Use of Long Island's Groundwater Resources for Geothermal Heating and Cooling

John Rhyner, P.G.
Vice President, Geothermal Services
P.W. Grosser Consulting, Inc.

2017

Use of Long Island's Groundwater Resources for Geothermal Heating and Cooling

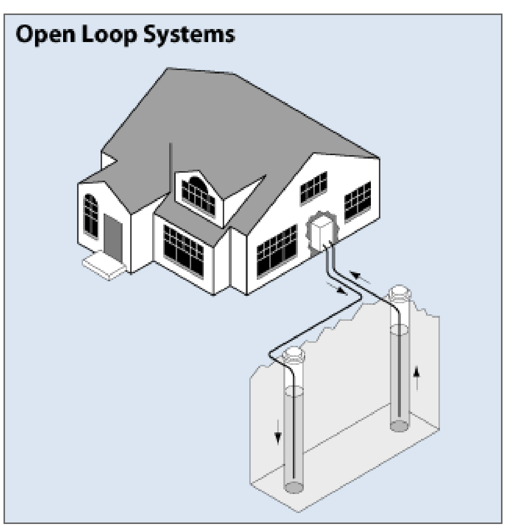
John Rhyner, P.G., Vice President, Geothermal Services, P.W. Grosser Consulting, Inc.

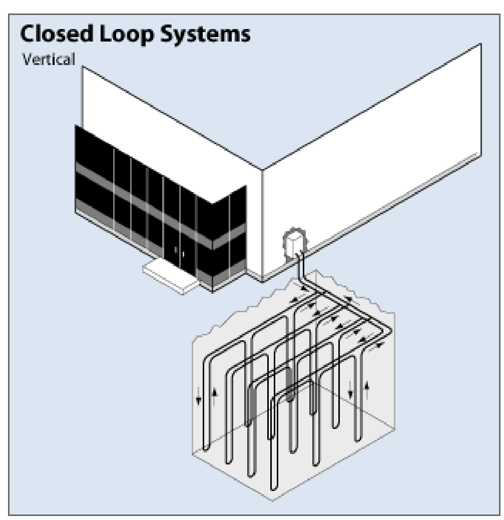
Abstract
Geothermal heat pumps (GHPs) are a technology in use on Long Island that tap into its cool naturally-occurring ground temperatures for energy-efficient space heating and cooling. GHP systems represent less than 1% of all the heating, ventilation, and air conditioning (HVAC) systems in use on Long Island, although they are expected to grow in the future. They presently make up a high percentage of the HVAC systems installed in new homes in some communities (Southampton and Laurel Hollow, for example). There are potential risks to the groundwater system that can result from widespread and unregulated use of geothermal systems, including thermal, hydrogeologic, and chemical effects. Further, there is a general lack of understanding about how GHP systems work and are installed and operated. This report provides a general description of the technology, presents the major questions and concerns, and provides recommendations to addresses the risks, raise awareness, and improve understanding by the stakeholder community.

Background Information

Introduction
Geothermal is a technology that taps into the cool naturally-occurring ground temperatures that exist in Long Island's aquifers for energy-efficient heating and cooling and, in some instances, domestic hot water heating. Utilizing this technology for HVAC systems provides an alternative to conventional fossil-fuel based furnaces used for heating, as well as chillers, cooling towers, and window air conditioning units used for conventional cooling systems. The primary difference between a GHP system and a conventional HVAC system is the use of two distinct components: 1) one or more GHPs are installed inside the building, and 2) a "ground coupling," or "ground heat exchanger" (GHE), is installed in the ground next to the building. Mechanical piping and ductwork inside the building are like a conventional HVAC system. A GHP system essentially couples the building's HVAC system to the ground.

Groundwater temperatures on Long Island range between 50°F and 55°F and provide a consistent and moderate temperature source of energy for heating and an energy sink for cooling. The two main types of GHEs in use on Long Island utilize either standard water wells (open loop system) or high-density polyethylene (HDPE) plastic "loops" (closed loop system). Both are routinely installed to depths of up to hundreds of feet deep in vertical drilled boreholes. Another type of GHE known as a direct exchange, or "DX," system is used but is uncommon on Long Island.





There is a general lack of understanding about how GHP systems work and are installed and operated. There have also been instances in which GHP systems have failed or locally impacted the aquifers on Long Island that has resulted in a general concern of local municipal and regulatory agency staff, members of the public, and some members of the Long Island Commission for Aquifer Protection over their use. This report addresses the major questions and concerns, which include:

- Gaps in regulatory and inspection responsibility for certain aspects and types of systems. For example, closed loop systems are largely unregulated in New York State, including Long Island,
- Lack of documentation of locations of some type/size systems,
- Potential impacts on other groundwater users, ecological resources, surface water bodies and wetlands, and on the groundwater resource, in general,
- Aggregate hydraulic and thermal effects on the aquifers from high concentration of many small GHP systems installed near each other, e.g., suburban environments,
- Increases in regional groundwater temperatures from extended operation of large air conditioning-only facilities (e.g., Roosevelt Field Mall/Mitchell Field complex),
- Potential cross contamination of aquifers by pesticides, herbicides, and any other contaminant spilled on or in the general vicinity of the property during drilling through confining clay units,
- Potential contamination of the aquifer from return water in open loop systems containing refrigerants (e.g., Freon contamination in northern Nassau County), and
- Potential contamination of groundwater by the working fluid in closed loop boreholes from leaks in the plastic piping.

State of the Geothermal Industry on Long Island

On Long Island, open loop GHP systems have been used for over a century for air conditioning and industrial and municipal process water cooling uses. The advent of the reversible heat pump in the 1960s allowed for the combined heating and cooling of buildings employing open loop wells and, more recently, closed loop GHEs.

There are roughly 4,000 to 5,000 operating GHP systems in use in Nassau and Suffolk Counties, with roughly 70% open loop and 30% closed loop. Figure 1 shows the locations of systems that have received Public Service Enterprise Group (PSEG) rebates (both open and closed loops) and open loop systems permitted by New York State Department of Environmental Conservation (NYSDEC) under the Long Island Well Permit (LIWP) program in Suffolk County [INTEND TO ADD NASSAU PERMITTED GHP WELLS THROUGH REVIEW OF DEC WELL RECORDS, IN PROGRESS]. GHP systems represent less than 1% of all the HVAC systems in use on Long Island. However, in certain communities (Southampton and Laurel Hollow, for example) GHP systems may represent 50-70% of the HVAC systems installed in new home construction.

GHP systems offer numerous benefits to Long Island residents and business owners. Despite their higher first cost compared to conventional HVAC systems, the GHP market on Long Island is expected to grow in the future. Various levels of state government, including the New York State Energy Research and Development Authority (NYSERDA), the New York State (NYS) Governor’s Office, and the Public Service Commission (PSC), PSEG; the NYS Legislature, and Suffolk County have recognized that GHPs can play an important role in the State’s goal to increase building efficiency and reduce energy consumption and greenhouse gas (GHG) emissions. On a local level, GHPs are the preferred alternative to oil and electric resistance heating in the Cleaner Greener Long Island Regional Sustainability Plan.

More widespread adoption of GHP systems benefits Long Island’s electric provider, PSEG, in numerous ways, which translate to lower electric costs to ratepayers, including:

1. Reduced summer peak load demand on the power plants and electric grid,
2. Reduced or eliminated need to construct new generation capacity,
3. Reduced utilization of inefficient peaking power plants and the purchase of more expensive off-grid power from outside vendors, and
4. Improved load factor of power plants in the winter when their current usage is otherwise low.

However, as noted above, there are numerous potential risks to the groundwater system that can result from widespread and unregulated use of geothermal systems. These potential risks are discussed in this report.

