut down criteria are met.

Groundwater

- Alternative GW-2 (Site Area FS) and Alternative 3 (Study Area FS):

- Continue to operate the Groundwater IRM to prevent off-site migration of groundwater; transition to natural attenuation with monitoring to address residual VOC impacts once Groundwater IRM system shut down criteria are met.

- Continue to operate other groundwater remedial systems to reduce VOC mass in Study Area, specifically the Northrop Grumman Main Facility and GM-38 Area remedial systems.

- Continue to operate wellhead protection systems at BWD Plants 4 and 5.

- Install and operate one new remedial well to reduce VOC mass in Study Area groundwater; treat extracted groundwater in existing Main Facility remedial system. Operate well full-time for 20 years, followed by 5 years of pulsed operation, followed by system shut down and 5 years of post-remediation groundwater monitoring. Actual operating times, shut down criteria, and post-remediation monitoring requirements will be determined over time based on field data.

- Use existing and newly installed monitoring wells to perform regular monitoring of remedial system performance and for reporting on remedial system effectiveness.

Additional Components of the Comprehensive Remedy

- Perform regular performance monitoring and reporting of remedial system effectiveness. As applicable, implement OM&M plans following remedial construction completion.

- Where applicable, environmental easements for institutional and engineering controls will be incorporated into the recommended alternative to help ensure that

the Recommended Remedy for the Site and Study Areas is maintained and is protective of human health for reasonably anticipated future land uses.

The total estimated cost for the Comprehensive Recommended Remedy is $64.5 million.

1. Purpose

The purpose of this FS is to identify and screen remedial technologies and evaluate remedial alternatives for contaminants in groundwater in the Study Area. This FS also presents the Comprehensive Recommended Remedy for OU3 which incorporates the existing remedial measures, the Site Area recommended remedy and the Study Area recommended remedy. The technology and alternatives evaluations for the Site Area are presented in the Site Area FS. (ARCADIS of New York, Inc. 2011)

This report was prepared by ARCADIS on behalf of Northrop Grumman. It is being submitted pursuant to Section II of the Administrative Order on Consent between the NYSDEC and Northrop Grumman, effective July 4, 2005 (NYSDEC 2005).

2. Study Area Description

2.1 Study Area

For the purposes of this FS, the "Study Area" is defined as the area of VOC-impacted groundwater hydraulically downgradient (i.e., south and southeast) of and impacted by the Site Area, plus the peripheral area (i.e., an area of significantly lower to non-detect concentrations of VOCs) that was used to delineate the impacted groundwater (**Figure 2-1**). The Study Area is contained within a larger region of VOC-impacted groundwater. Remedial measures already in place to address this larger region of VOC-impacted groundwater are discussed below in Section 3.7.

The term "Site Area" hereinafter refers to a portion of the Bethpage Community Park not subject to soil removal during Town redevelopment activities, plus the Former Grumman Plant 24 Access Road (Access Road). For the media soil gas and groundwater, the Site Area includes the entire Bethpage Community Park and the Access Road. A detailed description of the Site Area was presented in the Site Area RI Report (ARCADIS U.S., Inc. 2011b) and the Site Area FS. The Site Area FS addresses remediation of impacted groundwater, source areas, soil, and soil gas. Northrop Grumman implemented a Groundwater IRM in 2009, which is further described in Section 3.7 of this report. In accordance with design objectives, the Groundwater IRM is successfully controlling off-site migration of VOCs to downgradient locations.

The Study Area land surface elevation ranges from approximately 120 feet above mean sea level (ft msl) to 85 ft msl and, topographically, is generally flat. Natural surface water features do not exist in the Study Area, although man-made stormwater recharge

basins are present that receive runoff from paved surfaces and then recharge the groundwater system. Land use currently and historically is primarily residential with some commercial and industrial development. Surface features are shown on **Figure 2-1**.

2.2 Groundwater Use

The BWD operates five public supply wells in three wellfields in the Study Area (Plant 4 [Wells 4-1 and 4-2], Plant 5 [Well 5-1], and Plant 6 [Wells 6-1 and 6-2]) (**Figure 2-1**). Available information indicates that all residents in the Study Area receive water supply from BWD. BWD Plants 4, 5, and 6 are equipped with treatment systems that are operated by BWD to remove VOCs. BWD's wells are located in the area of regional VOC-impacted groundwater.

Northrop Grumman entered into an agreement with BWD on June 17, 1994 for BWD Plant 4 to fund the design and construction of a wellhead protection system using an air stripping tower. In addition, Northrop Grumman has been funding operation of the Plant 4 treatment system for the past 16 years. The agreement provides for Northrop Grumman's funding of wellhead protection to treat up to a concentration of 600 micrograms per liter (µg/L) TVOCs down to drinking water standards.

In the first half of 2010, liquid phase granular activated carbon (GAC) polishing was added to the existing wellhead protection system at BWD Plant 4. According to the "Engineering Report/Well Head Treatment Improvements For VOC Removal At Plant No. 4" (H2M 2008), the combined air stripper and GAC polishing system at BWD Plant 4 can treat a design influent TVOC concentration of 5,498 µg/L down to a concentration of less than 0.5 µg/L, while operating at its peak flow rate.

Similar to BWD Plant 4, the Navy entered into an agreement with BWD for Plant 5. The agreement provides for Navy's funding of wellhead protection up to a concentration of 600 µg/L down to a concentration of 5 µg/L for known contaminants (Fly. 2010).

Similar to BWD Plant 4, Northrop Grumman entered into another agreement with BWD for Plant 6 on May 22, 1990 (with three amendments, dated March 29, 1996, November 1999, and June 2005). The agreement provides for Northrop Grumman's funding of wellhead protection up to a concentration of 300 µg/L down to a concentration of non-detect for TVOCs.

3. Summary of RI and Current Remedial Operations

3.1 Previous/Other Investigations

The Study Area is part of the larger region of VOC-impacted groundwater that has been previously investigated and documented by Northrop Grumman, the Navy, the U.S. Geological Survey (USGS), and the OCC (hereinafter referred to as the regional area of either VOC-impacted or TVOC-impacted groundwater). Remedial measures are currently in place to address this regional area of VOC-impacted groundwater, as discussed in Section 3.7. Investigations conducted within the Study Area include the Northrop Grumman Study Area RI, a number of investigations conducted by Northrop Grumman prior to 2004, and preceding investigations completed by the Navy, and the USGS. Data from these investigations were incorporated, as applicable, into the conceptual site model (CSM) and the Study Area RI Report (ARCADIS U.S., Inc. 2010; 2011a).

The following subsections summarize the geology and hydrogeology of the Study Area, the nature and extent of Study Area groundwater impacts, and the CSM. More detailed discussions of these topics are provided in the Study Area RI Report.

Figures 3-1, 3-2, and **3-3**, originally included in the Study Area RI Report, are included in this report.

3.2 Study Area Geology

From land surface downward, the geologic sequence in the Study Area is as follows:

- Pleistocene-age (Upper Glacial) sands of varying grain size with silt, clay and gravel lenses in the unsaturated and saturated zones.

- Cretaceous-age (Magothy) interbedded fine to coarse sands and silts with discontinuous zones of lower permeability clays, sandy clays, and silty clays to a depth of approximately 820 feet below land surface (ft bls).

- Basal Magothy gravel zone, this was encountered during the Northrop Grumman Study Area RI drilling program in VP-104 (**Figures 3-2**) from 820 to 880 ft bls.

- Cretaceous age clay (Raritan Confining Unit) was encountered at 672 ft bls during the Study Area RI in VP-110R (**Figure 3-2**). Although it has been documented that regionally this unit underlies the Magothy formation and varies in depth, except for

at VP-110R, all VPBs that were drilled deep enough to reach this unit (based on USGS estimates of the depth of the clay) did not encounter it.

3.3 Study Area Hydrogeology

Groundwater in the Upper Glacial and Magothy aquifers occurs under unconfined conditions, with the Magothy aquifer exhibiting semi-confined to confined conditions with increasing depth. Groundwater elevation data indicate a general south-southeasterly groundwater flow direction (consistent with the regional flow direction) and a slightly downward vertical gradient. Groundwater velocity in the Study Area ranges from approximately 0.85 to 2.56 feet per day (ft/day). The downward flow has been accentuated by industrial pumping and recharge on the former Grumman Facility and the NWIRP, as well as by public supply well pumpage (ARCADIS 2009).

3.4 Nature and Extent of Groundwater Contamination in Study Area

Based on the Study Area RI, VOCs were determined to be COPCs in Study Area groundwater. Non-Site Area-related COPCs, consisting of Freons 12 and 22, were also detected in the Study Area and were attributed to a former ice rink operated by the Town. **Figure 3-2** depicts the maximum extent of VOC-impacted groundwater in the region in plan view. This figure depicts the average concentration of VOCs from wells for the period of 2004 to 2007 or more recent data for wells installed after 2007 and the maximum VOC concentration from vertical profile borings (VPBs) in the Study Area (Northrop Grumman completed 22 VPBs from 2006 to 2009 and Navy completed six VPBs from 2000 to 2002). Well and VPB depths vary throughout the region; however, the data were plotted on a single figure regardless of depth. Therefore, this figure shows the maximum lateral extent and concentration of VOCs in groundwater (i.e., at any particular depth, the VOC concentration would be equal to or less than the value depicted). The maximum extent of VOC-impacted groundwater identified in the Study Area during the RI is approximately 8,300 ft in length and 2,100 ft in width, with a maximum depth of 670 ft bls and a maximum thickness of 430 ft.

Figure 3-3 shows the TVOC concentrations in cross section. The highest TVOC concentrations observed in the Study Area were at depths ranging from approximately 75 ft bls (northern portion) to 590 ft bls (southern portion). VP-111 exhibited the maximum observed TVOC concentration in the Study Area (10,500 µg/L at a depth of 451 ft bls; TVOC concentrations are less than 500 µg/L at depths shallower than 411 ft bls and deeper than 531 ft bls). Trichloroethene (TCE) and cis-1,2-dichloroethene (cis-1,2-DCE) were determined to be the predominant VOCs detected (based on frequency

of detection and concentration) in groundwater above SCG values, followed by 1,1-dichloroethane (1,1-DCA); tetrachloroethene (PCE); 1,1-dichloroethene (1,1-DCE); vinyl chloride (VC); 1,2-dichloroethane (1,2-DCA); Freon 113; toluene, chloroform, 1,1,1-trichloroethane (1,1,1-TCA); and trans 1,2-dichlorothene (trans-1,2-DCE).

As detailed in the Study Area RI Report, the distribution and concentrations of perchlorate in the Study Area indicate that this constituent is not Site Area-related. The distribution and concentrations of chromium detected in the Study Area (based on the Study Area RI Report) also indicate that this constituent is not Site Area-related. Although the results of the samples collected from Monitoring Well MW111-4 (three rounds) exceed the NYSDEC standard for chromium of 50 µg/L (most recent result from April 2010 was 399 µg/L), the data from surrounding wells are below the standard and suggest a local source of the elevated chromium in Monitoring Well MW111-4. Chromium data will be considered further during remedial design to determine if it might have an effect on the treatment system design and costs.

3.5 Study Area Conceptual Site Model

The CSM developed for the Study Area is shown on **Figure 3-1** and is summarized as follows:

- VOC releases from the Site Area and industrial properties west and adjacent to the Site Area resulted in VOC impacts to groundwater.
- Historical pumping and recharge on the former Grumman and NWIRP properties caused mixing of VOCs and accentuated downward movement of VOC-impacted groundwater, resulting in impacts at depths greater than 500 ft bls. The VOC-impacted groundwater that migrated south of the above properties was further influenced by the pumping of public supply wells.
- Several downgradient public supply wells are presently affected by VOC-impacted groundwater.
- Wellhead treatment of public supply wells for VOCs results in no current human exposure to VOCs in groundwater.

3.6 Impacted Groundwater

Based on the current understanding, (i.e., initial conditions), the estimated VOC mass in the area of regional TVOC-impacted groundwater (including the Study Area) is approximately 147,000 pounds (lbs), which results from sources originating at the Site

Area, the former Grumman Facility, the former NWIRP site, and the OCC site. Estimates of mass removal for the remedial alternatives presented in Section 6 and Appendix A of this report are based on this estimated initial mass.

3.7 Current Remedial Operations

Several remedial systems have already been implemented, under the oversight of the NYSDEC or U.S. Environmental Protection Agency (USEPA) that collectively address groundwater within the regional area of TVOC-impacted groundwater. These systems consist of the following, which are discussed below:

- Groundwater IRM (referred to in the tables and figures of this report as the Site IRM)
- Northrop Grumman Main Facility (Main Facility) Remedial Systems
- Navy GM-38 Area Remedial System
- Navy Air Sparge/Soil Vapor Extraction (SVE) System
- OCC Biosparge System

Northrop Grumman voluntarily implemented the Groundwater IRM in July 2009, to prevent off-site migration of Site Area-related COPCs in groundwater. This is accomplished by extracting groundwater from four wells (Wells RW-1 to RW-4) installed along the Access Road property, with subsequent treatment of VOCs using an air stripper. As of the end of June 2009, the system has removed from groundwater and treated approximately 700 lbs of VOCs and is predicted to eventually remove a total of approximately 7,800 lbs of VOCs from groundwater. Additional details regarding the Groundwater IRM are provided in the Groundwater IRM Final Design Report (ARCADIS of New York, Inc. 2008).

Northrop Grumman operates two other groundwater remedial systems on the Main Facility in the region that pump a total of approximately 5.5 million gallons per day (mgd). Specifically, Northrop Grumman operates five remedial wells (Wells 1, 3, 17, 18, and 19) and two groundwater treatment systems on the Main Facility (Towers 96 and 102) to prevent off-site migration of VOC-impacted groundwater from the former Grumman facility and NWIRP site. The groundwater remedial treatment systems described above are effective in meeting their remedial objectives of preventing the off-

site migration of VOCs in groundwater and removing VOC mass from the regional area of VOC-impacted groundwater. As an example, TVOCs in a key monitoring well near the Main Facility have been reduced by 98 percent since system startup, and the Main Facility systems have removed and treated a total of approximately 150,000 lbs of VOCs since Tower 102 startup in 1998. The Tower 96 remedial system initiated operation in 1988.

The Navy operates the GM-38 Area VOC mass removal groundwater remedy, consisting of two remedial wells (GM-38 RW-1 and GM38 RW-3) which remove and treat a total of 1,100 gpm from the regional area of TVOC-impacted groundwater.

The above existing systems have been integrated into the development of the remedial alternatives presented in this FS as a component of the comprehensive solution to VOCs in regional groundwater.

As part of remediation of the NWIRP Bethpage facility, the Navy operated an air sparge/SVE system to address VOCs in shallow groundwater east of Plant 3. This system was operated for several years in the 1990s and was shut down when it reached its shut-down criteria.

As part of the USEPA-issued Groundwater Record of Decision (ROD) for the OCC Site, a biosparge system was installed and is currently operating on the northwest corner of the former Grumman Facility. The purpose of this system is to remediate vinyl chloride in groundwater originating from the OCC site.

4. Remedial Goals and Remedial Action Objectives

This section summarizes the remedial goals and the RAOs for the Study Area.

4.1 Standards, Criteria, and Guidance

Potentially applicable or relevant and appropriate federal, state, and local SCGs form the basis for the remedial goals and objectives for the project, the appropriate remedial alternatives, and the scope and extent to which retained remedial alternatives can be implemented. The SCGs identified for this FS are summarized in **Table 4-1**.

“Standards and criteria” are cleanup standards, standards of control, and other substantive environmental requirements, criteria or limitations that are generally applicable, consistently applied, and officially promulgated under federal or state law

that are either directly applicable to a contaminant, remedial action, location or other circumstance, or that are not directly applicable but are relevant and appropriate.

“Guidance” consists of non-promulgated criteria, advisories, and/or other guidance that are not legal requirements and do not have the same status as “standards and criteria”; however, remedial alternatives should consider guidance that, based on professional judgment, may be applicable to the project.

4.2 Remedial Goals

Section 27-1301 of the New York State Environmental Conservation Law states that the goals of the inactive hazardous waste disposal site remedial program are to "eliminate, remove, abate, control or monitor health and/or environmental hazards or potential hazards."

Pursuant to Title 6 NYCRR Part 375-2.8(a), (b), and (c) and the DER-10 guidance document (NYSDEC 2010), remedial goals for all remedial actions should include:

- Restoring the site to pre-disposal/pre-release conditions, to the extent feasible,
- Eliminating or mitigating all significant threats to public health and the environment through proper application of scientific and engineering principles,
- Removing sources of contamination to the extent feasible. “Feasible” is defined as suitable to site conditions, capable of being successfully carried out with available technology, implementable, and cost effective (6 NYCRR Part 375-1.2)

4.3 Remedial Action Objectives

RAOs developed for the Study Area to eliminate or mitigate all significant threats to human health and the environment are the following:

- Prevent exposure to Site Area-related VOCs in groundwater within the Study Area and
- Reduce VOC mass in Study Area groundwater to the extent feasible

5. Identification and Screening of Remedial Technologies

The purpose of this section is to identify and screen a range of remedial technologies to address groundwater. Selected technologies are developed into alternatives, which are then further evaluated during the detailed analysis of the remedial alternatives presented in Section 6 of this report.

The list of remedial technologies was developed in cooperation with the NYSDEC and is focused on those technologies that are considered by NYSDEC to be presumptive remedies for VOCs in groundwater. In accordance with NYSDEC guidance (2006), the identified technologies were screened using the following criteria:

- Effectiveness – Potential effectiveness in achieving RAOs; reliability of technology; and potential impacts to human health and the environment,
- Implementability – Technical and administrative feasibility of implementing the technology at the site, and
- Relative cost – Relative cost to implement the technology, including capital cost and cost for OM&M.

The results of the remedial technology screening conducted for Study Area groundwater are presented in **Table 5-1**. The technologies that passed the screening step are baseline/continued action, extraction wells, air stripping, recharge basins, injection wells, and natural attenuation.

6. Development and Analysis of Remedial Alternatives

Remedial alternatives to meet the Study Area RAOs were developed using technologies retained from Section 5. Groundwater modeling was used to develop and evaluate the remedial alternatives, as described below.

6.1 Modeling

The updated regional groundwater model was used to evaluate the ability of various remedial alternatives to achieve the Study Area RAOs. The groundwater modeling included the following tasks:

1. The existing model was updated using current data for aquifer pumping and discharge rates, and TVOC distribution. The model was also updated to reflect dual domain advection-diffusion mass transport, which is a method of transport modeling that represents both the mobile and immobile phases of the contaminants.

2. Particle tracking (advective transport) analysis was conducted to identify wells potentially impacted by TVOCs in the Study Area and to evaluate various remedial alternative conceptual designs.

