UNIVERSITY OF TORONTO

OFFICE OF THE GOVERNING COUNCIL

FOR RECOMMENDATION **PUBLIC** **OPEN SESSION**

TO: Planning & Budget Committee

SPONSOR: Scott Mabury, Vice President Operations and Real Estate Partnerships
CONTACT INFO: 416-978-2031, scott.mabury@utoronto.ca

PRESENTER: Ron Saporta, Chief Operating Officer, Property Services & Sustainability

CONTACT INFO: 416-978-5098, ron.saporta@utoronto.ca

DATE: August 30, 2019 for September 17, 2019

AGENDA ITEM: 5(f)

ITEM IDENTIFICATION:

Capital Project: Geothermal System at Robert Street Field

JURISDICTIONAL INFORMATION:

Pursuant to section 4.2.3. of the Terms of Reference of the Planning and Budget Committee, "…the Committee considers reports of project planning committees and recommends to the Academic Board approval in principle of projects (i.e. space plan, site, overall cost and sources of funds)."

Under the *Policy on Capital Planning and Capital Projects*, "…Capital projects over $5 million and up to $20 million will be considered by the Planning and Budget Committee for projects at the St. George campus and by the respective Campus Affairs Committees and Campus Councils for projects at University of Toronto Mississauga and University of Toronto Scarborough and recommended to the Academic Board for consideration. It is expected that such projects will be placed on the Board's consent agenda and be confirmed by the Executive Committee of the Governing Council. Execution of such projects is approved by the Business Board. […] If the project will require financing as part of the funding, the project proposal must be considered by the Business Board."

GOVERNANCE PATH:

A. Project Approval
1. **Planning and Budget [for recommendation] (September 17, 2019)**
2. Academic Board [for approval] (October 3 2019)
3. Business Board [for approval, financing] (October 7, 2019)
4. Executive Committee [for confirmation] (October 15, 2019)

B. Execution of the Project:
1. Business Board [for approval] (October 7, 2019)

PREVIOUS ACTION TAKEN:

On April 22, 2019, CaPS Executive Committee approval to engage consultants to initiate design services for the Robert Street Field Revitalization project was confirmed. Through a subsequent proposal call, ARUP was selected as the geothermal consultant for both the feasibility study and design phase.

HIGHLIGHTS:

University of Toronto's Carbon Reduction Commitment

The University of Toronto has joined 12 other leading research universities in North America in a coalition to reduce greenhouse gas emissions on their own campuses and in their communities. Members of the University Climate Change Coalition aim to mobilize their resources, research partnerships and expertise to help businesses, cities and regions implement research-driven climate solutions. As part of the coalition, U of T has set a goal to reduce greenhouse gas emissions by 37 per cent from 1990 levels by the year 2030. The university is also developing programming to engage the Toronto area community in sustainability.

In recent years, U of T has made great strides in reducing its carbon footprint across its three campuses, reducing its energy and water usage through various retrofits and sustainability initiatives. For example, despite a 26 per cent growth in floor space and a 50 per cent increase in the number of students, U of T lowered its total greenhouse gas emissions by 32 per cent from 2008 to 2016. Further to this, in 2018 U of T was named one of Canada's greenest employers – for the fifth time.

U of T has a carbon target of approximately 59,000 tonnes per year by 2030, which would represent a need to reduce our emissions by 70% from 2017. The bulk of the required reductions, and opportunities, are to be found at St. George Campus which represents ~90% of the total for U of T.

In an effort towards this target, U of T, has launched a series of greenhouse gas reduction projects. These projects were partially funded through the Ontario Government's cap and trade program and include:

a. Introduction of DDC building controls in a number of campus buildings currently equipped with legacy systems or having no automation system at all,
b. Installation of primary and sub-metering on all buildings currently without this technology on campus,
c. Installation of renewable systems which marry photovoltaic electrical producing arrays with solar thermal array systems, producing electricity and hot water simultaneously,
d. Upgrade of our aged chilled water infrastructure with energy efficient equipment.

These projects are part of the over $50-million in investments and are projected to reduce our greenhouse gas emissions by 8,000 tonnes of CO2 annually, starting in 2019.

Geothermal System at Robert Street Field

The Robert Street Field district geothermal system presents a unique opportunity for the University of Toronto to lower green-house gas emission levels. The proposed geothermal field will serve the new student residence, as well as tie into the university's direstrict energy system.

The University commissioned a study through Arup Canada to assess the feasibility of establishing the proposed district geothermal system. The study confirmed feasibility and recommended pursuing the project.

A preliminary design of the Robert Street Field district geothermal system has been developed based on the available borefield capacity and district thermal load. Lifecycle cost analysis of different borefield capacities were considered in the feasibility study, as well as the capital cost estimation of various design alternatives.

The proposed district geothermal energy system is projected to achieve greenhouse gas emissions reduction by 1050 ton of CO_2e or 90% comparing to a natural-gas based business-as-usual scenario. This greenhouse gas emission reduction is associated with the SSR and providing energy to the campus through the north west chiller plant. For the Spadina-Sussex Student Residence (SSR), the district geothermal system can help reduce its whole-building energy use intensity (EUI) and equivalent greenhouse gas emission by 35.6% and 69.2%.

The proposed district geothermal system is a two-pipe condenser water distribution system with decentralized heat pumps. The construction of the proposed district energy system is as follows:

- **Phase 1** will be the revitalization of the Robert Street Field that includes the construction a geoexchange system under the new soccer field, with the distribution piping (light green) capped at Sussex Mews Lands.

- **Phase 2** will be the construction of the Spadina-Sussex Student Residence (SSR) that includes the mechanical plant equipment, and the underground connections across Sussex Mews connecting the ground loop water piping from Sussex Mews Lands to the SSR.

- **Phase 3** will be the construction of the district distribution piping across Spadina Avenue (purple) to the University's Northwest Chiller Plant and adjacent existing/planned development.

Construction implementation schedule for the district geothermal system:

Schedule

The proposed schedule for the project is as follows:

- October 24, 2019 Governing Council, Cycle 1 2019-20
- August-September 2019 Construction Documents
- October 2019 Tender and Award
- November 2019 Estimated Construction Start
- June 2020 Estimated Completion Date

FINANCIAL AND PLANNING IMPLICATIONS:

Discussion of overall costs and sources of funds can be found in the *in camera* document for this project.

RECOMMENDATION:

Be It Recommended:

THAT the *Feasibility Study for Robert Street Field Geothermal System,* dated May 17, 2019, be approved in principle, to be funded by financing.

DOCUMENTATION PROVIDED:

- *Feasibility Study for Robert Street Field Geothermal System,* dated May 17, 2019.

University of Toronto

Feasibility Study for Robert Street Field Geothermal System

Final Report

Rev 2 | May 17, 2019

UNIVERSITY OF TORONTO

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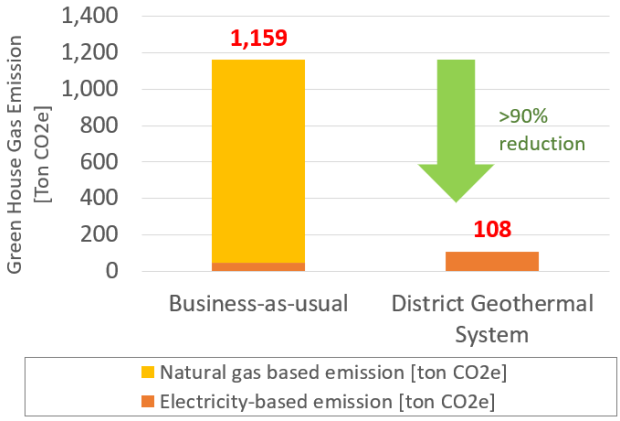
Arup Canada Inc.
121 Bloor Street East
Suite 900
Toronto ON M4W 3M5
Canada
www.arup.com

ARUP

Contents

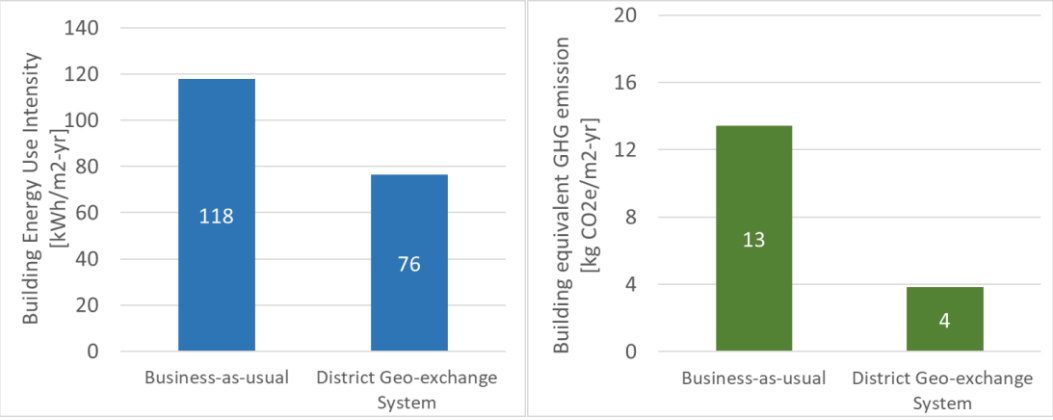
1 Executive Summary

The Robert Street Field district geothermal system presents a unique opportunity for the University of Toronto to lower green-house gas emission (CO_2e) level. Based on our findings, the district energy system can avoid approximately 1050 tons of CO_2e when compared to the business-as-usual scenario. The district geothermal energy system is achieving deep green-house gas emissions reduction by utilizing electricity for heating (in lieu of natural gas) for the Spadina-Sussex Student Residence, the Metro Private Residence, and Miles Nadal Jewish Community Centre.



