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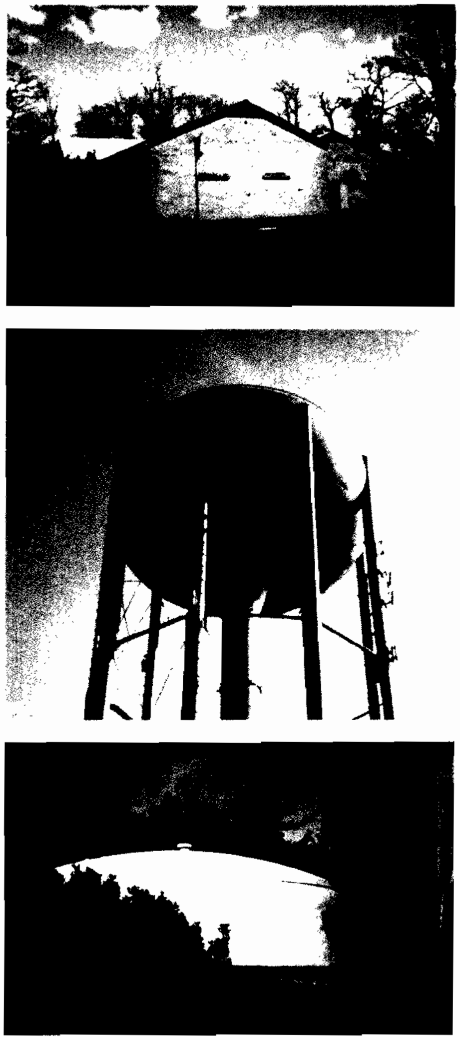
MASSAPEQUA WATER DISTRICT
NASSAU COUNTY, NEW YORK



ENGINEERING REPORT

WATER QUALITY STUDY

OCTOBER 2000

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RLA/MWD/1592(10/3/00)

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MASSAPEQUA WATER DISTRICT

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WATER QUALITY STUDY

INTRODUCTION

BACKGROUND

The Massapequa Water District supplies water to approximately 13,750 services in an area of approximately 6.5 square miles. The District service area includes the unincorporated area of Massapequa and the Incorporated Village of Massapequa Park.

The Massapequa Water District maintains four water supply sites with four well pump stations, eight operating supply wells, three booster pump stations, four storage tanks and approximately 146 miles of water mains. The District serves a residential population of approximately 40,000 persons.

The quality of the District's groundwater supply has been excellent, meeting Federal and State Drinking Water Standards, except that the concentration of iron in the water produced by five of the District's wells exceeds the aesthetic maximum containment level (MCL). The District treats all of its wells with phosphate to sequester the iron present in the water and to inhibit corrosion of the District's unlined cast iron water mains. The District also treats the water produced by all of its wells with sodium hypochlorite to oxidize any hydrogen sulfide that may be present in the raw well water. The chlorine treatment also maintains the quality of the water in the distribution system. Disinfection by chlorination is required by Part 5 of the New York State Sanitary Code.

Even though the water distributed by the District meets all Federal and State Drinking Water Standards, the District has always had a concern about the levels of iron present in the raw water, the need to treat with phosphates to sequester the iron and the need for chlorination.

PURPOSE AND SCOPE

The purpose of this study and report is to review the naturally occurring chemical composition of the water that the District pumps from the groundwater aquifer; to review the current water treatment practices, all of which add chemicals to the water before it is pumped to the distribution system; to investigate alternative treatment practices; to investigate any known health risks of the chemicals naturally present in the water and of those chemicals which are added to the water; and to present conclusions and recommendations.

This study was performed as a joint effort by Sidney B. Bowne and Son (Bowne) and Dvirka and Bartilucci (D&B). The Health Risk Literature Review was prepared by Walter W. Faber, Jr., Ph.D., Assistant Professor, Manhattan College.

HYDROGEOLOGIC SETTING

The geology of the District's service area has been covered in detail in many past United States Geological Survey reports and is only outlined briefly in this report. The area is part of the glaciated region of the Atlantic Coastal Plain, and as such has highly pervious surficial soils and is underlain by substantial thickness of sand and gravel, interbedded with finer deposits of silt and clay. A detailed description of the geologic formations and aquifer can be found in the New York State, Department of Conservation, Water Power and Control Commission Bulletin GW-18, titled "Mapping of Geologic Formations and Aquifer of Long Island, New York," dated 1949.

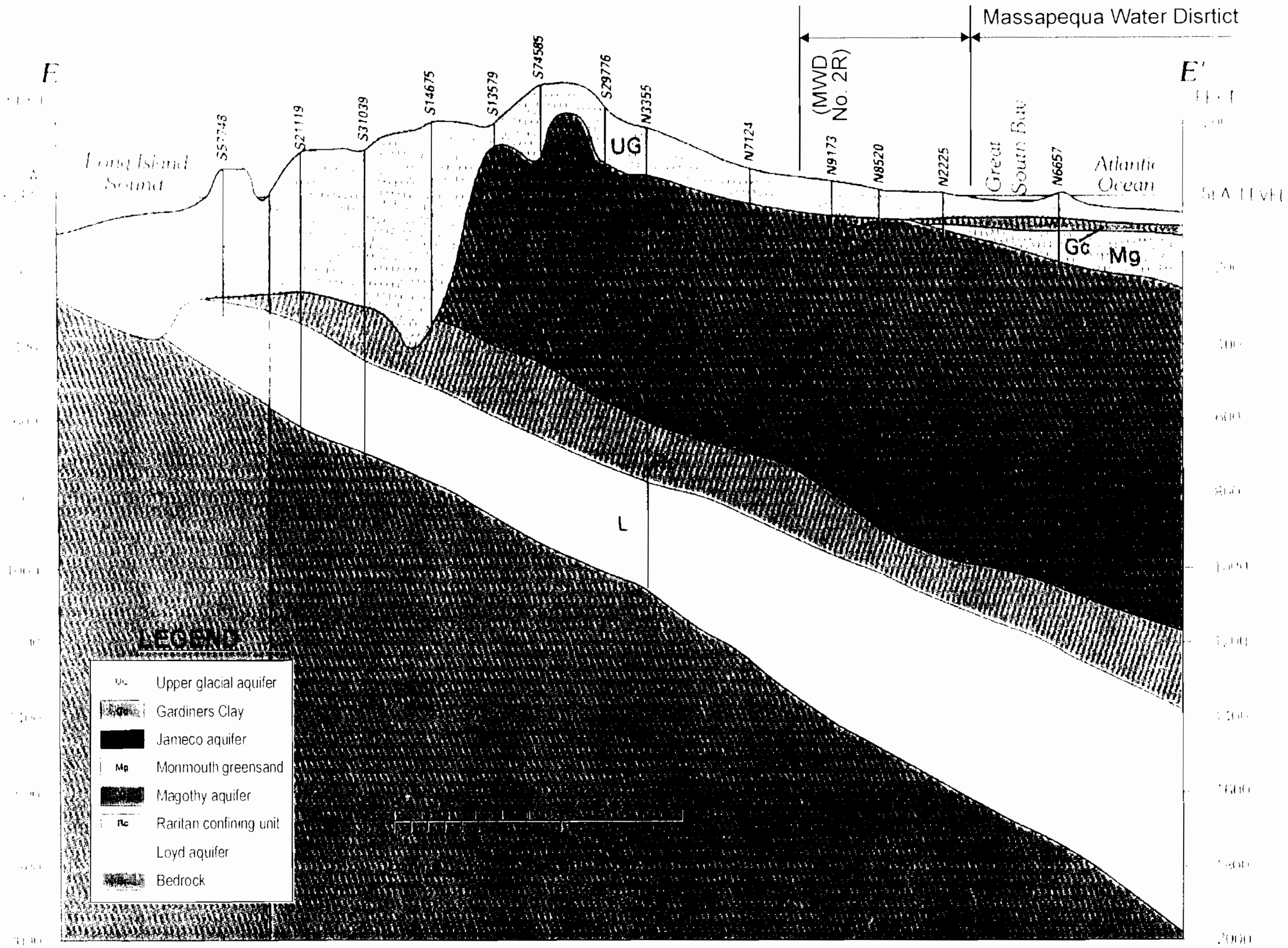
The ground surface elevations in the District's service area range from sea level on the southerly shores to an elevation of about 40 feet above mean sea level in the northeast corner of the service area. Bedrock lies at elevations ranging from approximately 1,550 to approximately 1,620 feet below sea level within the service area. Between the land surface and bedrock are four to five geological units, three of which are identifiable aquifer units composed of sand and gravel or unconsolidated sand. The stratigraphy is illustrated in Figure 1 which is north-south cross section of Long Island through east side of the service area.

The basal aquifer is the Lloyd Sand Member of the Raritan Formation. The Lloyd aquifer lies immediately above the bedrock, is approximately 300 feet thick and is overlain by the Raritan clay. The Lloyd consists of sand and gravel and produces high well yields. The aquifer is tightly confined and results in large areal drawdown when it is pumped. Further development of the Lloyd is restricted by the New York State Department of Environmental Conservation.

The Raritan clay is approximately 300 feet thick.

The Magothy Aquifer is approximately 750 feet thick and represents the upper aquifer of the Cretaceous-age sediments. The Magothy lies immediately above the Raritan clay. The formation consists of fine to coarse sand, with little gravel and much interbeded silt and clay. The aquifer generally has a lower hydraulic conductivity then the glacial units, but high transmissivity can be achieved in wells by utilizing the greater thickness of the aquifer with long well screens. For all but the northwest corner of the District's service area, the Magothy lies beneath the Gardiner's clay. In the northwest portion of the service area and north of the District's service area, there is no effective hydraulic separation between the Magothy and the Upper Glacial Aquifers. The Gardiners clay is approximately 10 to 50 feet thick.

The Upper Glacial aquifer lies above the Gardiners clay and the Magothy aquifer. The Upper Glacial aquifer is approximately 85 feet thick and is not used for public water supply, since it is susceptible to any chemical that may be discharged on the land surface.



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HYDROGEOLOGIC FRAMEWORK OF LONG ISLAND, NEW YORK
CROSS SECTION THROUGH MASSAPEQUA WATER DISTRICT
By; D.A. Smolensky, H.T. Burton, and P.K. Shernoff - 1989

FIGURE 1

All of the District's wells are screened in Magothy aquifer and range in depth from 455 to 850 feet below grade to the bottom of the screen.

EXISTING WATER SYSTEM

GENERAL DESCRIPTION

The District's water supply consists of eight active wells, with a total well capacity of 11,900 gallons per minute, screened at various depths in the Magothy aquifer. Four of the wells are located at the Northeast Well Field which takes up almost an entire block between Ocean Avenue and Philadelphia Avenue in Massapequa Park; two wells are located at the Northwest Well Field at the west end and north of Ontario Avenue, adjacent to the Tackapausha Preserve in Massapequa; and two wells are located at the Brooklyn Avenue Well Field which is located between Brooklyn Avenue and New York Avenue, west of Hicksville Road in Massapequa. The District has plans to construct a ninth well, which will also be screened, in the Magothy aquifer. The planned new well is proposed to be located on the north side of Sunrise Highway, west of Hicksville Road southwest of the Brooklyn Avenue Well Field.

The District has four storage tanks with a total capacity of 4,000,000 gallons. One 500,000-gallon ground storage tank and booster pump station is located at the Brooklyn Avenue Well Field. The other three tanks are located at a site which takes up an entire block on May Place between St. Regis Drive and Massapequa Avenue in Massapequa Park. A 1,000,000 gallon elevated tank, a 2,000,000 gallon ground storage tank, a 500,000 gallon ground storage tank and two booster pump stations are located at the May Place Site.

The District's water distribution system is comprised of push-on joint cast iron, ductile iron and transite water mains ranging in size from 6 inches to 18 inches in diameter. Some of the older cast iron mains in the District were installed with poured joints or universal joints. A listing of the mains by size and material is presented on Table 1. Of the 478,094.4 feet of cast iron and ductile iron pipe only 22,671 feet is cement lined ductile iron and the remainder is unlined cast iron pipe.

TABLE 1
MASSAPEQUA WATER DISTRICT
DISTRIBUTION SYSTEM
DECEMBER 1997

Size of Pipe (In.)	Cast Iron or Ductile Iron Feet of Main	Transite Feet of Main	Total Feet of Main
6	399,783.3	177,457.3	577,240.6
8	20,661.0	44,033.7	64,694.7
10	46,050.6	24,757.8	70,808.4
12	10,901.1	44,796.8	55,697.9
14	0	704.7	704.7
16	698.4	1,443.4	2,141.8
18	0	695.5	695.5
TOTAL	478,094.4	293,889.2	771,983.6 (146.21 miles)

WATER TREATMENT

The current water treatment facilities consist of chemical dosing facilities at each well to chlorinate, to adjust pH and to sequester iron in all water produced by the District's wells.

Disinfection by chlorination is required by Part 5 of the New York State Sanitary Code. The groundwater present in wells on the south shore of Long Island contain naturally occurring hydrogen sulfide. The District adds sodium hypochlorite at all of its wells to oxidize any hydrogen sulfide which may be present and to maintain the quality of the water in the distribution system.

The water produced by the District's wells is acidic with a pH in the range of 4.1 to 5.1. The District adds sodium hydroxide at all of its wells to increase the pH to a range of 7.5. to 8.5, which is slightly above neutral. Raising the pH in the water reduces the corrosion of the unlined cast iron water mains and of customers plumbing systems.

As previously indicated five of the District's wells produce water with an iron concentration in excess of the aesthetic MCL. Water produced by these wells and the other District wells is treated with phosphate to sequester the iron present in the water. Sequestering of the iron present in the water produced by the wells in proper amounts and with proper testing is an acceptable treatment method which is approved by the State Health Department for iron concentrations up to 1.0 mg/l using phosphates and for up to 2.0 mg/l using sodium silicate. Phosphate treatment also inhibits the corrosion of unlined cast iron water mains by coating the surfaces of the unlined mains. This dramatically reduces or eliminates the amount of iron added to the distribution system water from corrosion of the unlined cast iron mains. Phosphate treatment also coats the surface of the transite mains which protects these mains from deterioration.

All of the chemicals used by the District are commonly used by many water suppliers throughout the United States.

CHEMICAL DOSING SYSTEMS

The chemical dosing systems for the sodium hypochlorite, sodium hydroxide and phosphates consist of above ground chemical storage tanks, chemical metering pumps, chemical control panels and the required piping from the chemical tanks to the chemical metering pumps and from the chemical metering pumps to the injection points in the well pump discharge mains. A separate chemical metering pump is used for each chemical at each well. Figure 2 shows a typical well chemical treatment flow diagram.

Common chemical storage tanks are provided for all chemicals for Well No. 1 and Well No. 2R; for sodium hypochlorite for Well No. 3 and Well No. 8; for all chemicals for Well No. 4 and Well No. 5; and for all chemicals for Well No. 6 and Well No. 7. Separate sodium hydroxide and phosphate chemical storage tanks are provided for Well No. 3 and Well No. 8. A list of the District's chemical storage tanks is presented on Table 2.

TABLE 2

MASSAPEQUA WATER DISTRICT

CHEMICAL STORAGE TANKS

	Size of Tank (Gallons)		
Well No.	Sodium Hydroxide	Sodium Hydrochlorite	Phosphate
1 and 2R	3,000	Four 300	Two 300
3	2,000	Four 300	300
8	2,000		55
4 & 5	2,000	Five 300	Two 300
6 & 7	1,500 & 1,000	Four 300	Three 300

The chemical feed rates for each chemical for each well are constant based upon the flow and water quality (iron concentration; pH, etc.) of each individual well. Chemical feed rates are checked frequently and after each chemical delivery to insure that the proper chemical concentrations are maintained in the distribution system.

Three chemical safeties are provided for each chemical for each well. All three safeties must be satisfied before power is provided to operate the chemical metering pumps. The safeties are provided to insure that the individual well pumps are supplying water to the distribution system and/or to prevent the feeding of chemicals to the discharge mains if the well pump is not operating and not supplying water to the distribution system. In addition to the chemical safeties, each well is provided with a pH analyzer/controller which will shut down the sodium hydroxide chemical metering pump to prevent an overfeed if the pH of that particular well exceeds 8.5.

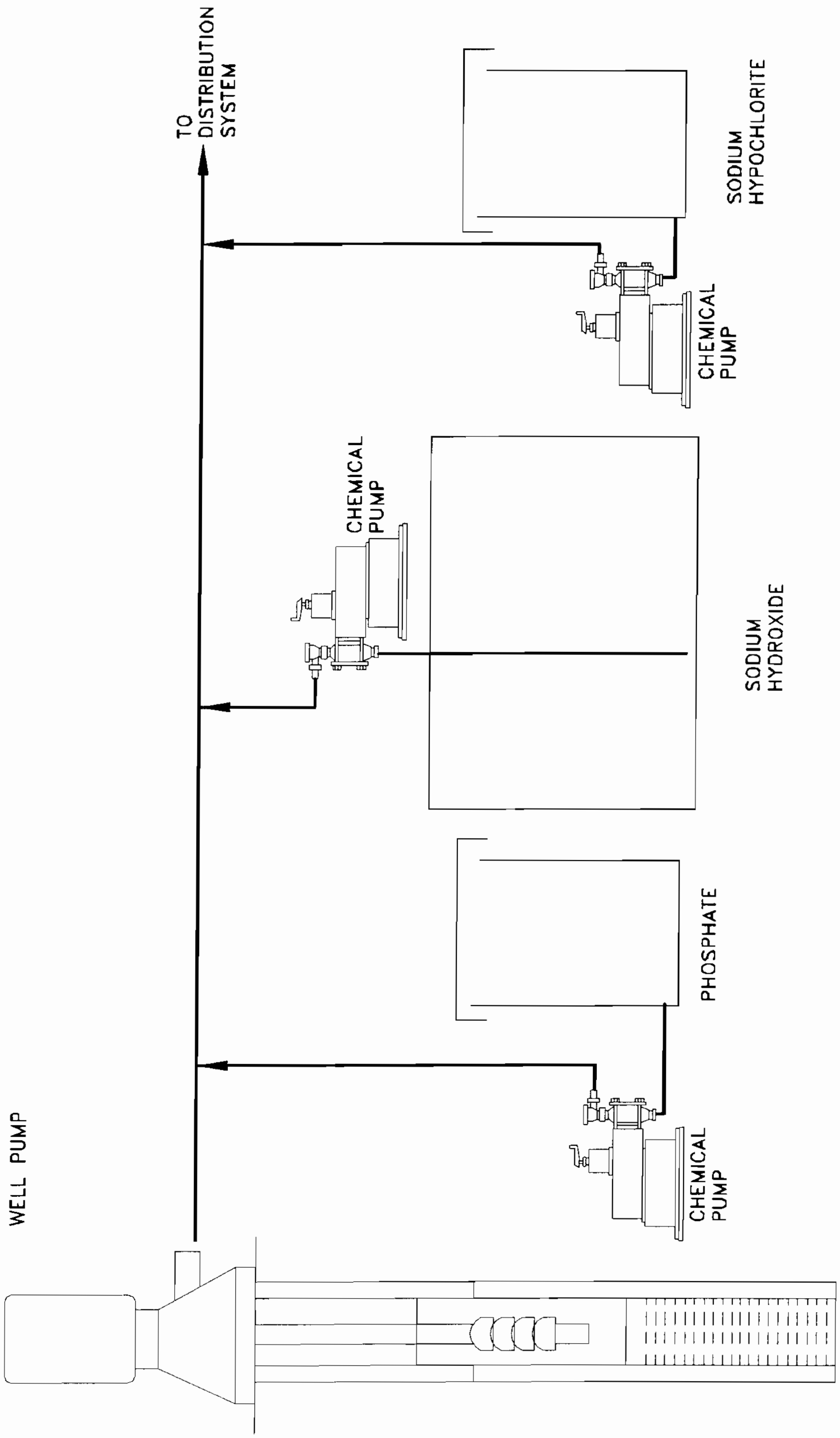
SYSTEM OPERATION

The District's water supply system is operated from a central control room located in the District's office at 84 Grand Avenue, Massapequa. Information from each well field and tank such as system pressure, storage tank levels, and which wells and booster pumps are operating are telemetered to the control room in the District office.

The goal of the system operation is to maintain a relatively constant pressure in the distribution system by maintaining the elevated water storage tank full. Fluctuations in demand are met by bringing well pumps and booster pumps drawing from the ground storage tanks, in and out of service. The well pumps and booster pumps are started and stopped automatically based upon the level of water in the elevated water storage tank. Pumps are started as the level drops and the pumps are stopped in reverse sequence as the elevated tank fills and the level of water rises. Operators select the sequence of

FIGURE 2

MASSAPEQUA WATER DISTRICT
TYPICAL WELL CHEMICAL TREATMENT FLOW DIAGRAM



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purnp operation on a matrix board which is electrically connected to the elevated tank level recorder.

All well and booster pumps discharge directly into the distribution system. The three ground storage tanks are filled from the distribution system via automatic control valves. The two 500,000 gallon ground storage tanks fill when the system pressure at the tank reaches 65 to 70 pounds per square inch (psi). The booster pumps at the two 500,000 gallon ground storage tanks are prevented from starting until the tanks are full. The 2,000,000 gallon ground storage tank fills after midnight each night. The booster pumps at the 2,000,000-gallon tank are not prevented from operating while the tank is filling.

WATER QUALITY

GENERAL

Distribution system water quality and raw water quality for the District's eight wells for the period of 1993 through 1997 was reviewed for the purposes of identifying any water quality concerns and for comparison to water quality standards. The distribution system samples are treated water samples and are representative of the water supplied to the consumers. The average water quality analyses results for distribution system water and well water samples for the years 1993 through 1997 and the applicable water quality standard for each constituent are presented in Appendix A.

