SOUTH FARMINGDALE WATER DISTRICT

NASSAU COUNTY, NEW YORK

ENGINEERING REPORT

FOR VOLATILE ORGANICS REMOVAL AT PLANT NO. 1

PROJECT NO. SFWD 03-02B

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DECEMBER 2003
2nd Edition

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HOLZMACHER, McLENDON & MURRELL, P.C.
575 Broad Hollow Road
Melville, New York 11747-5076

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Holzmacher, McLendon & Murrell, P.C. ◣ H2M Associates, Inc.
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December 22, 2003

Board of Commissioners
South Farmingdale Water District
P.O. Box 3319
Farmingdale, New York 11735

Re: South Farmingdale Water District
Engineering Report for Volatile Organics Removal at Plant No. 1
SFWD 03-02B

Gentlemen:

We are pleased to submit our engineering report entitled "*Engineering Report for Volatile Organics Removal at Plant No. 1*", dated December 2003. This report presents an analysis of the treatment alternatives available to treat the raw water from Well Nos. 1-2, 1-3 and 1-4 after they are impacted by the contaminated groundwater plume emanating from the Naval Weapons Industrial Reserve Plant and Northrop Grumman Corporation property located in Bethpage, New York. Previous studies and upgradient monitoring wells have forecasted that this well site would be impacted by the volatile organic compounds (VOCs) contaminated plume in future. Since iron that is naturally present in the underlying aquifers causes fouling and related detrimental impacts on the treatment processes used to remove VOCs, iron removal facilities will also need to be constructed in conjunction with VOC treatment.

This report includes an evaluation and cost analysis to determine the most cost-effective long-term method for iron and VOC removal from Well Nos. 1-2, 1-3 and 1-4. Our preliminary design, preliminary cost opinion and recommendations for the construction of an iron removal treatment system and a volatile organics removal system at Well Nos. 1-2, 1-3 and 1-4 are incorporated in this report.

Upon receipt and incorporation of your comments, copies of the report will be submitted to the Nassau County Department of Health and the New York State Department of Health for their concurrent review and approval.

Should you have any questions or comments, please contact me at your earliest convenience.

Very truly yours,

HOLZMACHER, McLENDON & MURRELL, P.C.

Gary E. Loesch, P.E.
GEL/RWH/mac
Enclosures
cc: Supt. William Bier
Business Manager Leonard J. Constantinopoli

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SOUTH FARMINGDALE WATER DISTRICT

ENGINEERING REPORT FOR VOC REMOVAL AT PLANT NO. 1
SFWD 03-02B

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1.0 INTRODUCTION

1.1 SCOPE AND PURPOSE

This engineering study was initiated at the request of the Board of Commissioners of the South Farmingdale Water District (District) to develop and determine the most viable treatment method for the eventual removal of volatile organic compounds (VOC's) from the raw water produced from supply well Nos. 1-2, 1-3, and 1-4. This report was implemented due to the widespread degradation of the groundwater quality upgradient of Plant No. 1 with respect to the stringent New York State water quality standards for VOC's. Holzmacher, McLendon & Murrell, P.C. (H2M) has been authorized by the Board of Commissioners to evaluate the feasibility of employing air stripping treatment technology for the removal of VOC's which are projected to impact Plant No. 1 in the near future. H2M will also evaluate the use of granular activated carbon (GAC) filtration and conduct cost-effective comparisons to air stripping treatment. This report will summarize and evaluate design parameters for the most suitable wellhead treatment system for Plant No. 1.

1.2 HISTORY

The United States Navy published a Record of Decision (ROD) in January 2003, in consultation with the New York State Department of Environmental Conservation and the New York State Department of Health, in regards to the Naval Weapons Industrial Reserve Plant located in Bethpage, New York. The ROD discussed the United States Navy's findings of a large VOC contaminated groundwater plume, the area affected by the plume, and the plume's potential to affect an even greater area in the near future. Based on the data provided in the ROD, an extensive VOC contamination plume has been found in the Glacial and Magothy formations positioned beneath the Northrop Grumman Corporation property and downgradient (geographically southward). The South Farmingdale Water District Plant No. 1 is located approximately 1.7 miles downgradient of the Northrop Grumman property.

Based on the findings made in previous studies and upgradient monitoring wells indicating VOC's above the New York State drinking water MCL's, the District faces the possible risk of "restricted use" or closing the wells located at Plant No. 1. To satisfy existing and future peak day and fire flow demands, this supply facility must be available for operation. The loss of any of these wells could adversely impact the Water District's ability to meet peak and emergency pumping requirements. This engineering study was prepared to establish the design of the most technically and economically feasible VOC treatment removal system at Plant No. 1. Our technical analysis, conclusions and recommendations are discussed herein.

2.0 EXISTING WATER SUPPLY SYSTEM

2.1 WATER DISTRICT DESCRIPTION

The South Farmingdale Water District presently supplies potable water to an estimated population of 44,700 through 12,675 metered service connections. Geographically, the District water supply service area covers an approximate 5.5 square mile area within the southwestern portion of Nassau County in the Town of Oyster Bay as depicted on Figure 2-1.

Adjacent water purveyors to the District include the Massapequa Water District and New York Water Service Corp. to the south; New York Water Service Corp. to the west; East Farmingdale Water District to the east; and the Incorporated Village of Farmingdale and Bethpage Water District to the north.

2.2 - SYSTEM AND SOURCE OF WATER SUPPLY

The District currently obtains its entire potable water supply from the Magothy formation through eleven (11) wells at six (6) individual plant sites throughout its service area. All eleven (11) supply facilities provide a combined available capacity of 20.12 million gallons per day (MGD). During short term electrical power outages, 13.25 MGD of stand-by well capacity is also available. A summary of each supply well location, authorized capacity and other pertinent data are presented on Table 2-1.

Raw water treatment methods employed by the District include pH adjustment, iron sequestering, corrosion control, and disinfection for all active wells. Sodium hydroxide is currently used for pH adjustment while sodium hypochlorite is employed for disinfection. A long chained phosphate (Aqua Mag) is utilized by the District for iron sequestering purposes at all eleven well sites. Iron removal systems are in place to remove the naturally occurring iron from the raw water at Well Nos. 2-2, 2-3, 5-1, and 6-2.

2.3 - DISTRIBUTION SYSTEM

Potable water is presently transmitted through 124 miles of mains within the District service area. The transmission and distribution piping ranges in size from 6 to 20 inches in diameter. Since a significant portion of the Water District was developed before the availability of cement lined ductile iron pipe, approximately 44 percent of the water mains maintained by the District are unlined cast iron piping. In addition to the 124 miles of piping, the District also maintains approximately 1,250 hydrants within the distribution system.

2.4 - STORAGE AND BOOSTER FACILITIES

The District currently maintains four (4) storage tanks with a total volume of 3.2 million gallons (MG) at four (4) locations in the system. The only elevated storage facility operated by the District is a 1.0 MG steel structure located at the main plant (No. 1). This elevated storage facility is used primarily to maintain and regulate static pressures throughout the service area. In addition, the elevated and ground storage tanks are used to optimize supply well pumpage and to satisfy peak and fire flow demand conditions. All remaining facilities are ground storage structures ranging in individual capacity from 0.6 to 1.0 MG. All three ground storage facilities are of concrete construction.

Booster pumps are used at Plants 2, 3 and 4 to pump water from the ground storage facilities into the distribution system. A total booster pump design capacity of 9,630 gpm (13.87 MGD) is available. A summary of all existing storage facilities is provided on Table 2-2.

2.5 – INTERCONNECTIONS

The Water District maintains seventeen (17) interconnections with five (5) other adjacent water suppliers. All of the interconnections are for emergency use in either direction by agreement with the adjoining water suppliers. The interconnection locations, sizes and adjacent suppliers are listed on Table 2-3.

3.0 PROJECT LOCATION AND EXISTING FACILITIES

3.1 PLANT NO. 1

Plant No. 1 is located at the Langdon Road Plant site and is situated in the northern portion of the District near the northern boundary of its service area. There are three wells at this plant site, Well 1-2 (N4043), 1-3 (N5148), and 1-4 (N7377). Wells Nos. 1-2, 1-3 and 1-4 were constructed in 1953, 1955 and 1963 respectively and screened in the Magothy formation. Well 1-2 was drilled to a terminal depth of 374 feet below grade, Well 1-3 was drilled to a terminal depth of 369 feet below grade, while Well 1-4 was terminated at a depth of 758 feet. Well 1-2 is screened from 317 to 374 feet, Well 1-3 is screened from 298 to 332 feet and 354 to 369 feet, and Well 1-4's screen intervals are from 608 to 628 feet, 643 to 658 feet, 669 to 679 feet and 732 to 758 feet. Well Nos. 1-2 and 1-3 each have an authorized capacity of 1,200 gpm (3.456 MGD), while Well No. 1-4 has an authorized capacity of 1,400 gpm (2.016 MGD), yielding a total design capacity of 5.472 MGD for the plant site.

All three wells are equipped with deep well vertical turbine pumping units which are primarily driven by vertical hollow shaft electric motors. In the event of short term regional power outages or for electric load shedding purposes, Well Nos. 1-3 and 1-4 can be operated by a stand-by natural gas engine. Well 1-2 presently has no stand-by power provisions. Present treatment methods employed at the plant site include pH adjustment, disinfection and iron sequestering. Sodium hydroxide is used for pH adjustment, sodium hypochlorite is employed for disinfection, while Aqua Mag, a long chained linear phosphate compound, is utilized for iron sequestering purposes. All treatment chemicals are injected in liquid form prior to the potable water entering the distribution system.

3.2 – PLANT NO. 1 PUMPAGE

The District maintains three wells at Plant No. 1, Well Nos. 1-2, 1-3 and 1-4. As tabulated on Table 3-1, the three supply wells at this plant site have pumped an average of 120.2 million gallons (MG) per year during the period of 1999 through 2002. In 2002, the combined production of Wells 1-2, 1-3, and 1-4 accounted for approximately 17 percent of the total annual District supply well pumpage. It should be noted that in 1999, which was a major pumping season, Plant No. 1 wells accounted for 32 percent of the total annual District supply well pumpage.

Based on the annual production of Wells 1-2, 1-3 and 1-4 and their strategic location within the District, these wells are critical for satisfying peak and fire flow demand conditions as well as meeting average day demand conditions. It should be noted that along with investigating a wellhead treatment system at Plant No. 1, this report will also review the possible need for iron removal prior to wellhead treatment, because iron has the propensity to precipitate, and therefore could foul the VOC removal media, rendering it costly to periodically inspect and replace the filter media when fouling takes place.

4.0 GROUNDWATER QUALITY

4.1 OVERVIEW

Historically, the general water quality found on Long Island has been exceptionally good. Through the 1970s and to the present, water quality has significantly deteriorated in a number of areas throughout Nassau and Suffolk Counties. This is primarily due to large increases in industrial chemical usage, lack of sewers in industrial and densely populated areas, the continued application of fertilizer and the application of increasing amounts of pesticides and herbicides.

Within the past 20 years, there has been a dramatic increase in the ability to test for even more minute concentrations of pollutants. During the 1940s through the 1970s, water quality issues on Long Island were related to parameters such as pH, iron, dissolved solids, chlorides, nitrate nitrogen, and bacteria. With the advent of new and improved technology, the detection of organic compounds has been incorporated into today's drinking water standards.

The June 1987 implementation of the 1986 Safe Drinking Water Act Amendments has brought water quality standards concerning organic compounds to a new level for water management planning. The NYSDOH has established maximum contaminant levels (MCLs) for organic compounds as follows:

CONTAMINANT	MCL
Principal Organic Compounds	<5 μg/L
Unspecified Organic Compounds	<50 μg/L

As summarized on Table 4-1, the United States Environmental Protection Agency (USEPA) regulations under the 1986 Amendments resulted in the lowering of MCLs for eight volatile organic compounds. The NYSDOH has established more rigorous requirements with MCLs of 5 μg/L for 45 other compounds also depicted on Table 4-1. The MCLs became enforceable by the NYSDOH as of January 9, 1989. If a well is used which does not meet these standards, the water supplier must notify the public of this fact. The NYSDOH requires that quarterly monitoring must be maintained when prior sampling has shown the presence of volatile organics or the source is considered potentially at risk.

In addition to the compounds listed in Table 4-1, regulations related to synthetic organic chemicals (SOCs) were published by the USEPA in January of 1991. These regulations include MCLs for 43 SOCs (see Table 4-2). Testing conducted from 2000 to 2003 has not yielded any detectable concentrations of the compounds listed on Table 4-2 in any of the District operated supply wells.

In addition to the water quality standards previously described, the District must test for and comply with primary and secondary standards for inorganic chemicals as established during March 1992 in Part 5 of the New York State Sanitary Code. These standards are summarized on Table 4-3. The standards for secondary contaminants were established to address aesthetic water quality concerns such as taste and odor and discolored or rusty water. The secondary contaminants listed on Table 4-3 do not pose a health risk to humans. The primary contaminants are based on public health concerns.

The more stringent VOC MCL's will significantly impact the typical water suppliers' planning procedures. In the past, a supplier usually had sufficient time to implement the construction of a treatment system between the time a contaminant was first detected until it exceeded the acceptable maximum level. In the past MCL's for volatile organic contaminants were set at 50 μg/L for any one VOC and 100 μg/L for the sum of all VOC's present. Under the current MCL's, a supplier will have little or no time to provide treatment after a contaminant is detected. Therefore, with the current MCL's all suppliers must plan for treatment once trace levels of a compound are detected to protect against the possibility that a well or wells may have to be taken out of service due to VOC contamination.

Deteriorating water quality as a result of VOC contamination is a trend that has impacted many Long Island water suppliers. The potential for the future loss of supply wells due to increasing organic compounds is a realistic threat. At which time or location contamination will occur is uncertain without performing extensive hydrogeologic investigations. These investigations are rather costly and would involve the drilling of several monitoring wells at strategic locations. This type of investigation can be used to precisely map the extent of VOC contamination and identify the source of contamination. Generally, sources of VOC contamination will occur hydraulically downgradient from industrial and/or commercially developed areas. Fortunately for the Water District, extensive monitoring wells and hydrogeologic data is available to assist in mapping and identifying the extent and source of VOC contamination. Analysis and further discussion of this data and update of critical statistics are provided in subsections 4.2 and 4.3 of this report.

4.2 SERVICE AREA WATER QUALITY

Dissolved iron is a naturally occurring element found in the aquifers of the South Shore of Long Island. Consequently, the water pumped from the underlying aquifers in many locations, such as the South Farmingdale area, does contain iron. The New York State drinking water standard for iron (0.3 mg/L) is a secondary standard based on the aesthetic quality or appearance of the water. Since iron concentrations above 0.3 mg/L may generate rusty water, but are not a health concern, the Nassau County Health Department does allow the addition of sequestering agents.

Article VI of the Nassau County Public Health Ordinance allows the use of polyphosphate treatment where raw water combined concentrations of iron and manganese are 1.0 mg/L or less and allows the use of sodium silicates where raw water combined concentrations of iron and manganese are 1.5 mg/L or less (manganese is extremely low and well below the standard in the South Farmingdale Water District wells). This regulation leaves the water purveyor with the choice of constructing an iron removal treatment system or to have the supply well restricted for use. Pursuant to Health Department approval, the South Farmingdale Water

District does add polyphosphates to sequester the iron, in an attempt to reduce rusty water appearance.

The South Farmingdale Water District obtains its entire water supply from the Magothy aquifer from eleven wells at six plant sites. The iron concentration varied considerably from well site to well site during 2002. An examination of water quality data from 2002 indicates that the iron concentrations in the District's supply wells ranged from 0.5 to 2.9 mg/L. The iron concentration in Well No. 1-2 had an average of 0.5 mg/L, and a maximum result of 0.9 mg/L. The iron concentration in Well No. 1-3 had an average of 0.5 mg/L, and a maximum result of 0.7 mg/L. The iron concentration in Well No. 1-4 had an average of 1.0 mg/L, and a maximum result of 1.6 mg/L. It must be noted that the iron levels at Well No. 1-4 are measured after an extensive blow-off period due to the high turbidity of the raw water upon start-up of the well. The District must blow-off for approximately 2 hours to clear up the discoloration.

The District, as indicated above, adds sequestering agents at all of its wells in an attempt to keep the iron that is present in solution. The sequestering agent utilized by the District is a stabilized blend of long chain phosphates. These agents also provide a protective coating on the piping within the distribution system and serve as a corrosion control inhibitor. This is particularly important in those segments of the distribution system where unlined iron pipe was utilized prior to the availability of cement lined pipe. Additionally, the District has historically addressed the iron concentration in its raw water through a combination of removal, treatment and operational procedures.

In addition to iron, as discussed above, the untreated water from supply wells located within the Water District can be generally characterized as:

1. Very corrosive with a low pH generally in the range of 3.5 to 5.2. The water can be expected to be aggressive and will generally cause undesirable amounts of corrosion to ferrous iron and copper piping, resulting in red and green water complaints if not

properly treated. The District presently utilizes sodium hydroxide (caustic) for pH adjustment at all supply well facilities, with a resulting target pH of 7.5 to 7.8.

2. Low in carbonate and non-carbonate hardness, which generally ranges from 1 to 15 mg/L. This characterizes the water as soft, making it excellent for laundering and most similar purposes, but also more corrosive or active toward piping and plumbing.

3. Low to moderate in total dissolved solids, generally between 22 and 149 mg/L.

4. Low to moderate in chloride, ranging between 2.1 and 42.3 mg/L. These levels are typical for the Magothy aquifer.

5. Contains very low levels of dissolved manganese which ranges in concentration from below detection limits to 0.12 mg/L. The aesthetic secondary standard for this parameter is established at 0.3 mg/L. The oxidation of high levels of manganese can results in "black" water consumer complaints.

Inorganic water quality from the District's wells is considered to be good with the exception of iron at Wells 1-2, 1-3, 1-4, 2-2, 2-3, 3-1, 5-1 and 6-2. Wells 2-2, 2-3, 5-1, and 6-2 are filtered for iron prior to being introduced into the water distribution system.

4.3 SITE SPECIFIC WATER QUALITY

Plant No. 1, which is the site of Well Nos. 1-2, 1-3 and 1-4, is situated approximately 1.7 miles southeast of the Northrop Grumman property and 1.1 miles northeast of the District's Plant No. 3. All wells at Plant No. 1 are screened into the Magothy formation, with Well No. 1-2 at a terminal depth 374 feet below grade, Well No. 1-3 at a terminal depth 369 feet below grade, and Well No. 1-4 at a terminal depth 758 feet below grade. The wells have been free from VOC contamination since their installations, ranging from 1953 to 1963. Although Well Nos. 1-2, 1-3 and 1-4 are presently free from VOC contamination, the water quality recorded in upgradient

Vertical Profile Borings (VPB), monitoring wells, and supply wells indicates that a plume emanating from the Northrop Grumman property is moving in a south/southeast direction toward Plant No. 1.