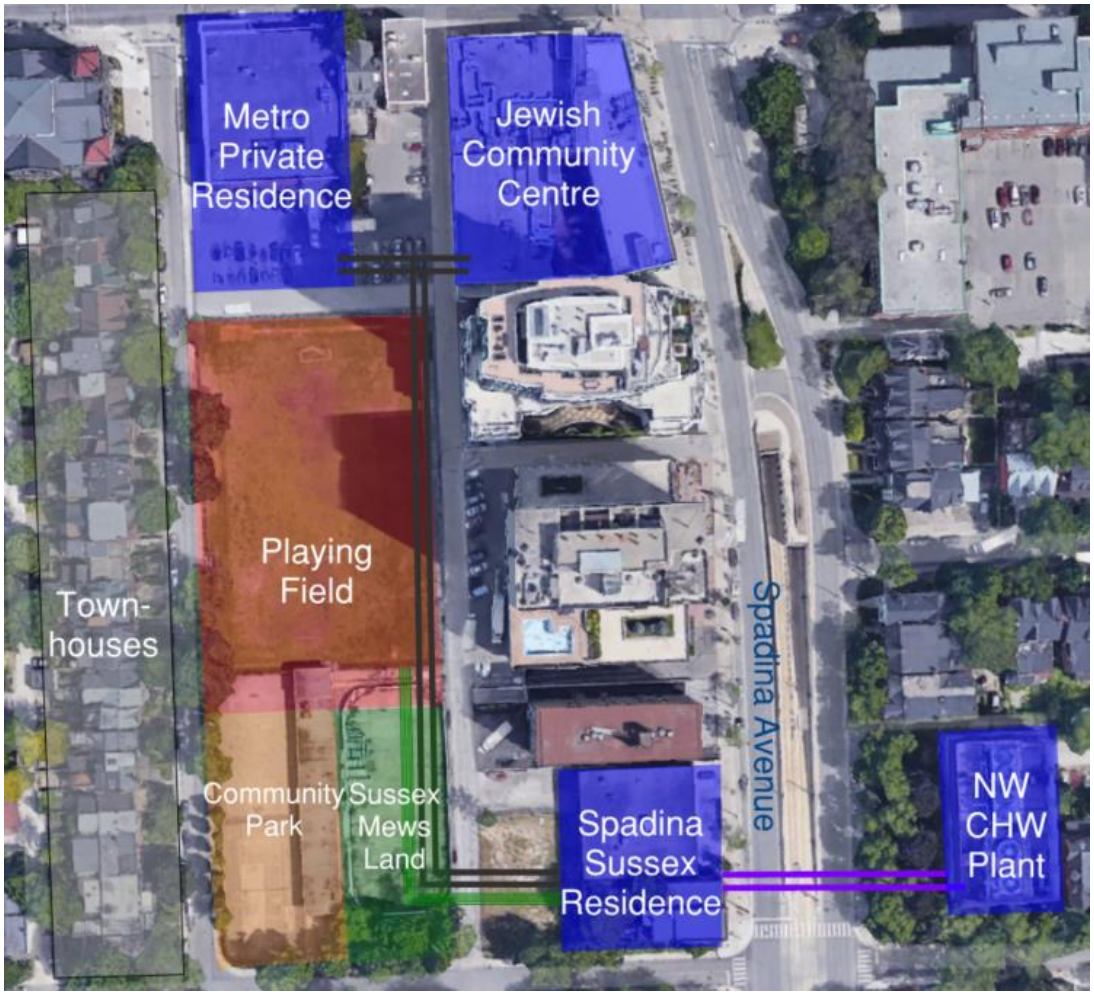
Note: GHG emission presented include space heating and cooling energy use only, and does not include emission related to lighting, equipment, plug and process load

For the Spadina-Sussex Student Residence (SSR), the district geothermal system is estimated to reduce its whole-building energy use intensity (EUI) and equivalent greenhouse gas emission by 36% and 69% respectively, reducing the EUI and GHGe as shown in the figure below. The higher building energy performance and lower building equivalent GHG emission can help the SSR potentially achieve a higher-level of LEED certification (i.e. LEED Gold) and higher Toronto Green Standards (TGS) tiers. Achieving higher TGS tiers allows the project to obtain partial development charge refunds from the City of Toronto.



The proposed district geothermal system is a two-pipe condenser water distribution system with decentralized heat pumps. A site distribution schematic is shown in the figure below. The construction of the proposed district energy system is as follows:

- **Phase 1** will be the revitalization of the Robert Street Field that includes the construction of 216 boreholes at the new soccer field and community park area, with the ground water distribution piping (light green) capped at Sussex Mews Lands.
- **Phase 2** will be the construction of the Spadina-Sussex Student Residence (SSR) that includes the mechanical plant equipment, and the underground connections across Sussex Mews connecting the ground loop water piping from Sussex Mews Lands to the SSR.
- **Phase 3** will be the construction of the district distribution piping (grey) to third-party buildings, or across Spadina Avenue (purple) to the University's Northwest Chiller Plant and adjacent existing/planned development.



The following tables present the Class D capital cost estimates by construction phases, and the life cycle cost analysis of the proposed district 2-pipe geothermal system below. The simple payback period for district geothermal energy system against a natural-gas based standalone building system is 28 years. It is worth noting that if the residential buildings are to meet the Toronto Green Standard (TGS) v3 tier 3 requirements, the business-as-usual system type is electricity-based air-source heat pumps sized for 50% of the peak thermal demand with gas topped-up per TGS Zero Emission Building Framework (ZEBF). A life cycle cost analysis with the air-source heat pump system as the business-as-usual system type will yield a considerably lower payback period.

Capital Cost Estimation	
Project Phase	**220 Boreholes**
Phase 1 – Geothermal Borefield	$3,942,000
Phase 2 – Spadina-Sussex Student Residence (SSR)	$1,756,000
Phase 3a – Third-Party Site Distribution	$1,445,000
Avoided Cost - Business as Usual SSR	($1,921,000)
Total with Phase 3a	$5,222,000
Phase 3b – NW Chiller Plant Connection	$1,797,573
Total with Phase 3b	$5,574,573

Note: exclude cost premium for design alternative such as geothermal vault in lieu of piping manifold at plant, optional supplementary equipment, and renewable system integration

Life Cycle Cost Analysis	
	220 boreholes
Total Capital cost	$5,222,000
Avoided (Added) Energy Cost	$11,283
Avoided Carbon Tax	$52,550
Avoided O&M Costs	$125,363
Net Avoided Costs	$189,196
Simple Payback (Years)	27.6

Note: assumed $50 per tonne based on pan-Canadian pricing on carbon pollution

Based on the findings of this feasibility study, Arup has the following recommendations:

- Considering the significant carbon emission reduction (avoidance) with the district geothermal system, the University's green house gas reduction pledge, and the limited timeline to perform earthwork at the Robert Street Field, Arup recommend the University to further pursue a district geothermal system at the Robert Street Field (project phase 1) and proceed to schematic and detailed design stages.

- Engage the City of Toronto regarding permitting issues with the implementation of the district geothermal system and utility infrastructure underneath public rights-of-way (across Sussex Mews and Spadina).
- Arup does not recommend proceeding with third party distribution piping construction until third parties have confirmed their commitment/participation in proposed district energy network.
- Arup does not recommend the cost premium design alternatives including inverted trench and geothermal vault, based on increased financial burden of technically equivalent solutions.
- In lieu of connecting the district geothermal system to third-party buildings, Arup recommends the University to further investigating connecting the district geothermal borefield to the University's Northwest Chiller Plant (across Spadina Avenue) and utilize the low-carbon energy source for the University's existing/planned buildings. This will help support the University of Toronto's pledge to reduce 37% campus-wide green house gas emission by year 2030 (based on 1990 level). Recommended further analyses to determine how the low-carbon district geothermal system can be integrated with the campus include but not limited to:
    - Assessment of existing/new building thermal load to be connected to the district geothermal system via the NW Chiller Plant. A hybrid geothermal system approach (geothermal supplemented by conventional fossil fuel system) is likely required to integrate with the main campus building load.
    - Perform a detailed technical analysis to refine and coordinate the requirements of horizontal directional drilling (HDD) across Spadina to connect the district geothermal system to the main campus. This includes but not limited to coordination with the foundation work of the SSR, permitting issue, spatial requirement of a launch pit near the Northwest chilled water plant, and implications of existing trees and utility infrastructure.
    - A life cycle cost analysis to integrate the district geothermal system with the NW Chiller Plant

2 General Overview

The University of Toronto St. George Campus is planning to revitalize the Robert Street Field and construct a new student residence building at the North-west corner of Spadina Avenue and Sussex Avenue. The following diagram depicts the locations and areas of the Robert Street Fields (RSF) and the new student residence tower.

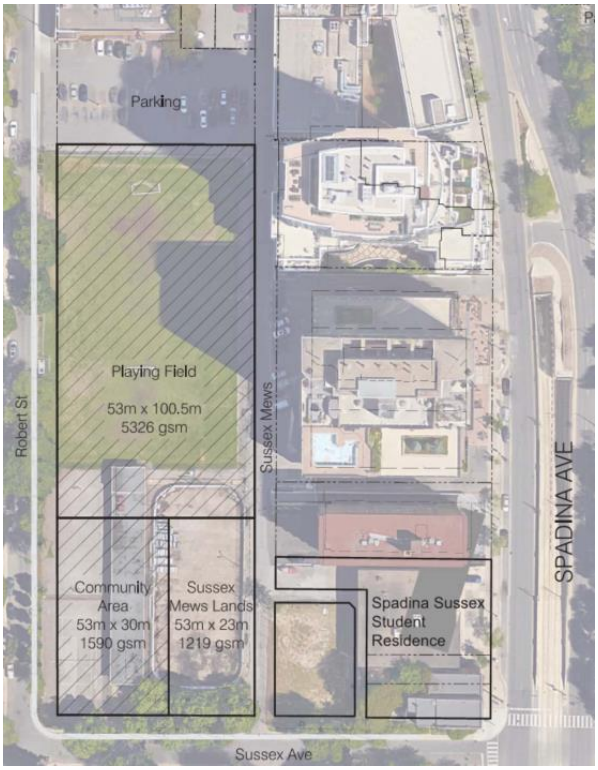


Figure 1: Location of the Robert Street Fields and the Spadina Sussex Student Residence

The new student residence, Spadina Sussex Student Residence (SSR), is a 24-storey tower currently in design development phase. The Robert Street Field (RSF) is located to the west of the planned new student residence, and the RSF can be broken down into three areas: (1) Playing Field, (2) Community Area, and (3) Sussex Mews Lands.

