5.4.6 Natural Groundwater Contamination

This section provides a profile and vulnerability assessment for the natural groundwater contamination hazard.

Hazard Profile

This section provides profile information including: description, location and extent, previous occurrences and losses and the probability of future occurrences.

Description

Groundwater is a natural resource that is used for drinking water, recreation, industry, and crops. It is water found underground in the cracks and spaces in soil, sand, and rock. Groundwater is stored in--and moves slowly through--layers of soil, sand, and rocks called aquifers. Aquifers typically consist of gravel, sand, sandstone, or fractured rock, like limestone. These materials are permeable because they have large connected spaces that allow water to flow through. The speed of groundwater flow depends on the size of the spaces in the soil or rock and how well the spaces are connected. The area where water fills the aquifer is called the saturated zone (or saturation zone). The top of this zone is called the water table. The water table may be located only a foot below the ground's surface or it can be hundreds of feet down.

Much of the U.S. depends on groundwater supply for freshwater withdrawals, agricultural use (mostly for irrigation), public water supply withdrawals, and primarily for drinking water (particularly in rural populations). In some areas of the world, people face serious water shortages because groundwater is used faster than it is naturally replenished or because groundwater has been polluted by human activities. In areas where material above the aquifer is permeable, pollutants can readily sink into groundwater supplies (Groundwater Foundation, 2007).

Groundwater contamination is defined as the addition of elements, compounds, and/or pathogens to groundwater that alter its composition. It can be contaminated in many ways and through a variety of compounds, both natural and man-made. In general, shallow, permeable water table aquifers are the most susceptible to contamination, but susceptibility of all aquifers to contamination is determined largely by such site-specific characteristics as:

- Distance from the contamination source to the aquifer and residence time of the water in the unsaturated zone
- Presence of clay and organic matter in the unsaturated zone materials
- Potential of a particular contaminant to biodegrade and decompose
- Amount of precipitation, which affects recharge and the rate at which contaminants move downward
- Evapotranspiration, which in recharge areas may decrease the amount of water that moves downward to the aquifer

Contamination sources can be grouped into five main categories: natural, municipal, agricultural, industrial and residential. Most concern over groundwater contamination has centered on pollution associated with human activities, including municipal, agricultural, industrial and residential uses. Human groundwater contamination can be related to waste disposal [private sewage disposal systems (septic systems), land disposal of solid waste (landfills), municipal wastewater, wastewater impoundments, land spreading of sludge, brine disposal from the petroleum industry, mine wastes, deep-well disposal of liquid wastes, animal feedlot wastes, radioactive wastes] or not directly related to waste disposal (accidents, certain agricultural activities, mining, highway deicing, acid rain, improper well construction and maintenance, road salt). It can be caused by the improper handling, transporting, stockpiling and storage of hazardous materials (e.g. underground or aboveground storage tanks) resulting in leaks or spills or poor housecleaning practices. Since groundwater contamination associated with human influence is not considered a natural hazard; only natural groundwater contamination is being assessed within this hazard profile for the purpose of this HMP.

Natural groundwater contamination is contamination of groundwater that is not associated with human activities. Groundwater contains some natural impurities. The types and concentrations of natural impurities depend on the nature of the geological material through which the groundwater moves and the quality of the recharge water. Natural sources of groundwater contamination refer to an assortment of water quality problems, including: natural deposits of salts, gypsum, nutrients, and metals in soils that leach into surface and ground waters; warm weather and dry conditions that raise water temperatures, depress dissolved oxygen concentrations, and dry up shallow water bodies; and low-flow conditions and tannic acids from decaying leaves that lower pH and dissolved oxygen concentrations in swamps draining into streams.

Groundwater moving through sedimentary rocks and soils may pick up a wide range of inorganic compounds such as magnesium, calcium, and chlorides. Some aquifers have high natural concentrations of dissolved constituents such as arsenic, boron, and selenium. The effect of these natural sources of contamination on groundwater quality depends on the type of contaminant and its concentrations. Most inorganic compounds are harmless at the concentrations commonly found in unpolluted groundwater, and some are even beneficial to human health.

Naturally occurring pollutants of groundwater include, but are not limited to, the following:

- *Microorganisms*: Bacteria, viruses, parasites and other microorganisms are sometimes found in water. Shallow wells, with water close to ground level, are at most risk. Runoff, or water flowing over the land surface, may pick up these pollutants from wildlife and soils. This is often the case after flooding. Some of these organisms can cause a variety of illnesses. Symptoms include nausea and diarrhea. These can occur shortly after drinking contaminated water. The effects could be short-term yet severe (similar to food poisoning) or might recur frequently or develop slowly over a long time. A common type of microorganism in groundwater is Coliform Bacteria. Coliform Bacteria occurs naturally in the environment and is associated with soils and plants and in the intestines of humans and other warm-blooded animals. This bacterium is used as an indicator for the presence of pathogenic bacteria, viruses, and parasites from domestic sewage, animal waste, or plant or soil material.
- *Dissolved Solids and Chlorides*: One of the most common water quality concerns is the presence of dissolved solids and chloride in concentrations that exceed the recommended maximum limits in federal secondary drinking water standards. The recommended limit are 500 mg/L (milligrams per liter or approximately equivalent to parts per million) for dissolved solids and 250 mg/L for chloride. Such concentrations are found at the seaward ends of all coastal aquifers and are quite common in aquifers at depths greater than a few hundred feet below the land surface in many parts of the United States.
- *Radionuclides*: Radionuclides are radioactive elements such as Gross Alpha particles, Beta particles and photon emitters, Radium 226 and Radium 228 (combined), and Uranium. They may be present in underlying rock and ground water and through erosion or decay of these natural deposits, groundwater contamination can occur. Most drinking water sources have very low levels of radioactive contaminants ("radionuclides"), which are not considered to be a public health concern. Of the small percentage of drinking water systems with radioactive contaminant levels high enough to be of concern, most of the radioactivity is naturally occurring.

