EVALUATION
OF
GEOTHERMAL ENERGY POTENTIAL
IN
SPRINGHILL, NOVA SCOTIA

PREPARED FOR:
NOVA SCOTIA DEPARTMENT OF ENERGY,
NOVA SCOTIA DEPT. OF NATURAL RESOURCES,
AND
THE TOWN OF SPRINGHILL

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EXECUTIVE SUMMARY

The Government of Nova Scotia has publicly stated its commitment to increase the province's reliance on renewable energy sources. Heating and cooling typically account for 60% of the total energy requirements for commercial, institutional and residential buildings, thus making it an important component of the overall energy and greenhouse gas emission picture. The objective of this review was to meet with municipal officials in the Town of Springhill, which lies within the boundaries of the Springhill Geothermal Resource Area (SGRA), to determine their continuing interest in geothermal resource development, to assess the relevant information currently available, and to identify what additional information is required for a detailed evaluation of the resource potential. Several geothermal mine water systems have been implemented in Springhill during the past 17 years and are currently operating.

Cavity Thermal Energy Storage.

Significant CTES-type geothermal resources have been identified associated with extensive abandoned subsurface mine workings. These resources have the potential to provide thousands of megawatt-hours of heating and cooling energy per year. Considerable information on the geology, hydrogeology and thermal regime of the area already exists, especially for the shallower portions of the mine workings. The workings extend to a depth in excess of 1000 m. The near surface mine water has an average temperature of approximately 15°C, but could increase slightly due to upward circulation of deeper water. Deeper mine waters could reach temperatures in excess of 35°C, given the local geothermal gradient. The mine water is hard, has a slightly alkaline pH, and is chemically dominated by calcium and bicarbonate. Deeper waters are strongly reducing with significant iron, ammonia, and hydrogen sulphide concentrations. Introduction of oxygen during reinjection of waters into the workings can lead to bio-fouling problems.

Additional field work is required to be able to fully delineate the CTES resource potential and to estimate the energy requirements for heating and cooling of buildings for potential clients in the town's business park. In accordance with the Public Utilities Act, the development and distribution of geothermal energy will require the establishment of a public utility that can co-ordinate the development, delivery and regulation of this energy resource. The utility also may be able to co-ordinate the distribution of other types of renewable energy production being developed in the area. The Town of Springhill, through its Earth Energy Committee, and the Provincial Government should determine, in consultation with other interested stakeholders, the mandate and establishment of this new renewable resource utility.

It is recommended that a technical working group be established by the Town of Springhill to co-ordinate the collection of the additional information required for a full evaluation of the CTES resource and that the Provincial Government should financially support the Town in the collection and evaluation of this additional information. The working group should also address issues arising from the current operating systems.

TABLE OF CONTENTS

Evaluation of Geothermal Energy Potential in Springhill, Nova Scotia

1.0 BACKGROUND

In the past two decades there has been an interest in exploring and developing, if possible, alternative energy sources in Atlantic Canada because of the region's high energy costs. On September 20th, 2006, the Minister for the Department of Energy in Nova Scotia, Mr. Bill Dooks, announced that the "government is making a commitment to renewable energy in Nova Scotia" and that "by 2013 the province wants at least 20% of Nova Scotia's electricity to be produced by renewable energy" (Nova Scotia Department of Energy, 2006). Although the announcement focused on the production of electricity using renewable energy sources, such as wind, tidal, solar, hydro, and biomass, there is also a need to explore and develop renewable energy sources for heating and cooling of buildings that will also reduce electrical consumption. Heating and cooling typically account for 60% of all energy used for commercial, institutional and residential buildings (NRCan, 2006) and, therefore, represents an important component of the overall energy and greenhouse gas emission picture.

The Earth is a natural store for heat absorbed from solar radiation and also generates heat internally. This internal heat production creates a geothermal gradient with heat flow toward the surface of the Earth. Typically, the temperature increases with depth along the geothermal gradient at an average rate of 25°C/km (Jessop, 1976). Deep sedimentary basins have been identified throughout the world as potential targets for the exploration of geothermal energy because of the presence of significant quantities of groundwater, which is a major medium for transferring and transporting heat from the rock at depth. In the 1980s, the Earth Physics Branch of Energy, Mines and Resources Canada (now Natural Resources Canada) initiated several geothermal investigations throughout Atlantic Canada and identified the Carboniferous sedimentary basins in Nova Scotia as having normal to above average temperature gradients.

The Earth Physics Branch studies measured temperature gradients and examined groundwater flow on a basin-wide scale to determine the geothermal potential of the rocks at depths greater than one kilometer for the purpose of direct space heating, similar to projects operating in the Paris Basin of France (Jessop, 1976). These studies did not include any investigation of the potential of the local shallower flooded coal mine workings as an energy store or source of heating, nor did they consider the potential for cold storage and cooling.

Springhill has been a world leader in championing the use of groundwater from flooded coal mine workings for heating and cooling of buildings since 1989. Watzlaf and Ackman (2006) have documented other attempts to follow the lead of Springhill. Since the original activity in the first half of the 1990s, the implementation of the technology in Springhill has not progressed as originally envisaged. Renewed interest in developing energy alternatives, as indicated by the September announcement by the Minister of Energy for Nova Scotia, has prompted this current consultation and assessment.

1.1 Terms of Reference

The author was invited by the Department of Natural Resources (DNR) and the Department of Energy for the Province of Nova Scotia to meet with municipal officials for the Town of Springhill in order to determine their continued interest in the potential for geothermal resource development and to assess the relevant information/data currently available. In addition, a meeting with DNR officials was to provide information on local coal mine records, plans, and methods of mine development.

As a follow up to these meetings, the author was asked to prepare a short report with the objective to provide:

1. an assessment of the information currently available for geothermal resource assessment and identification of any additional information that should be acquired,
2. a review of information generally utilized for geothermal resource investigation and assessment,
3. a preliminary evaluation of the geothermal resource potential,
4. an identification of critical issues that should be addressed to support sustainable use of the geothermal resource,
5. an explanation of alternative roles a municipality could undertake to administer geothermal resources in Nova Scotia under applicable legislation (Utility and Review Board Act); and, what resources (human and financial) would be required to assume each of these roles,
6. recommendations on any additional studies that would assist the municipality to administer and develop geothermal resources, and
7. references to case studies, professional services and contacts that would assist municipalities in their efforts to develop geothermal resource potential.

2.0 INTRODUCTION

Springhill is situated in north-central Nova Scotia within the Cumberland Basin, which contains sedimentary rocks that include several major coal-bearing units. The Town of Springhill is centered on latitude 45° 39' 00"N and longitude 64° 03' 30"W. An industrial park area has been designated immediately west of the town and overlies the majority of old abandoned mine workings in the area that have flooded since the cessation of mining in 1958.

The climate of the Springhill area is influenced by the water bodies of the Gulf of St. Lawrence and the Bay of Fundy (Atlantic Ocean), which moderate temperatures. The average annual temperature in the area is approximately 5.9°C and precipitation is distributed throughout the year with annual totals of approximately 1100 mm. Canadian climate normals for the period of 1971 to 2000 for nearby Truro indicate that the maximum and minimum daily temperatures are 24.1°C / 12.7°C in July and -1.5°C / -12.3°C in January (Environment Canada, 2006). Extreme maximum and minimum temperatures have been 33.5°C in July and -34.4°C in February. The average annual number of heating degree-days is 4518 and the number of cooling degree-days is 92.

From the climate data, it would appear that heating would be the primary consideration, however; in industrial and commercial buildings, excess heat is often produced from manufacturing equipment, lighting, and office equipment such as computers. Therefore, there is always an increased demand for cooling. In a recent study for the Town of Stellarton, CBCL (2006) report typical cooling requirements for light manufacturing facilities as 100 to 200 ft^2/ton of refrigeration, while heavy manufacturing facilities range from 60 to 100 ft^2/ton (Note: there are 10.75 ft^2 per m^2, so that 100 ft^2 is equal to 9.3 m^2).