The Playing Field will remain on the northern portion of the site but enlarged. No stadium seating and other permanent building structure is expected at the new Playing Field, but the area will be designed as an engineered system, completed with a new sub-surface drainage and irrigation systems. The Community Area currently includes tennis courts and a change facility building; all existing structures and play surfaces will be demolished and become a new community park for the adjacent community. The Sussex Mews Lands include an existing ice rink, which

is planned to be demolished and the area will be used as a construction staging ground for the new student residence. Future development may take place at the Sussex Mews Lands after the construction of the new student residence is completed. As part of an agreement with the City of Toronto, the Playing Field and the Community Area revitalization works are to be completed before above-grade construction work for the new student residence can begin, and the target date for Playing Field and Community Area revitalization works to be substantially completed by April 2020.

The University of Toronto has identified the Robert Street Field (RSF) as a Green House Gas (GHG) reduction opportunity for the University of Toronto to use geothermal technology to heat and cool adjacent buildings. The proposed geothermal field will serve the new student residence, as well as potential third-party buildings if capacity exists. The third-party properties are identified as (1) a new condominium development to the North of the Playing Field (Metro Private Residence), (2) the Miles Nadel Jewish Community Centre (MNJCC), and (3) residential townhouses/houses to the west of the Soccer field. The proposed district energy system will provide low-carbon energy source (or sink) for a district geothermal system, with the University of Toronto acting as a micro-utility. This objective of the study is to assist the University in preparing a full business case of the district energy concept. Potential to connect the geothermal field across Spadina to the University's Northwest Chiller plant is also explored. The study includes a rough order of magnitude capital cost estimate of horizontal directional drilling across Spadina to the NW chiller plant and new heat pumps to utilize the remainders of the geothermal borefield capacity after SSR.

Figure 2: Site map highlighting the primary load (SSR) and potential third-party user of the district geothermal system

3 Project Brief

The main objective of this study is to investigate the feasibility of establishing the proposed district geothermal system capable of providing both heating and cooling to the Spadina Sussex Student Residence (primary load) and potentially to adjacent third-party properties.

The feasibility study is based on the latest design drawings and planning document available at the time of study. The approach and methodology begin with the identification of the geothermal energy capacity from the available borefield areas. The thermal peak demand and annual thermal load profile of the SSR and the third-party buildings are also developed and matched against the borefield to determine the geothermal system temperature fluctuation and peak temperature. These analyses enable preliminary system design and discussion around system design and operation parameters. Once a preliminary system design is developed, the capital cost, annual utility and O&M cost of the district system as well as a business-as-usual scenario are developed to determine the lifecycle cost of the proposed district energy concept.

As part of the study, Arup has retained Beatty Geothermal Consulting as our local geothermal specialist consultant with support from our internal geothermal specialists from London, United Kingdom, and AW Hooker as our local cost estimators.

4 District Geothermal Capacity and Thermal Load Assessment

The Robert Street Field geothermal analysis and preliminary design is based upon the King's College Circle's (KCC) Geothermal Thermal Conductivity Report, performed by Geosource Energy Inc. for the University of Toronto, dated February 14, 2019. While significant difference in thermal conductivity is not expected between KCC and RSF, a site-specific thermal response test for RSF is recommended for the detailed design of the geothermal borefield. The King's College Circle field is approximate 800 meters south-east of the RSF. The thermal conductivity results in the report are not atypical considering the geology in the Downtown[1] Toronto area, summarized below:

- The thermal conductivity results in the report shows values ranging from 1.34 Btu/(hr *ft *F) (or 2.32 W/(m *K)) to 1.46 Btu/(hr *ft *F), (or 2.53 W/(m *K))

1

- Borehole tests showed a deep earth temperature of 53.5F to 53.9F (11.9C to 12.2C)
- The geology consists of 28 m of overburden, underlain by shale to 184.4 m, underlain by limestone to 189 m (end of test borehole)
- The estimated thermal diffusivity is 0.85 ft^2/day (0.08 m^2/day)
- Test borehole is at 620 ft (189m) deep

Parameter	BH1	BH2	BH3	BH4
Thermal Conductivity	1.34 Btu/(hr*ft*°F) 2.32 W/(m*°K)	1.36 Btu/(hr*ft*°F) 2.35 W/(m*°K)	1.46 Btu/(hr*ft*°F) 2.53 W/(m*°K)	1.36 Btu/(hr*ft*°F) 2.35 W/(m*°K)
Borehole Resistance	0.32 (hr*ft*°F)/Btu 0.19 (m*°K)/W	0.25 (hr*ft*°F)/Btu 0.14 (m*°K)/W	0.14 (hr*ft*°F)/Btu 0.08 (m*°K)/W	0.1 (hr*ft*°F)/Btu 0.06 (m*°K)/W
Ambient Deep Earth Temperature	53.9 °F 12.2 °C	53.5 °F 11.9 °C	53.5 °F 11.9 °C	53.5 °F 11.9 °C
Estimated Thermal Diffusivity	0.85 ft^2/day 0.08 m^2/day	0.85 ft^2/day 0.08 m^2/day	0.85 ft^2/day 0.08 m^2/day	0.85 ft^2/day 0.08 m^2/day

Table 1: Geothermal in-situ test results from King's College Circle

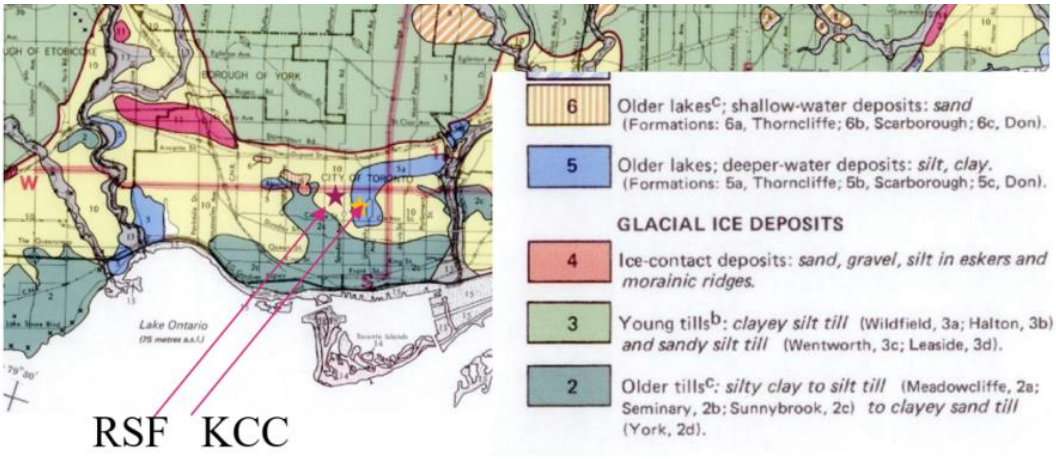


Figure 3: Quarternary Geology of Toronto and Surrounding Area (Source: Ministry of Energy, Northern Development and Mines)

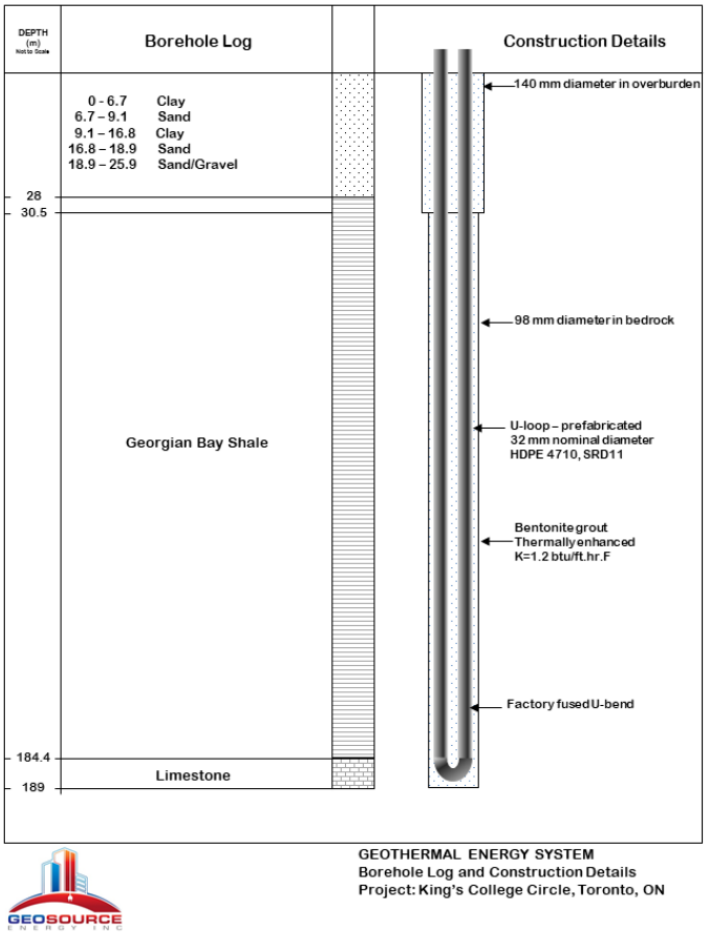


Figure 4: Geology at King's College Circle Geothermal Thermal Conductivity Report by Geosource Energy Inc

To develop a preliminary system design, building load profiles for the Spadina Sussex Student Residence (SSR) and third-party buildings are first developed and matched against the available geothermal capacity at Robert Street Field. A shoebox energy model was developed using energy modelling software, IES-VE v2017, based on TGS v3 tier 3 design parameters outlined in the Zero Emission Building Framework (ZEBF), with the exception that the base mechanical system is assumed to be a high efficiency chiller and condensing boiler, in lieu of 50% air-sourced heat pump with gas heating top up per TGS ZEBF. The peak design cooling and heating capacity of the SSR is calculated at 300 ton (1,055 kW_t) and 2,300 MBH (675 kW_t). Key outputs and profiles are presented in the tables and figures below. Energy model inputs can be found at Appendix A & B.

