# SUSSEX HEALTH CENTRE ATES, CANADA

## NAME, LOCATION:

**Sussex Health Centre ATES**

Town of Sussex, Province of New Brunswick, Canada

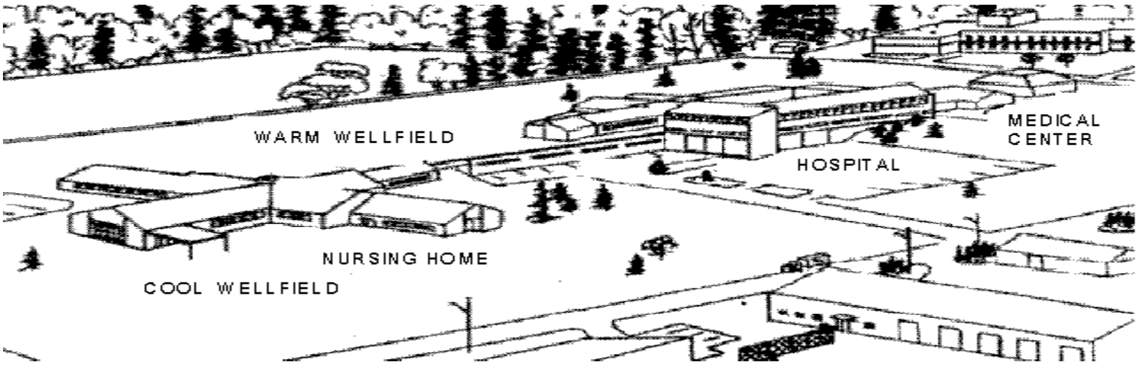
## PURPOSE:

**Heating and Cooling of Hospital Complex**

The purpose is to reduce electrical energy consumption for heating and cooling of the hospital complex and to avoid the capital cost associated with replacing a 700 kW chiller machine. A reduction in carbon dioxide emissions was also an important component of this project.

The Sussex Hospital has 8,000 m² in floor area and uses electricity as its only energy source. A recent addition to the Hospital has increased its floor area by about 1,000 m² and is referred to as the Hospital Extension. The Nursing Home has a floor area of 3,000 m² and uses fuel oil for heating. The Medical Centre has 1,300 m² of floor space and uses 21 water source heat pumps transferring energy to and from the groundwater system. The major heating assistance to the Hospital is air preheat. Direct ground source cooling, via the cooled aquifer store, is used in each of the buildings.

## PLAN OF SITE



## GEOLOGY (Storage material, overburden and bedrock stratification):

1. The bedrock aquifer is a northerly-striking, easterly-dipping very fine-grained haematitic, calcareous siltstone. It is overlain by a silty-sand till. Dip of bedding varies from 10 to 15 °.
2. The bedrock aquifer is pervasively fractured at a mean fracture frequency of 20 $m^{-1}$. Bedding-parallel fractures are about an order of magnitude more common than sub-vertical, bedding-normal fractures.
3. The aquifer is lithologically homogeneous on a scale of metres; there is no evidence of large-scale contrasts in rock composition other than slight changes in grain size and dominance of quartzo-feldspathic elements.
4. Red clay of unknown composition and haematite of possible diagenetic origin have effectively reduced matrix porosity to near zero.
5. For the purposes of ATES evaluation, the presence or absence of smectite has not been conclusively determined.
6. Wet rock samples are much stronger than dry ones. Although the rock has weakness paralleling bedding planes when dry, these surfaces are not ideally oriented as to induce well wall instability.

## Physical and Hydrogeologic Parameters of the Thermal Store:

| | |
|---|---|
| **Average (rock)density** | 2,200 $kg/m^3$ |
| **Average heat capacity** | 2.0 $MJ/(m^3K)$ |
| **Thermal conductivity:** | 2.3 W/(m K) |
| **Aquifer Type** | semi-confined/leaky |
| **Aquifer Permeability** | $2.7 * 10^{-6}$ $cm^2$ |
| **Groundwater Velocity** | 15 m/a |
| **Groundwater Level(s)** | ~19-20 m(amsl)/6-11m (bgs) |

## SYSTEM DESCRIPTIONS:

### Well Water Supply and Recharge:

Three wells are presently being used for water supply from the cool well field and two wells supply water from the warm well field. Another two wells in the warm well field are used for recharge. Heat exchangers are required within each of the buildings for groundwater heat transfer to take place between the buildings and the aquifer store The heat exchangers have an approach temperature of approximately 1.0 °C for cooling and 0.5 °C for heating. The heat exchangers allow for closed-loop hydronics with close control of water quality. Three way valves are used to allow groundwater to flow from one well field to the other.

On the groundwater side of each heat exchanger a modulating valve is used with Proportional Integral (PI) control in order to ensure the proper temperature increase or decrease across the heat exchanger.