3.0 SITE VISIT, SEPTEMBER 2006

The author visited with DNR staff in Halifax on September 18th and 22nd to discuss information relating to the coal mining operations and the context of the study. The Springhill area was visited from September 18th to 20th, during which time a series of meetings were held with municipal and county officials. A tour of the new Dr. Carson and Marion Murray Community Centre arena facility and the Ropak Corporation industrial geothermal installation were arranged during the author's visit. Discussions were held with personnel of Stealth Ventures, a company exploring the potential for methane recovery from unmined coal seams in the local area, later in the week. Subsequent to the site visit, discussions were also held with Vector Wind Energy, an Ottawa based company currently constructing wind powered electrical generating facilities in the Springhill area.

4.0 GEOTHERMAL RESOURCE INVESTIGATION OVERVIEW

Geothermal resource potential can be divided into three main categories based on the type of applications that are possible, which are usually related to the subsurface thermal conditions. These three categories relate to:

1. generation of electricity where temperatures exceed 150°C,
2. high temperature resources (>60°C) for direct space heating,
3. low temperature resources (<60°C) for space heating with or without the aid of heat pumps.

Category three utilization usually focuses on shallow boreholes (<200 m deep) and can incorporate applications for both heating and cooling by employing heat exchangers and heat pumps.

Traditional applications in all three categories have considered only the direct utilization of existing geothermal conditions. In this type of system, groundwater at the ambient subsurface temperature is employed as the ground source fluid. Heat is either added or removed from this water during cooling and heating applications, respectively, and the prime consideration is the ability to maintain a temperature differential between the groundwater and the cooling/heating plant fluid.

The concept of utilizing the subsurface for energy storage, especially in categories 2 and 3 introduces the ability to enhance and upgrade low-grade geothermal resources. Most subsurface thermal energy storage (TES) applications to date have involved the development of aquifers (ATES) with a water well field, or high density borehole systems (BTES) that transfer thermal energy between a carrier fluid and the subsurface materials into which the boreholes are drilled. Both ATES and BTES systems are being developed world wide for heating and cooling applications ranging from individual homes to large industrial and institutional complexes. To maximize the storage potential, one of the key considerations is to balance the heating and cooling loads as much as possible. Mr. Frank Cruickshanks of Environment Canada in Dartmouth is a a key player for this technology in Canada.

The utilization of subsurface caverns, often old mine workings, for thermal energy storage (CTES) has also been investigated (Michel et al., 2002; Watzlaf and Ackman, 2006). Essentially, there are two basic design concepts for seasonal storage of thermal energy in caverns, either as a single cavern system or as separate hot (or warm) and cold water stores within the workings.

In large isolated abandoned mine workings or deep workings with little perturbation from interconnecting groundwater flow paths, both hot and cold water theoretically could be stored simultaneously in what is known as a stratified layered system (SL system). In a SL system, the hot water 'floats' above the cold water because of density stratification, similar to lake water in the summer. With no or little perturbation of the static condition, the thermal stratification could be maintained over seasonal periods, provided the respective quantities are adequate and the cavern store remains stable. A zone of convection mixing and diffusion will occur at the boundary between the two thermal strata. Hence the depth of the cavern must be such that it can accommodate both the hot and cold water strata as well as the thickness of the diffuse zone.

In many abandoned mine workings that have subsequently flooded, interconnections between levels may provide pathways for deeper geothermally heated waters to migrate upward due to their lower density, and for cooler near surface waters to sink due to their higher density. This results in the formation of a slowly circulating convection system similar to water in a pot being heated on a stove. Therefore, one should expect a certain amount of circulation to develop in deep, well connected mine workings, whereas isolated shallow workings will contain only cooler near surface waters.

The second method of cavern thermal energy storage is to store the cold and hot thermal energies in separate water filled caverns or abandoned mine workings. Some interconnectivity between stores can be tolerated in such a scheme, provided thermal mixing is of limited occurrence. In such separate stores, the cold water provides air conditioning by acting as a heat sink for warm building air and is returned to the hot store cavern after passing through the heat exchanger. Water from the hot water store is circulated during the winter for transfer of its heat to the building air. The cooled water is then returned to the cold store. If required, the cold store can be enhanced by exchanging excess heat externally during the winter.

To evaluate geothermal energy resource potential, it is important to understand subsurface conditions in the area, especially the geology, hydrogeology, and thermal regime. In the case of mine workings, the configuration, extent and volume of the cavern(s) must also be considered. Based on the subsurface investigations one must then consider the feasibility of potential applications for the identified resource and whether it is better to utilize the resource directly (ambient temperature) or as an enhanced thermal energy store.

From a geological perspective, it is important to understand the rock units that are present as they relate to thermal conductivity, structure, rock type(s), and relationship(s) between units. For mine water projects, structural considerations must be given to the stability of the old mine workings and the potential for subsurface collapse if significant changes in water pressure are expected. The geological parameters relate directly to the ability of water to flow or not flow through the subsurface and also influence the chemistry of local groundwater. Collectively they are referred to as the hydrostratigraphy of an area.

Physical hydrogeology focuses on the flow of fluids (usually water) through the subsurface and is, therefore, dependent in large part on the hydrostratigraphy. To provide reliable estimates of flow, it is important to understand permeability, well capacities, drawdown caused by well pumping, and changes in flow pattern that might be caused by pumping. Water volume (quantity) is of concern when large-scale systems are under consideration, even for direct mine water / CTES applications where one might assume that large volumes are readily available. In addition, the chemistry of groundwater is of interest when considering corrosion or scaling issues and quality of water supply to other users, especially if there is a potential for deterioration in quality due to mixing with poor quality water. This is often encountered in coastal areas where salt water intrusion occurs due to over pumping of an aquifer too close to the ocean. Chemical issues can also arise due to the introduction of oxygen to a system that was oxygen free (reducing) or by optimizing growth conditions for bacteria. Temperature changes in the water of even a few degrees can also lead to chemical and bacteriological issues.

The thermal regime includes information on water temperature, knowledge of the geothermal gradient, and the thermal conductivity of the subsurface materials. In any system it is important to understand how the heat will circulate or dissipate in the subsurface, especially when storage is considered as part of the design. Subsurface materials with high thermal conductivities may enhance storage by readily transferring some of the heat from the water to the rock where it is stored locally rather than being transported further away. If significant water flow is expected, the heat will be carried by the water and affect the thermal distribution. For example, upward groundwater flow in an area can transport relatively high temperatures to surface, as found for many hot springs in the world. Water flow within boreholes, from one depth interval to another, can also generate false thermal gradients that must be identified during the investigative stage of development in order for proper evaluation of the resource potential and for proper system design to proceed.

On the basis of the subsurface information gathered, it is then possible to consider the types of applications and design configurations that are feasible. For heating and cooling applications it is important to consider whether there will be a number of individual stand alone users or whether there will be a single district type system that interconnects a number of users or individual buildings within a complex. The requirements for heating and cooling will vary with building use so that every building will have a somewhat unique consideration. Stand alone usage usually results in the need for more access points (wells) to the resource and can often create conflicts between users. The many stand alone ATES systems operating at industrial plants located at an industrial park in Winnipeg provide a good example of non co-ordinated use leading to the development of a large heat plume within the aquifer underlying the city (Ferguson and Woodbury, 2005). It also speaks of the importance of maintaining a balanced system. District systems have an advantage of being able to use the unique energy requirements of each building to design a system that can maximize energy use and minimize energy waste while minimizing conflicts between users. However, they also have a major disadvantage in that more piping of groundwater is required and there can be extensive heat loss during this transportation, which can negate many of the economic benefits.