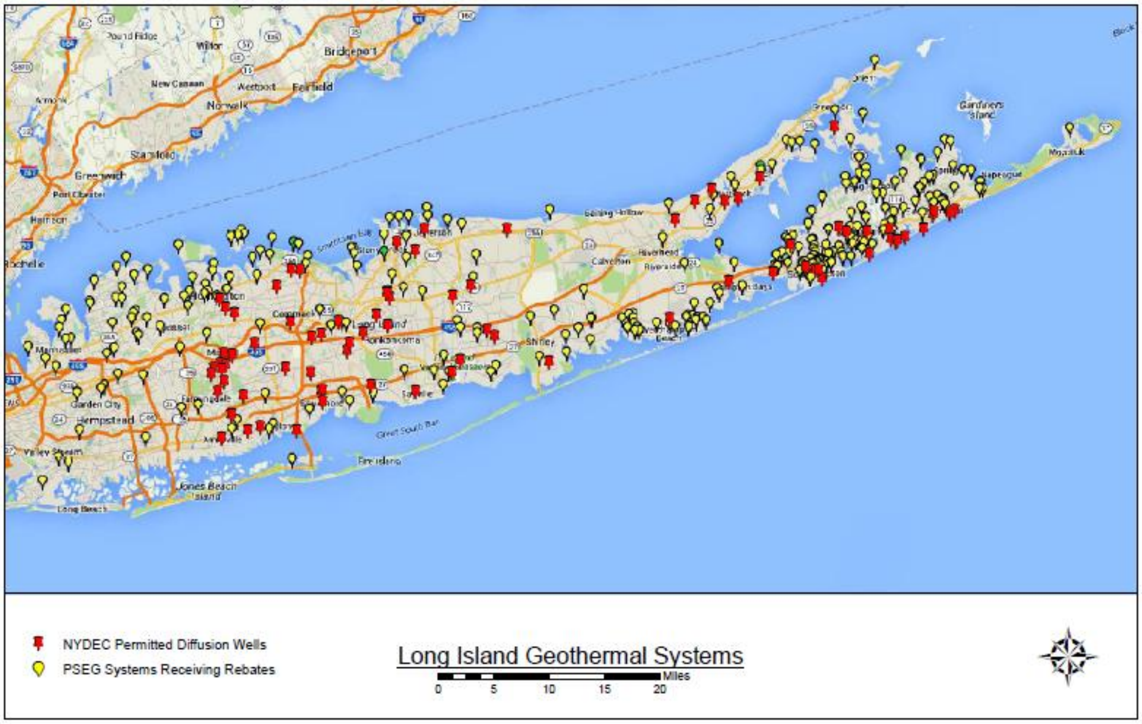


Figure 1 - Map of GHP Systems on Long Island

Geothermal Heat Pump System Components

Geothermal Heat Pumps

GHPs are mechanical devices that transfer heat between the GHE and the building spaces to be conditioned. A GHP is essentially a reversible chiller that can both cool and heat a building. Being all-electric systems, GHPs eliminate the use of fossil fuel-based boilers and the particulates and GHGs they emit. The two main types of GHPs are water-to-air and water-to-water heat pumps. A water-to-air heat pump heats or cools air which is ducted to and from the interior spaces. Water-to-water heat pumps produce chilled or hot water which is circulated to fan coil units for cooling or to radiant floor systems or fan coils for heating. A device called a de-superheater or dedicated GHPs can be utilized to heat domestic hot water.

Ground Heat Exchangers

A GHE is the in-ground, buried part of a GHP system where heat is transferred between a circulating heat transfer fluid (HTF) and the ground by the difference in temperature between the fluid and the ground. Depending on system type, the HTF is groundwater, fresh water, a fresh water/antifreeze mixture, or refrigerant. The predominant types of GHEs in use on Long Island are vertical closed loop boreholes and open loop systems, as described separately below.

Open Loop System

An open loop system withdraws ambient temperature groundwater from a standard supply well(s), passes the groundwater directly through the GHPs and returns the temperature-altered water back into the aquifer via a return, or "diffusion," well(s). Some system designers add an intermediate plate-frame heat exchanger (HX) to separate the building piping system and components from the groundwater (Figure 2).

The open loop system is one of the more common systems found on Long Island due to the highly productive aquifers. Well depths depend on the local hydrogeology. Wells must be sized to supply and return to the ground a consistent 1.5 to 3 gallons per minute (gpm) per ton of cooling or heating load (Note: a "ton" equals 12,000 British thermal units or BTUs per hour of heating and cooling demand).

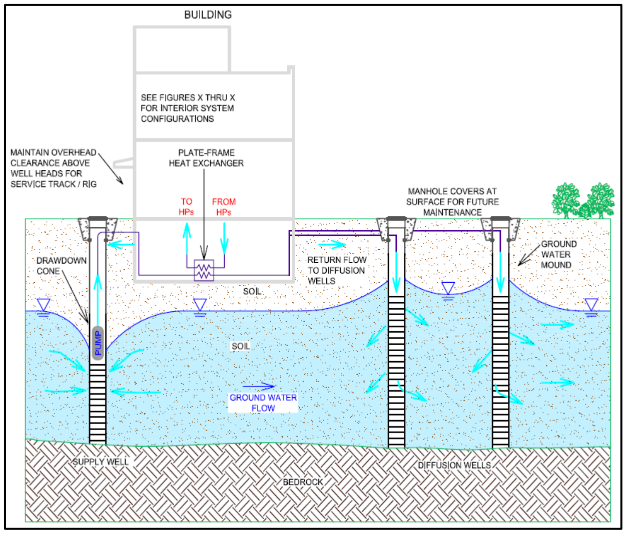


Figure 2 - Open Loop System

Despite misperceptions to the contrary, the daily and seasonal temperature range of the circulating HTF used in GHP systems is not constant, but varies by system type. An open loop system operates by pumping groundwater at its stable natural temperature. However, the return water temperature is typically 10-15 degrees Fahrenheit (deg. F) colder during winter heating and 15-30 deg. F warmer during summer cooling, than the ambient groundwater temperature (see Table 1). The groundwater passes once through the system.

Table 1 - Typical Temperatures of Heat Transfer Fluid

GHE	Heat Transfer Fluid	Summer Operation Temperature Range	Winter Operation Temperature Range	Remarks
Closed Loop	Water or water and antifreeze mixture	60-90 deg. F	30-45 deg. F	Typical ΔT between supply and return water is 5-10 deg. F. Antifreeze is required if winter operating temperatures will drop below 32 deg. F
Open Loop	Ground water	50-55 deg. F from supply well (ambient), 65-80 deg. F to diffusion wells	50-55 deg. F from supply well, 40-45 deg. F to diffusion wells	Constant supply well groundwater temperature; return temperature to diffusion wells depends on ΔT preference of designer

Notes:
ΔT = delta T or difference in temperature

For large open loop systems, research of local hydrogeology and groundwater testing are advisable to select well depths and gather data for proper well design. For systems requiring a LIWP (pumping rate >45 gpm; see Open Loop Systems under Chemical Effects), the NYSDEC reviews the site relative to the presence of and potential impacts to wells on adjoining properties, nearby ecological resources, groundwater contaminant plumes, or the freshwater-saltwater interface (coastal sites). In certain cases, the NYSDEC may require site testing which could include a test well, pumping test, and appropriate hydrogeologic analysis and/or groundwater modeling as part of the permitting process to demonstrate that there will be no impacts to these resources.

Closed Loop System

A closed loop system circulates either water (or a water and antifreeze mix) as the HTF through a series of HDPE plastic "loops" installed horizontally in trenches or, more routinely, vertically in drilled boreholes. Unlike an open loop system, a closed loop GHE does not involve pumping and re-injection of groundwater and the plastic piping isolates the HTF from the aquifer. Heat exchange occurs by conduction between the circulating fluid and the ground across the plastic piping.