3. Solute transport modeling was conducted to predict TVOC mass loading and peak concentrations at potentially impacted wells and proposed remedial wells under different remedial alternatives and to evaluate changes over time in the extent of the TVOC-impacted groundwater.

The details of the modeling tasks and results are presented in Appendix A. Except for Alternatives 1 and 2, each evaluated remedial alternative included installation of one or more new remedial well(s).

Results of the baseline particle tracking concluded:

- Particles from the Study Area VOC-impacted groundwater do not migrate beyond the most downgradient BWD well (i.e., Plant 5); and

- The following wells are either currently or potentially impacted in the future by VOCs in Study Area groundwater: BWD wells 4-1, 4-2, 5-1, and 6-2; Main Facility Wells 17, 18, and 19; and the GM-38 Area wells.

Main Facility Remedial Systems Wells 17 and 18, the GM-38 wells, and BWD Well 6-2 were not retained for further evaluation in this FS, because these wells are (1) addressed under the Operable Unit 2 (OU2) ROD, which provides for the protection of public health and the environment and (2) the wells are relatively distant from or shallow relative to VOCs in the Study Area. Although the OU2 ROD also addresses Remedial Well 19, this well was retained for further evaluation in this FS because it is a key component of the remedial alternatives evaluated in this FS, given the extent of its zone of capture within the Study Area.

Solute transport modeling was used to estimate the TVOC mass removed by each remedial alternative and to analyze TVOC concentration trends in proposed remedial

wells and potentially impacted wells (Appendix A, **Table A-2**). The model results, as presented in Appendix A, indicate that all alternatives (except for Alternative 1- No Action Alternative) achieve TVOC mass reduction in the Study Area and reduce peak concentrations of TVOCs at BWD Plants 4 and 5.

6.2 Description and Analysis of Alternatives

Using the results of the modeling efforts described in Appendix A and the screening of remedial technologies described in Section 5, remedial alternatives were developed and evaluated against the following two general criteria in 6 NYCRR Part 375-1.8:

a. Source Removal and Control Measures: Preference is for source removal and/or treatment. All sources, concentrated solid or semi-solid hazardous substances, dense non-aqueous phase liquid, light non-aqueous phase liquid, and/or grossly contaminated media shall be removed and/or treated; provided however, if the removal and/or treatment of all such contamination is not feasible, such contamination shall be removed or treated to the greatest extent possible.

b. Groundwater Protection and Control Measures: Restoration of groundwater shall be evaluated to determine the feasibility of measures to restore groundwater quality to meet applicable standards and guidance.

Additionally, under 6 NYCRR Part 375-4.8, "…the remedy selected shall eliminate or mitigate all significant threats to the public health and to the environment…". This criterion is considered a "threshold criterion" for selection of a remedy under DER-10 (NYSDEC 2010). Based on the results of the baseline modeling (**Figures 6-6 to 6-8**) and the BWD's stated treatment capacity of BWD Plants 4 and 5 (Section 2.2), protection of public health is satisfied under current and predicted future baseline conditions. That is, treatment of BWD supply wells at Plants 4 and 5 is common to all of the remedial alternatives evaluated (except for Alternative 1- the No Action Alternative) as detailed below:

- The conservative, design influent concentration to BWD Plant 4 is 5,498 µg/L TVOCs (H2M 2008). In comparison, the maximum TVOC concentrations predicted by the model are approximately 400 µg/L in Well 4-1 and 130 µg/L in Well 4-2 under baseline conditions (see **Figures 6-6 and 6-7)**. The maximum TVOC concentrations predicted by the model in Wells 4-1 and 4-2 under all the other active alternatives are lower than the predicted baseline concentrations.

Alternative 3 provides the greatest predicted reduction in TVOC concentrations in Wells 4-1 and 4-2, with concentrations attaining SCGs in approximately 20 years.

- The stated treatment capacity of BWD Plant 5 is 600 µg/L TVOCs (Fly 2010). In comparison, the maximum TVOC concentration predicted by the model is approximately 180 µg/L in Well 5-1 under baseline conditions (see **Figure 6-8)**. The maximum TVOC concentrations predicted by the model in Well 5-1under all other active alternatives are lower than the predicted baseline concentration. Alternative 3 provides the greatest predicted reduction in TVOC concentrations in Well 5-1.

Because human health is protected under all alternatives (other than Alternative 1), the remainder of this FS focuses on the mitigation of threats to the environment to the extent feasible (i.e., bulk reduction of groundwater contamination, per DER-10 Section 6.4).

In accordance with 6 NYCRR Part 375–1.8, the remedial alternatives were evaluated against seven remedial selection criteria and sustainability (as defined in **Table 6-1**). Six remedial alternatives were developed and, as summarized below, all alternatives are shown on **Figures 6-1 through 6-5**, except for Alternative 1.

1. Alternative 1 – No Action

2. Alternative 2 – Baseline/Continued Action

3. Alternative 3 – Alternative 2 Plus One New Remedial Well

4. Alternative 4 – Alternative 2 Plus Two New Remedial Wells

5. Alternative 5 – Alternative 2 Plus One New Remedial Well and Use of BWD Plant 4 as a Remediation System

6. Alternative 6 – Alternative 2 Plus Five New Remedial Wells

Table 6-2 summarizes and evaluates the remedial alternatives developed for Study Area groundwater.

6.3 Preliminary Assessment of Remedial Process Closure Requirements

Remedial process closure requirements (i.e., shutdown criteria) for the selected remedy will be developed and provided in a future OM&M plan or similar document. In accordance with guidance provided in DER-10 Section 6.4(b) treatment system shutdown criteria may include:

- Achieving asymptotic levels in remedial wells or water supply wells, and
- Achieving significant bulk reduction in contamination in groundwater.

Time versus concentration graphs developed from the modeling conducted, suggest that the time to reach an asymptote will vary among the remedial alternatives (see Appendix A, **Figures A-11 to A-15**); however, 20 years represents a reasonable average timeframe for costing purposes. The exception is BWD Well 4-1 under Alternative 4, which does not reach asymptotic levels in the 30-year timeframe (see Appendix A, **Figures A-11 to A-15**). A bulk reduction in VOCs in groundwater is also observed for each alternative evaluated.

Mass removal and operating cost estimates for the alternatives are based on an assumed 20 years of full-time operation for new remedial wells, followed by 5 years of pulsed operation. The mass and cost estimates are based on an assumed 15 years of Groundwater IRM operation and 30 years of operation for other remedial wells and the public supply wells in the Study Area. Actual operating times, shutdown criteria, and post-remediation monitoring requirements will be determined over time based on field data.

7. Recommended Remedy for Study Area

This section summarizes the Recommended Remedy for the Study Area, as well as the sustainability practices that are incorporated into the remedial alternatives.

7.1 Summary of Recommended Remedy for Study Area

Based on the analyses conducted in this FS, the Recommended Remedy for the Study Area incorporates components of the FS Recommended Remedy for the Site Area related to groundwater, and is summarized below.

Baseline Remedial Elements:

- Remediate Site Area VOC source areas (i.e., TVOCs greater than 10 ppm (in soil and groundwater) using ISTD to reduce TVOC concentrations to 1 ppm or less.

- Continue OM&M of the existing Groundwater IRM (four wells; total 210 gpm) to prevent groundwater from migrating off site. For cost estimating purposes, the Groundwater IRM is estimated to operate for 15 years.

- Continue to operate the following remedial systems to reduce VOC mass in the Study Area:

    - Main Facility Tower 102 remedial system (three wells; total 2,300 gpm) and

    - GM-38 Area Groundwater Remedy (two wells; total 1,100 gpm).

    The above remedial systems include ex-situ groundwater treatment via air stripping (with off-gas treatment) and discharge to local recharge basins and one injection well (GM-38 Area remedy only).

- Continue to operate the existing wellhead protection systems at BWD Plants 4 and 5.

New Remedial Elements:

- Install one new remedial well (Well RW-21, pumping at 1,000 gpm) to reduce VOC mass in the Study Area groundwater and pipe the recovered water to the Main Facility for treatment. Upgrade the Main Facility Remedial System (Tower 102) with a new air stripper blower to treat water from RW-21 and to achieve groundwater effluent discharge limits at the increased hydraulic loading rate. Discharge treated water into the South Basins.

- Install new monitoring wells and use with existing wells to perform plume management, performance, and effectiveness monitoring.

- Develop and implement an OM&M plan or similar document, following remedial construction completion.

- Operate Remedial Well RW-21 full-time for 20 years, followed by 5 years of pulsed operation, followed by 5 years of post-remediation groundwater monitoring/natural attenuation for residual VOCs. Actual operating times, shutdown criteria, and post-remediation monitoring requirements will be determined over time based on field data.

The new remedial elements, combined with the baseline remedial elements described above, represent the integral components of a comprehensive solution to VOCs in the regional groundwater. A detailed rationale for selection of the Recommended Remedy for the Study Area is provided in **Table 6-2**.

As presented in **Table 6-2**, the Recommended Remedy for the Study Area meets the following criteria:

- Protects human health through treatment of BWD water supplies to meet drinking water standards,
- Protects the environment through TVOC bulk mass removal,
- Capable of achieving RAOs,
- Complies with SCGs, to the extent feasible,
- Technically and administratively implementable,
- Effective in short term and long term,
- Reduces the toxicity, volume, and mobility of contaminants through treatment, to the extent feasible, and
- Cost effective approach to comprehensive solution to VOCs in regional groundwater.

7.2 Sustainable Practices for the Recommended Alternative

In addition to the above regulatory-driven selection criteria, Northrop Grumman has considered alternatives that conserve energy and other resources and will continue to evaluate use of sustainable practices during the remedy design, construction, and operation phases, such as:

- Return treated water to the aquifer (currently practiced),
- Maximize use of existing equipment (e.g., use of Main Facility remedial system to treat RW-21 effluent),
- Specify energy-efficient equipment; use variable frequency drives to reduce energy demands,
- Reduce equipment footprints to minimize land disturbance,
- Use green structures for housing equipment (e.g., Leadership in Energy and Environmental Design [LEED]-certified materials), and
- Conduct remedial system evaluations (RSEs) to routinely assess and optimize system performance and evaluate opportunities to reduce energy needs and downsize or reduce equipment, as appropriate.

8. Summary of Comprehensive Recommended Remedy

Section 3.7 of this FS discusses several remedial systems that are currently in place to address the regional area of VOC-impacted groundwater. As described in Section 7 of this FS, further groundwater remedies are recommended to supplement those already in place and provide a comprehensive solution to the regional area of VOC-impacted groundwater. Additionally, as detailed in the Site Area FS, remedies are also recommended to address impacted soils, soil gas, and source areas. Those remedies in combination with the recommended groundwater remedies create a comprehensive, integrated solution to contamination present in both the Site Area and Study Area. Detailed descriptions and estimated costs for the various remedial elements of the Comprehensive Recommended Remedy are provided in **Table 8-1** and are summarized below:

Soils

Park Soils - Alternative S-P2:

- Excavate upper 2 ft of soil across Park where Site Area-related COPCs exceed restricted-residential SCOs and replace with clean fill.

- Install a demarcation layer between clean fill and remaining soils, where applicable.

Access Road Soils - Alternative S-AR2:

- Install gravel cap over Access Road soils where Site Area-related COPCs exceed restricted-residential SCOs.
- Install fencing and signs to control access.

Source Areas

Alternative SA-3**:**

- Remediate Site Area VOC source areas (i.e., TVOCs greater than 10 ppm in soil and groundwater) using ISTD to reduce TVOC concentrations to 1 ppm or less.

Soil Gas

Alternative SG-2:

- Continue OM&M of the existing Soil Gas IRM to prevent the off-site migration of Site Area soil gas until IRM shutdown criteria are achieved (shutdown criteria will be provided in the OM&M Manual).

Groundwater

Alternatives GW-2 and 3:

- Continue to operate Groundwater IRM to prevent off-site migration of groundwater; transition to natural attenuation with monitoring to address residual VOC impacts once Groundwater IRM system shutdown criteria met.
- Continue to operate existing groundwater remedial systems to reduce VOC mass in the regional area of TVOC-impacted groundwater, including Main Facility and GM-38 Area groundwater remedial systems.
- Continue to operate wellhead protection systems at BWD Plants 4 and 5.

- Install and operate one new remedial well to reduce VOC mass in Study Area groundwater; treat extracted groundwater in existing Main Facility Tower 102 treatment system. Operate well full-time for 20 years, followed by 5 years of pulsed operation, followed by shutdown and 5 years of post-remediation groundwater monitoring. Actual operating times, shutdown criteria, and post-remediation monitoring requirements will be determined over time based on field data.

- Use existing and newly installed monitoring wells to perform regular monitoring of remedial system performance and for reporting on remedial system effectiveness.

Additional Components of the Comprehensive Recommended Remedy

- Perform regular performance monitoring and reporting of remedial system effectiveness. As applicable, implement OM&M plans following remedial construction completion.

- Where applicable, environmental easements for institutional and engineering controls will be incorporated into the recommended alternative to help ensure that the Comprehensive Recommended Remedy is maintained and is protective of human health for reasonably anticipated future land uses.

The rationale for the Comprehensive Recommended Remedy is that it achieves the RAOs, satisfies the FS selection criteria, and offers the following benefits:

- Protection of human health and the environment;

- Prevention of exposure to COPCs above restricted residential SCOs in soils or implementation of other approved approaches to eliminate or mitigate significant threats;

- Reduction of VOC concentrations in source areas to minimize potential migration of VOCs to groundwater and soil gas;

- Prevention of on-site exposure to Site Area-related VOCs in soil gas exceeding NYSDOH air guidelines;

- Control of off-site migration of VOCs in groundwater and soil gas;

- Prevention of exposure to COPCs in groundwater including ingestion of groundwater exceeding SCGs; and

- Reduction in VOC mass in groundwater to the extent feasible.

Furthermore, based on the conclusions in the HHRA prepared by Northrop Grumman for OU3, there are no significant threats to human health from subsurface soils and the Recommended Remedy for the Site Area is fully protective of human health under current and expected future site use conditions.

The total estimated cost for the Comprehensive Recommended Remedy is $64.5 million.

9. References

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Table 4-1. Potential Chemical-, Action-, and Location-Specific Standards, Criteria, and Guidelines (SCGs)
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Regulation	Citation	Potential Standard (S) or Guidance (G)	Summary of Requirements	Applicability to the Remedial Design/ Remedial Action
Chemical-Specific SCGs				
Clean Water Act (CWA) - Ambient Water Quality Criteria	40 CFR Part 131; EPA 440/5-86/001 "Quality Criteria for Water - 1986", superseded by EPA-822-R-02-047 "National Recommended Water Quality Criteria: 2002"	S	Criteria for protection of aquatic life and/or human health depending on designated water use.	Potentially applicable depending on designated water use.
CWA Section 136	40 CFR 136	G	Identifies guidelines for test procedures for the analysis of pollutants.	Potentially applicable depending on designated water use.
National Primary Drinking Water Standards	40 CFR Part 141	S	Establishes maximum contaminant levels (MCLs) which are health-based standards for public water supply systems.	Potentially applicable for groundwater related remedial actions.
RCRA-Regulated Levels for Toxic Characteristics Leaching Procedure (TCLP) Constituents	40 CFR Part 261	S	These regulations specify the TCLP constituent levels for identification of hazardous wastes that exhibit the characteristic of toxicity.	Potentially applicable to remedial activities that generate waste materials that may require sampling/analysis for TCLP constituents to determine if the materials are hazardous (based on the characteristic of toxicity) prior to disposal.
Universal Treatment Standards/Land Disposal Restrictions (UTS/LDRs)	40 CFR Part 268	S	Identifies hazardous wastes for which land disposal is restricted and provides a set of numerical constituent concentration criteria at which hazardous waste is restricted from land disposal (without treatment).	Applicable if waste material is determined to be hazardous and is designated for off-site land disposal.

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Table 4-1. Potential Chemical-, Action-, and Location-Specific Standards, Criteria, and Guidelines (SCGs)
Study Area Feasibility Study, Northrop Grumman Systems Corporation
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Regulation	Citation	Potential Standard (S) or Guidance (G)	Summary of Requirements	Applicability to the Remedial Design/ Remedial Action
New York State Environmental Remediation Programs	6 NYCRR Part 375, as amended 12/14/06	S/G	Describes process for the development and execution of remedial programs in New York State (NYS), and provides soil cleanup objectives (SCOs) for various site usages.	Applicable for site investigation, remedy selection, and site remediation.
NYSDEC Ambient Water Quality Standards and Guidance Values	Division of Water Technical and Operational Guidance Series (TOGS) Section 1.0 (6/98, revised 4/00)	S/G	Provides a compilation of ambient water quality standards and guidance values for toxic and non-conventional pollutants for use in the NYSDEC programs.	These standards and guidance values are applicable to site remedial programs and should be considered in evaluating groundwater and surface water quality, remediation, standards, and remediation water discharge standards.
Identification and Listing of Hazardous Wastes	6 NYCRR Part 371	S	Outlines criteria for determining if a solid waste is a hazardous waste and subject to regulation under 6 NYCRR Parts 370 thru 376.	Applicable for determining if waste material generated during implementation of remedial activities are hazardous wastes. These regulations do not set cleanup standards, but are considered when developing remedial alternatives.
New York State Surface Water and Groundwater Quality Standards	6 NYCRR Parts 700 thru 706	S	Establishes quality standards for surface water and groundwater.	Applicable for assessing water quality at the site during remedial activities.
Potential Action-Specific SCGs				
Occupational Safety and Health Act (OSHA) - General Industry Standards	29 CFR Part 1910	S	These regulations specify the 8-hour time-weighted average concentration for worker exposure to various compounds. Training requirements for workers at hazardous waste operations are specified in 29 CFR 1910.120.	Applicable where remedial construction, maintenance, or monitoring activities have the potential to exposure workers to site-related contaminants or create job related injury.

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Study Area Feasibility Study, Northrop Grumman Systems Corporation
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Regulation	Citation	Potential Standard (S) or Guidance (G)	Summary of Requirements	Applicability to the Remedial Design/ Remedial Action
OSHA - Safety and Health Standards	29 CFR Part 1926	S	These regulations specify the type of safety equipment and procedures to be followed during site remediation.	Applicable where remedial construction, maintenance, or monitoring activities have the potential to exposure workers to site-related contaminants or create job related injury.
OSHA - Record-keeping, Reporting and Related Regulations	29 CFR Part 1904	S	These regulations outline record-keeping and reporting requirements for an employer under OSHA, and apply to the company(s) contracted to install, operate, and maintain remedial actions at hazardous waste sites.	Applicable where remedial construction, maintenance, or monitoring activities have the potential to exposure workers to site-related contaminants or create job related injury.
RCRA - Preparedness and Prevention	40 CFR Part 264.30 - 264.31	S	These regulations outline requirements for safety equipment and spill control when treating, handling and/or storing hazardous wastes.	Potentially applicable to remedial activities.
RCRA - Contingency Plan and Emergency Procedures	40 CFR Part 264.50 - 264.56	S	Provides requirements for emergency contingency planning and procedures to be used following explosions, fires, etc. when storing hazardous wastes.	Potentially applicable to remedial activities.
CWA - Discharge to Waters of the U.S., and Section 404	40 CFR Parts 403, and 230 Section 404 (b) (1); 33 USC 1344	S	Establishes site-specific pollutant discharge limitations and performance standards that are designed to protect surface water quality. Types of discharges regulated under CWA include: indirect discharge to a POTW, and discharge of dredged or fill material into U.S. waters.	Potentially applicable to remedial activities.