5.0 ASSESSMENT OF EXISTING SUBSURFACE INFORMATION CURRENTLY AVAILABLE FOR SPRINGHILL

This section provides a brief summary of relevant data that exist for the Springhill area and directs the reader to the more detailed studies from which these data were sourced. Investigation of the potential for utilizing the mine workings at Springhill was first suggested in 1984 by Mr. Ralph Ross, who continues to be one of the main proponents and the most knowledgeable on the work completed to date. Test drilling of wells began in 1987 for the development of independent systems for businesses in Springhill and the industrial park. Several companies now operate mine water systems and in the fall of 2004, Springhill's Dr. Carson and Marion Murray Community Centre began operation of its arena facility with mine water as a cooling source. Interest has also been expressed by other potential businesses and community organizations so that additional geothermal development is expected in the future. All of the available reports have been compiled by the Town for reference by its 'Earth Energy Committee' and this compilation was made available to the author during his visit. Temperature data for the community centre were also provided after the visit. In addition, Springhill has hosted a conference on mine water utilization (Katherine Arkay Consulting, 1993) and hired consultants to examine the engineering aspects of developing the system (Vaughan Engineering Associates Limited, 1992), and the marketing aspects (Atlantic Institute for Sustainability Inc. and David C. Stewart & Associates Inc., 2004). Together, all of these reports provide important information on what is known, which aids in delineating what work is still required to fully evaluate the geothermal potential.

5.1 Geology

The geology of the Cumberland Basin in the Springhill area has been well documented through numerous studies, including Bell (1938), Shaw (1951), Copeland (1958), and Calder (1995). Due to the extensive production of coal for nearly 100 years from several seams to depths approaching 1200 m, the subsurface geology has been recorded both within the workings and from numerous boreholes probing coal seam quality and continuity. The mine workings in the Springhill area are in fact the deepest coal mine workings in Canada. More recently, deep borehole investigations by several companies have focused on the generation and recovery of methane gas associated with the unmined portions of the coal seams.

The Basin is faulted and folded in the Springhill area and dips to the west-southwest. The stratigraphic sequence contains Late Carboniferous age coal-bearing sediments that are estimated to average 335 m in thickness (Copeland, 1958). Although more than 20 individual seams have been identified, only five were thick enough to permit economic exploitation along the northwest limb of the Springhill anticline. This sequence of coal strata are generally found within competent sandstones, although finer grained shales and mudstones also occur.

5.2 Mine Development (Distribution of Potential Stores)

Most of the mining in Springhill has occurred in the area underlying the western part of the town, including the industrial park, but extends significantly beyond the park area for Seam 2 workings. Systematic mining, which began in 1868 and continued into the mid twentieth century, has created an extensive interconnected network of workings for each of the five mined seams. Seams 1 and 3 contain upper and lower subseams that were mined separately in places so that a total of seven distinct mining levels exist. All of the seams were accessed along slopes that were opened in the subcrop area, with subsurface development work progressing down dip to the west. The seams were numbered according to the order that they were initially mined, rather than by stratigraphic position (Figure 1). The degree to which any seam was mined depended on the thickness, continuity and quality of the coal. The mining technique varied with subsurface

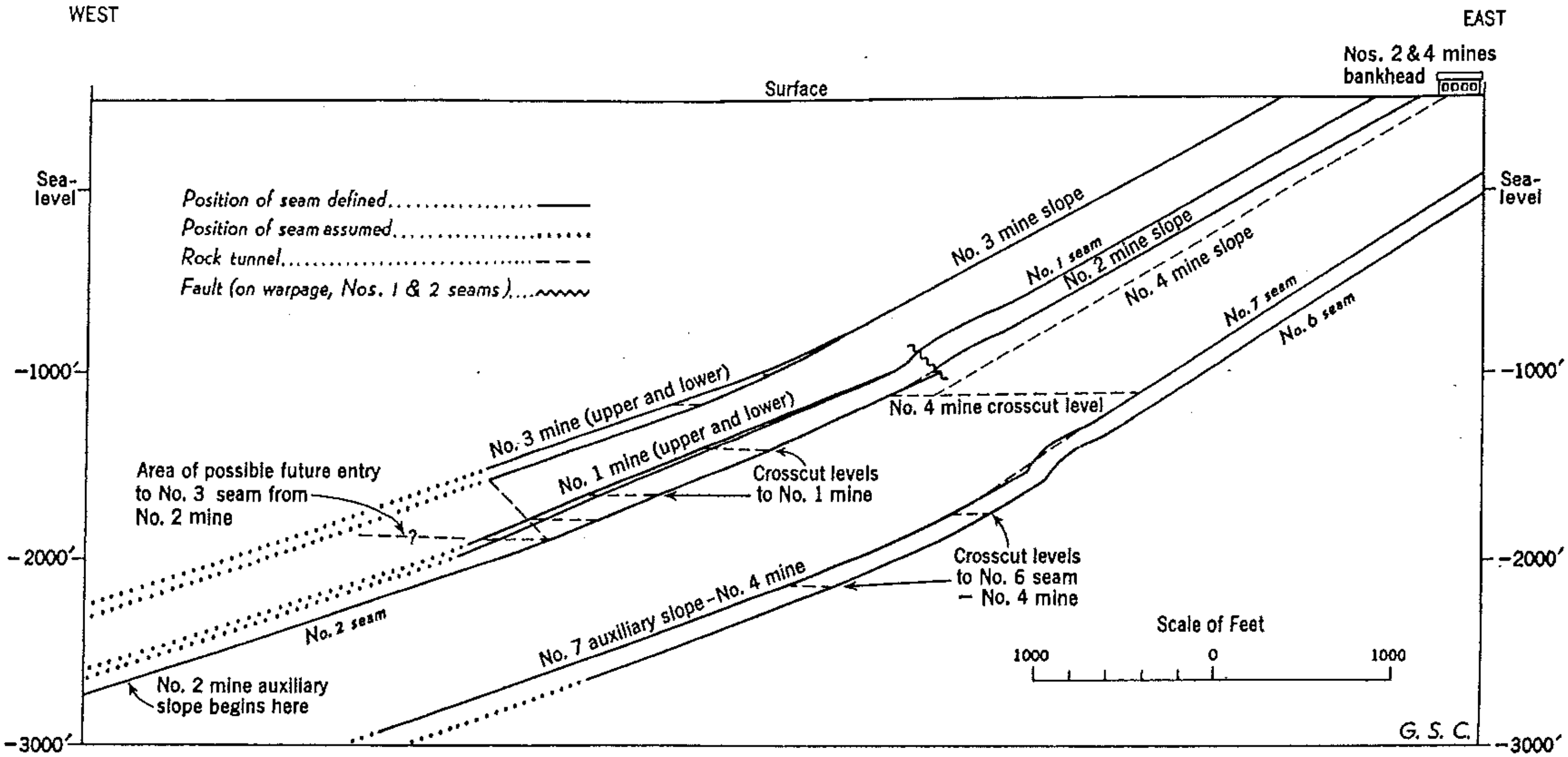

Figure 3. *Schematic cross-section through main slope pillar, Springhill coalfield, N.S. (Drawn in part from sections and plans of Cumberland Rail and Coal Co.)*

Figure 1: Schematic section of coal seams and working levels at Springhill. (From M. J. Copeland, 1958; Figure 3, p. 66).

conditions. The most common method was room and pillar, but included long wall and pillar recovery. Herteis (2006) estimated that approximately 68% of the coal from the number 2 Seam was recovered within the mining area, but due to collapse within the workings only 25% of the void space remains. Some workings were intentionally collapsed as pillars were removed, while others have subsequently collapsed with time. There have also been a number of cave-ins, fires and explosions through the many years of operation, which have led in some instances to sealing (separating) workings. Copeland (1958) provides a summary of the geology, mining history and annual mined tonnages up to 1956, just two years before the mines closed, as well as estimates of coal reserves. Mine records have been digitized by DNR staff and compiled in maps to show the distribution of workings for each seam. Figure 2 is a composite drawing that illustrates the extent of subsurface mining for the five seams (seven levels). Herteis (2006) has attempted to delineate in detail the individual workings in Seam 2 using GIS technology. Very little mining was conducted within approximately 30 m of surface as a precaution against potential roof collapse.