Part 141 – National Primary Drinking Water Regulations of Title 40 of the Code of Federal Regulations establishes primary drinking water regulations pursuant to Section 1412 of the Public Health Service Act as amended by the Safe Drinking Water Act (Public law 93-523); and related regulations applicable to public water systems. The primary drinking water regulations contain maximum contaminant levels for substances in drinking water. A maximum contaminant level (MCL) is the maximum permissible level of a contaminant in water which is delivered to any user of a public water system. The primary drinking water MCLs are considered standards. New York State has been delegated "Primary" by the EPA, which gives the State the authority to run the Federal drinking water program. The New York State Department of Health (NYSDOH) has adopted most USEPA MCLs and has set more stringent MCLs for some chemicals. Drinking water MCLs and monitoring requirements are published in Part 5 of the State Sanitary Code (Statutory Authority: Public Health Law, Section 225). The Nassau County Department of Health (NCDH) must adopt the NYSDOH MCLs but may be more stringent in the MCLs and monitoring requirements. The water standards (MCLs) listed in Appendix A are those found in Part 5 of the State Sanitary Code.

In general, the raw water produced by the District's wells can be characterized as being of excellent quality. The water is very soft with a Total Hardness of 5 milligrams per liter (mg/l) as calcium carbonate, or less; has low alkalinity and dissolved solids; and is highly aggressive (corrosive).

IRON

The only water quality parameter of concern is that the level of iron in the raw water produced by Well Nos. 1, 3, 4, 7 and 8 exceeds the aesthetic MCL of 0.3 mg/l and the other three wells also contain lesser concentrations of iron in the raw water. As a result, the level of iron in samples taken from the distribution system over the past seven years averaged between 0.25 and 0.40 mg/l. As previously indicated, the water produced by all of the District's wells is treated with a phosphate compound to sequester the iron present in the raw water and to inhibit corrosion of the District's unlined cast iron and transite water mains. The phosphate chemical feed rates at each well are adjusted as required to sequester the actual amount of iron present in the raw water of the particular well.

Even though all of the District's wells contain iron, some of which are higher than the MCL, and the presence of iron in the water might not be desired from an aesthetic perspective, the levels do not in any way pose a health concern. The levels of iron may however, contribute to the rusty water complaints. Sequestering the iron present in the water with phosphates is a treatment method that is acceptable to Federal, State and County regulatory agencies.

OTHER QUALITY ISSUES

Very low levels of bromodichloromethane and chloroform or chlorodibromomethane were detected in the distribution system in 1993, 1994 and in 1998, but have not been detected since then. Very low levels of chloroform were detected in Well No. 3 and Well No. 8 in 1997 in only one sample and in one sample from Well No. 6 in 1998, but was not detected in subsequent samples. Chloroform and bromodichloromethane are trihalomethanes (THMs) which are formed when chlorine reacts with natural organic matter. The natural organic mater is not normally present in either the District's wells or the District's distribution system. These compounds may have formed as a result of organic matter, such as leaves, inadvertently entering a well or storage tank during maintenance of these facilities. Once the organic matter dissipated and was no longer present for the chlorine to react with, the THMs were no longer formed or detected.

Dichlorodifluromethane was reported as being detected in water produced by one well in 1996, but subsequent sampling was unable to confirm the presence of this compound.

Methyl Tertiary Butyl Ether (MTBE) was detected in one sample from Well No. 3 in 1998, but was has not been detected in any other samples.

No other volatile organic compounds, synthetic compounds, pesticides or herbicides have been detected in any well water or distribution water samples.

COMPLAINTS

The water quality complaints received by the District can be categorized into two major types: (1) cloudy or colored (rusty) water; and (2) taste and odor. Rusty or cloudy water consumer complaints in a groundwater supply are generally from iron and manganese in the raw well water as well as iron from unlined cast iron pipe corrosion which can deposit in the piping system. Events in the distribution system such as flow reversals, high demands, opening hydrants, etc. can cause the iron deposits in the mains to be disturbed and carried in the water to the consumer's faucet. Taste and odor consumer complaints in a groundwater supply may be associated with the presence of hydrogen sulfide in the raw well water; iron and manganese and metallic products of corrosion; and with the use of chlorine for the disinfection of water.

RUSTY WATER COMPLAINTS

The District's rusty water complaint rate for the years 1993 through 1997 was compared to the complaint rate of four other suppliers that are located on the South Shore of Nassau County or in close proximity to the South Shore of Nassau County and have iron present in the raw water at concentrations above 0.3 mg/l. All of the water suppliers requested that their complaint rates be held in confidence. Consequently, only the complaint rates per customer were compared without naming any particular water supplier. One of the four suppliers treats with lime and uses silicates for iron sequestering and for inhibiting corrosion of unlined cast iron water mains, while the other three suppliers use sodium hydroxide for pH adjustment and some form of phosphate for iron sequestering and corrosion control. One supplier, Supplier B, has only a couple of its supply wells with iron concentrations above 0.3 mg/l. Following is a summary of the rusty water complaint rate survey:

SUPPLIER	Average Rusty Water Complaint Rate For Period of 1/1/93 through 12/31/97 (No. Complaints/1000 Customers/Year)
Massapequa Water District	6.9
A	6.8
B	4.9
C	27.9
D	43.7

This comparison shows that the District's rusty water complaint rate is among the lowest compared to the suppliers surveyed. The District's rusty water complaint rate increased in 1996 and 1997. The complaint rate has risen from an average of 3.2 in 1993 and 1994 to an average of 13.9 complaints per 1000 customers per year in 1996 and 1997. However, the complaint rate decreased dramatically in 1998 to 3.7 per 1000 customers for the year. Discussions with Superintendent Farley revealed that the District experienced problems with its chemical metering pumps and that the District replaced its chemical metering pumps for phosphates prior to 1998. The decrease in the complaint rate was apparently a result of feeding the proper amount of treatment chemicals.

The phosphate compounds used to sequester iron lose their ability to sequester iron over time and at elevated water temperatures. The District uses linear chain phosphates which are much more resistant to the effects of time and elevated temperatures.

As previously indicated, there are a number of events in a distribution system that can trigger consumer complaints. All of these events cause a higher than normal flow or a reversal in flow in the distribution system, which can re-suspend iron and manganese deposits from the distribution piping system and create the "rusty" or cloudy water consumer complaints. These events are generally beyond the control of the supplier. The current (1999) rusty water complaint rate of 2.7 per 1000 customers per year can be considered expected and normal for a typical Long Island South Shore groundwater supplier such as the Massapequa Water District.

The District has a program to flush the sediment out of the unlined cast iron distribution system once per year or more often depending on complaints.

TASTE AND ODOR COMPLAINTS

The District's taste and odor complaint rate for the years 1993 through 1997 was compared to the complaint rate of the same four suppliers that was used for the rusty water complaint rate. Following is a summary of the taste and odor complaint rate survey:

SUPPLIER	Average Taste and Odor Complaint Rate For Period of 1/1/93 through 12/31/97 (No. Complaints/1000 Customers/Year)
Massapequa Water District	2.9
A	2.4
B	1.1 (2 year average)
C	6.4
D	Not Available

This comparison shows that the District's taste and odor complaint rate is comparable to the rates received by the suppliers surveyed.

Over the past five years the taste complaints received by the District included: foul, bitter, metallic, bad, chlorine, chemical, sour, rotten eggs and medicinal. And over the past five years the odor complaints received by the District included: foul, smelly, rotten eggs, metallic, bad, chlorine, chemical, iodine, onion, fishy, sulfur, sour, iron and medicinal. All of the complaints received by the District can be attributed to the presence of hydrogen sulfide, iron and manganese in the raw water, the District's use of chlorine for the disinfection of water or the metallic products of corrosion due to the corrosive nature of the raw water pumped by the District.

Due to the nature of the raw water quality, the District has received taste and odor complaints since the District was established and since it has been using its own wells as a source of water.

The District retained Baldwin & Cornelius, PC. (B&C) in 1982 to investigate chronic taste and odor complaints for a period of over ten years in the vicinity of Jomar Court and Jomar Place, located at the south end of the District. At that time, the District was using sodium hydroxide for pH adjustment, was treating with chlorine to maintain the quality of the water in the distribution system and was using sodium hexametephosphate (calgon) to sequester the iron naturally present in the well water. The B & C study concluded that there was a very low flow rate in the affected area which resulted in quasi-stagnant conditions in the distribution mains for extended periods of time. The study further indicated that the extended time period resulted in a lowering of the chlorine residual, which permitted the growth of bacteria which then oxidized the iron from the sequestered state and also from unlined cast iron pipes. The complaints were alleviated after District personnel increased the calgon feed rate, increased the chlorine residual and flushed the system to eliminate the stagnant conditions.

The study found that once the measures taken by District personnel were stopped, the complaints recurred in a short time. The study recommended that the District continue to maintain a 0.5-milligram per liter chlorine residual in the south end of the District to control the growth of iron bacteria.

A discussion with Superintendent Farley revealed that the complaints in the Jomar Court area stopped after the unlined cast iron mains were cleaned and cement lined. Superintendent Farley also stated that it has been his experience that for every chemical, bitter, iodine, medicinal, iron and metallic taste complaint that the District received, there was very low or no chlorine residual at the location of the point of measurement. In many instances the symptoms of the complaint were not present when investigated by a District employee.

The current (1999) Massapequa Water District taste and odor complaint rate of 1.3 complaints per year per 1000 customers can be considered expected and normal for a typical Long Island South Shore groundwater supplier such as the Massapequa Water District.

OTHER INVESTIGATIONS

GENERAL

The Cancer Surveillance Program of the Bureau of Cancer Epidemiology, New York State Department of Health, performed an investigation and prepared a report titled "Cancer Incidence in Zip Codes 11701, 11735, 11758 and 11762, Nassau and Suffolk Counties, New York, 1983-1992 with Update on Bladder Cancer and Hodgkin's Disease 1993-1997." The report was published in April 2000 and covered the South Farmingdale/Massapequa area. The study included the most common cancer sites in the body of both males and females.

The 1992 study and the update of the study was requested by Assemblyman Phillip B. Healy, whose office had been contacted by residents concerned about the occurrence of Hodgkin's disease in the South Farmingdale/Massapequa area. Assemblyman Steven L. Labriola contacted the State Department of Health to move the study to completion.

The study was based on a comparison of the reported newly diagnosed cancer cases as obtained from the New York State Cancer Registry to the expected number of new cases. The expected number of cases is calculated from prior statistical data for cancer throughout the State (exclusive of New York City) for the period 1983 through 1987 and adjusted to the Massapequa and Massapequa Park area for differences in age, sex and degree of urbanization among residents.

The previous investigation found indications that suggest there may be an unusual number of cases of Hodgkin's disease in females in zip code areas 11735 and 11758 in the last two years 1988 and 1989 of the study period. This study was a result of recommendations in the previous study and found that, in general, the observed numbers of each type of cancer were either lower or equal to the expected numbers for the study area.

The summary from the April 2000 study is presented herein as Appendix B.

BREAST CANCER

The incidence of reported female breast cancer in the April 2000 study showed 937 cases observed as compared to 951 cases expected. The results show no significant difference in breast cancer between observed and expected cases within the area served by the Massapequa Water District.

Another recently released study by New York State and based upon the New York State Cancer Registry shows that the Breast Cancer rate on Long Island (Nassau and Suffolk Counties) is within 20 percent higher than the New York State average for the 1992-1996 period.

HEALTH RISK LITERATURE REVIEW

(By Walter W. Faber, Jr., Ph.D.)

INTRODUCTION

This literature review attempted to identify potential health effects associated with various chemicals either occurring naturally in the drinking water of the Massapequa Water District or added for disinfection or corrosion control. Water quality data from 1993 to 1997 was reviewed to identify these chemicals.

Only 15 chemicals, for which water tests are analyzed, were identified as being present in the drinking water. These included disinfection byproducts (considered as a group), which naturally form due to the sodium hypochlorite added as a disinfectant when organic matter is present (usually introduced when serving a well or pump or storage tank), and phosphates, which are added for corrosion control. In addition to these chemicals, caustic (sodium hydroxide) and hydrogen sulfide were included.

Methyl tertiary butyl (MTBE), a common gasoline additive in this part of the country, was also included in the literature review, since it is being detected in some Long Island water supplies. Current sampling does not indicate any problem within the Massapequa Water District.

Literature searches were conducted on the National Library of Medicine database (MEDLINE). Also, electronic searches were conducted on numerous databases including the American Cancer Society, the American Medical Association, the American Water Works Association, the American Water Works Association Research Foundation, the Environmental Health Information Service, the Environmental Research Foundation, the U.S. Centers for Disease Control and Prevention, and the U.S. Environmental Protection Agency.

No information on any associated or possible health risks could be found for exposure to chloride, iron, orthophosphates or total phosphates in drinking water. As such, these chemicals are not discussed. In addition, ammonia and zinc were only shown to have health effects when consumed by themselves, not when found in drinking water. Since exposure to these chemicals is very low in drinking water when compared to the health effects identified when consumed by themselves, these chemicals also are not discussed.

METALS

Calcium and Magnesium

These chemicals are related to the overall hardness of the drinking water and have not been shown to cause adverse health effects in humans. Several studies have suggested a health benefit to individuals with calcium and/or magnesium levels in their drinking water. One study demonstrated a high risk of sudden cardiac death in residents in an area receiving drinking water with a very low total hardness due to the paucity of calcium and magnesium salts (Bernardi *et al.* 1995).

Other studies carried out on the magnesium levels in drinking water have shown a reverse correlation between cardiovascular mortality and the magnesium level (Karppanen 1984; Durlach *et al.* 1985). A study of the levels of magnesium in drinking water of Taiwan residents from 1989 through 1993 who died from cerebrovascular conditions showed that an adjusted odds ratio (95 percent confidence interval) were 0.75 (0.65 to 0.85) for the group with water magnesium levels between 7.4 and 13.4 mg/l and 0.60 (0.52 to 0.70) for the group with magnesium levels of 13.5 mg/l or more (Yang 1998). In a Swedish study, mortality due to ischemic heart disease was significantly inversely related to the magnesium content of the drinking water, particularly for the men (Rylander *et al.* 1991). This beneficial effect needs further verification (Marx and Neutra 1997).

A recent matched case control study even suggested a protective effect of magnesium intake against gastric cancer, but only for those individuals with the highest levels in their drinking water (Yang *et al.* 1998a). A matched case control study suggested a significant protective effect of calcium intake from drinking water on the risk of developing gastric cancer (Yang *et al.* 1998a). No significant difference was seen with the level of calcium in drinking water and the risk of cerebrovascular death (Yang 1998).

Relationship to Massapequa Water District

The USEPA and NYSDOH have not issued maximum contaminant levels for either calcium or magnesium. The maximum levels found in Massapequa water have been 1.10 mg/l for calcium and 0.70 for magnesium. While these levels pose no adverse health effect, the relatively low values may not provide any protective benefit either.

Copper

Drinking water contaminated with high levels of copper have been suggested to be involved in several medical conditions. Contamination may be high in areas with soft acidic water that could lead to high corrosivity of water pipes and an increase in copper levels at the tap (Nordberg *et al.* 1985).Chronic copper toxicity has been seen in individuals with Wilson disease and infantile cirrhosis (Olivares and Uauy, 1996) and suggested for individuals with acute hemolysis due to a G-6-PD deficiency in their red blood cells (Calabrese and Moore 1979).

Researchers in the U.K. investigated the possible link between copper exposure and infantile liver problems, such as infantile cirrhosis (Fewtrell *et al.* 1996). This study revealed that for all the infant patients (220 out of 240) presenting at Kings College Hospital in London with specific liver problems and where an address could be determined, the public drinking water supplies which these patients used contained low levels of copper. Another study conducted in three towns in Massachusetts found that levels of copper in the drinking water of these towns ranged between 8.5 and 18.5 mg/l, and that yet there were no deaths in children under the age of six related to cirrhosis or any other liver disease (Scheinberg and Strenlieb 1994).

Epidemiological studies suggest that children under the age of ten are the most susceptible to copper toxicity (Sidhu *et al.* 1995). The symptoms observed are abdominal pain, nausea, vomiting, diarrhea, headache and dizziness (Knobeloch *et al.* 1994; Sidhu *et al.* 1995). These symptoms are not restrict to small children but have also been found in adults living in recently constructed or renovated homes, with elevated copper levels above the federal action limit of 1.3 mg/l at the tap (Knobeloch *et al.* 1994; Knobeloch *et al.* 1998).

The level of copper which may lead to toxicity in children is not known. A recent study investigated the World Health Organization's proposed standard of 2 mg/l for drinking water (Olivares *et al.* 1998). Children between 3 and 12 months of age were exposed to levels of copper in their drinking water ranging from less than 0.1 mg/l to 2.0 mg/l, without any adverse or toxic effects identified in any of the children.

In addition to the lack of information on the levels that lead to copper toxicity, little is known about the mechanisms involved in copper toxicity, although some potential mechanisms have been suggested. These include unusual reactions of the intestinal mucosa or variable synthesis and elimination of copper via bile (Dieter 1989)..

The lack of controlled studies causes much of the toxicity information on copper to be debatable and inconclusive (Olivares and Uauy 1996). Research currently underway may shed light on copper exposure and toxicity (Fitzgerald 1998).

Relationship to Massapequa Water District

The USEPA and NYSDOH have not issued a maximum contaminant level for copper but have issued an action level of 1.3 mg/l. An action level (AL), as defined, is the concentration which, when exceeded, triggers corrective action to be taken by a water supplier. The AL for copper is exceeded if the concentration of copper in more than 10 percent of the one liter first draw samples exceeds 1.3 mg/l. The maximum single sample level found in Massapequa water was 1.02 mg/l, although this may be considered as an anomaly as the vast majority of sampling data indicates lower levels. At these levels, no adverse health effect should be expected in any consumer.

Lead

Drinking water does not usually contain lead at the source, but rather picks up lead as the water approaches the tap, either from a lead service line, internal plumbing or lead solder. The amount of leaching that occurs is related to the acidity of the water. The contribution of lead in drinking water to the overall exposure has gained importance as other environmental exposures have been reduced. Although drinking water may contain a low amount of lead, cumulative exposure may contribute to the overall increase in lead accumulation in the body, and an elevated blood lead level.

Controversy surrounds the blood lead level that causes lead poisoning (Schoen 1995). Blood lead levels about 70 ug/dl may cause encephalopathy and seizures (Markowitz 1997). When blood levels reach 50 ug/dl, gastrointestinal symptoms occur, including abdominal pain, anorexia, vomiting and constipation (Markowitz 1997).

Subclinical symptoms have been suggested through numerous epidemiological studies (for example: Bellinger *et al.* 1987; McMichael *et al.* 1988; Dietrich *et al.* 1991). These studies found a significant association between blood lead levels of 10 to 20 ug/dl and neurological and behavioral problems.

The neurological problems due to lead exposure during development, manifest themselves in children, particularly as measured by IQ. These epidemiological studies are controversial. A review of 35 reports from five longitudinal epidemiological studies (including the three reports cited above) found inconsistencies in the data collection and analysis (Thacker *et al.* 1992). These researchers stated that no definitive conclusions could be reached regarding the effect of low lead levels on neurological development.

The behavioral problems associated with lead exposure are no less controversial. The behavioral problems that have been mentioned in studies on children (either maternal or teacher reported) include hyperactivity, nonadaptive behavior, poor conduct in school, inattentiveness and aggression (Sciarillo *et al.* 1992).

Exposure of pregnant mothers to lead have been implicated as contributing to the problems seen in children with high blood lead levels. Another epidemiological study investigated whether maternal exposure during pregnancy had other adverse health effects (Aschengrau *et al.* 1993). This study found an increase in the number of stillbirths for women exposed to detectable lead levels but the association was not statistically robust.

Obviously more research is needed to determine whether low lead levels do pose a serious public health risk.

Relationship to Massapequa Water District

The USEPA set an action limit for lead in drinking water at the tap of 15 ug/l. An action level (AL), as defined, is the concentration which, when exceeded, triggers corrective action to be taken by a water supplier. The AL for lead is exceeded if the concentration of lead in more than 10 percent of the one liter first draw samples exceeds 0.015 mg/l (15 ug/l). Based on the data that was reviewed, the maximum single sample level detected in Massapequa water was 14.1 ug/l, which is below the action limit. Uncertainty surround whether this level of lead in drinking water could contribute to adverse health effects.

Manganese

The health effects of manganese exposure through inhalation or ingestion of manganese dust have been established. A severe respiratory condition, called manganese pneumonia, may result, with symptoms of coughing, fever, chills, body aches and chest pain. Chronic exposure may lead to nervous system disorders, which manifests itself as difficulties with balance, memory, judgment and emotions. Exposure of manganese through drinking water is considered not a health risk due to the low levels involved. The dose of manganese from drinking water is estimated to be 1 percent of the total does of manganese from ingested food, although the exposure was higher (up to 17 percent) for persons drinking well water (Loranger *et al.* 1994).

The exposure of manganese in drinking water has been examined in animal studies. For example, in one study, adult Sprague-Dawley rats were given doses of 100 and 5,000 mg/l in their drinking water, with their motor skills tested weekly (Bonilla 1984). A significant decrease in motor skills was observed in the first month; however, no continuous decline was observed after the initial decrease. A problem with interpreting these results is that the levels given the rats are orders of magnitude higher than what would normally found in drinking water.

In a study in Greece, adults over the age of 50 were examined in three areas with difference concentrations of manganese in their drinking water: one area had a range of 0.004 to 0.015 mg/l; the second area had a range of 0.082 to 0.253 mg/l; and the third area had a range of 0.8 to 2.3 mg/l (Kondakis *et al.* 1989). Neurological scores and manganese levels in hair were significantly different for the three areas, with the third area experiencing a particularly higher prevalence of neurological signs and concentration in hair. Thus, chronic exposure (over many years or possibly decades) to high manganese levels may lead to neurological disorders. However, more research is needed to confirm this observation.