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Table 4-1. Potential Chemical-, Action-, and Location-Specific Standards, Criteria, and Guidelines (SCGs)
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Regulation	Citation	Potential Standard (S) or Guidance (G)	Summary of Requirements	Applicability to the Remedial Design/ Remedial Action
RCRA - General Standards	40 CFR Part 264.111	S	General performance standards requiring minimization of need for further maintenance and control; minimization or elimination of post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products. Also requires decontamination or disposal of contaminated equipment, structures and soils.	Potentially applicable to remedial construction maintenance, and monitoring activities.
Standards Applicable to Transporters of Applicable Hazardous Waste - RCRA Section 3003	40 CFR Parts 170-179, 262, and 263	S	Establishes the responsibility of off-site transporters of hazardous waste in the handling, transportation and management of the waste. Requires manifesting, recordkeeping and immediate action in the event of a discharge.	These requirements are applicable to any company(s) contracted to transport hazardous material.
United States Department of Transportation (USDOT) Rules for Transportation of Hazardous Materials	49 CFR Parts 107 and 171.1 - 172.558	S	Outlines procedures for the packaging, labeling, manifesting and transporting of hazardous materials.	These requirements are applicable to any company(s) contracted to transport hazardous material.
Clean Air Act-National Ambient Air Quality Standards	40 CFR Part 50	S	Establishes ambient air quality standards for protection of public health.	Applicable to remedial systems that generate air emissions.
USEPA-Administered Permit Program: The Hazardous Waste Permit Program	RCRA Section 3005; 40 CFR Part 270.124	S	Covers the basic permitting, application, monitoring and reporting requirements for off-site hazardous waste management facilities.	Any off-site facility accepting hazardous waste must be properly permitted. Implementation of the remedy will include consideration of these requirements.
New York Air Quality Classification System	6 NYCRR Part 256	S	Outlines the air quality classifications for different land uses and population densities.	Air quality classification system will be considered during the treatment process design.

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Table 4-1. Potential Chemical-, Action-, and Location-Specific Standards, Criteria, and Guidelines (SCGs)
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Regulation	Citation	Potential Standard (S) or Guidance (G)	Summary of Requirements	Applicability to the Remedial Design/ Remedial Action
National Emission Standards for Hazardous Air Pollutants (NESHAP)	40 CFR Part 61	S	Provides air emission standards for hazardous air pollutants.	Applicable to remedial systems that generate air emissions. Remedial system design will consider appropriate air emissions controls to meet these regulations.
New York Permits and Certificates	6 NYCRR Part 201	S	Provides instructions and regulations for obtaining a permit to operate an air emission source. Also provides instructions on what to do in case of malfunction.	NYS permits are not required for remedial actions implemented under Consent Order at NYS Inactive Hazardous Waste sites; however, documentation will be developed to assure relevant and appropriate permit conditions are complied with.
New York Emissions Testing, Sampling, and Analytical Determinations	6 NYCRR Part 202	S	Outlines requirements for emissions testing for air emission sources. States that independent emissions testing can be ordered by the Commissioner of the NYSDEC.	Applicable to remedial systems as emissions from treatment procedure must be analyzed.
New York Regulations for General Process Emissions	6 NYCRR Part 212	S	Outlines the procedure of environmental rating. The Commissioner determines a rating of emissions based on sampling.	The Commissioner will issue an environmental rating for emissions based on this regulation.
Protection of Significant Deterioration of Air Quality (PSD)	40 CFR Part 51.2	S	New major stationary sources may be subject to PSD review [i.e., require best available control technology (BACT), lowest achievable detection limit (LAEL), and/or emission off-sets.	If necessary, PSD procedures will be included in the remedial design/remedial action process. The procedures could be expanded to BACT and LAEL evaluations.
New York Air Quality Standards	6 NYCRR Part 257	S	Provides air quality standards for different chemicals (including those found at the site), particles, and processes.	Applicable to remedial systems. Emissions from treatment processes will meet the air quality standards.
Land Disposal Restrictions	40 CFR Part 268	S	Restricts land disposal of hazardous wastes that exceed specific criteria. Establishes Universal Treatment Standards (UTSs) to which hazardous waste must be treated prior to land disposal.	Waste materials that display the characteristic of hazardous waste or that are re-characterized after generation must be treated to 90% constituent concentration reduction capped at 10 times the UTS.

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**Table 4-1. Potential Chemical-, Action-, and Location-Specific Standards, Criteria, and Guidelines (SCGs)
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.**

Regulation	Citation	Potential Standard (S) or Guidance (G)	Summary of Requirements	Applicability to the Remedial Design/ Remedial Action
RCRA Subtitle C	40 U.S.C. Section 6901 et seq.; 40 CFR Part 268	S	Restricts land disposal of hazardous wastes that exceed specific criteria. Establishes UTSs to which hazardous wastes must be treated prior to land disposal.	Potentially applicable to remedial activities that include disposal of generated waste.
NYSDEC's Monitoring Well Decommissioning Guidelines	NPL Site Monitoring Well Decommissioning dated May 1995	G	This guidance presents procedure for abandonment of monitoring wells at remediation sites.	This guidance is applicable for remedial alternatives that require the decommissioning of monitoring wells.
Guidelines for the Control of Toxic Ambient Air Contaminants	DAR-1 (Air Guide 1)	G	Provides guidance for the control of toxic ambient air contaminants in New York State and outlines the procedures for evaluating sources of air pollution	This guidance is applicable for remedial alternatives that result in air emissions.
New York Hazardous Waste Management System - General	6 NYCRR Part 370	S	Provides definitions of terms and general instructions for the Part 370 series of hazardous waste management.	Applicable where hazardous waste is to be managed.
Hazardous Waste Manifest System and Related Standards for Generators, Transporters, and Facilities	6 NYCRR Part 372	S	Provides guidelines relating to the use of the manifest system and its recordkeeping requirements. It applies to generators, transporters and facilities in New York State.	This regulation is applicable to any company(s) contracted to do treatment work or to transport or manage hazardous material generated.
New York Regulations for Transportation of Hazardous Waste	6 NYCRR Part 372.3 a-d	S	Outlines procedures for the packaging, labeling, manifesting and transporting of hazardous waste.	These requirements are applicable to any company(s) contracted to transport hazardous material.
Waste Transporter Permits	6 NYCRR Part 364	S	Governs the collection, transport and delivery of regulated waste within New York State.	These requirements are applicable to any company(s) contracted to transport hazardous material.
NYSDEC Technical and Administrative Guidance Memorandums (TAGMs)	NYSDEC TAGMs	G	TAGMs are NYSDEC guidance that are to be considered during the remedial process.	Appropriate TAGMs will be considered during the remedial process.

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Table 4-1. Potential Chemical-, Action-, and Location-Specific Standards, Criteria, and Guidelines (SCGs)
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Regulation	Citation	Potential Standard (S) or Guidance (G)	Summary of Requirements	Applicability to the Remedial Design/ Remedial Action
New York Regulations for Hazardous Waste Management Facilities	6 NYCRR Part 373.1.1 - 373.1.8	S	Provides requirements and procedures for obtaining a permit to operate a hazardous waste treatment, storage and disposal facility. Also lists contents and conditions of permits.	These requirements are applicable to any off-site facility accepting waste.
Land Disposal of a Hazardous Waste	6 NYCRR Part 376	S	Restricts land disposal of hazardous wastes that exceed specific criteria.	New York defers to USEPA for UTS/LDR regulations.
National Pollutant Discharge Elimination System (NPDES) Program Requirements, Administered Under New York State Pollution Discharge Elimination System (SPDES)	40 CFR Parts 122 Subpart B, 125, 301, 303, and 307 (Administered under 6 NYCRR 750-758)	S	Establishes permitting requirements for point source discharges; regulates discharge of water into navigable waters including the quantity and quality of discharge.	Applicable to remedial activities that involve treatment/disposal of water.

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Table 4-1. Potential Chemical-, Action-, and Location-Specific Standards, Criteria, and Guidelines (SCGs)
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Regulation	Citation	Potential Standard (S) or Guidance (G)	Summary of Requirements	Applicability to the Remedial Design/ Remedial Action
NYSDEC Division of Environmental Remediation (DER) Numbered Technical Guidance Series Documents	DER-10 (Technical Guidance for Site Investigation and Remediation), DER-15 Presumptive/ Proven Remedial Technologies, and other applicable documents	G	DER-10: Provides guidance on NYSDEC-accepted site investigation and remediation processes. DER-15: Provides brief descriptions of generally accepted presumptive/proven remedial technologies.	Applicable to remedy evaluation process and site remedial activities.
Potential Location-Specific SCGs				
New York Preservation of Historic Structures or Artifacts	Section 14.09	Applicable	Requirements for preservation of historical/archeological artifacts.	Activities must be done to identify, preserve, and recover artifacts if the site has been identified as containing significant historical artifacts.
Local Building Permits	N/A	S	Local authorities may require a building permit for any permanent or semi-permanent structure, such as an on-site water treatment system building.	Substantive provisions are potentially applicable to remedial activities that require construction of permanent or semi-permanent structures.

DEFINITIONS:

CFR Code of Federal Regulations
EPA US Environmental Protection Agency
NYCRR Official Compilation of New York Code, Rules and Regulations
NYSDEC New York State Department of Environmental Conservation
POTW Publicly-Owned Treatment Works
NYS New York State

US DOT United Stated Department of Transportation

UTS Universal Treatment Standards
LDR Land Disposal Restrictions
N/A Not Applicable
DER NYSDEC Division of Environmental Remediation
TAGMs NYSDEC Technical and Administrative Guidance Memorandums
DAR-1 NYSDEC Division of Air Resources Guidelines for the Control of Toxic Ambient Air Contaminants
NPL National Priorities List

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Table 5-1. Screening of Remedial Technologies
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

General Response Action	Remedial Technology Type	Process Options	Technology Description	Effectiveness	Implementability	Relative Cost	Retained for Detailed Evaluation?
Baseline/Continued Action	Based on previous regulatory actions, several groundwater technologies/remedial actions are already in place and will continue to operate.	Based on previous regulatory actions, several groundwater technologies/remedial actions are already in place and will continue to operate.	Based on previous regulatory actions, the following groundwater technologies/remedial actions are already in place and will continue to operate: • Site IRM & Main Facility Remedial Systems. • Wellhead treatment at BWD supply wells. • GM-38 Area Remedial System.	**Effective** - Existing technologies/remedial actions are currently meeting their respective RAOs and operating as designed.	**Implementable** - Already Implemented	High	Yes
Collection/Treatment/ Discharge	Groundwater Extraction	Extraction Wells	Groundwater pumped from vertical extraction wells and conveyed to ex-situ treatment system.	**Effective** - Conventional technology to control migration of, and extract, contaminated groundwater from the aquifer. Can achieve RAOs. NYSDEC presumptive remedy for volatile organic compounds (VOCs) per DER-15.	**Implementable** - Readily implementable, conventional, proven technology in use at other area remedial actions. Requires monitoring program to confirm effectiveness.	Moderate	Yes
	Ex-Situ Groundwater Treatment	Air Stripping	Packed tower or tray stripper physically strips VOCs from water.	**Effective** - Conventional technology to treat VOCs in extracted groundwater. NYSDEC presumptive remedy for VOCs per DER-15.	**Implementable** - Readily implementable, conventional, proven technology in use at other area remedial actions. May require air stripper off-gas treatment to achieve SCGs. Requires monitoring program to confirm compliance with SCGs.	Low to Moderate	Yes
		Chemical/UV Oxidation	Chemical oxidants used with or without ultraviolet (UV) light activation to develop strong oxidants that break down organic compounds into non-toxic compounds.	**Effective** - Conventional technology for treating VOCs in extracted groundwater. Capable of achieving SCGs in treated water. NYSDEC presumptive remedy for VOCs per DER-15.	**Implementable** - Readily implementable, conventional, proven technology. Site-specific application requires use of UV light activation resulting in a significant energy demand and associated utility cost.	Very High	No
		Adsorption	Liquid phase granular activated carbon (LPGAC) used to remove VOCs from groundwater.	**Effective** - Conventional technology for treating VOCs in extracted groundwater. Capable of achieving SCGs in treated water. NYSDEC presumptive remedy for VOCs per DER-15.	**Implementable** - Readily implementable, conventional technology. Generates large volume of spent GAC requiring management and/or re-generation.	High	No

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Table 5-1. Screening of Remedial Technologies
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

General Response Action	Remedial Technology Type	Process Options	Technology Description	Effectiveness	Implementability	Relative Cost	Retained for Detailed Evaluation?
Collection/Treatment/ Discharge (Continued)	Treated Groundwater Discharge	Recharge Basin	Recharge basin recharges treated groundwater back into aquifer.	**Effective** - Conventional technology to recharge treated groundwater back to the aquifer.	**Implementable** - Readily implementable, conventional, proven technology in use at other area remedial actions. Requires additional treatment and OM&M, if significant iron is present in the groundwater.	Low to Moderate	Yes
		Injection Wells	Injection wells recharge treated groundwater back into aquifer.	**Effective** - Conventional technology to recharge treated groundwater back to the aquifer.	**Implementable** - Readily implementable, conventional, proven technology in use at other area remedial actions. May require significant additional treatment and OM&M compared to recharge basins.	Moderate to High	Yes
	In-Situ Groundwater Treatment	In-Situ Chemical Oxidation (ISCO)	Chemical oxidant injected into groundwater to break down VOCs into non-toxic compounds.	**Effective** - Conventional technology to treat VOCs in groundwater. Can achieve RAOs. NYSDEC presumptive remedy for VOCs per DER-15.	**Implementable** - Difficult to implement. Requires numerous deep injection and monitoring wells. Requires a significant volume of oxidant for maintenance injections due to the size and depth of the treatment zone and relatively high groundwater flow rate. Requires storage, handling, and transfer of hazardous materials in residential areas. Access to construct the remedial wells and infrastructure will likely not be obtainable in the primarily residential area.	Very High	No
		Air Sparging	Air is injected into groundwater enabling the transfer of dissolved phase VOCs into the vapor phase. Volatilized VOCs are captured by a vapor extraction system for treatment prior to discharge to the atmosphere.	**Not Effective** - NYSDEC presumptive remedy for VOCs per DER-15; however, technology is ineffective in saturated zones greater than 50 feet thick (DER-15). Will not achieve RAOs.	**Not Implementable** - Not implementable at the target treatment depths (>500 feet). Likely would generate uncontrolled VOC vapors in subsurface soils.	Very High	No

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Table 5-1. Screening of Remedial Technologies
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

General Response Action	Remedial Technology Type	Process Options	Technology Description	Effectiveness	Implementability	Relative Cost	Retained for Detailed Evaluation?
Collection/Treatment/ Discharge (Continued)	In-Situ Groundwater Treatment (Continued)	In-Well Air Stripping	In-well air stripping system that uses air lift pumping to volatilize VOCs from groundwater to the vapor phase. Pumped/partially treated water is discharged to an upper screen interval where a portion is recirculated to the lower screen, as required, to meet SCGs for groundwater. Off-gas is collected and treated through a variety of -treatment methods.	**Effective** - Conventional technology to treat VOCs in groundwater. Can achieve RAOs. NYSDEC presumptive remedy for VOCs per DER-15.	**Not Implementable -** Requires numerous remedial wells and associated infrastructure due to the significant treatment depths, required width of the treatment zone, and relatively high groundwater flow rate. Access to construct the remedial wells and infrastructure likely not obtainable in the primarily residential area.	Very High	No
		Enhanced Biodegradation	Organic substrate injected into groundwater to stimulate existing microbial communities that degrade VOCs through reductive dechlorination.	**Effective** - Conventional technology to treat VOCs in groundwater. Can achieve RAOs. NYSDEC presumptive remedy for VOCs per DER-15.	**Implementable** - Difficult to implement. Requires numerous deep injection and monitoring wells to be installed. Requires a large volume of organic carbon for maintenance injections due to the size and depth of the treatment zone and relatively high groundwater flow rate. Could produce toxic VOC daughter compounds such as vinyl chloride. Access to construct the remedial wells and infrastructure will likely not be obtainable in the primarily residential area.	High	No
		Natural Attenuation	Naturally occurring processes (e.g., dilution, dispersion, sorption, biodegradation) used following active remediation to attenuate low concentrations of contaminants.	**Effective** - Site-related groundwater contaminants treatable by natural attenuation processes. Can achieve RAOs when used in conjunction with, or following use of active remedial actions.	**Implementable** - Readily implementable; no construction required, except for additional monitoring well installation.	Low	Yes

DEFINITIONS:

BWD	Bethpage Water District
Site IRM	Interim Remedial Measure (pump & treat system) located south of Bethpage Community Park
Main Facility	Northrop Grumman Main Facility, used to referred to current remedial systems associated with OU2 (Tower 96 and Tower 102)
GM-38	Area where pump-and-treat system recently installed by the Navy.
RAOs	Remedial Action Objectives
NYSDEC	New York State Department of Environmental Conservation
DER-15	NYSDEC Division of Environmental Remediation's Presumptive /Proven Remedial Technologies Policy (dated February 27, 2007)
OM&M	Operation Maintenance and Monitoring
SCGs	Standards, Criteria, and Guidance

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Table 6-1. Evaluation Criteria for Remedial Alternatives
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Evaluation Criteria	Criteria Definition
Overall Protectiveness of Public Health and the Environment	Ability to protect public health and the environment, assessing how risks posed by existing and potential exposure pathways are eliminated or reduced, through removal, treatment, engineering controls, or institutional controls. Ability to achieve the RAOs is also evaluated.
Standards, Criteria, & Guidance (SCGs)	Ability to meet requirements of environmental laws, regulations, standards and guidance. If one or more SCGs are not met upon implementation of a remedial alternative, evaluation of whether a waiver is required is provided.
Long Term Effectiveness & Permanence	If wastes or residuals will remain at the site after implementation, then the following are evaluated: (1) the magnitude and nature of the residual risks posed by the remaining wastes; (2) the adequacy of the controls intended to limit the risks; (3) the reliability of these controls; and (4) the ability of the remedy to continue to meet the RAOs in the future.
Reduction of Toxicity, Mobility, or Volume with Treatment	Ability of an alternative to permanently and significantly reduce toxicity, mobility or volume of the wastes.
Short-Term Impacts and Effectiveness	Potential short-term impacts of a remedial action upon the community, the site workers, and the environment.The period of time required to achieve RAOs is estimated.
Implementability	The technical and administrative feasibility of implementing a remedial alternative. For technical feasibility, the difficulties associated with the construction and operation of the alternative and the ability to monitor the effectiveness of the remedy are evaluated. For administrative feasibility, the availability of the necessary personnel and material is evaluated, along with the difficulties in obtaining permits, rights-of-way, and site access.
Sustainability	The NYSDEC encourages the use of best management practices for sustainable remediation at contaminated sites. Sustainable practices result in cleanups that minimize the environmental and energy "footprints" of remedial actions taken during a project's duration. Examples of sustainable practices include reducing energy demands, minimizing waste generation, and minimizing land use and building footprints.
Cost Effectiveness	Capital costs and O&M costs are estimated on a present worth basis. Although cost is the last criterion evaluated, where two or more alternatives have satisfied the other evaluation criteria, cost effectiveness should be used as the basis for final remedy selection.