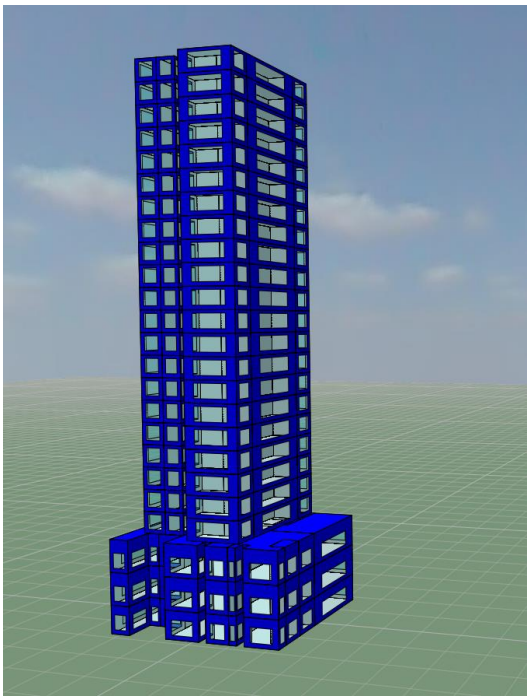


Figure 5: Energy model of the Spadina Sussex Student Residence

	Cooling	**Heating**
Peak Demand (Design)	300 ton (1,055 kW_t)	2,300 MBH (675 kW_t)
Peak Demand per Area	700 ft^2/ton (54.1 W_t/m^2)	12 btu/hr-ft^2 (37.8 W_t/m^2)
Annual Thermal Demand	1,003,110 kWh_t	1,407,545 kWh_t

Table 2: Key energy model outputs from the Spadina Sussex Student Residence energy model

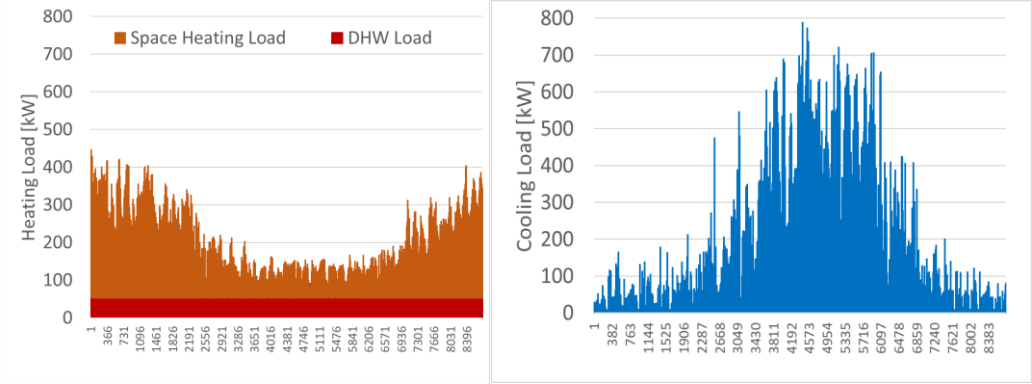


Figure 6: Annual thermal profiles of the Spadina Sussex Student Residence

To develop the district thermal profiles (including third-party buildings), the new Metro Private Residence load is determined based on adjacent residential development, the site area, building height, and similar building performance level as the Spadina Student Sussex Residence. The thermal load profiles for the Jewish Community Center and Robert Street Townhouses are developed using Arup's District Energy Feasibility Tool, based upon pre-1990s energy performance levels. The peak cooling demand and the district thermal load profile are summarized in the table and figure below.

It should be noted that townhouses have been dropped from the feasibility study based on discussion at progress meeting #1 due to their relatively low thermal demand and the considerable length of distribution piping required to connect the townhouses.

This feasibility study did not include an identification and assessment of the thermal demand with regards to integrating the district geothermal system to NW Chiller Plant. The thermal demand is expected to exceed the district geothermal capacity of the borefield, and as such a hybrid geothermal system (supplemented with conventional heating and cooling system such as boilers and chillers/cooling towers) will likely be required. Further technical analysis to identify and assess the thermal demand from buildings adjacent to the NW Chiller Plant is recommended. It should also be noted that the NW Chiller Plant is not part of a district heating system; new heating load from existing and/or new buildings will need to be identified for seasonal thermal balance of the district geothermal system.

Building	**Peak Cooling Demand**
Spadina Sussex Residence	300 Tons
Metro Private Residence	580 Tons
Jewish Community Centre	280 Tons
Robert Street Town Houses	90 Tons
TOTAL (Undiversified)[1]	**1160 Tons**
TOTAL (diversified)[1]	**990 Tons**
TOTAL (non-coincidental)[1]	**910 Tons**

Note 1: excludes Robert Street Town Houses

Table 3: Peak cooling demand from the third-party buildings

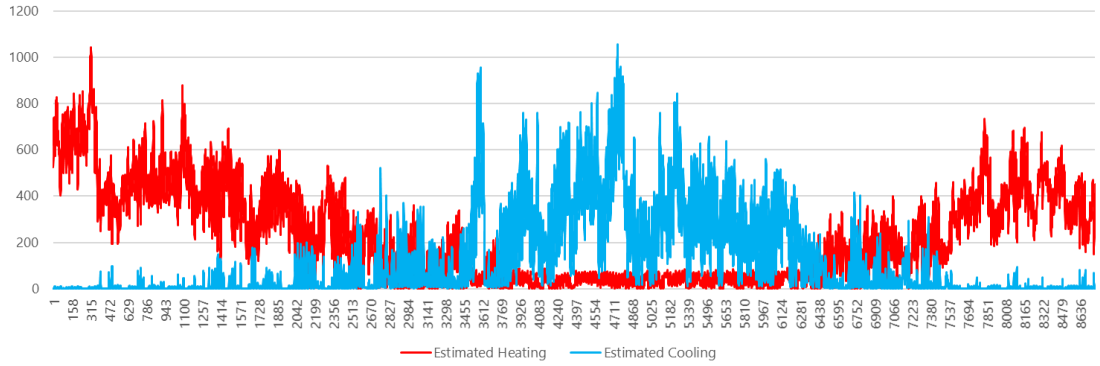


Figure 7: Annual thermal profiles of the Spadina Sussex Student Residence and third-party buildings

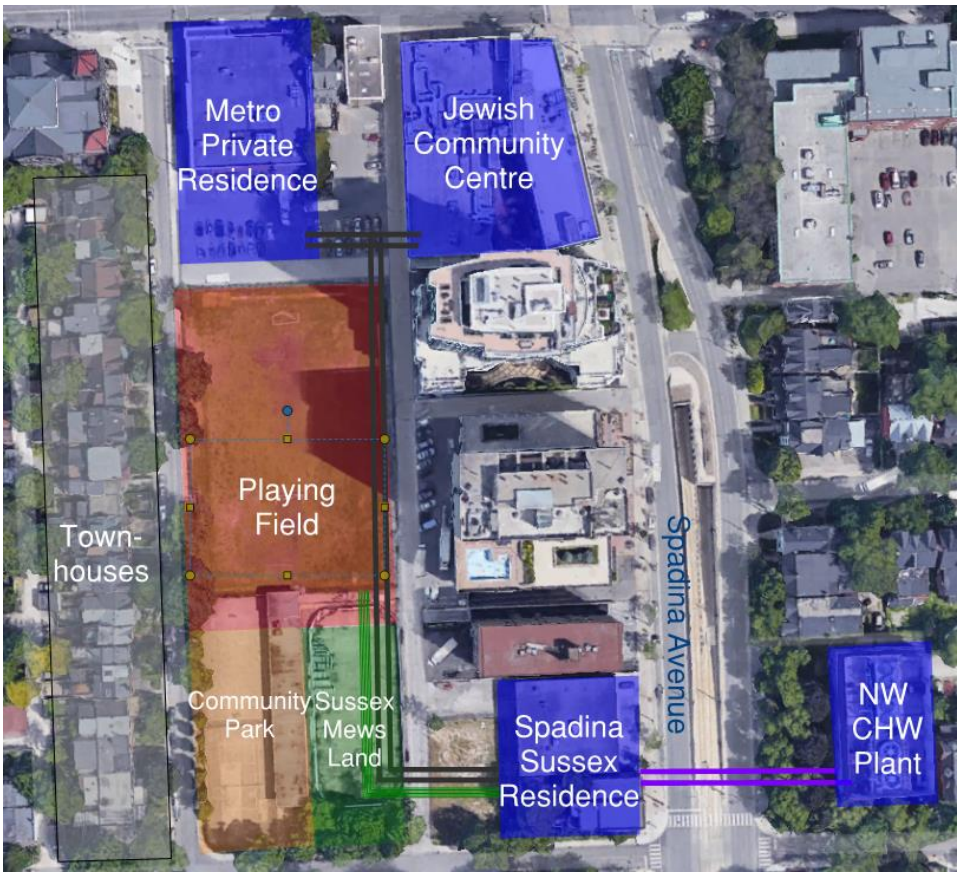


Figure 8: Proposed District Energy Network

5 Preliminary Design Schematics

Geothermal Borefield Layout and Borehole Details

The geothermal borefield layout for Robert Street Field and the maximum number of boreholes from each borehole field are presented in table 4 and figure 9. The geothermal boreholes will be connected in circuits of 9 boreholes each, in a parallel-reverse-return configuration. Typical details of boreholes circuits are shown in figure 10. Each circuit of 9 boreholes will be connected to the 75 mm (3") supply and return mains, oriented in a trench located parallel to the Sussex Mews lane. The 75 mm (3") supply and return mains will then be separately bundled and piped across Sussex Mews lane (see figure 10) and manifolded to 250 mm (10") supply and return header pipes located in the basement mechanical plant room at the SSR (see figure 9). The pipes can be bundled because all the supply and return mains contain the same respective temperature fluid. Figure 11 shows the header trench cross section of the supply and return mains. Figure 12 shows the supply/return manifold details at the SSR mechanical room. Based on discussions with the University in progress meetings, the preferred borehole combination is the Playing Field and the Community Area, for a total of 216 boreholes; the borefield layout of 216 boreholes is shown in figure 14.