Relationship to Massapequa Water District

The NYSDOH standard for a maximum contaminant level for manganese in drinking water has been set at 0.3 mg/l. The maximum level observed in Massapequa drinking water has been 0.02 mg/l. This level is below the standard, and well below the level in which increased neurological problems have been observed.

Sodium

The USEPA has added sodium to the Drinking Water Contaminant Candidate List. This allows the USEPA to conduct investigations into any potential health effects of sodium in drinking water. Currently no maximum contaminant level exists since the exposure to sodium in drinking water contributes only a small fraction of the total sodium in ingested foods.

Concern over the link of high dietary salt content to hypertension has lead to several studies involving the link between sodium in drinking water and cardiovascular diseases.

Several studies have shown no relationship between sodium in drinking water levels and high blood pressure in otherwise health individuals. For examples, one study was conducted on 635 rural children (12 to 14 years of age), and another was conducted on 2,740 children in the fourth grade (Armstrong *et al.* 1982; Robertson 1984). The second study compared drinking waters with levels ranging up to 105 mg/l. No association could be found between sodium levels in drinking water and elevated blood pressure. However, high school sophomores in another community with elevated sodium levels (107 mg/l) were shown to have elevated blood pressure distribution patterns in case control study (Tuthill and Calabrese 1979). The second study suggests the increased level of sodium in the drinking water may be associated with elevated blood pressure levels.

These conflicting studies are further complicated by another study conducted on 717 adults over the age of 25 in an area of Arizona receiving drinking water with a sodium level of 440 mg/l (Welty *et al.* 1986). In this study, no association was seen. In fact, for the non-Native American study participants, their average blood pressure was lower than the U.S. national average (Welty *et al.* 1986).

Relationship to Massapequa Water District

The NYSDOH has not set a limit for the amount of sodium in drinking water. In adding sodium to the Drinking Water Contaminant Candidate List, the USEPA established a drinking water equivalency level for sodium of 20 mg/l. Water containing more than 20 mg/l of sodium should not be used for drinking by people on severely restricted sodium diets. The maximum level (22.1 mg/l) found in Massapequa water is only slightly above this level, and between 1993 and 1998, the average has been slightly below 20 mg/l. The health effect of the amount is not considered to be significant.

OTHER CONTAMINANTS

Nitrates

High nitrate levels in drinking water have been recognized as a health hazard (Holmes *et al.* 1985). Nitrate contamination of drinking water is primarily due to the use of fertilizers (Levallois *et al.* 1998). The link between high nitrate levels in drinking water and methemoglobinemia (i.e., blue baby syndrome) has long been established and is the basis of current federal regulations (Levallois and Phaneuf 1994). None of the reported developmental problems, such as methemoglobinemia, associated with maternal ingestion of nitrate in drinking water have been shown to occur in areas supplying drinking water below the federal maximum contaminant level (Fan *et al.* 1996). Also, the contribution of nitrate in drinking water may be small when compared to overall dietary consumption. In the Finnish Mobile Clinic Health Examination Survey in 1967-1972, over 90 percent of the total dietary nitrate ingestion was due to vegetables, with a small percentage due to drinking water (Dich *et al.* 1996).

Recently, new potential health risks have been identified with elevated nitrate levels, such as spontaneous abortions in pregnant women (USCDC 1996). Another potential risk may be childhood-onset insulin-dependent diabetes mellitus.

A study from Colorado demonstrated a significantly increased risk for childhood diabetes in areas with higher nitrate levels (Kostraba *et al.* 1992). This association was demonstrated again in a study from Yorkshire, U.K., which found a significantly higher incidence of childhood diabetes in areas with elevated nitrate levels in their drinking water (Parslow *et al.* 1997). The significance of these studies lies in the nitrate levels investigated. The Yorkshire study found an association only when the nitrate levels were above 14.85 mg nitrate/l. However, the Colorado study found an increased risk in areas receiving drinking water containing 0.77 to 8.2 mg of nitrate per liter when compared to areas receiving 0.0 to 0.084 mg of nitrate per liter. Thus, possible lower levels than previously thought to be a health hazard may actually cause adverse health effects.

Elevated nitrate levels may be associated with increased cancer due to conversion of the nitrate into carcinogenic N-nitroso or nitrosamine compounds in the body (Moller *et al.* 1989; Levallois and Phaneuf 1994). Also, the possible conversion of other nitrogen compounds (such as ammonia and nitrite) into carcinogenic compounds has been suggested (Alaburda and Nishihara, 1998). In a study administering a dose of 100 mg nitrate per liter of drinking water to mice, no effect on numerous physiological parameters (liver function, kidney function, total iron, total serum protein, serum electrolytes, body weight, and N-glycolyl-neuraminic acid as a tumor marker) could be shown within the 18-month study period (Mascher and Marth 1993).

The evidence showing an association between nitrate level and cancer has been inconclusive. For example, a study investigating a possible link to stomach cancer in urban parts of the U.K. found a negative association (Beresford 1985), whereas a matched case control study demonstrated a significant positive association between nitrate exposure from drinking water and gastric cancer mortality (Yang *et al.* 1998a).

A possible link to elevated levels of non-Hodgkin's lymphoma in the population has been shown (Weisenburger 1993; Ward *et al.* 1996). A case control study in Nebraska demonstrated an elevated risk of non-Hodgkin's lymphoma associated with drinking water containing more than 4 mg nitrate-nitrogen/l (Ward *et al.* 1996). This association was significant, despite dietary nitrate levels not being associated with an increased risk. The levels reported here are below the current federal regulations, and suggest that chronic exposure to slightly elevated nitrate levels may pose health risks.

Relationship to Massapequa Water District

The NYSDOH and USEPA have designated a maximum contaminant level of 45 mg/liter for nitrate or 10 mg/liter for nitrate-nitrogen. The maximum concentration found in Massapequa water was 0.18 mg/liter. This level is well below the maximum contaminant level and poses no known adverse health effects.

Hydrogen Sulfide and Sulfates

In the body, hydrogen sulfide dissociates in the bloodstream into free sulfides (Guidotti 1996). *In vitro* studies using rat models have shown that this free sulfide, as demonstrated by administration of sodium sulfide, may cause extensive neurological damage (Nicholson *et al.* 1998). The research into the health effects of hydrogen sulfide centers solely on inhalation studies.

Acute low levels of hydrogen sulfide inhalation cause adverse effects. One study shown that an acute exposure of 5 ppm by health adults demonstrated metabolic changes in their muscles (Bhambhani *et al.* 1996). Exposure above 50 ppm could cause unconsciousness, brain damage and death (Tvedt *et al.* 1991; Kilburn and Warshaw 1995). Chronic exposure to low levels of hydrogen sulfide, as seen in sewer workers or pulp mill workers, has shown a reduction in lung function (Jappinen *et al.* 1990; Richardson 1995).

Although hydrogen sulfide may occur in drinking water, only one study was identified that considered the hydrogen sulfide levels in drinking water and any possible health effects (Krzywicki 1978). This study was unobtainable, so is not discussed here.

Sulfates, in the form of calcium or magnesium salts (commonly found in drinking water), have little public health significance. Possibly, sulfates in drinking water may be converted into sulfides, although no reference was located to support this contention. Animal studies have not demonstrated any adverse health effects with sulfates in drinking water. For example, a study of pig health demonstrated no adverse health effects for sulfates in concentrations up to 1,800 mg/l (Veenhuizen *et al.* 1992).

Sulfates are used as laxatives, for example Glaubers salt (sodium sulfate) or Epsom salts (magnesium sulfate). Individuals unaccustomed to drinking water containing sulfates may experience a laxative effect.

Relationship to Massapequa Water District

The NYSDOH and USEPA do not regulate hydrogen sulfide or sulfides in general in drinking water. In addition, no sample taken in Massapequa water's distribution system was positive for hydrogen sulfide. The maximum level of sulfates found in Massapequa water is 0.18 mg/l, well below the NYSDOH maximum contaminant level of 250 mg/l.

Caustic (Sodium Hydroxide)

In concentrated forms, ingestion of sodium hydroxide could cause severe abdominal pain, vomiting, corrosion of the upper digestive tract (lips, mouth, pharynx and esophagus) and death. Levels of sodium hydroxide at 1,000 mg/l have been shown to cause gastric cancer in rats (Kojima *et al.* 1987).

In drinking water, sodium hydroxide is highly dilute and used to raise the pH of the water. The sodium hydroxide dissociates into sodium salts and hydroxyl ions. Potential health effects of sodium have been previously described. Hydroxyl ions in water pose no known adverse health effect.

Relationship to Massapequa Water District

Sodium hydroxide is added to Massapequa Water for pH control. Obviously, the handling of the sodium hydroxide prior to its addition to the drinking water poses the greatest health risk and not the actual addition to the drinking water.

Asbestos

Asbestos is perhaps the most extensively studied contaminant associated with drinking water distribution as it can leach from cement-asbestos pipes. Research reports suggest that asbestos from this source does not pose significant human cancer risks (Harrington JM, et. al. – 1978; Howe HL, et. al, Public Health Rep – 1989; Sadler JD, et. al., J. Comm Health – 1989).

Several epidemiological studies have found an association between asbestos in drinking water and cancer of the esophagus, stomach and intestines; however, confounding factors and short follow-up times relative to the long latent period for tumor formation make it difficult to interpret the results (USEPA 1989, 1993).

An early study in California (Kanarek, et. al., Amer J. Epidem – 1980) suggested that there may be an elevation in colorectal cancer risk associated with asbestos in drinking water. It appears that these findings are limited to situations in which naturally occurring levels are high.

A subsequent, more detailed study of asbestos either from source water or leached from water distribution systems suggests that when asbestos is present at levels commonly found in drinking water, it does not pose a major cancer risk (Polissar, et. al., Amer J. Epidem – 1984 and DHHS Working Group – Env. Health Persp. – 1987).

The EPA has set the MCL for asbestos at 7 million fibers per liter (mfl) mainly because this is the lowest level to which water systems can reasonably be required to remove this contaminant should it occur in drinking water.

Asbestos is not known to cause any health problems when people are exposed to it at levels above the MCL for relatively short periods of time (USEPA – OGWDW, 1998).

Relationship to Massapequa Water District

The NYSDOH has set the maximum contaminant level (MCL) for asbestos at 7.0 mfl. Analysis of Massapequa water indicates asbestos fibers to be "nondetect" and therefore poses no adverse health effect.

CHLORINATED DISINFECTION BYPRODUCTS

Chlorination of drinking water leads to the formation of numerous chlorinated hydrocarbons (referred to as chlorinated disinfection byproducts or DBPs) due to the reaction between chlorine and naturally occurring organic compounds in the water. It should be noted that naturally occurring organic compounds are more prevalent in surface water supplies than deep well supplies such as Massapequa Water District, which has not experienced any organic compounds.

In humans, gastrointestinal and urinary tracts are the sites in the body associated with cancer due to DBPs (Koivusalo and Valiainen 1997). However, the contradictory evidence is not sufficient to draw complete conclusions (Cantor 1997).

Studying the patterns of mortality in Massachusetts between 1969 and 1983, identified an increase in bladder cancer deaths among people residing in areas receiving chlorinated drinking water (Zierler *et al.* 1986). Other studies have investigated the relationship between bladder cancer and DBPs. A population-based case control, conducted between 1990 and 1991 in Colorado, found years of exposure to chlorinated surface water significantly associated with the risk for bladder cancer (McGeehin *et al.* 1993). Total trihalomethane levels (used as a measurement for DBPs in drinking water) were not associated with an increased risk. The results of another study from Taiwan, conducted between 1982 and 1991 of 14 communities with chlorinated drinking water supplies and 14 matched (urbanization levels and sociodemographic characteristics) communities with nonchlorinated drinking water supplies found a positive association between consumption of chlorinated drinking water and cancer of the rectum, lung, bladder and kidney (Yang *et al.* 1998b). A retrospective case control study in Wisconsin of cancer deaths between 1972 and 1977 found a dose-dependent response between trihalomethane levels and colon cancer deaths (Kararek and Young 1982).

In Houston, urinary tract cancer deaths were examined prior to and following (1940 through 1970) the introduction of a chlorinated drinking water supply in 1956 (Cech *et al.* 1987). Overall, no increase in urinary tract cancers was demonstrated. An examination of cancer deaths between 1973 and 1976 in Erie County, New York, found no correlation between trihalomethane levels and esophageal, gastric, colon, rectal, bladder or pancreatic cancer (Carlo and Mettlin 1980).

A study in the U.K. identified a significant association between trihalomethane levels in drinking water and the incidence of leukemia (Foster *et al.* 1997).

A study from Ontario, Canada, calculated the risk for bladder cancer based on exposure to drinking water containing a total trihalomethane level above 0.005 mg/l (King and Marrett 1996). Exposure to the chlorinated drinking water for 35 or more years significantly increased the risk of bladder cancer over exposure to chlorinated drinking water for under 10 years (odds ratio = 1.41, 95 percent confidence interval = 1.10-1.81).

There is disagreement among the studies as to what would be considered a safe level of exposure. Many of the *in vitro and in vivo* studies use doses which far exceed the dose that a human would consume through drinking water exposure. For both chloroform and bromodichloromethane, the acute, oral, no-observed-adverse-effect level and lowest-observed-adverse-effect level for liver toxicity were shown to be 0.25 and 0.5 mmol/kg, respectively, in a Fischer 344 rat model (Keegan *et al.* 1998). Using a medaka fish model, dichloroacetic acid in levels of 0.5 and 2.0 g/l over a 4-week period induced significant changes in liver cells, including an elevation of glycogen (McHugh *et al.* 1998).

These changes in liver function have been investigated in humans. A study in Wisconsin on whether distribution of serum lipids, blood pressure or thyroid hormones differed according to the chlorination of the drinking water supply, revealed that among females, serum cholesterol levels and low density lipoprotein (so-called "bad") cholesterol community means are nearly identical in the chlorinated and nonchlorinated communities for each sex.

In addition to a potential increase in cancer risk and change in liver function, several studies have identified an association between chlorinated drinking water and reproductive problems. Using a rat model, increased levels of dichloroacetic acid was shown to have testicular toxicity (Linder *et al.* 1997). A dose of 54 mg/kg body weight/day for fourteen days led to delayed spemiation and the formation of atypical residual bodies. Decreases in sperm motility were seen after nine days with a dose of 480 mg/kg/day, and after fourteen days with a dose of 160 mg/kg/day.

Chlorination disinfection byproducts have been shown to have reproductive problems in females, including utero-, embryo- and fetotoxicity (Smith *et al.* 1986). Total trihalomethane levels above 0.1 mg/l increased the odds ratio above 1.5 for reduced birth weight and numerous birth defects, including central nervous system defects, oral cleft defects and major cardiac defects (Bove *et al.* 1995).

A recent prospective study investigated the relationship between trihalomethanes and spontaneous abortion in 5,144 pregnant women in a prepaid health plan (Waller *et al.* 1998). Women who drank greater than or equal to 70 glasses/day of cold tap water containing greater than or equal to 75 mg/l total trihalomethanes had an adjusted odds ratio of 1.8 for spontaneous abortion (95 percent confidence limit = 1.1-3.0). A previous study found no relationship with trihalomethane concentration in drinking water and adverse pregnancy outcomes, including miscarriage risk, preterm delivery and birth weight (Savitz *et al.* 1995). A higher incidence of preterm deliveries was significantly associated with maternal consumption of material dioxide disinfected drinking water (Tuthill *et al.* 1982).

Lastly, the situation with DBPs becomes more complicated when other water quality parameters are considered. For example, experimental results indicated that the total formation potential of DBPs significantly increased in the presence of turbidity (Lee *et al.* 1998).

Relationship to Massapequa Water District

The levels of trihalomethane potential, which includes chloroform, bromodichloromethane, chlorodibromomethane and bromoform, are well below the current USEPA and NYSDOH limits (a combined maximum contaminant level of 100 ppb). Trihalomethane potential is a test where samples are forced to form these products by superchlorinating and storing samples in the dark for a 7-day period. Routine sampling distribution water has shown that drinking water supplied to the Massapequa Water District's consumers contains very low levels of trihalomethanes and has been "nondetect" for the years 1997 and 1996. It should be noted that the THMs have not been detected in the raw or treated water, and even when low levels are detected in the trihalomethane potential test, it is only under laboratory conditions of superchlorination for long periods. There is no evidence at this time to suggest any health effects due to THMs.

RESIDUAL CHLORINE

Most studies regarding the health effects of chlorine in drinking water generally support the theory that by-products of chlorination are associated with increased cancer risks. In a 1992 study, published in the July issue of the *American Journal of Public Health*, researchers at the Medical College of Wisconsin in Milwaukee found that "people who regularly drink tap water containing high levels of chlorine by-products have a greater risk of developing bladder and rectal cancers than people who drink unchlorinated water." (Morris, MD., Ph.D., Audet, MD, et al).

Limited information is available on the chronic effects of chlorine when people are exposed to chlorine through drinking water and swimming pool water, where it is used as a disinfectant. The American Council of Government of Industrial Hygienists, in a 1986 study, reported that "Chronic exposure to chlorine concentrations of around 5 ppm caused respiratory complaints, corrosion of teeth, inflammation of the mucous membranes of the nose and increased susceptibility to tuberculosis in workers."

A 1991 study (Calabrese and Kenyon) concluded that no adverse effects on growth, life span, or fertility were reported in laboratory rats exposed to 100 ppm of chlorine in their drinking water for their entire life span, over seven generations. In addition, the study stated that chlorine has not been found to be carcinogenic in animals and no tumors were noted where rats were exposed again to 100 ppm in their drinking water over their life span for seven generations.

Another study in 1993, by the EPA in Cincinnati, OH, evaluated the potential carcinogenicity of chlorinated drinking water in rats and mice and found no statistically significant increase in tumors that could be related to the chlorinated water. The EPA has not classified chlorine for carcinogenicity.

A 1991 study by the AWWA Research Foundation, entitled “Health Effects of Disinfectants and Disinfection Byproducts” provided information on the toxicological effects associated with the residual concentrations of chlorine that remain when water is disinfected. Studies referenced in this report indicate that in some cases, toxicological effects of chlorine in high doses have been evidenced.

Of the studies conducted to address direct toxicological effects of chlorine by the oral route in humans at high doses (90 mg/l or higher), the observed systemic hazard was limited to “constriction of the throat, momentary strangulation, and irritation of the mucous membranes.” Other studies involving animal experiments showed no effect on body weight or gross histology or any evidence that chlorine presented a carcinogenic or teratogenic hazard.

A limited amount of evidence suggests that formation of chlorinated byproducts “in situ” is possible and that some of these chemicals are systemically absorbed by the body. It is not known if the same byproducts would be observed when humans drink water with residual concentrations of chlorine in the range of 0.5 to 2 mg/l. It is also suspected that with “low concentrations of hypochlorous acid and/or hypochlorite encountered in drinking water, the body’s antioxidant defenses are more than adequate to control any damage.”

The executive summary of the report states that “a rather substantial amount of toxicological information now indicates that there is little cause to be concerned over residual concentrations of chlorine normally used to maintain water quality in drinking water distribution systems.”

Relationship to Massapequa Water District

While chlorinated by products (trihalomethanes) increase the risk of developing bladder and rectal cancers in those people who regularly drink water with high levels, there is no indication or statistical evidence that chlorinated water containing low levels of trihalomethanes (THMs) is linked to any increase in cancer or any adverse effects on growth, life span or fertility under laboratory testing. Since Massapequa Water District routine sampling always has shown that drinking water supplied to its consumers contains no THMs, there is no evidence to suggest any health effects either from low levels of residual chlorine or disinfection by-products.

A statistical review of the chlorine residual concentration from routine monthly sampling of the Massapequa Water District distribution system has indicated that for the 624 samples taken during the year 1999, over 83% were in the range of 0.5 mg/l to 1.0 mg/l, with 12% being less than 0.5 mg/l, 5% being greater than 1.0 mg/l, and the highest being 1.3 mg/l. For the first eight months of the year 2000, similar results were found (77% in the range of 0.5 mg/l and 1.0 mg/l, 17% less than 0.5 mg/l and 6% greater than 1.0 gm/l). In general, the higher concentrations were found in close proximity to the well pump stations. Further discussions with the District's operating personnel have indicated that if the sample results at the well fields or within one block of the well fields are discounted, the average chlorine residual is approximately 0.62 mg/l.

METHYL TERTIARY BUTYL ETHER

Drinking water professionals in the United States are increasingly concerned about methyl tertiary butyl ether (MTBE) contamination, and with good reason. MTBE, a common gasoline additive, is associated with strong taste and odor effects and may pose a potential risk to human health. MTBE tends to migrate rapidly in groundwater and resists conventional water treatment processes. MTBE contamination of drinking water supplies is fairly widespread and may occur in almost any area where gasoline is used. Some areas, alarmed at growing evidence of contamination, have banned the use of MTBE in gasoline.

There is no evidence that MTBE is highly toxic, but uncertainty exists about its potential chronic toxicity and carcinogenic effects on humans that the USGS has classified MTBE as a possible human carcinogen (USEPA/600/R-98).

Anecdotal reports have detailed acute health symptoms resulting from inhalation of gasoline containing MTBE, including such effects as headaches dizziness, nausea and irritation of the eyes, sinuses and throat (National Science and Technology Council – 1997). A survey was undertaken in 1997-98 to assess the prevalence of MTBE in US surface water and groundwater supplies. In 342 wells in 17 states MTBE was detected at least once in 30 wells. – an occurrence level of nearly 9 percent. In addition, 92 surface water sites in 12 states were evaluated and MTBE was detected at least once at eight sites – an occurrence level of about 8.7 percent.

