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VANIER SCHOOL GROUND SOURCE HEAT PUMP PROJECT

BUSINESS CASE

April 2003

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1. Introduction

1.1 Background

The Energy Solutions Centre (ESC) strives to set the circumpolar standard for cost-effective, renewable and integrated energy services, environmental stewardship and northern innovation in the energy sector. The Centre participates in projects that result in energy cost savings and that reduce greenhouse gas emissions by utilizing renewable energy to decrease the reliance on fossil fuels.

In keeping with the corporate mandate, ESC has been assessing the feasibility of utilizing Ground Source Heat Pump (GSHP) technology in the Riverdale subdivision of Whitehorse. The overall goal is to develop a community heating system using the warm water aquifer that is situated underneath Riverdale and reduce reliance on fossil and wood heating systems.

In order to demonstrate and prove the technology, ESC began looking for a building that would serve as a pilot project. The test project would demonstrate sustainable resource technology to reduce overall energy consumption associated with building heating. As a result of the relatively good condition of the existing mechanical system and expected long service life of the building, Vanier Catholic Secondary School was selected as the location for the pilot project. The plan, if approved by the Yukon Government Department of Education, is for the conversion of a portion of the Vanier School to GSHP, instrumenting the system, and operation for one year. After acceptance by the Department of Education and Property Management Agency, the operation and maintenance of the system will be handed over to the respective agencies.

1.2 Work Performed to Date

Following meetings with Department of Education and Property Management Agency representatives, ESC commenced work on the pilot project. A report in January 2002 titled *Vanier School Ground Source Heat Pump Project: Site Setting & Conceptual Design* by Gartner Lee Limited concluded that there was significant potential for development of an Open-Loop Groundwater Heat Pump system. Based on the findings of the report, ESC filed a Class-B Water Use Licence Application with the Yukon Territory Water Board for the use of water in a heat pump project.

In conjunction with the application, a hydrogeological assessment involving a test well on site began in July 2002. The fieldwork consisted of construction of an observation well, a test well, and performance of pump tests on the overburden (Selkirk) aquifer and the basalt aquifer. The observation well was not completed due to the drill rig not being able to drill to the depths of the overburden aquifer. The depth of the aquifer at the Vanier location differed from other parts of Riverdale and this resulted in the incomplete observation well. The test well was drilled into the overburden aquifer and a short-term pump test was conducted on July 28, 2002. Following the pump test on the overburden aquifer, the screen was removed and the hole was advanced into the bedrock. Following the completion of the well, a 72-hour pump was planned on the basalt aquifer. However, ESC was then notified by DIAND Water Resources that the pump test constituted a use of water over 300 cubic metres per day and therefore a Water Use Licence was required. An application was made to the Yukon Territory Water Board and on November 27, 2002 a licence was received to perform the pump test. A pump test was performed on the basalt aquifer in early December 2002. A report titled *Vanier School Ground Source Heat Pump Project-Hydrogeological Assessment* by Gartner Lee Limited was received in February 2003. The report details the well completion, testing performed on the two aquifers, groundwater quality and makes recommendation as to what aquifer should be utilized for the project.

The report recommends that the Selkirk Aquifer be selected as the preferred water source for the Vanier School Heat Pump Project.

2. Cost Estimate

The objective for the design of the system is for the heat pumps to displace 50% of the peak block-heating load which represents approximately 70% of the annual heating requirements for the school. In order to achieve this objective a conceptual plan to install three 30-ton heat pumps was formulated. If the project is to proceed, the groundwater source is assumed to be the Selkirk Aquifer.

In general terms, the conceptual plan involves one production well supplying water for three heat pumps in series. Following use through the heat pumps, the water is then reinjected into the ground using two injection wells.

The following construction costs are costs that will be incurred from this point forward and do not include costs to date.

Selkirk Aquifer (70 m production well)

Item	#	Unit Cost	Total Cost
Permitting	1	$5 000	$5 000
Production/Injection Wells	2	$19 000	$38 000
Modifications of test well	1	$5 000	$5 000
Production Pump	1	$6 000	$6 000
Riser and Pump Installation	1	$6 000	$6 000
Variable Speed Pump Controller	1	$10 000	$10 000
Instrumentation	1	$40 000	$40 000
Pitless Adapter	3	$6 000	$18 000
Piping to buildings	30m	500	$15 000
Building Tie-in	1	$6 000	$6 000
Piping to injection well	130m	$300	$39 000
Manhole/Valve Chamber	2	$8 000	$16 000
Plate Exchanger	1	$10 000	$10 000
Heat Pumps	3	$30 000	$90 000
Plumbing & Install of Heat Pump	3	$25 000	$75 000
Electrical Upgrades	1	$10 000	$10 000