DEFINITIONS:

RAOs Remedial Action Objectives
O&M Operation & Maintenance
NYSDEC New York State Department of Environmental Conservation.

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Table 6-2. Detailed Evaluation of Remedial Alternatives
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Evaluation Criteria / Alternatives	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
	No Action. • Shut down all current groundwater remedial systems. • Shut down all public supply wellhead protection systems.	**Baseline Conditions/Continued Action.** • Conduct VOC source remediation at the Site. • Continue to operate the following remedial/treatment systems to protect water supply wells and reduce VOC mass in the Study Area (See Figure 6-1): - Existing BWD wellhead protection systems. - Site IRM (4 wells; total 210 GPM). - Main Facility remedial systems, including Tower 96 (2 wells; total 1,500 GPM) and Tower 102 (3 wells; total 2,300 GPM). - GM-38 Area (two wells; total 1,100 GPM). • Conduct current monitoring.	***Alternative 2, Plus One New Remedial Well (Well RW-21).*** • *Install and operate one new remedial well (Well RW-21) pumping at 1,000 gpm to reduce VOC mass in Study Area groundwater (See Figure 6-2).* •*Treat extracted groundwater from the new well at the existing Main Facility remedial system (Tower 102 - four wells total - 2,800 GPM).* • *Discharge treated water to Northrop Grumman South Basins.* • *Conduct expanded monitoring.*	**Alternative 2, Plus Two New Remedial Wells (RW-20 and RW-21).** • Install and operate two new remedial wells (Well RW-20 pumping at 500 gpm and Well RW-21 pumping at 500 gpm) to reduce VOC mass in Study Area groundwater (See Figure 6-3). • Treat extracted groundwater from new wells at the existing Main Facility remedial system (Tower 102 - 5 wells total - 2,800 GPM). • Discharge treated water to the South Basins. • Conduct expanded monitoring.	**Alternative 2, Plus Operate BWD Plant 4 as Remediation System, plus One New Remedial Well (RW-20), plus Replace BWD Plant 4 Capacity.** • Install and operate one new remedial well (Well RW-20 pumping at 500 gpm), and operate the two existing BWD Plant 4 wells, pumping a total of 2,700 GPM, to reduce VOC mass in Study Area groundwater (See Figure 6-4). • Treat extracted groundwater from the new well at the existing Main Facility remedial system (Tower 102 - 4 remedial wells - 2,300 GPM). • Discharge treated water to the South Basins. • Discharge treated water from BWD Plant 4 to combination of the Arthur Avenue recharge basin and 3 new shallow injection wells located near the basin. • Conduct expanded monitoring.	**Alternative 2, Plus Five New Remedial Wells (RW-22 to -26).** • Install and operate 5 new remedial wells (RW-22 to -26, pumping a total of 4,040 gpm) and 5 new treatment systems to attempt returning Study Area groundwater to pre-disposal conditions (See Figure 6-5). • Discharge treated water to 7 new injection wells (14 wells total: 7 operating, plus 7 backup). • Conduct expanded monitoring.
Overall Protectiveness of the Public Health and the Environment	Not protective of public heath or the environment.	Protective of public health and the environment. BWD water supplies treated to less than the drinking water standards, therefore, protective of public health[5]. However, existing wellhead protection at BWD Plant 5 may not be capable of achieving the BWD treatment goal of non-detect. TVOC mass removed from groundwater (100,000 lbs) protective of the environment.	***Same as Alternative 2 for protection of public health. Existing wellhead protection at BWD Plant 5 will be capable of achieving the BWD treatment goal of non-detect*** [5]. Additional mass removed from groundwater under this alternative (3,000 pounds; see discussion below) relative to Alternative 2 provides additional protection of the environment.	Same as Alternative 2 for protection of public health. Existing wellhead protection at BWD Plant 5 will be capable of achieving the BWD treatment goal of non-detect[5]. Additional mass removed from groundwater under this alternative (7,000 pounds; see discussion below) relative to Alternative 2 provides additional protection of the environment.	Same as Alternative 2 for protection of public health. Existing wellhead protection at BWD Plant 5 will be capable of achieving the BWD treatment goal of non-detect[5]. Additional mass removed from groundwater under this alternative (7,500 pounds; see discussion below) relative to Alternative 2 provides additional protection of the environment. Mass removal is similar to Alternative 4.	Same as Alternative 2 for protection of public health. Existing wellhead protection at BWD Plant 5 will be capable of achieving the BWD treatment goal of non-detect[5]. Additional mass removed from groundwater under this alternative (38,500 pounds; see discussion below) relative to Alternative 2 provides additional protection of the environment.
Standards, Criteria, & Guidance (SCGs)	Does not meet drinking water standards for public supply wells. Groundwater SCGs will not be achieved in the aquifer; waiver required.	Public supply well protection systems treat to less than drinking water standards[5]. Remedial systems operated to meet discharge SCGs. Groundwater SCGs will not be achieved in the aquifer; waiver required.	***Same as Alternative 2.***	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2. Remedial wells and majority of aquifer in the Study Area meet SCGs.
Long Term Effectiveness & Permanence	Does not meet RAOs and leaves significant risk to the public and the environment.	Proven and reliable remedial technologies and associated controls that leave no significant risk to the public or the environment and will continue to meet RAOs, when properly operated, maintained, and monitored. Existing wellhead protection at BWD Plant 5 may not be capable of achieving the BWD treatment goal of non-detect[5].	***Same as Alternative 2, except existing wellhead protection at BWD Plant 5 will be capable of achieving the BWD treatment goal of non-detect*** [5] .	Same as Alternative 2, except existing wellhead protection at BWD Plant 5 will be capable of achieving the BWD treatment goal of non-detect[5].	Same as Alternative 2, except existing wellhead protection at BWD Plant 5 will be capable of achieving the BWD treatment goal of non-detect[5].	Same as Alternative 2, except existing wellhead protection at BWD Plant 5 will be capable of achieving the BWD treatment goal of non-detect[5].
Reduction of Toxicity, Mobility, or Volume of Contamination through Treatment [3]	No reduction in toxicity, mobility, or volume of contamination.	Reduces mobility and volume of VOCs in the Study Area groundwater. Removes and treats (eliminates toxicity) approximately 144,000 (3) pounds of VOCs (100,000 lbs from groundwater and 44,000 lbs from the Site Area source area)	***Reduces mobility and volume of VOCs in the Study Area groundwater. Removes and treats (eliminates toxicity) approximately 147,000*** (3) pounds of VOCs (103,000 lbs from groundwater and 44,000 lbs from the Site Area source area). In addition, of all the alternatives, Alternative 3 has the greatest collective beneficial effect on BWD Plants 4 and 5 (i.e., lowest peak VOC concentration and greatest rate of decrease in VOC concentrations in the wells).	Reduces mobility and volume of VOCs in the Study Area groundwater and also removes more mass than Alternatives 2 and 3. Removes and treats (eliminates toxicity) approximately 151,000 (3) pounds of VOCs (107,000 lbs from groundwater and 44,000 lbs from the Site Area source area). Alternative 4 has less of a cumulative beneficial effect on BWD Plants 4 and 5 (i.e., lowest peak VOC concentration and greatest rate of decrease in VOC concentrations in the wells) than Alternative 3.	Reduces mobility and volume of VOCs in the Study Area groundwater and also removes more mass than Alternatives 2 and 3. Mass removal is similar to Alternative 4. Removes and treats (eliminates toxicity) approximately 151,500 (3) pounds of VOCs (107,500 lbs from groundwater and 44,000 lbs from the Site Area source area).	Reduces mobility and volume of VOCs in the Study Area groundwater and also removes more mass than other alternatives. Removes and treats (eliminates toxicity) approximately 182,500 [3] pounds of VOCs (138,500 lbs from groundwater and 44,000 lbs from the Site Area source area). Alternative 6 has less of a cumulative beneficial effect on BWD Plants 4 and 5 (i.e., lowest peak VOC concentration and greatest rate of decrease in VOC concentrations in the wells) than Alternative 3.

Table 6-2. Detailed Evaluation of Remedial Alternatives
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Evaluation Criteria / Alternatives	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
	No Action. • Shut down all current groundwater remedial systems. • Shut down all public supply wellhead protection systems.	Baseline Conditions/Continued Action. • Conduct VOC source remediation at the Site. • Continue to operate the following remedial/treatment systems to protect water supply wells and reduce VOC mass in the Study Area (See Figure 6-1): - Existing BWD wellhead protection systems. - Site IRM (4 wells; total 210 GPM). - Main Facility remedial systems, including Tower 96 (2 wells; total 1,500 GPM) and Tower 102 (3 wells; total 2,300 GPM). - GM-38 Area (two wells; total 1,100 GPM). • Conduct current monitoring.	*Alternative 2, Plus One New Remedial Well (Well RW-21).* *• Install and operate one new remedial well (Well RW-21) pumping at 1,000 gpm to reduce VOC mass in Study Area groundwater (See Figure 6-2).* *•Treat extracted groundwater from the new well at the existing Main Facility remedial system (Tower 102 - four wells total - 2,800 GPM).* *• Discharge treated water to Northrop Grumman South Basins.* *• Conduct expanded monitoring.*	Alternative 2, Plus Two New Remedial Wells (RW-20 and RW-21). • Install and operate two new remedial wells (Well RW-20 pumping at 500 gpm and Well RW-21 pumping at 500 gpm) to reduce VOC mass in Study Area groundwater (See Figure 6-3). • Treat extracted groundwater from new wells at the existing Main Facility remedial system (Tower 102 - 5 wells total - 2,800 GPM). • Discharge treated water to the South Basins. • Conduct expanded monitoring.	Alternative 2, Plus Operate BWD Plant 4 as Remediation System, plus One New Remedial Well (RW-20), plus Replace BWD Plant 4 Capacity. • Install and operate one new remedial well (Well RW-20 pumping at 500 gpm), and operate the two existing BWD Plant 4 wells, pumping a total of 2,700 GPM, to reduce VOC mass in Study Area groundwater (See Figure 6-4). • Treat extracted groundwater from the new well at the existing Main Facility remedial system (Tower 102 - 4 remedial wells - 2,300 GPM). • Discharge treated water to the South Basins. • Discharge treated water from BWD Plant 4 to combination of the Arthur Avenue recharge basin and 3 new shallow injection wells located near the basin. • Conduct expanded monitoring.	Alternative 2, Plus Five New Remedial Wells (RW-22 to -26). • Install and operate 5 new remedial wells (RW-22 to -26, pumping a total of 4,040 gpm) and 5 new treatment systems to attempt returning Study Area groundwater to pre-disposal conditions (See Figure 6-5). • Discharge treated water to 7 new injection wells (14 wells total: 7 operating, plus 7 backup). • Conduct expanded monitoring.
Short-Term Impacts and Effectiveness	No short-term impacts to the community, site workers, or the environment.	No short-term impacts to the community, site workers, or the environment.	***One remedial well and associated pipeline would be installed within a residential neighborhood. Short-term impacts to the community, site workers, and the environment will be controlled by: 1) dust and traffic control measures will be used and 2) potential for exposure to contaminated water will be mitigated by utilizing portable vessels for containment and transporting water back to the site each day. Water from operating remedial well will be conveyed with dual-wall pipeline, with leak detection and other engineering controls.***	Two remedial wells and associated pipelines would be installed within a residential neighborhood. Same as Alternative 3.	One remedial well, three injections wells, and associated pipelines would be installed within a residential neighborhood. Same as Alternative 3 plus increased use of administrative and engineering controls (e.g., dust control, traffic) to minimize disruptions to the community associated with re-purposing BWD Plant 4 to serve as a remedial system and for construction of a new wellfield/facility at another location.	Five remedial wells, 14 injections wells, five remedial systems, and associated pipelines would be installed within a residential neighborhood. Same as Alternative 3 plus substantially increased use of administrative and engineering controls (e.g., dust control, traffic) to minimize disruptions to the community associated with construction of five new remedial systems.
Implementability	Not applicable; no activities implemented.	Already being Implemented.	***Technically and administratively implementable; proven technology and construction methods; access agreements will be required for installation of remedial well and pipeline that is not on Northrop Grumman property.***	Technically and administratively implementable; access agreements will be required for installation of remedial wells and pipelines that are not on Northrop Grumman property. Two new locations for wells and pipelines will pose significant additional access difficulties, compared to Alternative 3.	Technically and administratively implementable; access agreements will be required for installation of remedial well, injection wells, and pipelines that are not on Northrop Grumman property. Will need to negotiate agreement to lease or acquire BWD Plant 4. Will need to obtain access for construction of a new wellfield to replace BWD Plant 4 at an alternate location.	There will be a significant amount of construction (five remedial wells, five treatment plants,14 injection wells, and associated pipelines) in a residential area, requiring numerous access agreements. It will be very difficult to obtain all the required access agreements.
Sustainability [4]	Not applicable; no activities implemented.	Most sustainable when compared to Alternatives 3, 4, 5, and 6; returns treated water to the aquifer through recharge basins; maximizes use of existing remedial equipment and requires no additional building footprint; and, utilizes energy-efficient equipment and/or variable frequency drives (e.g., existing system blower and discharge pump) where possible to reduce energy demand. Existing steam regenerative VPGAC system significantly minimizes waste volume produced from air treatment.	***Similar sustainability to Alternative 2, however, higher energy demand and larger footprint as a result of the addition of Remedial Well RW-21 and increase in blower motor size; returns treated water to the aquifer through recharge basins; maximizes use of existing remedial equipment and requires minimal additional footprint for new recovery well vault; and, utilizes energy-efficient equipment and/or variable frequency drives (e.g., proposed system blower, existing system discharge pump and proposed Remedial Well RW-21 well pump) where possible to reduce energy demand. Existing steam regenerative VPGAC system significantly minimizes waste volume produced from air treatment.***	Similar sustainability to Alternative 3, however, higher energy demand and larger footprint as a result of the addition of Remedial Well RW-20.	Less sustainable when compared to Alternatives 2, 3, and 4. Requires new water supply system and associated buildings for replacement of lost capacity; significant increase in energy demand due to inefficient recovery well location (i.e., requires significantly larger pumps to maintain comparable groundwater control when compared to Alternatives 2 and 3); requires installation and use of a new VPGAC control system resulting in additional footprint requirements and increased waste volume.	Least sustainable when compared to Alternatives 2, 3, 4, and 5. Requires several new remediation systems and associated buildings; significant increase in energy demand due to the use of multiple new remedial wells, associated air stripping blowers, and discharge pumps; requires installation and use of several new VPGAC control systems resulting in additional footprint requirements and increased waste volume.

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Table 6-2. **Detailed Evaluation of Remedial Alternatives**
Study Area Feasibility Study, Northrop Grumman Systems Corporation
Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Evaluation Criteria / Alternatives	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
	No Action. • Shut down all current groundwater remedial systems. • Shut down all public supply wellhead protection systems.	Baseline Conditions/Continued Action. • Conduct VOC source remediation at the Site. • Continue to operate the following remedial/treatment systems to protect water supply wells and reduce VOC mass in the Study Area (See Figure 6-1): - Existing BWD wellhead protection systems. - Site IRM (4 wells; total 210 GPM). - Main Facility remedial systems, including Tower 96 (2 wells; total 1,500 GPM) and Tower 102 (3 wells; total 2,300 GPM). - GM-38 Area (two wells; total 1,100 GPM). • Conduct current monitoring.	*Alternative 2, Plus One New Remedial Well (Well RW-21).* *• Install and operate one new remedial well (Well RW-21) pumping at 1,000 gpm to reduce VOC mass in Study Area groundwater (See Figure 6-2).* *•Treat extracted groundwater from the new well at the existing Main Facility remedial system (Tower 102 - four wells total - 2,800 GPM).* *• Discharge treated water to Northrop Grumman South Basins.* *• Conduct expanded monitoring.*	Alternative 2, Plus Two New Remedial Wells (RW-20 and RW-21). • Install and operate two new remedial wells (Well RW-20 pumping at 500 gpm and Well RW-21 pumping at 500 gpm) to reduce VOC mass in Study Area groundwater (See Figure 6-3). • Treat extracted groundwater from new wells at the existing Main Facility remedial system (Tower 102 - 5 wells total - 2,800 GPM). • Discharge treated water to the South Basins. • Conduct expanded monitoring.	Alternative 2, Plus Operate BWD Plant 4 as Remediation System, plus One New Remedial Well (RW-20), plus Replace BWD Plant 4 Capacity. • Install and operate one new remedial well (Well RW-20 pumping at 500 gpm), and operate the two existing BWD Plant 4 wells, pumping a total of 2,700 GPM, to reduce VOC mass in Study Area groundwater (See Figure 6-4). • Treat extracted groundwater from the new well at the existing Main Facility remedial system (Tower 102 - 4 remedial wells - 2,300 GPM). • Discharge treated water to the South Basins. • Discharge treated water from BWD Plant 4 to combination of the Arthur Avenue recharge basin and 3 new shallow injection wells located near the basin. • Conduct expanded monitoring.	Alternative 2, Plus Five New Remedial Wells (RW-22 to -26). • Install and operate 5 new remedial wells (RW-22 to -26, pumping a total of 4,040 gpm) and 5 new treatment systems to attempt returning Study Area groundwater to pre-disposal conditions (See Figure 6-5). • Discharge treated water to 7 new injection wells (14 wells total: 7 operating, plus 7 backup). • Conduct expanded monitoring.
Cost Effectiveness (1)	$0	Main Facility System O&M $19.9M Groundwater IRM O&M $4.7M Park Source Remediation $15.6M Plant 4 Wellhead Treatment $0.1M Baseline Total $40.3M (2)	Baseline Cost $40.3M Alt. 3 Capital Cost $5.9M Alt. 3 O&M Cost $7.8M Alt. 3 Total $54.0M	Baseline Cost $40.3M Alt. 4 Capital Cost $9.0M Alt. 4 O&M Cost $9.4M Alt. 4 Total $58.7M	Baseline Cost $40.3M Alt. 5 Capital Cost $22.3M Alt. 5 O&M Cost $33.4M Alt. 5 Total $96.0M	Baseline Cost $40.3M Alt. 6 Capital Cost $49.9M Alt. 6 O&M Cost $87.7M Alt. 6 Total $177.9M

Recommended Alternative Rationale	***Alternative 3 is recommended because it is capable of achieving the RAOs, provides the greatest cumulative beneficial effect on BWD Plants 4 and 5 (i.e., lowest peak VOC concentration and greatest rate of decrease in VOC concentrations in the wells), is effective in the short-term and long-term, and is cost effective. Alternative 1 is not recommended because it does not achieve RAOs. Alternative 2 is not recommended because it removes the least amount of VOC mass and has the least cumulative benefit to BWD Plants 4 and 5. Alternative 4 is not recommended because, although it removes a slightly greater quantity of VOC mass compared to Alternative 3, it has a higher cost and does not provide as great a cumulative benefit to BWD Plants 4 and 5 as Alternative 3. Alternative 5 is not recommended because, although it removes a slightly greater quantity of VOC mass than Alternative 3, its cost is nearly twice that of Alternative 3 and it provides less cumulative beneficial effect on BWD Plants 4 and 5. Alternative 6 is not recommended because, although it removes more VOC mass than Alternative 3, its cost is three times that of Alternative 3 and it provides no additional benefit to BWD Plants 4 and 5 compared to Alternative 3.***

NOTES:

(1) Detailed cost estimates are provided in Appendix B.
(2) Includes 30 year present worth cost for: OM&M of the existing Main Facility Treatment System, Site IRM (assumes the Site IRM operates for 15 years), and Plant 4 wellhead protection; and capital cost for Park source reduction.
(3) Estimates of TVOC mass removed calculated for each alternative, as follows: Model-predicted TVOC mass (see Appendix A, Table A-2) that will be removed after 30 yrs, reduced to account for pulsed operation of proposed remedial wells from Years 20-25 and shutdown of proposed remedial wells from Years 25-30 (per 6 NYCRR 6.4, see Section 6.3 of this Report), plus the Park source area VOC mass to be removed (estimated to be 44,000 lbs).
(4) In addition to the regulatory-driven selection criteria, Northrop Grumman has considered alternatives that conserve limited energy and other resources (see section 7).
(5) The Bethpage Water District treatment goal is non-detect for all volatile organic compounds (H2M 2008).