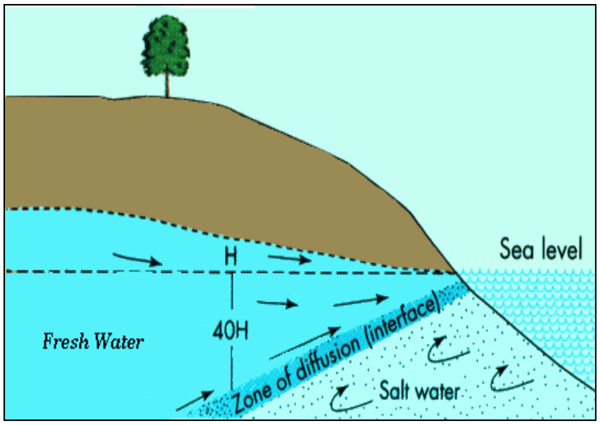
- *Radon*: Radon is a gas that is a natural product of the breakdown of uranium in the soil and can also pose a threat. Radon is most dangerous when inhaled and contributes to lung cancer. Although soil is the primary source, using household water containing Radon contributes to elevated indoor Radon levels. Radon is less dangerous when consumed in water, but remains a risk to health.
- *Nitrates and Nitrites*: Although high nitrate levels are usually due to human activities (see below), they may be found naturally in ground water. They come from the breakdown of nitrogen compounds in the soil. Flowing ground water picks them up from the soil. Drinking large amounts of nitrates and nitrites is particularly threatening to infants (for example, when mixed in formula). Most groundwater not affected by human activity contains less than 10 mg/L nitrate-nitrogen, the maximum concentration allowed by federal primary drinking water standards. Nationwide, nitrate-nitrogen concentrations of less than 0.2 mg/L generally represent natural conditions, whereas values greater than 3 mg/L may indicate the effects of human activities.
- *Heavy Metals*: Underground rocks and soils may contain inorganic chemicals, including arsenic, asbestos, barium, cadmium, chromium, copper, iron, lead, manganese, mercury and selenium. Erosion of these natural deposits can lead to the contamination of groundwater sources. However, these contaminants are not often found in household wells at dangerous levels from natural sources.
- *Arsenic*: Arsenic occurs naturally in sedimentary and hard rocks and soil, water, air, and plants and animals. Natural arsenic is also found in thermal and mineral waters, which reach the earth's surface either by natural discharge in springs or by geothermal exploitation, which may affect the environment if not treated or not reinjected. It can be further released into the environment through natural activities such as volcanic action, erosion of rocks and forest fires.
- *Cadmium*: Cadmium occurs naturally in zinc, lead, copper and other ores which can serve as sources to ground and surface waters, especially when in contact with soft, acidic waters.
- *Iron and Manganese*: Although not particularly toxic, iron and manganese in concentrations greater than the limits for federal secondary drinking water standards (0.3 mg/L for iron and 0.05 mg/L for manganese) can impair the taste of water; stain plumbing fixtures, glassware and laundry; and form encrustations on well screens, thereby reducing well-pumping efficiency
- *Fluoride*: Fluoride is helpful in dental health, so many water systems add small amounts to drinking water. However, excessive consumption of naturally occurring fluoride can damage bone tissue. High levels of fluoride occur naturally in some areas. It may discolor teeth, but generally levels are not high enough to present a health risk (U.S. Environmental Protection Agency [USEPA], 2006).

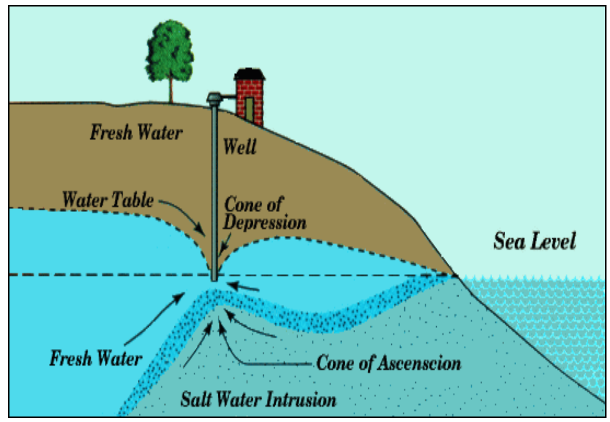
Saltwater Intrusion

Saltwater intrusion is a type of natural groundwater contamination, where the natural balance between freshwater and saltwater in coastal aquifers is disturbed by groundwater withdrawals and other human activities that lower groundwater levels, reduce fresh groundwater flow to coastal waters, and ultimately cause saltwater to intrude into the coastal aquifers making those aquifers no longer available for use. Although groundwater pumping is the primary cause of saltwater intrusion along the coasts, lowering of the water table by drainage canals also can lead to saltwater intrusion. Other hydraulic stresses that reduce freshwater flow in coastal aquifers, such as lowered rates of groundwater recharge in sewered or urbanized areas, also can lead to saltwater intrusion, but the impact of such stresses on saltwater intrusion, at least currently, likely is small in comparison to pumping and land drainage (Kumar, Date Unknown).

Saltwater intrusion is a natural process, but it becomes an environmental problem when excessive pumping of fresh water from an aquifer changes the water pressure and intensifies the effect, drawing salt water into new areas. When freshwater levels drop, the intrusion can proceed further inland until reaching a pumped well. Then one may get saltwater out of the pump, which becomes no longer available for drinking or irrigation (Ranjan, 2007). When one pumps out fresh water rapidly, one lowers the height of the freshwater in the aquifer forming a cone of depression. The salt water rises 40 feet for every 1 foot of freshwater depression and forms a cone of ascension (see Figure 5.4.6-1). Intrusion can affect the quality of water not only at the pumping well sites, but also at other well sites, and in undeveloped portions of an aquifer (Lenntech, 2005).

Figure 5.4.6-1. Salt Water Intrusion Process





Source: Lenntech, 2005

Extent

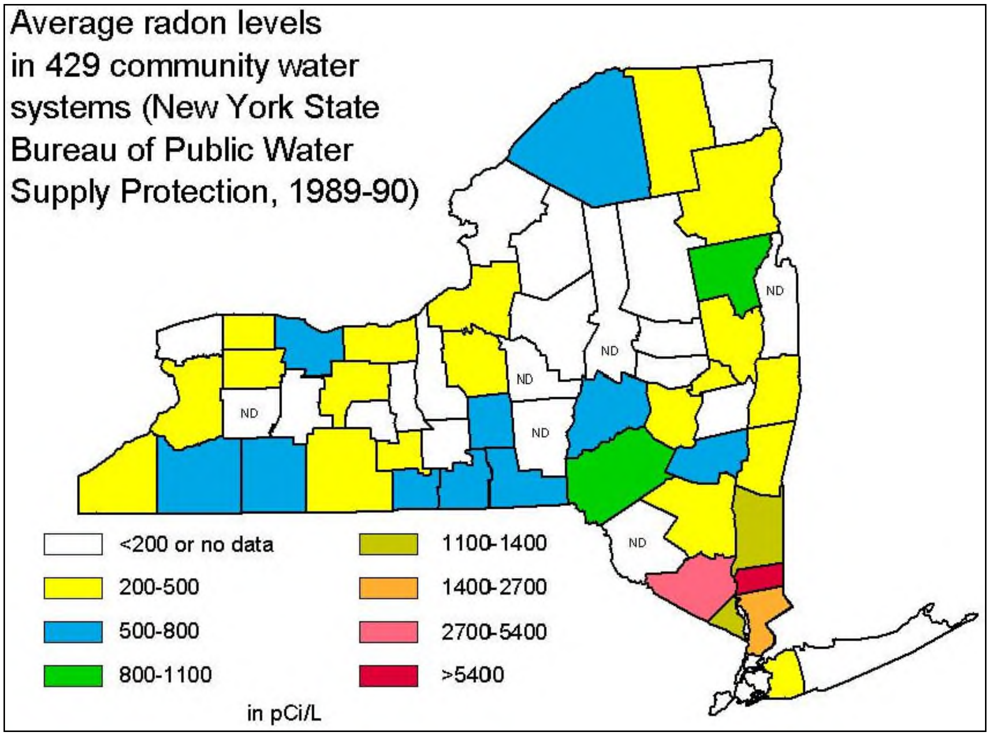
The 1974 Safe Drinking Water Act and its 1986 amendments require the USEPA set standards for contaminants in drinking water that may pose health risks to humans. Drinking water standards apply to public water systems, which provide water for human consumption through at least 15 service connections, or regularly serve at least 25 individuals. Public water systems include municipal water companies, homeowner associations, schools, businesses, campgrounds and shopping malls. The USEPA standard for lifetime exposures in drinking water, the maximum contaminant level (MCL), is the highest amount of a contaminant allowed in drinking water supplied by municipal water systems. Regulators use the reference dose to establish a MCL for a contaminant, assuming that the exposure comes from drinking 2 liters of contaminated water per day for 70 years (USEPA, 2006).