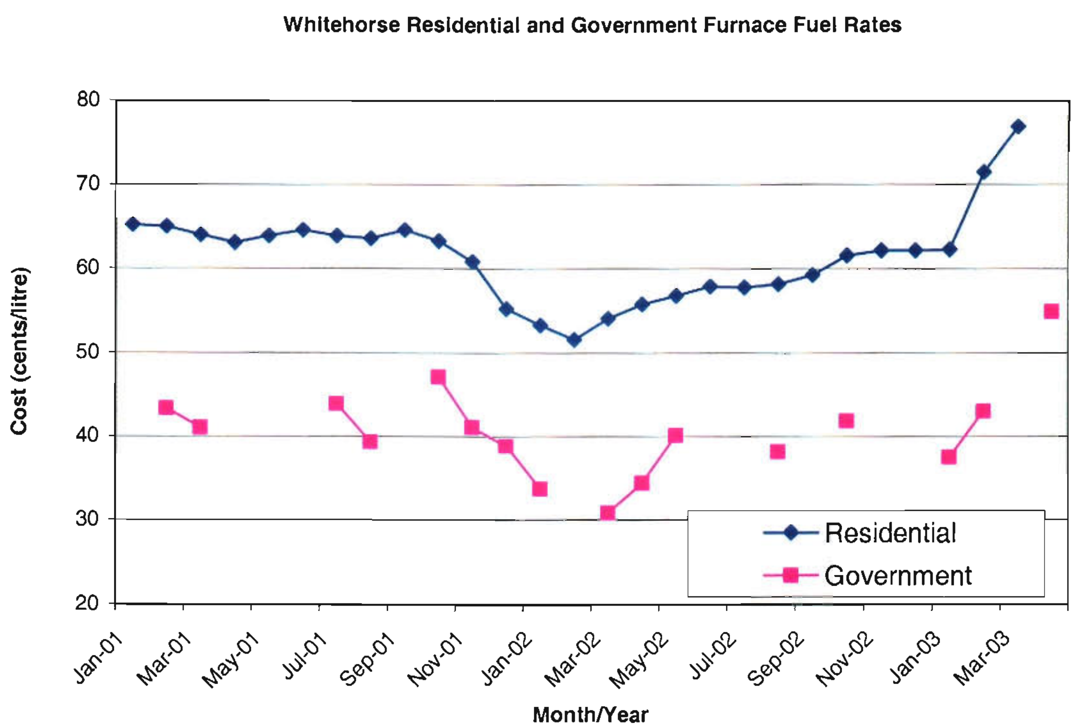
Total	$389 000
Engineering and Construction Supervision (20%)	$77 800
Contingency (20%)	$93 360
Grand Total	$560 160

3. Annual Costs of Operation

3.1 Costs of Operating and Maintaining Current Heating System

According to Department of Education, the Vanier School including the new cafeteria built in 2002 will be consuming 225, 000 litres per year of fuel for the oil fired boilers. As of April 2003, the Government of Yukon rate for furnace oil increased from 42.99 cents per litre to 54.89 cents per litre.

The cost of fuel for operating the oil boilers is influenced by a number of factors, many of which are beyond any local control. Below is a graph showing the cost of residential and government furnace fuel prices in the City of Whitehorse. The escalation of residential fuel prices from March 2002 to March 2003 is over 42% and the rise in government fuel prices from April 2002 to April 2003 is almost 60%. The most recent price for residential furnace oil is 76.9 cents per litre. The cost of furnace oil even for a bulk purchaser can be a volatile commodity. The rate that the government pays for furnace oil will follow the same trend as the residential fuel albeit with the volume discount.



*Residential Prices from Yukon Government website
*Prices in Canadian dollars and include all applicable taxes

<u>Assumed Cost of Fuel at 42.99 cents per litre</u>

Total Annual Cost = $99 278

Annual cost of fuel = 225 000 litres @ $0.4299/litre = $96 728
Annual boiler cleaning = $1 200
Annual boiler servicing and maintenance = $1 050
Annual filter changes = $300

<u>Assumed Cost of Fuel at 55 cents per litre</u>

Total Annual Cost = $126 300

Annual cost of fuel = 225 000 litres @ $0.55/litre = $123 750
Annual boiler cleaning = $1 200
Annual boiler servicing and maintenance = $1 050
Annual filter changes = $300

3.2 Cost of Operating and Maintaining New Heat Pump System

The cost for electrical energy to run the heat pumps and the well pump is assumed to be purchased at the secondary sales rate. The secondary sales rate is for the displacement of an alternate fuels source for space heating with an electrically generated heating source. The current rate for secondary energy is 3.3 cents per kWh, although this rate is subject to change with regulatory approval. To take into account periods when secondary sales may not be available, the use of the fuel oil boilers have been increased by 5 % per year. Rather than the oil boilers meeting 30 % of the annual heating requirements, this has been increased to 35%.

<u>Assumed Cost of Fuel at 42.99 cents per litre</u>

Total Annual Cost = $47 924

Annual electrical cost for running heat pumps =74.4kWx 4500hours = 334800 kWh
334 800 kWh x $0.033 = $11 048
Annual electrical cost for operating well pump = 12.6 kWx4500hours =56 700 kWh
56 700 kWh x $0.033 = $1 871
Annual cost for heat pump and well pump maintenance = $300
Annual cost for boiler maintenance = $850
Annual cost for boiler fuel = $33 855

Assumed Cost of Fuel at 55 cents per litre

Total Annual Cost = $57 382

Annual electrical cost for running heat pumps = 74.4kWx4500 hours=3334800kWh
334 800 kWh x $0.033 = $11 048
Annual electrical cost for operating well pump = 12.6 kWx4500 hours=56 700 kWh
56 700 kWh x $0.033 = $1 871
Annual cost for heat pump and well pump maintenance = $300
Annual cost for boiler maintenance = $850
Annual cost for boiler fuel = $43 313

3.3 Estimated Annual Savings

The annual savings from operating the new heat pump system will depend on the actual cost of fuel. Based on the two assumed fuel prices, the estimated annual savings are as follows:

Assumed Cost of Fuel at 42.99 cents per litre

$99 278 - $47 924 = $51 354

Assumed Cost of Fuel at 55 cents per litre

$126 300 - $57 382 = $68 918

3.4 Payback

Assumed Cost of Fuel at 42.99 cents per litre

30 year life cycle savings: $1 540 620
Initial capital cost: $560 160
Overall savings: $980 460
Overall savings evenly over 30 years: $32 682 per year
Simple payback on full system: 17.1 years

Assumed Cost of Fuel at 55 cents per litre

30 year life cycle savings: $2 067 540
Initial capital cost: $560 160
Overall savings: $1 507 380
Overall savings evenly over 30 years: $50 246 per year
Simple payback on full system: 11.1 years

4. Other Benefits

4.1 Reduced Emissions

The new heat pump system is designed to reduce 70% of the annual heating with the oil boilers. With the assumption that there may be periods when secondary sales are not available and the oil boilers will be utilized during these situations, the reduction in oil consumption becomes 65%. The approximate quantity of reduced fuel is 146 250 litres annually. This translates into the potential reduction of greenhouse gases as illustrated below:

Emission (Factor)	Annual Emission Reduction (g)	Annual Emission Reduction (kg)
CO_2 (2,830g/l)	413,887,500	413,888
CH_4 (0.026g/l)	3,802.5	3.8
N_20 (0.013g/l)	1,901.25	1.9

4.2 Improved Air Quality

Indoor air quality can be seriously affected by combustion of fossil fuels. All furnaces produce emissions either through incomplete combustion or even during the normal combustion cycle. Concerns over the air quality at the Vanier School have resulted in reports, studies, modifications and retrofits to the building. Recent reports completed by Northern Climate Engineering detail indoor air quality issues at the school and propose recommendations intended to improve the indoor air quality. Two reports on Indoor Air Quality are contained in Appendix A. A reduction in the use of the oil fire boilers with a heating source that does not produce harmful emissions can only improve the indoor air quality in the school.

The outdoor air quality is also an important consideration. Riverdale is subject to frequent inversions in the winter that can trap smoke and combustion exhaust gases from building furnaces and boilers. When the inversions occur, air intake filtration systems cannot effectively remove combustion exhaust and smoke from the air. Since a heat pump does not produce combustion exhaust gas, the outdoor air quality for school occupants and surrounding residents will be improved.

4.3 Air Conditioning

All heat pumps are dual use appliances that offer cooling as well as heating capabilities. As part of any detailed design, the cooling requirements of the school will be analyzed and provisions can made to either cool the entire building or known areas of the school that currently require air conditioning such as the school computer, server, electrical, and mechanical rooms.

4.4 Field Irrigation

The current concept involves drawing water from a production well located close to the back of the school, near the mechanical room, running the water through the heat pumps and then discharging the water back via two injection wells. In order to minimize any potential cooling of the water in the production well, the injection wells are located down gradient and a minimum distance away from the production well. The location of the injection wells is planned for the north side of the soccer field. During detailed design, the possibility of utilizing the water for field irrigation in the summers can be investigated. The school presently spends approximately $5 000 per year for watering the soccer fields.

4.5 Benefits Summary

The following table provides a summary of the potential benefits of proceeding with the installation of the heat pump system.

Factor	Potential Benefit	Measurement
Energy cost	Overall cost to heat building will be reduced	Comparison of the annual cost of heating the building before and after the new heating system is installed
Incremental cost	Through a fair and equitable financing agreement, the system can be achieved without an incremental cost to the Yukon Government. The preferred financing agreement would allow for savings to be used in the payback of the system.	A financing structure that results in no additional costs to the Department of Education
Emissions	Reduction in amount of emissions will be reduced, a stated goal of the Yukon Government	Reduction in oil consumption translating directly in reduced emissions
Indoor air quality	Improved indoor air quality by reducing combustion	Fewer complaints and reduced health issues
Outdoor air quality	Improved outdoor air quality by reducing combustion	Fewer complaints and reduced health issues
WCB interaction	Improved relationship with WCB by having to deal with less	Less time spent by Dept of Ed staff dealing with WCB

	complaints over health issues	
Health and Safety Committee interaction	Improved relationship with H&S Committee by having to deal with less complaints over health issues	Less time spent by Dept of Ed staff dealing with H&S Committee
Client satisfaction	Students and staff will have a more comfortable environment, the addition of building air conditioning will be of benefit	Fewer health issues, sick days and building occupants that are more satisfied with their environment
Field Irrigation	Utilization of the water for irrigation rather than injecting the entire quantity	Reduced expenses by using groundwater for field irrigation
Renewable technology	Department of Ed and PMA staff will gain knowledge and experience with a clean, renewable technology	More knowledgeable and trained staff
Potential for replication	Knowledge and experience gained through working with this new system will lend itself to repeating at other Yukon Government facilities	Other Government of Yukon buildings that install geothermal heat pump systems

5. Long Term Sustainability of the Groundwater Resource

If the project proceeds it is likely that the system will be in service for the entire life of the Vanier School building. Consequently, it is important to assess the long-term sustainability of the aquifer in terms of water quantity, quality and temperature. Since the project will utilize injection wells as the method of returning the water exiting the heat pumps back to the aquifer, there is no net change in groundwater volume. There is no change in water composition as a result of the heat pump process, so therefore no alteration in the water quality is to be expected. As for the temperature, with adequate separation between the production and injection wells there will be no effect on temperature in the long term. There is a continual flow of water across the well and this brings new water at the stable temperature. A report produced by Gartner Lee Limited that addresses the issue of the long-term use of the aquifer for the heat pump application is contained in Appendix B.

