CONNECTICUT DEPARTMENT OF PUBLIC HEALTH

Keeping Connecticut Healthy

REPORT TO THE GENERAL ASSEMBLY

RECOMMENDATIONS FOR REGULATION

OF

GEOTHERMAL WELLS

Revision 2.0 March 5, 2007

Connecticut Department of Consumer Protection

Connecticut Department of Environmental Protection

Connecticut Department of Public Health

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1.0 INTRODUCTION

On June 6, 2006 the Connecticut General Assembly passed Special Act 06-6. Section 34 of the act states the following:

Sec. 34. (*Effective July 1, 2006*) (a) The Department of Public Health, in consultation with the Departments of Consumer Protection and Environmental Protection, shall review and make recommendations regarding bore holes to be used for the development of closed loop geothermal heat pumps or similar systems, and specifically the abandonment, construction of and appropriate separating distances between such bore holes.

(b) On or before January 1, 2007, the Commissioner of Public Health shall submit the department's specific recommendations and findings based on such review to the joint standing committee of the General Assembly having cognizance of matters relating to public health, for review and appropriate action, in accordance with the provisions of section 11-4a of the general statutes.

Accordingly the information and recommendations presented below are in response to the act. The specific recommendations are a result of discussions between the Departments of Consumer Protection, Environmental Protection, and Public Health (hereafter referred to collectively as the Agencies).

2.0 DEFINITIONS

Annular Space – The space between casing or well screen and the wall of the borehole, or between drilling pipe and casing, or between two separate strings of casing.

Aquifer – A subsurface water-bearing layer of soil, sand, gravel, or rock that will yield usable quantities of water to a well.

Borehole – A hole drilled or bored into the earth, usually for exploratory or economic purposes; a hole into which casing, screen, and other materials may be installed to construct a well.

Casing - An impervious, durable pipe placed in a borehole to prevent the walls of the borehole from caving, and to seal off surface drainage or undesirable water, gas or other fluids and prevent entrance into a well.

Cone of Depression - A depression in groundwater levels, in the shape of an inverted cone, which occurs in the area around a well in response to groundwater withdrawal or pumping water.

Drinking Water – Water which is intended for human consumption and other domestic uses, and is considered to be free of harmful chemicals and disease-causing microorganisms.

Geo-thermal borehole – A hole drilled or bored into the earth into which piping is inserted for use in a geothermal system.

Geo-thermal system – A geothermal system uses the Earth's thermal properties in conjunction with electricity to provide greater efficiency in the heating and cooling of buildings.

Geo-thermal system (Closed Loop) – A mechanism for heat exchange which consists of the following basic elements: Underground loops of piping; heat transfer fluid; a heat pump; an air distribution system.

Ground water –Water beneath the earth's surface, that occurs between saturated soil and rock that supplies wells and springs.

Grout – A low permeability material that is emplaced in the space between the wall of the borehole and the casing of a well and, or, emplaced on the wall of the borehole. The emplacement of grout is to prevent the migration of water or fluid contaminants into and through the borehole.

Heat Exchanger - A device, usually made of coils of pipe, that transfers heat from one medium to another; for example, from water to air or water to water.

Heat transfer fluid – Any liquid used specifically for the purpose of transferring thermal energy from the heat source to another location.

Permeability - The propensity of a material to allow fluid to move through its pores or interstices. Permeability is an important soil parameter when flow of water through soil or rock is a matter of concern.

Separation/Isolation distances – The distance of a source of contamination from a surface drinking water source, a ground water source supply well, or any type of borehole.

Septic tank – A water-tight receptacle which is used for the treatment of sewage and is designed and constructed so as to permit the settling of solids, the digestion of organic matter by detention and the discharge of the liquid portion to a leaching system;

Sewage – Domestic sewage consisting of water and human excretions or other waterborne wastes incidental to the occupancy of a residential building or a non-residential building, as may be detrimental to the public health or the environment, but not including manufacturing process water, cooling water, waste water from water softening equipment, blow down from heating or cooling equipment, water from cellar or floor drains or surface water from roofs, paved surface or yard drains.

Sewage system – An underground system of pipes used to carry off sewage.

Surface water - Water located on the surface of the Earth in water bodies such as lakes, rivers, streams, ponds, and reservoirs.

Tremie - A tubing string (typically about 2 to 3 inches in diameter) that is temporarily installed into the borehole during well construction. The tremie pipe is used for installing annular material such as filter pack sand and grout.

Water supply well – A well used by public water systems, or non-public use, for extracting groundwater for human consumption.

3.0 BACKGROUND

Geothermal wells have been used for several decades as an adjunct to existing heating and cooling systems. The systems are designed to use the Earth's relatively constant subsurface temperature along with a heat exchanger to either add to or remove heat from a dwelling. Geothermal wells (also known as geoexchange systems) have two basic designs; open looped and closed looped systems.