Each loop consists of two pipes, ¾-inch to 1.25-inches in diameter, and connected at the bottom with a 180-degree "U" fitting, as shown in Figure 3. The loop assembly is lowered to the bottom of the borehole and the space between the borehole wall and the closed loop piping (the "annulus") is filled with a thermally-enhanced grout, which is a low-permeability clay, water, and sand mixture. The main purpose of the grout is to prevent migration of contamination from the surface into the aquifer or between multiple aquifers. The grout also provides a thermal bridge between the loop and the ground.

The loops are connected using horizontal HDPE piping. For larger systems, the loops are grouped into "circuits" of typically four to ten loops, as illustrated in Figure 4. The individual circuits are connected to supply and return mains that lead to a manifold in the mechanical room. The HDPE is joined together using a heat-fuse welding method. The HTF is circulated through the borefield and the GHPs using circulator pumps located in the mechanical room. The HDPE piping is comparable to piping used in the natural gas industry and is warrantied for 50 years by the manufacturers.

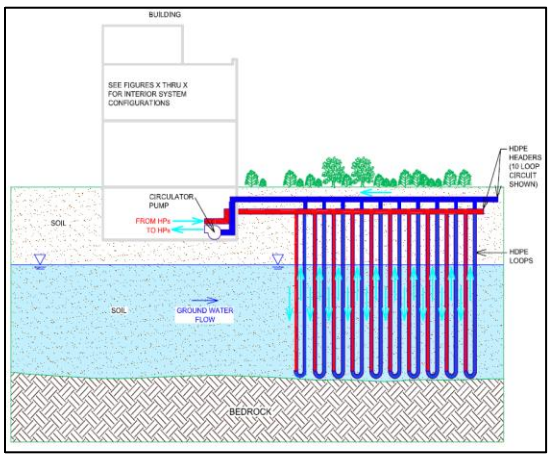


Figure 3 - Closed Loop System

The operating temperature of the HTF in a closed loop system varies daily and seasonally. At the start of a season, the temperature of the HTF may start at about the ground's natural temperature. However, its temperature will generally increase over the summer and decrease over the winter as more and more heat energy builds up or is depleted from the ground around the borefield, respectively (see Table 1).

For larger closed loop systems, a test closed loop is typically installed and a thermal conductivity test performed to confirm the geologic conditions and develop the data needed for borefield sizing and design. The piping can also be laid out horizontally in an open excavation in coils or in straight runs of piping in trenches and backfilled.

Figure 4 – U-Bend Fitting

HDPE coils can also be emplaced in an open water body (for example, a lake, marine bay, or river) and used for heat exchange if the water body meets certain minimum volume, depth, and quality criteria depending on the building's thermal load profile. Approval may also be necessary from the appropriate agencies as environmental impacts could occur from altering the temperature of the water body.

The closed loop piping undergoes multiple stages of pressure testing during construction to make sure there are no breaks and the joints are tight. Individual loops and circuits are pressure tested prior to backfilling. Finally, the entire system gets pressure tested after the circuits are connected to the main supply and return lines. The NYS Mechanical Code, under which most municipal agencies on Long Island operate, requires pressure testing of the piping system for closed loop GHP systems.

If the piping were to leak, and the HTF contained an antifreeze, this would result in a release of antifreeze into the groundwater (see Closed Loop Systems under Chemical Effects). Fort unately, leaks in the HDPE piping network are rare and when they occur it is usually by an excavator breaking a line. A leak can be detected by a loss of pressure in the working fluid across a loop or circuit. A loop or circuit with a leak can be repaired or isolated from the rest of the system and decommissioned. It is important to plot the locations of the individual loops and horizontal connector piping on a plot plan for future reference to prevent excavation and damage to the piping during future building maintenance or expansion. When ownership of the home or facility changes, transferal of this information to the new owner is critical.

Direct Exchange (DX) System

A DX system is a type of closed loop system with the following major differences: 1) the GHE is copper tubing, not HDPE pipe, and 2) the HTF is refrigerant (R-410A). Some configurations of a "DX-to-Ground Contact" DX system are shown in Figure 5. The copper tubing is installed in a vertical drilled borehole and grouted like an HDPE closed loop or buried in trenches in a horizontal configuration.

The copper tubing assembly is pressure tested prior to introducing refrigerant. DX systems must be protected against corrosion of the copper by using sacrificial anodes or other means of cathodic protection.

Figure 5 - "DX-to-Ground Contact" Systems

A version of a DX system, the GeoColumn© (Figure 6), submerges the copper tubing in an enclosed HDPE plastic cylinder filled with water which isolates the tubing from contact with the soil and aquifer.

The GeoColumn© is typically installed to a depth of 25 feet or less. Because of their shallow installation depth and the physical containment provided by the HDPE cylinder, these GHEs are not grouted.

Pressure testing, potential for leaks, and the need for adequate documentation of the buried piping are the same as the closed loop system.

Figure 6 - GeoColumn© "DX-to-Water Contact" System

Other Open Loop System Types

Other unconventional open loop systems, described below, are in use on Long Island. Although believed to be limited in number, it is recommended that these types of systems are disallowed except under the conditions noted. One option to prevent their use would be for the NYSDEC to require that dedicated supply and return wells are in use for all open loop GHP systems when renewing an existing permit or permitting new well installations. This is currently the case for systems governed under the LIWP program. However, smaller systems not regulated under the LIWP program (flow rate <45 gpm) only require filing of a Preliminary Report on Proposed Well form (PRPW). Technically, PRPWs must be filed only for new wells for consumptive use. Based on discussions with the NYSDEC, there may be instances where a permit to drill a new diffusion well(s) is issued without an associated supply well(s) and vice versa.

Public Water Supply Source

It is a practice for some homeowners, primarily on the North and South Forks, to use their domestic potable water connection as the source water to the system, in place of the standard approach to use on-site water supply wells. This practice should be disallowed, since it places an undue burden on public water suppliers, and is an inappropriate use of potable water. The NYSDEC should close the gap that allows permitting a new diffusion well(s) without an associated supply well(s).

Groundwater Return through Infiltration Devices Other Than Wells

It is possible to return groundwater to the aquifer through means other than return wells, such as a drywell, horizontal buried perforated pipe, or other means. This practice should be disallowed except where the supply well(s) taps the upper/first aquifer, such that return through the infiltration device is back to that same aquifer. The NYSDEC should close the gap that allows permitting a new supply well(s) without an associated diffusion well(s).

Groundwater Return through Infiltration through the Ground Surface

This practice is not presently regulated by NYSDEC but there have been reported instances of discharge water overflowing the property line and entering adjoining regulated water bodies and wetlands, in violation of NYSDEC wetlands regulations. Further, this practice has created nuisance conditions such as soil erosion, sedimentation, freezing, and migration onto adjacent private properties and public roadways. As such, this practice should be disallowed and the NYSDEC should close the gap that allows permitting a new supply well(s) without an associated diffusion well(s).

Groundwater Return to a Surface Water Body or Wetlands

The NYSDEC regulates all discharges to regulated surface water bodies and wetlands on Long Island. A State Pollutant Discharge Elimination System (SPDES) permit would be required and temperature limits apply to the discharge water. The NYSDEC should disallow this practice to avoid unintended impacts to these resources.

Dual Use Wells

Open loop system supply wells conceivably can be used for other purposes besides heating and cooling, for example, irrigation and drinking water. Where public water is not available, this practice should be allowed with approval of the local authorities. The Suffolk County Department of Health Services (SCDHS) General Guidance Memorandum #25 (Memo #25) prohibits cross connections between a potable water supply system and geothermal wells where a GHP system is proposed for a project with a new wastewater and/or water supply system (see County Codes and Guidelines, Suffolk County sectio). Otherwise, standards for acceptable design and installation of dual use (geothermal, potable water) wells are provided in the NYS Mechanical Code.