Over the past ten to fifteen years, H2M has prepared several wellhead treatment reports for neighboring Water Districts. These reports were written specifically to investigate the existence of extensive VOC contamination of the groundwater in areas surrounding the Northrop Grumman Corporation property. Along with these previous reports, several recent reports have been generated by Arcadis Geraghty & Miller (Arcadis), a consultant working for the United States Navy, to address the VOC issues of the Northrop Grumman site located in Bethpage, New York.

The most recent data indicates extensive VOC contamination is present both in the Glacial and the shallow and deep regions of the Magothy formations upgradient of Plant No. 1. As summarized on Table 4-4, the most prevalent compounds found in the monitoring wells, supply wells, and VPBs located upgradient of Plant No. 1 included Trichloroethene (TCE), Tetrachloroethene (PCE), 1,1,1-Trichloroethane (1,1,1-TCA), 1,1-Dichloroethene (1,1-DCE), 1,1-Dichloroethane (1,1-DCA), cis-1,2-Dichloroethene (CIS-1,2-DCE) and Chloroform. Trichloroethene was the most prevalent compound found in the wells and VPBs located upgradient of Plant No. 1. This historical sampling data indicates a large VOC plume traveling downgradient from the Northrop Grumman property toward Plant No. 1. The Arcadis report dated April 28, 2003 and titled "*Comprehensive Model Report for the U.S. Naval Weapons Industrial Reserve Plant, Northrop Grumman*", has projected that South Farmingdale Plant No. 1 will be impacted by this VOC plume in the near future.

The United States Navy has installed VPBs to gather groundwater quality and lithologic data in areas hydraulically downgradient from the Northrop Grumman property. The data will be used in the groundwater computer model prepared by Arcadis to aid in the placement of outpost monitoring wells. The VPBs were constructed in accordance with the Public Water Supply Protection Program, which was set forth by the New York State Department of Environmental

Conservation (NYSDEC) in their Groundwater Record of Decision (ROD) for the Naval Weapons Industrial Reserve Plant (NWIRP). The NWIRP site is located on the Northrop Grumman property.

In 2001, sampling conducted during the development of VPB-43 yielded maximum VOC levels exceeding the 5 μg/L MCL, including 8 μg/L of TCE. This boring is approximately 0.3 miles northwest of Plant No. 1, and 1.4 miles southeast of the Northrop Grumman property. The samples taken at VPB-43 also yielded trace amounts of 1,1,1-TCA, 1,1-DCA, and 1,1-DCE.

A second boring, VPB-47, is also located upgradient of Plant No. 1 in the path of the VOC plume. VPB-47 is approximately 0.9 miles northwest of Plant No. 1 and 0.8 miles southeast of the Northrop Grumman property. Sampling conducted in 2001 during this boring yielded a maximum TCE level of 770 μg/L. Results for 1,1-DCA, 1,1-DCE, CIS-1,2-DCE and PCE exceeded their MCL, with levels of 8 μg/L, 9 μg/L, 460 μg/L, and 110 μg/L respectively. Furthermore, trace amounts of 1,1,1-TCA were discovered during the boring.

A third boring, VPB-77, was bored in 2000, at a location upgradient of Plant No. 1 in the path of the VOC plume. VPB-77 is approximately 0.6 miles northwest of Plant No. 1 and 1.1 miles southeast of the Northrop Grumman property. Sampling conducted during this boring yielded a maximum TCE level of 25 μg/L. Results for 1,1,1-TCA, 1,1-DCE and PCE also exceeded their MCL, with levels of 17 μg/L, 8 μg/L and 100 μg/L respectively. Trace amounts of 1,1-DCA were also discovered during the boring.

A fourth boring, VPB-51, is also located upgradient of Plant No. 1 in the path of the VOC plume. VPB-51 is approximately 1.1 miles northwest of Plant No. 1 and 0.7 miles southeast of the Northrop Grumman property. Sampling conducted during this boring yielded a maximum TCE level of 830 μg/L. Results for 1,1,1-TCA, 1,1-DCE, CIS-1,2-DCE and PCE also exceeded their MCL, with levels of 110 μg/L, 10 μg/L, 1,100 μg/L, and 910 μg/L respectively. Furthermore, trace amounts of 1,1-DCA were discovered during the boring.

Bethpage Water District's Well Nos. 4-1 and 4-2 have been adversely impacted by VOC-contaminated groundwater emanating from the Northrop Grumman property. These wells have a terminal depth of approximately 608 and 611 feet respectively, and they are located 1.1 miles northwest of South Farmingdale Water District's Plant No. 1 and 0.6 miles southeast of the Northrop Grumman property. Samples collected from these wells between 2000 and 2003 have shown an increase in TCE levels from 2.2 μg/L to 7.7 μg/L. Additionally, these wells have been impacted by trace amounts of PCE, 1,1-DCA, and Chloroform.

Northrop Grumman monitoring wells GM-38D and GM-38D2 are located further upgradient, 1.1 miles northeast of Plant No. 1 and 0.6 miles southeast of the Northrop Grumman property. These monitoring wells were installed for the purpose of defining a "hot spot" of contamination and investigating the need for mass contaminant removal through groundwater extraction and treatment according to the Groundwater Remedial Program set up by the NYSDEC's Groundwater ROD. GM-38D penetrates deep into the Magothy layer at approximately 490 feet, while GM-38D2 is approximately 350 feet deep. Samples taken at GM-38D in 2001 show evidence of all the VOCs mentioned above, with MCL exceedances including results of 900 μg/L of TCE, 5.2 μg/L of 1,1,1-TCA, and 6.6 μg/L of 1,1-DCE. Quarterly samples taken at GM-38D from 1st Quarter 2002 to 2nd Quarter 2003 yield TCE results ranging from 314 μg/L to 1,000 μg/L. GM-38D2 had similarly high levels of TCE, ranging from 339 μg/L to 1,460 μg/L over the same time period. Also, GM-38D2 had an MCL exceedance during 2001 of 11.6 μg/L of CIS-1,2-DCE, as well as trace amounts of chloroform, 1,1,1-TCE, and 1,1-DCE.

The shallowest monitoring well investigated for this analysis was GM-36D, which has a terminal depth of 235 feet below grade. GM-36D is located 1.3 miles northeast of Plant No. 1 and 0.4 miles southeast of the Northrop Grumman property. Sampling conducted since 2000 has yielded TCE levels ranging from 10.8 μg/L to 45 μg/L. Trace amounts of PCE were evident up until the 3rd Quarter 2002 sampling period.

4.4 DESIGN CONSIDERATIONS

4.4.1 IRON REMOVAL SYSTEM DESIGN CONSIDERATIONS

As previously indicated, the wells at Plant No. 1 have yielded iron levels at elevated concentrations. A summary of supply well iron levels for Well Nos. 1-2, 1-3 and 1-4 are provided on Table 4-5.

Iron is a very common element found in the crust of the earth. This element is found in most water supply sources since iron is common in most igneous rocks and generally found in trace amounts in sediment and sedimentary rocks. Iron concentrations in natural waters can generally range from 0 to 10 mg/L. Iron concentrations above 0.3 mg/L will have an aesthetic impact on the color of the water. Iron in low pH and oxygen groundwater generally exists in the dissolved ferrous state. When oxidized, the dissolved iron becomes unstable and will rapidly precipitate by converting to the semisolid ferric state. The ferric ions after oxidation precipitate as ferric oxide or oxyhydroxides which coat surrounding surfaces. Under anaerobic conditions, high iron waters can promote the growth of iron bacteria. Crenothrix is the most common form of this type of bacteria. Under ideal growth conditions, iron bacteria can clog well screens, filter media and piping.

The District currently utilizes chemical treatment in the form of sequestering agents to keep the dissolved iron in solution at Well Nos. 1-2, 1-3 and 1-4. However, due to the known potential for iron to oxidize as part of a VOC treatment system, its impact must be strongly considered.

Precipitated iron and iron bacteria has the potential to clog the proposed VOC treatment system. Therefore, treatment for iron removal is recommended to be installed as the first step in the VOC treatment system. The average iron concentration at Well Nos. 1-2 and 1-3 over the last year have been approximately 0.5 mg/L, and the average iron concentration at Well No. 1-4 over the last year has been approximately 1.0 mg/L. Historic trends in other District supply wells has shown the potential for significant increases in iron concentration over time, with the highest iron concentrations found in Well No. 2-1 at 2.9 mg/L. This well was recently abandoned and replaced with another well at Plant No. 2. With the potential for similar increases at Well Nos. 1-2, 1-3 and 1-4, a maximum iron influent concentration of 3.0 mg/L will be utilized for design purposes. The treatment system will be designed to provide effluent iron levels of less than 0.10 mg/L. This provides for a treatment effluent goal of one third the 0.30 mg/L secondary standard for iron.

4.4.2 VOC TREATMENT SYSTEM DESIGN CONSIDERATIONS

Arcadis developed the Northrop Grumman Corporation Regional Groundwater Model in order to predict the flow path and assumed concentrations of the VOC plume eminating from the Northrop Grumman site. Based on assumptions made by Arcadis, this model predicted a time-to-detection of VOC's at South Farmingdale Well No. 1-2 of eleven (11) years, and a predicted total VOC impact of 5 μg/L. However, during the boring of the VPBs upgradient of Plant No. 1 (the data for which was not included in the Arcadis model), TCE levels were as high as 770 μg/L (as recorded at VPB-47). At depths comparable to the depths of the wells at Plant No. 1, TCE levels ranging from 180 μg/L to 280 μg/L were recorded at VPB-47. Considering that VPB-47 is a distance of 0.9 mi. hydraulically upgradient of Plant No. 1, and the sample was collected from a concentrated source, we do not expect Plant No. 1 to be impacted with contamination at concentrations of 770 μg/L TCE. However, even after evaluating the dilution affects of the aquifer, we expect the plant to be impacted by levels significantly higher than the 5 μg/L predicted in the model. Following our evaluation of the data, we have concluded that the expected TCE concentration level would be more in the range of 200 μg/L. In order to provide the District with a factor of safety due to the unknown potential of the impact, our recommended design level for treatment for VOC removal at Well Nos. 1-2, 1-3 and 1-4 will be 400 μg/L TCE.

5.0 WELL HEAD TREATMENT

5.1 TREATMENT ALTERNATIVES

The suitability of a groundwater treatment system for a particular site is based on two (2) distinct criteria: (1) the type and concentrations of contaminants in the raw water; and (2) the type and concentrations of contaminants that can safely be allowed in the treated water (drinking water standards). Selection among the technically feasible treatment systems will be based upon the results of an analysis of each system. Two (2) different treatment processes will be evaluated for the project site. The two (2) types of treatment which are most commonly employed for removal of organic contaminants from groundwater are air stripping and granular activated carbon (GAC) filtration. Resin adsorption systems will not be economically competitive for the contaminants under consideration and will not be considered in this study.

5.2 BASIS OF DESIGN

In order to accurately size any treatment system, the range of expected influent flows and contaminant concentrations must be known. In this case, the water to be treated will originate from three (3) wells with a total capacity of 3,800 GPM.

The report will address the anticipated contaminant levels to impact Plant No. 1. We anticipate that the concentrations of the influents at Plant No. 1 will be in the range of the recorded VOC levels sampled from VPB-47, including evaluations of the impact of dilution in the contaminant concentrations and provisions of safety factors for the treatment system design. Table 5-1 shows the expected maximum contaminant design levels for each contaminant..

The clay layers identified in the log of Well Nos. 1-2, 1-3 and 1-4 could possibly minimize the migration of highly concentrated plumes to the deeper sections of the Magothy aquifer. However, these clay layers are likely not continuous between Plant No. 1 and the upgradient source areas. It is anticipated that contaminants will migrate to the screened area of the well but will undergo dilution in the process.

The design influent is conservative but is justified based on several considerations:

1. The incremental operating and capital costs for an air stripping facility between the 400 μg/L TCE level and any defensible lower level will be insignificant. In comparison, the operating costs of a GAC filtration system increase tremendously with increasing influent levels, particularly for those contaminants that do not adsorb very easily.

2. The higher capacity treatment system will result in non-detectable effluent concentrations for most volatile organic compounds in the foreseeable future.

3. The higher influent design limit will avoid the necessity of extensive additional monitoring should observed contaminant levels increase. If levels begin to approach the design limits, then adequate time should remain to extend the air stripping tower in an orderly manner. Preventing breakthrough of a GAC filter under such circumstances cannot be reliably accomplished.

The selection of the design effluent level should be based on meeting drinking water standards of 5 μg/L as set by the State of New York. As a practical matter, the treatment system should be sized for a design effluent of 1 μg/L or less in accordance with the recommendations of the Nassau County Department of Health and the policy of the South Farmingdale Water District relative to "no detectable" VOC contamination in the treated water supply.

5.3 AIR STRIPPING TOWER

"Air stripping" as a water treatment process is implemented by pumping untreated water to the top of a tower which contains a particular height of inert "packing" material along with water distribution and collection systems. The tower has ambient air blowing up from the bottom of the tower as the water flows downward, hence the more proper name of "counter current packed tower".

Counter current packed towers have been utilized in the chemical process industry for decades as a standard unit operation to affect mass transfer, both in adsorption and desorption (stripping). For that reason, the physical chemistry and mass kinetics are well understood and documented. Essentially, the packed tower is a chemical engineering process unit which promotes intimate contact between a gas phase and a liquid phase so as to enhance the establishment of equilibrium between the phases. In adsorption, mass transfer occurs from the gas phase to the liquid phase, while in desorption (stripping), mass transfer is a function of the divergence from equilibrium. Once equilibrium is reached, mass transfer will no longer occur.

In the case of air stripping to remove volatiles, the solutes are the individual organics contained in water (liquid phase), which are desired to transfer to air (gas phase). From the foregoing discussion, the organic constituents in water must be at concentrations which exceed the equilibrium concentration in order to be removed. In order to understand the vapor-liquid equilibrium, some basic principles of physical chemistry must be outlined. The relationships can most clearly be presented starting with a principle of physical chemistry which is always valid, whether or not the gas behaves as an ideal gas. This relationship can be defined by the following equation:

1. $\overline{\rho}_A = \overline{\gamma}_A \rho$

Where, $\overline{\rho}_A$ *is the partial pressure of component A in the gas phase*

$\overline{\gamma}_A$ *is the mole fraction of component A in the gas phase*

ρ *is the total pressure*

In order to determine the partial pressure of a constituent in a solution, Raoult's law can be utilized, as follows:

2. $\overline{\rho}_{A} = \sim \chi_{A} Pa$

Where, $\sim \chi_{A}$ *is the mole fraction of component A in the liquid phase*

P*a is the vapor pressure of component A at the appropriate temperature.*

Raoult's law, however, only applies when both the liquid and gas behave as ideal solutions and gases, respectively. Experiment and experience has revealed that Raoult's law has shown applicability only when working with high concentrations. Fortunately, a more general form of Raoult's law is available and is known as Henry's law:

3. $\overline{P}a = \sim \chi_{A} H_{A}$

Where, H_{A} *is a constant (Henry's Constant) and is found experimentally for each particular contaminant. Henry's Constant can vary significantly with temperature.*

Henry's law has been seen to work well at low concentrations and provides for a linear relationship between partial pressure and concentration. By combining equations (1) and (3), an equilibrium relationship is developed for a component A in the vapor and liquid phases:

4. $\tilde{}\gamma_{A} = \overline{^{x}}_{A} H_{A} / \rho$

From the above equation, it can be seen that the greater the magnitude of the Henry's Constant, the higher $\tilde{}\gamma_{A}$ becomes and, therefore, the equilibrium mole fraction of a component

A increases in the gas phase. For any given compound in water, a higher Henry's Constant will mean that the compound would be more easily removed from water by stripping.

In the case of the specific problem at hand, namely moderate to low concentrations of volatile halogenated organics in water which are to be removed, the situation is certainly one in which Henry's law has been proven to be applicable. For design purposes, a water temperature of 10 degrees C is assumed. There is little or no effect of air temperature on the performance of air stripping towers. Values of Henry's Constant (atm-m^3-water/m^3-air) are available for selected compounds in the literature.

Compound	Henry's Constant (10°C)
Trichloroethene (TCE)	0.2315
1,1,1-TCA	0.1500
1,1-DCA	0.1584
Tetrachloroethene (PCE)	0.3640
cis-1,2-Dichloroethene	0.1162

The liquid phase resistance is the limiting factor in the transfer of the volatile organics from the liquid (water) to the gas (air). In general, the higher the value of the Henry's Constant for a particular contaminant, the easier it will be to remove by air stripping.

The removal efficiency of a particular size air stripping tower for a given contaminant is dependent upon the overall transfer coefficient, usually denoted as $K_L * a$, where K_L is the overall liquid film coefficient, and a is the specific surface of the packing media, expressed as wetted surface area per tower volume. The overall transfer coefficient can be determined empirically through the results of a pilot study.

Performance of a pilot study in this case in not necessary as the behavior of the proposed hollow spherical shaped packing material, 2-inch Tripacks, for these contaminants has been well proven during pilot studies performed by H2M and the manufacturer of the packing. For purposes of design, use of published values of Henry's Constant together with a conservative overall transfer coefficient value have proven successful. Transfer coefficients utilized in the design which are based on an air to water ratio of 30:1 are as follows:

Compound	**K_L * a (hour)$^{-1}$**
TCE	46.9
1,1,1-TCA	45
1,1-DCA	45
PCE	78
cis-1,2-DCE	45

The use of a packing media such as Tripacks, suitable for use with low air to water ratios, is recommended in an installation such as the one being discussed. For purposes of design, air to water ratios of 25:1 to 45:1 are typical with Tripacks, while high throughput media will usually operate at air to water ratios of 75:1 and higher. The maximum air to water ratio as allowed under the Recommended Standards for Water Works is 80:1. The expected savings in operational cost arising from reduced air flow rates for continuous operation over a period of years can be significant.

The design of an appropriate air stripping tower is based upon selection of reasonable overall transfer coefficients, liquid loading rates and packing height matched to the design conditions. Conventional practice in sizing the packing height for a tower of known cross section is based upon determining the height of a transfer unit (HTU) and then the number of transfer units (NTU) required to achieve the desired removal.