6. Conclusions

Based on the economic analysis the simple payback utilizing 30 year life cycle costs for the project is in the range of 11 to 17 years. This does not include possible air conditioning or field irrigation savings.

There are also a number of factors that either have an intangible benefit or there has been no attempt at placing an economic value on the benefit. The reduction of greenhouse gas emissions is a benefit and a goal of the Yukon Government. The reduction of emissions has an affect on indoor/outdoor air quality and this has a cost in terms of building repairs, employee and student health, sick days, and fatigue. This document has not attempted to quantify to what level the indoor air quality of the school will improve as a result of the new heating system. However, there will unquestionably be an improvement if there is less combustion of fossil fuel used in the heating process.

Appendix A

Vanier Indoor Air Quality Reports

By

Northern Climate Engineering

June 2002

And

November 20, 2002

Mechanical Evaluation and Code Review

General

northern climate engineering ltd. was contacted by YTG Property Management Agency to provide a review of the technical report on the IAQ at Vanier School as prepared by Van Hiep Nguyen, P. Eng. The purpose of our work was to review the recommended options outlined in the report and choose the most viable options for implementation.

The following is an evaluation of the IAQ Preventative Solutions in the Vanier Shool, Whitehorse. All conclusions are based upon on site inspections, documented data, applicable building codes and mechanical standards, and guidelines for good engineering practice.

Specific focus of this evaluation is to provide analysis of the following four sources of contaminents:

1. Exhaust Stacks
2. Boiler Room
3. Metal and Woodworking Shops
4. Ventilation System

Referenced Documents

- National Building Code (NBC – 1995)
- ASHRAE Standard 62-1999 *Ventilation for Acceptable Air Quality*
- CAN/CSA B139-00 *Installation Code for Oil-Burning Equipment*

The Existing School

The current school building was constructed from plans completed in 1972. Over the years the school has undergone numerous changes. There have been several major renovations and or additions, including work in 1985, 1987, 1997 and 2002. Many of these projects have involved alterations, additions and changes to the building's ventilation systems. The air handling units installed during the original construction are now approaching the expected lifespan.

1. Stacks

The stacks referred to in the IAQ Report are the 650mm chimney flue for the boilers and the three smaller chimney flues, two of which serve the hot water tanks and one of which is not connected. The concern with these sources of contaminants appears to be their proximity to the air intake on AHU-3 serving the old gymnasium.

The intake for AHU-3 is on the sidewall of the gymnasium wall, where the gymnasium extends above the main school roof and is located at the corner closest to the stacks. Currently the stacks extend between 2.5 and 3 metres above the main roof level but not above the roof level of the gymnasium. The stack for the boilers is located approx. 7m away from the corner of the gymnasium wall and the intake for AHU-3. The stacks serving the hot water heaters are further away, but likewise do not extend above the height of the gymnasium roof.

The recommended measures from the IAQ Report are:

- *To remove the stack caps since the stack caps deflect the exhaust jet horizontally towards the nearest fresh air intake of the gymnasium and have a detrimental effect on both minimum dilution and critical wind speed;*
- *To install vertical discharge cones on top of the stacks in order to raise the effective height of the stacks and to project the exhaust fumes upwards. Stacks should always be higher than neighbouring buildings and structures.*

Installation of discharge cones would extend the effective height of the chimneystacks. However, retrofitting to chimney cones would make it necessary to install drains on the bottom of all the chimneystacks.

Our recommendation would be to extend the actual height of the stacks to discharge at a level above the gymnasium roof level. This work would require the addition of sections to all the existing chimneystacks and additional guy wires to secure and restrain the extensions. The estimated budget for this work would be $5,000.

2. Boiler Room

These recommendations deal with two rooms: the boiler room itself and the oil tank room, which is a separate room, located inside the main boiler room.

The oil tank room is labeled on the 1972 plans as INCIN. 213. This room currently houses an interior fuel oil day tank serving the generator. The room has a grill installed on the exterior wall allowing for passive air transfer. The drywall at the bottom of the wall has been removed, both inside and outside the room. The removal of the drywall has created an opening at the bottom of the wall leaving this room open to the main boiler room.

The main equipment the boiler room houses consists of; three boilers, two hot water tanks, emergency generator and two air handling units, AHU-1 and AHU-2. The ceiling of the room is T-bar, which, according to available plans, was originally designed as the fire-rated separation required by the building code.

AHU-1 is the largest unit and provides ventilation to the classroom wing and the administration area. This unit has the supply air ducted in two main branches above the classroom wing corridors with branch ducts serving each classroom. Supply air is also ducted to each room in the administration area. The return air for the unit consists of a duct extending above the T-bar and terminating in the area directly above the boiler room. The return system uses the space above the T-bar ceiling as a plenum to draw air back to the air-handling unit.

While on-site it was noted that when the unit was operating, AHU-1 was drawing a significant amount of air from the boiler room. The corridor area immediately outside the boiler room also had a noticeable "wind" effect due to air being drawn back to the return duct. The condition of the T-bar has deteriorated to the point where it is now possible for the return air to be drawn up from the boiler room, through the T-bar, instead of drawing air back through the ceiling space plenum. The effectiveness of the ceiling system to act as a fire separation has been largely compromised.