**HVAC Systems Operation:**

The Nursing Home is heated with an oil-fired boiler with a water circulation temperature of 85 °C. In this instance, the relatively high water circulation temperature made the Nursing Home a poor candidate for retrofitting the heating to ATES. Therefore, groundwater is not used for heating in the Nursing Home. Cooling is by means of a centralised ducting system with one water-to-air coil. Heat is transferred from the air through the coil to the groundwater thus reducing the temperature of the air in the supply system.

The Medical Centre energy system is comprised of 21 separate zones, each with its own water-to-air heat pump. A water loop connects all heat pumps to a central groundwater heat exchanger, which serves as the interface with the well fields.

The largest HVAC system is in the Hospital. Its modifications to accommodate ATES allowed for three modes of operation; Conventional, ATES Heating and ATES Cooling.

**Conventional Operation of the Sussex ATES system:**

A 200 kW heat recovery chiller has been placed in parallel with an existing 700 kW unit. It is used for additional cooling and to transfer heat to the Hospital Extension and to the air handler coils from groundwater. When the 200 kW chiller is operating and building heating is not required, the roof top air condenser dissipates the heat.

Hospital primary heating is by means of electric coils in the air handling units (AHU's) with secondary heating (reheat coils, baseboards, etc.) being hydronic in the Hospital Extension and electric in the remainder. When possible, the heat recovery condenser (HRC) transfers heat to the primary heating loop with the 150 kW boiler used as necessary to maintain a water temperature of 48 °C. Moreover, allowances are made through the use of manually operated isolation valves for the system to operate in this manner. If there is any problem with the ground source system, the HVAC hydronics can be quickly switched over to the conventional mode of operation.

**Cooling and Heating:**

The secondary side of the heat exchanger acts as the primary loop in the HVAC system. To ensure total cooling always, the chillers have been placed in the cooling loop. Since they are close coupled to the loop, the design allows for the chillers to act only when necessary and only to the degree that the thermal store cannot reduce the temperature at a given time. However, even during initial operation, the groundwater heat transfer should be adequate for cooling. When the outside air temperature (OAT) is below approximately 12 °C, two 3-way valves change position, isolating the cooler groundwater from the air handler coils and connecting these coils to the heating system through a close coupled connection.

Primary heat supplied to this heating system is through the heat recovery condenser associated with the new 200 kW heat recovery chiller. Thus, heating can be transferred to the Hospital Extension coils and baseboards for total heating. Heating can also be transferred to the Hospital air handlers for air preheat. The existing 150 kW boiler within the heating loop will increase water temperature if necessary. Since the heat recovery chiller is close coupled to the HVAC groundwater loop (loop 1) heat is transferred from the groundwater to the heat recovery chiller evaporator.

**General Considerations:**

The water flow on the HVAC side of the Hospital heat exchanger is controlled by two pumps, one at 30 l/s and the other at 15 l/s. When in the heating mode total flow should be the lower value. This flow must be 30 l/s for maximum and mid-range cooling and 15 l/s during low cooling loads. Variable speed pumps were installed after the first year of operation.

To avoid problems with changes in pump static pressure the water circulation loops are designed in accordance with the primary/secondary philosophy and thus are independent of each other. This also allows for optimum sizing of the pumps with minimal change in head under variable pumping conditions.

The hospital is cooled through direct heat exchange, electric resistance is used for perimeter heating. Nursing home: Hydronic hot water heating with # 2 oil and direct coil ground water cooling. The medical centre has 21 water to air heat pumps connected to an hydronic loop.

**Operating temperature(s):**

hospital heating: 45 °C (Hot Water Supply)
hospital cooling: 10 °C (Chilled Water Supply)

**Type of heat pump(s):**

hospital: scroll based reversible chiller
medical centre: reciprocating water to air heat pump