The derivation of the mass balance equation can be found in the literature. The formulation results are shown in the following equation for determining the packing height of the tower:

$$Z = \frac{Q}{(1-A)(K_La)} \text{ x } Ln(A+[(1-A)\ \frac{C_i}{C_e}]) = \text{(HTU) x (NTU)}$$

Where, Q = *Tower loading rate (ft/hr)*

A = *Absorption factor (dimensionless)*= $[(H)(R)]^{-1}$

K_La =*Overall transfer coefficient* $(hour)^{-1}$

$$NTU = \frac{1}{1-A} x\ Ln\ (A+[(1-A)\frac{Ci}{Ce}])$$

$HTU = Q/K_La$ *(ft)*

Z = *packing height of the tower*

C_i = *Influent concentration of the contaminant compound*

C_e = *Effluent concentration of the contaminant compound*

H = *Henry's Constant*

R = *Air to Water ratio*

The tower loading rate (Q) is based upon the well flow (L) in GPM, the diameter of the tower in feet, the area of the tower (D) in square feet and is calculated as follows:

$$Q = \frac{L}{D}$$

The absorption factor (A) is based upon the air to water ratio (R), which is dimensionless, and Henry's Constant (H), also dimensionless, for the contaminant compound to be absorbed.

Based on the contaminant concentrations outlined in Table 5-1, calculations were preformed using the respective transfer coefficients and Henry's constants for each contaminant. We also ran calculations of air-to-water ratios of 30:1, 45:1 and 60:1. TCE at 400 μg/L and cis-1,2-DCE at 200 μg/L are the dictating contaminants as each relates to air stripper design. Also, an air-to-water ratio of 45:1 proved to be most effective in balancing costs of operation and treatment efficiency.

Accordingly, the calculations performed include a TCE design influent concentration of 400 µg/ℓ and a cis-1,2-DCE design influent concentration of 200 µg/L. These influent concentrations, which provide the South Farmingdale Water District with a factor of safety, will be used for the basis of design and evaluation.

In addition, with the sensitivity of the surrounding residential neighborhoods in mind, the calculations will be performed utilizing towers with the largest reasonable diameter as it relates to liquid loading rates. The design concept for the air stripping towers will be as follows:

- For the single well flow of 1,200 GPM from Well 1-2, one 10 ft. diameter tower will be used.

- For the dual well flow of 2,600 GPM from Wells 1-3 and 1-4, two 10 ft. diameter towers will be used in a lead/lag operational sequence. Well 1-4 has the higher flow capacity of the wells, at 1,400 GPM, therefore both the lead and lag towers will be designed to treat a flow rate of 1,400 GPM. This will allow either of the lead/lag towers to treat either one of the wells, with the second tower on stand-by should the other well turn on.

For purposes of this report the following design parameters will be utilized.

$R = 45$
C_i = from Table 5-1
$C_e = 1$ µg/L
H = from page 5-5
K_La = from page 5-6

For three (3) air stripping towers, each with a diameter of 10 feet and treatment for 400 µg/L TCE, the height of the tower packing for each air stripping tower is determined as follows:

Design Parameters:

Air Stripping Tower No.1 *(for Well No. 1-2)*

$C_i = 400\ \mu g/L$

$H = 0.2315$

$K_La = 46.9/hour$

$L = 1{,}200\ GPM$

$$D = \pi\ x\ \frac{10^2}{4} = 78.54\ sf$$

$$Q = \frac{1{,}200 GPM}{78.54\ ft^2}\ x\ 60 \frac{\min.}{hr.}\ x\ 0.1337 \frac{cf}{gal} = 122.57\ ft/hr$$

$$R = \frac{7{,}218}{1{,}200}\ x\ 7.481 = 45$$

$$A = [(H)(R)]^{-1} = [0.2315\ x\ 45]^{-1} = 0.096$$

$$Z = \frac{122.57\ \ ft/hr}{(1-0.096)\ (\frac{46.9}{hr})} \quad Ln\ (0.096 + [(1-0.096)\ \frac{400\ \mu g/L}{1\ \mu g/L}])$$

Z = 17.03 ft. say 17 ft.

Air Stripping Tower No.2 *(lead tower for Well Nos. 1-3 and 1-4)*

$C_i = 400\ \mu g/L$

$H = 0.2315$

$K_La = 46.9/hour$

$L = 1{,}400\ GPM$

$$D = \pi\ x\ \frac{10^2}{4} = 78.54\ sf$$

$$Q = \frac{1{,}400 GPM}{78.54\ ft^2}\ x\ 60 \frac{\min.}{hr.}\ x\ 0.1337 \frac{cf}{gal} = 142.99\ ft/hr$$

$$R = \frac{8{,}421}{1{,}400}\ x\ 7.481 = 45$$

$$A = [(H)(R)]^{-1} = [0.2314\ x\ 45]^{-1} = 0.096$$

$$Z = \frac{142.99\,ft/hr}{(1-0.096)\,(\frac{46.9}{hr})} \quad Ln\,(0.096 + [(1-0.096)\,\frac{400\,\mu g/L}{1\,\mu g/L}])$$

Z = 19.9 ft. say 20 ft.

***Air Stripping Tower No.3** (lag tower for Well Nos. 1-3 and 1-4)*

$C_i = 400\ \mu g/L$

$H = 0.2315$

$K_La = 46.9/hour$

L = 1,400 GPM

$$D = \pi\ x\ \frac{10^2}{4} = 78.54\ sf$$

$$Q = \frac{1{,}400GPM}{78.54\,ft^2}\ x\ 60\frac{min.}{hr.}\ x\ 0.1337\frac{cf}{gal} = 142.99\,ft/hr$$

$$R = \frac{8{,}412}{1{,}400}\ x\ 7.481 = 45$$

$$A = [(H)(R)]^{-1} = [0.2314\ x\ 45]^{-1} = 0.096$$

$$Z = \frac{142.99\,ft/hr}{(1-0.096)\,(\frac{46.9}{hr})} \quad Ln\,(0.096 + [(1-0.096)\,\frac{400\,\mu g/L}{1\,\mu g/L}])$$

Z = 19.9 ft. say 20 ft.

A summary of similar calculations for the other contaminant compounds is shown in Table 5-2. A summary of all of the air stripping design parameters is shown in Tables 5-3A, 5-3B, and 5-3C.

Based upon the results shown in Table 5-2, the TCE loading will govern the tower design. In order to anticipate any possible maximum loadings, the towers will be sized to treat TCE at 400 µg/L. Air Stripper No. 1 for Well No. 1-2 will be 10 feet in diameter and have a packing height of 17 feet, and Air Stripper Nos. 2 and 3, the lead and lag towers for Well Nos. 1-3 and 1-4, will be 10 feet in diameter and have a packing height of 20 feet.

The exhausted air emissions from the towers, which are negligible, are exempt from NYSDEC emissions standards.

5.4 GAC FILTRATION

GAC filtration units have distinctly different operational and cost features as compared to air stripping units. As a generalization, GAC units have lower capital costs and are quicker to construct. However, the operating costs of GAC rise rapidly with increasing contaminant levels while those for an air stripping tower remain relatively constant independent of the contaminant loading.

The operational reliability of GAC units is much lower than for air stripping units. This arises from the great difficulty of operating GAC units during freezing weather unless they are enclosed. More importantly, unpredictable variations in influent VOC concentrations will require impractical sampling frequencies in order to prevent breakthrough of the GAC filter bed.

The adsorption capacity of activated carbon for organic contaminants can be estimated from an adsorption isotherm, which relates the concentration of a contaminant in water to that which is adsorbed by the GAC. This is derived by fitting the results of multiple batch equilibrium isotherm tests to the Freundlich equation to obtain values of empirical coefficients that characterize the properties of the carbon used and the contaminant adsorbed.

Carbon adsorption isotherms are available for many common groundwater contaminants. An isotherm for TCE is presented in Figure 5-1. Isotherms for the other compounds encountered are contained in Figures 5-2, 5-3, 5-4, and 5-5 for 1,1,1-Trichloroethane, 1,1-Dichloroethane, Tetrachloroethene, and cis-1,2-Dichloroethene respectively. These isotherms were developed from laboratory measurements which utilized "Filtrasorb 300" carbon by Calgon Carbon Company.

The Freundlich equation can be expressed as:

$$\frac{C_o - C_f}{M} = K\,(C_f)^{1/n}$$

Where, C_o *is the contaminant concentration of the influent (mg/L)*
C_f *is the contaminant concentration of the effluent (mg/L)*
M is the total weight of carbon
K and $^{1/n}$ *are empirical constants unique to the contaminant and carbon*

The ultimate capacity of the carbon can be estimated by defining carbon as reaching saturation when the contaminant influent concentration equals the effluent concentration. Choosing the point on the isotherm where $C_f = C_o$ will yield a value of carbon adsorption capacity $(C_o - C_f)/M$ at the contaminant concentrations.

Based on the adsorption isotherm and the contaminant levels previously discussed for each contaminant, 1,1-DCA and cis-1,2-DCE become the dictating contaminants when evaluating the GAC removal system. 1,1-DCA will be used for evaluation of the GAC treatment system.

For water treated at the design contaminant level of 20 µg/L for 1,1-DCA applied to the isotherm in Figure 5-3, results in adsorptive capacity of 1.2 milligrams (mg) contaminant adsorbed per gram of carbon. This information can be converted to more meaningful units as follows:

$$\frac{(20\ micrograms)}{liter} \div \frac{(1{,}000\ micrograms)}{milligram} \div \frac{(1.2\ milligrams)}{gram\ carbon} \div \frac{(453.59\ grams)}{pound} \times \frac{(3{,}785{,}000\ liter)}{million\ gallons} = 139\ pounds$$

of carbon consumed per million gallons of water treated.

In similar manner, carbon consumption for the other compounds can be calculated. The results are as follows:

Compound	Influent Level	Freundlich Adsorptivity	Carbon Consumption Per Million Gallons of Treated Water
TCE	400 μg/L	49 mg/gm	68 lbs
1,1,1-TCA	20 μg/L	2.8 mg/gm	60 lbs
1,1-DCA	20 μg/L	1.2 mg/gm	139 lbs
PCE	100 μg/L	60 mg/gm	14 lbs
Cis-1,2-DCE	200 μg/L	12 mg/gm	139 lbs

At the expected contaminant concentrations, the adsorption of different compounds can be approximated as being independent of the other contaminants present. In this case, the design contaminant loading due to 1,1-DCA is the governing factor in determining the ultimate adsorption capacity of the activated carbon, but may not remain so.

Changes in the contaminant concentration found in the well will alter the consumption rate of activated carbon. The isotherms in Figures 5-1 through 5-5 can be utilized to estimate the adsorptive capacity of the carbon at potential future contaminant levels. The impact of increasing contaminant levels on the consumption of carbon would yield increased carbon costs per gallon of water treated.

The carbon consumption predicted by the Freundlich isotherm must be used carefully when evaluating a GAC treatment system. Field experience has shown that only 50 to 70 percent of the predicted batch adsorptivity will be obtained in typical installations.

For example, the Freundlich isotherm adsorptivity for PCE at 100 μg/L is 60 mg of contaminant per gram of carbon, which would result in 14 lbs of carbon consumed per million gallons of water treated. Therefore, PCE is highly absorptive in GAC treatment. The Freundlich isotherm adsorptivity for TCE at 400 μg/L is 49 mg per gram of carbon, which would result in 68 lbs of carbon consumed per million gallons of water treated. The Freundlich isotherm adsorptivity for 1,1-DCA at 20 μg/L is 1.2 mg per gram of carbon, which would result in 139 lbs of carbon consumed per million gallons of water treated. Cis-1,2-DCE has a similar Freundlich isotherm adsorptivity to 1,1-DCA, although increased by a factor of ten. Accordingly, the same amount of carbon is required to treat 20 μg/L of 1,1-DCA as 200 μg/L of cis-1,2-DCE.

Therefore, 1,1-DCA at low to moderate concentrations governs the carbon consumption of a GAC filter unit. The impact of contaminant concentration increases on operating costs will be examined in following sections.

In order to size the vessels, the expected treatment capacity between change outs versus the amount of water that can be pumped through the filter vessels must be analyzed. The potential pumpage of any supply well in any year can vary greatly. Factors such as precipitation, temperature and availability of other supply wells during peak pumping seasons will impact annual pumpage. In order to anticipate annual pumpage capacities of each well, we will look back to the year 1999 when the District had two wells out of service for construction purposes. Refer to Table 3-1 for 1999 annual pumpage for Wells 1-2, 1-3 and 1-4.

The following design criteria are used to size the vessels (Summary on Table 5-4):

Flow Well No. 1-2:	1,200 GPM	or	181.6 MG/yr
Flow Well No. 1-3:	1,200 GPM	or	243.4 MG/yr
Flow Well No. 1-4:	1,400 GPM	or	191.8 MG/yr
Head Loss:	12 psi		

Anticipated Contaminant Levels:

	Maximum
TCE	400 μg/L
1,1,1-TCA	20 μg/L
1,1-DCA	20 μg/L
PCE	100 μg/L
CIS-1,2-DCE	200 μg/L

Empty Bed Contact Time: 7.5 minutes

Effluent Contaminant Level: 1 μg/L or less

The expected treatment capacity between carbon change outs for moderate contaminant levels is controlled by 1,1-DCA with a carbon consumption of 139 lbs per million gallons (MG) of treated water. Assuming carbon will not be exchanged more than once annually then,

The carbon required (lbs) = Annual pumpage (MG) x carbon consumption (lbs)/MG

Well No. 1-2 = 181.6 MG x 139 lbs/MG = 25,242 lbs.

Well No. 1-3 = 243.4 MG x 139 lbs/MG = 33,833 lbs.

Well No. 1-4 = 191.8 MG x 139 lbs/MG = 26,660 lbs.

If each filter vessel contains 20,000 lbs of carbon, then the District would require the following number of vessels to treat the wells at the current five (5) year average annual pumping rates, changing carbon once per year:

a.	Moderate Contaminant Loading:	At 70% Efficiency
	Well No. 1-2 = $\frac{25,242\ lbs}{20,000\ lbs / vessel} = 1.3\ or\ 2\ vessels$	1.8 or 2 vessels
	Well No. 1-3 = $\frac{33,833\ lbs}{20,000\ lbs / vessel} = 1.7\ or\ 2\ vessels$	2.4 or 3 vessels

$$\text{Well No. 1-4} = \frac{26{,}660\ lbs}{20{,}000\ lbs / vessel} = 1.3\ or\ 2\ vessels \qquad 1.9 \text{ or } 2 \text{ vessels}$$

Total = 7 vessels

At 70% Freundlich efficiency, the number of vessels required becomes 7 vessels to treat the anticipated flow of all three wells assuming GAC change outs once per year.

For practical purposes, the number of GAC filters required per well must be based on the maximum anticipated loading including the Freundlich efficiency of 70%. Therefore, the report will consider utilizing a total of 7 vessels. The five (5) filter vessels for Well Nos. 1-3 and 1-4 will be housed in one building, and the two (2) filter vessels for Well No. 1-2 will be located in a separate building adjacent to Well No. 1-2.

5.5 GENERAL DESIGN REQUIREMENTS

The requirements to be fulfilled by the well head treatment installations are to treat a total flow of 3,800 GPM from Well Nos. 1-2, 1-3 and 1-4. The nature and concentration of contaminants were tabulated in previous sections.

Factors which must be considered in the design and economic analysis of the GAC filter or air stripper installation include not only the treatment equipment but all buildings, piping, pumps and tanks associated with each treatment alternative. Regulatory requirements such as chlorination contact time and GAC filter contact time must also be addressed in the design.

5.5.1 GAC FILTRATION

Some of the advantages of Granular Activated Carbon (GAC) filtration as compared to air stripping are: a GAC installation can normally be constructed more quickly than an air stripping facility; there is no noise associated with the GAC operation; the filter building tends to be of lower profile than an air stripper.

Hydraulic considerations of installing GAC filter vessels include minimizing friction losses due to piping and especially through the carbon bed and filter underdrain. The well pump will experience an increase backpressure and corresponding decrease in flow. A piping configuration will be established that will allow the supply wells at Plant No. 1 to filter to waste, backwash to waste and to isolate individual filter vessels for carbon loading and unloading operations.

Any proposed filter vessel should be an ASME Code pressure vessel with underdrain and overdrain system and piping for carbon filling and removal, filtering and backwashing. Taps for influent and effluent sampling with pressure gauges and flow metering capability shall be provided. The filter configuration, as proposed, would be a vertical cylinder having dished ends and supporting legs. The filters will have a 12 foot straight shell height and be 10 foot in diameter.

The existing blow-off system will be utilized to accept the water used to backwash the filter vessels and to rinse and settle the carbon bed prior to pumping to the system. Additional blow-off pits would be required to be installed.

In order to utilize the GAC system year round, the filters would need to be enclosed and heated. To reduce the building height, the building can be constructed with a portion of the filters below grade.

5.5.2 AIR STRIPPING

An air stripping installation would consist of several distinct components. The discharge of the well would be piped to the top of the air stripping tower. The tower itself would contain an inlet water distribution system, demisters, packing media, support gratings, flow redirectors, effluent water collection system and influent air connection. A blower and motor would be required to provide a filtered air supply for the tower. Restaging of the well pumps may be required due to the reduction in the discharge pressure from the well.

After air stripping, a 30 minute contact time for standby chlorination is required. The clearwell after Air Stripper No. 1 (which would treat Well No. 1-2) would have a volume equal to the volume of flow times the contact time which is: 1,200 GPM x 30 min. ÷ 7.481 gals./CF or 4,815 CF. A tank 22′ wide x 22′ long x 10′ deep is required for Clearwell No. 1. The clearwell after Air Stripper Nos. 2 and 3 (which act as the lead and lag towers for flow from Well Nos. 1-3 and 1-4) would have a volume equal to the combined maximum volume of flow from each well times the contact time which is: 2,600 GPM x 30 min. ÷ 7.481 gals./CF or 10,428 CF. A tank 33′ wide x 33′ long x 10′ deep is required for Clearwell No. 2. The reinforced concrete clearwells will be constructed below grade to receive the treated effluent from the respective air stripping towers and to provide the necessary contact time. Each tower would be located on top of the associated clearwell.

Vertical turbine booster pumps will be utilized to pump from each clearwell into the distribution system. The pump would be sized to match the capacities of the existing well pumps, equaling 1,200 GPM for Air Stripper No. 1, and 1,400 GPM for Air Stripper Nos. 2 and 3, with variable frequency control for each. One (1) backup booster pump will be provided for each clearwell. The control logic of the booster pump would be configured to maintain a constant water level in the clearwell. The well pump would be controlled by the demands of the distribution system. A building will be constructed over the clearwell to house the tower, pumps, controls and blowers. Since this plant is in a residential neighborhood and since the District desires to remain a good neighbor, all treatment equipment will be housed within the building.