DEFINITIONS:

Park	Portion of the Bethpage Community Park not subject to soil removal during Town redevelopment activities
Main Facility	Northrop Grumman Main Facility, used to referred to current remedial systems associated with OU2 (Tower 96 and Tower 102)
BWD	Bethpage Water District
VOCs	Volatile Organic Compounds
RAOs	Remedial Action Objectives
SCGs	Standard, Criteria and Guidelines
gpm	gallons per minute
IRM	Interim Remedial Measure
Remedial System	Remedial wells, air stripping tower, off-gas air treatment (VPGAC and, in some cases, PPZ), and discharge to local basin(s).
PPZ	Potassium permanganate impregnated zeolite
VPGAC	Vapor phase granular activated carbon
Expanded Monitoring	Plume management, performance, and effectiveness monitoring (as described in NYSDEC DER-10)
NYSDEC	New York State Department of Environmental Conservation
DER	Division of Environmental Remediation

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Table 8-1. Summary of Comprehensive Recommended Remedy For Site and Study Areas, Study Area Feasibility Study, Northrop Grumman Systems Corporation Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

Media/Area	Recommended Alternative [4]	Cost ($MM) (1)
Soils		
Park	**S-P2:** • Excavate upper 2 ft of soil to Restricted-Residential SCOs and backfill with clean soil. • Install demarcation barrier between the clean soil and the underlying soils. • Implement land-use restriction in the form of an environmental easement to limit site use where residual soil impacts exist above Unrestricted Use SCOs.	8.0
Access Road	**S-AR2:** • Install gravel cap over areas where soil exceeds Restricted Residential SCOs. • Implement land-use restriction in the form of an environmental easement to limit site use where residual soil impacts exist above Unrestricted Use SCOs. • Install fencing and signage to limit access.	0.6
Source Areas	**SA-3:** • Remediate VOC source areas using ISTD.	15.6
Soil Gas	**SG-2:** • Continue to operate, maintain, and monitor the existing Soil Gas IRM system to prevent offsite migration of soil gas from the Site Area until termination criteria are achieved (to be developed and included in the OM&M Manual) . • Establish environmental easement that requires installation of engineering controls to control vapor intrusion for any new structures constructed onsite. Maintain environmental easement until onsite soil gas meets applicable RAOs.	1.9 [2]
Groundwater [3]	**GW-2:** • Continue to operate, maintain, and monitor the existing Groundwater IRM system to prevent offsite migration of VOCs in groundwater that exceed 5 ug/L total VOCs in the upper 20 feet of the aquifer and 50 ug/L at depths below the upper 20 feet of the aquifer. • Implement groundwater use restriction through an environmental easement to prevent use of onsite groundwater. • Shut down the Groundwater IRM when termination criteria are achieved (to be developed and included in the OM&M Manual) • Following IRM shutdown, conduct natural attenuation monitoring for residual VOCs. **Alternative 3:** • In addition to GW-2 above, continue to operate, maintain, and monitor the following remedial/treatment-systems to protect public water supplies and reduce VOC mass in the Study Area: 1) BWD wellhead treatment systems; 2) Main Facility remedial system, and 3) GM-38 Area remedial system. • Install and operate one new remedial well (Well RW-21) to reduce VOC mass in Study Area groundwater. Treat extracted groundwater from the new well at the existing Main Facility remedial system.	38.4 [2]
TOTAL		**64.5**

Notes:

1. Detailed cost breakdowns are provided in Appendix B.
2. The operational periods of the Groundwater and Soil Gas IRMs are assumed to be significantly reduced if VOCs source areas are remediated via Alternative SA-3. Accordingly, the costs in this table are less than those provided in Tables 7-6 and 7-7 in the Site Area FS and reflect reduced IRM operational timeframes and a significant reduction in VOC mass treated by the IRMs. The Soil Gas IRM is assumed to operate for 10 years and the Groundwater IRM is assumed to operate for 15 years.
3. Cost for Alternative 3, unlike Table 6-2, do not include costs for source remediation at the Park, nor the Groundwater IRM, as these costs are already included above.
4. See Site Area FS for discussion and evaluation of remedies for Site Area soil, source areas, soil gas, and groundwater.

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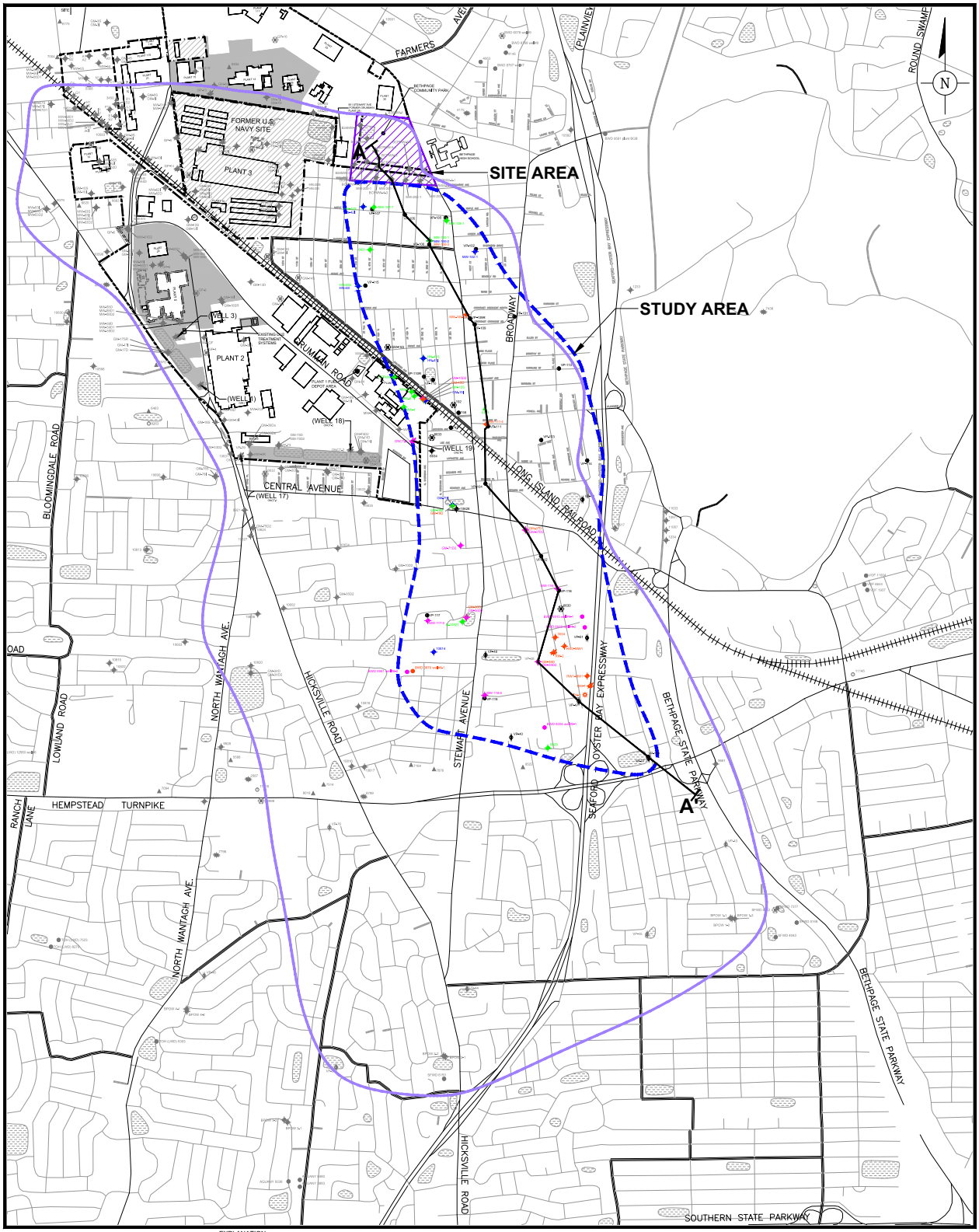

EXPLANATION:

- PROPERTY BOUNDARY OF THE FORMER GRUMMAN AEROSPACE PROPERTY
- PROPERTY BOUNDARY OF THE FORMER U.S. NAVY PROPERTY
- PROPERTY BOUNDARY OF THE FORMER OCC PROPERTY
- STUDY AREA LIMIT (APPROXIMATE)
- APPROXIMATE LIMIT OF REGIONAL AREA OF VOC-IMPACTED GROUNDWATER
- LONG ISLAND RAILROAD
- DENOTES NORTHROP GRUMMAN OWNED PROPERTY
- DENOTES FORMER U.S. NAVY OWNED PROPERTY
- RECHARGE BASIN
- A — A' LINE OF SECTION
- SITE AREA
- MICROGRAMS PER LITER
- OBSERVATION, MONITORING WELL
- INDUSTRIAL WELL
- PUBLIC SUPPLY WELL
- IRRIGATION WELL
- INJECTION WELL
- NORTHROP GRUMMAN OR NAVY PRODUCTION WELL
- OU2 VERTICAL PROFILE BORING
- OU3 VERTICAL PROFILE BORING
- ABANDONED WELL

DESIGNATION OF HYDROGEOLOGIC ZONE FOR MONITORING WELL SCREENED INTERVALS (ARCADIS 2003)

- SHALLOW
- INTERMEDIATE
- DEEP
- DEEP2

NOTES:

1. VERTICAL PROFILE BORING LOCATIONS BASED ON FIELD MEASUREMENTS.
2. HYDROGEOLOGIC ZONE BASED ON MODEL LAYER ELEVATIONS PRESENTED IN COMPREHENSIVE GROUNDWATER MODEL (ARCADIS 2003).

0 800' 1600'
SCALE IN FEET

ALL COORDINATES REFERENCED TO NORTH AMERICAN DATUM 1983

STUDY AREA FEASIBILITY STUDY
NORTHROP GRUMMAN SYSTEMS CORPORATION
OPERABLE UNIT 3 (FORMER GRUMMAN SETTLING PONDS)
BETHPAGE, NEW YORK

STUDY AREA SHOWING WELL AND VERTICAL PROFILE BORING LOCATIONS AND LINE OF SECTION A-A'

ARCADIS

FIGURE
2-1

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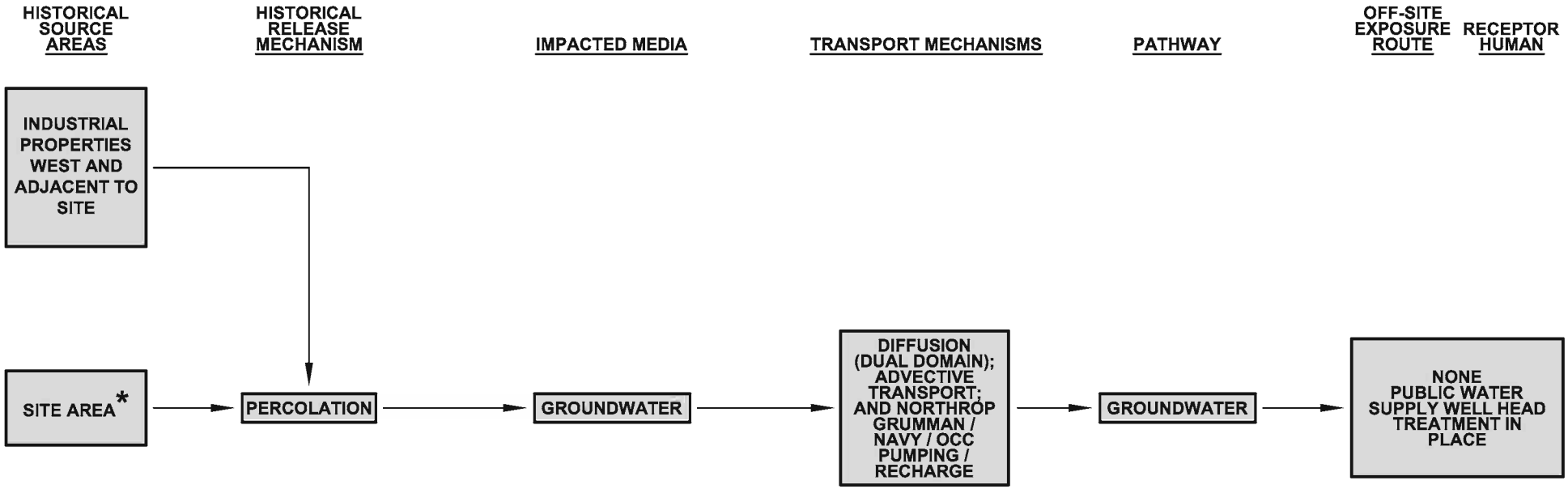

* OFF-SITE MIGRATION OF VOCs NOW CONTROLLED BY INTERIM REMEDIAL MEASURE SINCE JULY 2009

STUDY AREA FEASIBILITY STUDY
NORTHROP GRUMMAN SYSTEMS CORPORATION
OPERABLE UNIT 3 (FORMER GRUMMAN SETTLING PONDS)
BETHPAGE, NEW YORK

STUDY AREA CONCEPTUAL SITE MODEL

ARCADIS

FIGURE
3-1

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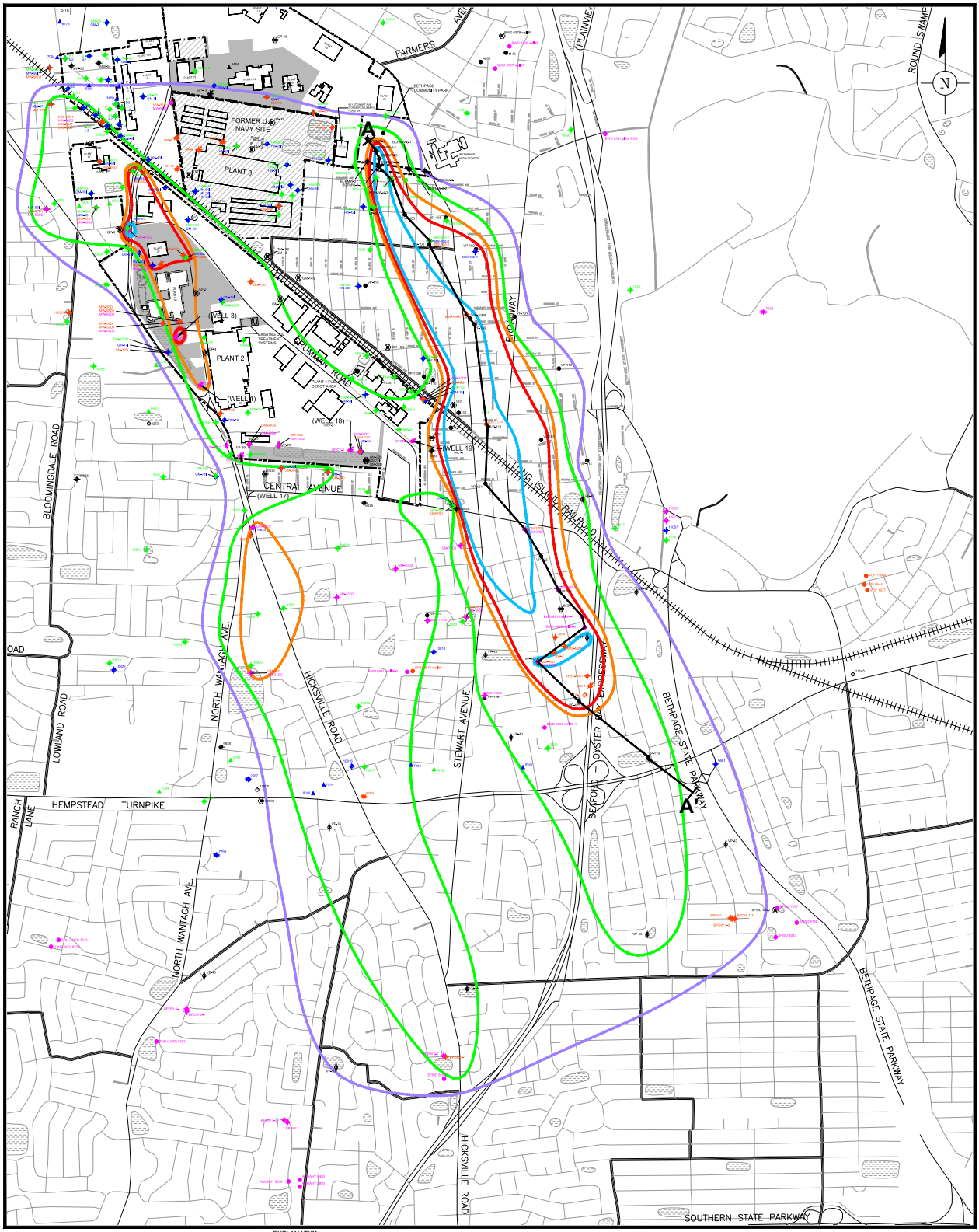