In an open looped system groundwater is pumped from a water well into a heat exchanger located in a surface dwelling. The water drawn from the Earth is then pumped back into the aquifer through a different well, or in some cases the same well. Alternatively the groundwater could be discharged to a surface water body. In the heating mode cooler water is returned to the Earth, while in the cooling mode warmer water is returned.

In a closed looped system, an opening (either a borehole or trench) is made in the Earth. A series of pipes are installed into the opening and connected to a heat exchange system in the dwelling. The pipes form a "closed loop" (hence the name) and are filled with a heat transfer fluid. The fluid is circulated through the piping from the opening into the heat exchanger and back . The system functions in the same manner as the open looped system, except there is no pumping of groundwater.

With the recent increase in energy costs, the use of geothermal exchange systems is gaining popularity and becoming more economical. The US Environmental Protection Agency and the Department of Energy both recommend geoexchange systems as a "green" technology for lowering energy costs and dependency on fossil fuels. Nonetheless, the Agencies have concerns that the potential for significant harm to Connecticut's groundwater resources requires regulation of this largely unregulated industry.

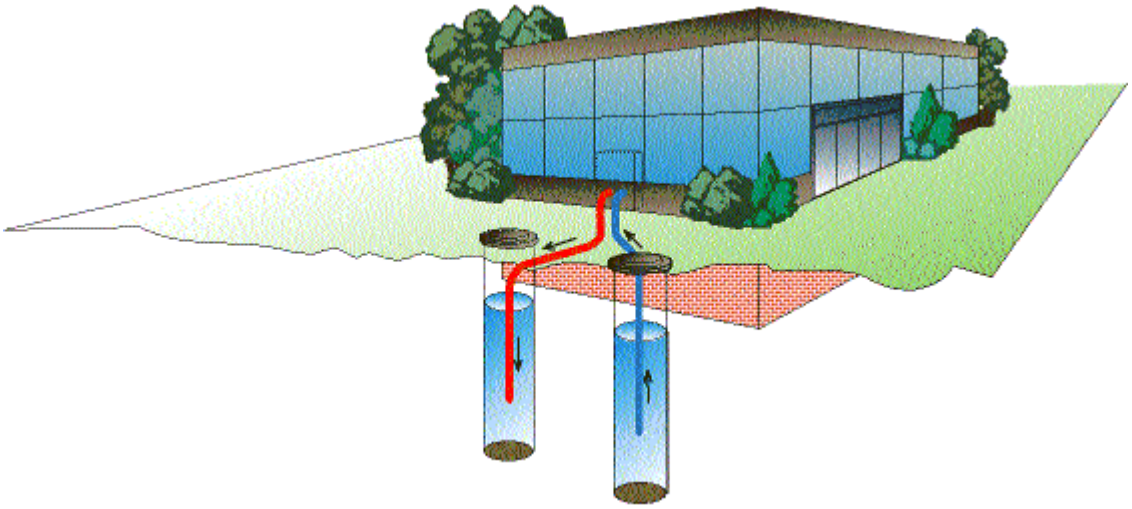
In the spring of 2006 the Connecticut Water Well Association (CWWA) approached the Department of Public Health (DPH) concerning regulation of the geothermal well industry. The CWWA was concerned about the need for standards in the industry in order to protect the environment and prevent substandard work practices. Following meetings with the DPH, the CWWA submitted proposed changes to the Well Drilling Code. While the Agencies involved are not in full agreement with all the proposed changes, the Agencies applaud the CWWA for its efforts and proactive stance on this issue. The Agencies do not intend to restrict the use of geothermal systems, but rather desire to promote a safe handling of our natural resources for the benefit of all. This can be accomplished by avoiding unnecessary risks of potential contamination and by paying close attention to possible groundwater overuse situations.

4.0 OPEN LOOPED SYSTEMS

The primary focus of this paper is on closed looped systems. However open looped systems are currently in use in Connecticut and therefore deserve some comment. In general the Agencies have serious concerns regarding potential adverse environmental impacts associated with open looped systems. The installation of geothermal open loop wells (not the geoexchange system, but the actual well) is currently regulated as a water supply well as defined in CGS Section 25-126. The construction and abandonment procedures are delineated in the Well Drilling Code, while separation distances are listed in the Public health Code. Open loop geothermal well discharges have been regulated through the DEP's *General Permit for the Discharge of Non-Contact*

Cooling and Heat Pump Water. The permit states "discharge of minor non-contact cooling water to groundwater shall be derived solely from once-through heat exchange systems or condensate which does not receive chemical additions of any kind and which uses on-site groundwater, public water, or surface water as source water." Heat pumps used for residential buildings with flows under 50,000 gallons per day of groundwater are exempt from registration. Sites with existing groundwater contamination require a case by case site review and must receive written approval from DEP prior to construction.