Based on the design parameters and our calculations, 99.75% removal of TCE is obtainable at Air Stripper Nos. 1, 2 and 3. The manufacturer's design data for the proposed packing indicates that up to 50 GPM per square foot can be used without flooding the tower. Currently accepted design procedures indicate that liquid flow rates of about 50% of the media flood flow rate should be utilized to provide a reasonable safety factor. This factor yields an approximate flow rate of 25 GPM per square foot, which will be incorporated in this design as a maximum liquid cooling rate.

For three towers designed to handle the authorized capacities of Well Nos. 1-2, 1-3 and 1-4, a design liquid loading rate of 15.3 GPM per square foot for Air Stripper No. 1 and 17.8 GPM per square foot for Air Stripper Nos. 2 and 3 will be specified. An air to water ratio of 45:1 yields an air flow rate of 7,218 CFM for Air Stripper No. 1 and 8,412 CFM for Air Stripper Nos. 2 and 3. The specified towers would meet the necessary design criteria to treat the raw water from Well Nos. 1-2, 1-3 and 1-4.

The distribution of liquid entering the tower is an important factor in maintaining desired mass transfer within the towers. Although not essential, nozzles would provide optimal initial liquid distribution, but would add to the energy cost of operating the well pump to the tower, due to approximately 12 psi of head loss that would result at the nozzles. An efficient trough and weir arrangement has proven satisfactory on other projects and should be considered cost effective to accomplish this objective, and a simple weir and perforated plate distribution system has also served the desired purpose. It is also good design practice to maintain sufficient air-to-water contact throughout the depth of each tower. It is recommended that sidewall flow deflectors be placed at the ¼, ½, and ¾ points in the packing height to reduce sidewall channeling. The proposed packed towers will also be equipped with inspection manways installed at the 80 percent and 20 percent packed bed depth interval. Retainers will be retrofitted on the manways to allow for unimpeded visual inspection of the packing media. Air distribution is also an important consideration for mass transfer in a stripping unit. For this reason, the detailed design must consider the method of entry to the towers. The tower influent air must be brought through the sidewall of the plenum and allowed to enter with a downward flow component before it reaches the tower plenum centerline. This will provide more lateral uniformity of air distribution over the cross sectional area. The air blowers will be a backward inclined blade fan with provisions for adjustable pitch sheaves in order to provide for adjustable blower (air) output. The blower motor and blower will be sized to be underloaded at desired air flow, and can be increased if influent contaminant levels were to increase beyond the anticipated maximum levels stated within this report.

In a potable water application, supply air to the blower must be prefiltered before use. As a minimum, a two-step particulate filter, which can furnish air at the equivalent of FDA or acceptable criteria in food applications, would be appropriate. Pressure drops through these filters, under normal operating conditions, should be approximately 1/2-inch of water. The air flow and pressure drop through the filters will be monitored to ensure that the filters are changed when necessary.

All chemical feed injection points will require modification. The existing chemical feeders will be replaced or modified to accommodate water quality changes associated with air stripping treatment. Caustic soda, for pH adjustment, and sodium hypochlorite, for disinfection, will be injected into the effluent clearwell piping. Chemical overdosing will be strictly avoided through an existing safety interlock control of all feed equipment. Provisions will be made for injecting sodium hypochlorite before the treatment towers for standby or emergency disinfection purposes. A recirculation line will be provided to allow a closed loop flow to chlorinate the towers. Provisions for direct blow-off from the stripping towers will also be made.

5.5.3 IRON REMOVAL

Direct pressure filtration is a common treatment method employed in the removal of iron found naturally in potable water. Pressure filtration units operated at a hydraulic loading of 3 to 4 gallons per minute per square foot (GPM/SF) have been frequently employed in the water supply industry for iron removal. According to the provisions contained in the Ten States Standards, filtration rates are recommended not to exceed 3 GPM/SF unless pilot testing or other related performance experience, as approved by the local regulatory authority, demonstrates effective and successful removal. Rapid rate pressure filtration is generally used in groundwater supply treatment applications since multiple source wells and individual smaller flows are generally encountered. Pressure filtration also allows for higher terminal head losses thereby minimizing backwash cycles, and the pressure filters can also be easily automated. Manganese greensand or "greensand" is used in multi media applications for the removal of iron by filtration. The use of filtration media results in both adsorption and oxidation occurring at the surface of the media.

The District currently operates iron removal systems at three (3) plant sites (Plant Nos. 2, 5 and 6). The system at Plant No. 2 was originally installed in the 1960's. The system is a conventional sand system that treats Well No. 2-2 and the recently completed Well No. 2-3. The systems at Plant Nos. 5 and 6 were installed in 1999 and are both manganese greensand systems which treat one well at each site (Well Nos. 5-1 and 6-2). With our experience of manganese greensand systems and the fact that the District already operates two such systems, we recommend that the District construct a similar manganese greensand system to remove iron at Well Nos. 1-2, 1-3 and 1-4.

As summarized on Table 5-5A, two (2) 8 foot diameter by 20 foot long dual cell horizontal filter vessels, configured for parallel operation, would be required to treat the design flow of 1,200 GPM at Well No. 1-2, based on a hydraulic loading of 3.8 GPM/SF. This will also allow for the continuous treatment of the well by a single filter at 7.6 GPM/SF during the backwash cycles. A backwash loading rate of 12 GPM/SF is recommended with the manganese greensand systems, which equates to a 960 GPM flow requirement per filter cell.

Table 5-5B summarizes the iron removal design for Well Nos. 1-3 and 1-4 as, three (3) 8 foot diameter by 22 foot long dual cell horizontal filter vessels, configured for parallel operation, would be required to treat the design flow of 2,600 GPM, based on a hydraulic loading of 5.0 GPM/SF. This will also allow for the continuous treatment of both wells by two filters at 7.5 GPM/SF during the backwash cycles. A backwash loading rate of 12 GPM/SF is recommended with the manganese greensand systems, which equates to a 1,056 GPM flow requirement per filter cell.

The recommended pretreatment oxidation method for pressure filtration of iron is chlorination. The use of chlorine compounds to oxidize divalent iron is widely used in water treatment practice. Chlorination pretreatment also provides a preventative measure by controlling bacteriological growth in the filter system. Theoretically, 1 mg of chlorine will oxidize 1.6 mg of ferrous iron. In general, optimum oxidation with chlorine will occur when the pH is 7.0. For effective iron oxidation, the effluent water should contain free chlorine at approximately 0.4 mg/L.

It must be noted that the oxidation of ferrous iron is highly pH dependent. Temperature is also another factor that should be considered but has a much lower impact than pH. Past studies have revealed that iron oxidation can increase by 100 fold for each unit increase in pH at a given temperature. High alkalinity will also promote oxidation. Optimum oxidation based on minimizing contact time can be obtained generally at pH values of 7.0 or greater.

Backwashing for the proposed filtration would be automated, with provisions for manual operation should conditions warrant. Motorized and rate of flow control valves actuated based on timer and/or pressure loss within the filter bed would be employed to initiate and complete automatic backwashing. Depending upon suspended solids loading conditions, the period between required backwash cycles could vary between 8 to 30 hours. Backwash cycles would take approximately 20 minutes per filter vessel to complete. Based on the preliminary design values used, the maximum hydraulic loading introduced into the treatment system with one vessel out of service during backwash or maintenance purposes would be approximately 7.5 GPM/SF. Disposal issues are discussed in detail in Section 5.5.3.1 of this report.

5.5.3.1 BACKWASH WATER DISPOSAL

Another important operational consideration associated with iron removal treatment is the disposal of the filter backwash water. Based on the preliminary pressure filtration design parameters summarized in Table 5-5A of this study, two (2) pressure filtration vessels providing 160 SF of media per vessel would be required at Well No. 1-2. An influent iron concentration of

3.0 mg/L would require backwashing of the filter vessels after treating approximately 1.2 MG of water, or after approximately 16.7 hours of use based on a design flow of 1,200 GPM. A backwash rate ranging from 12 to 15 GPM/SF is commonly used. In order to minimize the volume of backwash water, a rate of 12 GPM/SF is proposed and will be used for evaluation purposes. Backwashing each cell is estimated to take approximately 10 minutes per cell. Based on the proposed treatment system configuration, the backwash flow rate per cell will be 960 GPM over an approximate 40-minute period (10 minutes per cell). To backwash each cell over a 10-minute period, approximately 9,600 gallons per cell or a total of 38,400 gallons of rejected water will be produced. Based on the expected maximum influent iron concentration of 3 mg/L and a 24-hour capacity of 1.73 MGD, a maximum of 45 lbs. Of iron per day will be produced.

Based on the preliminary pressure filtration design parameters summarized in Table 5-5B of this study, three (3) pressure filtration vessels providing 176 SF of media per vessel would be required at Well Nos. 1-3 and 1-4. An influent iron concentration of 3.0 mg/L would require backwashing of the filter vessels after treating approximately 2.0 MG of water, or after approximately 13.0 hours of use based on a design flow of 2,600 GPM. A backwash rate ranging from 12 to 15 GPM/SF is commonly used. In order to minimize the volume of backwash water, a rate of 12 GPM/SF is proposed and will be used for evaluation purposes. Backwashing each cell is estimated to take approximately 10 minutes per cell. Based on the proposed treatment system configuration, the backwash flow rate per cell will be 1,056 GPM over an approximate 60-minute period (10 minutes per cell). To backwash each cell over a 10-minute period, approximately 10,560 gallons per cell or a total of 63,360 gallons of rejected water will be produced. Based on the expected maximum influent iron concentration of 3 mg/L and a 24-hour capacity of 3.74 MGD, a maximum of 98 pounds of iron per day will be produced.

The District will need to undertake discussions with Nassau County Department of Public Works (NCDPW) officials regarding the sewer capacity and pretreatment requirements, if any. The NCDPW will also need to be contacted in order to obtain the appropriate permit for indirect disposal of the backwash water to the county operated wastewater plant.

A survey of Nassau County water suppliers who employ filtration for iron removal treatment, including the District, indicated that the NCDPW has granted permits for the indirect discharging of backwash water to the sanitary sewer system. This required the construction of a suitable holding or equalization tank, which allowed for the slow and off peak discharge of the backwash water. It is recommended that an equalization tank be employed in order to control the flow and to minimize any impact on the local sewer system. A tank suitable for holding the volume of at least one backwash cycle plus an adequate freeboard would be required. At Well No. 1-2, we would recommend a tank design with a volume of approximately 54,600 gallons. Similarly, at Well Nos. 1-3 and 1-4, we would recommend a tank design with a volume of approximately 92,500 gallons.

6.0 ECONOMIC ANALYSIS

A generalized comparison between GAC filtration and air stripping reveals that the most appropriate installation depends not only upon the concentration and type of contaminant but also is sensitive to the total hours of operation and correspondingly the total pumpage from the well to be treated. The anticipated costs for any treatment facility can include capital costs, which are fixed, and operating costs, which vary with the degree of utilization of the facility. The costs presented in this report are stated as present day costs, however adjustments should be made at the time of final project design in order to update the costs.

Operating costs for direct pressure filtration for iron removal will vary with the amount of water treated and the raw water dissolved iron concentration. For contact filtration with greensand media, chlorination will be employed as the oxidation method. The theoretical reaction rate for oxidation by chlorination is 0.62 mg/L of chlorine to 1.0 mg/L of iron. pH adjustment is generally required as well.

6.1 CAPITAL COSTS

Total capital costs must also include the expected cost of the facilities outlined under "General Design Requirements" in Section 5.4. It should be noted that the annualized values calculated for various alternatives are equivalent uniform payments over the expected life of the project. These payments have the same present worth as the initial cost of the project. Uniform series payments are the most useful way to compare the various alternatives, particularly for those having differing expected life spans.

Capital improvements required for iron removal include:

- Horizontal pressure multi-media filter vessel units
- Pretreatment equipment
- A treatment building for each iron removal facility

- Backwash water equalization tanks and equipment
- Mechanical work
- Piping modifications
- Electrical work, instrumentation, controls

Capital improvements required for GAC include:

- GAC filter vessels
- Foundation, slab and treatment building
- Initial carbon loading
- Piping modifications
- Site improvements
- Electrical improvements

The air stripping alternative involves the following capital improvements:

- Air stripping towers and equipment
- A treatment building
- A concrete clearwell
- Piping modifications
- Booster pumps and mechanical work
- Site improvements
- Electrical work, instrumentation and controls

The opinion of cost for GAC treatment with an iron removal system is $7,360,000.

The opinion of cost for air stripping treatment with an iron removal system is $8,704,000.

Breakdowns of the opinions of cost for the capital improvements for the treatment alternatives are given in Tables 6-1 and 6-2.

6.2 OPERATING COSTS

Operating costs, which vary with the amount of water being treated, consist primarily of the purchase and disposal cost of activated carbon for the GAC filtration alternative. The decreased output caused by the head loss across the GAC filters is not included in this analysis. The operating costs for the air stripping alternative consist of electric usage and demand charges to run the blower and booster pumps.

As discussed previously, the contaminant concentration encountered in Well Nos. 1-2, 1-3 and 1-4 are expected to vary during the life span of the implemented alternative. The variable costs associated with the GAC filtration alternative are sensitive to changes in contaminant type and concentration while those for the air stripper will change very little for moderate changes in contaminant concentration.

The contaminant 1,1-DCA requires significant amounts of carbon for removal. Moderate increases in the concentration and high pumpage rates will require carbon change outs of at least once per year. As stated in Section 5.3, the evaluation of the GAC alternative will utilize seven (7) 20,000 lb GAC filter vessels.

The adsorptive capacity of activated carbon varies with the influent concentration of a contaminant. While the efficiency of carbon adsorption increases with increasing concentration, the rate at which the carbon reaches it adsorptive capacity increases even more quickly.

GAC consumption costs at various contaminant levels are shown in Table 6-3. Electrical consumption and demand charges associated with GAC treatment systems and with the proposed air stripping treatment systems are illustrated in Tables 6-4 and 6-5.

The comparison of operating costs for the GAC versus the air stripping tower can best be illustrated by selecting a range of plausible contaminant loadings. The pumpage rate anticipated at Well Nos. 1-2, 1-3, and 1-4 will likely increase in the foreseeable future once the treatment systems are in place. The electrical demand charges associated with the air stripping option are the only variables which, on a per thousand gallon treated basis, would depend on the total annual pumpage.

A desirable side effect of the air stripping process is that carbon dioxide will be removed from the water in the air stripping tower. This will reduce the acidity of the water and lower the caustic dosage required for pH adjustment. Experience at similar sites suggests a reduction of caustic dosage of 10 mg/L may occur. This would reduce treatment costs by an average of $0.01 per 1,000 gallons pumped. Similarly, other chemical treatment costs associated with each treatment system, such as hypochlorite, are also incidental as compared to other operating and maintenance costs. Accordingly, chemical usage is not part of the operating and maintenance cost comparison.

Regardless of the selected treatment method, the South Farmingdale Water District will obviously incur additional operation and maintenance costs associated with the treatment system. In addition to additional operation and maintenance costs related to electrical usage, GAC replacements and chemical needs, as discussed briefly above, costs associated with equipment replacements and equipment life, costs associated with additional labor to operate the facilities, and costs associated with additional laboratory costs will be incurred by the District.

Tables 6-4 and 6-5 have been prepared to summarize the expected additional operation and maintenance costs associated with each treatment option over a thirty-year period. The present worth value of each annual operation and maintenance cost summary for the thirty-year period is also provided. The projected increase in annual operating costs for GAC treatment is estimated to be $270,928 per year. By assuming an operating and maintenance inflation rate of 5%, over a treatment system life of 30 years, and an annual investment interest rate of 1.5%, the present worth value of the GAC operating costs is estimated to be $13,868,000. Similarly, the projected increase in annual operating costs for air stripping treatment is estimated to be $184,328 per year. Over the 30 year treatment system life and the assumed 5% operating and maintenance inflation rate and an annual investment interest rate of 1.5%, the present worth value of the air stripping treatment costs is estimated to be $9,435,000. The increase in annual operating costs for GAC treatment ($270,928) is 47% higher than for air stripping ($184,328).

6.3 TOTAL COSTS

The selection among the various alternatives must be based upon an evaluation of the capital costs and the annual operating costs taken in combination. The total capital cost for air stripping vs. GAC treatment for an annual flow for Well Nos. 1-2, 1-3 and 1-4 of 181.6 MG, 243.4 MG, and 191.8 MG respectively, are listed on Tables 6-1 and 6-2. Due to the potential for iron to clog either the GAC system or the air stripping system, the cost opinion for each option includes the installation of a manganese greensand filter iron removal system upstream of the VOC treatment system.

At projected loading conditions, the capital cost of air stripping ($8,704,000) is approximately 18% higher than that for GAC ($7,360,000). However, with the necessity of carbon changeouts at approximately $140,000 annually (assuming $1.00 per pound of carbon), the cost advantage of GAC filtration rapidly diminishes. The excessive cost of carbon replacement is magnified when considering the effects of inflation over the 30 year operational life. This analysis reveals that carbon replacement is the most significant factor in evaluating the estimated operating and maintenance costs for the two treatment processes.

The District should be aware that the capital and operational costs associated with the treatment systems are based on cost opinions prepared in present day dollars. For planning and funding purposes, the District should re-evaluate these costs, at a minimum, depending on when the treatment systems will be designed and constructed.

With the potential for increased contaminant loading of 1,1–DCA, more frequent carbon replacements could be required. This would further increase the annual operating costs for a GAC filtration system. As currently evaluated, GAC and air stripping treatment are relatively close in total cost over the projected 30 years of operation at the expected annual pumpage of

616.8 MG for Plant No. 1. Although the estimated capital cost of the air stripping treatment system is 18% higher than that for GAC, the estimated annual operating costs for GAC treatment are 47% higher than those for air stripping. Due to the fact that the influent VOC levels may potentially increase over the life of the treatment system, the annual operating costs are a significant concern.

A comparison of the costs for a higher annual pumpage will not change the capital costs, but will alter the operating costs. Increasing the hours of pumpage makes the air stripping option increasingly attractive in comparison to the GAC option due to the impact on operational costs. The costs for the GAC filtration are very sensitive to changes in contaminant type, concentration, and pumpage, while operating costs for the air stripping process will remain relatively unchanged for moderate changes in contaminant concentrations, type, or pumpage.

Based upon the economic analysis performed, the present worth cost analysis, the yearly pumpage of Plant No. 1 and the forecasted maximum contaminant levels, air stripping for organics removal is the most cost effective treatment alternative.