**heating power**: hospital: 300 kW
medical centre: 2.5 kW to 22 kW

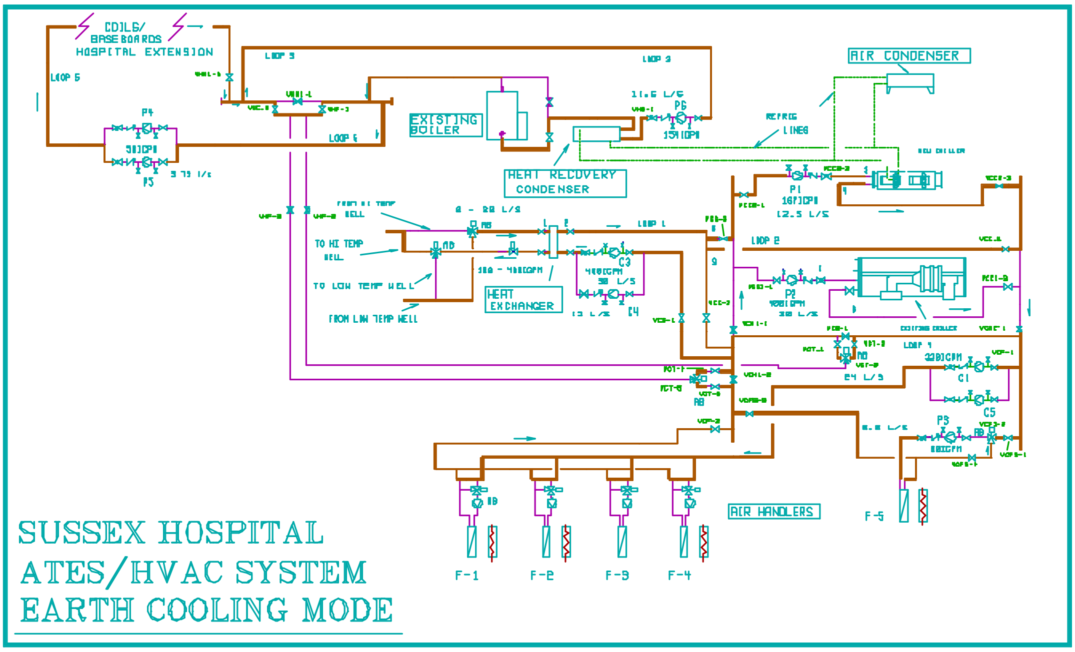
**cooling power**: hospital: 200 kW
medical centre: 1.75 kW - 15 kW; total energy demand for heating (h) and cooling (c):
1,000 MWh/a

## STORAGE TECHNOLOGY:

**type of storage:** leaky artesian aquifer
**storage volume**: 300,000 m³
**shape**: based on 72 hour aquifer test; elliptical in a North-South direction
**number of wells**: 11, 4 for cooling, 5 for heating and 2 observation wells. One inclined core-hole was also drilled
**depth of wells**: 90 m
**diameter of wells**: 200 to 300 mm for heating and cooling and 150 mm for observations wells
**distance between the wells**:
100 m between wellfields and 30 m between wells. The two newest wells are placed an additional 50 m from the original well fields
**flow rates**: a maximum 55 m³/h (heating), 110 m³/h (cooling)
**performance:** heat capacity: 500 MWh/cycle
**mean storage temperatures (warm/cold)**: 14 °C / 6 °C
**charging/discharging performance rates:** 250 kW (h) / 500 kW (c)
**main energy source:** waste heat (heat recovery) from summer air conditioning

**energy savings**: 600 MWh/a (or MWh/cycle) (heating), 400 MWh/a (or MWh/cycle) (cooling)

## SYSTEM BLOCK DIAGRAM



## ECONOMICS:

Storage system in operation since 1994. Total investment costs for system research work included): 550,000 US$ total annual operating costs: 15,000 US$ annual cost savings due to energy savings: 65,000 US$

## MONITORING:

### Monitored data, measurement interval(s):

**Above Ground**: Groundwater flows through system, temperatures, groundwater pressure**,** energy transfer to/from ATES system.

**Below Ground:** Ground temperature, water levels, pH, conductivity, groundwater flows to and from system, values are taken each second and stored each hour. Hourly means etc. are available.

### Type of monitoring system (sensors, transducers, data processing):

PC compatible processing system. Temperature sensors are RTD´s and thermo-couples. Flow is by means of magnetic rotor with voltage to current transducer.

## OPERATING EXPERIENCES:

The system is working satisfactorily. However, it is important to continuously check the various parameters by means of the on-line monitoring system in order to determine where there are problems and to correct them. The ongoing monitoring and correction component is vital to the success of this project. The controls parameters and operation philosophy are being reviewed and updated continuously. At this time the heat and cold energy usage is not balanced. Discussions are underway to correct this imbalance by using more of the thermal energy available in the warm store. There is thermal stratification occurring in the warm well field that is somewhat affecting the cold well field in the first month of cooling operations. This situation wil also be addressed.

**Lifetime expectancy of total system / of components :**
With proper maintenance, the system should last 25 to 30 years.

## ESTIMATED POTENTIAL OF TECHNOLOGY:

Through the use of ongoing monitoring and reporting, both above and below ground, the Sussex Health Centre ATES system should increase knowledge concerning the use of underground thermal energy and storage. This should assist in reducing dependency on non renewable energy sources.

## PROJECT WORK, DESIGN BY:

Adsett & Associates Ltd. of Keswick Ridge, N.B. Canada

## FINANCIAL SUPPORT:

This project is a joint venture of the Sussex Health Centre, Environment Canada (EC), the Panel for Energy Research and Development (PERD), The

Canadian Electrical Associaton (CEA) and New Brunswick Power Commission (N.B. Power) and the new Brunswick Department of the Environment.

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