Borehole Field Area	Max Number of Boreholes	Equivalent Cooling Capacity [1]
Playing Field (Borehole Field A)	162	527 ton or 1850 kW_t
Community Area (Borehole Field B)	54	175 ton or 617 kW_t
Sussex Mews Land (Borehole Field C)	27	88 ton or 308 kW_t
Spadina Sussex Student Residence (Borehole Field D)	65	211 ton or 743 kW_t
Total	**308**	**1001 ton or 3520 kW_t**

Note [1]: Equivalent cooling capacity is a simplified metric that is estimated based on a rule-of-thumb of 200 ft per ton and 3.25 ton per borehole. Actual cooling capacity is dependent on the field's geology and associated thermal conductivity, borehole depth, mechanical system design and operational parameters, calculated using geothermal simulation software.

Table 4: Tabulated Geothermal Boreholes and equivalent cooling capacity for Robert Street Field District Geothermal System

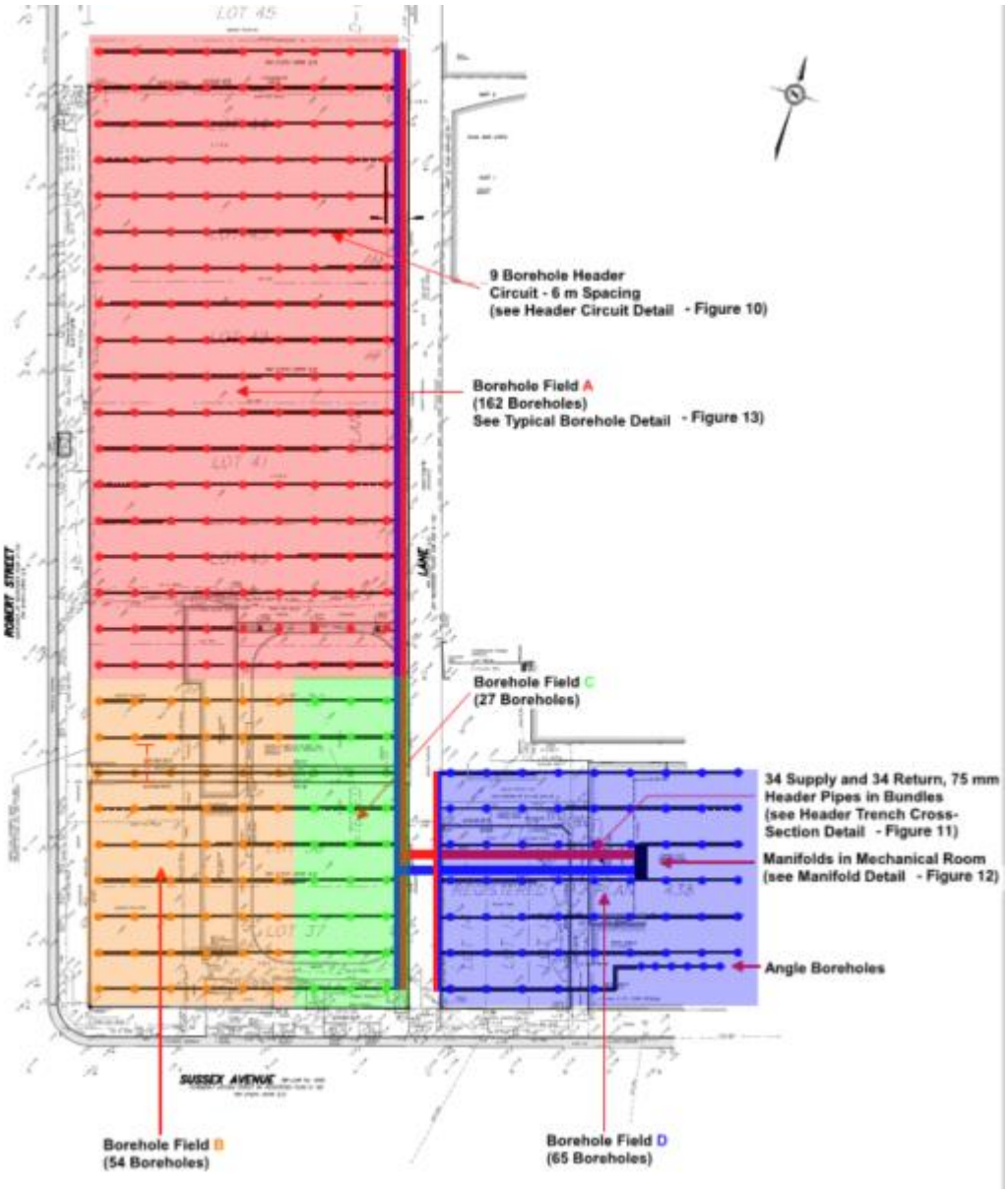


Figure 9: Geothermal Borefield Layout for Robert Street Field District Geothermal System

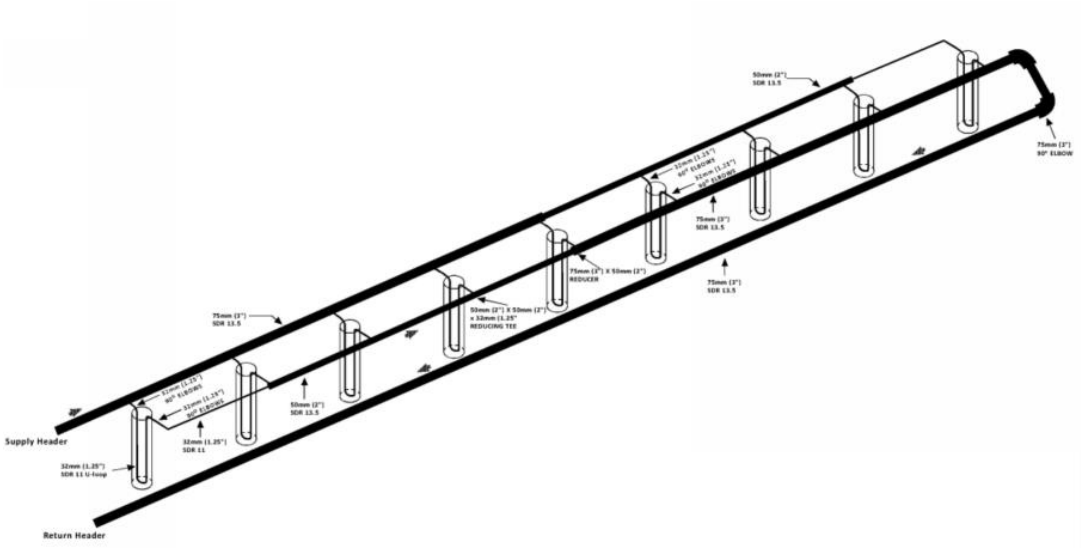
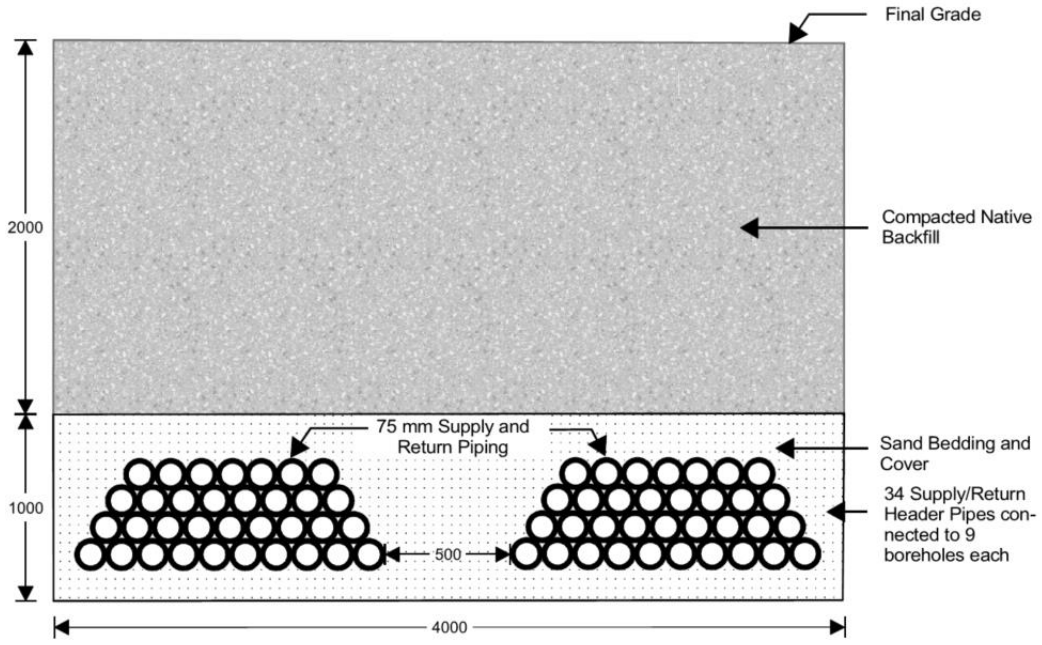


Figure 10: Typical Header Circuit of the Robert Street Field Geothermal System



Note: Dimensions in mm. Drawing note to scale

Figure 11: Header Trench Cross Section for Robert Street Fields District Geothermal System