Existing treatment processes designed for removing other organic chemicals may not be very efficient at removing MTBE. For those supplies already affected, MTBE contamination may necessitate changes in operating conditions, construction of new treatment facilities, or development of alternative sources of supply. As MTBE contamination affects more and more supplies in the United States, the drinking water industry may incur significant expenditures in future years to remove it (JAWWA – January 2000).

From a local Long Island perspective, MTBE is now showing up in water supply wells. Ten percent of public water supply wells in Suffolk County (4-6 years of data) and Nassau County (one year of data) have small concentrations of MTBE. Almost all wells are below 10 ug/l (parts per billion), which is the level expected to be established by the New York State Department of Health as the MTBE maximum contaminant level for drinking water. It may be that this is only the tip of the iceberg and continued monitoring and pumping may indicate higher concentrations of MTBE and more wells affected.

Relationship to Massapequa Water District

For the Massapequa Water District, none of the supply wells show evidence of MTBE contamination with the exception of the Well No. 3, which showed a trace amount in the raw water in 1998 sampling and none in sampling since then.

Testing done by the District continues to show no MTBE's in the water supply and there is no evidence to suggest any health effects.

TREATMENT METHODS LITERATURE REVIEW

INTRODUCTION

This literature review was performed to identify the various treatment methods available to the District to use to provide the treatment required by regulatory agencies prior to distribution to the District's customers.

A detailed description of the District's current treatment practices and the need for the treatment provided by the District is presented in the Water Treatment and Chemical Dosing System sections of this report. The District currently treats all water produced by its wells with: chlorine for destruction of hydrogen sulfide and for disinfection; sodium hydroxide to raise the pH of the water for corrosion control; and phosphates to sequester iron and manganese and for corrosion control.

This literature review identified the available treatment methods for removal of hydrogen sulfide, for treatment of iron and manganese, for disinfection and for corrosion control.

Literature searches were conducted electronically through the American Water Works Association and American Water Works Research Foundation. Physical literature searches were also performed on product literature that is available from manufacturers and manufacturer's representatives.

HYDROGEN SULFIDE TREATMENT

There are numerous treatment processes available to remove hydrogen sulfide (H_2S) from groundwater. These include aeration, adsorption, filtration and oxidation.

Hydrogen sulfide is a gas and is generally found dissolved in the groundwater under the communities on the south shore of Long Island. There are no standards for hydrogen sulfide in drinking water. Hydrogen sulfide must be removed because it affects the aesthetic quality of drinking water, since it produces a "rotten egg" ordor when it is present.

Aeration is the most common method for hydrogen sulfide removal for surface water treatment systems. In the aeration process water and air are brought into contact with each other for the purpose of transferring volatile substances, such as H_2S, to or from the water. Aeration strips the hydrogen sulfide gas out of the water and releases it to the atmosphere. Aeration equipment presently used in water treatment can be classified into two general categories – diffused aerators and waterfall aerators.

In diffused aerators, aeration is accomplished by injecting bubbles of air (usually compressed air) into the water by means of submerged diffusers or porous plates. Bubbles of air are passed up through the water, thereby providing the contact between the air and water to remove dissolved gases. Diffused aeration requires aeration tank or basin. *Diffused aeration is generally only feasible for groundwater systems that pump well water to a ground storage tank. Diffused aeration is not considered economically feasible for the Massapequa Water District because of the need to construct a contact basin or tank and the need to double pump the water.*

Waterfall type aeration equipment presently used in water treatment includes packed towers, spray aerators, tray aerators and eductor systems. The most common aeration equipment used for removing H_2S from groundwater systems are spray aerators and tray aerators. Spray aerators like Diffused aerators are generally only feasible in groundwater systems that pump water to a ground storage tank, since spray aerators require a tank or basin. *Spray aerators also are not economically feasible because of the need to construct a contact basin or tank and the need to double pump.*

Tray aerators can be economically feasible if this type of treatment is considered during the initial design of aeration water system. The Village of Freeport's system, for example, was designed with two separate well fields each with its own elevated tank. The water from the four wells at each well field is pumped to the top of an elevated tank and distributed to four tray aerators located inside of the tanks. *Tray aerators with aeration blower for forced aeration would be the most economically feasible aeration method for* H_2S *removal to install at an existing groundwater supply.* The equipment required would include the tray aerator unit, aeration tank sized to hold a 30-minute detention time of the well capacity and booster pumps to pump the water to the distribution system.

IRON AND MANGANESE CONTROL

Available methods for controlling iron and manganese in drinking water can be included in three categories. These are sequestration, treatment (removal) and aquifer oxidation.

Sequestration

Sequestration is a process that is used to control iron and manganese without removing them from water. The commonly used sequestering agents are polyphosphates and sodium silicate. Polyphosphates sequester unoxidized iron and manganese and sequester best when added as early as possible before chlorination. Sodium silicate sequesters oxidized iron and manganese and sequester best when added at the time of oxidation.

Sequestering techniques have been found to be successful when iron and manganese, either separately or total, are present at less than 1.0 mg/l. The New York State and Nassau County Departments of Health limit the use of sequestration with polyphosphates to waters with iron, manganese or a combination at a concentration not greater than 1.0 mg/l. The New York State Health Department limits the use of sequestering with sodium silicate to waters with iron, manganese or a combination at concentrations less than 2.0 mg/l and the Nassau County Health Department's limit is 1.5 mg/l.

As previously indicated, the District is currently using sequestration with phosphates to control the iron which is naturally present in the water pumped from its wells.

Treatment

Treatment for the removal of iron and manganese is dependent upon the characteristics of the raw water, including the oxidation state of the metals, the organic and natural silica content of the water and the levels of alkalinity and hardness. Iron and manganese exist in water at two levels of oxidation. These are bivalent, ferrous (Fe^{+2}) and manganous (Mn^{+2}) and trivalent, ferric (Fe^{+3}) and quadrivalent manganic (Mn^{+4}). The ferrous and manganous compounds are soluble in water while the ferric and manganic compounds are insoluble. The soluble forms of iron and manganese must be oxidized to the insoluble forms for removal to be effective. The District's water has no organic content and the levels of silica, alkalinity and hardness do not appear to be such to have an effect on oxidant demands.

There are three broad treatment technique categories for the removal of iron and manganese. These are oxidation/filtration, ion exchange and biological iron removal.

Oxidation/Filtration

Oxidation/filtration is the most common method for iron and manganese removal treatment. This method involves conversion of the soluble ferrous and manganous compounds to the insoluble ferric and manganic compounds for mechanical removal via filtration. Oxidation methods include chemical and aeration. The chemical oxidants which are used in iron and manganese removal include chlorine, potassium permanganate, chlorine dioxide and ozone.

Chlorine is the most commonly used and least expensive chemical oxidant for iron and manganese removal. Iron oxidation is rapid, while manganese oxidation using chlorine generally takes one to two hours. Potassium permanganate is a stronger chemical oxidant than chlorine. Potassium permanganate tends to be used more frequently in the oxidation of manganese than that of iron. It is important not to feed excess potassium permanganate, since it adds a faint pink color to the water. Potassium permanganate is sometimes added in line prior to manganese greensand filtration. Prechlorination is frequently used in conjunction with potassium permanganate to reduce the dosage of the more costly potassium permanganate.

Chlorine dioxide, like potassium permanganate, is more frequently used to oxidize manganese than iron. When phenolic compounds are present, chlorine dioxide is sometimes used in place of prechlorination. Ozone is a stronger oxidant than chlorine, potassium permanganate or chlorine dioxide. Ozone has been tested for iron and manganese removal, but it is rarely used in the United States to oxidize iron and manganese. Manganese oxidation requires higher dosages of ozone compared to that required for the oxidation of iron.

Aeration is sometimes used to replace or supplement chemical oxidation for the removal of iron, but is rarely used for manganese removal. Aeration helps to oxidize iron by providing contact with oxygen and sometimes by releasing any carbon dioxide in the water, which tends to lower the pH of the water. Aeration may result in the formation of more compact, less flocculant iron precipitates than those formed by chemical oxidation.

Many water suppliers use pH control chemicals such as lime, caustic soda or soda ash to hasten the chemical oxidation of iron and manganese. The rate of air oxidation of iron is very slow below a pH of 6.5 and air oxidation of manganese is very slow below a pH of 8.5. The generally acceptable pH required for reasonably rapid oxidation by air is above 7.5 for iron and above 9.0 for manganese.

Detention or sedimentation tanks are used to provide additional contact time for complete oxidation and/or precipitation of iron and manganese for very high iron and manganese levels or where oxidation may be inhibited by organic compounds, silica or hardness/alkalinity. The New York State Department of Health requires a minimum detention time of 20 minutes when a detention tank is provided following aeration to insure that the oxidation reactions are as complete as possible. The detention basin is designed as a holding tank with no provision for sludge collection, but with sufficient baffles to prevent short circuiting within the tank. Sedimentation basins are used when treating water with high iron and/or manganese content, or where chemical coagulation is used to reduce the load on filters. Provisions for sludge removal are typically made. Lime and lime/soda softening processes provide very good iron and manganese removals.

Filtration is used for removing iron and manganese floc and other suspended matter following aeration, chemical oxidation, detention, sedimentation, or lime, lime/soda softening. Types of filtration systems include gravity, pressure and vacuum. Types of filter media include filter sand, coal, garnet sand, contact media, and diatomaceous earth. Filter sand is the most commonly used filter media by water suppliers that remove iron and manganese. Filter sand of 0.7 to 1.0 mm effective size is generally satisfactory for removing iron and manganese concentrations up to 1.5 to 2.0 mg/l.

Contact filter media, which removes iron and manganese by sorption and oxidation at the media surface, include manganese zeolite or "greensand" and manganese-coated sand. Hydrated ferric and manganic oxides on the media sorb bivalent metal ions, such as ferrous and manganese ions, and act as insoluble catalysts to enhance the reaction between dissolved oxidizing agents and the unoxidized ferrous and manganese ions. In the past, practically all water utilities that used manganese green sand for iron and manganese removal used intermittent regeneration with potassium permanganate to restore the capacity of the zeolite. Today, most new manganese zeolite systems regenerate continuously to save regenerant and regeneration time. Unlike manganese greensand which stress excess regenerant until needed, manganese-coated sand normally requires a continuous supply of excess oxidant to act as a catalytic filter.

Diatomaceous earth is another filter media that is sometimes used for the removal of iron and manganese. Magnesite (MgO) has been used to aid the oxidation and removal of iron by diatomaceous earth. The diatomaceous earth is discarded after each filtration cycle.

Ion Exchange

Both ferrous iron and manganeous manganese can be removed from water by the ion exchange method. Either a sodium resin or a hydrogen cation exchange material may be used. This method is of limited applicability because calcium and magnesium are removed with the iron and manganese. Because the process can be almost completely automated, this method is applicable and economical under certain conditions. Fouling of the resin with ferric iron must be guarded against and consequently consideration must be given to provision of arrangements for periodic chemical cleaning of the resin. Disposal of the wastewater (wash and rinse) may prove to be a problem because of either the chloride or acid content. The use of ion exchange is limited by the New York State Department of Health to waters containing less than 0.3 mg/l of iron, manganese, or combination thereof. *Because of iron concentrations in well water greater than 0.3 mg/l, this method cannot be considered for the District.*

Biological Oxidation

Biological iron removal techniques have been developed as a result of some shortcomings in the conventional iron removal processes. Biological iron removal methods require less equipment and a more compact design than conventional oxidation/filtration methods. A typical biological process would include aeration of the water prior to a high rate filter containing a coarse sand (biological reacter), chlorination and detention prior to distribution. The capital and operating costs of biological methods are estimated to be lower than conventional methods. There is still a significant amount of evaluation needed to determine the optimum pH, the specific bacteria to use, etc., for optimum efficiency.

The use of trickling filters is another biological method that has been studied for iron removal. Trickling filters provide the required oxidation, biological removal and filtration in a single unit. An advantage of trickling filters is that no external mechanical air supply is required. Air is naturally convected through the filter as a result of the temperature difference between the interior and exterior o the filter. The biological oxidation within the filter allows twice as much iron removal, which gives this method a high iron removal capacity. Oxidation and filtration occur simultaneously with no chemicals required for pH control or for flocculation. The trickling filters require backwash, but the amount of backwash water is very small compared to the amount of water treated.

To date, biological iron removal techniques have only been studied and no full scale treatment plant is currently in operation. United States water suppliers have avoided the use of biological treatment. The acceptance of biological treatment for removal of iron, or for water supply treatment in general, by the health departments is yet to be determined.

Aquifer Oxidation

Aquifer oxidation involves injecting oxidized water into the groundwater surrounding a supply well. This concept of in situ purification of groundwater began with the observations of two Finnish well drillers in the early 1950's. After pumping aerated water into wells with water quality problems, it was noted that many times the injected volume of water could be extracted having a much improved quality. Such findings developed into the patented "Vyredox Method" of underground aeration. The Vyredox procedure employs a ring of satellite wells for injecting and dispersing aerated water around the yield zone of the central production well. This method has only been successfully used for shallow wells. Potential problems with this method include a chemical oxygen demand within the aquifer which would use the oxygen before it oxides the soluble iron and fouling of the injection wells. Also oxidation of manganese with this method is difficult.

DISINFECTION

Chlorine has always been considered the best choice for disinfection since chlorine is cost effective and reliable. Chlorine is simple to operate, easy to maintain, reliable and produces a detectable residual which provides protection throughout the distribution system. Chlorine reacts with naturally occurring organic materials prevalent in surface waters to form chloroform and other trihalomethanes (THMs). These disinfection byproducts (DBPs) associated with disinfection have raised concerns over the use of chlorine as a disinfectant, but these concerns are primarily applicable to surface water supply systems. The organic materials which chlorine reacts with to form THMs is rarely present in well water.

Chlorine can be employed as chlorine gas, liquid chlorine or sodium hypochlorite. Liquid and gaseous chlorine is very poisonous and corrosive. Chlorine storage and handling systems must be designed with full safety considerations. The hazards of chlorine handling and storage have resulted in the use of hypochlorite solutions. Hypochlorite is more expensive, loses strength in storage and is more difficult to feed. However, for safety reasons, sodium hypochlorite is generally used instead of chlorine gas or liquid.

In recent years alternative disinfection practices have been employed by surface water systems as a substitute for chlorine. Chloramination has been employed as a successful and effective disinfectant. Benefits of chloramination include, increased disinfectant residual maintenance, lower THMs, improved taste and odors and adequate control of microbial contaminants. Disadvantages of chloramines are that it is much weaker than chlorine as a disinfectant for bacteria and less effective in inactivating protozoal cysts and enteric viruses. Chloramine also may promote bacteria growth in the distribution system due to the production of ammonia. Nitrification becomes an important concern with the use of chloramine. Chloramine residuals can also cause problems for individual on dialysis machines.

Chlorine dioxide (ClO_2) has been used as an effective disinfectant in Europe, but has limited application in the United States. It is particularly effective at a higher pH (8) than chlorine (6.5-7). An advantage of chlorine dioxide is that it maintains a residual in the distribution system for extended periods of time. Chlorine dioxide also helps to minimize the corrosion of lead and copper. In use for surface waters, chlorine dioxide lowers THM production and doesn't form halogenated organic DBPs. Chlorine dioxide may also be more effective in inactivating viruses. It is fairly simple to convert a chlorine system to chlorine dioxide system.

The disadvantages of chlorine dioxide include the following:

- Higher operational costs than chlorine or sodium hypochlorite.
- Has the potential to form chlorite and chlorate ions which can be toxic at certain concentrations.

- It must be generated on site by reacting sodium chlorite with chlorine.

Effective chlorite removal methods are necessary to increase the applicability of the use of chlorine dioxide as a disinfectant.

Ozone (O_3) is another disinfectant process that has been implemented. Because of concerns of post contamination and the need for a residual, however, the use of ozone will require chlorination, or chloramination, as a final disinfection step. The advantages of ozone are that it is extremely strong, it is not affected by pH, it destroys THM precursors and forms a limited number of DBPs. Ozone also has no residual toxicity. Ozone is also beneficial in color removal, taste and odor control, oxidation of organics, iron removal, as well as being a disinfectant. Ozone, used prior to chlorination, will also reduce the likelihood of trihalomethane formation in surface waters. The disadvantages of ozone are the extremely high capital and operating costs and the lack of a residual in the distribution system. Another disadvantage of ozone is that it has to be manufactured on site. Ozone also produces DBPs such as bromate, aldehydes, ketones and peroxides. The greatest problem is with bromide, which reacts with ozone to form bromate. Ozone could also react with natural humic materials that may promote growth of bacteria in the distribution system. Ozone may require a separate contact tank because of the difficulty in handling ozone gas above the water surface, which adds to the costs. Ozone requires a high degree of maintenance and requires cooling water. There are also potential safety hazards regarding ozone leaks.

Hydrogen peroxide can be used in conjunction with ozone to create greater oxidation potential and less selective reactants. This is a more effective process in surface waters for destroying taste and odor causing compounds and removing precursor material. Hydrogen peroxide is a strong oxidant, but a weak disinfectant. It does not provide a residual nor does it produce any undesirable by-products.

Another, non-chemical, process for disinfection is ultraviolet radiation (UV). There are three (3) types of UV systems, low pressure - low intensity, low pressure - medium intensity, and medium pressure - high intensity. The low pressure, low intensity system is the most common UV system in use. Generally, there are forty (40) lamps required per million gallons of water. The lamp arrangements may be horizontal or vertical. Low pressure, low intensity UV systems offer the best electrical efficiency and have the simplest design of the UV systems. They also require a lot of lamps, which must be manually cleaned and require a lot of space. The medium pressure, high intensity system may be self cleaning and requires fewer lamps, but has a lower efficiency and uses more power than the low pressure systems.

The main advantage of any UV system is that no chemicals are added, thus there are no DBPs. UV disinfection is most effective after treatment such as carbon adsorption filters, water softeners, etc. The drawback to UV disinfection is that there is no measure to determine if proper disinfection is taking place. The UV devices must be cleaned periodically to ensure proper transmittal of the light. Pretreatment may be required to remove suspended solids and organic matter to avoid shielding the organisms in the water from the UV. UV devices are more effective on bacteria than viruses or parasites.

CORROSION CONTROL

There are basically three (3) types of methods for control corrosion in distribution systems. One method is calcium carbonate precipitation. The purpose of this method is to maintain a high level of calcium and carbonate in the water so that calcium carbonate precipitates out in the distribution system. If the concentrations of these two compounds are not high enough, they may be adjusted. Hydrated lime may be added to increase the calcium concentrations and soda ash, sodium bicarbonate or carbon dioxide may be added to increase the concentration of carbonate.

Calcium carbonate precipitation requires a great deal of operator attention. Calcium carbonate, which forms a protective coating on the pipes, will also clog bins, tanks, pumps, etc. The storage bins must be kept dry and the feed systems must be acid cleaned. In addition, the calcium carbonate may cause a build up in the customer's hot water heaters.

This method is generally used for lead only. The precipitate may not form on copper piping and the water produced from the chemicals may become too corrosive for copper.

Another popular method of corrosion control is passivation. This treatment consists of adding chemicals to produce a less corrosive water. This is accomplished by either raising the pH and alkalinity of the water, or by adding inhibitors. There are several products that are used to alter the pH of drinking water supplies. The addition of lime is the most effective and least expensive alternative. Lime, however, raises the total hardness of the water and has limited solubility in carbon dioxide free water. Lime is also difficult to use and is very operator intensive.

Caustic soda or sodium hydroxide (NaOH) is another popular chemical added to raise the pH. Caustic soda is generally used as a fifty (50) percent solution or as a twenty-five (25) percent solution. It is relatively easy to handle and store, although it must be stored indoors and heated. The reaction time of caustic soda is very fast. The increased levels of sodium in the treated water caused by the addition of NaOH is minimal compared to the daily intake from other sources.

Another method of raising the pH level in water is the addition of soda ash. The use of this treatment method has decreased because of the high cost of soda ash and the high dosage as compared to the lime and caustic soda. Soda ash is used when the addition of hardness to the water is not desired and where alkalinity in the water is insufficient for stability.

Inhibitors are added to water to either sequester corrosion or to form a protective coating on the pipe surface to prevent corrosion. Inhibitors are generally silicate or phosphate based. Silicates are generally used for corrosion on steel, but they can be used on copper pipes. Sodium silicate (Na_2SiO_3) will produce a protective coating on the pipes and will also raise the pH of the water. Silicates provide good protection for carbon steel, galvanized steel and copper. Sodium silicate has no calcium carbonate scale inhibitor properties.

Phosphate related treatment products are more commonly used on Long Island. The main types of phosphate products are polyphosphates and blended polyphosphate-orthophosphates. Phosphate products are used to sequester iron and to form a protective coating on the pipes to prevent future corrosion. Zinc may also be added to the polyphosphates.

Limestone contactors are another method of elevating the pH and alkalinity of water. This method is uncommon and is used if the raw water is soft and slightly acidic. In this treatment, water flows over a packed bed of crushed limestone. This dissolves the calcium carbonate and thus increases the pH, calcium and alkalinity of the water. This method is very uncommon. Effective operation of the contactors requires proper control of water pH, hardness, CO_2 and other materials that can foul the limestone surface.

Another non-chemical alternative to corrosion control is aeration. Aeration has been used to remove hydrogen sulfide, methane, iron, manganese, etc. Aeration may also be an effective corrosion control treatment, if the initial pH alkalinity and dissolved inorganic carbon (DIC) are appropriate. Aeration will remove carbon dioxide which will increase the pH and affect the DIC. This may in turn make the water less corrosive, which may affect lead and copper solubility.

There are several different types of aeration processes, which were described in detail under the hydrogen sulfide section.