Typical GHE Depths

Table 2 presents the typical install depths for GHEs. DX boreholes/loops are installed to the shallowest depths of all the GHEs. In virtually all cases, GeoColumns© would terminate above or slightly into the Upper Glacial Aquifer where the depth to the water table lies less than about 25 feet deep. With a typical depth of up to 100 feet, “DX-to-Ground Contact“ DX systems would terminate in the Upper Glacial Aquifer or potentially into the top of the Magothy Aquifer where it may be shallower than 100 feet (most of Nassau County and the extreme west end of Suffolk County).

Most open loop wells terminate at relatively shallow depths in the Upper Glacial Aquifer to keep drilling costs down. Approximately 89% of Nassau County’s public drinking water supply wells are screened in the Magothy Aquifer (Long Island Regional Planning Board, 1993), and, therefore, would not be impacted by open loop GHP systems. This percentage is significantly higher in Suffolk County - per the Suffolk County Water Authority’s website (SCWA, 2015), approximately 45% of its wells are installed in the Upper Glacial aquifer. If a proposed GHP system must be permitted under the NYSDEC LIWP program (flow rate >45 gpm) and is located within the capture zone of an existing public supply well field, the NYSDEC should require the owner of the system to perform the appropriate aquifer testing and modeling to assess the potential impact to the well field to the satisfaction of the water supplier. Smaller proposed GHP systems that are not regulated under the NYSDEC LIWP program can be addressed as discussed in future report sections.

Closed loop borehole depths vary depending on subsurface conditions, driller preference, and size of the property. Their depths are not usually dependent on hydrogeology. Although clay has a low thermal conductivity, more loops drilled to a shallower depth and terminated above a major clay unit might be a preferred option for a GHP system designer.

Table 2 - Typical Installed Depths of GHEs

GHP System Type/GHE	Typical Depth (feet below ground surface)	Remarks
Open Loop Supply and Diffusion Wells	Variable; dependent on depth to water table and suitable aquifer conditions	Generally constructed in Upper Glacial Aquifer to minimize cost, with suitable thickness and water quality
Closed Loop Vertical Boreholes	200-500 feet deep	Depth depends on available land to drill and driller capabilities, not aquifer conditions; avoid thick clay, if possible
Closed Loop	4-10 feet deep	Where sufficient land area exists;

Horizontal		typically not installed below the water table
“DX to Ground“ Vertical	100 feet deep	Depth depends on available land to drill and driller capabilities, not aquifer conditions
“DX to Ground“ Horizontal	4-10 feet deep	Where sufficient land area exists; typically not installed below the water table
“DX to Water“ (“GeoColumn©”)	<25 feet deep	Water containment device is standard 20 feet long

Standards, Guidelines, and Regulations

Presently, comprehensive regulations covering all types of GHP systems do not exist and standards and guidelines that do exist are not consistently applied on Long Island. Therefore, impacts to the aquifers beneath Long Island from widespread unregulated use of GHP systems are possible. There are ongoing efforts by the GHP industry throughout the State to put into effect uniform design, installation, and maintenance standards and code to address concerns over potential environmental impacts of GHP systems. Depending on the outcome of these efforts, formal regulations may need to be enacted to safeguard Long Island’s aquifers from such impacts.

Standards, Code, and Guidelines

National design and installation standards and guidelines exist for GHP systems and have been published by the following organizations: American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), American Society of Mechanical Engineers (ASME), American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), Air-Conditioning and Refrigeration Institute (ARI), Air Conditioning Contractors Association (ACCA), and the Refrigeration Section of the International Building Code. The following additional standards and guidelines apply for specific GHP system types:

- Open Loop Systems: National Ground Water Association (NGWA) and American Water Works Association (AWWA) water well construction guidelines,
- Closed Loop Systems: International Ground Source Heat Pump Association (IGSHPA) installation guidelines, and
- DX Systems: Canadian Standards Association (CSA) and National Association of Corrosion Engineers (NACE).

IGSHPA certifies geothermal drilling contractors for closed loop borehole drilling and installation, and IGSHPA and the HDPE manufacturers certify the piping installation contractors for heat-fuse welding. The equipment and materials manufacturers also recommend that their guidelines, methods, and specifications are followed. Recently, IGSHPA and NGWA have also developed GHP system inspector training programs that are being offered to the public.
Most recently, the CSA, in conjunction with ANSI, published C448 Series-16, a comprehensive set of standards for the installation, testing, operation, and maintenance of all types of GHP systems. These standards were developed by a bi-national (United States and Canada) working group of industry representatives and trade groups including IGSHPA and NGWA.

Most Long Island municipalities have adopted or otherwise defer to the NYS Mechanical Code (NYSMC) for building HVAC design and construction requirements, which, in turn, has adopted the International Mechanical Code (IMC). Section 1210 of the IMC covers certain aspects of closed loop GHP systems, including pressure testing and flushing requirements for the piping and the HTF. Local GHP industry representatives are in discussion with NYS code officials and representatives of the IMC, as well as the Uniform Solar Energy and Hydronics Code (USEHC), the competing code to the IMC, about adopting the C448 Series-16 standards into their respective code. To that end, the USEHC committee has proposed to add a reference to the CSA standards into its next code revision in 2018.

Another means to address concerns over GHP systems that the local GHP industry is undertaking is to tie utility rebates to adherence to strict quality control measures. The NYS Governor has released an “emergency” rebate program for GHP installations to offset loss of the federal tax credits that expired at the end of 2016. As part of that program, NYSERDA will issue rigorous quality control measures that must be followed to earn the rebates. Local GHP representatives are in discussion with PSEG to consider issuing similar measures as part of PSEG’s rebate program.

State and Federal Regulations

Open Loop System

As discussed earlier, the NYSDEC requires that a PRPW is filed before drilling for any planned new water well (including open loop GHP wells) with its Region 1 Division of Water in Stony Brook, New York. Further, any proposed well(s) with a rated pumping capacity greater than 45 gpm, or 64,800 gallons per day (or if there are existing wells on the property, then the combined pumping rate for the existing and proposed wells if exceeding 45 gpm) is regulated under the NYSDEC LIWP program. This 45 gpm threshold equates to up to approximately 25 tons of peak heating or cooling capacity (2 gpm/ton). All open loop wells must be installed by a NYSDEC-registered well driller and the submersible pump must be installed and the system started up by a NYSDEC-registered water well driller.

Hydrogeologic calculations and details on the well design, use, and construction must be provided with the LIWP application. As noted earlier, the NYSDEC reviews the site relative to potential impacts to other nearby groundwater users, public drinking water wells, surface waters, wetlands and ecological resources, contaminated groundwater remedial systems, and the freshwater-saltwater interface at coastal sites. In some instances, the NYSDEC will require that a more detailed engineering report be prepared and submitted with the LIWP application. Among other items, the engineering report involves more in-depth hydrogeological analysis, potentially along with groundwater testing and modeling to demonstrate no impact to these resources.

The NYSDEC regulations do not specify either upper or lower limits on the temperature of the return water, although regulations do state that the discharge must not prevent others from being able to use the groundwater for its best intended usage. As with any water supply well, an open loop well system may be designated a Class I Action under the State Environmental Quality Review Act (SEQRA) by the NYSDEC if its rated pumping capacity exceeds 2 million gallons per day (or 1,388 gpm), thus triggering a SEQRA review.

The United States Environmental Protection Agency (USEPA) must be notified of all return wells of an open loop system, as these wells are designated Beneficial Re-Use Class V wells in the federal Underground Injection Control (UIC) regulations under the Safe Drinking Water Act. USEPA can authorize operation of such wells “by rule” pursuant to the regulations.