Radon

Currently, there is no federally-enforced drinking water standard for radon. The USEPA has proposed to regulate radon in drinking water from community water suppliers (water systems that serve 25 or more year-round residents); however, they do not regulate private wells. The USEPA has proposed to require community water suppliers to provide water with radon levels no higher than 4,000 pCi/L, which contributes to approximately 0.4 pCi/L of radon to the air in a home. Under the proposed regulation, states that choose not to develop enhanced indoor air programs, community water systems in the state would be required to reduce radon levels in drinking water to 300 pCi/L. Even if a state does not develop an enhanced indoor air program, water systems may choose to develop their own local indoor radon program and meet a radon standard for drinking water of 4,000 pCi/L (USEPA 2012).

According to a groundwater study of 429 community water systems in New York State, Suffolk County was identified as having a low average of radon levels in its groundwater supply [less than 200 picocuries per liter between 1989 and 1990 (Figure 5.4.6-2)]; however, though it is the most recent such study available, this study is significantly outdated, does not represent all water systems, and may not represent the present day radon conditions.

Figure 5.4.6-2. Average Radon Levels of 429 Community Water Systems (1989-1990)



Source: NYSDOH, Date Unknown

According to the Suffolk County Water Authority's (SCWA) 2013 Annual Drinking Water Quality Report, for the period of January 1, 2012 through December 31, 2012, 87 representative locations were tested for radon, for a total of 87 samples. The test results ranged from Non-Detect (no radon was detected) to 336 picocuries per liter (pCi/L). Those locations within Suffolk County that had detected levels of radon, which ranged between 200 and 336 pCI/L, include Distribution Areas 5, 12, and 26, as shown in Table 5.4.6-1.

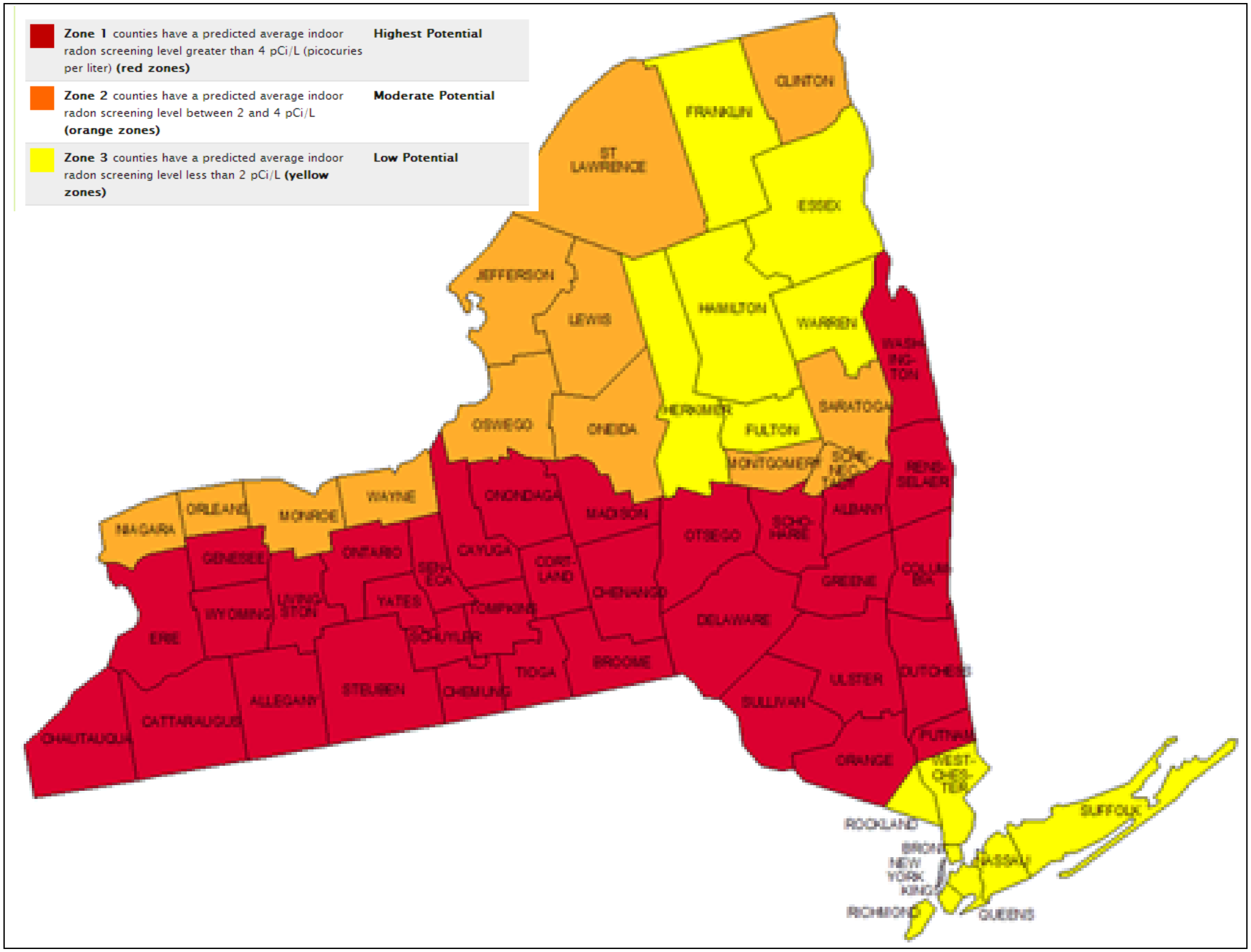
Table 5.4.6-1. Water Distribution Areas with Detected Levels of Radon

Distribution Area	Jurisdictions	Maximum Reading (pCi/L)
5	Hamlet of Huntington and Village of Huntington Bay	221
12	Hamlets of Deer Park, Hauppauge, Manorville, Medford, Middle Island, Ridge, Ronkonkoma, Smithtown, Wyandach, and Yaphank; Village of Shoreham	276
26	Hamlet of Montauk	336

If indoor radon gas levels are high and groundwater is consumed in a household, it is advised that groundwater should be tested. If the radon level is low in the air, there is generally no need to test the groundwater. In general, 10,000 pCi/l of radon in water contributes roughly 1 pCi/l of airborne radon throughout the house. The USEPA currently advises consumers to take action if the total household air level is above 4 pCi/l (CDC, 2003).