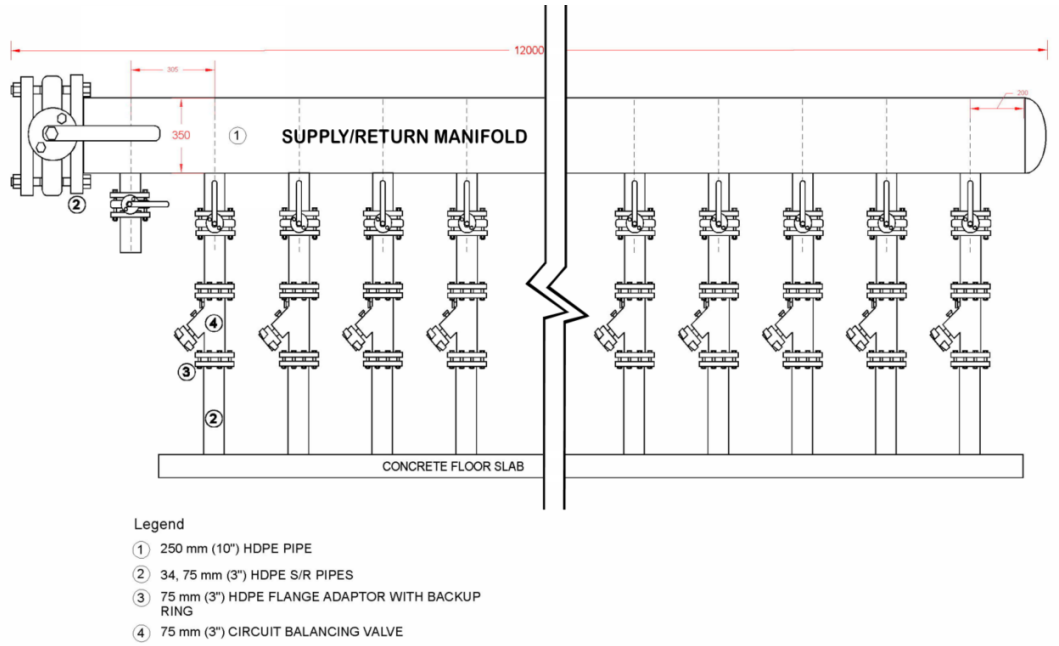


Figure 12: Typical Supply/Return Manifold Details

The basis of design borehole depth is 650 ft (or 198 m) and typical borehole details at this depth is presented in Figure 13. This depth was chosen because it represents the maximum depth currently attainable by typical Ontario geothermal drilling contractors under their ECA restrictions at the time of writing. Considering the geological condition at the site, deeper boreholes would yield a higher average borehole thermal conductivity because limestone has a higher thermal conductivity than shale bedrock. For a given number of boreholes, the total borehole field capacity of Robert Street Field can be increased with deeper boreholes. We are aware of at least one geothermal drilling contractor in Ontario who has started to install geothermal boreholes up to a depth of 800 ft. Although this type of deep borehole is uncommon in Ontario, it is regularly done in other countries such as Sweden and Switzerland.

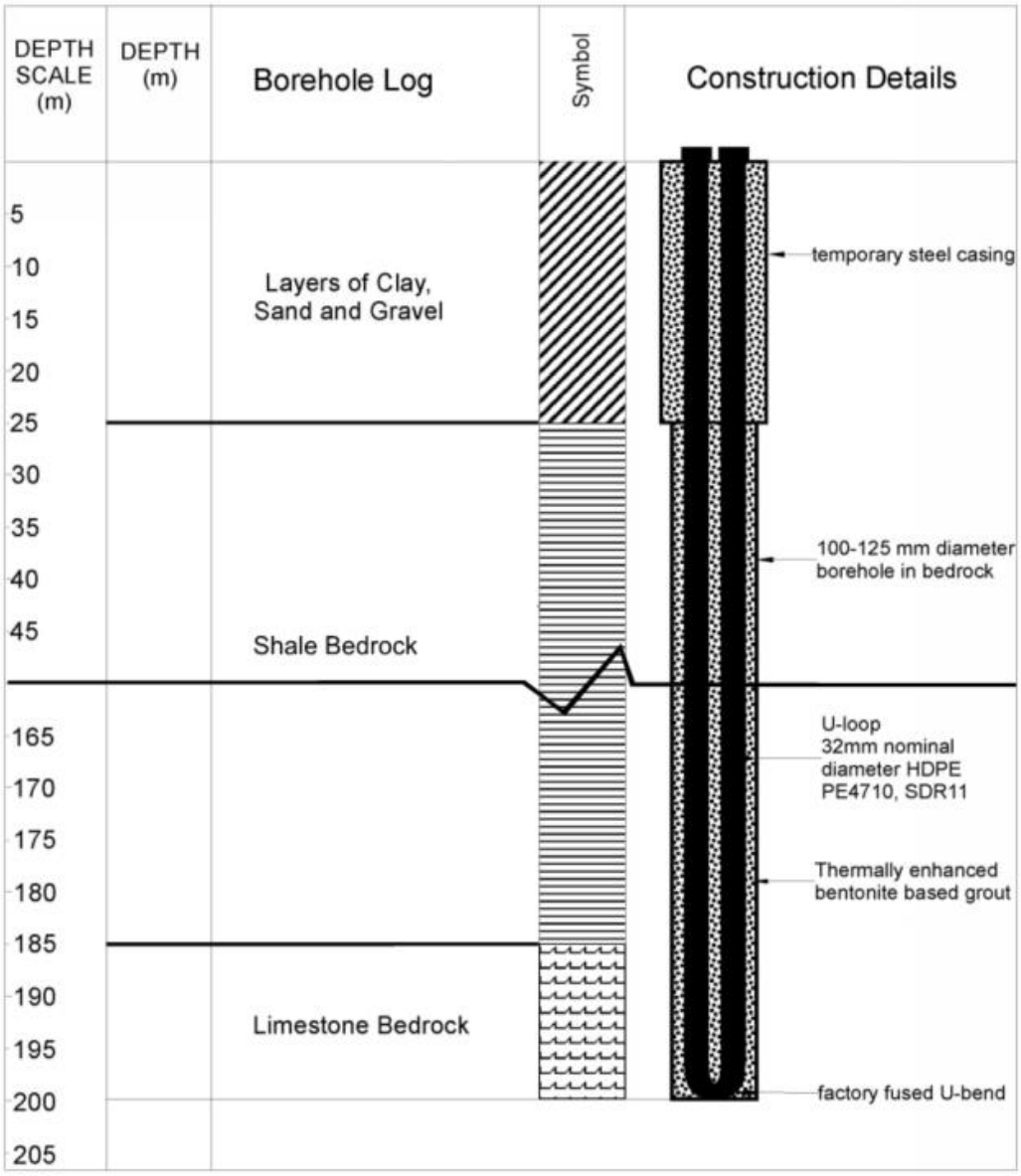


Figure 13: Typical Borehole Details for Robert Street Fields District Geothermal System

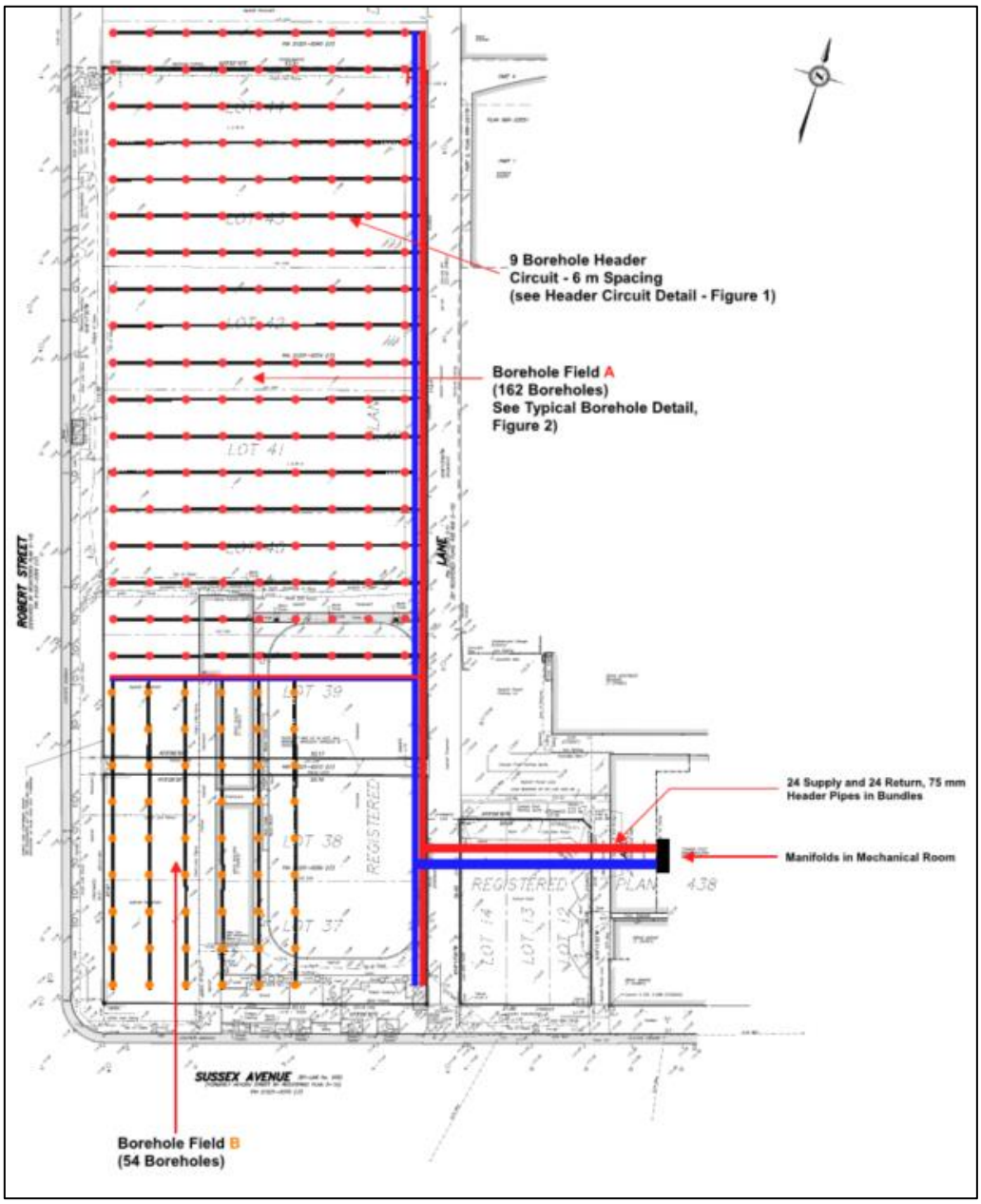


Figure 14: Preferred Borefield Layout for the Robert Street Fields District Geothermal System