Closed Loop and DX Systems

NYSDEC presently does not regulate closed loop or DX systems with the exception that a permit is required from the NYSDEC Division of Mineral Resources (DMN) if drilling will be deeper than 500 feet which is an uncommon practice in the industry on Long Island.

Because the fluid within a closed loop/DX GHE does not directly contact the environment, it is not considered a Class V well under the federal UIC regulations. Therefore, the USEPA has no jurisdiction over these GHEs.

County Code and Guidelines

Nassau County

Nassau County claims no jurisdiction and defers regulatory authority for GHP systems to the NYSDEC and the local towns and villages.

Suffolk County

SCDHS Memo #25

The SCDHS, Department of Wastewater Management, regulates GHP systems that are proposed to be installed in conjunction with a proposed wastewater and/or water supply system. The SCDHS requirements are contained within its General Guidance Memorandum #25. The major requirements relate to setbacks for open loop wells and closed loop boreholes from public and private water supply wells, sanitary and storm water system structures and piping, property lines and other utilities. The SCDHS guidelines also stipulate that there shall be no cross-connection between the GHP system and domestic water supply system. Memo #25 was recently revised to incorporate in its entirety the Model Geothermal Code developed by the Suffolk County Planning Commission (see next section). SCDHS requires that the proposed geothermal wells or borehole locations and piping routes are shown on the site plan with the proposed sanitary and storm drainage structures and submitted to SCDHS for approval prior to construction.

Suffolk County Planning Commission (SCPC) Model Geothermal Code

In 2014, Suffolk County adopted the Suffolk County Uniform Model Geothermal Code ("Model Code"), developed by the SCPC in association with the local GHP trade organization the Long Island Geothermal Energy Organization ("LI-GEO"). Input to the code was provided by key stakeholders including the NYSDEC, SCDHS, SCWA, the Suffolk County Legislature, and the NYS Department of State's Division of Building Standards and Codes. The main objectives of the Model Code were to address concerns that local municipalities have about GHP systems, provide a uniform filing process for the typical GHP systems that are being installed on Long Island, and in the process facilitate more widespread acceptance and deployment of systems. The Model Code identifies standards, best practices, and environmental protections specifically for systems proposed to be installed in "non-sensitive areas," which comprise most GHP systems. The Model Code also requires well drilling contractors to notify the SCWA of the location of open loop wells installed within SCWA's service area. The Model Code provides a basic working framework for local jurisdictions to incorporate into their existing code or simply be issued as guidelines to its building inspectors.

Local Municipalities

Some local municipalities disallow certain types or any GHP system installations for various reasons. Specifically, the Villages that are serviced by the Water Authority of Great Neck North (WAGNN) and the Village of Sands Point Water Department, and the Town of Shelter Island disallow GHP systems over concerns on impacts on the stressed aquifers upon which these locales rely for drinking water. The Town of Oyster Bay has issued a referendum on new GHP systems until a suitable process is established. Otherwise, the filing and permitting process within jurisdictions that allow GHP systems varies widely. The Towns of North Hempstead and Hempstead allow closed loop systems but not open loop systems. The Town of North Hempstead is required by its own statute to review and discuss with the WAGNN any application for any new well within the WAGNN's service area.

The towns, cities, and villages on Long Island have not readily adopted Suffolk's Model Code, partly due to confusion over professional sign-off responsibility of the in-ground portion of the system. Two exceptions are the Towns of Smithtown and Brookhaven that have adopted the Model Code into their administrative framework, requiring sign-off by a professional engineer for the design, installation, and as-built drawings. Other municipalities not mentioned above allow and permit new GHP systems within their jurisdictions under their existing building department code.

Other State and Federal Regulations

Any size or type of GHE intended to be installed in or within a regulated distance from a wetland, floodplain, pond, lake, river, or coastal erosion hazard area requires state and/or federal environmental agency approval. Additionally, if the return water from an open loop system is intended to be discharged into a regulated wetland or surface water body, state and/or federal permits are required.

Potential Impacts to Long Island's Groundwater Resources

Heating and cooling with a GHP system is just one of the many uses of Long Island's groundwater resources. Factors that distinguish a GHP system from other uses are:

- It is a non-consumptive use of groundwater,

- The temperature of the groundwater is altered, either increased or decreased on a seasonal basis, and
- For an open loop GHP system, the groundwater is injected back into the aquifer after it is used.

These processes have the potential to cause certain thermal, chemical, and hydraulic effects that need to be understood and controlled to protect the aquifers. Each of these potential effects are discussed in this section along with other significant issues and conditions relevant to aquifer protection.

Thermal Effects

GHP systems seasonally increase the local groundwater temperature during the summer and decrease the temperature during the winter (one exception is a cooling-only open loop system where only the groundwater temperature is increased during the cooling months). The thermal effect on the aquifer dissipates some distance from an operating system depending upon groundwater flow velocities and soil characteristics and varies between the different types of systems, as discussed below.

Open Loop Systems

For an open loop system, the thermal effect occurs around the diffusion wells where the thermally-altered water is injected into the aquifer. The effect is generally localized at the depth of the diffusion well screens. The affected distance around the wells will depend on the thermal load imposed on the aquifer, which is determined by the injection flow rate, injection water temperature, and duration. Since all groundwater flows, albeit slowly, open loop GHP systems cause seasonal thermal “pulses” of cool or warm water flowing away from the diffusion wells along the natural groundwater flow path. Each pulse dissipates as it moves away from the diffusion wells through the processes of conduction, advection, and mixing of the thermally-altered water with ambient temperature groundwater. The distance where the natural groundwater temperatures are re-established depends on the thermal load, aquifer properties, and the groundwater flow velocity.

The long-term effect of these thermal pulses varies between a cooling-only system and one used for both heating and cooling. The overall length of the thermal plume for a heating and cooling system will be shorter because the alternating seasonal warm and cool pulses mix and cancel each other out. An example of such a system is shown in Figure 7, illustrating the effect after operating a large open loop geothermal system for heating and cooling for 20 years. The system heats for seven months each year with a return water flow rate of 275 gpm at a temperature of 41 deg. F. The system cools for the other five months with a return water flow rate of 430 gpm at a temperature of 71 deg. F. There are numerous public water supply well fields located within 1-2 miles from the diffusion wells. Public supply well fields located downgradient of the diffusion wells were modeled to pump continuously over the 20-year period at a flow rate of 900 gpm each. Based on numerical model simulation, the thermal effect on the aquifer dissipates within a significantly shorter distance than the groundwater flows over the same duration, because of the mixing of the seasonal warm and cool pulses (1,200 feet versus 2,550 feet). Therefore, there will be no effect from this system on the temperature of the groundwater drawn from the public supply wells.