Aeration is advantageous because it is easily understood, well established, simple and inexpensive. It is also easily maintained and operated. Aeration, however, has several disadvantages such as calcium carbonate deposits, low dissolved inorganic carbon water and possible microbiological activity due to exposure to the atmosphere.

Since the Massapequa Water District well water has a low pH, low alkalinity and low calcium content, pH/alkalinity adjustment or use of a corrosion inhibitor are the only corrosion control treatment techniques that would be applicable for the District. All Long Island water suppliers are using either pH/alkalinity adjustment or a corrosion inhibitor for corrosion control treatment.

Regulations require that a demonstration study be performed before any changes are made in corrosion control treatment.

DISCUSSION OF PRIOR SECTIONS

RAW WATER QUALITY

Previous sections of this report examined the District's raw water quality and found it to be of excellent quality except that at times it contains hydrogen sulfide, water produced by some wells contain iron and the water is highly aggressive (corrosive). As previously indicated, the District treats all water with chlorine to oxidize any hydrogen sulfide that may be present in the raw water; treats all water with phosphates to sequester the iron present in the raw water and to inhibit corrosion of unlined cast iron water mains and customer plumbing systems; and treats all water with sodium hydroxide to raise the pH to reduce the corrosivity of the water. Thus all raw water quality parameters of concern are currently being effectively treated by methods which are approved by the State and Nassau County Health Departments.

DISTRIBUTION SYSTEM WATER QUALITY

Results of the distribution system water quality analyses indicate that the water in the distribution system in general is of the same excellent quality as the raw water. The results show that although the corrosivity has been substantially reduced, the water is still slightly corrosive. The treatment of pH adjustment with sodium hydroxide and the addition of phosphate is effective in controlling the corrosivity of the water. The results of lead and copper sampling performed by the District indicate that the District is considered to have optimal corrosion control treatment. Even with optimal corrosion control, the distribution system sample results indicate that there is some minimal corrosion taking place in the distribution system.

HEALTH RISK LITERATURE REVIEW

The health risk literature review did not identify any obvious health effects with the concentration of the various chemicals either occurring naturally or being added for treatment.

TREATMENT MEHTODS LITERATURE REVIEW

The treatment methods literature review identified the various methods for treating the hydrogen sulfide, iron, disinfection and corrosion control requirements necessary due to the quality of the raw water produced by the District's wells. These methods will be discussed further under the Alternative Approaches part of this section.

COMPLAINTS

The Districts rusty water and taste and odor complaints were reviewed and compared to four other suppliers located on or in close proximity to the south shore of Nassau County and with raw water quality similar to the District's raw water quality. The review found that the District's rusty water complaint rates were among the lowest compared to the suppliers surveyed and the taste and odor complaints were comparable to the other suppliers. Both the District's rusty water and taste and odor complaint rates can be considered expected and normal for a typical Long Island south shore water supply. Based upon discussions with consulting engineers doing business nationwide, there is no water system in the United States that does not register any complaints about rusty water or taste and odor.

ALTERNATIVE TREATMENT APPROACHES

There are three water quality parameters of the raw water produced by the District's wells that require some form of treatment. In addition, paragraph 5-1.30 (a) of Part 5 of the New York State Sanitary Code requires disinfection by chlorination or other disinfection methods acceptable to the department as a minimum treatment for a groundwater source. As previously indicated, the District is currently providing treatment for each of these parameters. Alternative approaches to the District's current treatment practices are discussed in the following sections.

Hydrogen Sulfide

The treatment methods used for hydrogen sulfide include absorption, aeration, filtration and chemical oxidation. The two treatment methods found to be the most practical and cost effective are aeration and chemical oxidation. Aeration is a process in which water and air are brought into contact with one another for the purpose of transferring volatile substances to or from water. Hydrogen sulfide is a gas and therefore is a volatile substance. The treatment methods review identified the various types of aeration treatment available. The two types that would be most applicable to the District are tray aerators and packed towers.

As previously indicated, the District uses chlorine to chemically oxidize the hydrogen sulfide gas that may be present in the raw water. This method is the most cost effective, especially if chlorination for disinfection is practiced by a water supplier. Under this method the chlorine is added to the water as it is pumped to the distribution system and the hydrogen sulfide is oxidized before water reaches the customers tap. The capital cost for this type of treatment system on a 2.0MGD well is typically under $10,000 and the operating costs are limited to the cost of chlorine and the minimal amount of electricity needed to operate the chemical feed pump are approximately $5.50 per million gallons.

With a tray aerator or packed tower, the water is pumped to the treatment unit and then flows by gravity through the unit. A clear well is required to collect the water after it flows through the treatment unit. Booster pumps are then used to pump the water to the distribution system.

The EPA is considering the implementation of mandatory disinfection of groundwater supplies. Consequently, the clear well may have to be sized for a minimum detention time of 30 minutes. The capital cost of an aeration treatment system for a 2 MGD well, including the aerator unit, blower, clear well, booster pump and associated electrical and piping work is estimated at $388,000. The operating cost consists of the power to operate the blower and booster pump and is estimated at $102.00 per million gallons.

Iron

There are two treatment methods that are used to treat the iron naturally present in some wells on Long Island. These are sequestering and removal by one of the various methods identified in the treatment methods literature review.

Sequestering with a linear chain polyphosphate is the most common sequestering method used on Long Island, has been found to be the most effective method for sequestering and it is the method currently used by the District. Under this method the liquid phosphate is added to the water immediately as it is brought to the surface and as far as practical before the addition of chlorine. The phosphate must be added first to sequester the iron, since the chlorine will oxidize the iron and cause it to precipitate out in the distribution system. The linear chain phosphate also forms a microscopic coating on the walls of unlined cast iron and transite mains, which inhibits corrosion of the mains. This also inhibits iron from the cast iron mains from being added to the water in the distribution system. The capital cost of a phosphate treatment system for sequestering iron for a 2.0 MGD well is typically under $10,000 and the operating cost is limited to the cost of phosphate and the negligible amount of electricity to operate the chemical feed pump or approximately $23 per million gallons.

Studies have identified oxidation/filtration as the most applicable iron removal treatment technology for groundwater systems, since these processes can be operated under pressure, thus eliminating the need for re-pumping into the distribution system. The more conventional iron removal treatment using oxidation followed by either sedimentation or gravity filtration is effective in removing iron, but it requires re-pumping. The oxidation/filtration process using manganese green sand has been found to be the most feasible technology for groundwater systems.

In the manganese green sand process, chlorine and potassium permanganate are added to oxidize the iron (and any manganese) and sodium hydroxide is added to raise the pH to approximately 6.5. During normal operation, the water is pumped through the filters to the distribution system. Sodium hydroxide is added after the filters to raise the pH to between 7.5 and 8.5.

Periodic backwashing of the filters is required to remove the precipitated material. Typically, the filters would be backwashed twice a day, resulting in approximately 54 minutes of down time and a product loss of approximately 5.4 percent of the total flow produced by a well. In general, two filters are used and are backwashed sequentially with filtered effluent from one filter used to backwash the other. Water from the distribution system will have to be used to supplement the water from the filter(s) in order to meet the required backwash rate.

Backwash water is generally discharged to the sanitary sewer system. The Nassau County Department of Public Works would have to be contacted to determine whether or not treatment of the backwash water is required and to determine whether or not there would be any restrictions on the discharge rate to the sewers. Investigating the methods available for disposal of the backwash water is beyond the scope of this report.

The capital cost in 1999 dollars for a 2.0MGD manganese green sand iron removal treatment facility is estimated at $2,100,000 and the operating cost is estimated at $96.00 per million gallons.

Since the most feasible alternative for iron removal treatment requires chlorine to oxidize the iron such that it can be filtered out, the District would be required to chlorinate to maintain proper residuals in the distribution system as required by the Health Department, or if it is possible to obtain a chlorination waiver, dechlorinate the water prior to the distribution system. The cost of dechlorination is not included in the above estimates.

Disinfection

As previously stated, the State Health Department requires disinfection by chlorination or other disinfection methods acceptable to the Department as a minimum treatment for groundwater sources. The State may grant a waiver to this disinfection rule for groundwater sources on the submission of a written application and providing the supplier meets certain criteria. When chlorine is used as a disinfectant, the State requires the supplier to maintain a free chlorine residual at representative points in the distribution system.

The treatment methods literature review identified other disinfection methods, but none of the other methods offer the same reliability nor are they as cost effective as chlorination. Disinfection by products (DBPs) are generally not found in a groundwater system, since the precursors needed for the chlorine to react with to form the DBPs are generally not present in a groundwater source.

The most feasible alternatives available to the District are to continue to practice disinfection by chlorination or to obtain a waiver from chlorination. In order to obtain a waiver from chlorination, the District would first have to construct aeration treatment facilities at each of its wells to eliminate the need to treat with chlorine to oxidize hydrogen sulfide. And, if the District elects to construct iron removal treatment facilities that use chlorine to oxidize the iron, de-chlorination would be required as part of the iron removal treatment facility. As an alternative, the District could construct aeration and iron removal facilities and continue disinfection with a low concentration of chlorine.

Other consequences to evaluate when considering cessation of chlorination are the lack of a chlorine residual in the distribution system to protect against a microbial problem that may occur, and past experience of the District with complaints when the chlorine residual dissipated due to long residence times in the distribution system in some low flow areas. The 1982 B&C study hinted that the taste and odor complaints that the District received in the 1970s may have been due to the reduction of sulfates to hydrogen sulfide. This could not be verified at the time of the study because adequate levels of chlorine were present during the study period. Sulfate reduction only occurs in the absence of dissolved oxygen and/or chlorine.

Corrosion Control

The District currently uses pH/alkalinity and treatment with orthophosphates for corrosion control. The pH/alkalinity treatment is the primary corrosion treatment used by the District. The District uses phosphates to sequester the iron present in the source water, but also uses the phosphates to inhibit corrosion of the unlined cast iron mains and customers plumbing systems.

As previously indicated, the District uses sodium hydroxide to raise the pH of the raw water. Lime is the only viable alternate chemical available to the District for pH adjustment. The District converted from lime treatment to sodium hydroxide treatment for pH adjustment a number of years ago, because lime treatment requires a lot of operating personnel time and is difficult to use. The District is able to maintain adequate pH and alkalinity levels for corrosion control with the sodium hydroxide treatment.

There is no designated limit for a maximum contaminant level for sodium, but the State Health Department recommends that water containing more than 20 mg/l should not be used in drinking by people on severely restricted sodium diets and that water containing more than 270 mg/l of sodium should not be used for drinking by people on moderately restricted diets. Even though the District uses sodium hypochlorite for chlorination, sodium hydroxide for pH adjustment and sodium phosphate for sequestering iron, the total level of sodium in the water delivered to customers ranges from approximately 10mg/l to 24 mg/l.

As indicated in a prior section, iron removal treatment is an alternate to sequestering the iron with phosphates and that was discussed in that section. Sodium silicate is an alternate chemical that is used to sequester iron and to inhibit corrosion of unlined cast iron mains. One of the suppliers used for comparison of complaint rates currently uses sodium silicate for sequestering and for inhibiting corrosion of unlined cast iron mains and lime for pH adjustment. That supplier had a higher complaint rate than the District's complaint rate and is currently investigating alternate sequestering and corrosion inhibitor chemicals. If the District elects to remove iron in lieu of sequestering it, phosphate treatment may still be required to sequester any iron that may not be removed and to inhibit corrosion of the unlined cast iron water mains. Phosphates are the best available treatment for this application.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The conclusions reached by this study follow:

1. Raw Water Quality – The District's raw water is highly aggressive (corrosive), is very soft, contains iron and, at times, contains hydrogen sulfide which produces a rotten egg odor. The quality of the raw water has been relatively consistent over the past few years with no apparent increase in any of the chemicals for which analysis are performed. The District's raw water is considered to be of excellent

quality because it meets drinking water quality MCLS and because it does not contain any harmful parameters that require removal prior to distribution.

2. Distribution System Water Quality – The water in the District's distribution system is mildly corrosive. Iron concentrations in the distribution system water appear to reflect the concentrations in the raw water, but slightly higher copper levels indicate that minimal corrosion is taking place. The District's distribution water is considered to be of excellent quality.

3. Treatment – Based upon the District's rusty or cloudy water complaint rate, the treatment of iron present in the raw water is being effectively treated by sequestering it with phosphates. The lead and copper sampling results indicate that with the addition of sodium hydroxide to raise the pH of the raw water and the addition of phosphates, the District has optimized corrosion control treatment. The chlorine, which is added to oxidize any hydrogen sulfide that may be present in the raw water and to maintain water quality in the distribution system has been effective as the District continues to have negative results for microbial sampling analyses year after year. Treatment provided by the District has been optimized to meet the intended goals.

   The capital and operating cost for aeration treatment at each well to remove hydrogen sulfide in lieu of oxidation of the hydrogen sulfide is excessive and its justification is questionable. Based upon past studies and the District's experience, the District will still be required to chlorinate the water produced by each of its wells to maintain a chlorine residual in the distribution system, to avoid potential taste and odor complaints as a result of the reduction of sulfate to hydrogen sulfide.

   The capital and operating cost for iron removal treatment at each well to remove iron in lieu of sequestering the iron with phosphates is excessive and its justification is questionable, since the sequestering is effective and there would be a minimal benefit. The addition of phosphates as a corrosion inhibitor will still be required to inhibit the corrosion of the unlined cast iron mains and most likely, to also maintain optimal corrosion control. The addition of phosphates also coats and protects the transite mains in the distribution system.

4. Complaints – The District's rusty and cloudy water and taste and odor complaint rates are low compared to comparable suppliers on the south shore in Nassau County. There is no known health related problem associated with the rusty water, tastes or odors in those areas where complaints were received or in any other area of the District.

5. Causes of Complaints – The major factors in the cause of rusty water complaints are the corrosive nature of the water, hydraulic dead ends in the distribution system and actual dead end pipes. Over the past several years, the District eliminated complaints from customers on dead end pipes by replacing the unlined cast iron pipes with cement lined ductile iron mains. The District also eliminated complaints from a hydraulic dead end area by mechanical cleaning and cement lining of the mains in the area.

The major factor in the cause of most of the taste and odor complaints has been attributed to the lack of a chlorine residual in the distribution system.

By taking the actions it has over the past several years and by maintaining proper levels of phosphate and chlorine treatment the District has effectively addressed complaints.

RECOMMENDATIONS

Following are recommendations regarding water quality and treatment for the Massapequa Water District.

1. General – It is recommended that the District wait until the EPA promulgates the Groundwater Rule (GWR) prior to considering any changes in treatment. The statutory deadline for promulgation of the GWR is May, 2002, but the EPA intends to promulgate the rule by November, 2000.

   The EPA desires to allow three years for compliance and to ensure simultaneous compliance by groundwater systems with the Stage 1 Disinfection By Products Rule (DBPR) and the GWR. Groundwater systems must begin the sampling under the Stage 1 DBPR in November 2003. Under the GWR, the EPA is considering mandatory disinfection of groundwater systems. Latest information indicates that the EPA may include provisions for waivers from mandatory disinfection in the GWR, but the criteria is not known at this time. The GWR may require contact time prior to pumping to the distribution systems. This will require a change from the current practice of adding the disinfectant as the water is pumped to the distribution system.

2. Hydrogen Sulfide and Chlorine Treatment – It is recommended that the District continue with its current treatment for removal of hydrogen sulfide, which consists of oxidizing the hydrogen sulfide with chlorine. Past District experience indicates that the District receives complaints whenever there is a low or no chlorine residual in the distribution system. A prior study indicated that there may be iron bacteria in the distribution system. Chlorine is required to control the iron bacteria. The District has been chlorinating its system for so many years, that cessation of chlorination may result in positive coliform samples and, potentially, the required public notification that the MCL is exceeded. The Nassau County Commissioner of Health is against issuing waivers from mandatory chlorination and is of the opinion that all water systems should be chlorinated. Stopping and restarting chlorination may result in more consumer complaints than if chlorination was continuous. In any event, it is recommended that the District not do anything with its current chlorination treatment until the EPA promulgates the Groundwater Rule. The current treatment practice for removal of hydrogen sulfide is effective and the least costly method.

   It is recommended that the District continue to maintain distribution system chlorine residuals as low as practicable and as close to an average of 0.5 mg/l as possible without resulting in consumer complaints. It is also recommended that the District monitor any ongoing or future studies regarding possible human health effects from ingesting water with chlorine residuals.

3. Iron Removal Treatment – It is recommended that the District continue to sequester the iron naturally present in the well water with a linear chain polyphosphate. Sequestering iron is the most cost effective method for treatment of the iron. The District should continue to monitor the concentration of iron present in its wells and consider iron removal treatment if the concentration of iron exceeds one milligram per liter. The excessive cost of iron removal treatment is not warranted since there will be little or no benefit.

4. Phosphate Treatment – It is recommended that the District continue to treat all the water produced by its wells with a linear chain polyphosphate to sequester the iron in the well water and to inhibit corrosion of the distribution system (especially unlined cast iron mains) and customers plumbing systems. Even if the District provides treatment to remove the iron from the well water, it is recommended that the District continue to treat all well water with phosphates to inhibit corrosion of the unlined cast iron water mains. In addition, the phosphate treatment may be required to obtain optimal corrosion control treatment and should not be stopped without prior pilot testing.

5. pH Adjustment Treatment – It is recommended that the District continue to treat with Sodium hydroxide to raise the pH of the well water prior to pumping it to the distribution system. Adjusting pH with sodium hydroxide is the most cost effective method. The District has achieved optimal corrosion control treatment using sodium hydroxide for pH adjustment and phosphates.

6. Flushing of Distribution System – It is recommended that the District continue its current program of flushing water mains to remove sediment that may deposit in the mains.

7. Monitor Consumer Complaints – It is recommended that the District continue to monitor consumer complaints and consider improvements to the distribution system in high repetitive complaint areas.

PRELIMNARY COST ESTIMATES

Preliminary cost estimates were developed for alternative treatment methods. The estimates of cost reflect the mid range of bid prices expected to be received for improvements in 1999 and include a twenty percent allowance for engineering fees, legal fees and contingencies. Following are the preliminary cost estimates for the alternative treatment methods:

TRAY AERATORS WITH BLOWERS, CLEAR WELL AND BOOSTER PUMPS FOR REMOVAL OF HYDROGEN SULFIDE FOR TWO 2.0 MGD WELLS

Tray aerators with blowers, clear well and booster pumps is an alternate to the current oxidation with chlorine method the District is currently using for treatment of hydrogen sulfides. The preliminary cost estimate for a treatment facility to treat two of the District's 2MGD wells including two tray aerators, two blowers, two booster pumps, a clear well, piping modifications, electrical work and a building to house the electrical equipment and booster pumps: $775,000

MANGANESE GREEN SAND IRON REMOVAL TREATMENT FACILITY FOR A 2.0 MGD WELL

The manganese green sand iron removal treatment facility would consist of a building to house the filters, chemical storage equipment and chemical feed pumps and electrical equipment; piping modifications, electrical work; and a backwash equalization storage tank: $2,520,000

HEALTH RISK REFERENCES

Alaburda J. and Nishihara L. 1998. Occurrence of nitrogen compounds in well water. *Revista de Saude Publica* 32(2):160-5.

Armstrong B.K., Margetts B.M., Binns C.W., Campbell N.A., Masarei J.R. and McCall M.G. 1982. Water sodium and blood pressure in rural school children. *Archives of Environmental Health* 37(4):236-45.

Aschengrau A., Zierler S. and Cohen A. Quality of community drinking water and the occurrence of late adverse pregnancy outcomes. *Archives of Environmental Health* 48(2):105-113.

Bellinger D., Leviton A., Watemaux C., Needleman H. and Rabinowitz M. 1987. Longitudinal analyses of prenatal and postnatal exposure and early cognitive development. *New England Journal of Medicine* 316: 1037-1043.

Beresford S.A. 1985. Is nitrate in the drinking water associated with the risk of cancer in the urban U.K.? *International Journal of Epidemiology* 14(1):57-63.

Bernardi D., Dini F.L., Azzarelli A., Giaconi A., Volterrani C. and Lunardi M. 1995. Sudden cardiac death rate in an area characterized by high incidence of coronary artery disease and low hardness of drinking water. *Angiology* 46(2):145-149.

Bhambhani Y., Burnham R., Snydmiller G., MacLean I. and Martin T. 1996. Effects of 5 ppm hydrogen sulfide inhalation on biochemical properties of skeletal muscle in exercising men and women. *American Industrial Hygiene Association Journal* 57(5):464-468.

Bilyk A., Kolwzan B. and Traczewska T.M. 1996. Evaluation of mutagenic activity in water disinfected with chlorine. *Rocz Panstw Zakl Hig* 47(1):77-85.

Bonilla E. 1984. Chronic manganese intake induces changes in the motor activity of rats. *Experimental Neurology* 84(3): 696-700.

Bove F.J., Fulcomer M.C., Klotz J.B., Esmart J., Dufficy E.M. and Savrin J.E. 1995. Public drinking water contamination and birth outcomes. *American Journal of Epidemiology* 141(9):850-862.

Brennan R.J. and Schiestl R.H. 1998. Chloroform and carbon tetrachloride induce intrachromosomal recombination and oxidative free radicals in *Saccharomyces cerevisiae. Mutation Research* 397(2): 271-278.

Bull R.J. Birnbaum L.S., Cantor K.P. Rose J.B., Butterworth B.E., Pegram R. and Tuomisto J. 1995. Water chlorination: essential process or cancer hazard? *Fundamental and Applied Toxicology* 28(2): 155-66.

Bull R.J., Robinson M., Meier J.R. and Stober J. 1982. Use of biological assay systems to assess the relative carcinogenic hazards of disinfection byproducts. *Environmental Health Perspectives* 46:215-27.