FIGURE 1 OPEN LOOP SYSTEM



Large open loop systems (those drawing greater than 50,000 gallons per day of groundwater) require a diversion permit and an individual wastewater discharge permit from the DEP. Currently the DEP has two such systems under individual State discharge permits and three systems under individual diversion permits. Authorization under a diversion permit is available for those wells withdrawing between 50,000 and 250,000 gallons per day of groundwater as long as they meet certain strict provisions regarding potential effects on water resources within the well's area of influence.

The Agencies' major concern is protecting the groundwater resource as the potential for open loop systems causing contamination of the aquifer is great. Open loop systems could have many potential problems:

- By pumping a large volume of groundwater a hydraulic gradient is generated. This results in an unusually high rate of replenishment of groundwater to the specific area where the extraction of groundwater occurs. This extensive groundwater pumping could draw groundwater from a connected source of pollution into; a nearby drinking water well, the geothermal well itself, or an uncontaminated aquifer. The net result would be spreading the groundwater contamination to uncontaminated zones and thereby causing the plume to be more widely distributed in the aquifer.

- Without an adequate Phase I Environmental Site Assessment (ESA) there is no way to determine if the groundwater is potentially impacted prior to installing the geothermal; system. Areas with industrial/ commercial activities would have a greater potential for groundwater impacts and a greater need for a Phase I ESA.

- Depending on the pumping volume and the location of the discharge, the open loop system could generate a large cone of depression affecting any nearby private or public drinking water supply wells.

- If the open loop system is discharging to surface water body or a shallow discharge well, the difference in the chemistry of the deep groundwater and surficial water could have an adverse effect on the surficial water. Any increase in temperature might also cause an increase in bacterial growth, which again could cause the water to become unsuitable for consumption.

The main focus of this report is on "closed loop" as opposed to "open loop" systems. This report recommends new standards and regulations for installing closed loop systems to provide clarity for well drillers and to monitor proper installation of geo-exchange systems. Geo-exchange systems offer improved energy efficiency and therefore lower utilization of fossil fuel. The benefit of reducing air pollution from better fuel efficiency is a positive "green" consideration. However, moving forward the Agencies need to monitor both closed and open loop systems to avoid potential negative impacts to the ground and surface water resources. Also, standards and regulations for open loop systems should be similar to those that we are recommending for closed loop systems. Comparable regulation for both open and closed loop system is needed to avoid creating an unfair incentive for one type of system over the other. The Agencies need to maintain an ongoing dialog on the issues surrounding open loop systems and to address resource issues concerning regulation of all geo-exchange systems.

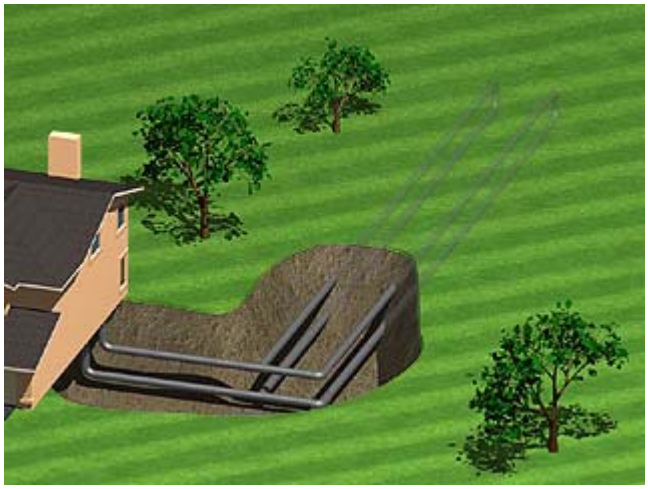
As permit programs are in place to regulate the construction of any open loop well, and to adequately review the environmental effects of any such well that withdraws or discharges more than 50,000 gallons per day of groundwater, the Agencies are most concerned about the individual and cumulative effects of small open loop systems that withdraw and discharge less than 50,000 gallons per day of groundwater without environmental review.

5.0 CLOSED LOOPED SYSTEM DESCRIPTIONS

The major types of closed looped systems are horizontal loop, vertical loop, and pond loop. In a horizontal loop (see Figure 2) a trench is dug (3-6 foot depth). A series of parallel pipes is laid in the trench, which is then backfilled so as not to damage the pipes. The pipes are connected to the heat exchanger and heat transfer fluid is circulated through the pipes. Variations of this system include using a "slinky" (coils) of pipes instead of straight pipe.