5.3 Hydrogeology

The Town of Springhill has in the past developed wells to supply groundwater as a municipal supply. A test well drilling program south of Springhill, in the late 1970s, found that local sandstones of the Cumberland Group contained excellent primary and secondary permeability and a high average storativity value of 1.49×10^{-3} (Vaughan and Somers, 1980). Well yields in the sandstone varied from 7.6 to 23 L/s (100 to 300 Igpm). In addition, a large surficial sand and gravel aquifer south and east of the community was also identified as a potential water supply source. The groundwater quality was considered to be good, with low total dissolved solids. More recently, Springhill has switched to a surface water supply.

Test drilling into the old mine workings for development of the geothermal energy systems has been conducted by several consultants, including Jacques Whitford & Associates Limited (JWA 1987, 1988), Ralph Ross (1992), and Hy-Grade Geoscience (2004). All of the drilling has been confined to relatively shallow depths of less than 100 m (Ross and Kavanaugh, 1993). The greatest problem encountered was identifying the exact location of the workings. Test wells that did not intersect workings, but rather pillars, generally provided little water and were abandoned. Those wells that did encounter the workings usually had test flow rates exceeding 10 to 15 L/s. Blow back testing with air to estimate yields led to errors due to loss of the air and water into the workings rather than back up the borehole. Pumping tests, or in the case of the community centre wells, injection tests, were required to evaluate true well capacities.

Water chemistry analyses identified the shallower groundwater as similar in composition to the town's former groundwater supply (hard calcium bicarbonate type); however, with increased pumping and/or depth the water chemistry displayed a shift to a hard calcium sulphate/bicarbonate type that contained significant iron concentrations and strongly reducing conditions. The reducing conditions led to the formation of hydrogen sulphide gas and ammonia in the water (JWA, 1988). The inadvertent introduction of oxygen into

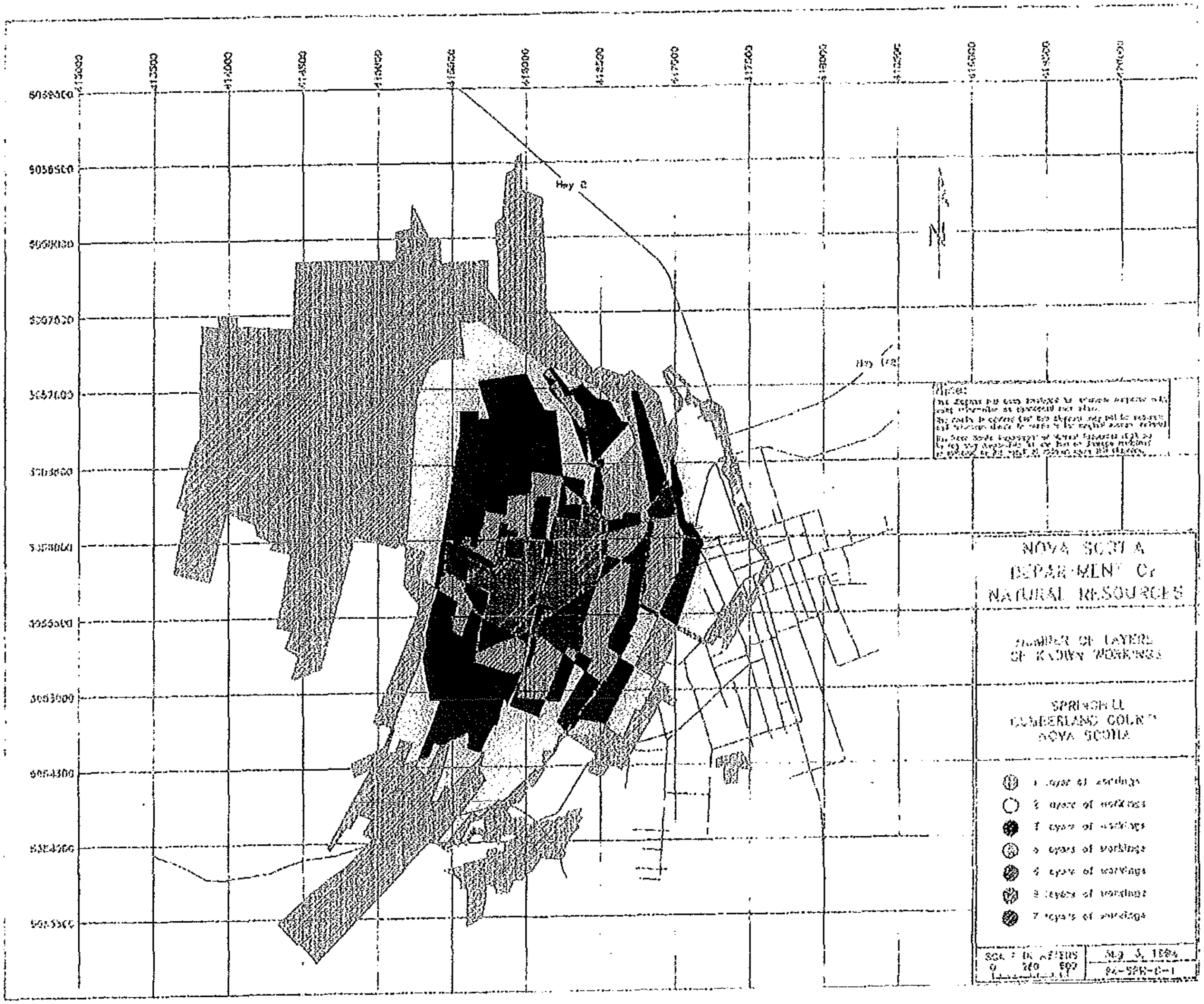

Figure 2: Composite plan showing extent of underground workings at Springhill for seven levels of mining operations. (From Nova Scotia Department of Natural Resources).

mine waters through wells operated by Surrette Battery Limited caused well clogging by iron bacteria and led to a study of the problem by Dr. John Young of Saint Mary's University in 1996.

5.4 Geothermal Data

Temperature data for the mine waters are limited to measurements taken during the drilling and testing of wells in the 1987 to 1991 period. Initial measurements at the time of drilling indicate that water temperatures were generally between 11.5 and 13.5°C. By comparison, shallow groundwater temperatures were approximately 9°C. During several days of continuous pumping tests, temperatures tended to increase to as high as 18°C. This rise in temperature was attributed to the upwelling of warmer deeper mine waters as the pumping tests progressed. Measurements of supply temperatures at several of the geothermal installations by Bagnell (1994) in the summer of 1994 indicate that operating temperatures were between 11.5 and 16.9°C at that time.

Daily well water supply temperatures for the arena facility in the community centre are quite variable, but display an increasing trend since opening in 2004 (average temperatures: 15.5°C for November 2004 to March 2005; 20°C for September 2005 to March 2006; 22°C for September 2006 to January 2007) (Figure 3). The temperatures start relatively high in the fall and decrease to a low in January, at which time they start to rise again. The seasonal fluctuation probably reflects the capture and reuse of the waste heat within the building during the winter when outside temperatures are at a minimum; this is also apparent in the lower differentials between supply and return water temperatures during this period. Although the upward year to year trend might be due to the upward migration of deeper mine waters, the close proximity of the pumping and reinjection wells for the community centre (approximately 30 m apart), their position close to Ropak Corporation wells (<100m) and the seasonal variation in supply temperatures could be indicative of an interference problem. Utilization of water with elevated temperatures for cooling is not efficient and needs to be addressed.

