
Technical Bulletin: Earth (Geothermal) Energy Systems

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This fact sheet is for earth energy systems, also known as geothermal heating systems, as they relate to drinking water source protection. It explains the types of activities that are associated with the construction and operation of systems which utilize water, either directly or indirectly, for heating or cooling. It also identifies how such activities are or could potentially be addressed under the Clean Water Act requirements.

Installing earth energy systems requires making holes in the ground. If these holes are wells, which would apply if there were any tests for or on groundwater in the boring or installation, they must meet the requirements of Regulation 903 to minimize the risk of contaminating groundwater. Improperly constructed, maintained and abandoned wells can create pathways for contamination to move from the surface down into the groundwater or from one water-bearing horizon to another. Most of these systems will not be on record, so this creates an unknown in terms of pathways and vertical vulnerability. The Canadian Standards Association has published C448.2-01 and C448.2-02 for the Design and Installation of Earth Energy Systems, which recommends using high density polyethylene plastic pipe and pressure testing the system at key points to determine if there are any leaks at key points during the installation. Furthermore, the CSA standard also requires that boreholes be filled with grout for the entire length of the hole which would minimize the potential for contamination or leakage. However, the CSA Standard is only applied when there is an application for a building permit and there is a poor understanding of the need for the permit.

What is an earth energy system and how does it work?

O.Reg. 177/98 under the Environmental Protection Act defines a ground source heat pump as a heating and cooling system for buildings that use a liquid to exchange heat with the ground or ground water.



Geothermal (or earth) energy comes from the soil and rock of the earth. Ground temperature is relatively constant all year long. Groundwater flowing slowly through soil pores and bedrock fractures also has similar constant temperatures. In winter, the ground is warmer than the air, and in summer, it is cooler. An earth energy system (heat pump) harnesses this underground temperature to heat and cool buildings.

There are two basic types of earth energy heat pump systems - open and closed loop. Stated simply, open loop systems extract water from the environment to use for heating and cooling and then discharge the water back to the environment either directly or indirectly. Closed loop systems circulate a heat transfer fluid (HTF) through pipes installed in the environment (typically in the ground) to utilize the thermal gradient between the HTF and the environment for heating or cooling. HTFs typically used include ethanol or propylene glycol.

How are earth energy systems considered for Drinking Water Source Protection?

Earth energy systems have the potential to affect both the quantity and quality of source water for drinking purposes. The taking of water from surface water or groundwater regimes for open loop systems could have an affect on the water budget for a given area. The presence of the HTF has the potential to impact the quality of source waters if it is released into the environment and could, therefore, be considered a threat to the quality of the source water. The presence of wells for the purpose of earth energy systems may also serve as a conduit or transport pathway for the potential transfer of contaminants from the surface down to aquifers or for water between aquifers within the ground.

Earth Energy Systems and Water Quantity Risks

Where these systems extract water from the environment, this withdrawal should be considered under the water budget and water quantity risk assessment, where applicable. It is estimated that single residential systems typically use 25 to 40 litres per minute for heating and cooling, with maximums of 25000 to 40000 litres per day. Larger commercial or industrial systems would use even greater amounts of water.

While permits to take water for residential earth energy water taking systems are not required if they are for normal household use (such as heating), the withdrawal should be considered in the overall water budget, particularly at a Tier 3 stage.

It should be further noted that the operation of open loop systems could have a notable effect on the groundwater flow regime through the induction of piezometric changes due to the withdrawal and recharge of the water used.



Earth Energy Systems and Water Quality Risks

The withdrawal and recharge of water for use in earth energy systems can result in a thermal gradient in the groundwater regime, but this is typically limited to a local effect. Depending on the degree to which the temperature of the water changes, the configuration of the system and the nature of the hydrogeochemical environment, it could also induce minor changes in groundwater chemistry but not likely induce threats to water quality.

The presence of HTFs in the subsurface in earth energy systems can pose a threat to water quality, particularly if they should leak in the subsurface piping. While this activity is not a prescribed threat under the current legislation, preliminary analysis suggests that:

- residential systems with low volumes of HTFs, would be considered a low drinking water threat in areas with a vulnerability of greater than 7, and
- larger commercial or industrial systems with higher volumes of HTFs would be a:
 - significant drinking water threat in areas with a vulnerability score of 10,
 - moderate threat in areas with vulnerability scores between 7.5 and <10, and
 - low threat in areas with vulnerability scores between 5 and <7.5.

Earth Energy Systems as Transport Pathways

The presence of boreholes or wells associated with these systems could be considered a transport pathway in the Assessment Report, where its construction provides a conduit from the surface down to an aquifer or allows for enhanced flow between aquifers. In this circumstance, the groundwater vulnerability may be adjusted higher to account for the transport pathway. Under the current legislation, where a transport pathway is confirmed as a factor in contributing to a significant drinking water threat, addressing the pathway could be part of the risk management plan for addressing such a threat. This could include, but not be limited to:

- requiring or confirming that the construction complies with CSA requirements
- testing the well or boring, where possible, to determine if it provides a conduit for flow
- monitoring the system to determine if there is enhanced flow or if there is any loss of HTF from the system
- providing an emergency contingency plan in the event that there is a leak to minimize the impact on source waters
- restricting the installation or application of earth energy systems
- decommissioning faulty or high risk earth energy systems

Earth Energy Systems with Source Water Issues

Where there is an existing deterioration of water quantity or quality for a municipal residential drinking water system, this can be considered an issue under the Clean Water Act. Where such



an impact on source water is associated with an earth energy system, the system could be considered a significant threat and require risk management measures, as mentioned above, to mitigate the risk to the drinking water supply.

Summary

Considerations of Earth Energy Systems in drinking water source protection can be done as part of the assessment of transport pathways. Where such pathways are associated with significant threats to drinking water sources, they could be addressed in a risk management plan for that threat.

The activity of Earth Energy Systems is not a prescribed threat under the current regulations. However, if it were to be added, preliminary analysis suggests that it would only be a significant threat for ethanol and propylene glycol heat transfer fluids in a relatively large volume commercial/industrial system in a vulnerable area with a score of 10. Within a vulnerable area of any lesser score with such a system or any residential system, this activity would not be a significant threat under the current assessment.

Additional Information

For more information on these types of systems, please refer to the Technical Bulletin on Constructing Earth Energy Systems in Ontario released in September 2009. <http://www.ene.gov.on.ca/publications/7219e.pdf>