If the area of disturbance is large enough, construction of horizontal closed loop systems may need to be registered with the DEP's Permitting and Enforcement Division under the General permit for Stormwater and Dewatering Wastewaters from Construction Activities. This general permit applies to construction activities that result in the disturbance of one or more total acres of land area on a site. For construction projects with a total disturbed area between one and five acres, the permittee is required to adhere to the erosion and sediment control land use regulations of the town in which the construction is located.

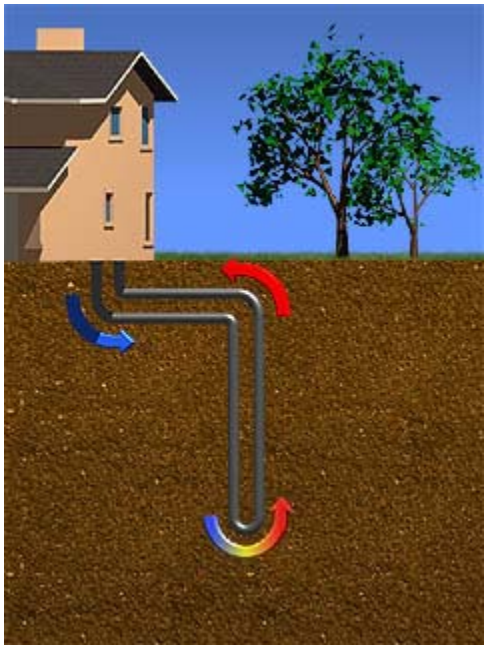
FIGURE 2 CLOSED LOOP HORIZONTAL SYSTEM



No DEP registration of this permit shall be required for such construction activity as long as it receives review and written approval by the town. In those instances where there is no town review or the total disturbed area is greater than five acres, registration with the DEP is required.

Vertical loop systems (see Figure 3) require a borehole that typically extends several hundred feet beneath the surface. Pipes are installed with U-bends at the bottom of the borehole. Again the pipes are connected to the heat exchanger and heat transfer fluid is circulated through the pipes.

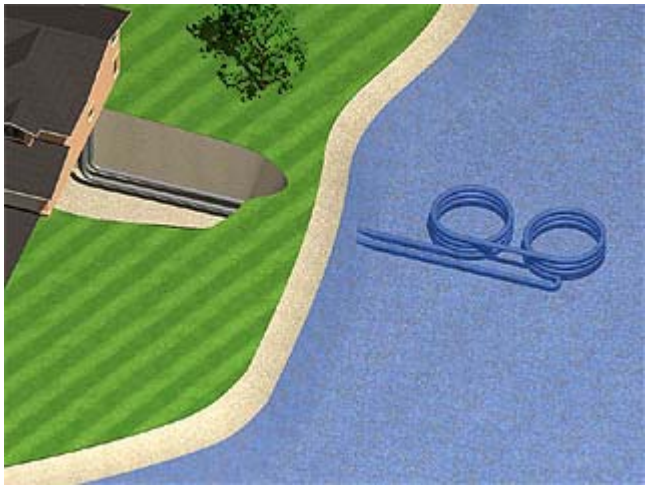
FIGURE 3 CLOSED LOOP VERTICAL SYSTEM



In a pond loop system (see Figure 4) a body of surface water such as a pond or lake is used as the heat source or sink. A trench is dug from the dwelling to the pond and piping is run form the heat

exchanger into the pond and back. Typically a coil of piping is placed in the pond to increase the efficiency of the system.

FIGURE 4 CLOSED LOOP POND SYSTEM



Construction and operation of a closed-loop pond system is subject to the jurisdiction of the Inland Wetlands and Watercourse Act (Sections 22a-36 through 22a-45a of the CGS). The local inland wetlands and watercourses agency would regulate privately-owned closed loop pond systems while such systems proposed by State agencies would be regulated by DEP's Inland Water Resources Division. Regulated activities include, but are not limited to, filling or excavation within the pond, or any harmful thermal effect resulting from the ongoing operation of the system. In addition, certain activities taking place within an "Upland Review Area" adjacent to the pond could be regulated by a local wetland and watercourse agency

If construction of the system involves placement of more than 5,000 square feet of fill into the waters of the United States, the activity may fall under the jurisdiction of Section 404 of the Federal Clean Water act administered by the United States Army Corps of Engineers (the Corps). If such jurisdiction is assumed by the Corps, a Section 404 permit can't be issued by the Corps until DEP's Inland Water Resources Division issues a Section 401 Water Quality Certificate certifying that the "discharge" of the fill is consistent with Connecticut's water quality standards.

Special Act 06-6 requires recommendations regarding boreholes used for the development of closed loop geothermal heat pumps or similar systems. Although boreholes are only used with closed loop vertical systems, commentary and recommendations are also given for all geothermal systems concerning construction materials, heat transfer fluids, and separation distances.