Temperature data from deep boreholes in the area were compiled by J. A. Leslie & Associates (Leslie 1981, 1982) as part of a federal government investigation of the geothermal potential of deep sedimentary basins in the Maritimes. Calculated geothermal gradients for the local Cumberland Basin area average 25°C/km, and are relatively typical for deep sedimentary basins in Canada. Since the deepest mine workings extend to a depth of just over a km and near surface groundwater temperatures are approximately 9°C, it is possible that the deepest mine waters could attain temperatures in excess of 35°C. However, no measurements of deep mine waters are available at present. To the west of Springhill, where the basin sediments thicken, there is a potential for the direct testing occurrence of deep thermal waters with temperatures in excess of 60°C; however, again no deep boreholes or temperature data exist. This area is beyond the scope of the present study, as is the abandoned coal mine workings in the Joggins area of Cumberland County.

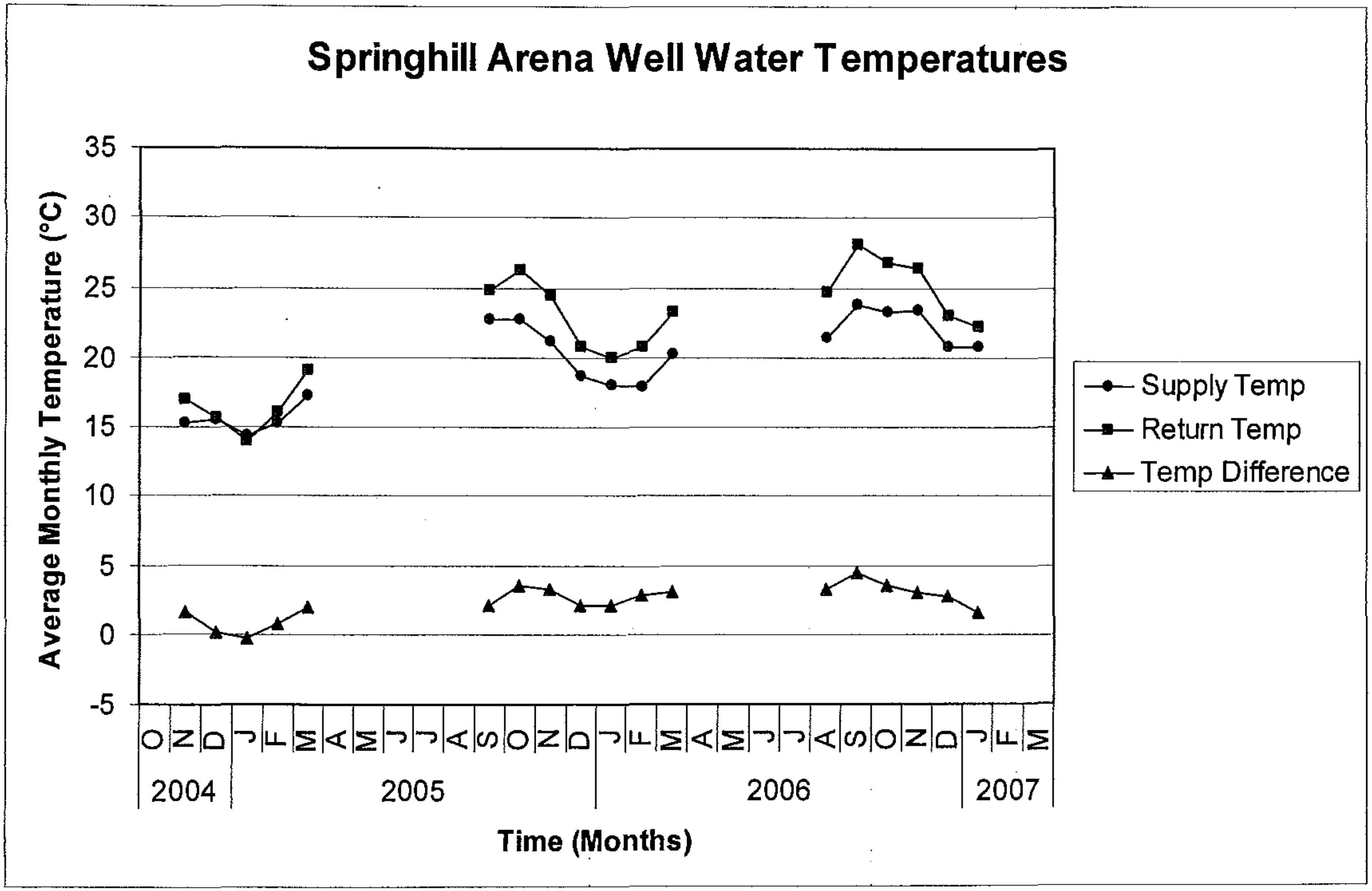

Figure 3 Monthly average well water temperatures for Springhill's Dr. Carson and Marion Murray Community Centre arena facility since the start of operations in 2004.

6.0 GEOTHERMAL RESOURCE POTENTIAL FOR SPRINGHILL

The Town of Springhill first considered the possibility of a geothermal resource from the water in the abandoned mine workings in 1984 when Mr. R. Ross raised the issue. Investigations began in 1987 and resulted in the first Canadian operational system coming on line in 1989 at the Ropak plastic manufacturing facility, where cooling was the major requirement. Additional geothermal users tapped into the mine workings with wells during the early 1990s so that by 1993, seven geothermal systems were in operation. Since the mid 1990s, only the new community centre arena complex was added in 2004.

All of these systems demonstrate that the mine waters do possess a potential for providing heating and cooling energy. However, the actual potential depends primarily on the size (volume) of the workings and in-situ temperatures. System design can also play a secondary role through improvements in energy efficiency.

The first attempt to estimate the volume of mine workings was made by Vaughan Engineering Associates Limited (VEAL) in a 1992 report on the feasibility of establishing a community system in Springhill. VEAL estimated, on the basis of a blanket 20% porosity for the mine workings, that the No. 2 Seam could contain approximately 4,350,000 m^3 of water, while the No. 1 Seam (upper and lower) held the potential for 1,058,400 m^3 of water. Herteis (2006) undertook a much more detailed GIS analysis of the No. 2 Seam workings and estimated a total of 5,582,588 m^3 of water. No estimates have been established for other mine workings in seams 3, 4, 6, or 7, although operational geothermal wells are tapping water currently from Seams 6 and 7.

Most demonstration and operational wells to date have been drilled into the shallower mine workings, close to the facilities in need of water. No drilling has been undertaken to examine the mine workings at depth. Herteis (2006) estimated an average ground water temperature of 15°C based on five operating wells (GTW-6 to 10). Initial groundwater temperatures for the 18 wells drilled to date have ranged from as low as 9°C to as high as 16.75°C. Temperatures during short duration pumping tests have reached 18.8°C (GTW-6), probably due to flow from depth within the mine workings.

One can roughly estimate the energy potential of a geothermal resource for heating and cooling by examining ideal system requirements. Although the actual requirements for heating and especially cooling will be dependent on the individual user's operations, it is possible to calculate a baseline energy requirement for a building where one is simply raising or lowering the outside air temperature using solely groundwater and no heat pumps. This would provide an air temperature that is equal to the groundwater temperature, assuming 100% efficiency. Further heating or cooling would require heat pumps or other supplemental systems. Often cooling as low as the groundwater temperature is not required. Typical shallow open loop heat pump systems require groundwater flow rates of 1 to 3 litres per minute per kilowatt (kW) of heating or cooling (PDEP, 2001).

Development of the mine workings as an energy source assumes that all of the workings are fully interconnected and that the water will be used at the ambient subsurface temperature for heating or cooling as required. For this design, withdrawl (pumping) wells are placed at convenient locations so as to intersect the mine workings. A second set of reinjection wells are also placed to intersect the workings, but at a distance sufficiently removed from the withdrawl wells as to not create any temperature interference. At Springhill, this might be accomplished by utilizing different seams for the withdrawl and reinjection wells. For this model, it is assumed that the temperature of the water will re-equilibrate to that of the subsurface store before the water is withdrawn again. Each well is operated in one mode only, either for withdrawl or reinjection.