Figure 5.4.6-3 shows the USEPA map of radon zones for New York State. The map was developed using indoor radon measurements, geology, aerial radioactivity, soil permeability, and foundation type. The figure shows that Suffolk County is located in Zone 3 (low potential). Counties located in this zone have a predicted average indoor radon screening level less than 2 pCi/L.

Figure 5.4.6-3. New York State Radon Levels



Source: *USEPA 2013*
Note: *Suffolk County is shown has being located within Zone 3 (low potential).*

According to the Wadsworth Center of the New York State Department of Health (NYS DOH), in February 2007, 358 homes were tested for indoor radon estimates within Suffolk County. Estimates were collected in the living areas and basements of the homes. Homes were not tested evenly throughout the townships of the County; therefore, estimates do not provide enough information to identify those areas within the County most susceptible to higher indoor radon levels. Table 5.4.6-2 presents the results of this testing.

Table 5.4.6-2. Indoor Radon Estimates, Percent Homes Above 4 pCi/L (February 2007)

Jurisdiction	Homes Measured	Living area*		Basement**	
		Best Estimate (%)	Range # (%)	Best Estimate (%)	Range # (%)
Babylon	40	0.2	(0.1 - 0.4)	3	(2 - 5)
Brookhaven	66	0.1	(0.1 - 0.4)	4	(3 - 6)
East Hampton	13	0.6	(0.2 - 1.7)	7	(4 - 12)
Huntington	110	0.8	(0.5 - 1.3)	11	(9 - 13)
Islip	51	0.2	(0.1 - 0.4)	3	(2 - 4)
Poospatuck Reservation	0	0.2	(0.1 - 1.3)	4	(1 - 10)
Riverhead	6	0.3	(0.1 - 1.0)	4	(2 - 8)
Shelter Island	1	0.3	(0.1 - 1.6)	6	(1 - 15)
Shinnecock Reservation	0	0.2	(0.1 - 1.3)	4	(1 - 10)
Smithtown	47	1.2	(0.6 - 2.60)	9	(7 - 13)
Southampton	17	0.1	(0.1 - 0.4)	3	(1 - 5)
Southold	7	0.7	(0.2 - 2.7)	8	(5 - 14)
Suffolk County	**358**	**0.5**		**6**	

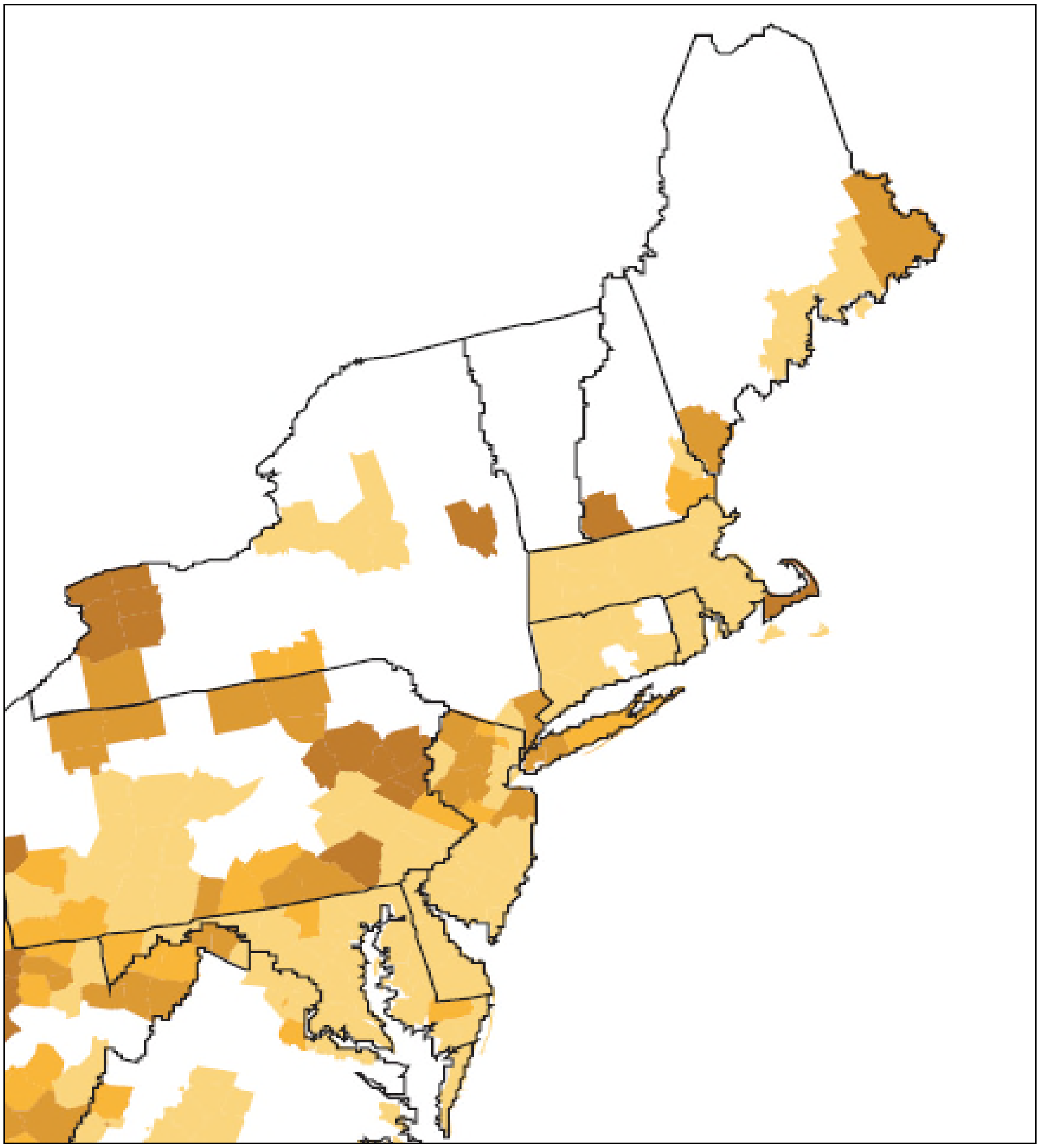
Source: NYSDOH, 2007
Note: ** Long-term measurement, 90 days to one year.*
***Short-term measurement, typically 2 to 7 days.*
 # Uncertainty range of one sigma corresponds to a 68-percent confidence interval.