7.0 PROPOSED PROJECT SCHEDULE

As discussed in Section 3.0 of this report, Plant No. 1 is a critical peak and average day supply facility. This facility is especially critical during the peak summer pumping season. It is anticipated that treatment facilities at Plant No. 3 will be on-line by September 2005. In order to not overburden the District with major construction at two plants simultaneously, we recommend that the work at Plant No. 3 be completed prior to the commencement of work at Plant No. 1. Also, the contamination plume is predicted in the Arcadis model to impact Plant No. 3 prior to Plant No. 1. Accordingly, a proposed project schedule has been prepared and is summarized in Table 7-1. Advertisements for bids are tentatively scheduled for September 2006. Construction is tentatively scheduled to start during November 2006, pending Health Department approval and completion of the treatment facility at Plant No. 3.

8.0 CONCLUSIONS

The more stringent volatile organic compound MCLs have significantly impacted the typical water supplier's planning procedures. In the past, a supplier usually had sufficient time to implement the construction of a treatment system between the time a contaminant was first detected and when it first exceeded the acceptable maximum level. Prior to 1989, the MCL for principal VOCs was set at 50 μg/L for any one VOC and 100 μg/L for total VOCs present in the product of a supply well. Under the present MCLs of 5 μg/L, a supplier has little or no time to plan for treatment after a contaminant is detected. Therefore, with the current MCLs, suppliers should plan additional reserve capacity to protect against the possibility that a well may have to be taken out of service due to organic contamination.

1. Upstream well data indicate that low level VOCs are prevalent in the Upper Glacial and shallow Magothy formation upgradient of Plant No. 1 (Well Nos. 1-2, 1-3 and 1-4).

2. Based on available data, TCE, 1,1-DCA, 1,1,1-TCA, PCE, and cis-1,2-DCE are the most prevalent compounds projected to impact Plant No. 1. These compounds are projected to impact the supply facility at low to moderate levels.

3. Plant No. 1 is critical to the average and peak day pumpage operations of the Water District. The abandonment or closure of Plant No. 1 would translate into a lost well capacity of 5.472 MGD (3,800 GPM). This is not an option for the District.

4. Raw water iron levels recorded from Well Nos. 1-2, 1-3 and 1-4 have been found in excess of the 0.30 mg/L secondary standard. Data from 2002 indicates that the concentration of iron at Well Nos. 1-2 and 1-3 have averaged approximately 0.5 mg/L, and at Well No. 1-4 the average has been 1.0 mg/L. The concentration of iron at each well has the potential for increase as compared to other District

supply wells. Influent iron concentrations of these levels will increase clogging due to precipitation of iron in either VOC treatment alternative.

5. Oxidation with chlorination and direct rapid rate pressure filtration is recommended for the treatment removal of iron from the product of Well Nos. 1-2, 1-3 and 1-4.

6. To treat the flow from Well No. 1-2, two (2) 8 foot diameter by 20 foot long horizontal pressure multi-media filter vessel units, operated in parallel, will provide sufficient treatment for removal of iron.

7. To treat the flow from Well Nos. 1-3 and 1-4, three (3) 8 foot diameter by 22 foot long horizontal pressure multi-media filter vessel units, operated in parallel, will provide sufficient treatment for removal of iron.

8. Backwashing of the proposed iron removal filtration system for Well No. 1-2 is estimated to be required to be performed every 16 hours of operation, based on a design flow of 1,200 GPM and a design iron concentration of 3.0 mg/L. The estimated volume of backwash water for each backwash cycle will be 38,400 gallons.

9. Backwashing of the proposed iron removal filtration system for Well Nos. 1-3 and 1-4 is estimated to be required to be performed every 13 hours of operation, based on a design flow of 2,600 GPM and a design iron concentration of 3.0 mg/L. The estimated volume of backwash water for each backwash cycle will be 63,360 gallons.

10. The District should dispose of the backwash water via indirect discharge from an equalization tank to the local sanitary sewer system, provided NCDPW accepts the waste volume.

11. Pretreatment with chlorination will be required for oxidation of the dissolved iron. The proposed system will provide a product water with iron levels at or below 0.1 mg/L, one third the 0.30 mg/L secondary standard.

12. Based on the economic analysis performed, production from the Plant No. 1 supply wells, and the nature and concentration of the VOCs projected to impact the facility, it has been determined that air stripping is the most technically viable and cost effective treatment method for Plant No. 1. The recommended treatment system will allow the plant facility to meet current MCLs while allowing the supply wells to function adequately with increasing raw water concentrations up to 400 μg/L for TCE, 20 μg/L for 1,1-DCA, 20 μg/L for 1,1,1-TCA, 100 μg/L for PCE, and 200 μg/L for cis-1,2-DCE.

13. Three air stripping towers will be operated at an air-to-water ratio of 45:1. Air Stripper No.1 (for Well No. 1-2) will have 17 feet of packing and a 10 foot diameter, and will be operated at a liquid loading rate of 15.3 GPM/SF. Air Stripper No.2 (the lead tower for Well Nos. 1-3 and 1-4) will have 20 feet of packing and a 10 foot diameter, and will be operated at a liquid loading rate of 17.8 GPM/SF. Air Stripper No.3 (the lag tower for Well Nos. 1-3 and 1-4) will have 20 feet of packing and a 10 foot diameter, and will be operated at a liquid loading rate of 17.8 GPM/SF. These air strippers will be sufficient for the removal of the contamination expected to impact Plant No. 1. The proposed treatment system will provide water from the Plant No. 1 supply wells at or below 1 μg/L, with the intention of providing drinking water with "non-detectible" VOC contamination.

14. The present day capital cost for constructing an air stripping treatment system at Plant No. 1 is estimated to be $8,704,000. This estimate includes the iron removal filter units; face piping and valves; pretreatment equipment; new iron

removal treatment buildings or building additions; backwash water equalization tanks and equipment; electrical, mechanical and site work; air stripping treatment towers; tower foundations; transfer clearwells and pumps; treatment, electrical and mechanical modifications; filters and blowers; air stripper buildings; standby generators and enclosures; site work; well pump modifications; engineering; construction administration; legal; and contingencies.

15. The present day value of additional annual operation and maintenance costs associated with the air stripping treatment system with iron removal are estimated to be $184,328. This estimate includes the major operational components which impact costs, including additional electrical usage, filter replacements, additional laboratory monitoring, additional plant monitoring (labor), and maintenance of major equipment items. For a projected operating period of 30 years, the present day value of the additional operating and maintenance costs for each air stripping treatment system is estimated to be $9,435,000.

9.0 RECOMMENDATIONS

Based on the conclusions developed within this report, H2M recommends the following:

1. Based on the production from the supply well at Plant No. 1, the nature and concentration of the compounds projected to impact the supply facility, the critical need to have the facility for meeting average and peak day demands and the cost analysis performed, it is recommended that air stripping treatment for organics removal be implemented at Plant No. 1.

2. It is recommended the District proceed with the construction of an iron removal treatment system consisting of oxidation with chlorination and direct rapid rate multi-media pressure filtration for the removal of iron and air stripping for the removal of organic contamination from the product of Well Nos. 1-2, 1-3 and 1-4.

3. It is recommended that copies of this report, along with the treatment system design plans and specifications, be forwarded to the New York State Department of Health in Albany, as well as to the Nassau County Department of Health Services, for their concurrent review and approval.

4. It is recommended that the SEQRA process be initiated with respect to the proposed project.

5. It is recommended that the capital and operating costs be re-evaluated at the time of final project design in order to account for any increase in the costs.

6. It is recommended that this project, not proceed until the recommended treatment system at Plant No. 3 be completed and placed on line. The VOC contamination plume is projected to impact Plant No. 3 in advance of impacting Plant No. 1. Therefore, design should begin by October 2005.

7. In order to reduce the impact of the height of the tower and to address any concerns about bacteriological contamination in the clearwell, the site must be investigated for any perched groundwater at relatively shallow depths (15′± below existing grade). It is recommended that a soil boring investigation be instituted. The results of such investigation will determine where the foundation of the clearwell will be set, which in turn will establish the elevation of the stripping tower.

At this time, it is recommended that this engineering report be adopted for implementation of a well head treatment system for Plant No. 1 to meet the present and future needs of the District.

TABLES

TABLE 2-1

SOUTH FARMINGDALE WATER DISTRICT
SUMMARY OF SUPPLY WELL FACILITIES

Water District Well No.	Year Placed in Service	NYSDEC No.	Plant Location	Terminal Depth (feet)	Formation	Approved Capacity (GPM)	Power
1-2	1953	N-4043	Langdon Road	374	Magothy	1,200	E
1-3	1955	N-5148	Langdon Road	369	Magothy	1,200	E/NG
1-4	1963	N-7377	Langdon Road	758	Magothy	1,400	E/NG
2-2	1957	N-6149	Lourae Drive	640	Magothy	1,200	E/NG
2-3	2003	TBA	Lourae Drive	640	Magothy	1,200	E/NG
3-1	1959	N-6150	Route 107	612	Magothy	1,400	E/NG
4-1	1957	N-6148	Linden Street	566	Magothy	1,200	E
5-1	1965	N-7515	Heisser Lane	347	Magothy	1,400	E/NG
5-2	1965	N-7516	Heisser Lane	584	Magothy	1,400	E/NG
6-1	1971	N-8664	Route 107 (North of S. S. Pkwy)	610	Magothy	1,400	E
6-2	1971	N-8665	Route 107 (North of S. S. Pkwy)	560	Magothy	1,400	E

LEGEND:
E - Electric; NG - Natural Gas
GPM - Gallons Per Minute

TABLE 2-2

SOUTH FARMINGDALE WATER DISTRICT
STORAGE TANK CAPACITY

Plant No.	Location	Type of Facility	Capacity (Gallons)
1	Langdon Road	Elevated Steel	1,000,000
2	Lourae Drive	Ground Concrete	1,000,000
3	Route 107	Ground Concrete	600,000
4	Linden Street	Ground Concrete	600,000
		Total Capacity	**3,200,000**

TABLE 2-3

SOUTH FARMINGDALE WATER DISTRICT INTERCONNECTIONS WITH NEIGHBORING WATER SUPPLIERS

Water Supplier	Location	Interconnection Size (Inches)
Village of Farmingdale	Hempstead Tpke. & East Gate	8 x 8
	Staple & James Streets	8 x 8
Bethpage Water District	Stewart & N. Boundary Aves.	6 x 6
	Plainedge Drive & Dennis Lane	6 x 6
	Shelly Lane	6 x 6
	Frey Road	6 x 6
	Bernard & High Streets	6 x 6
New York Water Service	Alken Ave.	6 x 6
	Wicks Ave.	6 x 6
	Emily Street	6 x 8
Massapequa Water District	Jerusalem Ave. & Route 107	6 x 6
	Jerusalem Ave. & Hicksville Road	10 x 10
	Jerusalem Ave. & Broadway	10 x 8
	Pacific Street & Violet Ave.	6 x 6
East Farmingdale Water Distric	Saxon Road & Barbara Drive	6 x 6
	Mill Road & Mill Lane	8 x 8
	Main Street & Spruce Court	6 x 6

TABLE 3-1

SOUTH FARMINGDALE WATER DISTRICT
ANNUAL WATER PUMPAGE (MILLION GALLONS)

	Annual Pumpage			
	1999	**2000**	**2001**	**2002**
Well 1-2	181.6	66.5	93.6	132.8
Well 1-3	243.4	183.8	106.6	75.1
Well 1-4	191.8	30.0	83.4	53.8
All Supply Wells	1,944.0	1,755.0	2,045.4	1,546.0
Plant 1 Total vs. All Supply Wells	31.7%	16.0%	13.9%	16.9%

TABLE 4-1

SOUTH FARMINGDALE WATER DISTRICT

DRINKING WATER STANDARDS

CURRENT MCLs AS DETERMINED UNDER THE FEDERAL SAFE DRINKING WATER ACT (1986)

PARAMETER	MCL (ug/L)
benzene	5
vinyl chloride	2
carbon tetrachloride	5
trichloroethene	5
1,1-dichloroethene	5
1,1,1-trichloroethane	5

Additional Compounds with MCLs established as 5 ug/L by NYSDOH/SCDHS (Date of Enforcement - January 2002)

- bromobenzene
- bromochloromethane
- bromomethane
- n-butylbenzene
- sec-butylbenzene
- tert-butylbenzene
- chlorobenzene
- chloroethane
- chloromethane
- 2-chlorotoluene
- 4-chlorotoluene
- 1,2-dichlorobenzene
- 1,3-dichlorobenzene
- 1,4-dichlorobenzene
- dibromomethane
- dichlorodifluoromethane
- 1,1-dichloroethane
- *cis* -1,2-dichloroethene
- trans-1,2-dichloroethene
- 1,2-dichloropropane
- 1,3-dichloropropane
- 1,2-dichloroethane
- 2,2-dichloropropane
- 1,1-dichloropropene
- *cis* -1,3-dichloropropene
- trans-1,3-dichloropropene
- ethylbenzene
- trichlorofluoromethane
- hexachlorobutadiene
- p-isopropyltoluene
- methylene chloride
- methyl tertiary butyl ether
- n-proplybenzene
- styrene
- 1,1,1,2-tetrachloroethane
- 1,1,2,2-tetrachloroethane
- tetrachloroethene
- toluene
- 1,2,3-trichlorobenzene
- 1,2,4-trichlorobenzene
- 1,2,4-trimethylbenzene
- 1,3,5-trimethylbenzene
- m-xylene
- o-xylene
- p-xylene
- 1,1,2-trichloroethane
- Bromoform
- Bromodichloromethane
- Chloroform
- Chlorodibromomethane

TABLE 4-2

SOUTH FARMINGDALE WATER DISTRICT
DRINKING WATER STANDARDS
SYNTHETIC ORGANIC CHEMICALS

SYNTHETIC ORGANIC CHEMICALS	MCL (ug/L)
Alachlor	2
Aldicarb	3
Aldicarb Sulfone	2
Aldicarb Sulfoxide	4
Atrazine	3
Carbofuran	40
Chlordane, Total	2
DBCP (G)	0.2
2,4,D	50
Endrin	2
1,2-Dibromoethane (EDB)	0.05
Heptachlor	0.4
Heptachlor Epoxide	0.2
Lindane	0.2
Methoxychlor	40
Polychlorinated Biphenyls (PCB's	0.5
Pentachlorophenol	1
Toxaphene	3
2,4,5-TP (Silvex)	10
Aldrin	5
Benzo(a)pyrene	0.2
Butachlor	50
Carbaryl	50
Dalapon	200
Di(2-ethylhexyl)adipate	400
Di(2-ethylhexyl)phthalate	6
Dicamba	50
Dieldrin	5
Dinoseb	7
Diquat	20
Endothall	100
Glyphosate	700
Hexachlorobenzene	1
Hexachlorocyclopentadiene	50
3-Hydroxycarbofuran	50
Methomyl	50
Metolachlor	50
Metribuzin	50
Oxamyl (Vydate)	200
Picloram	500
Propachlor	50
Simazine	4
2,3,7,8-TCDD (Dioxin)	0.00003

TABLE 4-3

SOUTH FARMINGDALE WATER DISTRICT

NEW YORK STATE PRIMARY AND SECONDARY STANDARDS FOR INORGANIC CHEMICALS

INORGANIC CHEMICALS	MCL (mg/L)
Antimony	0.006
Arsenic	0.05
Barium	2.0
Beryllium	0.004
Cadmium	0.005
Chloride	250
Chromium	0.1
Color	15 units
Copper	1.3(A)
Cyanide, Free	0.2
Flouride	2.2
Iron	.3(B)
Lead	.015(A)
Manganese	.3(B)
Mercury	0.002
Nickel	0.1
Nitrate as N	10.0(C)
Nitrite as N	1.0(C)
Odor	3 units
Selenium	0.05
Silver	0.1
Sodium	(D)
Sulfate	250
Thallium	0.002
Turbidity	5 units
Zinc	5.0

(A) - USEPA Action Level.

(B) - The combined concentration of iron and manganese should not exceed 0.5 mg/L.

(C) - The total Nitrate and Nitrite should not exceed 10.0 mg/L.

(D) - The NYSDOH recommends that the sodium level not excced 20 mg/L for severely restricted sodium diets and 270 mg/L for moderately restricted diets.