EXPLANATION:

- PROPERTY BOUNDARY OF THE FORMER GRUMMAN AEROSPACE PROPERTY
- PROPERTY BOUNDARY OF THE FORMER U.S. NAVY PROPERTY
- PROPERTY BOUNDARY OF THE FORMER OCC PROPERTY
- LONG ISLAND RAILROAD
- DENOTES NORTHROP GRUMMAN OWNED PROPERTY
- DENOTES FORMER U.S. NAVY OWNED PROPERTY
- RECHARGE BASIN
- A—A' LINE OF TVOC CROSS-SECTION
- OBSERVATION, MONITORING WELL
- INDUSTRIAL WELL
- PUBLIC SUPPLY WELL
- IRRIGATION WELL
- INJECTION WELL
- NORTHROP GRUMMAN OR NAVY PRODUCTION WELL
- OU2 VERTICAL PROFILE BORING
- OU3 VERTICAL PROFILE BORING
- ABANDONED WELL

TVOC TOTAL VOLATILE ORGANIC COMPOUND
MICROGRAMS PER LITER
VPB VERTICAL PROFILE BORING
BPOW BETHPAGE OUTPOST WELL
RW REMEDIAL WELL
BWD BETHPAGE WATER DISTRICT
SFWD SOUTH FARMINGDALE WATER DISTRICT
VOF VILLAGE OF FARMINGDALE
TOH (LWD) TOWN OF HEMPSTEAD (LEVITTOWN WATER DISTRICT)

DEFINITIONS OF TVOC CONCENTRATION CONTOURS IN GROUNDWATER

- 5
- 50
- 500
- 1000
- 5000

0 800' 1600'
SCALE IN FEET

TVOC DATA DISPLAYED CONSISTS OF:

- AVERAGE OF MONITORING WELL AND PUBLIC SUPPLY WELL DATA FROM 2004 THROUGH 2007
- NORTHROP GRUMMAN AND NAVY VERTICAL PROFILE BORING INFORMATION

NOTE:

1. VPB LOCATIONS BASED ON FIELD MEASURMENTS.

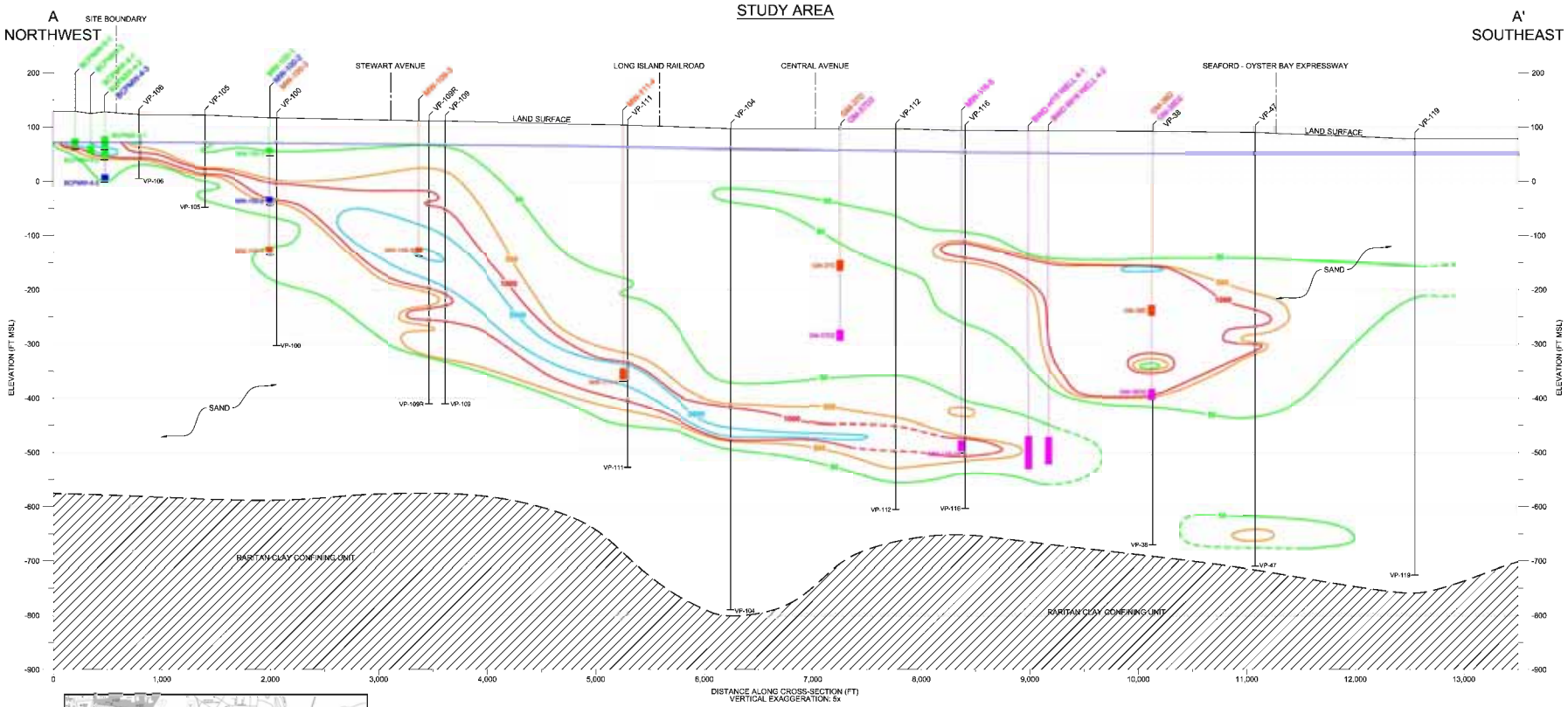
ALL COORDINATES REFERENCED TO NORTH AMERICAN DATUM 1983

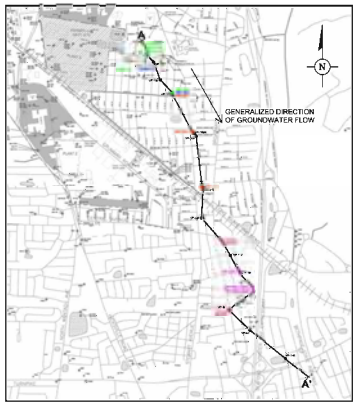
STUDY AREA FEASIBILITY STUDY
NORTHROP GRUMMAN SYSTEMS CORPORATION
OPERABLE UNIT 3 (FORMER GRUMMAN SETTLING PONDS)
BETHPAGE, NEW YORK

CONCENTRATIONS OF TVOCs IN REGIONAL AREA GROUNDWATER - PLAN VIEW

ARCADIS

FIGURE
3-2





PLAN VIEW SHOWING LINE OF SECTION A-A'

0 2000' 4000'
SCALE IN FEET

EXPLANATION

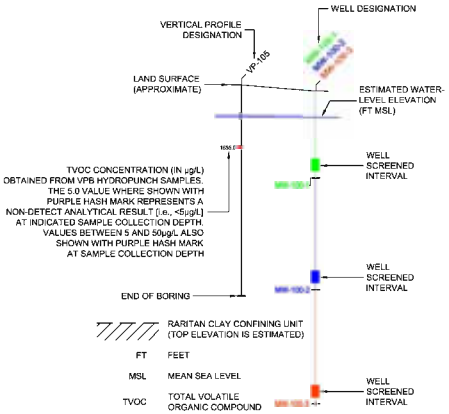
- OBSERVATION, MONITORING WELL
- PUBLIC SUPPLY WELL
- OU2 VERTICAL PROFILE BORING
- OU3 VERTICAL PROFILE BORING
- A—A' LINE OF SECTION

DESIGNATION OF HYDROGEOLOGIC ZONE FOR MONITORING WELL SCREENED INTERVALS (ARCADIS 2003)

- SHALLOW
- INTERMEDIATE
- DEEP
- DEEP2

TVOC CONTOURS

- 50 µg/L
- 500 µg/L
- 1000 µg/L
- 5000 µg/L



NOTES:

1. HYDROGEOLOGIC ZONE BASED ON MODEL LAYER ELEVATIONS PRESENTED IN COMPREHENSIVE GROUNDWATER MODEL (ARCADIS 2003).
2. VERTICAL PROFILE BORING LOCATIONS ARE BASED ON FIELD MEASUREMENTS.
3. MONITORING WELLS SURVEYED TO NAD 1983.
4. THE FIGURE UTILIZES DATA PRESENTED IN STUDY AREA REMEDIAL INVESTIGATION REPORT (ARCADIS 2011).
5. LAND SURFACE ESTIMATED FROM USGS QUADRANGLES (AMITYVILLE, HUNTINGTON, FREEPORT, AND HICKSVILLE)
6. THE GEOLOGICAL TERM "SAND" REFERENCED ABOVE IS DEFINED IN DETAIL IN THE STUDY AREA REMEDIAL INVESTIGATION REPORT. LOCALIZED LENSES OF LOWER PERMEABILITY NOT SHOWN. REFER TO STUDY AREA REMEDIAL INVESTIGATION REPORT FOR THIS INFORMATION (ARCADIS 2009).
7. A GROUNDWATER INTERIM REMEDIAL MEASURE WAS INSTALLED IN JULY 2009 TO CONTAIN ON SITE TOTAL VOLATILE ORGANIC COMPOUND PLUME. THE EFFECTIVENESS OF THE GROUNDWATER INTERIM REMEDIAL MEASURE WILL BE DOCUMENTED IN OPERATION, MAINTENANCE AND MONITORING REPORTS.

ALL COORDINATES REFERENCED TO NORTH AMERICAN DATUM 1983

STUDY AREA FEASIBILITY STUDY
NORTHROP GRUMMAN SYSTEMS CORPORATION
OPERABLE UNIT 3 (FORMER GRUMMAN SETTLING PONDS)
BETHPAGE, NEW YORK

CONCENTRATIONS OF TVOCs IN GROUNDWATER (CROSS SECTION A-A')

ARCADIS

FIGURE 3-3

CITY:(Reed) DIV/GROUP:(Reed) DB:(Reed) LD:(Opt) PIC:(Opt) PM:(Reed) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
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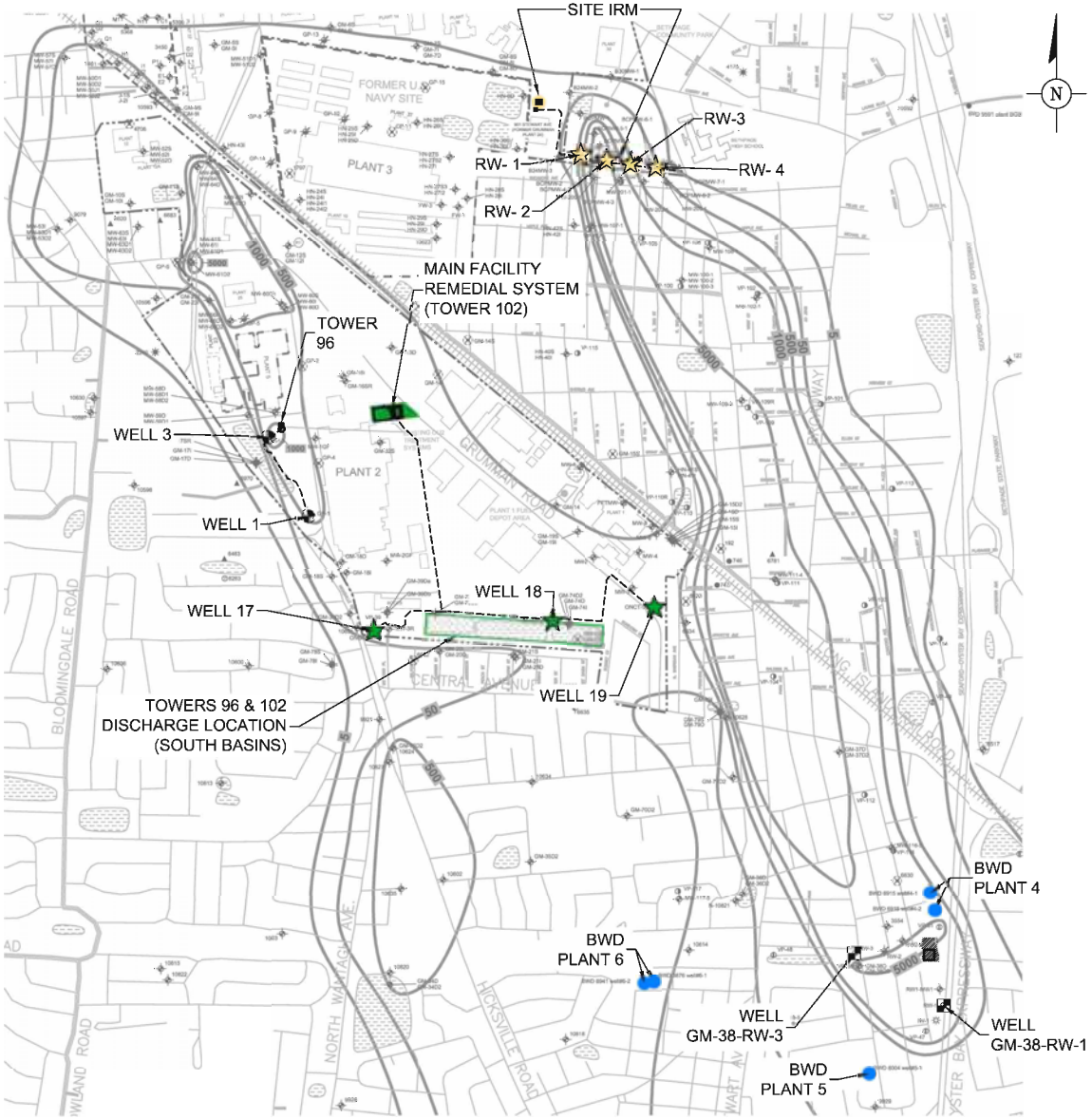

LEGEND:

- PROPERTY BOUNDARY OF THE FORMER GRUMMAN AEROSPACE CORPORATION SITE
- PROPERTY BOUNDARY OF THE FORMER U.S. NAVY SITE
- PROPERTY BOUNDARY OF THE FORMER OCC SITE
- LONG ISLAND RAILROAD
- RECHARGE BASIN
- TVOC ISO-CONCENTRATION CONTOUR IN MICROGRAMS PER LITER (µg/L)
- PUBLIC SUPPLY WELL
- EXISTING MAIN FACILITY REMEDIAL WELL (TOWER 96)
- STUDY AREA PUBLIC SUPPLY WELL
- EXISTING THIRD PARTY REMEDIAL WELL (GM-38 AREA)
- EXISTING THIRD PARTY REMEDIAL TREATMENT SYSTEM (GM-38 AREA)
- EXISTING MAIN FACILITY REMEDIAL WELL (TOWER 102)
- EXISTING MAIN FACILITY REMEDIAL TREATMENT SYSTEM (TOWER 102)
- EXISTING SITE IRM REMEDIAL WELL
- EXISTING SITE IRM GROUNDWATER TREATMENT SYSTEM
- EXISTING SYSTEM INFLUENT PIPELINE

BWD BETHPAGE WATER DISTRICT
TVOC TOTAL VOLATILE ORGANIC COMPOUND
GPM GALLONS PER MINUTE
IRM INTERIM REMEDIAL MEASURE

NOTE:

1. BASELINE CONDITIONS/CONTINUED ACTION, PLUS SOURCE AREA REMOVAL AT SITE AREA. CONTINUE TO OPERATE SITE IRM, MAIN FACILITY, AND GM-38 REMEDIAL TREATMENT SYSTEMS. OPERATE EXISTING BWD WELL HEAD PROTECTION SYSTEMS.