It requires 4,186 joules (J) of energy to change the temperature of 1 kg of water by 1°C. Hence, cooling 1 kg (or 1 litre) of water releases about 4,200 J (4.2 kJ) of energy per degree of temperature change, while heating absorbs about 4.2 kJ. If mine water is pumped at a rate of 10 litres per second (L/s), the total quantity of water circulated in one day (24 hours) will be 864,000 litres. If the temperature of this water is changed by 1°C, the energy potential is:

$$1^{\circ}\text{C} \times 4200 \text{ J/L} \times 864{,}000 \text{ L/d} \times (0.2778\times10^{-6}) = 1{,}008 \text{ kWh/d} = 1.01 \text{ MWh/d}$$

Increasing either the temperature differential (net change) or the flow rate will increase the daily energy potential. For example, pumping at a rate of 20 L/s with a temperature change of 10°C would result in a value of 20.2 megawatt hours per day (MWh/d). For a given energy requirement, an increase in the temperature differential will permit a decrease in the flow rate. Thus it is important to consider both parameters for system design.

Long term climate data available for Truro, located 106 km southeast of Springhill, indicate that January is the coldest month with an average temperature of -6.9°C, while July is the warmest month with an average temperature of +18.4°C (Environment Canada, 2006). From the geothermal data analysis, a well would likely encounter an average water temperature in the mine workings of 15°C, although upward flow of water within the workings may raise this temperature slightly.

If a single store concept is utilized, the temperature of outside air brought into a building will be raised or lowered to the constant water temperature of 15°C, assuming 100% efficiency with no transmission or conversion losses. Table 1 shows the resulting temperature differentials and the calculated energy potential available for flow rates of 10, 30 and 60 L/s. Most of the energy is for heating of outside air between September and June. With this constant water temperature, cooling of outside air to 15°C is only necessary during July and August. The cooling potential represents only 5.2% of the total energy potential calculated; 22,445 MWh per year at a flow rate of 60 L/s.

Industrial processes and commercial operations often generate excess heat and significantly increase the cooling requirements beyond that of the outside air. Since the

Annual Energy Potential Calculations

	Days	Mean Ambient Temp (Celcius)	Mine Water Temp (Celcius)	Temp Difference (Celcius)	Geotherma System Function	Energy Potential MWh/day at flow of 10 litres/sec	Energy Potential MWh/day at flow of 30 litres/sec	Energy Potential MWh/day at flow of 60 litres/sec	Energy Potential MWh/month at flow of 10 litres/sec	Energy Potential MWh/month at flow of 30 litres/sec	Energy Potential MWh/month at flow of 60 litres/sec
January	31	-6.9	15	21.9	heating	22.1	66.3	132.5	685	2,054	4,108
February	28	-6.5	15	21.5	heating	21.7	65.0	130.1	607	1,821	3,642
March	31	-1.8	15	16.8	heating	16.9	50.8	101.7	525	1,576	3,151
April	30	3.9	15	11.1	heating	11.2	33.6	67.2	336	1,007	2,015
May	31	9.8	15	5.2	heating	5.2	15.7	31.5	163	488	975
June	30	14.7	15	0.3	maintenanc	0.3	0.9	1.8	9	27	54
July	31	18.4	15	-3.4	cooling	3.4	10.3	20.6	106	319	638
August	31	17.8	15	-2.8	cooling	2.8	8.5	16.9	88	263	525
Septembe	30	13.4	15	1.6	maintenanc	1.6	4.8	9.7	48	145	290
October	31	7.7	15	7.3	heating	7.4	22.1	44.2	228	685	1,369
November	30	2.8	15	12.2	heating	12.3	36.9	73.8	369	1,107	2,215
December	31	-3.5	15	18.5	heating	18.7	56.0	111.9	578	1,735	3,470
Annual	**365**	**5.8**	**15**	**9.2**					**3,742**	**11,227**	**22,453**

Table 1: Calculation of energy potential for mine water at a constant temperature of 15°C.

mine water temperature of 15°C is below normal room temperature (20°C), it is still possible to remove all of the excess internally generated heat using direct cooling with the mine water. This type of cooling potential is not shown in the table, but is expected to be significant for the business park clients and could be calculated on a case by case basis. Therefore, even this basic analysis should be considered as a minimum energy potential estimation.

The calculation of 22,445 MWh per year is based on a flow rate of 60 L/s, which would involve the circulation of 1,892,160 m^3 of water per year, or approximately 33% of the total volume calculated by Herteis (2006) for the No. 2 Seam. Therefore, circulation of mine water in the No. 2 Seam at an average rate of once per year would provide an estimated minimum of 67,000 MWh per year of heating and cooling energy. Water contained in the other mined seams would add to this total potential. Since all circulated water is reinjected back into the mine workings, the volume of water in the system never diminishes. Provided sufficient time is permitted for the reinjected water to re-equilibrate to 15°C, the energy potential becomes almost limitless.

A second concept, which requires a better understanding of the subsurface workings and a more detailed design, envisages two separate stores, one for cold storage and one for storage of heat. These stores must be relatively isolated from one another and should be capable of operating simultaneously. At Springhill, Seams 1, 2, and 4 may act as one reservoir, while Seams 6 and 7 form the second reservoir. Water is withdrawn from the hot store for heating of buildings by transferring the heat across a heat exchanger to the building loop. The chilled groundwater is then returned to the cold store. Water from the cold store is used for cooling of buildings with the aid of a heat exchanger, whereby heat is now transferred into the groundwater. This heated groundwater is then returned to the hot store. To optimally utilize the geothermal gradient present, the hot store would be located at depth and the cold store would be located closer to surface. Provision must be included in the design for differences in the total heating and cooling requirements of the buildings and for differences in water volumes circulated within each store. If required, water in the cold store can be further chilled on cold winter days to decrease temperatures, or the cold store can be designed to receive snow melt water in the spring. All of the groundwater should be returned to the mine workings and it is important to minimize energy losses during transmission of the water through pipelines during delivery to the customer. Ideally, such a two store system could increase the energy potential by over 35% because of the reuse of the waste heat or cold. Some of this energy also could be captured directly within the individual plant operation if their system is designed to utilize such secondary energy sources.

To consider the economic potential of the resource, it is necessary to calculate all of the costs (capital, maintenance and operating) involved in a conventional heating and cooling system as compared to a geothermal system. For the geothermal system, pumping costs are one of the largest operating costs to consider. Data from other thermal energy storage projects and widespread utilization of ground source heat pumps generally show that capital costs are higher for geothermal than for conventional systems by 20 to 50%; however, the operating costs are significantly lower (approximately 1/3). Maintenance costs for ground source heat pump systems are also about 33% of conventional systems (Watzlaf and Ackman, 2006). For the current calculations of energy potential, every one cent per kilowatt hour, or $10/MWh, of cost reduction would translate into an annual energy cost savings of $200,000 for a 20,000 MWh/yr operating system, or $1,000,000 per five cent cost reduction. A detailed analysis is beyond the scope of this report, but it is important to note that geothermal systems have proven to be cost effective in many applications.

7.0 CRITICAL ISSUES

7.1 CTES Development of Mine Workings

The subsurface mine workings at Springhill represent a major potential geothermal energy resource that will need to be developed and managed in a systematic manner. To date, only a small fraction of the potential resource has been tapped by individual users of the geothermal technology. Due to the slow development of the technology, the utilization has proceeded on a case by case basis; the primary concern being one of drilling a well successfully into the closest identified workings.

In Nova Scotia, geothermal resources are regulated under the Mineral Resources Act, which treats them as if they were a mineral resource. Through this Act, the rights to explore for and develop geothermal energy resources are issued by the Department of Natural Resources (DNR). In accordance with Section 8A, subsection 1, clauses a and b, of the Mineral Resources Act, the Governor in Council may designate geothermal resource areas, such as the Springhill Geothermal Resource Area (SGRA) (N.S. Order in Council 92-906 and 92-1025). The town originally received an exploration permit (SL4/93) that subsequently expired and is the subject of ongoing discussions with DNR.