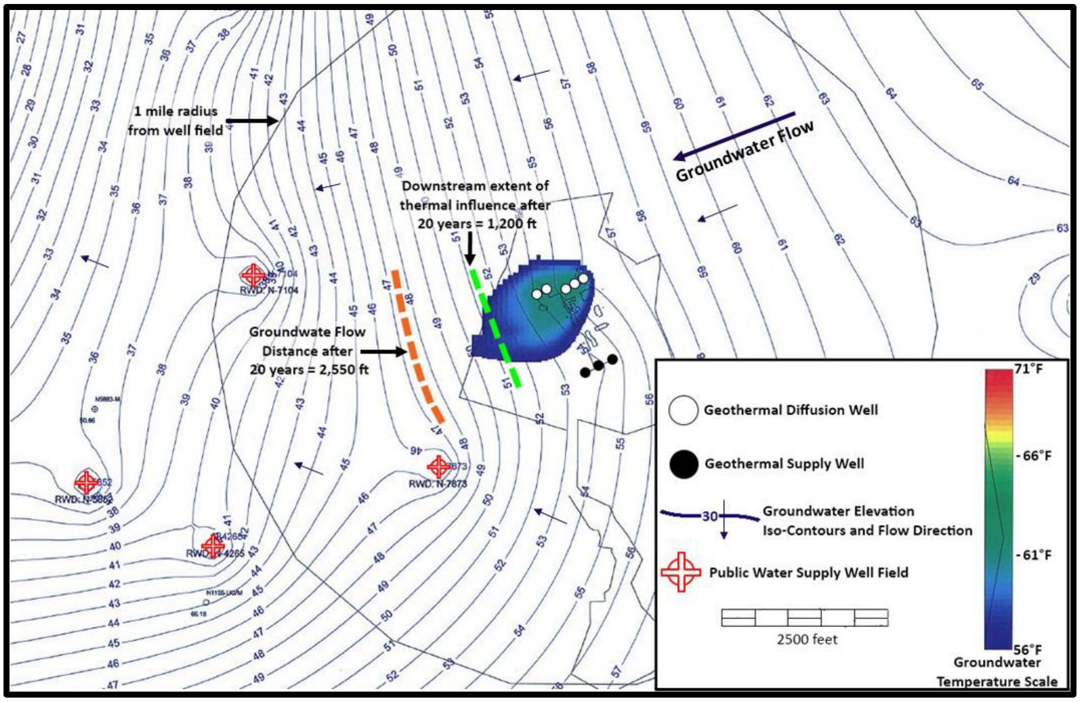


Figure 7 - 20-Year Simulation of Large Open Loop GHP System (Heating and Cooling)

Figure 8 is an example showing the results from a numerical model simulation of an extreme case of a large cooling-only open loop system after operating for 30 years. A public water supply well field is located approximately 3,500 feet directly downgradient of the diffusion wells. The GHP system is simulated to pump and recharge continuously at the peak design flow rate of 3,600 gpm. The public supply well field has three wells that are simulated to pump continuously over the 30-year period at a combined flow rate of 1,200 gpm. The return water temperature to the aquifer is 10 deg. F warmer than ambient conditions or approximately 65 deg. F. The return water cools via advection, conduction, and blending with cooler surrounding groundwater as it moves along the natural groundwater flow path. After 30 years, the temperature of the water reaching the well field from the diffusion wells is approximately 2 to 3 deg. F warmer than the natural groundwater temperature. However, because the public supply wells draw in water radially from all sides, besides groundwater originating at the diffusion wells, there will be no measurable effect on the public supply wells water temperature.

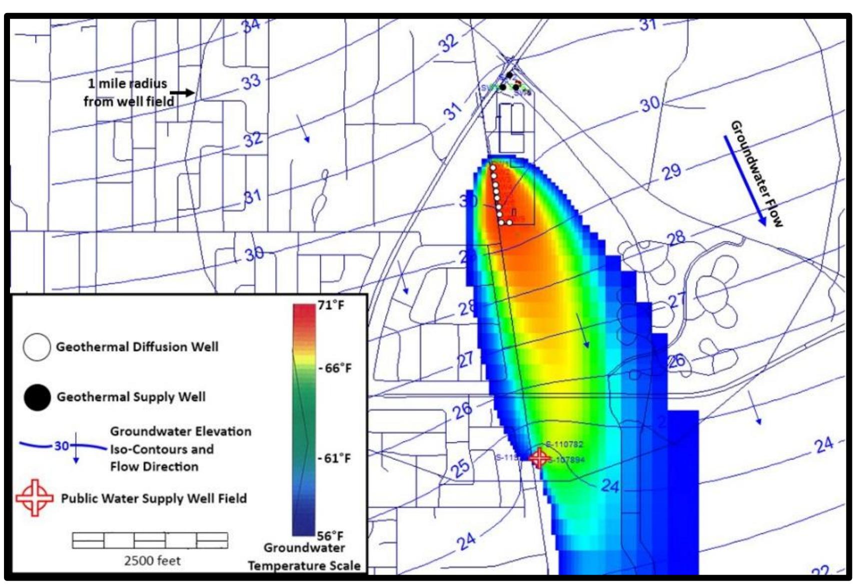


Figure 8 - 30-Year Simulation of Large Open Loop GHP System (Cooling Only)

Closed Loop and DX Systems

For a closed loop or DX system, the thermal effect occurs within the volume of the aquifer material directly surrounding each closed loop or DX borehole. The heat is injected into or extracted from the interval lying between the surface and the completed depth of each borehole. The radial thermal effect around a closed loop or DX borehole is on the order of 10-15 feet, thus much smaller than an equivalent capacity open loop system since the thermal energy is spread out over a significantly thicker vertical depth interval.

The temperature is greatest within the center of a closed loop or DX borefield and decreases outwards where the heat can dissipate by conduction to the surrounding ambient temperature aquifer materials. In the winter, the pattern is reversed. Temperatures within the "core" of the borefield are coolest as heat is extracted from the ground and heat energy flows into the borefield from the surrounding aquifer that is at higher ambient temperatures.

Closed loop and DX borefields exhibit the same seasonal thermal "pulses" of cool or warm water flowing away from the borefield as an open loop system, and are controlled by the same factors as described above. The long-term effect of thermal pulses from closed loop and DX borefields used for both heating and cooling will be like an open loop system as described above.

The borefield temperatures are at their highest in late summer and lowest in late winter. As presented in Table 1, the typical temperature of the HTF circulating in a closed loop borefield is as low as 30 deg. F during heating (if antifreeze is used in the HTF) and as high as 90 deg. F during cooling. The resulting temperatures in the surrounding aquifer between the boreholes do not reach these extremes due to the heat loss across the HDPE piping and grout.

During the spring and fall, the residual heat or "cold" in the ground continues to flow through and beyond the boundaries of the borefield with the natural groundwater flow. Due to the slow flow rate of groundwater, when winter arrives, there is normally still some stored heat within the borefield left over from the previous summer season that can be extracted for heating. Similarly, when summer arrives, there is normally still some stored "cold" from the previous heating season that can be used for cooling.

Conclusions on Potential Thermal Impacts

The thermal effect of large GHP systems, either open or closed loop type, may extend beyond the property boundaries. Therefore, large systems could potentially alter the temperature of groundwater being extracted from nearby wells and interfere thermally with other GHP systems on adjoining and/or downgradient properties. Thermally-impacted groundwater could also discharge into downgradient surface water bodies or wetlands and result in ecological impacts and violations of NYSDEC limits.

A better understanding of thermal transport from large GHP systems in Long Island's aquifers and potential impacts on ecological resources is necessary. Regulations should be enacted to prevent such impacts, including requiring modeling or other means to determine "safe" setbacks from these resources. Areas served by small private drinking water wells would be particularly susceptible to impacts from large GHP system thermal plumes. As noted previously, under the LIWP program, the NYSDEC requires demonstration that there will be no thermal impact by large open loop systems on nearby drinking water supply wells, thus offers protection of public drinking water systems.

A high concentration of small open loop geothermal systems serving individual homes on small lots (particularly dense suburban areas of Nassau, western Suffolk, and much of the south shore) would result in some thermal interference between neighboring systems. The current state policy of "first-come-first-served" for underground water rights may need to be re-assessed to address cumulative effects. In the meantime, a system of better tracking the installation of small open loop systems (not regulated under the LIWP) is warranted; for example, modifying the SCPC code to require drilling contractors and the NYSDEC to notify not only the SCWA but all public drinking water suppliers.