Calabrese E.J. and Kenyon, E.H. 1991. Air Toxics and Risk Assessment. *Lewis Publishers*, Chelsea, MI.

Calabrese E.J. and Moore G.S. 1979. Can elevated levels of copper in drinking water precipitate acute hemolysis in G-6-PD deficient individuals? *Medical Hypotheses* 5(4): 493-8.

Cantor K.P. 1997. Drinking water and cancer. *Cancer Causes and Control* 8(3):292-308.

Carlo G.L. and Mettlin C.J. 1980. Cancer incidence and trihalomethane concentrations in a public drinking water system. *American Journal of Public Health* 70(5):523-524.

Cech I., Holguin A.H., Littell A.S. Henry J.P. and O'Connell J. 1987. Health significance of chlorination byproducts in drinking water: The Houston experience. *International Journal of Epidemiology* 16(2):198-207.

Daniel F.B., Schenck K.M. Mattox J.K., Lin E.L., Haas D.L. and Pereira M.A. 1986. Genotoxic properties of haloacetonitriles: drinking water byproducts of chlorine disinfection. *Fundamental and Applied Toxicology* 6(3):447-453.

Dich J., Jarvinen R., Knekt P. and Penttila P.L. 1996. Dietary intakes of nitrate, nitrite and NDMA in the Finnish Mobile Clinic Health Examination Survey. *Food Additives and Contamination* 13(5):541-552.

Dieter H.H. 1989. Essential biochemical aspects and toxicology of copper. *Offentl Gesundheitswes* 51(5):222-227.

Dietrich K.N., Succop P.A., Berger O.G., Hammond P.B. and Bornschein R.L. 1991. Lead exposure and the cognitive development of urban preschool children: The Cincinnati Lead Study cohort at age 4 years. *Neurotoxicology and Teratology* 13:203-211.

Dunnick J.K. and Melnick R.L. 1993. Assessment of the carcinogenic potential of chlorinated water: experimental studies of chlorine, chloramine and trihalomethanes. *Journal of the National Cancer Institute* 85(10):817-822.

Durlach J., Bara M. and Guiet-Bara A. 1985. Magnesium level in drinking water and cardiovascular risk factor: a hypothesis. *Magnesium* 4(1):5-15.

Fan A.M. and Steinberg V.E. 1996. Health implications of nitrate and nitrite in drinking water: an update on methemoglobinemia occurrence and reproductive and developmental toxicity. *Regulatory Toxicology and Pharmacology* 23(1 Pt 1):35-43.

Fewtrell L. Kay D. Jones F., Baker A. and Mowat A. 1996. Copper in drinking water—an investigation into possible health effects. *Public Health* 110(3):175-177.

Fitzgerald D.J. 1998. Safety guidelines for copper in water. *American Journal of Clinical Nutrition* 67(5 Suppl): 1098S-1102S.

Foster A.M., Prentice A.G., Copplestone J.A., Cartwright R.A. and Ricketts C. 1997. The distribution of leukemia in association with domestic water quality in south west England. *European Journal of Cancer Prevention* 6(1):11-19.

Guidotti T.L. 1996. Hydrogen sulphide. *Occupational Medicine* 46(5):367-371.

Harrington JM, Craun GF, Meigs JW, Landrigan PJ, Flannery JT, Woodhaull RS. An investigation of the use of asbestos cement pipe for public water supply and the incidence of gastrointestinal cancer in Connecticut, 1935-1973. 107:96-103 (1978).

Health and Environmental Assessment of MTBE. Report to the Governor and Legislature of the State of California as sponsored by SB521.

Holmes T., Jensen E.L. and Conway J.B. 1985. Nitrate contamination of domestic potable water supplies: a social problem? *American Journal of Preventive Medicine* 1(1):51-57.

Howe HL, Wolfgang PE, Burnett WS, Nasca PC, Youngblood L. Cancer incidence following exposure to drinking water with asbestos leachate. Public Health Rep 104:251-256 (1989).

Jappinen P., Vilkka V., Marttila O. and Haahtela T. 1990. Exposure to hydrogen sulphide and respiratory function. *British Journal of Industrial Medicine* 47(12):824-828.

Kanarek M.S. and Young T.B. 1982. Drinking water treatment and risk of cancer death in Wisconsin. *Environmental Health Perspectives* 46:179-186.

Kanarek MS, Conforti PM, Jackson LA, Cooper RC, Murchio JC. Asbestos in drinking water and cancer incidence in the San Francisco Bay area. AM J Epidemiol 112:54-72 (1980).

Karppanen H. 1984. Ischaemic heart disease. An epidemiological perspective with special reference to electrolytes. *Drugs* 28(Suppl 1):17-27.

Keegan T.E., Simmons J.E. and Pegram R.A. 1998. NOAEL and LOAEL determinations of acute hepatotoxicity for chloroform and bromodichloromethane delivered in an aqueous vehicle to F344 rats. *Journal of Toxicology and Environmental Health* 55(1):65-75.

Kilburn K.H. and Warshaw R.H. 1995. Hydrogen sulfide and reduced sulfur gases adversely affect neurophysiological functions. *Toxicology and Industrial Health* 11(2):185-197.

King W.D. and Marrett L.D. 1996. Case control study of bladder cancer and chlorination by products in treated water (Ontario, Canada). *Cancer Causes and Control* 7(6):596-604.

Knobeloch L., Schubert C., Hayes J., Clark J., Fitzgerald C. and Fraundorff A. 1998. Gastrointestinal upsets and new copper plumbing—is there a connection? *Wisconsin Medical Journal* 97(1):49-53.

Knobeloch L., Ziarnik M., Howard J., Theis B., Farmer D., Anderson H. and Proctor M. 1994. Gastrointestinal upsets associated with ingestion of copper-contaminated water. *Environmental Health Perspectives* 102(11): 958-961.

Koivusalo M. and Vartiainen T. 1997. Drinking water chlorination byproducts and cancer. *Review of Environmental Health* 12(2):81-90.

Kojima N., Matsukura N., Shimizu Y., Yoshiyuki T., Nishi K., Wada M., Tokunaga A., Tanaka N., Onda M. and Asano G. 1987. Induction of intestinal metaplasia in rats by N-ethyl-N'-nitro-N-nitrosoguanidine but not by sodium hydroxide. *Japanese Journal of Cancer Research* 78(2):126-133.

Kondakis X.G., Makris N., Leotsinidis M., Prinou M. and Papapetropoulos T. 1989. Possible health effects of high manganese concentration in drinking water. *Archives of Environmental Health* 44(3):175-178.

Kostraba J.N., Gay E.C., Rewers M and Hamman R.F. 1992. Nitrate levels in community drinking waters and risk of IDDM. An ecological analysis. *Diabetes Care* 15(11):1505-1508.

Krzywicki J. 1978. The effect of mouth rinsing with hydrogen sulfide containing water on the morphology of the periodontium and its diseases. *Czasopismo Stomatologiczna* 31(7):675-684.

Lee J.F., Liao P.M., Tseng D.H. and Wen P.T. 1998. Behavior of organic polymers in drinking water purification. *Chemosphere* 37(6):1045-1061.

Levallois P. and Phaneuf D. 1994. Contamination of drinking water by nitrates: analysis of health risks. *Canadian Journal of Public Health* 85(3):192-196.

Levallois P., Theriault M., Rouffignat J., Tessier S., Landry R., Ayotte P., Girard M., Gauvin D. and Chiasson C. 1998. Groundwater contamination by nitrates associated with intensive potato culture in Quebec. *Science of the Total Environment* 217(1-2):91-101.

Linder R.E., Klinefelter G.R., Strader L.F., Suarez J.D. and Roberts N.L. 1997. Spermatotoxicity of dichloroacetic acid. *Reproductive Toxicology* 11(5):681-688.

Loranger S., Bibeau M.C. and Zayed J. 1994. Manganese in drinking water and its contribution to human exposure. *Rev Epidemiol Sante Publique* 42(4):315-321.

Markowitz M.E. 1997. The diagnosis and treatment of childhood lead poisoning. *Resident & Staff Physician* 43(3):27-38.

Marx A. and Neutra R.R. 1997. Magnesium in drinking water and ischemic heart disease. *Epidemiological Reviews* 19(2):258-272.

Mascher F. and Marth E. 1993. Metabolism and effect of nitrates. *Central European Journal of Public Health* 1(1):49-52.

McGeehin M.A., Reif J.S., Becher J.C. and Mangione E.J. 1993. Case control study of bladder cancer and water disinfection methods in Colorado. *American Journal of Epidemiology* 138(7):492-501.

McHugh Law J., Lopez L., and DeAngelo A.B. 1998. Hepatotoxicity of the drinking water disinfection byproduct, dichloroacetic acid, in the medaka small fish model. *Toxicology Letters* 94(1):19-27.

McMichael A.J., Baghurst P.A., Wigg N.R., Vimpani G.V., Robertson E.F. and Roberts R.J. 1988. Port Pirie Cohort Study: Environmental exposure to lead and children's abilities at the age of four years. *New England Journal of Medicine* 319:468-475.

Moller H., Landt J., Pedersen E., Jensen P., Autrup H. and Jensen O.M. 1989. Endogenous nitrosation in relation to nitrate exposure from drinking water and diet in a Danish rural population. *Cancer Research* 49(11):3117-3121.

Morris, R.D., Audet, A., Angelillo, I.F., Chalmers, T.C. and Mosteller, F. 1992. Chlorination, Chlorination By-Products, and Cancer: A Meta-Analysis. American Journal of Public Health 82(7):955-977.

National Science and Technology Council Committee on Environmental and Natural Resources and Interagency Oxygenated Fuels Assessment Steering Committee (1994).

Nicholson R.A., Roth S.H. Zhang A., Zheng J., Brookes J., Skrajny B. and Bennington R. 1998. Inhibition of respiratory and bioenergetic mechanisms by hydrogen sulfide in mammalian brain. *Journal of Toxicology and Environmental Health* 54(6):491-507.

Nordberg G.F., Goyer R.A. and Clarkson T.W. 1985. Impact of effects of acid precipitation on toxicity of metals. *Environmental Health Perspectives* 63:169-180.

Olivares M., Pizarro F., Speisky H., Lonnerdal B. and Uauy R. 1998. Copper in infant nutrition: Safety of World Health Organization provisional guideline value for copper content of drinking water. *Journal of Pediatric Gastroenterology and Nutrition* 26(3):251-257.

Olivares M. and Uauy R. 1996. Limits of metabolic tolerance to copper and biological basis for present recommendations and regulations. *American Journal of Clinical Nutrition* 63(5):846S-852S.

Parslow R.C., McKinney P.A., Law G.R., Staines A., Williams R. and Bodansky H.J. 1997. Incidence of childhood diabetes mellitus in Yorkshire, northern England, is associated with nitrate in drinking water: An ecological analysis. *Diabetologia* 40(5):550-556.

Richardson D.B. 1995. Respiratory effects of chronic hydrogen sulfide exposure. *American Journal of Industrial Medicine* 28(1):99-108.

Robertson J.S. 1984. Water sodium, urinary electrolytes and blood pressure of adolescents. *Journal of Epidemiology and Community Health* 38(3):186-194.

Rylander R. Bonevik H. and Rubenowitz E. 1991. Magnesium and calcium in drinking water and cardiovascular mortality. *Scandinavian Journal of Work and Environmental Health* 17(2):91-94.

Sadler TD, Rom WN, Lyon JL, Mason JO. The use of asbestos-cement pipe for public water supply and the incidence of cancer in selected communities in Utah. J Commun Health 9:285-293 (1984).

Savitz D.A., Andrews K.W. and Pastore L.M. 1995. Drinking water and pregnancy outcome in central North Carolina: Source, amount, and trihalomethane levels. *Environmental Health Perspectives* 103(6):592-596.

Scheinberg I.H. and Sternlieb I. 1994. Is non-Indian childhood cirrhosis caused by excess dietary copper? *Lancet* 344(8929):1002-1004.

Schoen E.J. 1995. Lead poisoning alert-False alarm? *Western Journal of Medicine* 162(5):474.

Sciarillo W.G., Alexander G. and Farrell K.P. 1992. Lead exposure and child behavior. *American Journal of Public Health* 82(10):1356-1360.

Sidhu K.S., Nash D.F. and McBride D.E. 1995. Need to revise the national drinking water regulation for copper. *Regulatory Toxicology and Pharmacology* 22(1):95-100.

Smith M.K., Zenick H. and George E.L. 1986. Reproductive toxicology of disinfection byproducts. *Environmental Health Perspectives* 69:177-182.

Soffritti M., Belpoggi F., Lenzi A. and Maltoni C. 1997. Results of long-term carcinogenicity studies of chlorine in rats. *Annals of the New York Academy of Sciences* 837:189-208.

Thacker S.B., Hoffman D.A., Smith J., Steinberg K. and Zack M. 1994. Effect of low-level body burdens of lead on the mental development of children: Limitations of meta-analysis in a review of longitudinal data. *Archives of Environmental Health* 47(5):336-346.

Tuthill R.W. and Calabrese E.J. 1979. Elevated sodium levels in the public drinking water as a contributor to elevated blood pressure levels in the community. *Archives of Environmental Health* 34(4):197-203.

Tuthill R.W., Giusti R.A., Moore G.S. and Calabrese E.J. 1982. Health effects among newborns after prenatal exposure to ClO_2-disinfected drinking water. *Environmental Health Perspectives* 46:39-45.

Tvedt B., Skyberg K., Aaserud O, Hobbesland A. and Mathiesen T. 1991. Brain damage caused by hydrogen sulfide: A follow-up study of six patients. *American Journal of Industrial Medicine* 20(1):91-101.

USCDC. 1996. Spontaneous abortions possibly related to ingestion of nitrate-contaminated well water—LaGrange County, Indiana, 1991-1994. *Morbidity & Mortality Weekly Report* 45(26):569-572.

USEPA. Oxygenates in Water: Critical Information and Research Needs. Office of Research and Development. Washington. EPA/600/R-98/048 (1998).

Veenhuizen M.F., Shurson G.C. and Kohler E.M. 1992. Effect of concentration and source of sulfate on nursery pig performance and health. *Journal of the American Veterinary Medical Association* 201(8):1203-1208.

Waller K., Swan S.H., DeLorenze G. and Hopkins B. 1998. Trihalomethanes in drinking water and spontaneous abortion. *Epidemiology* 9(2):134-140.

Ward M.H., Mark S.D., Cantor K.P., Weisenburger D.D., Correa-Villasenor A. and Zahm S.H. 1996. Drinking water nitrate and the risk of non-Hodgkin's lymphoma. *Epidemiology* 7(5):465-471.

Weisenburger D.D. 1993. Potential health consequences of groundwater contamination by nitrates in Nebraska. *Nebraska Medical Journal* 78(1):7-12.

Welty T.K., Freni-Titulaer L., Zack M.M., Weber P., Sippel J., Huete N., Justice J., Dever D. and Murphy M.A. 1986. Effects of exposure to salty drinking water in Arizona community. Cardiovascular mortality, hypertension prevalence and relationships between blood pressure and sodium intake. *Journal of the American Medical Association* 255(5):622-626.

Yang C.Y. 1998. Calcium and magnesium in drinking water and risk of death from cerebrovascular disease. *Stroke* 29(2):411-414.

Yang C.Y., Cheng M.F., Tsai S.S. and Hsieh Y.L. 1998a. Calcium, magnesium and nitrate in drinking water and gastric cancer mortality. *Japanese Journal of Cancer Research* 89(2):124-130.

Yang C.Y. Chiu H.F., Cheng M.F. and Tsai S.S. 1998b. Chlorination of drinking water and cancer mortality in Taiwan. *Environmental Research* 78(1): 1-6.

Zeighami E.A., Watson A.P. and Craun G.F. 1990. Chlorination, water hardness and serum cholesterol in forty-six Wisconsin communities. *International Journal of Epidemiology* 19(1):49-58.

Zierler S., Danley R.A. and Feingold L. 1986. Type of disinfectant in drinking water and patterns of mortality in Massachusetts. *Environmental Health Perspectives* 69:275-279.

TREATMENT RELATED STUDIES AND REFERENCES

Cook, N.E., Silverstein, J., Hogrewe, W. and Hammad, K.: 1990, Denitrification of Potable Water in a Packed Tower Biofilm, Proceedings of the 1990 Specialty Conference on Environmental Engineering (A.S.C.E.).

Small System Compliance Technology List for the Non-Microbial Contaminants Regulated Before 1996, September 1998, United State Environmental Protection Agency.

Mouchet, P.: 1992, From Conventional to Biological Removal of Iron and Manganese in France, Journal AWWA, April 1992, pp 158-167.

Nyer, E.K.: 1985, "Groundwater Treatment Technology", 1st Edition, Van Nostrand Reinhold.

Viessman, Jr., W. & Hammer, M.J.: 1985, "Water Supply and Pollution Control", 4th Edition, Harper & Row.

"Water Quality & Treatment", 3rd Edition, AWWA, McGraw Hill.

Snoeyink, V.L. & Jenkins, D.: 1980, "Water Chemistry", 1st Edition, John Wiley & Sons.

Michalakos, G.D., etal.: 1997, Removal of Iron from Potable Water Using a Trickling Filter, Water Res., Vol. 31, No. 5, pp 991-996.

Robinson, R.B.: 1992, Iron and Manganese Sequestration Facilities Using Sodium Silicate, Journal AWWA, April 1992.

Baadsgaard, M. & Pai, P.E., P.: 1991, Iron and Manganese Removal from Groundwater Wells, Public Works, February 1991, p 59.

APPENDIX A

WATER QUALITY DATA

MASSAPEQUA WATER DISTRICT
WATER QUALITY DATA
DISTRIBUTION SAMPLES

ND = NOT DETECTABLE

MCL = MAXIMUM CONTAMINANT LEVEL

PHYSICAL (AESTHETICS) & OTHER PARAMETERS	1999 MCL OR GUIDELINE	ACTUAL TESTS						
		1993	1994	1995	1996	1997	1998	1999
Color	15 UNITS	5.0	ND	ND	2.5	2.5	ND	ND
Odor	3 UNITS	0.67	0	0	0	0	0	0
Turbidity	5 UNITS	0.37	0.39	< 1	< 1	< 1	< 1	< 1

INORGANIC	1999 MCL OR GUIDELINE	ACTUAL TESTS (mg/l)						
		1993	1994	1995	1996	1997	1998	1999
Silver	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Barium	2.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Calcium	No MCL	---	---	0.66	0.67	0.66	0.60	0.75
Calcium Hardness	No MCL	2.67	4.00	2.00	2.00	1.67	1.25	1.75
Cadmium	0.005 mg/l	ND	ND	ND	ND	ND	ND	ND
Chloride	250 mg/l	8.07	8.275	9.50	6.50	5.83	5.75	6.28
Chromium	0.1 mg/l	ND	ND	ND	ND	ND	ND	ND
Copper	1.3 mg/l	0.23	0.085	0.35	0.27	0.17	0.01	0.02
Fluoride	2.2 mg/l	ND	ND	ND	ND	ND	ND	ND
Iron	0.3 mg/l	0.335	0.325	0.33	0.36	0.25	0.28	0.40
Total Hardness	No MCL	3.50	5.00	2.50	2.50	2.50	2.25	2.75
Mercury	0.002 mg/l	ND	ND	ND	ND	ND	ND	ND
Langlier Index	No MCL	---	-2.175	-3.10	-3.31	-3.23	-2.09	-2.37
Detergents	No MCL	ND	ND	ND	ND	ND	ND	ND
Magnesium	No MCL	---	---	0.21	0.31	0.29	0.29	0.34
Manganese	0.3 mg/l	0.008	ND	0.005	ND	ND	ND	ND
Sodium	20 & 270 mg/l*	19.05	16.20	18.60	20.30	18.20	19.80	19.40
Ammonia (as N)	No MCL	ND	0.01	ND	ND	ND	ND	ND
Nitrite (as N)	1.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	10.0 mg/l	0.003	0.09	ND	ND	ND	ND	ND
Lead	0.015 mg/l	0.0025	0.0015	0.0066	0.007	ND	ND	ND
pH	6.5 - 8.5 units	7.60	7.55	7.20	7.10	7.30	8.10	7.73
Selenium	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Sulfate	250 mg/l	4.96	6.225	ND	ND	1.30	4.00	ND
Total Alkalinity	No MCL	32.50	30.75	28.00	32.00	28.00	24.45	34.25
Total Dissolved Solids	No MCL	46.70	43.00	49.50	70.00	38.00	79.75	59.25
Zinc	5.0 mg/l	0.0115	0.01	0.01	0.01	ND	ND	0.01
Thallium	0.002 mg/l	---	---	---	---	---	ND	ND
Cyanide, Free	0.2 mg/l	---	---	---	---	---	ND	ND

* 20 mg/L is limit recommended by many physicians for people on severely sodium restricted diets.