In Springhill, most, but not all, of the mine workings lie beneath the business park land that is the primary target for development and is situated on the western edge of the town. Small businesses and municipal buildings in the western part of Springhill may also benefit from geothermal development. Ultimately, any development of geothermal resources must be approved by DNR. DNR has a responsibility to ensure that the resource is developed and managed in a manner that is in the best interests of the citizens of the province.

DNR has the authority to permit an individual or a company to develop a geothermal energy system for its private use. However, if that person or corporation "own, operate, manage or control ... any plant or equipment ... for the production, transmission, delivery or furnishing of geothermal energy or heat either directly or indirectly to or for the public", then they are considered to be a 'public utility' as defined by Section 2, clause e(vi) of the Public Utilities Act and are providing a 'service' if they are compensated for the production, transmission, delivery or furnishing of geothermal energy or heat to the public (Section 2, clause f(viii)).

The critical questions that need to be addressed if further development is to be encouraged in the Springhill area are: how should the geothermal resources at Springhill be developed and by whom? These questions are relevant for the business park, but also should address those areas of the SGRA that extend beyond the boundaries of the business park. For example, if a decision was made by a company to utilize geothermal energy from the mine workings beneath their facility, who would be charged with the responsibility of providing this 'service', or would the company be permitted to privately implement a geothermal system as has been the case to date? What about a neighbouring business that did not overlie any workings? Since the geothermal resource does not belong to the owner of the surface rights, could this nearby business ask permission to develop the resource underlying an adjacent property? How would future conflicts between users be determined and resolved?

The Town of Springhill in 2005 established an "Earth Energy Committee" that has a mandate "to foster stewardship (defined as preservation of the resource) and to promote Earth energy resources for economic and community development in the Springhill area" (EEC minutes, Oct. 19, 2005). This goes beyond geothermal to encompass all types of Earth energy types. There has been no geothermal development since the community centre arena complex in 2004, thus the committee has not yet had to play a decision making role for geothermal development. Mr. Ross, an advisor to the committee and a long term proponent for the technology, is a businessman who benefits directly from the installation of geothermal facilities and is probably the only knowledgeable person concerning all of the existing facilities. It is through his enthusiasm and commitment that the existing systems continue to operate. However, if development is to move forward, it would be unfair to Mr. Ross to place him in a conflict of interest situation, but at the same time his input and advice is very important for the future successful development and implementation of the geothermal technology. Ultimately, what is the authority of the Earth Energy Committee for development and management of geothermal resources in the SGRA?

Any development of the geothermal resources associated with the mine workings (either within or beyond the boundaries of the business park) must include a two line system (supply and return) and at least two wells (pumping and reinjection). This is imperative whether one is dealing with a single small-scale user, or a large district-scale operation. The wells must be sufficiently separated, or completed in separate workings (seams) to ensure no thermal short circuiting of the system. Thermal contamination between wells is the greatest concern for a CTES system. For those portions of the business park where multiple workings at different depths exist, this should not be difficult to achieve. When multiple users are utilizing the geothermal resource, there needs to be co-ordination of well and system development, i.e., overall management of the resource and its commercial development.

At the current level of activity, each geothermal user is more or less on their own when it comes to system development, operation and maintenance. Drilling has been and continues to be a hit or miss game, often financed at least in part by the town, but the successful wells appear to 'belong' to the geothermal user. Operational/maintenance issues are dealt with individually or not at all. An exception was the iron bacteria biofouling problem that arose in the mid 1990s when oxygen was accidently (poor design?) introduced to the workings during reinjection; the federal government provided funding for a major study. Currently, the arena's reinjection well is uncapped, overflowing and discharging iron-rich water to surface drainage, while the temperature of the supply well water continues to rise on a year to year basis. Is this latter issue a case of thermal contamination from other geothermal wells associated with the arena, the adjacent Ropak complex, or other geothermal users? These issues have not been addressed or even approached by the Earth Energy Committee or the municipality as operator of the arena complex. Who is responsible for addressing these issues?

To date, development of the geothermal resource has been relatively minor and based on the requirements of individual businesses. For future growth, development should be co-ordinated and regulated to ensure that the above issues are addressed in a timely manner. This can be accomplished in one of several ways. First, it is possible to continue to develop small-scale systems on an individual basis and anticipate potential conflicts, provided each potential user has ample space (land) for separation of pumping and reinjection wells. Second, it is possible to group users together that would utilize small communal systems where pumping and reinjection wells can be distributed advantageously according to the location of mine workings and the users. The third option would involve the development of somewhat larger communal systems for well placement so as to utilize the separate mine workings as distinct hot and cold stores. Economics dictate that this final option probably only be considered for areas where energy requirements are large and there is a diversity of requirements; i.e., large cooling requirements at one business and significant heating demands at another. Regardless of the design chosen at any given time, the issues of well ownership, distribution of water between the wells and the geothermal energy users, co-ordination, regulation and maintenance all need to be addressed.

A final issue of potential concern is the possibility of subsidence as older mine workings collapse. Collapse of shallow workings and the development of 'sink holes' at ground surface have been observed by the author in the Timmins and Cobalt mining camps of Northern Ontario; however, these have been restricted to workings at depths of less than 50 m. Collapse is of greatest concern in the shallowest workings as this is the area closest to ground surface where the workings may not be completely filled with water. The deeper workings could experience some collapse if water pressures vary significantly during operation of the overall CTES systems (all mine workings collectively); however, system design should require reinjection of all water to the subsurface, which will minimize pressure differentials. Therefore, if properly constructed and operated, the geothermal systems should have a minimal impact on the subsurface and not increase the potential for collapse and surface subsidence in the area. The author is not aware of any shallow workings having collapsed during the past decade of geothermal well operation in the most subsidence-prone portion of the mine workings in Springhill. Nevertheless, caution must be exercised to ensure that this type of problem does not develop in the future.

All of these issues are raised to ensure that the development of the geothermal resource can proceed in an organized and co-ordinated fashion with few if any surprises.

8.0 INFORMATION REQUIRED

Sufficient information is available to determine that a geothermal energy resource exists within the mine workings underlying the proposed business park and adjacent areas. However, all of the investigations to date have been concentrated on the relatively shallow, near-surface workings; the investigation, identification and development of the entire resource will require additional information. Specifically, it is important to locate as accurately as possible the subsurface workings, including pillars, open versus collapsed workings based on mining method, and connections between working levels for the various seams. A detailed GIS study for each seam, similar to one recently completed for the No. 2 Seam at Springhill by Herteis (2006), is required to permit the accurate identification and location of potential drill targets.

Exploratory drilling, based on the GIS survey, will be needed to identify the current status of the deeper targeted workings (open or collapsed), the water chemistry, and water temperature. Once several exploratory wells are completed, a series of standard pumping tests should be conducted for determination of interconnectedness with the non-pumping observation wells and any natural flow points. This work will also assist in quantifying well capacities and the overall hydraulics of the subsurface workings for design purposes. The pumping tests should involve relatively large flow volumes and all pumped water should be reinjected into the workings in such a way as to not compromise water quality.

Storage Capability

In addition, a preliminary evaluation of system requirements for development of the business park phases is necessary to provide input for system capacity design. This will require estimation of water quantity and heating/cooling requirements for each potential business, which could simply be classified at this time into categories, such as commercial retail, light manufacturing, heavy manufacturing, etc. This information will provide guidance for the number and location of pumping and reinjection wells, size of pipelines, system layout, and expansion potential. Since development will be gradual, any system design must in the long term contain an element of flexibility so that wells drilled at various times can be regrouped as requirements change. Once all of this information is available, a financial analysis should be undertaken to determine the economic feasibility of the design and to estimate user rate charges. Previous studies by Vaughan Engineering (1992) and the Atlantic Institute for Sustainability Inc. and David Stewart & Associates Inc. (2004) provide very useful comments on the issues of feasibility and marketing, as do the 1992 Springhill geothermal conference discussions (Katherine Arkay Consulting, 1993).