6.0 GROUNDWATER PROTECTION CONCERNS FOR CLOSED LOOP VERTICAL SYSTEMS

As stated in Section 4, protection of groundwater resources and Connecticut's drinking water are the Agencies' primary concern. Anytime a borehole is drilled into the Earth, the potential for contamination of the groundwater is increased exponentially. Surface contaminants can be channeled directly into the groundwater through leaks and cracks in the grout used to seal the

geothermal well. Wells can be damaged through movement of heavy equipment on the surface during and after well construction. Leaks in the piping could allow the heat transfer fluid to enter the groundwater. Wells installed near sources of pollution, such as septic tanks, leaching fields, sewer laterals and associated pumps, and underground fuel tanks may allow pollutants to contaminate the groundwater and endanger the public health. Additionally studies have shown that larger closed loop systems affect the temperature of the aquifer resulting in an increase in the overall bacteria counts in the groundwater (1). Therefore there is a potential for the promotion of pathogenic microorganisms. A borehole can also act as a connection between different aquifers or a zone of contamination and an aquifer. This would allow contaminants to flow into an uncontaminated aquifer, resulting in contamination of both aquifers.

As of this date the Agencies are not aware of any uniform database, which identifies statewide, the location of all potential sources of pollution to ground water and surface water. Information concerning specific sites of potential contamination would most likely be available at the municipal level of government. The Connecticut General Assembly may wish to consider providing resources for further examination of the extent to which Connecticut ground water and surface water sources are vulnerable to contamination from well drilling.

In order to minimize the potential for any contamination of groundwater by the installation of, use of, or abandonment of closed loop vertical geothermal wells regulations should be developed to ensure protection of the groundwater. These regulations should set standards for the following activities and components during installation of a geothermal system:

- Construction
- Grout
- Separation Distances
- Heat Transfer Fluids
- Abandonment
- Personnel

6.1 Construction

Closed loop vertical geothermal wells should be constructed with materials of such quality to ensure the integrity of the well during and after the construction process. In general the construction of a closed loop vertical system should follow the existing requirements of the Well Drilling Code with some modifications. The Well Drilling Code currently requires all water supply wells to have a steel casing that extends the length of the well and extends at least six inches above the surface. Additionally if a water supply well is drilled into bedrock, the casing must extend at least ten feet into the bedrock. The Agencies feel that casings are not necessary for geothermal boreholes, provided the borehole is filled with grout in a timely manner and the minimum separation distances from potential sources of pollution are met. However, casings should be used during the installation of the borehole to protect the borehole from collapsing. The casing could be removed as the borehole is filled with grout. All boreholes should be filled with grout within 7 days of installation. After the borehole is installed the casing should be capped until the grouting process begins. If a borehole is drilled so that it connects different aquifers, the construction must be such that the aquifers remain isolated from one another (i.e. groundwater from one aquifer should not be allowed to flow into another aquifer). Boreholes installed in areas of potential contamination, such as Brownfields sites, require special considerations. The borehole must not become a connective apparatus so that potential areas of pollution are connected with uncontaminated groundwater. A permit should be required for any borehole installation. If the local health director was aware of existing areas of pollution of hazardous

materials at a given site, the appropriate state agency should be contacted for guidance prior to issuance of any permit.

The borehole of the closed loop geothermal well should be terminated at least four feet below the surface. Boreholes terminated in a structure should be terminated flush with the finished floor. The vertical loops of the system are encased in grout, which aids in protecting the pipes from damage as well as providing a heat transfer medium. The material the pipes are constructed of must be resistant to any corrosive effects from the heat transfer fluid and the underground environment. The grout would help to contain any spilled heat transfer fluid. Prior to completion the geothermal loop (pipes) must be pressure tested to ensure no leaks are present. Any system found to leak must be replaced.

A specialized geothermal well completion report should be completed and filed with the local director of health after the system is installed.

6.2 Grout

The type of grout and its proper installation in the borehole is critical to protecting the groundwater. The grout must have a low permeability to water so that water cannot easily penetrate the grout allowing contamination from either the surface or another aquifer to enter the uncontaminated aquifer. Therefore the grout must have a maximum coefficient of permeability of 10^{-7} cm/s. The grout must form a good hydraulic seal with the pipes used for the geothermal loop so that water cannot flow along the pipe. Ideally the grout should also have good thermal conductivity so the geothermal system functions efficiently. The grout must be installed correctly by filling the borehole from the bottom up using a minimum 1¼-inch tremie. The entire borehole must be filled with grout.

There are several commercial grouts available specifically formulated for geothermal applications. These grouts typically used bentonite for a good hydraulic seal and silica sand for enhanced thermal properties. Since the grout might come in contact with the drinking water aquifer, it must not add chemicals to the aquifer. The National Sanitation Foundation (NSF) along the American National Standards Institute (ANSI) sets standards for chemicals and additives that come in contact with drinking water. Any additives, other than bentonite, silica sand and water, should meet the requirements of NSF/ANSI Standards 60 and 61.