Arsenic

The USEPA adopted a standard for arsenic in drinking water at 10 parts per billion (ppb), and has required systems to comply with this standard since January 23, 2006. This standard for drinking water was established to protect consumers served by public water systems from the effects of long-term, chronic exposure to arsenic (USEPA, 2013).

Since May 2000, the U.S. Geological Survey (USGS) has published three maps summarizing a national data set on arsenic in groundwater. These maps were intended as a big-picture view of patterns in naturally occurring arsenic across the United States (Ryker, 2001). According to the May 2000 map (Figure 5.4.6-4), counties with arsenic concentrations exceeding possible new MCLs in 10 percent or more of groundwater samples between 1973 and 1997 were identified. This county map is based on 18,850 groundwater samples and shows arsenic concentrations in at least 10-percent of samples per county. Suffolk County had arsenic concentrations exceeding 3 parts per billion in 10-percent or more of samples. An update of this map was completed with 31,350 groundwater samples collected between 1973 and 2001 (Figure 5.4.6-5). This map indicated arsenic concentrations were identified in at least 25-percent of groundwater samples in each county, with arsenic concentrations ranging between 1 and 50 parts per billion. One location along the southern shoreline of Suffolk County appeared to have identified arsenic concentrations ranging between 10 and 50 parts per billion. The actual location of the higher concentrations could not be determined through the review of Figure 5.4.6-6.

Figure 5.4.6-4. Concentrations of Arsenic 1973 to 1997

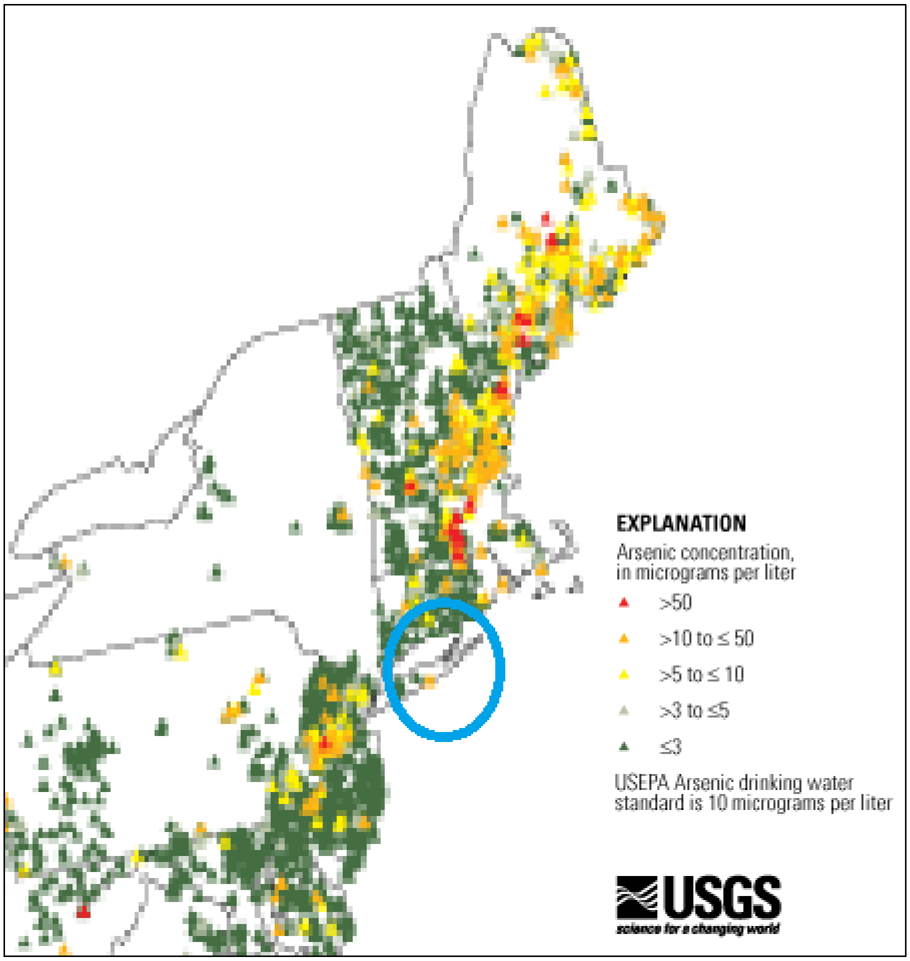


Source: USGS, 2000

Note: Counties with arsenic concentrations exceeding possible new MCLs in 10 percent or more of ground-water samples between 1973 and 1997. This county map is based on 18,850 ground-water samples and showed arsenic concentrations found in at least 10-percent of samples per county.

Arsenic concentrations exceeding 10 µg/L in 10 percent or more of samples.
Arsenic concentrations exceeding 5 µg/L in 10 percent or more of samples.
Arsenic concentrations exceeding 3 µg/L in 10 percent or more of samples.
Fewer than 10 percent of samples exceeding 3 µg/L, representing areas of lowest concentration.
Insufficient data in the USGS data base to make estimates.

Figure 5.4.6-5. Concentrations of Arsenic in Groundwater, 1973 to 2001



Source: *USGS 2011*

Note (1): *USGS used arsenic concentration data for 20,043 groundwater samples collected in 1973 to 2001 from across the U.S. The values are shown in micrograms per liter.*

Note (2): *The map shows arsenic concentrations in groundwater in Suffolk County to range from less than 3 to between greater than 5 but less than 10.*

According to the Suffolk County Water Authority's (SCWA) 2013 Annual Drinking Water Quality Report, for the period of January 1, 2012 through December 31, 2012, all wells were tested for arsenic. The test results ranged from non-detect to 4.5 micrograms per liter (µg/L). Those locations within Suffolk County that had detects included Water Distribution Areas 1, 12, 20 and 23. Results (detects only) are shown in Table 5.4.6-3.