0 600' 1200'
SCALE IN FEET

ALL COORDINATES REFERENCED TO NORTH AMERICAN DATUM 1983

STUDY AREA FEASIBILITY STUDY
NORTHROP GRUMMAN SYSTEMS CORPORATION
OPERABLE UNIT 3 (FORMER GRUMMAN SETTLING PONDS)
BETHPAGE, NEW YORK

ALTERNATIVE 2 - BASELINE
CONTINUED ACTION
CONCEPTUAL SITE LAYOUT

ARCADIS

FIGURE
6-1

CITY:(Read) DIV/GROUP:(Read) DB:(Read) LD:(Cob) PIC:(Cop) PM:(Read) TM:(Cob) LYR:(Opt)On=*;OFF=*REF*
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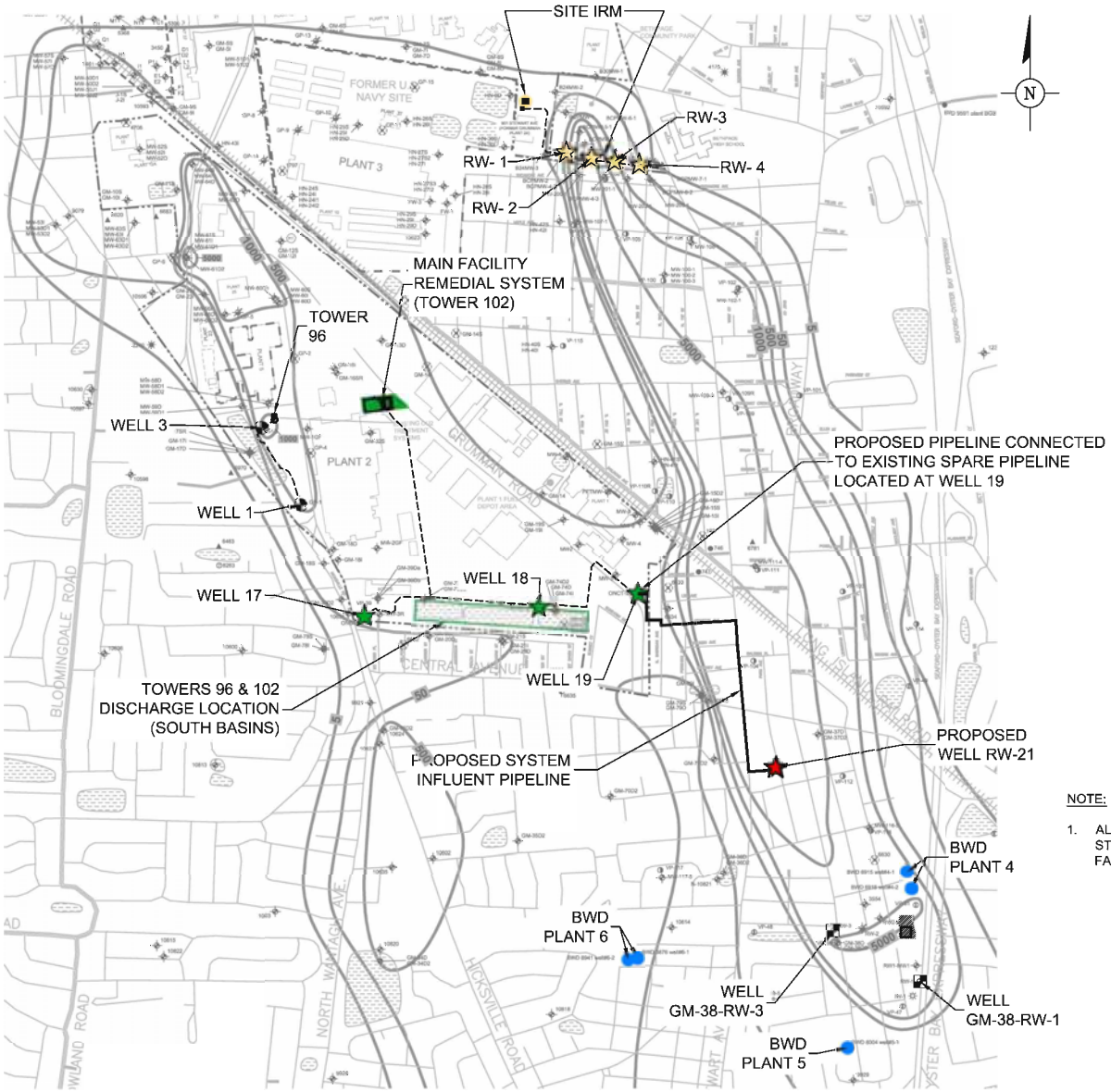
XREFS:
PROJECTNAME: ----



LEGEND:

- PROPERTY BOUNDARY OF THE FORMER GRUMMAN AEROSPACE CORPORATION SITE
- PROPERTY BOUNDARY OF THE FORMER U.S. NAVY SITE
- PROPERTY BOUNDARY OF THE FORMER OCC SITE
- LONG ISLAND RAILROAD
- RECHARGE BASIN
- TVOC ISO-CONCENTRATION CONTOUR IN MICROGRAMS PER LITER (µg/L)
- PUBLIC SUPPLY WELL
- EXISTING MAIN FACILITY REMEDIAL WELL (TOWER 96)
- STUDY AREA PUBLIC SUPPLY WELL
- EXISTING THIRD PARTY REMEDIAL WELL (GM-38 AREA)
- EXISTING THIRD PARTY REMEDIAL TREATMENT SYSTEM (GM-38 AREA)
- EXISTING MAIN FACILITY REMEDIAL WELL (TOWER 102)
- EXISTING MAIN FACILITY REMEDIAL TREATMENT SYSTEM (TOWER 102)
- EXISTING SITE IRM REMEDIAL WELL
- EXISTING SITE IRM GROUNDWATER TREATMENT SYSTEM
- EXISTING SYSTEM INFLUENT PIPELINE
- PROPOSED REMEDIAL WELL
- PROPOSED SYSTEM INFLUENT PIPELINE

BWD BETHPAGE WATER DISTRICT
TVOC TOTAL VOLATILE ORGANIC COMPOUND
GPM GALLONS PER MINUTE
IRM INTERIM REMEDIAL MEASURE

NOTE:

1. ALTERNATIVE 2 PLUS NEW REMEDIAL WELL RW-21 PUMPING AT 1,000 GPM TO REDUCE VOC MASS IN STUDY AREA GROUNDWATER. EXTRACTED GROUNDWATER WILL BE TREATED AT THE EXISTING MAIN FACILITY REMEDIAL TREATMENT SYSTEM.

0 600' 1200'
SCALE IN FEET

ALL COORDINATES REFERENCED TO NORTH AMERICAN DATUM 1983

STUDY AREA FEASIBILITY STUDY
NORTHROP GRUMMAN SYSTEMS CORPORATION
OPERABLE UNIT 3 (FORMER GRUMMAN SETTLING PONDS)
BETHPAGE, NEW YORK

ALTERNATIVE 3 - ALTERNATIVE 2 PLUS
ONE NEW REMEDIAL WELL
CONCEPTUAL SITE LAYOUT

ARCADIS

FIGURE
6-2

CITY:(Read) DIV/GROUP:(Read) DB:(Read) LD:(Cut) PIC:(Cop) PM:(Read) TM:(Cut) LYR:(Cut)On=*;OFF=*REF*
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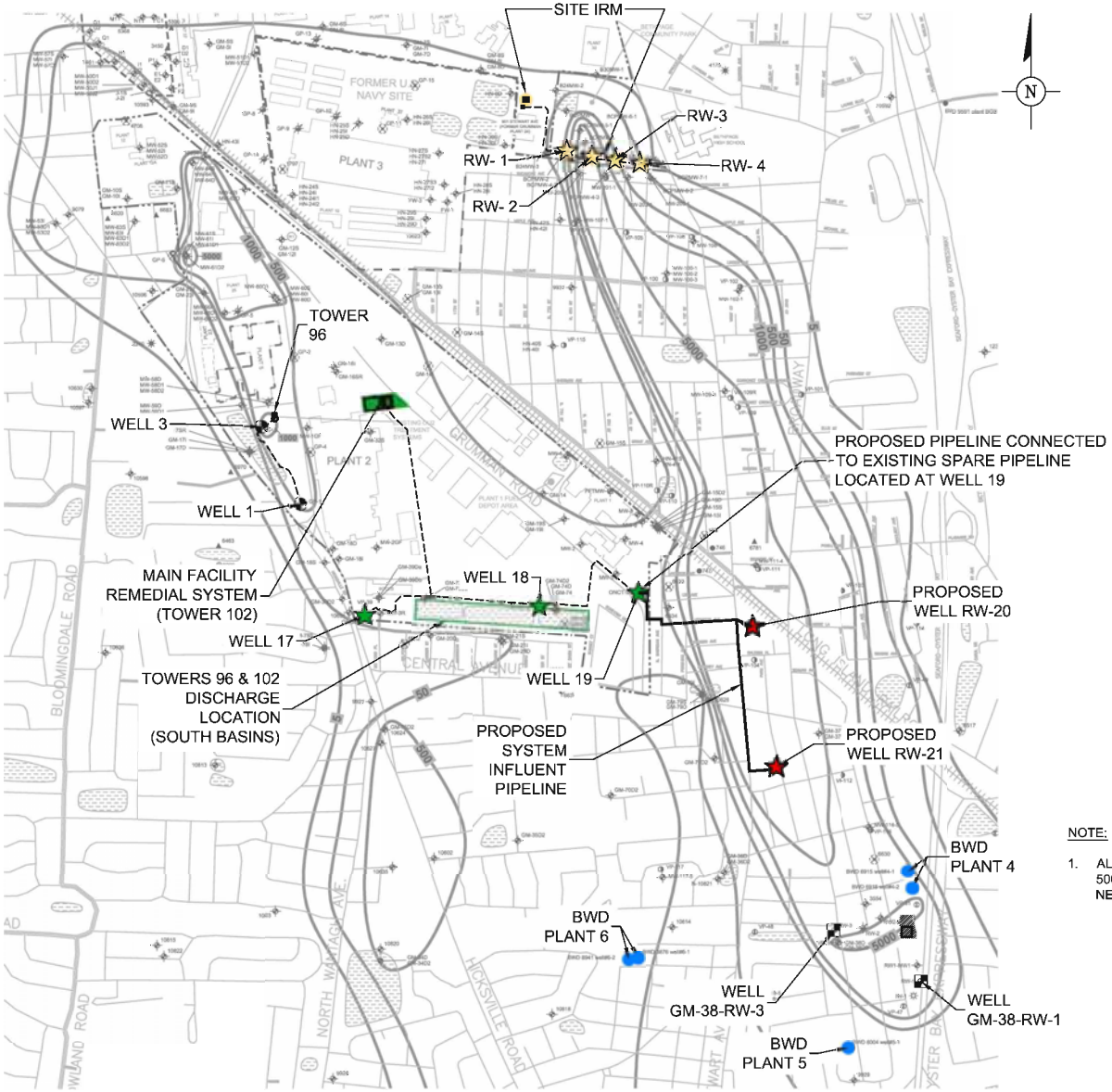

LEGEND:

- PROPERTY BOUNDARY OF THE FORMER GRUMMAN AEROSPACE CORPORATION SITE
- PROPERTY BOUNDARY OF THE FORMER U.S. NAVY SITE
- PROPERTY BOUNDARY OF THE FORMER OCC SITE
- LONG ISLAND RAILROAD
- RECHARGE BASIN
- TVOC ISO-CONCENTRATION CONTOUR IN MICROGRAMS PER LITER (µg/L)
- PUBLIC SUPPLY WELL
- EXISTING MAIN FACILITY REMEDIAL WELL (TOWER 96)
- STUDY AREA PUBLIC SUPPLY WELL
- EXISTING THIRD PARTY REMEDIAL WELL (GM-38 AREA)
- EXISTING THIRD PARTY REMEDIAL TREATMENT SYSTEM (GM-38 AREA)
- EXISTING MAIN FACILITY REMEDIAL WELL (TOWER 102)
- EXISTING MAIN FACILITY REMEDIAL TREATMENT SYSTEM (TOWER 102)
- EXISTING SITE IRM REMEDIAL WELL
- EXISTING SITE IRM GROUNDWATER TREATMENT SYSTEM
- EXISTING SYSTEM INFLUENT PIPELINE
- PROPOSED REMEDIAL WELL
- PROPOSED SYSTEM INFLUENT PIPELINE

BWD BETHPAGE WATER DISTRICT
TVOC TOTAL VOLATILE ORGANIC COMPOUND
GPM GALLONS PER MINUTE
IRM INTERIM REMEDIAL MEASURE

NOTE:

1. ALTERNATIVE 2 PLUS TWO (2) NEW REMEDIAL WELLS: WELL RW-20 AND WELL RW-21 EACH PUMPING AT 500 GPM, TO REDUCE VOC MASS IN STUDY AREA GROUNDWATER. EXTRACTED GROUNDWATER FROM NEW WELLS WILL BE TREATED AT THE EXISTING MAIN FACILITY REMEDIAL TREATMENT SYSTEM.

0 600' 1200'
SCALE IN FEET

ALL COORDINATES REFERENCED TO NORTH AMERICAN DATUM 1983

STUDY AREA FEASIBILITY STUDY
NORTHROP GRUMMAN SYSTEMS CORPORATION
OPERABLE UNIT 3 (FORMER GRUMMAN SETTLING PONDS)
BETHPAGE, NEW YORK

ALTERNATIVE 4 - ALTERNATIVE 2 PLUS TWO NEW REMEDIAL WELLS CONCEPTUAL SITE LAYOUT

ARCADIS

FIGURE 6-3

CITY (Req'd) DIV/GROUP (Req'd) DB (Req'd) LD (Cut) PIC (Cpl) PM (Req'd) TM (Cut) LYR (Cut/On=*;OFF=*REF*
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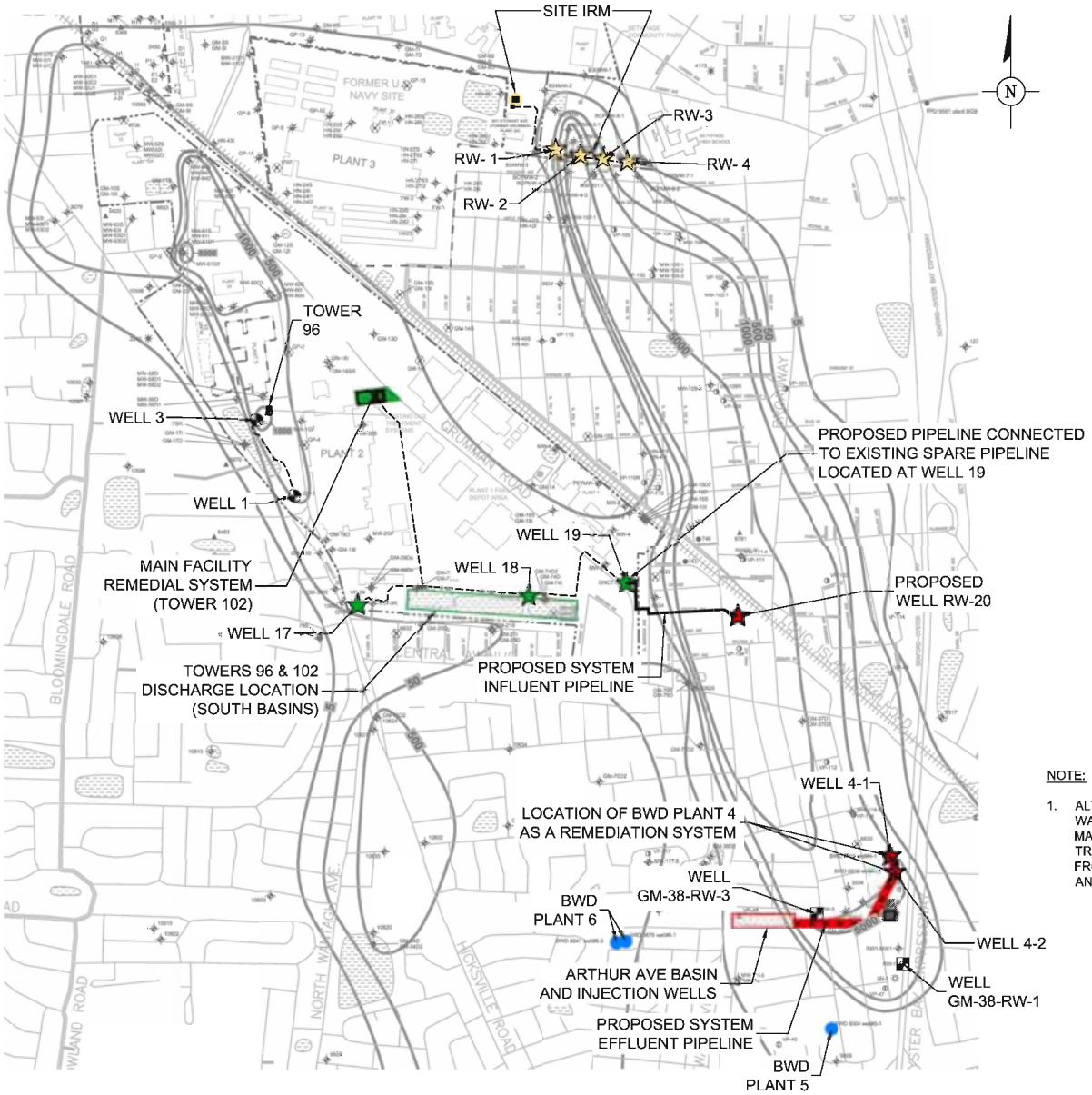

LEGEND:

- PROPERTY BOUNDARY OF THE FORMER GRUMMAN AEROSPACE CORPORATION SITE
- PROPERTY BOUNDARY OF THE FORMER U.S. NAVY SITE
- PROPERTY BOUNDARY OF THE FORMER OCC SITE
- LONG ISLAND RAILROAD
- RECHARGE BASIN
- TVOC ISO-CONCENTRATION CONTOUR IN MICROGRAMS PER LITER (µg/L)
- PUBLIC SUPPLY WELL
- EXISTING MAIN FACILITY REMEDIAL WELL (TOWER 96)
- STUDY AREA PUBLIC SUPPLY WELL
- EXISTING THIRD PARTY REMEDIAL WELL (GM-38 AREA)
- EXISTING THIRD PARTY REMEDIAL TREATMENT SYSTEM (GM-38 AREA)
- EXISTING MAIN FACILITY REMEDIAL WELL (TOWER 102)
- EXISTING MAIN FACILITY REMEDIAL TREATMENT SYSTEM (TOWER 102)
- EXISTING SITE IRM REMEDIAL WELL
- EXISTING SITE IRM GROUNDWATER TREATMENT SYSTEM
- EXISTING SYSTEM INFLUENT PIPELINE
- PROPOSED REMEDIAL WELL
- PROPOSED SYSTEM INFLUENT PIPELINE
- PROPOSED SYSTEM EFFLUENT PIPELINE

BWD BETHPAGE WATER DISTRICT
TVOC TOTAL VOLATILE ORGANIC COMPOUND
GPM GALLONS PER MINUTE
IRM INTERIM REMEDIAL MEASURE

NOTE:

1. ALTERNATIVE 2 PLUS NEW REMEDIAL WELL RW-20 PUMPING AT 500 GPM, AND THE TWO (2) BETHPAGE WATER DISTRICT (BWD) PLANT 4 WELLS PUMPING AT A COMBINED RATE OF 2,700 GPM TO REDUCE VOC MASS IN STUDY AREA GROUNDWATER. EXTRACTED GROUNDWATER FROM NEW WELL WILL BE TREATED AT THE EXISTING MAIN FACILITY REMEDIAL TREATMENT SYSTEM. TREATED GROUNDWATER FROM BWD PLANT 4 WELLS WILL BE DISCHARGED TO A COMBINATION OF EXISTING RECHARGE BASIN AND SHALLOW INJECTION WELLS LOCATED AT ARTHUR AVE. REPLACE BWD PLANT 4 CAPACITY.