AHU-2 has been modified since originally installed and now serves primarily the classroom south of the IA shop, the Home Ec. Rooms, the classroom to the north of the Home Ec. Rooms and the corridor serving this area. There are two supply grilles from this system into the IA shop. The return air is drawn through a duct, which terminates above rooms 204 and 205 on the 1972 plans. There are no significant concerns with the operation of this unit with respect to the IAQ contaminants from the boiler room.

The recommended measures from the IAQ Report are:

- *To connect the return duct with the existing openings on the wall separating the boiler room and the rest of the school;*
- *To remove the return duct and to install it outside the boiler room. The return fan can stay there, but the return duct should be extended to take the return air above the ceiling of the classes;*
- *To install filters on the return duct by boosting the return fan in order to accommodate the additional filter pressure;*
- *To seal the ceiling of the boiler room as tight as possible;*
- *To build a holding reservoir for the oil tank (to prevent the oil spill from spread into the boiler room) and to negatively pressurize the oil tank room.*

Our recommendations for the oil tank room include installing a metal dike surrounding the fuel tank to contain any spills. Installation of this dike would necessitate removing the concrete housekeeping pad that was left over from previous room usage. In addition to installing the dike, the room should be properly sealed and negatively pressurized. The estimated budget cost of this work will be $2500.

Extending the return duct from AHU-1 to terminate on the wall separating the boiler room from the corridor would require removal of the T-bar ceiling in the boiler room in order to install this large (10 foot by 2 foot) duct and reworking existing services accordingly. Additionally, the wall in this area is open above the T-bar level to facilitate the open plenum return originally designed. Placing the duct in this location will still leave it in close proximity to the boiler room and would not solve the problem of the air being drawn from the boiler room.

Changing the return ducting to extend to the area above the classrooms would also have the same problems of installing the large new duct as above. This option would deal with the problem that there does not appear to be any path in the ceiling plenum for return air from the classroom wing. Reworking existing obstructions to accommodate the duct would be onerous.

Our recommendations for the boiler room would combine parts of several of the options in order to deal with the concerns outlined. We have identified two possible approaches to deal with the IAQ Report options. Both approaches would seal the boiler room and provide the required fire-rated separation. There are advantages and disadvantages to both methods. The estimated budget cost of either approach would be $25,000 to $40,000.

The first approach would be to remove all the current T-bar structure and replace it with a suspended structure supporting Type X drywall. This method would seal the ceiling of the boiler room and re-establish the required fire rating. This method would follow the intent of the original design and incorporate the existing fire dampers in the ducts in the rated assembly. This approach would not necessitate changing the existing ducts or piping. The fire-rating requirements for the boiler room would also mean building fire-rated shafts around the chimneys in the ceiling plenum. The removal and relocation of boiler room lighting would also be required to complete this work. This approach involves creating a fire-rated separation over a large area with many obstructions.

The second approach would be to establish the sealing and fire-rating using the walls around the boiler room area. This approach would make it necessary to include four additional service rooms inside the rated separation. These room would include: the Janitor's Room and Electrical Room to the east of boiler room; and the office and storage room to the west of the boiler room. The three doors into these rooms would need to be changed to fire rated assemblies. The T-bar in the boiler room would still need to be removed in this approach to allow access for work. The wall between the corridor and boiler room would need to be extended up to the roof deck with metal studs and Type X drywall installed. The wall between the office and storage area, and the IA shop would need to have Type X drywall installed above the T-bar level and any penetrations fire sealed. The wall between the Electrical Room and the Classroom wing would need to have the existing Type X drywall above the T-bar fire sealed. The installation of fire rated shafts for the chimneystacks would not be required in this option.

The second approach would also make it necessary to extend the return ducts to draw air from outside the sealed boiler room area. Extending several smaller ducts from the existing duct location would be required. Relocation of some heating pipes and other obstructions would be required even with smaller ducts. New fire dampers would be required on all the return ducts where they would penetrate the new fire separation, as well as installing fire dampers in all the existing supply ducts at any penetration of the new fire separation.

In addition to replacing the boiler room ceiling, installation of transfer grilles with fire dampers should be located in the rated wall structure separating the east classroom wing from the west wing in order to establish a clear path for the return air to from this area to the return duct. The use of unducted transfer grilles would eliminate the complicated and costly work of installing the large ducts while still allowing a path for the return air to be drawn from the desirable locations. The estimated budget cost for this work would be $3000.

3. Metal and Woodworking Shops

The recommended measures from the IAQ Report are:

- *To remove the doors which open to the corridor and to build a solid wall in place of the doors;*
- *To build an entrance space between the corridor and the shops so that one needs to open two doors before entering either shop. This entrance space will be pressurized to prevent fumes from leaking out towards the corridor;*
- *To permanently operate the exhaust ventilation of the metal shop so that it is continuously under negative pressure;*
- *To build an enclosure outside the metal shop in which skidoos can be started and exhaust fumes are contained.*

Removing the doors providing access to the two shops does not seem to be a reasonable solution. This would mean students would have to go outside during the winter in order to get from the main school to there shop classes.