9.0 ROLE OF MUNICIPALITY

Exploration and development of geothermal resources is regulated by DNR under the Mineral Resources Act, while the production and delivery of the energy is governed by the Nova Scotia Utility and Review Board in accordance with the Public Utilities Act. Any individual or corporation that decides to develop a geothermal energy resource must have the approval of the government, which is ultimately responsible to the citizens of the province to ensure that resources are developed efficiently and effectively.

For a large-scale project, such as a business park that is owned by the municipality, the most efficient way to ensure that development occurs with a minimum of conflict between users would involve a co-ordinated approach as described earlier. Construction, operation and maintenance of production and reinjection wells, plus pipeline systems to transport the water to businesses throughout the park, would constitute a utility as defined within the Public Utilities Act. Other utilities, such as telephone, cable, hydroelectricity, and natural gas providers, can be public or private corporations; however, all of them are required to operate in accordance with various government regulations.

Similarly, a geothermal utility could be established as a private or public corporation. The establishment of such a utility in Springhill should be mandated to provide geothermal energy, where feasible, for all of the SGRA, not just the business park. This would involve potential development of all CTES type resources where mine workings exist.

Since the business park land in Springhill is owned by the municipality, and since most of the mine workings underlie the business park, it would be natural to assume that the municipality would be a logical choice for establishing a geothermal energy utility. However, with the presence of additional abandoned mine workings in the Joggins area and the potential for deep basin geothermal resource development in some western parts of the Cumberland Basin, one may want to consider whether such a utility, either as a public or private corporation, should be established at the regional or county level. Regardless of the type of corporation, it is important that all of the affected players be supportive of the venture.

Several businesses in Springhill are utilizing geothermal energy currently and have at least some form of informal permission/agreement with the municipality concerning their energy systems. Any agreements, whether verbal or written, should be recognized as the utility moves toward the introduction of a co-ordinated development plan and the institution of user fees. These businesses together represent an accumulated knowledge of the geothermal resource and will be key players in the marketing of the resource to future clients.

As an energy utility, the corporation may also need to examine other opportunities for the production and/or delivery of energy to its customer base. The government of the Province of Nova Scotia has stated that it is committed to the increased development of renewable energy resources. Private corporations are already exploring the potential for developing various types of alternative energy resources. In the Springhill area, Stealth Ventures Inc. is examining the potential of methane gas production from deeper unmined coal seams, and Vector Wind Energy Inc. has several wind turbine generators currently under construction. The generation of electricity from wind turbines is being considered throughout the province, as is biomass, tidal, solar and mini-hydro. All of these new energy developments need to be able to access customers. Therefore, it is important to consider whether the establishment of a geothermal energy utility should be mandated more broadly as a renewable energy utility that could serve as an intermediary for this new energy production and be capable of providing a mix of renewable energy sources to its customers. The utility should also have the ability to buy from and sell electrical energy into the Nova Scotia power grid. The Town of Springhill is in a unique position in that it has already established an Earth Energy Committee to explore some of these issues and could play an important role in the establishment of a renewable energy utility corporation.

The manpower and financial resources required to establish such a utility would vary depending on the terms of reference for the utility and a detailed analysis is beyond the scope of this report. At the very least, to begin the planning for systematic development of the geothermal resources for the business park at Springhill, it would be necessary to staff an office with a hydrogeologist and an engineer familiar with geothermal systems and the heating and cooling requirements of potential clients. The establishment of a technical group by the municipality would allow the municipality to control the timetable for further geothermal resource definition and ensure that it is compatible with its schedule for development of the business park. They could also review the feasibility of developing a communal geothermal system for retail businesses and municipal buildings in the western part of Springhill, as originally proposed in 1990. The development of such a system, in conjunction with the community centre complex in 2004, would help to showcase the latest geothermal technology and help to market Springhill to potential clients.

The initial tasks of the group would include obtaining the information required as outlined in section 8.0. The Earth Energy Committee, through its one current staff person, has already compiled much of the historical documentation for geothermal development, and these data would provide the technical group with a good starting base. Together with the financial officers of the municipality, the Earth Energy Committee and the technical group could establish a comprehensive plan that would permit the systematic development of the resource in a timely manner.

For any of this to happen, the municipality will need to dedicate manpower and financial resources. As a community, they have demonstrated their commitment to pursuing the development of geothermal energy as a viable alternative renewable energy resource. It is important for the government of the Province of Nova Scotia to recognize this commitment and to assist the municipality in whatever way they can.

10.0 CONCLUSIONS

The abandoned coal mine workings at Springhill represent a significant geothermal renewable energy resource with the potential to provide thousands of megawatt-hours of heating and cooling energy per year. Shallow portions of the mine workings have been utilized for geothermal systems over the past 17 years due to the visionary thinking of several community members; however, the resource potential has not been fully defined and development to date has been a patchwork of independently operating systems. Additional information is required so that the resource can be properly evaluated. This information includes detailed GIS studies for each seam and the interconnection between seams, exploratory drilling of the deeper workings to evaluate the conditions of the workings (open versus collapsed), water temperature, water chemistry, and flow connections. These additional data, in conjunction with an estimation of system requirements for development of the entire area, will permit development to occur in a co-ordinated manner that can optimize the resource to the benefit of everyone.

A number of critical issues remain that concern the co-ordinated development of the resource, the identification and resolution of potential conflicts between users, and the maintenance and delivery of the energy resource. With the potential for development of various alternative energy resources in the Springhill area, it is important to consider the formation of a public or private utility with the aim of encouraging the development and delivery of these new energy resources. Since the Town of Springhill has already established an Earth Energy Committee, it would be appropriate to mandate this committee with the responsibility of moving forward toward the creation of an energy utility corporation. This utility could begin as a geothermal utility, but ultimately should encompass the delivery of all energy resources in the area, which could include just the Springhill area or expand as a county-wide utility that would oversee potential development of energy resources throughout the region.

There needs to be a technical group established that can work toward the collection of additional required data, preliminary system design and co-ordinated development of the geothermal resources, and that can address outstanding issues of current geothermal operational systems. This group should be mandated to report to the Earth Energy Committee.

The provincial government needs to recognize the commitment made by the municipality and assist it in whatever way they can to ensure the orderly and timely development of the local alternative energy resources, since this will ultimately benefit all citizens of the province.

11.0 RECOMMENDATIONS

To develop geothermal resources as part of the overall provincial strategy for increasing the percentage of energy derived from renewable sources, it is necessary to define fully the size and capacity of the identified potential geothermal resources in the Springhill area. The following recommendations are aimed at helping to move the Province of Nova Scotia and the Town of Springhill toward the realization of this goal.

1. The Town of Springhill should establish a technical working group, consisting of at least a hydrogeologist and an HVAC engineer familiar with geothermal systems, to co-ordinate the collection of information still required for the consideration and design of geothermal systems and the determination of their capacity to provide heating and cooling to customers in the proposed business park and adjacent areas.

2. Exploratory drilling of the deeper mine workings, temperature logging, water chemistry sampling, and testing of flow interconnections using pumping tests should be undertaken as a priority. Detailed GIS studies of the workings associated with each seam also need to be conducted.

3. Outstanding issues with currently operating geothermal systems should be addressed as soon as possible by the technical working group. This group should also undertake a review of all the operating systems to ascertain how these systems could be improved and/or incorporated into a co-ordinated development program that optimizes the resource.

4. The Provincial Government should be prepared to financially assist the Town of Springhill in the collection and evaluation of the additional information required.

5. The Town of Springhill and the Provincial Government should determine in consultation with other interested parties how to proceed in establishing a renewable/geothermal energy utility and what the mandate of the utility will encompass. The existing Earth Energy Committee and the technical working group should lead this endeavor. Special consideration should be given to businesses currently operating geothermal systems.

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Don't Thank
me thank
The Mayor
& His Continued
Support

Respectfully submitted

Frederick A. Michel, Ph. D.

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