Table 5.4.6-3. Water Distribution Areas with Detected Levels of Arsenic

Distribution Area	Jurisdictions	Maximum Reading (ug/L)
1	Amityville, North Amityville, Babylon, Bay Shore, North Bay Shore, West Bay Shore, Brightwaters, Bayport, Bellport, North Bellport, West Bellport, Blue Point, Bohemia, Brentwood (all other southern or western Brentwood areas), Brookhaven, Copiague, Amity Harbor, Deer Park, East Islip, Great River, Great River North, Holbrook, South Holbrook, Islip, Islip Terrace, Lindenhurst, North Lindenhurst, North Babylon, Oakdale, Patchogue, E. Patchogue, Hagerman, Selden, North Selden, West Babylon, West Islip, West Sayville, Wyandanch, Wheatley Heights, Yaphank,	1.5

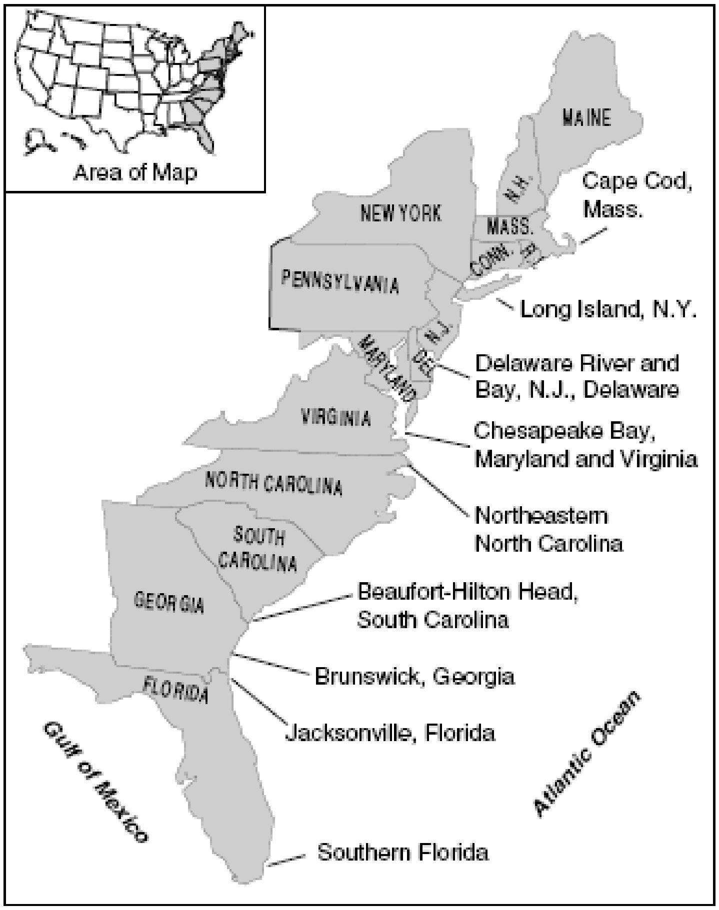
Distribution Area	Jurisdictions	Maximum Reading (ug/L)
	South	
12	Bellport North of Sunrise Hwy, Bohemia, Brentwood, Edgewood, Brentwood Water District, Center Moriches, Centereach, South Centereach, Central Islip, Coram, Deer Park, Eastport, Farmingville, Great River North, Hauppauge, South Hauppauge, Holbrook, East Holbrook, Holtsville, Huntington, Islandia, Lake Grove, Lake Ronkonkoma, Sachem, Lakeland, Manorville, South Manor, Mastic N. of Sunrise Hwy, Medford, Middle Island, Moriches, Nesconset, Nissequogue, Southwest Head of the Harbor, Ridge, South Ridge, Ronkonkoma, Saint James, Western Saint James, Shirley, North, Shoreham, Smithtown, The Branch, Wading River, Wyandanch, Wheatly Heights, Yaphank, West Yaphank, East Yaphank, South Yaphank, Yaphank, East	4.5
20	Center Moriches, East Moriches, Eastport, Mastic S. of Sunrise Hwy, Mastic Beach, Remsenburg, Shirley, Speonk, Westhampton, Westhampton Beach	2.0
23	Amagansett, Bridgehampton, Scuttlehole, Sag Harbor, East Hampton, Sagaponack, Sag Harbor (includes Village of Sag Harbor), Bridgehampton, Southampton, North Sea, Wainscott, Water Mill	1.2

Source: SCWA, 2013
Note: The MCL for arsenic is 10 ug/L. The likely source of arsenic in these samples is erosion of natural deposits.

Salt Water Intrusion

The extent of saltwater intrusion depends, among other factors, on the rate of freshwater discharge to the sea. Other factors include the total rate of groundwater that is withdrawn compared to the total freshwater recharge to the aquifer, the distance of the stresses (wells and drainage canals) from the source (or sources) of saltwater, the geologic structure and distribution of hydraulic properties of the aquifer, and the presence of confining units that may prevent saltwater from moving vertically toward or within the aquifer. Moreover, the time required for saltwater to move through an aquifer and reach a pumping well can be quite long. The depth of the aquifer at the seaside, through which the saltwater intrudes the aquifer, also has a major effect on the degree of intrusion. Depending on the location and lateral width of the transition zone, many years may pass before a well that is unaffected by saltwater intrusion suddenly becomes contaminated (Barlow and Wild, 2002). This makes saltwater intrusion a management problem, since the freshwater discharge to the sea is the sum of the natural and the artificial recharge minus pumping. However, controlling saltwater intrusion is costly and/or management intensive. Extensive studies have been carried out in many parts of the world to clarify the mechanism of saltwater intrusion and to control it from better exploitation of coastal aquifers (Goosen and Shayya, 1999).

Figure 5.4.6-6. Selected areas along the Atlantic coast where saltwater has intruded into freshwater aquifers.



Source: Barlow and Wild, 2002

According to Hofstra University, excessive discharge on Long Island causes intrusion of the water table by sea water. Because freshwater is lighter than saltwater, fresh groundwater forms a barrier to saltwater flow, lying between the land surface and deeper infiltrating saltwater. However, excessive removal of freshwater from the aquifer pulls the saltwater farther inland and closer to the surface, where it can find its way into wells. Long Island pumps (discharges) more water from the aquifers than they can naturally recharge. If this is done for a long period of time, the aquifer shrinks and is replaced by salt water (Bennington, Date Unknown). In many locations throughout Long Island, water supply wells have been shut down or abandoned as a result of salt water intrusion.

The degree of saltwater intrusion varies widely among localities and hydrogeologic settings. In many instances, the area contaminated by saltwater is limited to small parts of the aquifer and has little or no effect on wells pumped for groundwater supply. In other instances, contamination is of regional extent and has substantially affected groundwater supplies (Kumar, Date Unknown).

Location

The aquifer system of Long Island is part of the Northern Atlantic Coastal Plain aquifer system that extends from Long Island, New York, through North Carolina. This is a thick, multi-layered aquifer system that underlies thousands of square miles (Barlow, 2002). Long Island's groundwater system is one of the largest and most important groundwater systems in New York State supporting over 3 million people. Its groundwater system has been designated by the USEPA as a sole-source aquifer (SSA), which is defined as an aquifer that supplies at least 50 percent of the drinking water consumed in the overlying area and that, if contaminated, would create a significant hazard to public health (Cartwright, 2004).