In addition, the cumulative thermal effect of large numbers of these type systems could be to change the average groundwater temperature in the aquifer (most likely increase since some percentage of such open loop systems are used for cooling only purposes). This may be of concern in areas within the capture zone of a drinking water supply well where the Upper Glacial Aquifer is used for drinking water supply (most small open loop system wells are shallow and tap this aquifer). Regional modeling (building on the USGS groundwater model) could be performed to define the "safe" concentration of such systems that would prevent this from occurring, with appropriate limits enacted by either NYSDEC or the local municipalities.

Because the thermal effect around a residential closed loop system dissipates within 10-15 feet away, there would be no or only insignificant thermal interference between neighboring systems in dense suburban areas. For the same reason, there would be no significant cumulative thermal effect on downstream ecological resources, drinking water supply wells, or other groundwater users. Unlike open loop systems, closed loop systems must be used for heating and cooling which balances out the thermal effect on the ground. Nevertheless, it would be prudent to track the installation of small closed loop systems as recommended above for small open loop systems.

Historically, the aquifer below the Roosevelt Field Mall/Mitchell Field complex has become thermally impacted (overheated) from extended operation of numerous large, commercial open loop type air conditioning systems. It is presumed that the systems' wells were permitted before NYSDEC established the LIWP or became aware of the potential for overheating of the aquifers by air conditioning systems. The increased groundwater temperatures have resulted in lowered system efficiencies and abandonment of some of these systems.

Chemical Effects

Open Loop Systems

The return water of an open loop system that does not employ an intermediate HX could become contaminated by refrigerants (e.g., Freon) and other chemicals used in the mechanical equipment, should a breach occur in the heat pump or chiller coils. This has contaminated the aquifer at several locations in northern Nassau County. In addition, there are existing, older operating open loop systems that do not employ HXs and may presently be leaking refrigerants to the groundwater or could in the future. Modern HX technology provides an additional physical barrier that protects the aquifer from contamination by refrigerants.

Closed Loop Systems

If an antifreeze is used in the HTF of a closed loop borefield and a leak or break occurs in the buried HDPE piping, antifreeze would be released to the aquifer. A concern would be what impact this could have on the drinking water source and if remediation of such a situation is warranted. The three main antifreezes used in the industry are methanol, propylene glycol, and ethanol (ethyl alcohol). Neither the NYSDEC nor the USEPA have established groundwater quality or discharge standards or guidelines for any of these three chemicals. Methanol is the most common antifreeze and is the same product also used in windshield washer fluid. Besides being used as an antifreeze, propylene glycol is also a common additive to food products. Methanol and ethanol are highly volatile and flammable liquids in their raw form and are toxic to humans if ingested at high concentrations. However, antifreeze is not used at a full concentration in closed loop GHP systems but mixed with water typically at a 20-25% mix or less. All three compounds biodegrade quickly in groundwater and none are presently designated as carcinogens or mutagens. Nevertheless, all precautions should be taken to prevent a release of these compounds from a GHP system, including enforcing strict pressure testing as discussed earlier and other best practices described throughout this report.

DX Systems

If a leak occurred in the buried copper piping of a "DX-to-Ground Contact" loop, refrigerant could be released to the surrounding aquifer. Refrigerants are regulated by both the NYSDEC and the USEPA. Concerns related to these types of DX systems are that there are no regulations for monitoring, reporting, or mitigating a release of refrigerants nor for checking and replacing the sacrificial anodes and cathodes when depleted.

If a leak occurred in the copper piping submerged in the water containment of a "DX-to-Water Contact" loop ("GeoColumn©"), the leak would be contained within the containment device and not be released to the surrounding soil or aquifer. Refrigerant could leak to the ground through the horizontal piping, thus double-wall piping should be required.

Hydrogeologic Effects

Of the three GHP system types discussed in this report, only open loop systems affect the natural groundwater flow. The water table around a pumping supply well is drawn down in the shape of a cone, and mounds up around the return wells as shown in Figure 2. The extent of these areas is a function of the pumping and diffusion rates and the hydraulic conductivity of the surrounding geologic materials. However, there is no net effect on groundwater in storage since 100% of the extracted water is returned to the aquifer. The effect on groundwater levels is localized around the wells and, when pumping stops, groundwater flow patterns return quickly to the natural non-pumping conditions.

Like the thermal effects discussed above, the hydrogeologic effect of a large operating open loop GHP system may extend beneath an adjoining property or into a nearby surface water body or wetland. The water levels could be lowered or raised depending on the location of these resources relative to, respectively, the supply or return wells. It is also possible that a large GHP system could interfere hydrogeologically with another GHP system or other water supply well on an adjoining property. The effect would be greatest during the peak heating and cooling seasons. In any case, any such interference and potential impact of a large open loop GHP system would be identified and addressed by the NYSDEC as part of the LIWP process, as is the case for all new water supply well applications.

The hydrogeologic effect around a small open loop system is much more localized and less likely to extend beyond the property boundary or potentially impact a nearby natural resource. Given Long Island's prolific aquifers, the maximum amount of drawdown and mounding of the water table around the wells serving a typical residence (2-3 ton cooling or heating demand, or approximately 4-6 gpm peak flow) would not exceed 1-2 feet and is temporary during system operation only. The same would be true for a high density of small GHP systems as the drawdown and mounding effects offset one another.

Other Issues and Sensitive Environments

Penetration of Major Confining Clay Units

An un-grouted borehole that penetrates a major confining clay unit represents a conduit for vertical migration of contamination in the shallow Upper Glacial Aquifer into the deeper aquifers, and contamination of a shallow freshwater aquifer by saltwater present below the clay unit. The locations of major confining clay units on Long Island are shown on Figure 9 (in production).

Alteration of Contaminated Groundwater Plumes

The thermally-impacted aquifer beneath the Roosevelt Field Mall/Mitchell Field complex discussed earlier was also impacted by the release of volatile organic compounds (VOCs) from the prior industrial usage of some of the properties. The extensive and sustained pumping and re-injection of contaminated groundwater by commercial open loop air conditioning systems has distributed VOCs throughout the aquifer. As noted previously, this practice may have preceded close regulation of water supply wells under the NYSDEC LIWP program. The NYSDEC now checks under the LIWP program that proposed new water wells (including open loop GHP system wells) will not alter the pathway of pre-existing legacy contamination plumes or impact groundwater remediation efforts at regulated contaminated sites.

Sensitive Aquifers

Sensitive aquifers exist beneath the Great Neck peninsula and portions of the Port Washington peninsula, Shelter Island, and portions of the North and South Forks. These aquifers are limited in size as they are surrounded by salty groundwater, thus they are particularly susceptible to the potential impacts from GHP systems discussed previously. GHP systems may need to be curtailed or restricted in these areas due to their sensitive nature.

Lloyd Aquifer

The NYSDEC disallows the installation of open loop geothermal wells in the Lloyd Aquifer. Because closed loops are not pumping wells, neither the current NYSDEC regulations nor Lloyd Aquifer moratorium exclude closed loops from being drilled and installed into the Lloyd Aquifer, although the authors are not aware of any such systems installed in this manner. [HAVE REQUESTED POLICY FROM NYSDEC]

Mitigation of Potential Impacts

While there are gaps in the existing regulations, the following programs exist that protect Long Island's aquifers and regulated ecological resources:

- The NYSDEC and the SCDHS have construction guidelines in place for open loop wells including grouting/sealing of the annular space, including through clay units that are penetrated,
- For open loop systems regulated under the LIWP program, the NYSDEC performs a rigorous review of potential impacts of a system on the groundwater, surface water, and wetlands resources. This includes a search for sites of environmental concern within the area of influence of the system and an evaluation of the potential thermal and hydraulic effects on neighboring systems and other groundwater users, and
- Activities within sensitive areas (e.g., flood zones, wetlands, and surface water bodies) are regulated by several other state and federal agencies.