					ACTUAL TESTS (ug/l)			
TRIHALOMETHANES	1999 MCL	1993	1994	1995	1996	1997	1998	1999
THM Potential	100 ug/l	---	---	0.012	21	8.3	10	ND
Chloroform	100 ug/l	---	0.0817	0.0075	14	5	6	ND
Bromodichloromethane	100 ug/l	---	0.0070	0.0035	5	2.3	3	ND
Chlorodibromomethane	100 ug/l	---	0.0006	0.001	1	1	1	ND
Bromoform	100 ug/l	---	ND	ND	ND	ND	ND	ND

					ACTUAL TESTS (ug/l)			
VOLATILE ORGANICS	1999 MCL	1993	1994	1995	1996	1997	1998	1999
Benzene	5 ug/l	---	---	---	ND	ND	ND	ND
Carbon tetrachloride	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	2 ug/l	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	5 ug/l	---	---	---	ND	ND	ND	ND
Bromochloromethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Bromomethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
n-Butylbenzene	5 ug/l	---	---	---	ND	ND	ND	ND
sec-Butylbenzene	5 ug/l	---	---	---	ND	ND	ND	ND
tert-Butylbenzene	5 ug/l	---	---	---	ND	ND	ND	ND
Chlorobenzene	5 ug/l	---	---	---	ND	ND	ND	ND
Chloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Chloromethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,3-Dichloropropane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	5 ug/l	---	---	---	ND	ND	ND	ND
Isopropylbenzene	5 ug/l	---	---	---	ND	ND	ND	ND
p-Isopropyltoluene	5 ug/l	---	---	---	ND	ND	ND	ND
n-Propylbenzene	5 ug/l	---	---	---	ND	ND	ND	ND
Ethylbenzene	5 ug/l	---	---	---	ND	ND	ND	ND
Styrene	5 ug/l	---	---	---	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Toluene	5 ug/l	---	---	---	ND	ND	ND	ND
1,2,3-Trichlorobenzene	5 ug/l	---	---	---	ND	ND	ND	ND
1,2,4-Trichlorobenzene	70 ug/l	---	---	---	ND	ND	ND	ND
1,1,2-Trichloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND

		ACTUAL TESTS (ug/l)						
VOLATILE ORGANICS (cont.)	**1999 MCL**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
1,2,3-Trichloropropane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	5 ug/l	---	---	---	ND	ND	ND	ND
1,3,5-Trimethylbenzene	5 ug/l	---	---	---	ND	ND	ND	ND
m-Xylene	5 ug/l	---	---	---	ND	ND	ND	ND
o-Xylene	5 ug/l	---	---	---	ND	ND	ND	ND
p-Xylene	5 ug/l	---	---	---	ND	ND	ND	ND
Dichloromethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Bromoform	100 ug/l	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	100 ug/l	0.27	0.0007	ND	ND	ND	0.1167	ND
Chloroform	100 ug/l	0.94	0.0006	ND	ND	ND	ND	ND
Chlorodibromomethane	100 ug/l	ND	ND	ND	ND	ND	0.0833	ND
o-Chlorotoluene	5 ug/l	---	---	---	ND	ND	ND	ND
p-Chlorotoluene	5 ug/l	---	---	---	ND	ND	ND	ND
m-Dichlorobenzene	5 ug/l	---	---	---	ND	ND	ND	ND
o-Dichlorobenzene	5 ug/l	---	---	---	ND	ND	ND	ND
p-Dichlorobenzene	5 ug/l	---	---	---	ND	ND	ND	ND
Methylene Chloride	5 ug/l	---	---	---	---	---	ND	ND
Methyl Tertiary Butyl Ether	50 ug/l	---	---	---	---	---	ND	ND

		ACTUAL TESTS (ug/l)						
PESTICIDES AND SOC'S	**1999 MCL**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Atrazine	3 ug/l	ND	ND	ND	ND	ND	---	---
2,4-D	50 ug/l	ND	ND	ND	ND	ND	---	---
Polychlorinated biphenyls (PCB	0.5 ug/l	ND	ND	ND	ND	ND	---	---
Pentachlorophenol	1 ug/l	ND	ND	ND	ND	ND	---	---
Toxaphene	3 ug/l	ND	ND	ND	ND	ND	---	---
2,4,5-TP (Silvex)	10 ug/l	ND	ND	ND	ND	ND	---	---
Benxo(a)pyrene	0.2 ug/l	ND	ND	ND	ND	ND	---	---
Butachlor	50 ug/l	ND	ND	ND	ND	ND	---	---
Dalapon	200 ug/l	ND	ND	ND	ND	ND	---	---
di(2-ethylhexyl)adipate	400 ug/l	ND	ND	ND	ND	ND	---	---
di(2-ethylhexyl)phthalates	6 ug/l	ND	ND	ND	ND	ND	---	---
Dicamba	50 ug/l	ND	ND	ND	ND	ND	---	---
Dinoseb	7 ug/l	ND	ND	ND	ND	ND	---	---
Diquat	20 ug/l	ND	ND	ND	ND	ND	---	---
Endothall	100 ug/l	ND	ND	ND	ND	ND	---	---
Glyphosphate	700 ug/l	ND	ND	ND	ND	ND	---	---
Hexachlorobenzene	1 ug/l	ND	ND	ND	ND	ND	---	---
Metolachlor	50 ug/l	ND	ND	ND	ND	ND	---	---
Metribuzin	50 ug/l	ND	ND	ND	ND	ND	---	---
Hexachlorocyclopentadiene	50 ug/l	ND	ND	ND	ND	ND	---	---
Pichloram	500 ug/l	ND	ND	ND	ND	ND	---	---
Propachlor	50 ug/l	ND	ND	ND	ND	ND	---	---
Simazine	4 ug/l	ND	ND	ND	ND	ND	---	---

MASSAPEQUA WATER DISTRICT
WATER QUALITY DATA
WELL NO. 1

ND = NOT DETECTABLE

MCL = MAXIMUM CONTAMINANT LEVEL

PHYSICAL (AESTHETICS) & OTHER PARAMETERS	1999 MCL OR GUIDELINE	ACTUAL TESTS						
		1993	1994	1995	1996	1997	1998	1999
Color	15 UNITS	ND	ND	ND	ND	ND	ND	ND
Odor	3 UNITS	0	0	0	1	2	0	0
Turbidity	5 UNITS	0.2	0.15	ND	ND	ND	ND	ND

INORGANIC	1999 MCL OR GUIDELINE	ACTUAL TESTS (mg/l)						
		1993	1994	1995	1996	1997	1998	1999
Silver	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Barium	2.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Calcium	No MCL	---	---	0.59	0.71	0.86	0.85	0.77
Calcium Hardness	No MCL	2.0	ND	1.0	2.0	2.0	2.0	2.0
Cadmium	0.005 mg/l	ND	ND	ND	ND	ND	ND	ND
Chloride	250 mg/l	5.42	2.95	5.0	5.0	10.0	6.0	5.8
Chromium	0.1 mg/l	ND	ND	ND	ND	ND	ND	ND
Copper	1.3 mg/l	ND	ND	ND	ND	ND	ND	ND
Fluoride	2.2 mg/l	ND	ND	ND	ND	ND	ND	ND
Iron	0.3 mg/l	0.26	0.516	0.32	0.46	0.54	0.57	0.51
Total Hardness	No MCL	2.0	1.2	3.0	3.0	5.0	5.0	4.0
Mercury	0.002 mg/l	ND	ND	ND	ND	ND	ND	ND
Langlier Index	No MCL	---	-6.47	-6.30	-7.12	-6.94	-6.84	-6.79
Detergents	No MCL	ND	ND	ND	ND	ND	ND	ND
Magnesium	No MCL	---	---	0.42	0.47	0.70	0.72	0.56
Manganese	0.3 mg/l	ND	ND	0.02	0.02	0.02	0.02	0.02
Sodium	20 & 270 mg/l*	2.52	3.59	3.20	3.20	0.02	4.00	3.72
Ammonia (as N)	No MCL	0.09	ND	ND	ND	ND	ND	ND
Nitrite (as N)	1.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	10.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Lead	0.015 mg/l	ND	ND	ND	ND	ND	ND	ND
pH	6.5 - 8.5 units	4.3	5.2	5.4	4.5	4.6	4.7	4.8
Selenium	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Sulfate	250 mg/l	5.29	2.43	ND	ND	ND	6.4	5.0
Total Alkalinity	No MCL	ND	1.9	ND	ND	ND	ND	ND
Total Dissolved Solids	No MCL	37	135	40	39	20	48	35
Zinc	5.0 mg/l	0.03	0.048	0.03	0.03	0.06	0.05	0.04
Antimony	0.006 mg/l	ND	ND	ND	---	---	ND	ND
Beryllium	0.004 mg/l	ND	ND	ND	---	---	ND	ND
Nickel	0.1 mg/l	ND	ND	ND	---	---	ND	ND
Thallium	0.002 mg/l	ND	ND	ND	---	---	ND	ND
Cyanide, Free	0.2 mg/l	ND	ND	ND	---	---	ND	ND

* 20 mg/L is limit recommended by many physicians for people on severely sodium restricted diets.

MASSAPEQUA WATER DISTRICT
WATER QUALITY DATA
WELL NO. 2-R

ND = NOT DETECTABLE

MCL = MAXIMUM CONTAMINANT LEVEL

PHYSICAL (AESTHETICS) & OTHER PARAMETERS	1999 MCL OR GUIDELINE	ACTUAL TESTS						
		1993	1994	1995	1996	1997	1998	1999
Color	15 UNITS	5	ND	ND	ND	ND	ND	ND
Odor	3 UNITS	0	0	0	0	0	0	0
Turbidity	5 UNITS	0.65	0.12	ND	ND	ND	ND	ND

INORGANIC	1999 MCL OR GUIDELINE	ACTUAL TESTS (mg/l)						
		1993	1994	1995	1996	1997	1998	1999
Silver	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Barium	2.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Calcium	No MCL	---	---	ND	ND	ND	ND	0.21
Calcium Hardness	No MCL	4.0	ND	ND	ND	ND	ND	1.0
Cadmium	0.005 mg/l	ND	ND	ND	ND	ND	ND	ND
Chloride	250 mg/l	3.33	5.68	5.0	3.0	2.0	24.0	3.0
Chromium	0.1 mg/l	ND	ND	ND	ND	ND	ND	ND
Copper	1.3 mg/l	ND	ND	ND	ND	ND	ND	ND
Fluoride	2.2 mg/l	ND	ND	ND	ND	ND	ND	ND
Iron	0.3 mg/l	0.09	0.09	0.07	0.27	0.31	0.06	0.07
Total Hardness	No MCL	4.0	7.2	ND	ND	ND	ND	1.0
Mercury	0.002 mg/l	ND	ND	ND	ND	ND	ND	ND
Langlier Index	No MCL	---	-7.10	-7.27	-7.27	-7.07	-7.17	-6.95
Detergents	No MCL	ND	ND	ND	ND	ND	ND	ND
Magnesium	No MCL	---	---	ND	ND	ND	ND	ND
Manganese	0.3 mg/l	ND	ND	ND	ND	ND	ND	ND
Sodium	20 & 270 mg/l*	2.00	2.54	2.30	2.40	2.50	2.50	2.58
Ammonia (as N)	No MCL	0.11	ND	ND	ND	0.02	ND	ND
Nitrite (as N)	1.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	10.0 mg/l	ND	ND	ND	ND	ND	ND	0.55
Lead	0.015 mg/l	0.007	ND	0.0075	ND	ND	ND	ND
pH	6.5 - 8.5 units	4.8	4.7	4.9	4.9	5.1	5.0	5.2
Selenium	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Sulfate	250 mg/l	2.73	6.18	6.18	ND	ND	ND	ND
Total Alkalinity	No MCL	1.0	1.1	ND	ND	ND	ND	ND
Total Dissolved Solids	No MCL	97	108	21	45	18	29	20
Zinc	5.0 mg/l	0.02	0.039	ND	0.03	0.05	0.06	0.03
Antimony	0.006 mg/l	ND	ND	ND	---	---	ND	ND
Beryllium	0.004 mg/l	ND	ND	ND	---	---	ND	ND
Nickel	0.1 mg/l	ND	ND	ND	---	---	ND	ND
Thallium	0.002 mg/l	ND	ND	ND	---	---	ND	ND
Cyanide, Free	0.2 mg/l	ND	ND	ND	---	---	ND	ND

* 20 mg/L is limit recommended by many physicians for people on severely sodium restricted diets.

MASSAPEQUA WATER DISTRICT
WATER QUALITY DATA
WELL NO. 3

ND = NOT DETECTABLE

MCL = MAXIMUM CONTAMINANT LEVEL

PHYSICAL (AESTHETICS) & OTHER PARAMETERS	1999 MCL OR GUIDELINE	ACTUAL TESTS 1993	1994	1995	1996	1997	1998	1999
Color	15 UNITS	5	ND	ND	ND	ND	ND	ND
Odor	3 UNITS	0	0	0	2	2	0	0
Turbidity	5 UNITS	0.14	0.16	ND	ND	ND	ND	ND

INORGANIC	1999 MCL OR GUIDELINE	ACTUAL TESTS (mg/l) 1993	1994	1995	1996	1997	1998	1999
Silver	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Barium	2.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Calcium	No MCL	---	---	0.60	0.81	0.75	0.75	0.92
Calcium Hardness	No MCL	2.0	1.6	2.0	2.0	2.0	2.0	2.0
Cadmium	0.005 mg/l	0.003	ND	ND	ND	ND	ND	ND
Chloride	250 mg/l	7.14	7.60	4.0	5.0	8.0	9.0	7.3
Chromium	0.1 mg/l	ND	ND	ND	ND	ND	ND	ND
Copper	1.3 mg/l	ND	ND	0.02	0.05	ND	ND	ND
Fluoride	2.2 mg/l	ND	ND	ND	ND	ND	ND	ND
Iron	0.3 mg/l	0.30	0.463	0.039	0.51	0.56	0.56	0.66
Total Hardness	No MCL	4.0	8.0	3.0	4.0	4.0	4.0	5.0
Mercury	0.002 mg/l	ND	ND	ND	ND	ND	ND	ND
Langlier Index	No MCL	---	-7.47	-7.09	-6.96	-7.00	-6.90	-6.81
Detergents	No MCL	ND	ND	ND	ND	ND	ND	ND
Magnesium	No MCL	---	---	0.47	0.61	0.53	0.59	0.73
Manganese	0.3 mg/l	ND	ND	ND	0.02	0.02	0.02	0.02
Sodium	20 & 270 mg/l*	3.0	4.2	3.3	4.0	4.3	4.4	4.78
Ammonia (as N)	No MCL	0.09	ND	ND	ND	ND	ND	ND
Nitrite (as N)	1.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	10.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Lead	0.015 mg/l	0.001	ND	0.0015	ND	ND	ND	ND
pH	6.5 - 8.5 units	4.5	4.8	4.6	4.6	4.6	4.7	4.7
Selenium	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Sulfate	250 mg/l	5.0	4.4	ND	ND	ND	ND	5.2
Total Alkalinity	No MCL	ND	0.2	1.0	ND	ND	ND	ND
Total Dissolved Solids	No MCL	41	91	24	46	19	37	48
Zinc	5.0 mg/l	0.03	0.044	0.02	ND	0.03	0.02	0.04
Antimony	0.006 mg/l	ND	ND	ND	---	---	ND	ND
Beryllium	0.004 mg/l	ND	ND	ND	---	---	ND	ND
Nickel	0.1 mg/l	ND	ND	ND	---	---	ND	ND
Thallium	0.002 mg/l	ND	ND	ND	---	---	ND	ND
Cyanide, Free	0.2 mg/l	ND	ND	ND	---	---	ND	ND

* 20 mg/L is limit recommended by many physicians for people on severely sodium restricted diets.

MASSAPEQUA WATER DISTRICT
WATER QUALITY DATA
WELL NO. 4

ND = NOT DETECTABLE

MCL = MAXIMUM CONTAMINANT LEVEL

PHYSICAL (AESTHETICS) & OTHER PARAMETERS	1999 MCL OR GUIDELINE	ACTUAL TESTS						
		1993	1994	1995	1996	1997	1998	1999
Color	15 UNITS	5	ND	ND	ND	ND	ND	ND
Odor	3 UNITS	0	0	0	0	0	0	0
Turbidity	5 UNITS	0.2	0.76	ND	ND	ND	ND	ND

INORGANIC	1999 MCL OR GUIDELINE	ACTUAL TESTS (mg/l)						
		1993	1994	1995	1996	1997	1998	1999
Silver	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Barium	2.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Calcium	No MCL	---	---	ND	0.59	0.57	0.52	0.55
Calcium Hardness	No MCL	4.0	ND	ND	1.0	1.0	1.0	1.0
Cadmium	0.005 mg/l	ND	ND	ND	ND	ND	ND	ND
Chloride	250 mg/l	5.83	4.53	4.0	6.0	4.0	3.0	3.5
Chromium	0.1 mg/l	ND	ND	ND	ND	ND	ND	ND
Copper	1.3 mg/l	ND	0.03	0.15	0.05	0.04	0.02	0.03
Fluoride	2.2 mg/l	ND	ND	ND	ND	ND	ND	ND
Iron	0.3 mg/l	0.20	0.27	0.21	0.47	0.30	0.31	0.30
Total Hardness	No MCL	4.0	4.0	ND	2.0	2.0	2.0	2.0
Mercury	0.002 mg/l	ND	ND	ND	ND	ND	ND	ND
Langlier Index	No MCL	---	-6.71	-5.52	-7.60	-6.92	-6.76	-6.83
Detergents	No MCL	ND	ND	ND	ND	ND	ND	ND
Magnesium	No MCL	---	---	ND	0.31	0.31	0.29	0.29
Manganese	0.3 mg/l	ND	ND	0.02	ND	ND	ND	ND
Sodium	20 & 270 mg/l*	2.40	3.18	6.90	3.30	3.10	3.50	3.20
Ammonia (as N)	No MCL	0.15	ND	ND	ND	ND	ND	ND
Nitrite (as N)	1.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	10.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Lead	0.015 mg/l	0.005	0.005	0.005	ND	0.005	0.0012	0.0034
pH	6.5 - 8.5 units	4.7	4.9	5.7	4.1	4.6	5.0	4.9
Selenium	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Sulfate	250 mg/l	4.11	4.74	ND	ND	ND	ND	ND
Total Alkalinity	No MCL	1.0	1.3	9.0	ND	ND	ND	ND
Total Dissolved Solids	No MCL	30	15	44	32	13	32	12
Zinc	5.0 mg/l	0.02	ND	ND	0.04	ND	ND	ND
Antimony	0.006 mg/l	ND	ND	ND	---	---	---	---
Beryllium	0.004 mg/l	ND	ND	ND	---	---	---	---
Nickel	0.1 mg/l	ND	ND	ND	---	---	---	---
Thallium	0.002 mg/l	ND	ND	ND	---	---	---	---
Cyanide, Free	0.2 mg/l	ND	ND	ND	---	---	---	---

* 20 mg/L is limit recommended by many physicians for people on severely sodium restricted diets.

MASSAPEQUA WATER DISTRICT
WATER QUALITY DATA
WELL NO. 5

ND = NOT DETECTABLE

MCL = MAXIMUM CONTAMINANT LEVEL

PHYSICAL (AESTHETICS) & OTHER PARAMETERS	1999 MCL OR GUIDELINE	ACTUAL TESTS 1993	1994	1995	1996	1997	1998	1999
Color	15 UNITS	ND	ND	ND	ND	ND	ND	ND
Odor	3 UNITS	0	0	0	0	0	0	0
Turbidity	5 UNITS	2.5	0.22	ND	ND	ND	ND	ND

INORGANIC	1999 MCL OR GUIDELINE	ACTUAL TESTS (mg/l) 1993	1994	1995	1996	1997	1998	1999
Silver	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Barium	2.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Calcium	No MCL	---	---	0.29	0.37	0.43	0.35	0.39
Calcium Hardness	No MCL	1.6	ND	ND	1.0	1.0	1.0	1.0
Cadmium	0.005 mg/l	ND	ND	ND	ND	ND	ND	ND
Chloride	250 mg/l	3.38	3.17	12.00	4.00	3.00	3.00	2.90
Chromium	0.1 mg/l	ND	ND	ND	ND	ND	ND	ND
Copper	1.3 mg/l	ND	0.05	0.05	0.03	0.03	0.03	0.05
Fluoride	2.2 mg/l	ND	ND	ND	ND	ND	ND	ND
Iron	0.3 mg/l	ND	0.15	0.15	0.14	0.28	0.16	0.19
Total Hardness	No MCL	2.6	2.4	2.4	1.0	2.0	1.0	2.0
Mercury	0.002 mg/l	ND	ND	ND	ND	ND	ND	ND
Langlier Index	No MCL	---	-6.51	-6.51	-7.60	-6.94	-6.83	-6.28
Detergents	No MCL	ND	ND	ND	ND	ND	ND	ND
Magnesium	No MCL	---	---	0.20	0.24	0.26	0.25	0.25
Manganese	0.3 mg/l	ND	ND	ND	ND	ND	ND	ND
Sodium	20 & 270 mg/l*	6.21	2.72	2.20	2.90	3.00	2.70	2.90
Ammonia (as N)	No MCL	ND	ND	ND	ND	ND	ND	ND
Nitrite (as N)	1.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	10.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Lead	0.015 mg/l	ND	0.002	0.0028	ND	ND	ND	0.0011
pH	6.5 - 8.5 units	5.2	5.0	5.0	4.3	5.5	5.1	5.6
Selenium	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Sulfate	250 mg/l	3.53	3.45	ND	ND	ND	ND	ND
Total Alkalinity	No MCL	18.5	1.6	1.6	ND	ND	ND	ND
Total Dissolved Solids	No MCL	13	53	53	17	13	25	16
Zinc	5.0 mg/l	0.00	ND	ND	0.03	ND	ND	ND
Antimony	0.006 mg/l	ND	ND	ND	---	---	---	---
Beryllium	0.004 mg/l	ND	ND	ND	---	---	---	---
Nickel	0.1 mg/l	ND	ND	ND	---	---	---	---
Thallium	0.002 mg/l	ND	ND	ND	---	---	---	---
Cyanide, Free	0.2 mg/l	ND	ND	ND	---	---	---	---

* 20 mg/L is limit recommended by many physicians for people on severely sodium restricted diets.