The aquifer system beneath Suffolk County consists of a sequence of unconsolidated deposits comprising three aquifers that overlie a southeastward-dipping bedrock surface. Sediment thickness ranges from about 500 feet in the northwest to almost 2,000 feet beneath the barrier beaches in southwestern Suffolk County. The uppermost aquifer is the Pleistocene-aged upper glacial aquifer, which is about 700 feet thick in the northern half of the island and generally thins to about 100 feet thick in the south. It is found within the upper Pleistocene deposits, which consist primarily of two terminal moraines, outwash, glaciolacustrine deposits, and marine clay on the extreme south shore. Till, an unsorted mixture of clay, sand, gravel and boulders, is found mostly along the north shore and in the moraines. Outwash deposits that consist of fine to very coarse quartzose sand and gravel are found between and south of the moraines. Glaciolacustrine deposits that consist of silt, clay, and some sand and gravel are found mostly in central and eastern Suffolk County. Most private wells in the County are completed in the upper glacial aquifer. Below the upper glacial aquifer is the Cretaceous-aged Magothy aquifer, which ranges in thickness from 0 in extreme northwestern Suffolk County to more than 1,000 feet in the south and extends as deep as 1,200 feet below land surface (Cartwright, 2004).

According to the Suffolk County Water Authority (SCWA), the water table is highest along the center of the island. This is also where the greatest rainfall occurs. Groundwater tends to flow from recharge areas in the center of the island to discharge areas along the north and south shores. The total depth of the Long Island Aquifer System is smallest on the north shore (approximately 600 feet) and deepest along the south shore (approximately 2,000 feet) (SCWA, 2007).

The aquifer system of Suffolk County is highly vulnerable to contamination. A variety of sources have indicated that groundwater contamination is present throughout Suffolk County; however, most documented contamination is primarily associated with human influences (e.g., pesticides, nitrates, heavy metals, hazardous releases and/or wastes) and not with natural contamination sources. Although there are many natural contaminants; those contaminants of natural origin that have been well documented for Suffolk County include radon, arsenic, and saltwater (through salt water intrusion). Other natural pollutants do impact the County; however, resources and documented cases regarding the location of natural contamination impacts are limited.

Previous Occurrences and Losses

Due to natural and/or manmade groundwater contamination being an ongoing issue affecting Long Island's population directly or indirectly, former occurrences and losses/impacts in association with specific natural contamination incidences within Suffolk County are difficult to quantify. The primary impact or loss associated with natural groundwater contamination is that the groundwater source becomes no longer available for any type of use. Once pollutants enter an aquifer, the environmental damage can be severe and long-lasting, partly because of the very long time needed to flush pollutants out of the aquifer.

Probability of Future Events

Groundwater quality will naturally continue to be disrupted from a variety of natural and human factors. In reference to future salt water intrusion, in recent years, water use/pumpage in Suffolk County appears to have exceeded the anticipated amount projected by the SCWA. In 2002, the SCWA reported a 45-percent increase in water use over the previous 10 years. This is more than double the increase projected in the Suffolk County comprehensive management plan at that time. An increase in groundwater consumption is one factor that can impact the equilibrium of fresh water and fresh groundwater, causing the freshwater-groundwater interface to move inland and exacerbate the problem of salt water intrusion. As more people develop and reside within Suffolk County's coastal communities, it is anticipated that water demands will continue to increase, creating a high probability of occurrence of salt water intrusion in Suffolk County.

Earlier in this section, the identified hazards of concern for Suffolk County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used in this ranking process. Based on historical records and input from the Planning Committee, the probability of occurrence for natural groundwater contamination events in the County is considered 'frequent' [hazard event that occurs more frequently that once in 10 years].

Climate Change Impacts

Climate change is beginning to affect both people and resources in New York State, and these impacts are projected to continue growing. Impacts related to increasing temperatures and sea level rise are already being felt in the State. ClimAID: the Integrated Assessment for Effective Climate Change in New York State (ClimAID) was undertaken to provide decision-makers with information on the State's vulnerability to climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge (New York State Energy Research and Development Authority [NYSERDA], 2011).

Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. Suffolk County is part of Region 4, New York City and Long Island. Some of the issues in this region, affected by climate change, include: contains the highest population density in New York State; sea level rise and storm surge increase coastal flooding, erosion, and wetland loss; challenges for water supply and wastewater treatment; heat-related deaths increase; illnesses related to air quality increase; and higher summer energy demand stresses the energy system (NYSERDA, 2011).

Temperatures are expected to increase throughout the state, by 1.5 to 3ºF by the 2020s, 3 to 5.5ºF by the 2050s and 4 to 9ºF by the 2080s. The lower ends of these ranges are for lower greenhouse gas emissions scenarios and the higher ends for higher emissions scenarios. Annual average precipitation is projected to increase by up to five-percent by the 2020s, up to 10-percent by the 2050s and up to 15-percent by the 2080s. During the winter months is when this additional precipitation will most likely occur, in the form of rain, and with the possibility of slightly reduced precipitation projected for the late summer and early fall. Table 5.4.6-4 displays the projected seasonal precipitation change for the New York City and Long Island ClimAID Region (NYSERDA, 2011).

Table 5.4.6-4. Projected Seasonal Precipitation Change in Region 4, 2050s (% change)

Winter	Spring	Summer	Fall
0 to +15	0 to +10	-5 to +10	-5 to +10

Source: NYSERDA, 2011

Even though an increase in annual precipitation is projected, other climate change factors, such as an extended growing season, higher temperatures, and the possibility of more intense, less frequent summer rainfall, may lead to additional droughts and increased short-term drought periods (Cornell University College of Agriculture and Life Sciences, 2011). Droughts can cause deficits in surface and groundwater used for drinking water. The New York State Water Resources Institute at Cornell University conducted a vulnerability assessment of drinking water supplies and climate change. To assess water supplies in New York State, it was assumed that long-term average supply will remain the same but the duration and/or frequency of dry periods may increase. Both types of water supplies, surface water and groundwater, were divided into three categories: sensitive to short droughts (two to three months), sensitive to moderate and longer droughts (greater than six months), and relatively sensitive to any droughts. Major reservoir systems are presumed to have moderate sensitivity to drought because there is a likelihood of decreases in summer and fall water availability (Cornell University College of Agriculture and Life Sciences, 2011). The greatest likelihood of future water shortages is likely to occur on small water systems (Cornell University College of Agriculture and Life Sciences, 2011). In addition, increased draw on freshwater aquifers due to drought conditions will exacerbate saltwater infusion (see above), further contaminating groundwater supplies.