The manner by which the boreholes are grouted is also important. Boreholes should be protected from surface water intrusion and cross-aquifer mixing during construction. Boreholes should also be grouted as soon as reasonably possible after the geoexchange piping system has been installed and pressure tested. Boreholes should not be left open for significant lengths of time after they are drilled. As a steel casing would be in place prior to completion of the geothermal well, the casing should be capped when not in use.

6.3 Separation Distances

The Public Health Code specifies separation distances for drinking water wells, sub-surface sewage (septic) systems, drains, etc. The separation distances were developed to provide adequate protection of drinking water supplies from sources of contamination. The distances are based upon the time it would take probable contaminants to migrate from the source of pollution to the well taking into account the natural attenuation factors. Section 19-13-B51(d) of the Public Health Code states that drinking water wells shall “be as far removed from any known or probable source of pollution as the general layout of the premises permit; and so far as possible,

be in a direction away from groundwater flow from any existing or probable source of pollution." Separation distances vary based on the type of structure, groundwater withdrawal rates, and manner of construction. Any changes to the existing separation distances should be made via changing the Public Health Code, not the Well Drilling Code.

Table 1 § 19-13-B51(d) Separation Distances

Water Supply Well Withdrawal Rate	Separation Distance from sewage system or other source of pollution	Separation Distance from high water mark of any surface water body or drain carrying surface water or of a foundation drain
<10 gal/min	75 Feet	25 Feet
10 to 50 gal/min	150 Feet	50 Feet
>50 gal/min	200 Feet	50 feet

6.4 Heat Transfer Fluids

Heat transfer fluids are an important concern of all Agencies involved with geothermal wells. The concerns are not only limited to vertical systems, but horizontal and pond loop systems as well. If a system should leak or fail, allowing the heat transfer fluid to leak into the environment, not only might the aquifer become contaminated, but also significant costs could be incurred to the property owner for cleaning up any contaminated soil and remediating any damage to the aquifer. The Agencies feel that the types of heat transfer allowed be limited to non-toxic materials such as potable water, and aqueous solutions of food grade propylene glycol or potassium acetate. Consideration should also be given to requiring owners of geothermal systems obtain insurance in case of systems causing contamination. Routine pressure testing of the systems should also be required to ensure no leaks have developed.

6.5 Abandonment of Geothermal Systems

It can be expected that at some point in time any geothermal system will be put out of service. When this occurs the well must be properly abandoned in order to protect the groundwater. The procedure used for abandonment should be the same as is currently in the Well Drilling Code with a few modifications. Initially the heat transfer fluid must be removed via displacement with grout. The fluid should be collected and disposed of according to current State and Federal regulations. Closed loop geothermal wells do not have a cap over the vertical section of the well that prevents water from defusing into the well. On abandonment the top of the borehole should be uncovered and capped with grout.

6.6 Personnel Requirements

The Agencies recommend that requirements for contractors be established for those activities related to geothermal borehole installation. These standards should be set by the Well Drilling Board when appropriate.

7.0 Recommendations

7.1 Construction Standards

7.1.1 The Agencies recommend that prior to construction of any geothermal system, a well drilling permit be obtained from DCP and the permit be approved by the local director of health, prior to construction. The applicant shall supply the local director of health a site map or sketch indicating the proposed location of the geothermal system and the presence of any existing structures, existing property lines, water supply wells, sub-surface sewage disposal systems, sewer lines including any associated pumps, underground or above ground storage tanks, and any other potential source of contamination.

7.1.2 The Agencies recommend that if the local director of health is aware of existing areas of pollution or hazardous materials at a site proposed for the installation of a geothermal system, the local director of health contact the Department of Environmental Protection for guidance prior to issuing any permit.

7.1.3 Closed loop heat exchanger construction. The Agencies recommend the only acceptable materials for the underground portion of the closed-loop heat exchanger are as follows:

Polyethylene - all material shall maintain a 160 psi hydrostatic design basis at 73.4 degrees F per ASTM D-2837, and shall be listed in PPI TR4 as a PE3408 piping formulation. The material shall be high density, polyethylene extrusion compound having a cell classification of PE345434C or PE 355434C with a UV stabilizer of C, D or E as specified in ASTM D- 3350 with the following exception: this material shall exhibit zero (FO) when tested for 192 hours or more under D-1693, condition C, as required in ASTM D-3350.

Additionally, the only acceptable method for joining buried pipe systems is by:

1) The heat fusion process in accordance with the pipe manufacturer's specifications and by the approved International Ground Source Heat Pump Association mechanical stab fittings. The resultant assembly shall be leak-proof.