Building a vestibule entrance to both shops would provide an acceptable solution. This system would still require changes to the mechanical system to pressurize these spaces. This possible solution would contain the contaminants produced in these areas from the rest of the school but would mean the students in these classes would be exposed to higher levels of contaminants. . This solution does not deal with the possible contaminants; it will only isolate them in one area, which will be occupied by students.

Providing improved general exhaust to these areas and installing door closers on the corridor doors would be the recommended course of action. Given that these two shops are supplied by a dedicated AHU, adding general exhaust and making adjustments to the AHU, is the most appealing option. The new system would be balanced to maintain the shops under negative pressure. The addition of door closers to the two corridor doors will ensure doors are always closed properly.

During site visits, it was noted that there was a transfer grill in the wall above the paint/finish area. This grill may allow the passage of fumes to the adjacent classroom area that should be removed and the opening sealed. Estimated budget costs for this work will be $10,000.

If the metal shop will continue to be used for small engine repair work, the addition of source extraction for the running engines may need to be considered. Source extraction systems are expensive at an estimated budget cost of $6,000.

4. Ventilation Systems

The concerns of this section deal with the air-handling units drawing contaminants into the building from the outdoor air supplies. During periods of temperature inversions during the winter the presence of wood smoke in the outside-air would enter the building through the ventilation system.

The option given in IAQ Report is *"the use of carbon impregnated filters that can absorb most of chemicals including combustion gases..."*. Similar concerns regarding the presence of wood smoke in Riverdale were brought up during work on Grey Mountain Primary. For the Grey Mountain School, carbon-impregnated filters were installed during a 1994 upgrade that included new blower fans. The carbon filters were added to the project after initial design work and this change required the blower fan sizing to be increased.

Installing carbon-impregnated filters would increase the maintenance costs and could require a major overhaul on the complete ventilation system. Given the high pressure drop through these filters installing them into an existing system would require the completion of a much more in-depth investigation of all existing ventilation equipment and ducting. Once information was collected on the complete system, design work would need to determine if the current blower fans are capable of handling the increased pressure drop of the filter.

It is recommended that installation of carbon impregnated filters wait until such time as more major work on the air-handling units is planned.

INDUSTRIAL ARTS AIR QUALITY REPORT
VANIER SECONDARY SCHOOL
November 20, 2002

Introduction

The purpose of this report is to review design data and on-site conditions relating to the metal and power mechanics shop, and the woodwork shop, in regard to the indoor air quality. The report is intended to provide recommendations for improving the IAQ in a cost effective manner.

Background

From the original design and construction circa 1972, the industrial arts area has undergone a major expansion in 1985 and a few minor changes in the recent seven years. The 1985 expansion towards the north resulted in a dedicated Metal and Power Mechanical Shop, a room to house both an air-handling unit (AHU) and a dust collector, plus a new general purpose classroom currently used for drama classes. The original ventilation system serving the industrial arts area was modified to suit the new layout. Although the majority of the supply air from this system was distributed to 'clean' areas such as Home Ec and classrooms, 280 l/s was supplied to the woodwork shop. The new two-speed AHU was interlocked with a new welding area exhaust fan and a new forge area exhaust fan. The unit was to run during occupied periods on low speed introducing 325 l/s of outdoor air (20% of the total 1620 l/s supply air) to the woodworking and metal shops. When either of the exhaust fans energized, the AHU would toggle to high speed and double the amount of outdoor air delivered. Each exhaust fan was designed to remove 440 l/s from the metal shop

In 1997, the original Industrial Area 'B', an adjacent conference room, plus an ancillary room, were combined to form a dedicated CADD Room. The relief air path from the woodwork shop is through an acoustically insulated transfer duct to the ceiling space over the computer room. Since 1997, mechanical modifications include the installation of a convertible exhaust system near the double exterior doors. The intent is to use this system for general exhaust or source exhaust using flexible hose and screened inlet boxes. The fan for this new system was relocated from the unused forge exhaust system. The exhaust duct from this older system was capped at the fan connection point.

During occupied periods when the air-handling systems would operate without the exhaust fans running, the design data indicates that 605 l/s (280 plus 325) of excess air was to be introduced into the industrial arts areas. The relief path, in this mode, was through the transfer duct noted above and through general air leakage. This pressurization of the spaces would lead to odours and dust migrating towards the remainder of the school. When the exhaust systems operated, the imbalance of supply air vs. relief air would have decreased to 50 l/s on the positive side.

Current Situation

Based on site visits on November 18 and 19, there are a few issues to be sorted out in the ventilation systems for these areas, as follows:

1. Welding Area Exhaust Fan; We investigated the poor performance of the welding area exhaust system, noted by Russ Tait. The drive pulley on the motor is dislodged from the shaft. Consequently, the fan is not moving any air. Jim McManus informed PMA of this with the intent to initiate a Work Request.
2. Industrial Arts Air-handling Unit; Rather than move to fixed damper positions for the outdoor air quantities noted in the original sequence of operation, the dampers were observed to continually 'hunt'. It appears that the dampers are modulating based on a mixed air control. The three-way control valve consequently modulates in order to maintain the supply air discharge.
3. Pressurization; During the site visit, with no exhaust fans operating, the industrial arts area was measured to have a 2 to 3 Pa negative pressure relative to the corridor. While consistent with the general positive pressurization in the school, this situation is contrary to the anticipated scenario outlined previously. While the pressure relationship observation may have coincided with the IA AHU dampers being at a full return position, the 280 l/s of excess air delivered by the original system should have produced a positive pressure. No airflow was discernable at the transfer air duct. Other avenues of air leakage were investigated to explain the situation. There is an obsolete roof exhaust hood, with the uncapped duct packed with batt insulation, located at the woodwork shop ceiling. (This was associated with an original general exhaust system deleted in 1985.) While no airflow was readily apparent, the batt insulation will not provide a suitable air/vapour seal.