Energy Distribution Strategy

The proposed energy distribution strategy is a 2-pipe district condenser water distribution system that utilizes decentralized heat pumps at the building plant level, shown in figure 15. A 2-pipe district distribution system with terminal heat pumps and a 4-pipe district chilled water and hot water distribution are also presented in figure 16 and 17. There are some advantages (and disadvantages) when comparing

the 2-pipe district condenser water distribution system versus a traditional 4-pipe district chilled water (CHW) and hot water (HW) distribution system. The main advantage of the 2-pipe district distribution system is the lower site distribution infrastructure capital cost and higher flexibility to adjust CHW and HW supply setpoint at individual building levels. A qualitative comparison of the different energy delivery schemes is shown in table 5. Per discussions in bi-weekly progress meetings with the University, the two-pipe decentralized heat pump option is preferred.

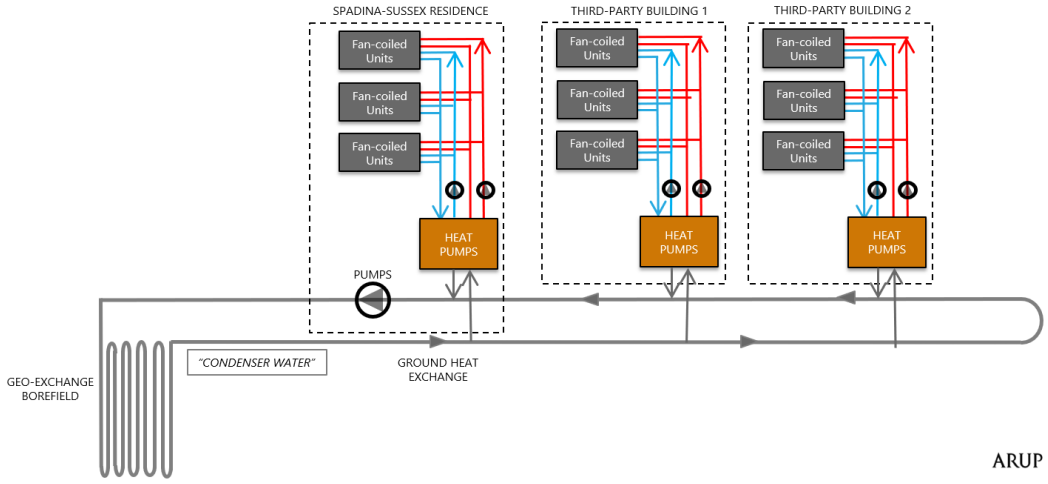


Figure 15: two-pipe district condenser water distribution with building level heat pumps

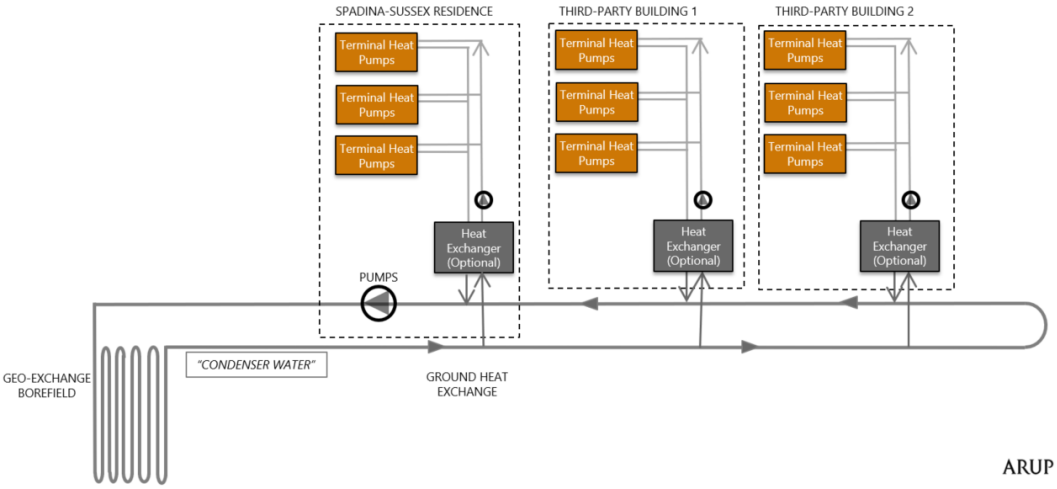


Figure 16: two pipe district condenser temperature water distribution with terminal heat pumps

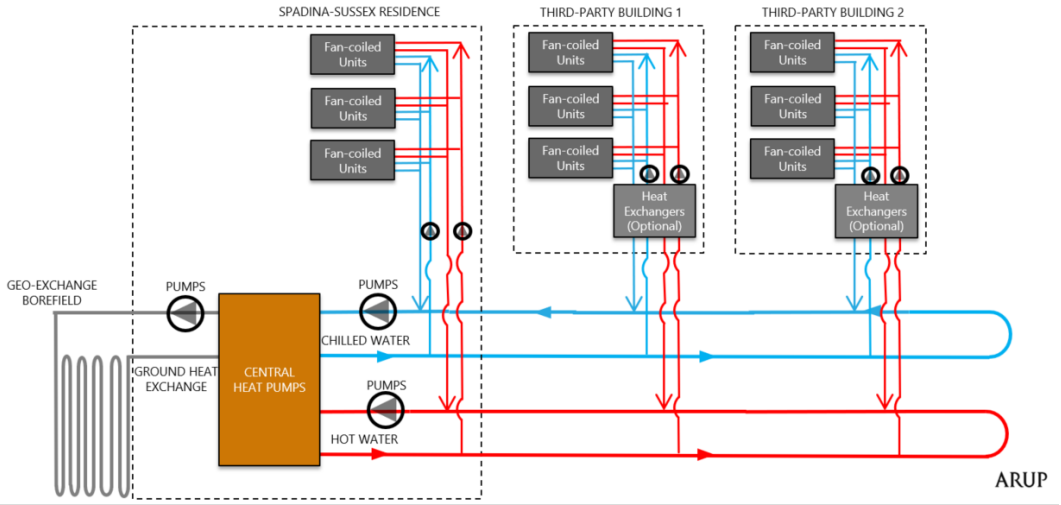


Figure 17: 4-pipe district chilled water and hot water distribution

#	ENERGY DELIVERY OPTIONS	CAPITAL COST	ENERGY EFFICIENCY	O&M MAINTENANCE	SPATIAL REQUIREMENT	OTHER CONSIDERATIONS
1	DECENTRALIZED BUILDING HEAT PUMP PLANTS (2-PIPE SITE DISTRIBUTION)	MEDIUM (2-pipe site distribution & 4-pipe bldg. distribution)	HIGHEST (building level thermal load heat recovery, individual bldg. supply temperature control/setback)	MEDIUM-HIGH (Distributed plant equipment, one less set of loop and pump sets)	Distributed heat pumps at individual buildings should not be a significant requirement for new construction. Flexibility to use terminal heat pumps.	Distributing GW to third-party properties. Potential ownership/maintenance of plant equipment at third-party properties.
2	DECENTRALIZED TERMINAL HEAT PUMPS (2-PIPE SITE DISTRIBUTION)	MEDIUM (2-pipe site & bldg. distribution, higher terminal unit cost)	LOW (relatively lower system efficiency, some possible heat recovery on geo-exchange loop)	HIGH (Distributed terminal HP, more maintenance cost comparing to FCU)	Less spatial requirement at the plant, but more spatial requirement at the zone level.	Distributing GW to third-party properties. Terminal units are noisier
3	CENTRALIZED HEAT PUMP PLANT (4-PIPE SITE DISTRIBUTION)	HIGH (4-pipe site & bldg. distribution)	MEDIUM (district thermal load heat recovery, const. supply temp)	MEDIUM (Centralized plant equipment)	All central plant equipment to be housed within the new Student Residence. Two heat exchangers for inter-connections to buildings	Distributing CHW/HW to third-party properties. Relatively easier to integrate.

Table 5: Tabulated Geothermal Boreholes and equivalent cooling capacity for Robert Street Field District Geothermal System

Mechanical System

The condenser water from the borefield are manifolded at the basement mechanical plant of the SSR in a 250 mm (10”) high-density polyethylene (HDPE) header pipes, and then distributed to third-party buildings by site distribution pumps located at the SSR basement mechanical plant. Figure 18 and 19 are the plant room layout and the single line diagram of the proposed district geothermal system. The estimated plant room area requirement for the geothermal header, piping, pumps,

heat exchangers, and heat pumps is approximately 2,130 square feet or 198 square meters (Figure 18).