In addition, the following local GHP industry practices and programs are in place or in the planning stages with the goal to ensure quality of installations and thus prevent impacts to groundwater and the environment:

- The current industry practice for commercial and large residential open loop GHP systems is to separate/isolate the "well loop" from the building's HVAC equipment and distribution system with an intermediate HX to prevent contamination of the return water by refrigerants and other chemicals present in the mechanical equipment. The HXs are made of appropriate material, e.g., stainless steel or titanium, for the site groundwater quality,
- Standard industry practices and guidelines for closed loop GHP systems that use antifreeze in the HTF include pressure testing of the loops and piping at multiple stages of installation to prevent leaks of antifreeze to the aquifers,
- Additional best practices designed to protect Long Island's aquifers from potential impacts from GHP systems have been implemented by Suffolk County through Memo #25 and by municipalities that have adopted the Model Code,
- GHP system inspector training programs have been developed by IGSHPA and NGWA, and LI-GEO is developing a training program specifically for Long Island municipal building inspectors,
- The local GHP industry is in discussion with NYS, IMC, and USEHC code officials about adopting the comprehensive ANSI/CSA standards into their respective code, and
- Quality control and contractor certification requirements are being developed that must be met for owners to receive rebates from PSEG for GHP systems.

Recommendations

The following recommendations are made to further address expressed concerns over potential impacts of GHP systems on Long Island's aquifers. These recommendations may be best discussed and finalized through a working group comprised of representatives from both counties and local municipal government officials, NYSDEC, USGS, private industry, including LI-GEO/NY-GEO, and other stakeholders.

1. As an interim measure until GHP system installation standards are incorporated into the NYSMC, further development of a local uniform code and consistent permitting and approvals process should be explored. Suffolk County's Model Code could serve as the starting point and be modified as necessary, for example, by incorporating elements of the ANSI/CSA C448 standards. Given Long Island's multiple layers of governance, a county-level code would provide more comprehensive aquifer protection across the entire island.

2. Towns, cities, and villages on Long Island that have not adopted the Model Code should be encouraged to do so. This would provide greater aquifer protection across the island by incorporating the environmental protections provided in the Model Code into the administrative framework of more of the island's municipalities. Municipalities at their discretion can impose stricter requirements given local hydrogeologic conditions and concerns.

3. The feasibility of establishing a centralized database and map of existing GHP systems and a process to add future installations to the database should be explored.

4. For a proposed open loop GHP system permitted under the NYSDEC LIWP program and located within the capture zone of an existing public supply well field, the NYSDEC should require the owner of the system to perform the appropriate aquifer testing and modeling to assess the potential impact to the well field to the satisfaction of the water supplier.

5. For all open loop systems, the NYSDEC should confirm that dedicated supply and return wells are in use when an existing permit is being renewed or new permit application filed to prevent the practices of using public water for supply water or discharging the return water to the ground.

6. The NYSDEC should disallow discharge of the return water from an open loop system to a regulated surface water body or wetlands.

7. GHP systems may need to be curtailed or restricted in sensitive aquifer areas. Local municipalities in these areas can opt to disallow GHP systems entirely or certain types of systems at their discretion.

8. The NYSDEC should clarify whether closed loops can be drilled and installed into the Lloyd Aquifer even though they are not pumping wells (the authors are not aware of any such systems installed in this manner). [HAVE REQUESTED POLICY FROM NYSDEC]

9. Regulations should be enacted for reporting and addressing a release of refrigerants from a "DX-to-Ground Contact" system and for replacing the sacrificial anodes and cathodes as recommended by the appropriate standards (CSA and NACE)

10. Regulations should be enacted to require double-wall piping of the horizontal return pipes for a "DX-to-Water Contact" system ("GeoColumn©") to prevent a release of refrigerant to the ground from a break or leak in the piping.

11. Besides the best practices and environmental protections already included in the Model Code, the following additional measures could be considered and incorporated into a modified Model Code or other code developed as a follow-up to this document:

    - Decrease the threshold for open loop systems requiring an intermediate HX to 25 gpm peak flow rate, from 45 gpm as set forth in the Model Code.
    - For small open loop GHP systems without intermediate HXs, require heat pumps with cupro-nickel internal heat exchangers and baseline and periodic testing of the discharge groundwater quality for select constituents, e.g., copper, nickel, and refrigerants.
    - A mechanism should be set up such that all water suppliers are notified that a GHP system has been permitted to be installed in their service area.
    - Require an inspection sign-off by an IGSHPA-accredited GHP system installer (AI), GHP system inspector, or certified geothermal designer (CGD) for grouting of closed loop boreholes if major confining clay layers are penetrated. Local municipalities also can opt to limit the drilling depth of GHP boreholes so as not to penetrate clay layers located within their jurisdiction.
    - Prior to designing and installing a large closed loop GHP system, conduct due diligence comparable to what is required under the LIWP program for open loop systems, focused on determining the presence, depth, and thickness of major clay confining units, potential presence of contaminated soil or groundwater, and presence and distance to sensitive ecological receptors, water supply wells, and other GHP systems.
    - Better define as-built drawing requirements to include showing other buried infrastructure that could conflict with a GHP borefield or wells, such as drywells, on-site sanitary, underground storage tanks, etc. and transfer to the new owner when the property changes hands.
    - Demonstrate that the GHE is properly sized for the heating and cooling load profile for large GHP systems, as determined through a suitable building energy model. Any serious imbalance in the load profile must be addressed and, if warranted, measures taken to reduce

the loads and/or incorporate conventional mechanical equipment into the design to supplement the GHP system (i.e., a “hybrid design”).

12. Engage a study with input from the NYSDEC, the SCWA, the USGS and other agencies to map the depth below ground surface to major clay confining units. The objective would be to define the maximum closed loop borehole depth in these areas to terminate before drilling into the clays, e.g., in Shelter Island, the North and South Forks, and the Smithtown clay.

13. Engage a study with input from the the NYSDEC, the SCWA, and the USGS on the feasibility of using Aquifer Thermal Energy Storage (ATES) systems on Long Island, whereby the usual thermal effects on the aquifer are contained rather than allowed to migrate beyond the site’s boundaries.

14. The potential thermal effects of individual operating GHP systems on groundwater, surface water, and ecological resources needs to be better understood, through research and modeling by local colleges and universities, the NYSDEC, the SCWA, the counties, private industry, and the USGS, with a goal to establish procedures to determine “safe” setbacks from these resources and to enact appropriate regulations if needed.

15. The current state policy of “first-come-first-served” for underground water rights may need to be re-assessed to address cumulative thermal and hydrogeologic effects of high concentrations of small GHP systems. Regional modeling (building on the USGS groundwater model) could be performed to define the “safe” concentration of such systems that would prevent this from occurring, with appropriate limits enacted by either the NYSDEC or the local municipalities.

16. If not already standard practice, the NYSDEC should require use of an intermediate HX for open loop systems permitted under the LIWP program. The NYSDEC should also require installation of an intermediate HX on existing systems that do not employ HXs before permits are renewed. NYSDEC could reach out to owners of existing systems without HXs in advance of the permit date regarding voluntary retrofit of their systems with HXs.

17. The NYSDEC, Division of Water, might consider adding due diligence for LIWP applications for large GHP systems that is required by Region 2 (commensurate with the higher density development and urban nature of Brooklyn and Queens as compared to the eastern portion of Long Island).

18. The NYSDEC and county health departments should delineate areas over or near known contamination plumes where GHP systems may not be recommended and promulgate the appropriate restrictions.

19. Efforts to raise awareness and better educate and train the public, municipal officials, architects, system designers and installers, and potential end users on the proper implementation of GHP systems should be encouraged, perhaps facilitated by LI-GEO/NY-GEO in association with the counties and the NYSDEC or other agencies.

20. A GHP system inspector training program should be developed specifically for Long Island municipal building inspectors in conjunction with LI-GEO.