0 600' 1200'
SCALE IN FEET

ALL COORDINATES REFERENCED TO NORTH AMERICAN DATUM 1983

STUDY AREA FEASIBILITY STUDY
NORTHROP GRUMMAN SYSTEMS CORPORATION
OPERABLE UNIT 3 (FORMER GRUMMAN SETTLING PONDS)
BETHPAGE, NEW YORK

ALTERNATIVE 5 - ALTERNATIVE 2 PLUS ONE NEW REMEDIAL WELL AND BWD PLANT 4 AS A REMEDIATION SYSTEM CONCEPTUAL SITE LAYOUT

ARCADIS

FIGURE 6-4

CITY (Req'd) DIV/GROUP (Req'd) DB (Req'd) LD (Out) PIC (Opt) PM (Req'd) TM (Out) LYR (Opt/On=*;OFF=*REF*)
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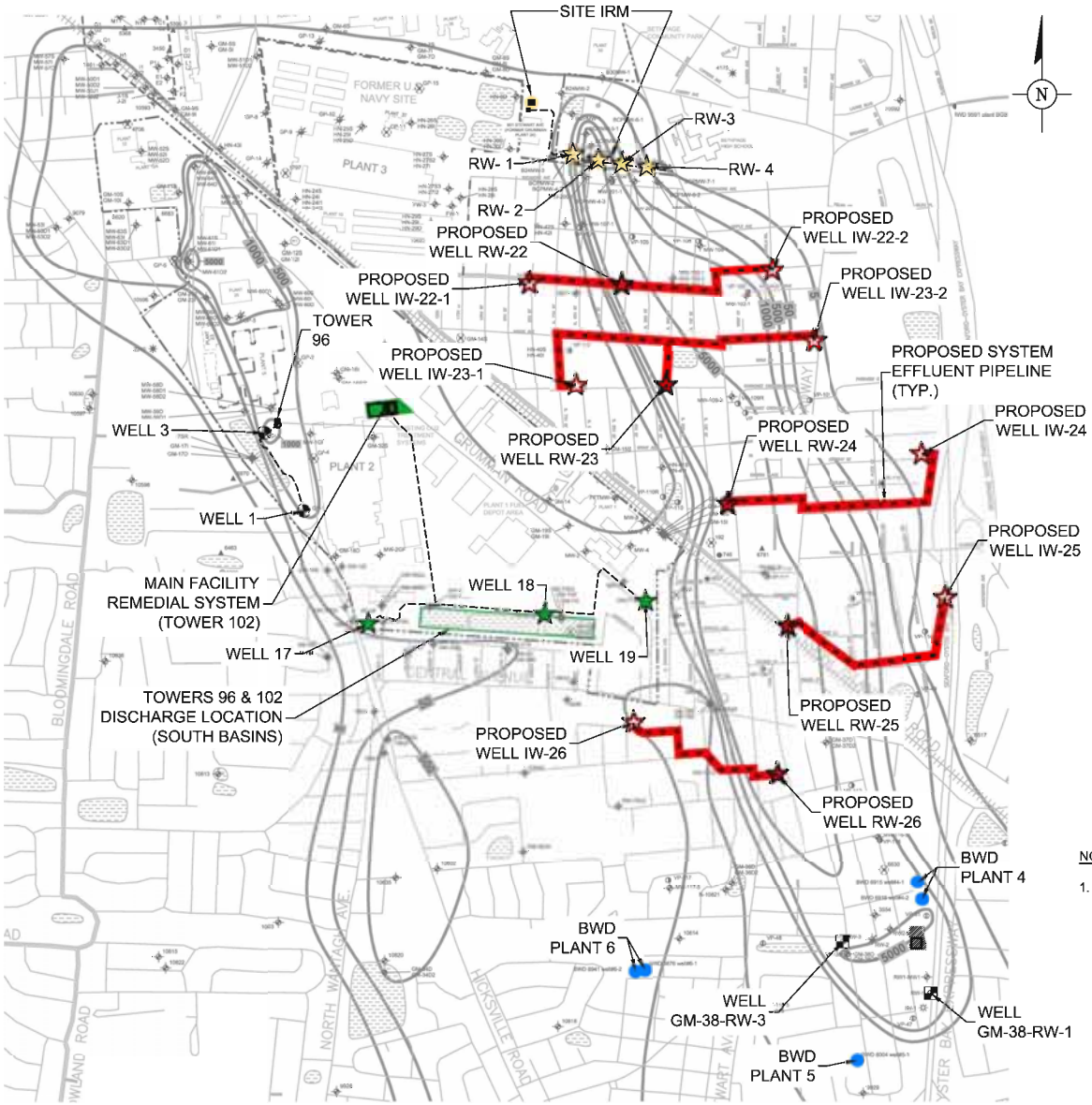

LEGEND:

- PROPERTY BOUNDARY OF THE FORMER GRUMMAN AEROSPACE CORPORATION SITE
- PROPERTY BOUNDARY OF THE FORMER U.S. NAVY SITE
- PROPERTY BOUNDARY OF THE FORMER OCC SITE
- LONG ISLAND RAILROAD
- RECHARGE BASIN
- TVOC ISO-CONCENTRATION CONTOUR IN MICROGRAMS PER LITER (µg/L)
- PUBLIC SUPPLY WELL
- EXISTING MAIN FACILITY REMEDIAL WELL (TOWER 96)
- STUDY AREA PUBLIC SUPPLY WELL
- EXISTING THIRD PARTY REMEDIAL WELL (GM-38 AREA)
- EXISTING THIRD PARTY REMEDIAL TREATMENT SYSTEM (GM-38 AREA)
- EXISTING MAIN FACILITY REMEDIAL WELL (TOWER 102)
- EXISTING MAIN FACILITY REMEDIAL TREATMENT SYSTEM (TOWER 102)
- EXISTING SITE IRM REMEDIAL WELL
- EXISTING SITE IRM GROUNDWATER TREATMENT SYSTEM
- EXISTING SYSTEM INFLUENT PIPELINE
- PROPOSED REMEDIAL WELL/TREATMENT SYSTEM
- PROPOSED LOCATION OF INJECTION WELLS (ONE OPERATING/ONE BACKUP)
- PROPOSED SYSTEM EFFLUENT PIPELINE

BWD BETHPAGE WATER DISTRICT
TVOC TOTAL VOLATILE ORGANIC COMPOUND
GPM GALLONS PER MINUTE
IRM INTERIM REMEDIAL MEASURE

NOTE:

1. ALTERNATIVE 2 PLUS ATTEMPT TO RETURN STUDY AREA GROUNDWATER TO PRE-DISPOSAL CONDITIONS USING FIVE (5) NEW REMEDIAL WELLS, SEVEN (7) OPERATING (SEVEN BACKUP) INJECTION WELLS, AND FIVE (5) NEW REMEDIAL TREATMENT SYSTEMS.

0 600' 1200'
SCALE IN FEET

ALL COORDINATES REFERENCED TO NORTH AMERICAN DATUM 1983

STUDY AREA FEASIBILITY STUDY
NORTHROP GRUMMAN SYSTEMS CORPORATION
OPERABLE UNIT 3 (FORMER GRUMMAN SETTLING PONDS)
BETHPAGE, NEW YORK

ALTERNATIVE 6 -
ALTERNATIVE 2 PLUS
FIVE NEW REMEDIAL WELLS
CONCEPTUAL SITE LAYOUT

ARCADIS

FIGURE
6-5

CITY:(Read) DIV/GROUP:(Read) DB:(Read) LD:(Out) PIC:(Opt) PM:(Read) TM:(Out) LYR:(Opt)On=*;OFF=*REF*
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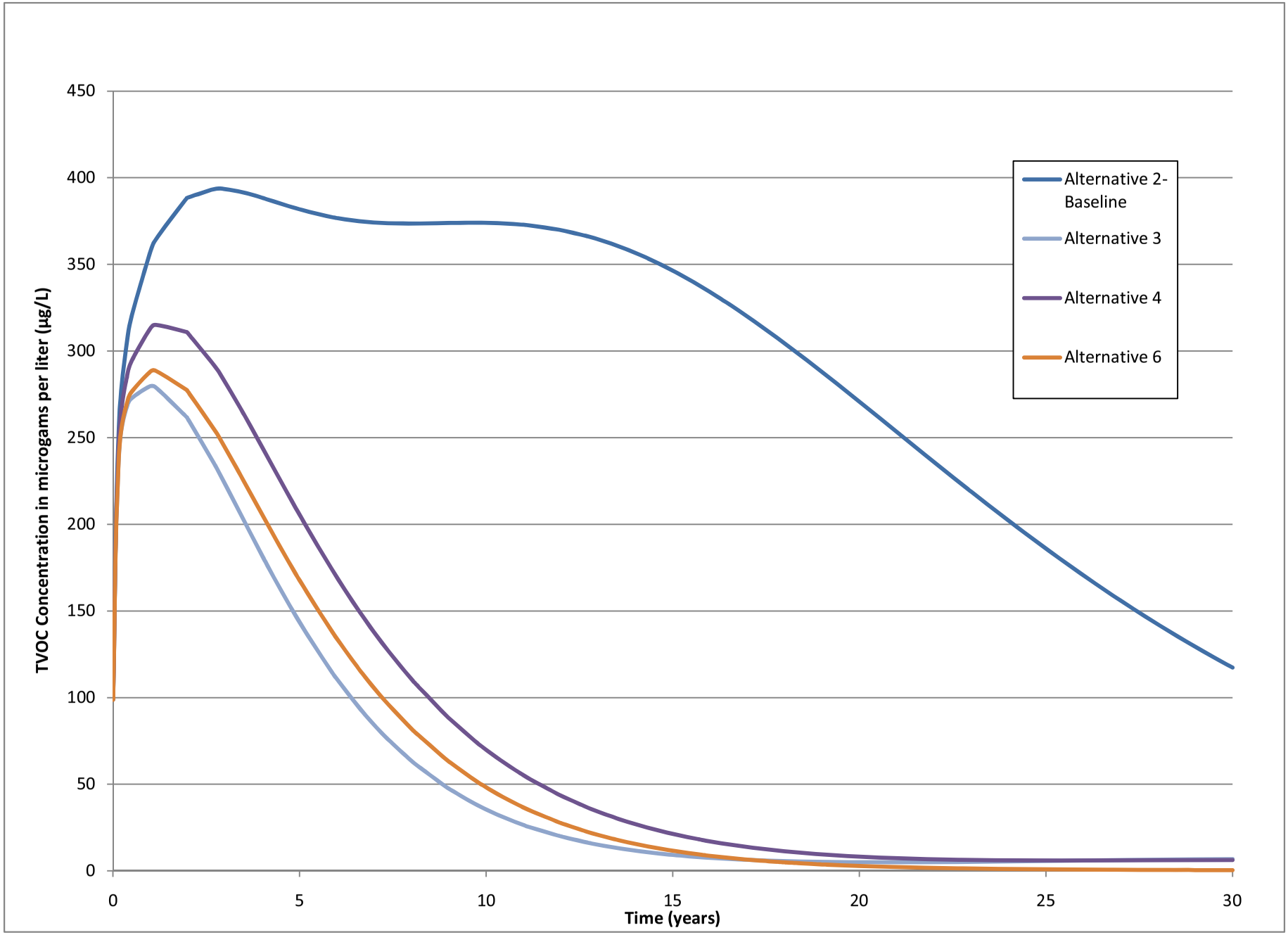
XREFS:
PROJECTNAME: ----

Figure 6-6. Comparison of Model-Predicted TVOC Concentrations at BWD Well 4-1 by Remedial Alternative,
Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.



G:\ENVCAD\Melville-NY\ACT\NY001496\0811\FS0D4\00006\7-6_7_8 Comparison of Alternative Performance.xlsx BWD 4-1

Figure 6-7. Comparison of Model-Predicted TVOC Concentrations at BWD Well 4-2 by Remedial Alternative,
Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.

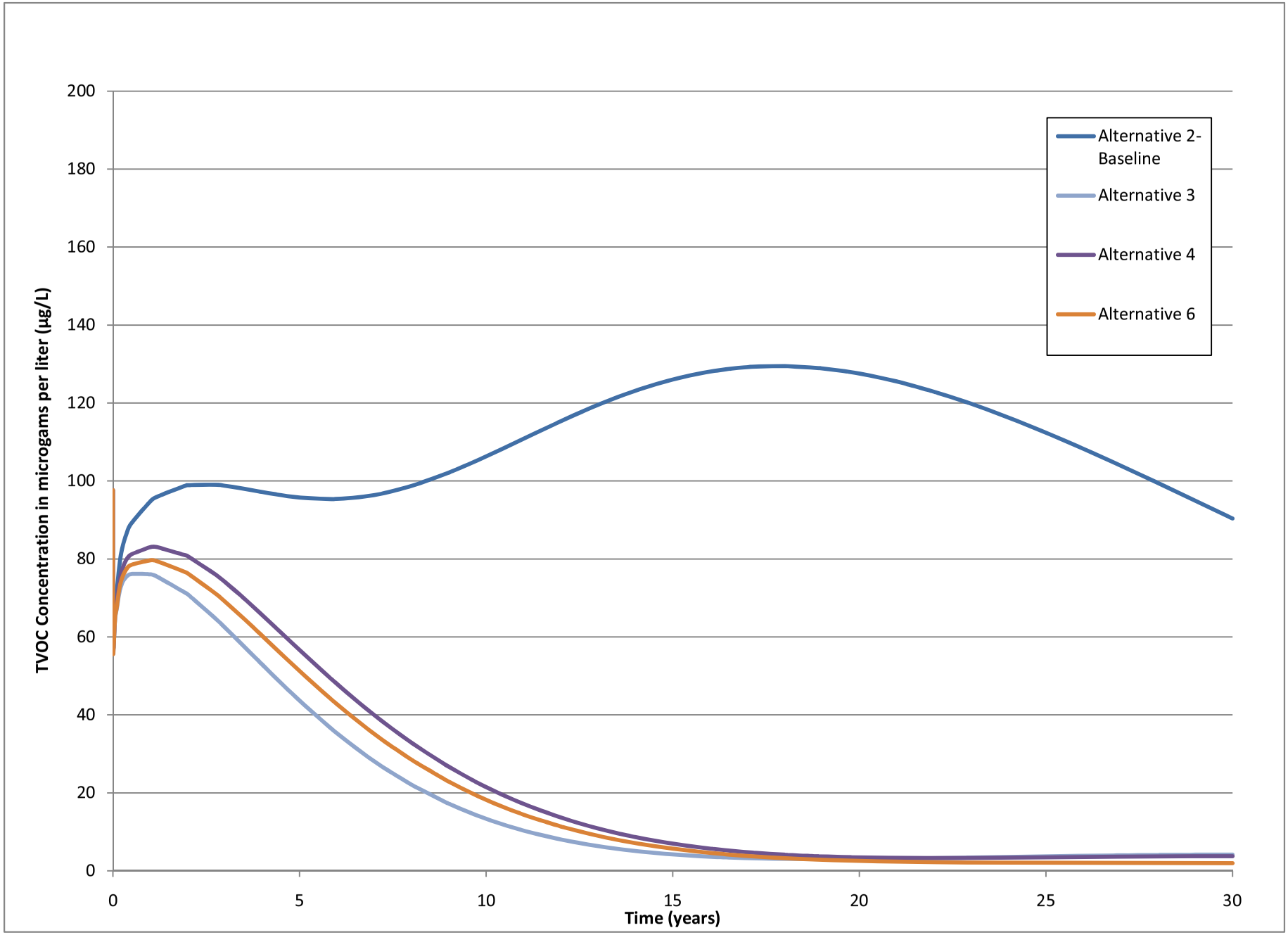


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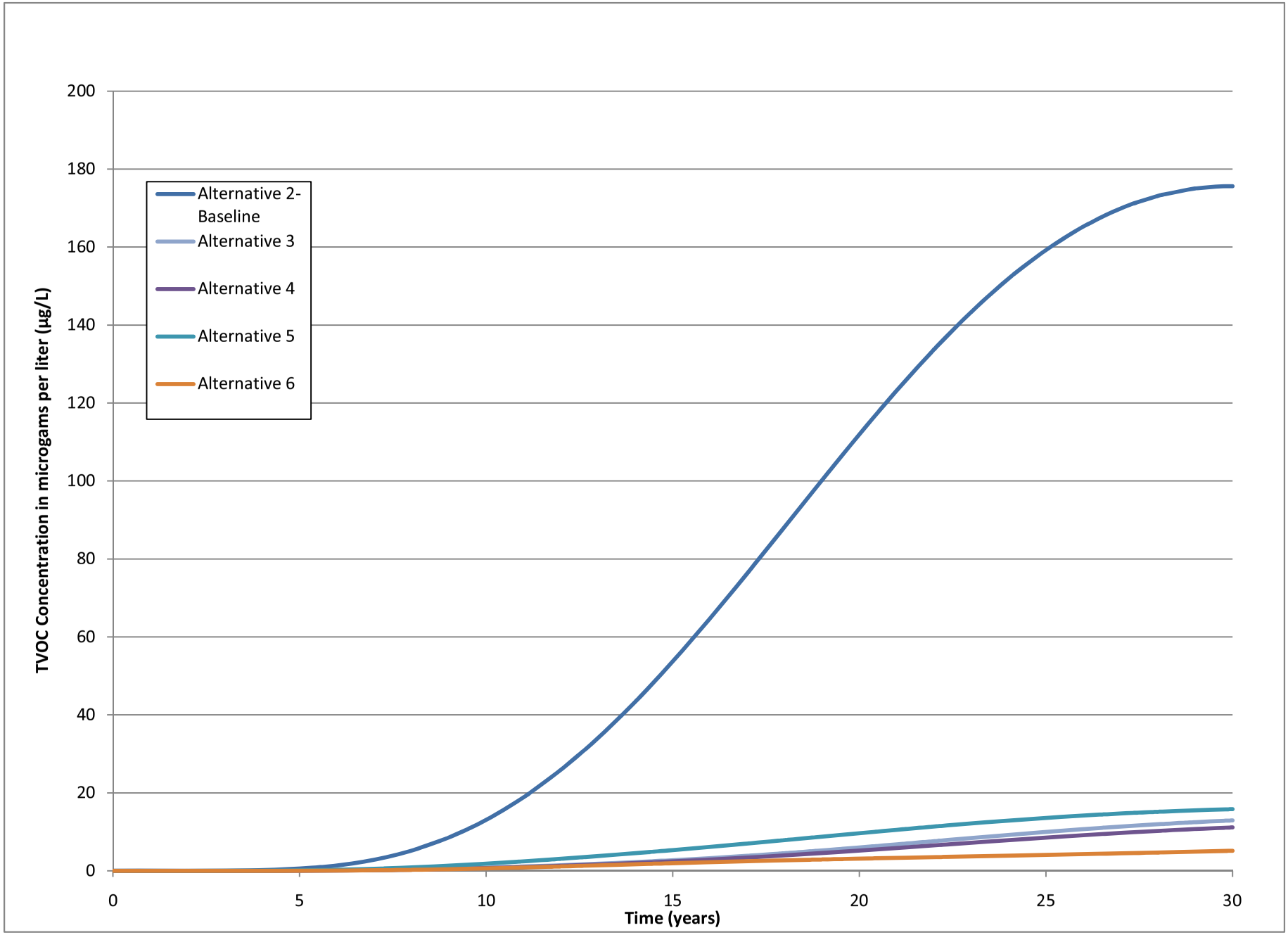
Figure 6-8. Comparisons of Model-Predicted TVOC Concentrations at BWD Well 5-1 by Remedial Alternative,
Study Area Feasibility Study, Northrop Grumman Systems Corporation, Operable Unit 3 (Former Grumman Settling Ponds), Bethpage, New York.



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