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For natural groundwater contamination, all of Suffolk County has been identified as the hazard area. Therefore, all assets, particularly the County's population, as described in the County Profile section, are vulnerable to this hazard. The following text evaluates and estimates the potential impact of severe storms on Suffolk County including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, health and safety of residents, (2) general building stock, (3) critical facilities, (4) economy, and (5) future growth and development
- Effect of climate change on vulnerability
- Change of vulnerability as compared to that presented in the 2008 Suffolk County Hazard Mitigation Plan
- Further data collections that will assist understanding this hazard over time

Overview of Vulnerability

Long Island's groundwater system is a federally-designated "sole source" aquifer. The area is also identified as a Primary Water Supply Aquifer by New York State Department of Health (1981) and NYSDEC (1987) (USEPA, 2007). The total capacity of the aquifers underlying Suffolk County is about 70 trillion gallons. Precipitation is the sole source of all naturally occurring fresh groundwater on Long Island. Seasonal- or long-term fluctuations in precipitation volume and, thus, in recharge, are reflected by the water levels in all aquifers.

There are more than 1,100 active public water supply wells in Suffolk County that serve more than 90% of the County's population. Water is withdrawn from three major aquifers found beneath the County (Lloyd, Magothy, and Upper Glacial). In addition, individual on-site private wells provide water to approximately 50,000 year-round and seasonal homes in the County (Suffolk County Office of Water Resources 2014).

Natural contamination to Long Island's groundwater system, a federally-designated "sole source" aquifer, is a significant concern. This aquifer supplies drinking water to all public and private water supply systems in Suffolk County. Additionally, this natural resource is used for recreation, industry and to support the agricultural community. Estimated losses are difficult to quantify, however natural groundwater contamination will severely impact Suffolk County's population and economy.

Data and Methodology

Due to a lack of historic loss information, a qualitative assessment was conducted to evaluate the assets exposed to this hazard and the potential impacts associated with this hazard. Over time, additional data will be collected to allow better analysis for this hazard. Available information and a preliminary assessment are provided below.

Impact on Life, Health and Safety

A majority (more than 90%) of Suffolk County's residents obtain their drinking water from three major aquifers, whether supplied from public or private systems. Compromised groundwater quality could impact the entire Suffolk County population. According to the U.S. Census, the 2013 estimated population for the County was 1,499,273; approximately 1.3 million are served by public water and over

200,000 residents (50,000 year-round and seasonal homes) are on private wells (U.S. Census, 2014; Suffolk County Office of Water Resources, 2014; Suffolk County Department of Health Services, 2014).

In general, private well owners/users are more vulnerable to natural groundwater contamination. USEPA regulates public water system and sets standards for contaminants in drinking water that may pose health risks. However, USEPA does not have the authority to regulate private drinking water wells. Private well water quality testing and water treatment is the responsibility of the well owner. In general, private well water quality is not tested as frequently as required by public water suppliers. Additionally, areas that rely on private wells for drinking water often use septic systems for sanitary waste water disposal, which may be another source of contamination.

In areas that lack public water supply, the Suffolk County Department of Health Services (SCDHS) operates a comprehensive water quality testing program. The program provides a comprehensive water quality analysis and recommendations if necessary. If the monitoring discovers significant water quality problems that may affect other nearby wells, a survey is conducted by testing adjacent wells (SCDHS, 2014). Proper water testing, well construction and continued maintenance are keys to the safety of private water supply.

People who drink contaminated water may, immediately or over time, suffer from a variety of health problems depending upon the type of contamination. Depending upon the contaminant of concern, infants, young children and individuals with compromised immune systems may be more susceptible to illnesses from contaminated groundwater. It is difficult to measure and quantify the health costs that might be incurred due to natural groundwater contamination.

Impact on General Building Stock and Critical Facilities

No structures are anticipated to be directly affected by natural groundwater contamination.

Impact on Economy

Groundwater contamination's impact on the economy and estimated dollar losses are difficult to measure. Where groundwater becomes polluted, property values can drop and land may become unsellable. The price to remediate contaminated groundwater can be expensive and tax-payers may be burdened with this cost. Clean-up costs depend on many factors, including the type of contaminant, its concentrations and extent. In many cases, the full cost of remediation is not realized, even after years have passed. Increased demand for bottled water may result in shortages and a higher cost for this resource. Industries that rely on water for business may also be impacted (e.g., agriculture).

Effect of Climate Change on Vulnerability

Even though an increase in annual precipitation is projected, other climate change factors, such as an extended growing season, higher temperatures, and the possibility of more intense, less frequent summer rainfall, may lead to additional droughts and increased short-term drought periods (Cornell University College of Agriculture and Life Sciences, 2011). Droughts can cause deficits in surface and groundwater used for drinking water. The New York State Water Resources Institute at Cornell University conducted a vulnerability assessment of drinking water supplies and climate change. To assess water supplies in New York State, it was assumed that long-term average supply will remain the same but the duration and/or frequency of dry periods may increase. Both types of water supplies, surface water and groundwater, were divided into three categories: sensitive to short droughts (two to three months), sensitive to moderate and longer droughts (greater than six months), and relatively sensitive to any droughts. Major reservoir systems are presumed to have moderate sensitivity to drought because there is a likelihood of decreases in summer and fall water availability (Cornell University College of Agriculture and Life Sciences, 2011). The greatest likelihood of future water shortages is likely to occur on small water systems (Cornell University College of Agriculture and Life Sciences, 2011). In addition, increased draw on freshwater aquifers due to drought conditions will exacerbate saltwater infusion (see above), further contaminating groundwater supplies.

Change of Vulnerability

As discussed above, more than 90% of Suffolk County's residents obtain their drinking water from public water supply systems that are sourced by large groundwater aquifers beneath the County. The aquifers are likely to remain the main source of potable water supply for residents. The vulnerability, from a population standpoint, is likely to remain the same as the 2008 HMP. However, as future development occurs and technology advances there is the potential to expand potable water treatment facilities that help mitigate the County's vulnerability to the effects of groundwater contamination.

Future Growth and Development

As discussed in Section 4, areas targeted for future growth and development have been identified across Suffolk County. Any areas of growth could be potentially impacted by natural groundwater contamination because the entire County is exposed and vulnerable to the hazard. Areas targeted for potential future growth and development in the next five (5) years have been identified across the County at the municipal level. Refer to the jurisdictional annexes in Volume II of this HMP.

Additional Data and Next Steps

Obtaining historic costs incurred to treat contaminated groundwater to meet state and federal quality standards may help with modeling future losses, given a margin of uncertainty. Population growth, especially in Suffolk County's coastal communities, and demands on the Long Island Aquifer System should continue to be monitored to prevent over-pumping and exacerbating the problem of saltwater intrusion. Additional studies can also be conducted to delineate and continuously monitor the current extent of saltwater intrusion in Suffolk County.

Overall Vulnerability Assessment

Natural groundwater contamination can significantly impact the County's population and economy. For future plan updates, any additional information regarding localized concerns and past impacts will be collected and analyzed.