Other issues noted during the site visits included the presence of two open oil containers; one being a oil drain pan, the other being a mop pail. In addition, the chemical storage cabinets were not vented and had open vent fittings. These situations are contributing to the IAQ problems.

Recommendations

The following list of recommendations is intended to improve the IAQ in a cost effective manner:

1. Eliminate the 280 l/s air supply from the original system into the woodworking area. The grilles should be removed, with the branch take-offs capped.
2. Seal the transfer duct between the woodwork shop and the CADD room.
3. Reduce the outdoor air quantity at the IA air-handling unit from 325 l/s of O/A at low speed to 150 l/s.
4. Following remedial work at the welding area fan, set the exhaust rate at 300 l/s. Revise the control of the fan such that it operates continuously.
5. Ensure the interlock between the metal shop convertible exhaust system is interlocked with the IA AHU operation on high speed. The dampers shall move to introduce 500 l/s of outdoor air.
6. Provide direct vents for the chemical storage cabinets.

Comments and Conclusions

The operation of the IA AHU is essentially controlled by electric devices. Given that the majority of the school is currently controlled by DDC systems, there is some merit in upgrading the AHU control at this time. The recent project issued by YTG to upgrade the school time clock and remote devices could have the scope increased to include a larger module for control of this air-handling unit in addition to time control only. The incremental cost for this work would be on the order of $2000.

As noted in the other reports, it is essential to continue to monitor the indoor air quality and the health of the occupants at the school. It should be noted that prior to implementing the reduction of the outdoor air quantity measure, measurements of the current airflows should be provided.

Appendix B

Long Term Groundwater Temperature Trends for Vanier School
Groundwater Heat Pump

By

Gartner Lee Limited

March 25, 2003

Gartner Lee Limited

March 25, 2002

Ron Gee, Technical Advisor
Energy Solutions Centre Inc.
206A Lowe Street
Whitehorse, Yukon Y1A 1W6

Dear Mr. Gee

Re: 22-292 – Long Term Groundwater Temperature Trends for Vanier School Groundwater Heat Pump

Gartner Lee Limited has been asked to comment on the potential for long-term cooling or thermal effects in conjunction with the proposed Vanier School Groundwater Heat Pump (GWHP) system. Specifically, the Government of Yukon Department of Education (operators of the Vanier School), have asked whether long-term operation of the school's proposed GWHP, will eventually cause groundwater temperature to drop sufficiently such that the GWHP system would no longer work efficiently. For more complete information on operation of groundwater heat pumps, the reader is referred to Chapter 6 of the ASHRAE design manual for ground source heat pumps entitled "*Ground-Source Heat Pumps: Design of Geothermal Systems for Commercial and Institution Buildings*" (Kavanaugh and Rafferty 1997).)

Thermal buildup, or specifically, a buildup of cold water in the vicinity of a heating-cycle dominated groundwater heat pump, is typically not a concern in groundwater (open-loop) heat pump system such as that proposed for the Vanier School project,. Thermal buildup is a consideration in most closed-loop, or ground coupled (GCHP) systems. When sizing closed-loop systems, a multi-year analysis is conducted and the total length of the loop is adjusted for the long-term thermal buildup (see Kavanaugh and Rafferty 1997).

Groundwater based heat pump systems take advantage of the natural flow of groundwater past the system and therefore long-term cooling of the aquifer is not a concern. The proposed system at Vanier school consists of a production well adjacent to the school which will be completed in the Selkirk Aquifer, a highly productive aquifer,. After passing through the heat pumps, the groundwater will be returned to the aquifer using a pair of injection wells located approximately 130 m north of the production well. The injection wells are located downgradient (i.e downstream) of the production well so that cooled water from the GWHP is continuously returned to the aquifer downgradient of the production well