MASSAPEQUA WATER DISTRICT
WATER QUALITY DATA
WELL NO. 6

ND = NOT DETECTABLE

MCL = MAXIMUM CONTAMINANT LEVEL

PHYSICAL (AESTHETICS) & OTHER PARAMETERS	1999 MCL OR GUIDELINE	ACTUAL TESTS						
		1993	1994	1995	1996	1997	1998	1999
Color	15 UNITS	ND	ND	ND	ND	ND	ND	ND
Odor	3 UNITS	0	0	0	1	2	0	0
Turbidity	5 UNITS	0.2	0.15	ND	ND	ND	ND	ND

INORGANIC	1999 MCL OR GUIDELINE	ACTUAL TESTS (mg/l)						
		1993	1994	1995	1996	1997	1998	1999
Silver	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Barium	2.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Calcium	No MCL	---	---	0.33	0.37	0.35	0.30	0.35
Calcium Hardness	No MCL	2.0	ND	ND	1.0	1.0	1.0	1.0
Cadmium	0.005 mg/l	ND	ND	ND	ND	ND	ND	ND
Chloride	250 mg/l	3.23	3.04	4.00	5.00	3.00	3.00	3.30
Chromium	0.1 mg/l	ND	ND	ND	ND	ND	ND	ND
Copper	1.3 mg/l	ND	0.05	0.02	0.03	0.03	ND	ND
Fluoride	2.2 mg/l	ND	ND	ND	ND	ND	ND	ND
Iron	0.3 mg/l	0.09	0.18	0.15	0.19	0.32	0.25	0.21
Total Hardness	No MCL	2.0	3.2	3.2	1.0	3.0	1.0	1.0
Mercury	0.002 mg/l	ND	ND	ND	ND	ND	ND	ND
Langlier Index	No MCL	---	-6.33	-6.33	-7.10	-7.03	-6.79	-6.73
Detergents	No MCL	ND	ND	ND	ND	ND	ND	ND
Magnesium	No MCL	---	---	ND	0.21	0.58	ND	0.20
Manganese	0.3 mg/l	ND	ND	ND	ND	ND	ND	ND
Sodium	20 & 270 mg/l*	2.20	2.81	2.90	2.90	2.80	3.40	2.80
Ammonia (as N)	No MCL	0.14	ND	ND	ND	ND	ND	ND
Nitrite (as N)	1.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	10.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Lead	0.015 mg/l	ND	0.003	ND	ND	ND	0.0026	0.0040
pH	6.5 - 8.5 units	4.9	5.1	5.1	4.2	4.9	5.2	5.2
Selenium	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Sulfate	250 mg/l	3.02	2.91	ND	ND	ND	ND	ND
Total Alkalinity	No MCL	1.5	2.1	2.1	4.0	4.0	ND	ND
Total Dissolved Solids	No MCL	19	60	60	55	<10	43	28
Zinc	5.0 mg/l	0.04	ND	ND	0.03	ND	ND	ND
Antimony	0.006 mg/l	ND	ND	ND	---	---	ND	ND
Beryllium	0.004 mg/l	ND	ND	ND	---	---	ND	ND
Nickel	0.1 mg/l	ND	ND	ND	---	---	ND	ND
Thallium	0.002 mg/l	ND	ND	ND	---	---	ND	ND
Cyanide, Free	0.2 mg/l	ND	ND	ND	---	---	ND	ND

* 20 mg/L is limit recommended by many physicians for people on severely sodium restricted diets.

MASSAPEQUA WATER DISTRICT
WATER QUALITY DATA
WELL NO. 7

ND = NOT DETECTABLE

MCL = MAXIMUM CONTAMINANT LEVEL

PHYSICAL (AESTHETICS) & OTHER PARAMETERS	1999 MCL OR GUIDELINE	ACTUAL TESTS						
		1993	1994	1995	1996	1997	1998	1999
Color	15 UNITS	ND	ND	ND	ND	ND	ND	ND
Odor	3 UNITS	0	0	0	0	0	0	0
Turbidity	5 UNITS	0.18	0.95	ND	ND	ND	ND	ND

INORGANIC	1999 MCL OR GUIDELINE	ACTUAL TESTS (mg/l)						
		1993	1994	1995	1996	1997	1998	1999
Silver	0.05 mg/l	0.008	0.008	ND	ND	ND	ND	ND
Arsenic	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Barium	2.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Calcium	No MCL	---	---	0.36	0.51	0.38	0.43	0.50
Calcium Hardness	No MCL	2.0	ND	ND	1.0	1.0	1.0	1.0
Cadmium	0.005 mg/l	ND	ND	ND	ND	ND	ND	ND
Chloride	250 mg/l	3.91	4.02	4.00	5.00	3.00	4.00	5.50
Chromium	0.1 mg/l	ND	ND	ND	ND	ND	ND	ND
Copper	1.3 mg/l	0.021	0.03	0.04	0.02	0.06	ND	ND
Fluoride	2.2 mg/l	ND	ND	ND	ND	ND	ND	ND
Iron	0.3 mg/l	0.19	0.27	0.27	0.34	0.29	0.30	0.35
Total Hardness	No MCL	2.0	2.4	2.4	2.0	2.0	2.0	2.0
Mercury	0.002 mg/l	ND	ND	ND	ND	ND	ND	ND
Langlier Index	No MCL	---	-7.45	-7.45	-7.16	-6.99	-6.84	-7.07
Detergents	No MCL	ND	ND	ND	ND	ND	ND	ND
Magnesium	No MCL	---	---	ND	0.37	0.33	0.35	0.36
Manganese	0.3 mg/l	ND	ND	ND	ND	ND	ND	ND
Sodium	20 & 270 mg/l*	2.3	2.3	2.3	3.0	2.8	2.8	3.0
Ammonia (as N)	No MCL	0.14	ND	ND	ND	ND	ND	ND
Nitrite (as N)	1.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	10.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Lead	0.015 mg/l	0.001	0.001	0.0012	ND	ND	ND	ND
pH	6.5 - 8.5 units	4.7	4.8	4.8	4.6	4.9	5.0	4.7
Selenium	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Sulfate	250 mg/l	4.34	4.48	ND	ND	ND	ND	ND
Total Alkalinity	No MCL	0.5	0.3	0.3	1.0	ND	ND	ND
Total Dissolved Solids	No MCL	20	20	20	10	11	28	38
Zinc	5.0 mg/l	0.04	ND	ND	0.03	ND	ND	ND
Antimony	0.006 mg/l	ND	ND	ND	---	---	ND	ND
Beryllium	0.004 mg/l	ND	ND	ND	---	---	ND	ND
Nickel	0.1 mg/l	ND	ND	ND	---	---	ND	ND
Thallium	0.002 mg/l	ND	ND	ND	---	---	ND	ND
Cyanide, Free	0.2 mg/l	ND	ND	ND	---	---	ND	ND

* 20 mg/L is limit recommended by many physicians for people on severely sodium restricted diets.

MASSAPEQUA WATER DISTRICT
WATER QUALITY DATA
WELL NO. 8

ND = NOT DETECTABLE

MCL = MAXIMUM CONTAMINANT LEVEL

PHYSICAL (AESTHETICS) & OTHER PARAMETERS	1999 MCL OR GUIDELINE	ACTUAL TESTS 1993	1994	1995	1996	1997	1998	1999
Color	15 UNITS	10	ND	ND	ND	ND	ND	ND
Odor	3 UNITS	0	0	0	0	0	0	0
Turbidity	5 UNITS	0.4	0.16	ND	ND	ND	ND	1.4

INORGANIC	1999 MCL OR GUIDELINE	ACTUAL TESTS (mg/l) 1993	1994	1995	1996	1997	1998	1999
Silver	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Arsenic	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Barium	2.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Calcium	No MCL	---	---	ND	0.19	ND	ND	ND
Calcium Hardness	No MCL	2.0	1.6	1.6	0.0	ND	ND	ND
Cadmium	0.005 mg/l	ND	ND	ND	ND	ND	ND	ND
Chloride	250 mg/l	3.23	3.01	3.00	1.80	3.00	3.00	3.80
Chromium	0.1 mg/l	ND	ND	ND	ND	ND	ND	ND
Copper	1.3 mg/l	ND	ND	3.00	ND	ND	ND	ND
Fluoride	2.2 mg/l	ND	ND	ND	ND	ND	ND	ND
Iron	0.3 mg/l	0.54	0.992	0.81	1.00	1.40	0.80	0.81
Total Hardness	No MCL	2.0	8.0	8.0	0.0	0.0	ND	ND
Mercury	0.002 mg/l	ND	ND	ND	ND	ND	ND	ND
Langlier Index	No MCL	---	-7.47	-7.47	-6.79	-6.87	-7.07	-7.17
Detergents	No MCL	ND	ND	ND	ND	ND	ND	ND
Magnesium	No MCL	---	---	ND	0.12	ND	ND	ND
Manganese	0.3 mg/l	ND	ND	ND	ND	ND	0.01	ND
Sodium	20 & 270 mg/l*	1.90	2.21	2.10	1.80	2.00	2.10	2.10
Ammonia (as N)	No MCL	0.10	ND	ND	ND	ND	ND	ND
Nitrite (as N)	1.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Nitrate (as N)	10.0 mg/l	ND	ND	ND	ND	ND	ND	ND
Lead	0.015 mg/l	ND	ND	ND	ND	ND	ND	ND
pH	6.5 - 8.5 units	5.1	4.8	4.8	5.1	5.3	5.1	5.0
Selenium	0.05 mg/l	ND	ND	ND	ND	ND	ND	ND
Sulfate	250 mg/l	2.59	2.34	ND	ND	ND	ND	ND
Total Alkalinity	No MCL	2.0	0.2	0.2	2.0	ND	ND	ND
Total Dissolved Solids	No MCL	23	91	91	42	ND	24	ND
Zinc	5.0 mg/l	0.02	0.043	ND	0.02	0.03	0.03	ND
Antimony	0.006 mg/l	ND	ND	ND	---	---	---	---
Beryllium	0.004 mg/l	ND	ND	ND	---	---	---	---
Nickel	0.1 mg/l	ND	ND	ND	---	---	---	---
Thallium	0.002 mg/l	ND	ND	ND	---	---	---	---
Cyanide, Free	0.2 mg/l	ND	ND	ND	---	---	---	---

* 20 mg/L is limit recommended by many physicians for people on severely sodium restricted diets.

MASSAPEQUA WATER DISTRICT
WATER QUALITY DATA
ALL WELLS

ND = NOT DETECTABLE

VOLATILE ORGANICS	1999 MCL	1993	1994	1995	1996	1997	1998	1999
		ACTUAL TESTS (ug/l)						
Benzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Carbon tetrachloride	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	2 ug/l	ND	ND	ND	ND	ND	ND	ND
Bromobenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Bromochloromethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Bromomethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
n-Bromobenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
sec-Butylbenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
tert-Butylbenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Chloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Chloromethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Dibromomethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane	5 ug/l	ND	ND	ND	ND*	ND	ND	ND
1,1-Dichloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,3-Dichloropropane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
2,2-Dichloropropane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloropropene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Hexachlorobutadiene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Isopropylbenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
p-Isopropyltoluene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
n-Propylbenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Ethylbenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Styrene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,1,1,2-Tetrachloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Toluene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trichlorobenzene	70 ug/l	ND	ND	ND	ND	ND	ND	ND
1,1,2-Trichloroethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Trichlorofluoromethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,2,3-Trichloropropane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
m-Xylene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
o-Xylene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
p-Xylene	5 ug/l	ND	ND	ND	ND	ND	ND	ND

VOLATILE ORGANICS (cont.)	1999 MCL	ACTUAL TESTS (ug/l) 1993	1994	1995	1996	1997	1998	1999
Dichloromethane	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Bromoform	100 ug/l	ND	ND	ND	ND	ND	ND	ND
Bromodichloromethane	100 ug/l	ND	ND	ND	ND	ND	ND	ND
Chloroform	100 ug/l	ND	ND	ND	ND	ND**	ND***	ND
Chlorodibromomethane	100 ug/l	ND	ND	ND	ND	ND	ND	ND
o-Chlorotoluene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
p-Chlorotoluene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
m-Dichlorobenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
o-Dichlorobenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
p-Dichlorobenzene	5 ug/l	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	5 ug/l	---	---	---	---	---	ND	ND
Methyl Tertiary Butyl Ether	50 ug/l	---	---	---	---	---	ND****	ND

* Dichlorodiflouromethane = 1.1 ug/l, was resampled and no chemical was detected

** Chloroform at 0.8 ug/l detected at Well Nos. 3 and 8, no further detections in next two quarterly samples

*** Chloroform at 0.5 ug/l detected at Well No. 6 in one sample, other samples were non-detectable

**** Methyl Tertiary Butyl Ether at 4.8 ug/l detected at Well No. 3 in one sample, other samples were non-detectable

PESTICIDES AND SOC'S	1999 MCL	ACTUAL TESTS (ug/l) 1993	1994	1995	1996	1997	1998	1999
Atrazine	3.0 ug/l	ND	ND	ND	ND	ND	ND	ND
2,4-D	50.0 ug/l	---	---	---	ND	ND	ND	ND
Polychlorinated biphenyls (PCB)	0.5 ug/l	ND	ND	ND	ND	ND	ND	ND
Pentachlorophenol	1.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Toxaphene	3.0 ug/l	---	---	---	ND	ND	ND	ND
2,4,5-TP (Silvex)	10.0 ug/l	---	---	---	ND	ND	ND	ND
Benxo(a)pyrene	0.2 ug/l	ND	ND	ND	ND	ND	ND	ND
Butachlor	50.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Dalapon	200 ug/l	ND	ND	ND	ND	ND	ND	ND
di(2-ethylhexyl)adipate	400 ug/l	ND	ND	ND	ND	ND	ND	ND
di(2-ethylhexyl)phthalates	6.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Dicamba	50.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Dinoseb	7.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Glyphosphate	700 ug/l	ND	ND	ND	ND	ND	ND	ND
Hexachlorobenzene	1.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Metolachlor	50.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Metribuzin	50.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Hexachlorocyclopentadiene	50.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Pichloram	500 ug/l	ND	ND	ND	ND	ND	ND	ND
Propachlor	50.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Simazine	4.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Lindane	0.2 ug/l	---	---	---	ND	ND	ND	ND
Heptachlor	0.4 ug/l	---	---	---	ND	ND	ND	ND
Aldrin	5.0 ug/l	---	---	---	ND	ND	ND	ND
Heptachlor epoxide	0.2 ug/l	---	---	---	ND	ND	ND	ND
Dieldrin	5.0 ug/l	---	---	---	ND	ND	ND	ND
Endrin	2.0 ug/l	---	---	---	ND	ND	ND	ND
Methoxychlor	40.0 ug/l	---	---	---	ND	ND	ND	ND
Chlordane	2.0 ug/l	---	---	---	ND	ND	ND	ND

PESTICIDES AND SOC'S (cont.)	1999 MCL	ACTUAL TESTS (ug/l) 1993	1994	1995	1996	1997	1998	1999
Alachlor	2.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Aldicarb sulfone	-----	ND	ND	ND	ND	ND	ND	ND
Aldicarb sulfoxide	-----	ND	ND	ND	ND	ND	ND	ND
Aldicarb	-----	ND	ND	ND	ND	ND	ND	ND
Oxamyl	200 ug/l	ND	ND	ND	ND	ND	ND	ND
Methomyl	50.0 ug/l	ND	ND	ND	ND	ND	ND	ND
3-Hydroxycarbofuran	50.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Carbofuran	40.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Carbaryl	50.0 ug/l	ND	ND	ND	ND	ND	ND	ND
Total Aldicarb	7.0 ug/l	---	---	---	ND	ND	ND	ND
1,2 -Dibromoethane (EDB)	0.05 ug/l	---	---	---	ND	ND	ND	ND
1,2-Dibromo-3-Chl.Propane	0.2 ug/l	---	---	---	ND	ND	ND	ND
Diquat	20.0 ug/l	---	---	---	---	---	ND	ND
Dioxin	30.0 ug/l	---	---	---	---	---	ND	ND
Endothall	50.0 ug/l	---	---	---	---	---	ND	ND

1993 - Tested as a composite of Well Nos. 1, 2-R and 3 and of Well Nos. 6 and 7
1994 - Tested as composites of Well Nos. 4 and 5 and of Well No. 8
1995 - Tested at all wells except Well Nos. 4 and 5
1996 - Tested for once at three wells
1997 - Tested for once at three wells
1998 - Tested for once at Well Nos. 1, 2-R, 3, 6 and 7
1999 - Tested for once at all wells

APPENDIX B

NEW YORK STATE DEPARTMENT OF HEALTH
SUMMARY OF METHODS AND FINDINGS
INVESTIGATION OF CANCER INCIDENCE
IN ZIP CODES 11701, 11735, 11758 and 11762

New York State Department of Health
Bureau of Chronic Disease Epidemiology and Surveillance

Summary of Methods and Findings

Investigation of Cancer Incidence
In ZIP Codes 11701, 11735, 11758 and 11762
Nassau and Suffolk Counties, New York, 1983-1992
(with Update on Hodgkin's Disease and Bladder Cancer 1993-1997)

Investigation of newly diagnosed cancer cases in ZIP Codes 11701, 11735, 11758 and 11762 in Nassau and Suffolk Counties was undertaken for the years 1983-1992. This investigation was initiated to follow up on a previous study of Hodgkin's disease cases in this area. The previous study found an unusual number of Hodgkin's disease cases among females in 1988 and 1989 in ZIP Codes 11735 and 11758.

METHODS

- The **expected numbers** of newly diagnosed cancer cases, by sex and location in the body, were calculated based on the age and sex distribution of persons in the study area.
- The actual **observed numbers** of newly diagnosed cancer cases, by sex and location in the body, were counted from New York State Cancer Registry records.
- Observed numbers of each type of cancer were compared to expected numbers for the study area as a whole and for each of the four ZIP Codes separately.

FINDINGS

Cancer Cases among Males

- The observed **total** number of newly diagnosed cancer cases was significantly lower than the number expected (2728 cases observed, 2889 cases expected) for the study area as a whole.
- Among **specific cancer sites**, significant deficits in numbers of cases observed compared with the numbers expected were found for cancers of the pancreas (54 observed, 79 expected); prostate (436 observed, 530 expected) and brain (38 observed, 54 expected). No significant elevations in observed numbers of cases were found for the study area as a whole.
- In analyses of specific cancer sites for each of the four ZIP Codes taken separately, a statistically significant excess of bladder cancer was found for ZIP Code 11735 (69 cases observed, 48 cases expected). None of the sixteen other types of cancer studied among males, including Hodgkin's disease, showed statistically significant excesses in any of the four ZIP Code areas. Numbers of cases of Hodgkin's disease were elevated in one ZIP Code area, 11758, although this difference was not statistically significant (18 cases observed, 12 cases expected).

Cancer Cases among Females

- The observed **total** number of newly diagnosed cancer cases was not significantly different from the number expected (3016 cases observed, 3105 cases expected) for the study area as a whole.
- Among **specific cancer sites**, a significant deficit in numbers of cases observed compared with the numbers expected was observed for leukemia (49 cases observed, 65 cases expected). No significant elevations in observed numbers of cases were found for the study area as a whole.

- In analyses of specific cancer sites for each of the four ZIP Codes taken separately, a statistically significant excess in numbers of bladder cancer cases was found for ZIP Codes 11735 (28 cases observed, 17 cases expected) and 11758 (44 cases observed, 32 cases expected). None of the eighteen other types of cancer studied among females, including Hodgkin's disease, showed a statistically significant excess in any of the four ZIP Code areas. Numbers of cases of Hodgkin's disease were elevated in one ZIP Code area, 11758, although this difference was not statistically significant (15 cases observed, 11 expected).

Update on Hodgkin's Disease and Bladder Cancer for the years 1993-1997

- In ZIP Code area 11758, which had shown non-significant excesses of **Hodgkin's disease** among both males and females, the number of cases among males was close to the number expected, while the number among females remained non-significantly high in the update time period. Females with Hodgkin's disease diagnosed after 1992 tended to live in the southern section of the ZIP Code, while those with Hodgkin's disease diagnosed between 1988 and 1992 tended to live in the northern section. The other ZIP Codes studied did not show any excesses of Hodgkin's disease.

- In ZIP Code 11735, which had shown statistically significant excesses of **bladder cancer** among both males and females, the differences between the observed and expected numbers of cases were no longer statistically significant. In ZIP Code 11758, which had shown a non-significant excess among males and a significant excess among females, numbers of cases among males remained nonsignificantly high, while numbers were close to the number expected among females. The other ZIP Codes studied did not show any excesses of bladder cancer.

Discussion

- This study showed an excess in numbers of Hodgkin's disease cases among females residing in ZIP Code area 11758 that was not statistically significant, and statistically significant excesses in numbers of bladder cancer cases in ZIP Code areas 11735 and 11758. However, none of the 19 other types of cancer studied showed statistically significant excesses in any of the ZIP Code areas.

> Hodgkin's disease is one type of lymphoma, or cancer of the lymph system. Although the cause or causes of this disease are not known, it has been associated with various social, genetic, infectious, immunologic and occupational factors. The excess in Hodgkin's disease among females was concentrated in the northern section of ZIP Code 11758 during 1988-1992, and in the southern section during 1993-1997.
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> Bladder cancer has been associated with cigarette smoking, and with exposure to certain chemicals found in the workplace, and several occupations. The excess in bladder cancer cases appeared to have diminished during 1993-1997.

- When this study was originally requested, citizens had expressed concerns over two inactive hazardous waste disposal sites, the Old Bethpage Landfill, located north of ZIP Code 11735, and the Liberty Industrial Finishing site, located within ZIP Code 11735. Hazardous substances have been identified at these sites and both sites are in various stages of remediation (cleanup). Some individuals may have been exposed to hazardous substances at these sites in the past. None of the substances found to be at either site, however, have been specifically linked with either Hodgkin's disease or bladder cancer.

For further information on the occurrence of cancer or for additional questions regarding this investigation, please contact Ms. Aura L. Weinstein, New York State Department of Health, Cancer Surveillance Program, at (518) 474-2354.

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