7.1.4 All closed loop geothermal well systems should be pressure tested upon installation. The system should be pressure tested with air or water to 150 percent above the manufacturers heat pump operating specifications for a period of 30 minutes. Any system found to leak must be replaced or repaired and retested before put in service.

7.1.5 During construction, the Agencies recommend a vertical geothermal borehole have a steel casing in place as per the Well Drilling Code. The casing shall be capped from the time of installation until the installation of the geothermal piping. After the borehole is grouted, the casing may be removed.

7.1.6 The Agencies recommend that closed loop vertical boreholes terminate at least four feet below the surface, unless the borehole terminates in a dwelling. If a borehole terminates in a dwelling, it shall be terminated flush with the floor.

7.1.7 The Agencies recommend that after installation and testing of the vertical closed loop geoexchange system, the entire borehole, including the annular space if present, shall be filled with thermally enhanced bentonite grout using the tremie method. A minimum 1¼-inch tremie shall be used. All boreholes should be grouted within seven days of installation.

7.1.8 Any geothermal borehole or excavation for the installation of a horizontal closed loop or pond loop system shall be in accordance with Sections 25-128-37 and 25-128-53 of the Well Drilling Code.

Sec. 25-128-37. Manner of construction

The construction of any well shall be planned and carried out in a manner to guard against waste and contamination of groundwater resources.

Sec. 25-128-53. Construction of non-water supply wells

All wells used for other purposes than the supply of water for human consumption shall be constructed, repaired, and maintained in such a manner that they are not a source or cause of groundwater contamination.

7.1.9 The Agencies recommend that after the geothermal system has been installed, the top of the borehole be covered with a protective layer of grout. The grout shall be at least two feet thick and three feet in diameter, centered over the top of the borehole. The protective layer of grout should be installed by the appropriate licensed individual who connects the upper elbow of the piping exiting the borehole to the heat exchanger.

7.1.10 The Agencies recommend a well completion report, approved by the Department of Consumer Protection, specific for geothermal wells be completed and filed with the local director of health within 60 days of completion of the installation. The well completion report shall be specific for geothermal systems and include at a minimum the following information:

- Name, Address, Registration Number of the Contractor, Type of work completed i.e. Drill Boreholes, Install & Grout Loops, Borehole Abandonment.

- System Location: Town, Driller Map Number, GPS Coordinates, Address, Zip Code.

- System Owner: Name, Company Name, Address, City, State, Zip, Phone No. ,

- Borehole Specifications:
  Date first Borehole Drilled, Total number of Boreholes Drilled, Diameter of Boreholes, Depth in feet, Spacing Intervals of Boreholes in feet, Average Depth of Bedrock in feet, Date last Borehole Drilled, Geologic materials and thickness of materials penetrated, Amount and type of casing, Static water levels.

- Loop Field Installation: Installer Name, Registration Number, Number of Loops Installed, Date last Loop Installed, Average Number of Bags to Grout each Loop, Lb per Bag, Cubic feet Grout for each Borehole, Depth Closed Loop in feet, Type of Grout Used, Date Borehole(s) Grouted.

- Denote Heat Transfer Fluid used in Closed Loops and volume of fluid used.

- Install Detectable Underground Tape above Borehole Location.
- Attach Diagram showing Major Buildings, Septic Systems and Water Supply Wells on site.

7.11 Owners of any geothermal exchange system should be encouraged to purchase pollution insurance if such insurance policies are available.

7.2 Grout

7.2.1 The Agencies recommend that all grout used for geothermal exchange systems be bentonite grout having a minimum of 20% by weight bentonite. Any additives to the grout other than silica sand and water must meet the NSF/ANSI Specifications 60 and/or 61 as appropriate.

7.2.2 The Agencies recommend the grout should be thermally enhanced bentonite grout. Silica sand should be used to enhance the heat transfer properties of the grout.

7.2.3 The Agencies recommend that all grouts must have a maximum coefficient of permeability of 10^{-7} cm/s.

7.2.4 The Agencies recommend grouts are to be mixed and installed in accordance with manufacturer's specification.

7.2.5 Where the grout extends through zones of saltwater, the Agencies recommend a saltwater resistant grouts be used.

7.2.6 The Agencies recommend that drilling mud or cuttings not be mixed into the borehole.

7.3 Separation Distances

7.3.1 The following separation distances are recommended by the Agencies for geothermal closed loop boreholes and trenches associated with horizontal closed loop systems if all recommended activities and components for installation of geothermal systems are complied with:

Table 3 Geothermal Closed Loop Borehole and Horizontal Loop Separation Distances (1)