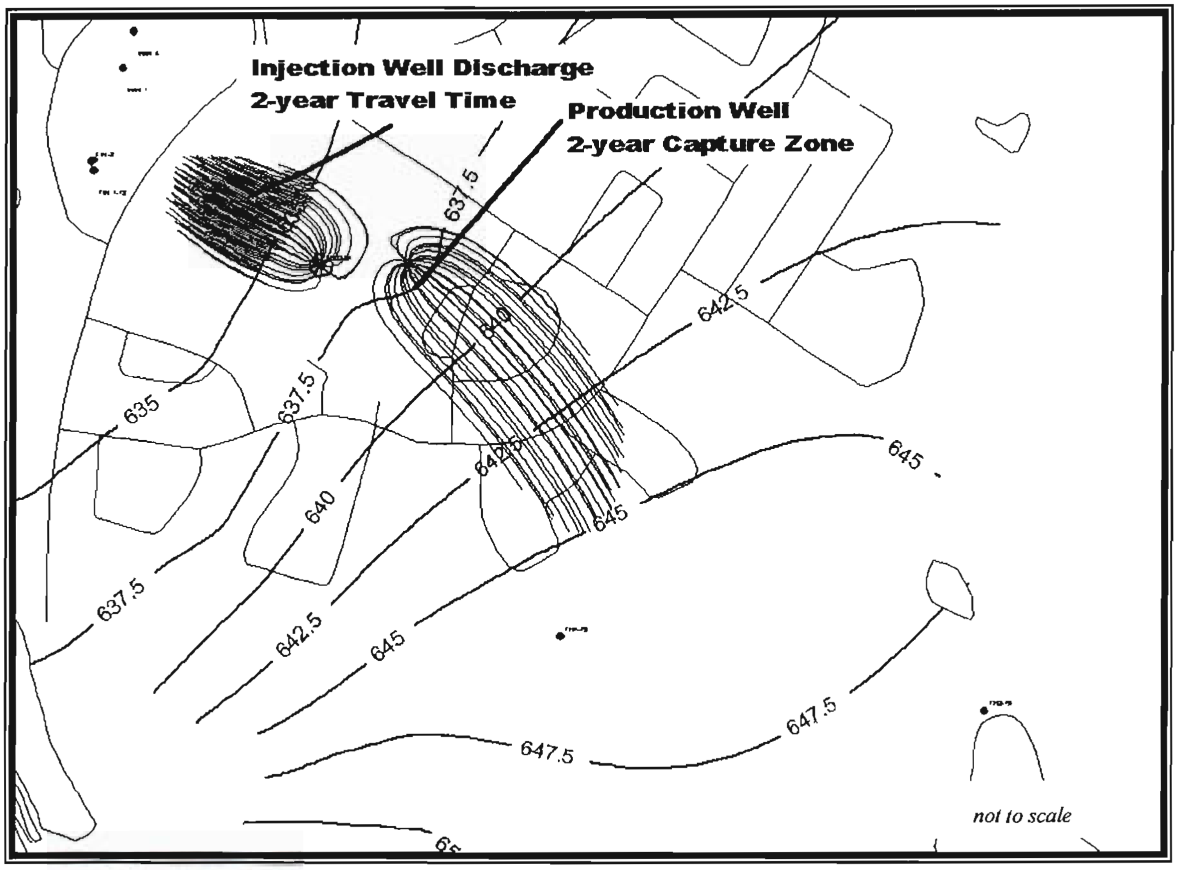
There maybe some re-circulation of cooled groundwater from the injection wells, back to the production wells, however, adequate well separation is key to reducing this effect. Kavanaugh and Rafferty (1997) note:

> "In GWHP application, it is acceptable to have some flow from the injection well to the production well. Although the water would transfer (cold) to and from the aquifer materials while flowing from one well to the other, the temperature upon arriving at the production well would be essentially the same as the ambient groundwater temperature, assuming low flow rates between the two wells."

In the case of the Vanier School proposal, groundwater flow modelling of the site suggests almost no cooled water would flow from the injection well back to the production well. This scenario was run in the Gartner Lee's numerical groundwater flow model of the Selkirk Aquifer. Figure 1. illustrates the flow of water into the production well (shown in red) and the discharge of cooled water from the injection well (shown in blue). The particle tracking shows that none of the cooled "particles" from the injection well return to the production well.

The groundwater flow system preventing cold buildup around the production well is further enhanced by the fact that the cooled groundwater will rapidly equilibrate and return to mean ground temperatures. Specifically, the aquifer materials and associated groundwater have a huge thermal mass that is continuously heated by both solar radiation and deep ground heat. Groundwater temperatures in the Selkirk Aquifer represents the deep ground temperatures—in the case of the lower portion of the aquifer, this ground temperature is approximately 5.5 degree Celsius. Groundwater entering from the surface warms to this ground temperature as it flows through the aquifer. In the case of the Selkirk Aquifer, it is estimated that it takes approximately 10 years for groundwater to flow from the Hidden Lakes area to the Vanier School area. That is more than ample time for the heat to diffuse into the body of colder water and bring the temperature back to the mean.

Figure 1. Particle Tracking from Proposed Vanier School Production/Injection Well Pair*



** Note: For illustration purposes, this is not a thorough capture zone analysis or detailed groundwater flow simulation.*

With respect to water quantity and water levels in the aquifer, all groundwater used by heat pump system will be returned to the Selkirk Aquifer, and therefore there will be no net loss of groundwater, and therefore, no depletion of the aquifer. A cone of depression will form around the production well, but based on recent numerical groundwater modelling of the Selkirk Aquifer for the City of Whitehorse, this maximum drawdown in the well vicinity at steady-state is predicted to be on the order of three to four metres. The well is designed to accommodate this drawdown. Smaller groundwater mounds will form in the vicinity of the two injection wells.

In summary, the proposed Vanier School Groundwater Heat Pump will have no net depletion of groundwater from Selkirk Aquifer, if operated as described above. Based on the separation and configuration of the injection well pair, and the rapid groundwater flow rates in the area, the production well will intercept primarily warm groundwater from upgradient of the site. Minimal "cooled" groundwater should be intercepted by the production well and therefore the heat pump system will sustainable produce "warm" water, representative of aquifer temperatures (e.g. 5.5 degrees C).

I trust that this information helps explain the sustainable nature of the proposed project. If we can be of any further assistance, please feel free to contact the undersigned at (867) 633-6474 extension 23.

GARTNER LEE LIMITED

Forest Pearson, B.Sc., P.Eng.,
Geological Engineer

FKP:fkp