TABLE 4-4

SOUTH FARMINGDALE WATER DISTRICT
WATER QUALITY SAMPLING RESULTS FOR VOCs (ug/L)

2000 Maximum Levels

VOC	GM 36D	GM 38D	GM 38D2	GM 39D	GM 39D2	GM 73D	GM 73D2	VPB 43	VPB 47	VPB 77	VPB 51	BWD 4-1	BWD 4-2
Trichloroethene	45	890	730	N	N	N	N	N	N	25	N	2.2	2.8
1,1,1-Trichloroethane	-	4.1	-	O	O	O	O	O	O	17	O	-	-
1,1-Dichloroethane	-	1.9	-							2		0.8	-
1,1-Dichloroethene	-	3.6	-	D	D	D	D	D	D	8	D	-	-
cis-1,2-Dichloroethene	-	1.4	4.6	A	A	A	A	A	A	-	A	-	-
Chloroform	-	1	1.3	T	T	T	T	T	T	-	T	0.9	0.7
Tetrachloroethene	1.5	1	-	A	A	A	A	A	A	100	A	-	1.2

2001 Maximum Levels

VOC	GM 36D	GM 38D	GM 38D2	GM 39D	GM 39D2	GM 73D	GM 73D2	VPB 43	VPB 47	VPB 77	VPB 51	BWD 4-1	BWD 4-2
Trichloroethene	27	900	1400	N	N	N	N	8	770	N	830	1.9	3.6
1,1,1-Trichloroethane	-	5.2	1.2	O	O	O	O	4	1	O	110	-	-
1,1-Dichloroethane	-	2.9	-					4	8		3	1.3	-
1,1-Dichloroethene	-	6.6	1.4	D	D	D	D	2	9	D	10	-	-
cis-1,2-Dichloroethene	-	1.7	11.6	A	A	A	A	-	460	A	1100	0.5	0.6
Chloroform	-	0.8	2.1	T	T	T	T	-	1	T	2	0.8	0.8
Tetrachloroethene	1.1	1.2	-	A	A	A	A	-	110	A	910	-	-

1st Quarter 2002

VOC	GM 36D	GM 38D	GM 38D2	GM 39D	GM 39D2	GM 73D	GM 73D2	VPB 43	VPB 47	VPB 77	VPB 51	BWD 4-1	BWD 4-2
Trichloroethene	18.8	722	1160	N	N	N	N	N	N	N	N	7.7	5.6
1,1,1-Trichloroethane	-	2.6	-	O	O	O	O	O	O	O	O	-	-
1,1-Dichloroethane	-	-	-									1.3	-
1,1-Dichloroethene	-	2.1	-	D	D	D	D	D	D	D	D	-	-
cis-1,2-Dichloroethene	-	1.1	4.8	A	A	A	A	A	A	A	A	1.6	0.5
Chloroform	-	1	1.5	T	T	T	T	T	T	T	T	1.9	0.8
Tetrachloroethene	0.6	-	-	A	A	A	A	A	A	A	A	-	-

2nd Quarter 2002

VOC	GM 36D	GM 38D	GM 38D2	GM 39D	GM 39D2	GM 73D	GM 73D2	VPB 43	VPB 47	VPB 77	VPB 51	BWD 4-1	BWD 4-2
Trichloroethene	N	661	1350	N	N	N	N	N	N	N	N	N	N
1,1,1-Trichloroethane	O	-	-	O	O	O	O	O	O	O	O	O	O
1,1-Dichloroethane		-	-										
1,1-Dichloroethene	D	-	-	D	D	D	D	D	D	D	D	D	D
cis-1,2-Dichloroethene	A	-	3.4	A	A	A	A	A	A	A	A	A	A
Chloroform	T	-	-	T	T	T	T	T	T	T	T	T	T
Tetrachloroethene	A	-	-	A	A	A	A	A	A	A	A	A	A

TABLE 4-4 (CONT'D)

SOUTH FARMINGDALE WATER DISTRICT
WATER QUALITY SAMPLING RESULTS FOR VOCs (ug/L)

rd Quarter 2002

VOC	GM 36D	GM 38D	GM 38D2	GM 39D	GM 39D2	GM 73D	GM 73D2	VPB 43	VPB 47	VPB 77	VPB 51	BWD 4-1	BWD 4-2
richloroethene	19.7	626	1170	-	-	780	840	N	N	N	N	N	N
,1,1-Trichloroethane	-	-	-	-	-	-	-	O	O	O	O	O	O
1,1-Dichloroethane	-	-	-	-	-	-	-						
,1-Dichloroethene	-	-	-	-	-	-	-	D	D	D	D	D	D
is-1,2-Dichloroethene	-	-	2.6	-	-	-	3	A	A	A	A	A	A
Chloroform	-	-	-	-	-	-	-	T	T	T	T	T	T
etrachloroethene	0.7	-	-	-	-	-	-	A	A	A	A	A	A

4th Quarter 2002

VOC	GM 36D	GM 38D	GM 38D2	GM 39D	GM 39D2	GM 73D	GM 73D2	VPB 43	VPB 47	VPB 77	VPB 51	BWD 4-1	BWD 4-2
richloroethene	19	-	1460	23	110	510	1200	N	N	N	N	N	N
1,1,1-Trichloroethane	-	-	1.1	-	-	-	-	O	O	O	O	O	O
1,1-Dichloroethane	-	-	-	-	-	-	-						
,1-Dichloroethene	-	-	2.2	-	-	-	-	D	D	D	D	D	D
cis-1,2-Dichloroethene	-	-	8.6	-	-	-	-	A	A	A	A	A	A
Chloroform	-	-	1.6	-	-	-	-	T	T	T	T	T	T
etrachloroethene		-	-	-	-	-	4	A	A	A	A	A	A

1st Quarter 2003

VOC	GM 36D	GM 38D	GM 38D2	GM 39D	GM 39D2	GM 73D	GM 73D2	VPB 43	VPB 47	VPB 77	VPB 51	BWD 4-1	BWD 4-2
Trichloroethene	N	1000	N	21	110	680	1100	N	N	N	N	N	N
1,1,1-Trichloroethane	O	5	O	-	-	-	-	O	O	O	O	O	O
,1-Dichloroethane		2		-	-	-	-						
,1-Dichloroethene	D	7	D	-	-	-	-	D	D	D	D	D	D
cis-1,2-Dichloroethene	A	2.6	A	-	0.6	-	-	A	A	A	A	A	A
hloroform	T	1.6	T	-	-	-	-	T	T	T	T	T	T
etrachloroethene	A	1.2	A	-	0.4	2	5	A	A	A	A	A	A

nd Quarter 2003

VOC	GM 36D	GM 38D	GM 38D2	GM 39D	GM 39D2	GM 73D	GM 73D2	VPB 43	VPB 47	VPB 77	VPB 51	BWD 4-1	BWD 4-2
Trichloroethene	10.8	314	339	N	N	N	N	N	N	N	N	N	N
1,1,1-Trichloroethane	-	3.6	1.2	O	O	O	O	O	O	O	O	O	O
1,1-Dichloroethane	-	1.7	-										
1,1-Dichloroethene	-	-	-	D	D	D	D	D	D	D	D	D	D
cis-1,2-Dichloroethene	-	1.7	5.4	A	A	A	A	A	A	A	A	A	A
hloroform	-	1.4	1.6	T	T	T	T	T	T	T	T	T	T
Tetrachloroethene	-	-	-	A	A	A	A	A	A	A	A	A	A

H2MGROUP

TABLE 4-5

SOUTH FARMINGDALE WATER DISTRICT
WELL NOS. 1-2, 1-3 AND 1-4 IRON CONCENTRATIONS (mg/L)
2002

WELL	DATE	IRON CONCENTRATION (mg/L)
Well 1-2	10-Jan	0.455
Well 1-2	24-Jan	0.455
Well 1-2	31-Jan	0.468
Well 1-2	7-Feb	0.470
Well 1-2	28-Feb	0.435
Well 1-2	7-Mar	0.427
Well 1-2	14-Mar	0.420
Well 1-2	21-Mar	0.447
Well 1-2	28-Mar	0.448
Well 1-2	4-Apr	0.448
Well 1-2	11-Apr	0.458
Well 1-2	18-Apr	0.441
Well 1-2	16-May	0.443
Well 1-2	23-May	0.447
Well 1-2	6-Jun	0.425
Well 1-2	20-Jun	0.420
Well 1-2	27-Jun	0.411
Well 1-2	11-Jul	0.455
Well 1-2	18-Jul	0.451
Well 1-2	25-Jul	0.454
Well 1-2	1-Aug	0.457
Well 1-2	8-Aug	0.490
Well 1-2	15-Aug	0.522
Well 1-2	22-Aug	0.530
Well 1-2	12-Sep	0.521
Well 1-2	26-Sep	0.536
Well 1-2	3-Oct	0.512
Well 1-2	10-Oct	0.488
Well 1-2	17-Oct	0.483
Well 1-2	14-Nov	0.477
Well 1-2	27-Nov	0.498
Well 1-2	5-Dec	0.937
Well 1-2	12-Dec	0.496

AVERAGE FOR WELL 1-2 (2002) **0.480**

TABLE 4-5 (CONT'D)

SOUTH FARMINGDALE WATER DISTRICT
WELL NOS. 1-2, 1-3 AND 1-4 IRON CONCENTRATIONS (mg/L)
2002

WELL	DATE	IRON CONCENTRATION (mg/L)
Well 1-3	14-Mar	0.612
Well 1-3	18-Jul	0.704
Well 1-3	8-Aug	0.467
Well 1-3	15-Aug	0.493
Well 1-3	22-Aug	0.488
Well 1-3	29-Aug	0.470
Well 1-3	19-Sep	0.455
Well 1-3	26-Sep	0.498
Well 1-3	3-Oct	0.465
Well 1-3	14-Nov	0.503
Well 1-3	19-Dec	0.597

AVERAGE FOR WELL 1-3 (2002) **0.523**

WELL	DATE	IRON CONCENTRATION (mg/L)
Well 1-4	4-Mar	1.570
Well 1-4	2-Jul	0.960
Well 1-4	3-Jul	0.940
Well 1-4	18-Jul	0.929
Well 1-4	1-Aug	0.885

AVERAGE FOR WELL 1-4 (2002) **1.057**

TABLE 5-1

SOUTH FARMINGDALE WATER DISTRICT MAXIMUM CONTAMINANT DESIGN LEVELS

COMPOUND	SCENARIO "B" TWICE THE POTENTIAL LEVEL (ug/L)
TCE	400
1,1-DCA	20
1,1,1-TCA	20
PCE	100
CIS-1,2-DCE	200

TABLE 5-2

SOUTH FARMINGDALE WATER DISTRICT
AIR STRIPPING TOWER SIZING

Q Water = 1,200 GPM
Q Air = 7,218 CFM

COMPOUND	DESIGN EFFLUENT (ug/L)	AIR STRIPPER NO. 1	
		DESIGN INFLUENT (ug/L)	REQUIRED PACKING HEIGHT (ft)
TCE	1	400	17.0
1,1-DCA	1	20	9.0
1,1,1-TCA	1	20	9.0
PCE	1	100	8.0
CIS-1,2-DCE	1	200	17.0

Q Water = 1,400 GPM
Q Air = 7,218 CFM

COMPOUND	DESIGN EFFLUENT (ug/L)	AIR STRIPPER NO. 2	
		DESIGN INFLUENT (ug/L)	REQUIRED PACKING HEIGHT (ft)
TCE	1	400	20.0
1,1-DCA	1	20	11.0
1,1,1-TCA	1	20	11.0
PCE	1	100	9.0
CIS-1,2-DCE	1	200	20.0

TABLE 5-2 (CONT'D)

SOUTH FARMINGDALE WATER DISTRICT
AIR STRIPPING TOWER SIZING

Q Water = 1,400 GPM
Q Air = 5,614 CFM

COMPOUND	DESIGN EFFLUENT (ug/L)	SCENARIO "B"	
		DESIGN INFLUENT (ug/L)	REQUIRED PACKING HEIGHT (ft)
TCE	1	400	20.0
1,1-DCA	1	20	11.0
1,1,1-TCA	1	20	11.0
PCE	1	100	9.0
CIS-1,2-DCE	1	200	20.0

TABLE 5-3A

SOUTH FARMINGDALE WATER DISTRICT

PACKED COUNTER CURRENT TREATMENT TOWER
FOR WELL NO. 1-2
PRELIMINARY DESIGN SUMMARY

Air Stripper No.1 (Well No.1-2)

Design Capacity	1,200 GPM
Design Contaminant	TCE
Probable Upper Raw Water Influent Level	400 ug/L
Treated Effluent Level	1 ug/L
Percent TCE Removal	99.75
Liquid Loading Rate	15.3 GPM per square foot
Temperature	55 degrees F
Henry's Constant	0.2315
Mass Transfer Coefficient	46.9 HR^{-1}
Air-to-Water Ratio	45:1
Air Flow	7,218 CFM
Packing	2-inch diameter Jaeger Tripacks
Tower Diameter	10 feet
Packing Height	17 feet
Overall Tower Height	29 feet (approximate)
Approximate Clearwell Size, 30 Min. Contact Time	22' wide x 22' long x 10' deep

TABLE 5-3B

SOUTH FARMINGDALE WATER DISTRICT

PACKED COUNTER CURRENT TREATMENT TOWER
FOR WELL NO. 1-3
PRELIMINARY DESIGN SUMMARY

Air Stripper No.2 (Lead Tower for Well Nos. 1-3 and 1-4)

Design Capacity	1,400 GPM
Design Contaminant	TCE
Probable Upper Raw Water Influent Level	400 ug/L
Treated Effluent Level	1 ug/L
Percent TCE Removal	99.75
Liquid Loading Rate	17.8 GPM per square foot
Temperature	55 degrees F
Henry's Constant	0.2315
Mass Transfer Coefficient	46.9 HR^{-1}
Air-to-Water Ratio	45:1
Air Flow	8,412 CFM
Packing	2-inch diameter Jaeger Tripacks
Tower Diameter	10 feet
Packing Height	20 feet
Overall Tower Height	32 feet (approximate)
Approximate Clearwell Size, 30 Min. Contact Time	24' wide x 24' long x 10' deep

TABLE 5-3C

SOUTH FARMINGDALE WATER DISTRICT

PACKED COUNTER CURRENT TREATMENT TOWER FOR WELL NO. 1-4 PRELIMINARY DESIGN SUMMARY

Air Stripper No.2 (Lag Tower for Well Nos. 1-3 and 1-4)

Design Capacity	1,400 GPM
Design Contaminant	TCE
Probable Upper Raw Water Influent Level	400 ug/L
Treated Effluent Level	1 ug/L
Percent TCE Removal	99.75
Liquid Loading Rate	17.8 GPM per square foot
Temperature	55 degrees F
Henry's Constant	0.2315
Mass Transfer Coefficient	46.9 HR^{-1}
Air-to-Water Ratio	45:1
Air Flow	8,412 CFM
Packing	2-inch diameter Jaeger Tripacks
Tower Diameter	10 feet
Packing Height	20 feet
Overall Tower Height	32 feet (approximate)
Approximate Clearwell Size, 30 Min. Contact Time	24' wide x 24' long x 10' deep

TABLE 5-4A

SOUTH FARMINGDALE WATER DISTRICT

GAC FILTRATION TREATMENT SYSTEM
FOR WELL NO. 1-2
PRELIMINARY DESIGN SUMMARY

Design Capacity	1,200 GPM
Design Contaminant	1,1-DCA
Probable Upper Raw Water Influent Level	20 ug/L
Number of Filter Units	Two (2)
Operation	Parallel
Carbon	20,000 pounds per vessel
Filter Unit Size:	
Bed Height	12 feet
Diameter	10 feet
Total Height	19 feet
Hydraulic Loading	7.6 GPM/SF
Design Flow per Vessel	600 GPM
Pressure Drop across each Filter Unit	12 psi
Design Empty Bed Contact Time	11.8 minutes
Minimum Empty Bed Contact Time	7.5 minutes
Useful Filter Bed Volume	785 cubic feet

TABLE 5-4B

SOUTH FARMINGDALE WATER DISTRICT

GAC FILTRATION TREATMENT SYSTEM FOR WELL NOS. 1-3 AND 1-4 PRELIMINARY DESIGN SUMMARY

Design Capacity	2,600 GPM
Design Contaminant	1,1-DCA
Probable Upper Raw Water Influent Level	20 ug/L
Number of Filter Units	Five (5)
Operation	Parallel
Carbon	20,000 pounds per vessel
Filter Unit Size:	
Bed Height	12 feet
Diameter	10 feet
Total Height	19 feet
Hydraulic Loading	6.6 GPM/SF
Design Flow per Vessel	520 GPM
Pressure Drop across each Filter Unit	12 psi
Design Empty Bed Contact Time	13.6 minutes
Minimum Empty Bed Contact Time	7.5 minutes
Useful Filter Bed Volume	785 cubic feet

TABLE 5-5A

SOUTH FARMINGDALE WATER DISTRICT

IRON REMOVAL TREATMENT SYSTEM
FOR WELL NO. 1-2
PRELIMINARY DESIGN SUMMARY

Design Capacity	1,200 GPM
Maximum Iron Level	3.0 mg/L
Hydraulic Loading Rate	3.8 GPM/SF
Recommended Oxidation Method	Chlorination
Recommended Filter Media	Manganese Greensand
Number of Filter Units	Two
Operation	Parallel
Filter Unit Size:	
Diameter	8 feet
Length	20 feet
Filtration Area Per Unit	160 SF
Number of Cells Per Unit	2
Design Flow Per Filter	600 GPM
Maximum Flow Per Filter With One Unit Out of Service	1,200 GPM (7.6 GPM/SF)
Backwash Loading Rate	12 GPM/SF
Estimated Backwash Cycle Based on Influent Iron Level of 3 mg/L	Every 16 hours (1.152 MG) for 10 minutes per cell
Backwash Flow Rate Per Cell	960 GPM
Estimated Iron Sludge Generated Based on 3 mg/L	45 lbs./day
Total Volume of Backwash Water Produced	38,400 gallons per cycle
Recommended Backwash Water Disposal Method	Discharge to sanitary sewer system

TABLE 5-5B

SOUTH FARMINGDALE WATER DISTRICT

IRON REMOVAL TREATMENT SYSTEM FOR WELL NOS. 1-3 AND 1-4 PRELIMINARY DESIGN SUMMARY

Design Capacity	2,600 GPM
Maximum Iron Level	3.0 mg/L
Hydraulic Loading Rate	5.0 GPM/SF
Recommended Oxidation Method	Chlorination
Recommended Filter Media	Manganese Greensand
Number of Filter Units	Three
Operation	Parallel
Filter Unit Size: Diameter Length	 8 feet 22 feet
Filtration Area Per Unit	176 SF
Number of Cells Per Unit	2
Design Flow Per Filter	867 GPM
Maximum Flow Per Filter With One Unit Out of Service	1,300 GPM
Backwash Loading Rate	12 GPM/SF
Estimated Backwash Cycle Based on Influent Iron Level of 3 mg/L	Every 13 hours (2.0 MG) for 10 minutes per cell
Backwash Flow Rate Per Cell	1,056 GPM
Estimated Iron Sludge Generated Based on 3 mg/L	98 lbs./day
Total Volume of Backwash Water Produced	63,360 gallons per cycle
Recommended Backwash Water Disposal Method	Discharge to sanitary sewer system

TABLE 6-1

SOUTH FARMINGDALE WATER DISTRICT

OPINION OF COST
PLANT NO. 1
GAC TREATMENT WITH IRON REMOVAL SYSTEM

1.	Site work, drainage and utilities, landscaping	$300,000
2.	GAC Filter Buildings, general construction	$1,000,000
3.	GAC Filters (20 vessels) with initial carbon	$500,000
4.	Electrical controls and power distribution, new generator sets	$1,000,000
5.	Well pump restaging for each well	$150,000
6.	Mechanical work and piping	$400,000
	GAC TREATMENT SUBTOTAL	**$3,350,000**
7.	Iron removal treatment equipment, filter vessels, pretreatment equipment	$800,000
8.	Treatment buildings, general construction	$600,000
9.	Backwash water equilization tanks and equipment	$300,000
10.	Mechanical work, piping modifications	$300,000
11.	Electrical work, instrumentation, controls, modifications	$400,000
	IRON REMOVAL TREATMENT SUBTOTAL	**$2,400,000**
	CONSTRUCTION SUBTOTAL	**$5,750,000**
	Engineering, Permits and Design & Construction Administration	$690,000
	Construction Observation	$287,500
	Legal	$57,500
	Contingencies	$575,000
	PROJECT TOTAL	**$7,360,000**

TABLE 6-2

SOUTH FARMINGDALE WATER DISTRICT

OPINION OF COST
PLANT NO. 1
AIR STRIPPING TREATMENT WITH IRON REMOVAL SYSTEM

1.	Site work, drainage and utilities, landscaping	$300,000
2.	Stainless steel air stripping towers with packing, blowers and blower motors, inlet weirs, redistribution, inlet air filtering,	$750,000
3.	Air Stripper Buildings, general construction	$800,000
4.	Installation of electrical controls and power distribution associated with the treatment system, new generator sets	$1,500,000
5.	Installation of clearwells	$400,000
6.	Mechanical work, piping modifications	$500,000
7.	Well pump work at each well	$150,000
	AIR STRIPPING SUBTOTAL	**$4,400,000**
8.	Iron removal treatment equipment, filter vessels, pretreatment equipment	$800,000
9.	Treatment buildings, general construction	$600,000
10.	Backwash water equilization tanks and equipment	$300,000
11.	Mechanical work, piping modifications	$300,000
12.	Electrical work, instrumentation, controls, modifications	$400,000
	IRON REMOVAL TREATMENT SUBTOTAL	**$2,400,000**
	CONSTRUCTION SUBTOTAL	**$6,800,000**
	Engineering, Permits and Design & Construction Administration	$816,000
	Inspection	$340,000
	Legal	$68,000
	Contingencies	$680,000
	PROJECT TOTAL	**$8,704,000**

TABLE 6-3

SOUTH FARMINGDALE WATER DISTRICT

OPINION OF COST
GAC CONSUMPTION - WELLS AT PLANT NO. 1

COMPOUND	INFLUENT CONCENTRATION (ug/L)	CARBON CONSUMPTION (lbs) PER MILLION GALLONS[1] OF TREATED WATER	CARBON COST PER 1,000 GALLONS TREATED WATER[2]
TCE	200	68	$0.0680
1,1,1-TCA	20	60	$0.0600
1,1-DCA	20	139	$0.1390
PCE	100	14	$0.0140
CIS-1,2-DCE	200	139	$0.1390

(1) Assumes 70% of Freundlich Prediction is obtained

(2) Assumes cost of carbon and subsequent disposal is $1.00/pound

TABLE 6-4

SOUTH FARMINGDALE WATER DISTRICT

SUMMARY OF ADDITIONAL ANNUAL OPERATING COSTS AFTER INSTALLATION OF NEW TREATMENT SYSTEM GRANULAR ACTIVATED CARBON

INCREASE IN ANNUAL ELECTRICAL OPERATING COSTS

1. Electric Utility Provider: LIPA
2. Electrical Rate Code: 285
3. Existing Plant Electrical Demand Prior to New Treatment System: 280 KW
   New Plant Electrical Demand Including New Treatment System: 346 KW
   Increase in Plant Electrical Demand: 86 KW

4. Demand Charges:

Increased Demand	Monthly Rate Charge	Monthly Charges	Annual Costs
86 KW	$19.65 / KW	$1,689.90	$ 20,280

5. Consumption Charges:

Increased Demand	Operating Hours*	Annual Demand	Electrical Rate Charge	Annual Costs
86 KW	1580 Hrs	135,880 KW Hrs	$0.0877 / KW Hr	$ 11,920

Increase in Annual Electrical Operating Costs = $20,280 + $11,920 = **$ 32,200**

* - Based on average Annual Pumpage over the last five years.