Structure	Geothermal Separation Distance
Private Water Supply well, withdrawal rate < 10 gal/min	25 Feet
Private Water Supply well, withdrawal rate >10 gal/min	50 Feet
Public Water supply well, withdrawal rate <10 gal/min	25 feet
Public Water Supply well, withdrawal rate >10 and <50 gal/min	50 feet
Public Water Supply well, withdrawal rate > 50 gal/min	200 Feet
Source of Pollution (subsurface sewage, leaching field, grinder pump on sewer lateral, known releases of hazardous materials, structures or containers (tanks) of hazardous substances located above or below ground or other known source of contamination)	50 Feet. A separation distance of 25 feet may be used for septic tanks that meet the performance testing criteria specified in Section V(A)(6) of the Technical Standards for Subsurface Sewage Disposal Systems

Separation Distance from high water mark of any surface water body or drain carrying surface water or of a foundation drain	10 Feet

1. All distances measured horizontally.

7.3.2 Separation distances for open loop systems shall follow the current distances set forth in Section 19-13-B51(d) of the Public Health Code. Distances from open looped geothermal wells to water supply wells should be the same as specified in Table 1 of Section 19-13-B51(d) of the Public Health Code.

7.4 Heat Transfer Fluids

7.4.1 The Agencies recommend all heat transfer fluids be non-toxic and food grade.

7.4.2 The Agencies recommend that all water used in the system must be potable.

7.4.3 The Agencies recommend that heat transfer fluids for closed loop geothermal systems be limited to the following:

- Potable Water
- Aqueous Solutions of Potassium Acetate not to exceed 20% by weight
- Aqueous solutions of Propylene Glycol not to exceed 20% by weight

7.5 Abandonment

7.5.1 The Agencies recommend that upon abandonment all heat transfer fluids shall be removed from the system by displacement with grout. The fluids shall be collected and disposed of according to all State and Federal Regulations.

7.5.2 The Agencies recommend that after the heat transfer fluid is displaced the grout shall be allowed to spill over into the excavation to provide a cap at least one foot thick above the loop pipe. The remainder of the excavation shall be filled with compacted earth or pavement.

7.6 Recommendations for Personnel

It is recommended the following licenses be established:

Contractor – Limited to Well Casing Extension W-5: Well Casing Extension Contractor, shall permit persons licensed to perform plumbing and piping work pursuant to chapter 393 to perform well casing extension, repair and maintenance work.

Contractor–Limited to Geoexchange Bore Hole Drilling W-7 : As provided by Section 25-129 of the General Statutes, the Board hereby establishes certain requirements for the registration of well drilling contractors. This registration permits the registrant to construct a geoexchange borehole or Geoexchange system, which may include the installation, repair and maintenance of pumps, pump motors, pump piping, valves, wiring, electric controls and tanks. Before any registration is issued to any individual the Board shall require that the applicant submit:

(1) His full, legal name, street address, city, state and zip code;

(2) A certificate of liability insurance specifying well drilling purposes and providing liability coverage for bodily injury of at least one hundred thousand dollars ($ 100,000) per person with an aggregate of at least three hundred thousand dollars ($ 300,000), and for property damage of at least fifty thousand dollars ($ 50,000) per accident with an aggregate of at least one hundred thousand dollars ($ 100,000);

(3) Documentation that he has been actively engaged in the well drilling trade as a well driller for a period of thirty-six (36) months prior to the date of his application and/or has held a valid W-8 registration for at least two years;

(4) The name(s) and address(es) of his employee(s) who holds a master driller registration;

(5) Letters of references from a Connecticut registered well contractor, a local public health official and one (1) other responsible citizen which attest to the applicant's integrity and ability to act as a well driller; and

(6) He shall be found in compliance with all provisions of subsection (e) (1) of Section 25-129 of the General Statutes, concerning his conduct in the well drilling industry.
Secs. 25-128-59--25-128-60. Repealed, May 21, 1993.

Limited Well Casing Extension Journeyperson W-6 : Well Casing Extension Journeyperson, shall permit persons licensed to perform plumbing and piping work pursuant to chapter 393 to perform well casing extension, repair and maintenance work while in the employ of a licensed contractor for such work.

Driller Limited to Geoexchange Bore Hole Drilling W-8: The requirements for this registration shall be three (3) years as an apprentice driller or possess equivalent experience and training. This registration permits the registrant to construct a geothermal borehole or Geoexchange system, which may include the installation, repair and maintenance of pumps, pump motors, pump piping, valves, wiring, electric controls and tanks only while the registrant is in the direct and regular employment of a contractor registered for such work. The applicant shall demonstrate his knowledge of well drilling by passing a written examination conducted pursuant to Sections 21a-7 (1) and 21a-8 (5) of the General Statutes.

8.0 References

8.1 *Effects of a Large Scale Geothermal Heat Pump Installation on Aquifer Microbiota*, York, K.P., et al., Richard Stockton College of New Jersey.