INCREASE IN HEATING OPERATING COSTS

1. Existing Plant Heating System: 50 KW Electric Heat
2. New Plant Heating System: 110 KW Electric Heat
3. Assume Seven (7) Month Heating Season (October through April)
4. Demand Charges:

Increased Demand	Monthly Rate Charge	Monthly Charges	Annual Costs
60 KW	$4.68 / KW	$280.08	$ 1,970

5. Consumption Charges:

Increased Demand	Operating Hours*	Annual Demand	Electrical Rate Charge	Annual Costs
60 KW	5040 Hrs	302,400 KW Hrs	$0.077 / KW Hr	$ 23,285

Increase in Annual Electrical Operating Costs = $1,970 + $23,285 = **$ 25,255**

TABLE 6-4 (CONT'D)

SOUTH FARMINGDALE WATER DISTRICT

SUMMARY OF ADDITIONAL ANNUAL OPERATING COSTS AFTER INSTALLATION OF NEW TREATMENT SYSTEM GRANULAR ACTIVATED CARBON

GAC REPLACEMENT COSTS

1. Quantity of vessels: 7
2. Carbon per vessel: 20,000 lbs.
3. Frequency of carbon replacement: Annually

Annual GAC Replacement Costs = ($1.00 per lb.) ($140,000 lbs.) = **$140,000**

INCREASE IN ANNUAL LAB MONITORING OPERATING COSTS

1. Monthly VOC and IOC Water Samples Required for Raw and Treated Water
2. VOC Sample Rate Charge = $295 / Sample
3. IOC Sample Rate Charge = $375 / Sample
4. Total Sample Rate Charge = $670 / Sample
5. Annual Number of Samples Required = 6 Samples / Month x 12 Months = 72 Samples

Increase in Annual Lab Monitoring Operating Costs = $670 x 72 Samples = **$ 48,240**

INCREASE IN ANNUAL PLANT MONITORING LABOR COSTS

1. Required Additional Plant Monitoring = 2 Hrs / Day
2. Required Additional Man-hours = 2 Hrs / Day x 365 Days / year = 730 Hrs

Increase in Annual Plant Monitoring Labor Costs = $30 / Hr* x 730 Hrs = **$ 21,900**

* - Estimated hourly rate for plant operator

INCREASE IN COSTS ASSOCIATED WITH 30 YEAR LIFE OF NEW EQUIPMENT

Iron Removal Media:

Replace Every Fifteen Years
Cost for Media Replacement = $50,000
Lifetime Costs for Media = $50,000 x 2 = $100,000

Annual Costs for 30 Year Life of New Equipment = $\frac{\$100{,}000}{30}$ = **$ 3,333**

TABLE 6-4 (CONT'D)

SOUTH FARMINGDALE WATER DISTRICT

SUMMARY OF ADDITIONAL ANNUAL OPERATING COSTS AFTER INSTALLATION OF NEW TREATMENT SYSTEM GRANULAR ACTIVATED CARBON

SUM OF INCREASE IN ANNUAL DISTRICT OPERATING COSTS

1. Increase in Annual Electrical Operating Costs:	$ 32,200
2. Increase in Annual Heating Operating Costs:	$ 25,255
3. Annual GAC Replacement Costs:	$140,000
4. Increase in Annual Lab Monitoring Operating Costs:	$ 48,240
5. Increase in Plant Monitoring Operating Costs:	$ 21,900
6. Increase in Annual Costs Associated with 30 Year Life of New Equipment:	$ 3,333
SUM OF INCREASE IN ANNUAL DISTRICT OPERATING COSTS:	**$270,928**

PRESENT WORTH VALUE

Additional Annual Operating Costs:	$270,928
Treatment System Life:	30 Years
Operating Cost Inflation Rate:	5.0%
Investment Interest Rate:	1.5%

PRESENT WORTH VALUE: **$13,868,000**

TABLE 6-5

SOUTH FARMINGDALE WATER DISTRICT

SUMMARY OF ADDITIONAL ANNUAL OPERATING COSTS AFTER INSTALLATION OF NEW TREATMENT SYSTEM AIR STRIPPING

INCREASE IN ANNUAL ELECTRICAL OPERATING COSTS

1. Electric Utility Provider: LIPA
2. Electrical Rate Code: 285
3. Existing Plant Electrical Demand Prior to New Treatment System: 280 KW
   New Plant Electrical Demand Including New Treatment System: 436 KW
   Increase in Plant Electrical Demand: 156 KW

4. Demand Charges:

Increased Demand	Monthly Rate Charge	Monthly Charges	Annual Costs
156 KW	$19.65 / KW	$3,065.40	$ 36,785

5. Consumption Charges:

Increased Demand	Operating Hours*	Annual Demand	Electrical Rate Charge	Annual Costs
156 KW	1580 Hrs	246,480 KW Hrs	$0.0877 / KW Hr	$ 21,615

Increase in Annual Electrical Operating Costs = $36,785 + $21,615 = **$58,400**

* - Based on average Annual Pumpage over the last five years.

INCREASE IN HEATING OPERATING COSTS

1. Existing Plant Heating System: 50 KW Electric Heat
2. New Plant Heating System: 110 KW Electric Heat
3. Assume Seven (7) Month Heating Season (October through April)
4. Demand Charges:

Increased Demand	Monthly Rate Charge	Monthly Charges	Annual Costs
60 KW	$4.68 / KW	$280.08	$ 1,970

5. Consumption Charges:

Increased Demand	Operating Hours*	Annual Demand	Electrical Rate Charge	Annual Costs
60 KW	5040 Hrs	302,400 KW Hrs	$0.077 / KW Hr	$23,285

Increase in Annual Electrical Operating Costs = $1,970 + $23,285 = **$25,255**

TABLE 6-5 (CONT'D)

SOUTH FARMINGDALE WATER DISTRICT

SUMMARY OF ADDITIONAL ANNUAL OPERATING COSTS AFTER INSTALLATION OF NEW TREATMENT SYSTEM AIR STRIPPING

ANNUAL FILTER REPLACEMENT OPERATING COSTS

1. Pre-Filters Must Be Replaced Every Month of Operation
2. Filters Must Be Replaced Twice per Year
3. Cost of Replacing Pre-Filters = $900
4. Cost of Replacing Filters = $1,800

Annual Filter Replacement Operating Costs = ($900 x 12) + ($1,800 x 2) = **$ 14,400**

INCREASE IN ANNUAL LAB MONITORING OPERATING COSTS

1. Monthly VOC and IOC Water Samples Required for Raw and Treated Water
2. VOC Sample Rate Charge = $295 / Sample
3. IOC Sample Rate Charge = $375 / Sample
4. Total Sample Rate Charge = $670 / Sample
5. Annual Number of Samples Required = 6 Samples / Month x 12 Months = 72 Samples

Increase in Annual Lab Monitoring Operating Costs = $670 x 72 Samples = **$ 48,240**

INCREASE IN ANNUAL PLANT MONITORING LABOR COSTS

1. Required Additional Plant Monitoring = 2 Hrs / Day
2. Required Additional Man-hours = 2 Hrs / Day x 365 Days / year = 730 Hrs

Increase in Annual Plant Monitoring Labor Costs = $30 / Hr* x 730 Hrs = **$ 21,900**

* - Estimated hourly rate for plant operator

INCREASE IN COSTS ASSOCIATED WITH 30 YEAR LIFE OF NEW EQUIPMENT

1. Iron Removal Media:

Replace Every Fifteen Years
Cost for Media Replacement = $50,000
Lifetime Costs for Media = $50,000 x 2 = <u>$100,000</u>

TABLE 6-5 (CONT'D)

SOUTH FARMINGDALE WATER DISTRICT

SUMMARY OF ADDITIONAL ANNUAL OPERATING COSTS AFTER INSTALLATION OF NEW TREATMENT SYSTEM AIR STRIPPING

2. Air Stripping Media:

Replace Every Fifteen Years
Cost for Media Replacement = $30,000
Lifetime Costs for Media = $30,000 x 2 = $60,000

3. Blowers (Total of Three):

Overhaul Blower Motor Every Five Years
Cost for Blower Motor Overhaul = $1,000
Lifetime Costs for Blower Motor Overhauls = $1,000 x 12 = $12,000
Replace Blower Every Fifteen Years
Cost for New Blower = $2,000
Lifetime Costs for New Blowers = $2,000 x 6 = $12,000

4. Booster Pumps (Total of Five):

Rehabilitate Booster Pump and Motor Every Five Years
Cost for Booster Pump and Motor Rehabilitation = $5,000
Lifetime Costs for Booster Pump and Motor Rehabilitations = $5,000 x 20 = $100,000
Replace Booster Pump and Motor Every Fifteen Years
Cost for New Booster Pump and Motor = $20,000
Lifetime Costs for New Booster Pumps and Motors = $20,000 x 10 = $200,000

Total Costs Associated with 30 Year Life of New Equipment:

1. Lifetime Costs for Iron Removal Media Replacement:	$100,000
2. Lifetime Costs for Air Stripping Media Replacement:	$ 60,000
3. Lifetime Costs for Blower Motor Overhauls:	$ 12,000
4. Lifetime Costs for New Blowers:	$ 12,000
5. Lifetime Costs for Booster Pump and Motor Rehabilitations:	$100,000
6. Lifetime Costs for New Booster Pumps and Motors:	$200,000
Total Costs Associated with 30 Year Life of New Equipment:	$484,000

Assumed Annual Costs for 30 Year Life of New Equipment = $\frac{\$484,000}{30}$ = **$ 16,133**

TABLE 6-5 (CONT'D)

SOUTH FARMINGDALE WATER DISTRICT

SUMMARY OF ADDITIONAL ANNUAL OPERATING COSTS AFTER INSTALLATION OF NEW TREATMENT SYSTEM AIR STRIPPING

SUM OF INCREASE IN ANNUAL DISTRICT OPERATING COSTS

1. Increase in Annual Electrical Operating Costs:	$ 58,400
2. Increase in Annual Heating Operating Costs:	$ 25,255
3. Annual Filter Replacement Costs:	$ 14,400
4. Increase in Annual Lab Monitoring Operating Costs:	$ 48,240
5. Increase in Plant Monitoring Operating Costs:	$ 21,900
6. Increase in Annual Costs Associated with 30 Year Life of New Equipment:	$ 16,133
SUM OF INCREASE IN ANNUAL DISTRICT OPERATING COSTS:	**$ 184,328**

PRESENT WORTH VALUE

Additional Annual Operating Costs:	$184,328
Treatment System Life:	30 Years
Operating Cost Inflation Rate:	5.0%
Investment Interest Rate:	1.5%

PRESENT WORTH VALUE: **$9,435,000**

TABLE 7-1

SOUTH FARMINGDALE WATER DISTRICT

AIR STRIPPING FOR ORGANICS REMOVAL AT PLANT NO. 1

PROPOSED PROJECT SCHEDULE

TASK	DATE
1. Engineering report completion and submission to Health Department.	December 2003
2. Commence with preparation of plans and specifications.	October 2005
3. Submit plans, specifications and permits to Health Department.	April 2006
4. Receive Health Department approval.	August 2006
5. Advertise and receive bids.	September 2006
6. Execute contract and proceed with construction.	November 2006
7. Complete construction and treatment system testing.	November 2007

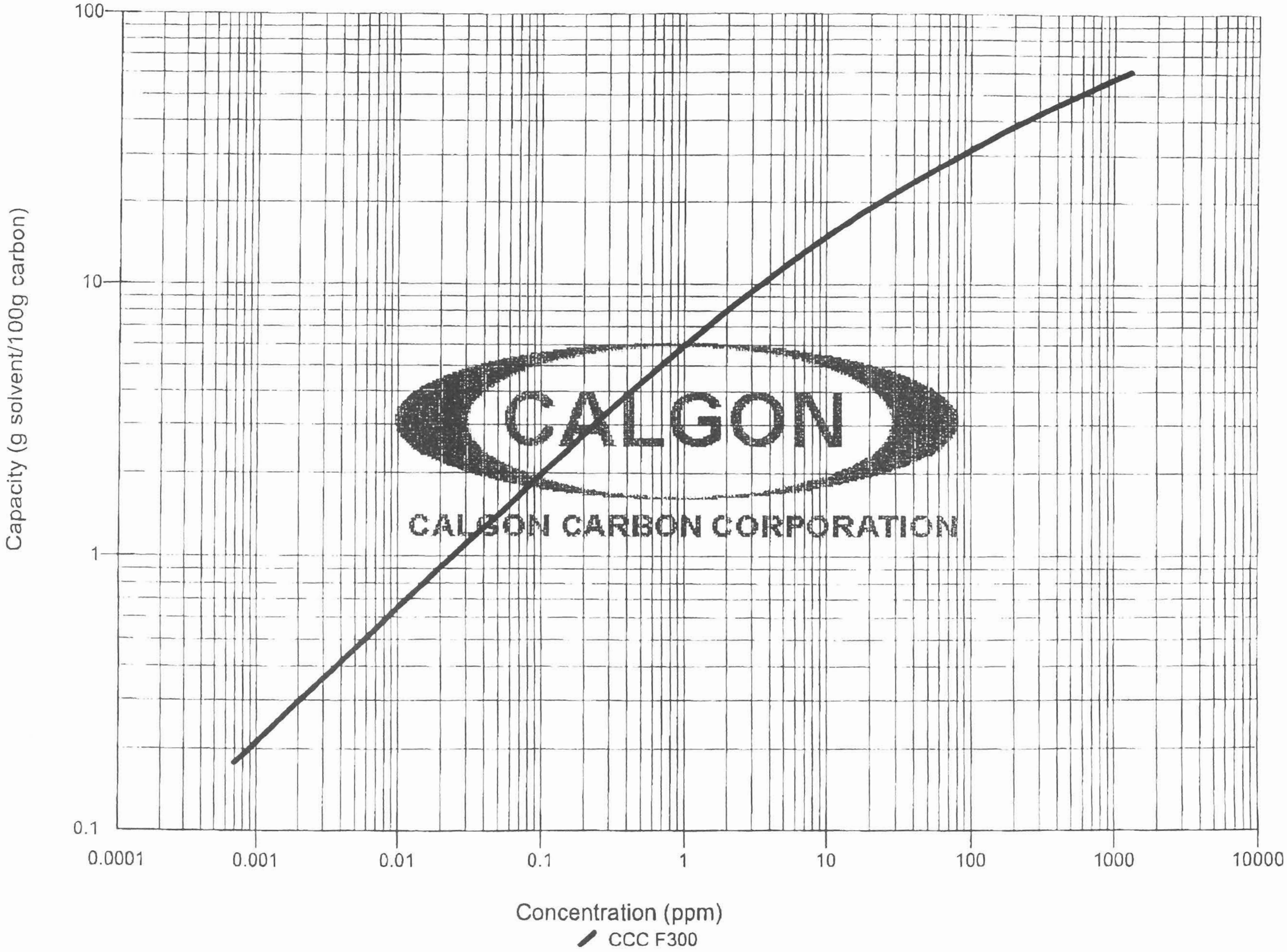
FIGURES

FIGURE 2-1

SOUTH FARMINGDALE WATER DISTRICT
LOCATION MAP

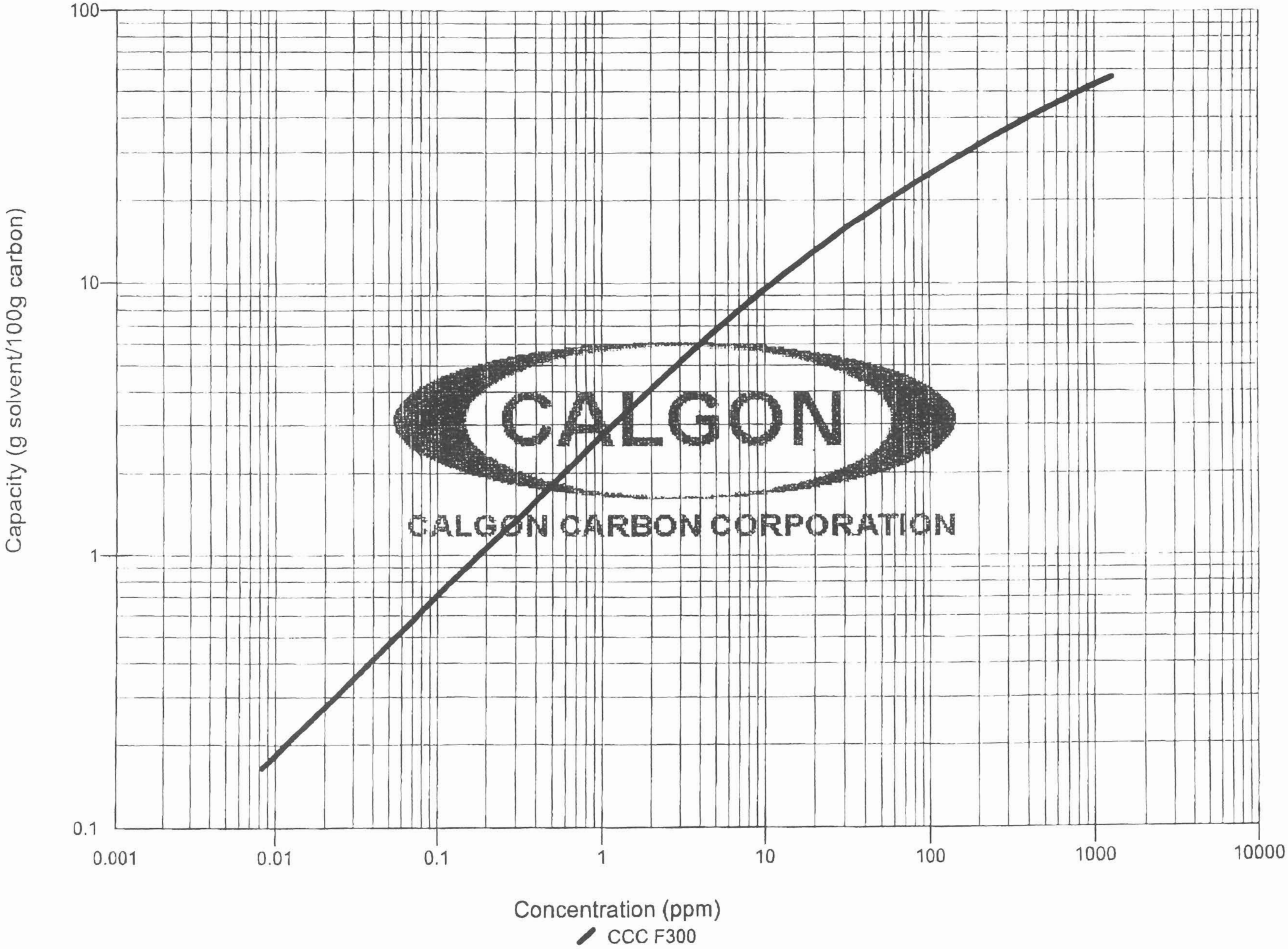
NO SCALE

Liquid Phase Isotherm for Trichloroethylene at 25 C and 1 psia



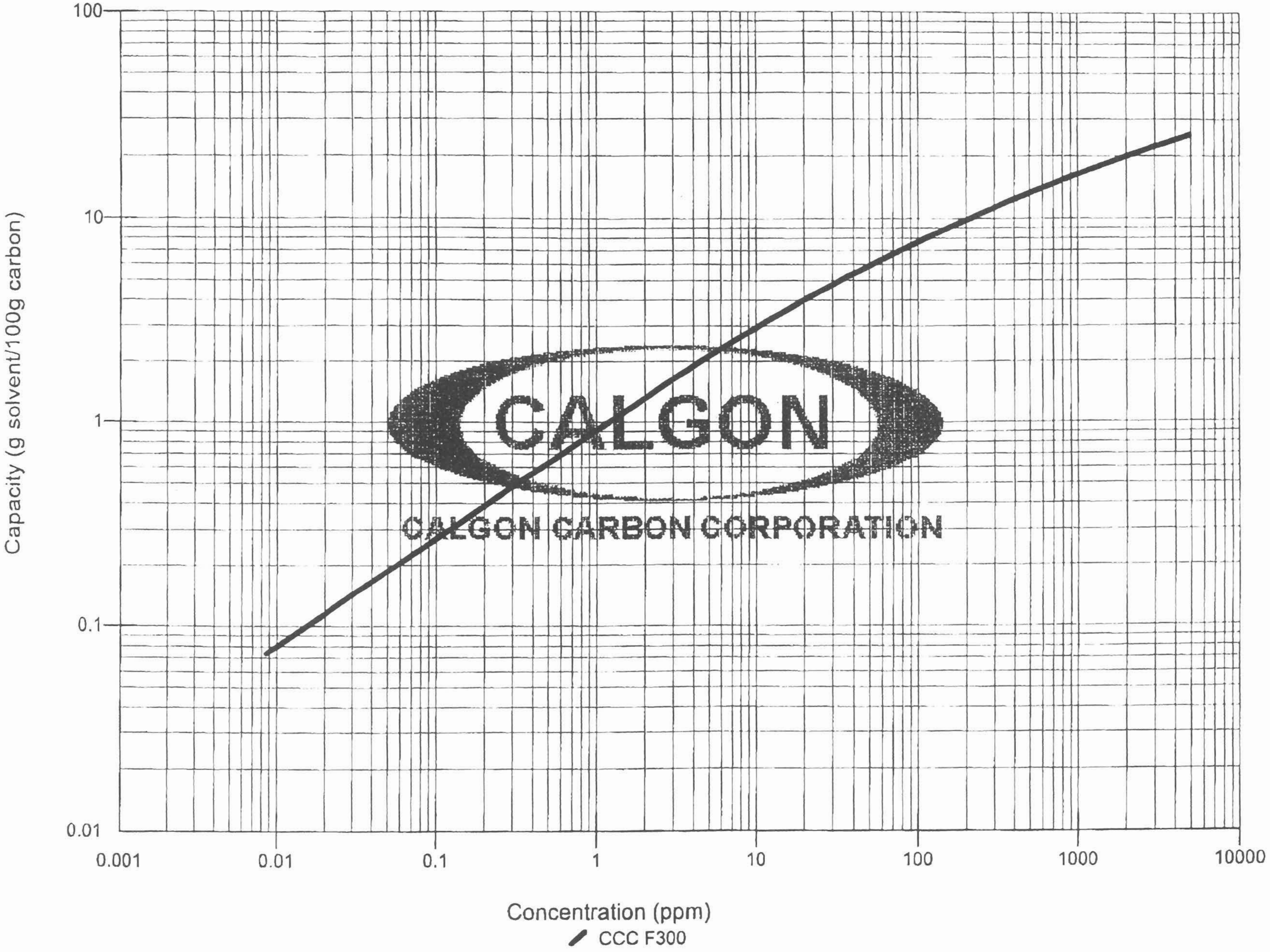
This information has been generated using Calgon Carbon's proprietary predictive model. The model provides an adsorbent use rate estimate based on the input conditions specified by the user. There is no expressed or implied warranty regarding the suitability or applicability of results.

Liquid Phase Isotherm for 1,1,1-Trichloroethane at 25 C and 1 psia



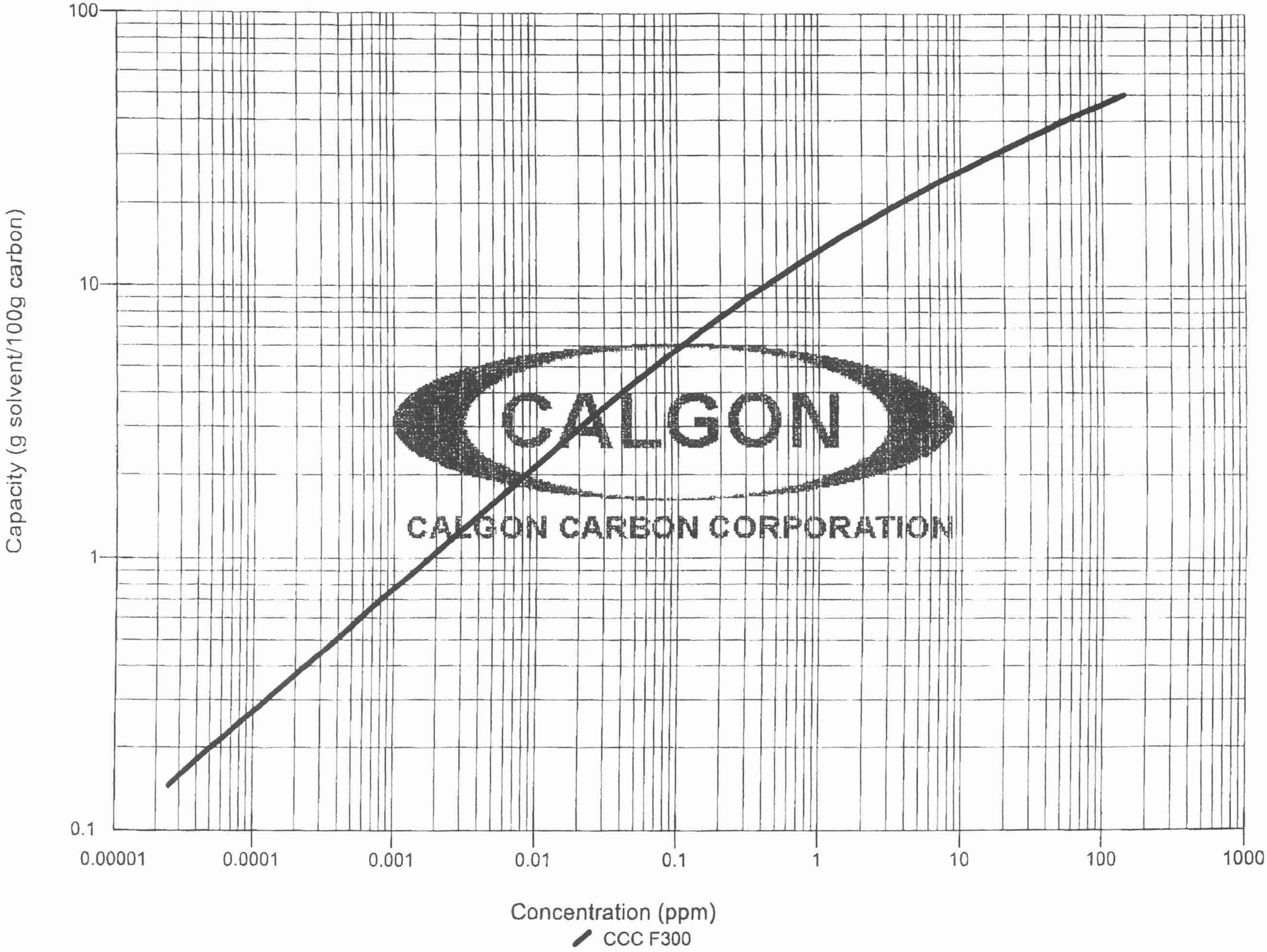
This information has been generated using Calgon Carbon's proprietary predictive model. The model provides an adsorbent use rate estimate based on the input conditions specified by the user. There is no expressed or implied warranty regarding the suitability or applicability of results.

Liquid Phase Isotherm for 1,1-Dichloroethane at 25 C and 1 psia



This information has been generated using Calgon Carbon's proprietary predictive model. The model provides an adsorbent use rate estimate based on the input conditions specified by the user. There is no expressed or implied warranty regarding the suitability or applicability of results.

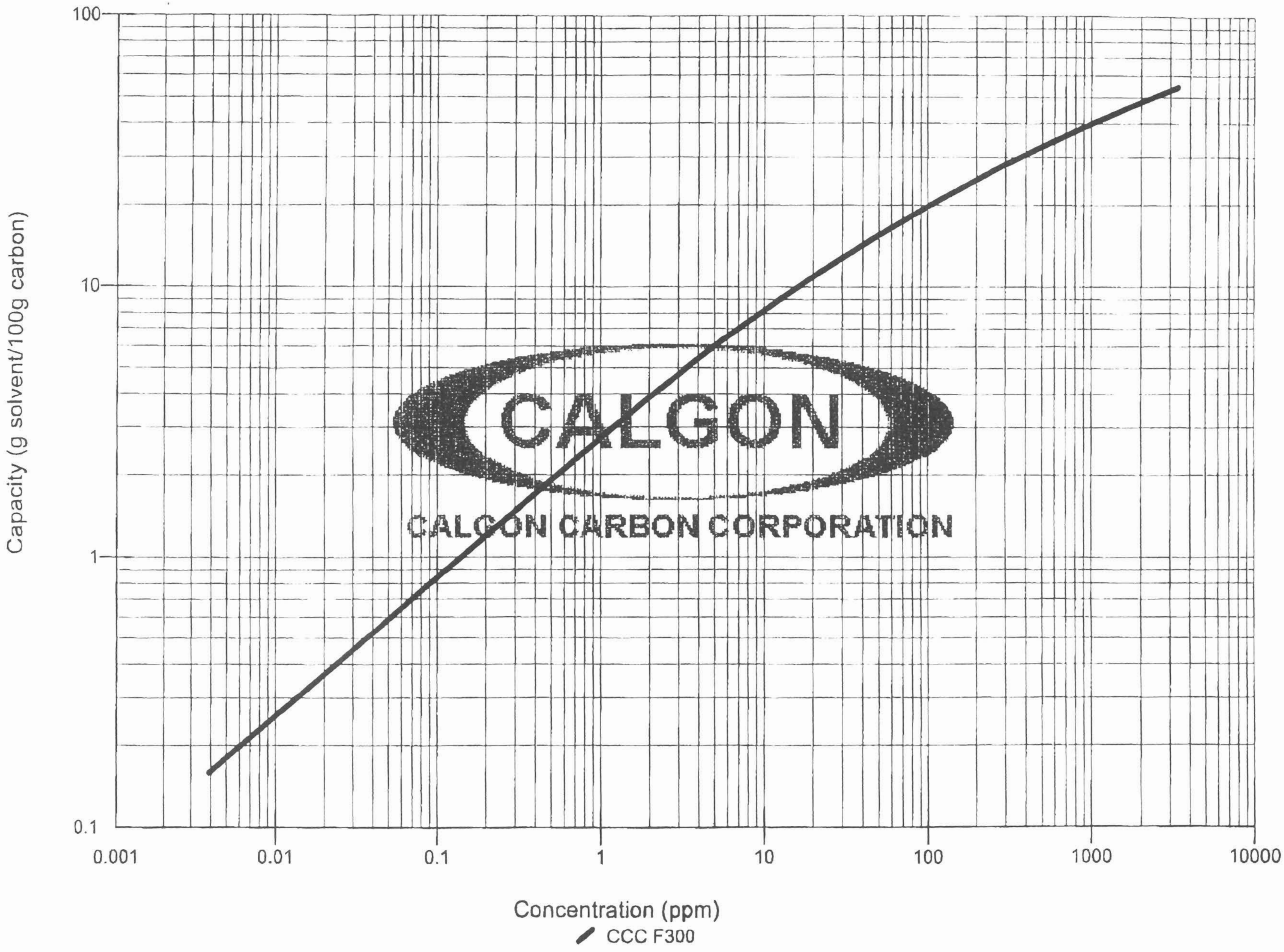
Liquid Phase Isotherm for Tetrachloroethylene at 25 C and 1 psia



This information has been generated using Calgon Carbon's proprietary predictive model. The model provides an adsorbent use rate estimate based on the input conditions specified by the user. There is no expressed or implied warranty regarding the suitability or applicability of results.

3/14/02

Liquid Phase Isotherm for 1,2-Dichloroethylene(cis) at 25 C and 1 psia



This information has been generated using Calgon Carbon's proprietary predictive model. The model provides an adsorbent use rate estimate based on the input conditions specified by the user. There is no expressed or implied warranty regarding the suitability or applicability of results.

PLAN VIEW AND LINE OF SECTION

0' 1000' 2000'
SCALE: 1" = 1000'

EXPLANATION

▬ ▬ ▬ ▬	PROPERTY BOUNDARY OF THE FORMER RUCO POLYMER SITE
▬ - - ▬	PROPERTY BOUNDARY OF THE FORMER GRUMMAN AEROSPACE SITE
▬ · ▬ · ▬	PROPERTY BOUNDARY OF U.S. NAVY SITE
▒	DENOTES NORTHROP GRUMMAN OWNED PROPERTY
▨	DENOTES U.S. NAVY OWNED PROPERTY
▤	BASINS
6781 ▲	INDUSTRIAL WELL
747 ●	PUBLIC SUPPLY WELL
9918 ◆	OBSERVATION, MONITORING WELL
8799 ✱	IRRIGATION WELL
6635 ?	UNKNOWN USE OF WELL
GP-4 ✱	NORTHROP GRUMMAN OR NAVY PRODUCTION OR EXTRACTION WELL
▬	SHALLOW WELLS
▬	INTERMEDIATE WELLS
▬	DEEP WELLS
▬	DEEP 2 WELLS
SFWD	SOUTH FARMINGDALE WATER DISTRICT
LWD	LEVITTOWN WATER DISTRICT
NYWS	NEW YORK WATER SERVICE
BWD	BETHPAGE WATER DISTRICT
TOH	TOWN OF HEMPSTEAD WATER DISTRICT
HWD	HICKSVILLE WATER DISTRICT
VOF	VILLAGE OF FARMINGDALE WATER DISTRICT
VPB	VERTICAL PROFILE BORING
◈	ABANDONED OR DESTROYED WELL
⊗ VPB-51	EXISTING VPB LOCATION AND DESIGNATION

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CONSULTANTS

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MARK	DATE	DESCRIPTION

ISSUE:	
PROJECT NO:	SFWD 03-02B
DATE:	NOVEMBER 2003
CAD DWG FILE:	SITE-GRDG.DWG
XREF DWG FILE:	XR_SITE
SCALE:	
FILE LOCATION:	–
DESIGNED BY:	–
DRAWN BY:	TAA
CHECKED BY:	MAC
REVIEWED BY:	RWH

SOUTH FARMINGDALE WATER DISTRICT

ENGINEERING REPORT FOR VOLATILE ORGANICS REMOVAL AT PLANT No. 1

CONTRACT

NOT FOR CONSTRUCTION

SHEET TITLE

WELL LOCATIONS
NORTHROP GRUMMAN
BETHPAGE, NY

SHEET NUMBER

3-1

M:\cadd\SFWD\0302B\SITE.dwg Last Modified: Sep 25, 2003 - 10:18am Plotted on: Nov 18, 2003 - 3:17pm By cadd118