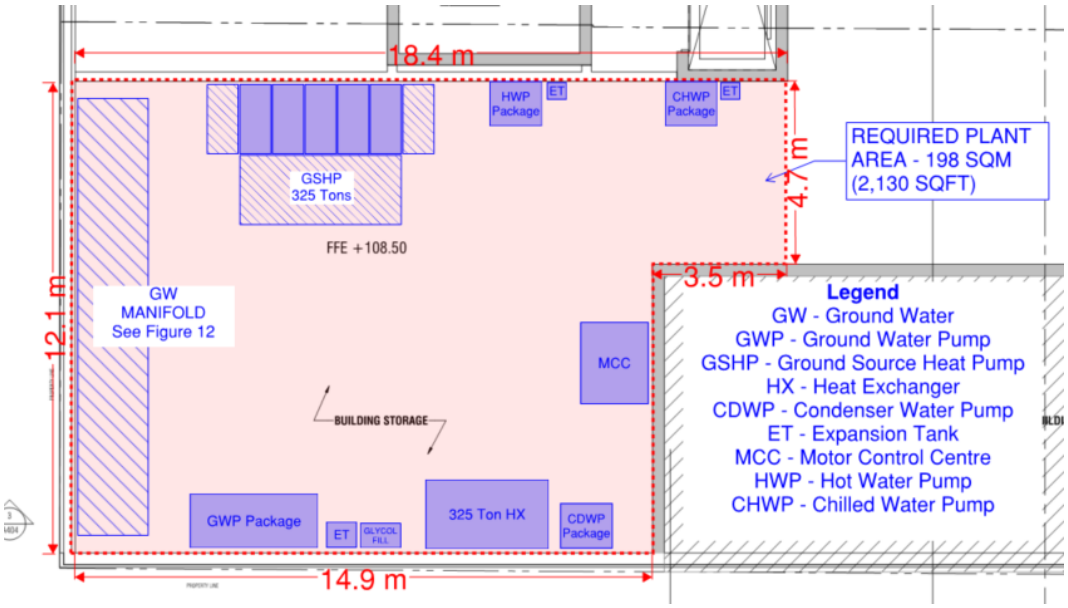


Figure 18 – SSR Required Plant Room Area

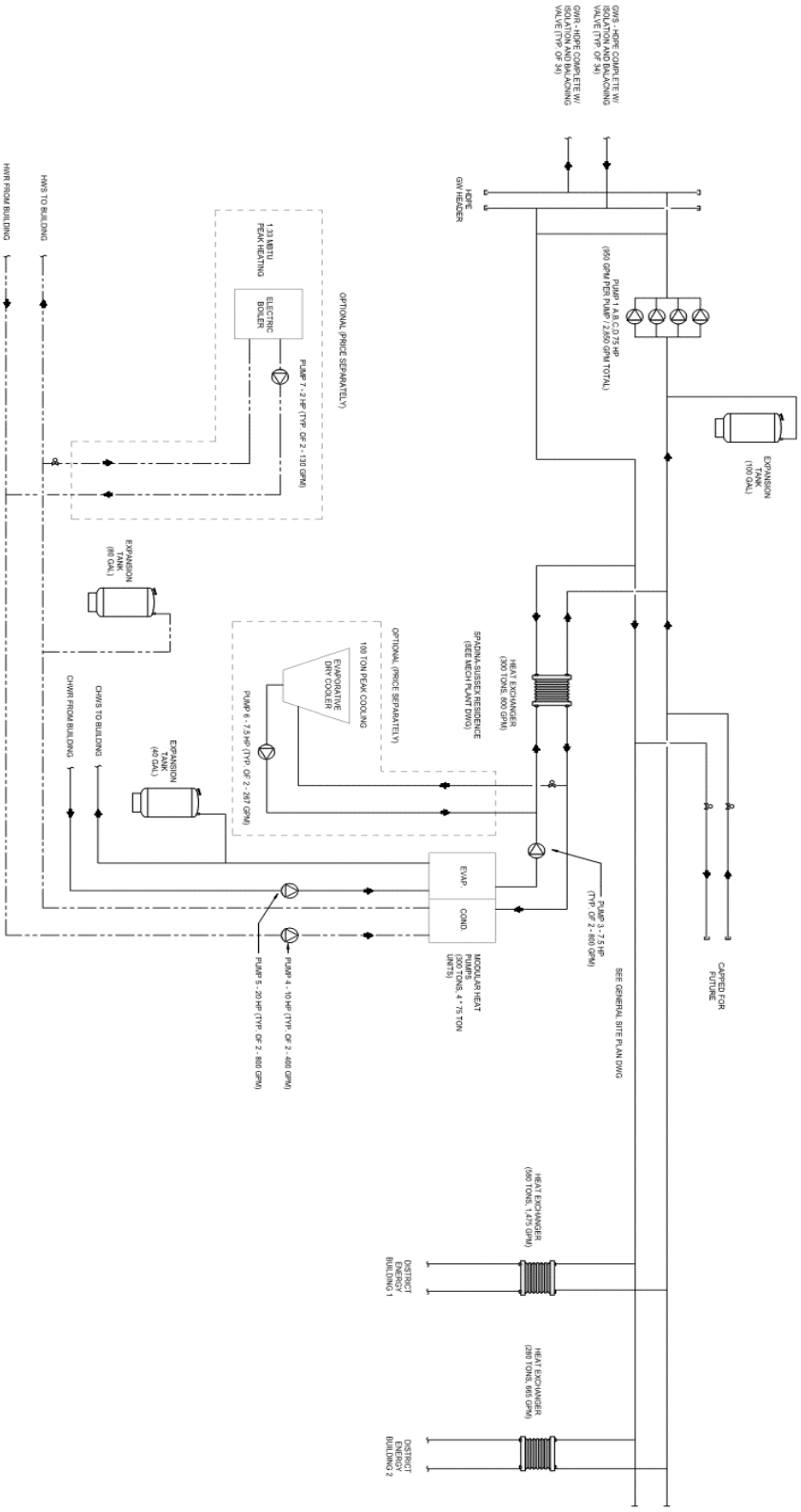


Figure 19 – Mechanical Single Line Diagram

Modular Heat Pump System

The proposed heat pumps for this concept would be electric water-cooled units with modular scroll or centrifugal compressor. The heat pump can reverse the refrigerant cycle to use condenser water fluid from the borefield as an energy source for heating, energy sink for cooling, and simultaneous heating and cooling operation (heat recovery mode). The modularity of the heat pump allows for system redundancy and variable heating and cooling supply to match the demand. Each module could have two refrigerant circuits for redundancy if required.

The heat pump performance is expected to range from COP 4.7 at design conditions (i.e. 85F or 29.4C condenser entering temperature) to COP 6.8 when condenser entering temperature approach 65F or 18.3C. Heating COP is expected to range between 3.4 to 5.0 depending on evaporator leaving fluid temperature. At simultaneous heating and cooling operation (heat recovery), a COP 6.3 is expected.

Figure 20 – Example Modular Heat Recovery Chillers (source: Multistack)

Primary Site Distribution Pumps

The district energy distribution pumps for the geothermal condenser water circuit would include four (4) in-line centrifugal pumps completed with variable frequency drives (VFD). The pumps would be arranged in a parallel configuration to provide duty/duty/duty/standby operation and maximize operation efficiency and resilience. The pumps are currently estimated for 75 HP (56 kW) each.

Figure 21 – Site Distribution Pumps

District Energy Distribution Piping

Due to the relative temperature of the condenser fluid temperature to the ground water temperature and its location below grade (minimum 1.5m), it is unnecessary to insulate the district energy distribution piping. Therefore, it is recommended to use a high-density polyethylene (HDPE) direct-buried pipe system for the district energy distribution piping. Inverted trench is also priced and included in the capital cost estimates as a cost premium. This product is durable, efficiently installed, and matches with the design used for the field geothermal distribution and borehole piping.

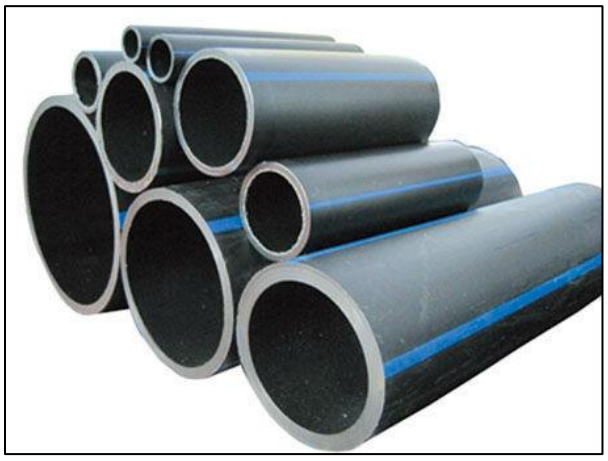


Figure 22 – HDPE Distribution Piping

Terminal Heat Transfer Station

The geothermal fluid coming from the site contains 23.5% propylene-glycol. To hydraulically separate the geothermal fluid from the building(s) connected to the district energy condenser loop, plate & frame type heat exchangers will be utilized at each building. Plate & frame heat exchangers provide efficient heat transfer with a small footprint compared to the shell and tube type heat exchangers and offer flexibility for expansion in the event heat transfer requirements change after installation. The heat exchangers at the terminal heat transfer stations do not need to be a double-walled heat exchanger, as the water flow on the secondary side is not domestic water.

Figure 23 – Plate and Frame Heat Exchangers (Source: Tranter)

Optional Peaking Electric Boilers

To provide additional heating capacity during peak heating demand and add resilience to the system, an electric boiler can be added for peaking and/or redundancy purposes. The electric boiler has less capital cost but higher operating cost when compared to a high efficiency gas fire boiler.

Figure 24 – Electric boiler (Source: Cleaver-Brooks)

Typical Control Sequence

The building level heat pumps should operate to maintain chilled water (CHW) and heating water (HW) supply setpoint. The building level CHW and HW circulating pumps will operate in a variable speed control function to circulate the CHW and HW via vertical risers to terminal fan-coiled units. A design CHW and HW supply temperature are 45F (7.2C) and 130F (54.4C), respectively, is recommended and should setback based on load demand or outside air temperature per ASHRAE 90.1-2013 when conditions permit.

The geothermal field loop pumps will operate using a VFD, circulating the glycol mixture through the field and distribution piping. This loop will be decoupled from the heat pumps with heat exchangers. The VFD on the geothermal district distribution pumps will be controlled via control valves at each building heat exchanger (or source side of the heat exchanger) to maintain a constant system pressure. The control valve on the source side of the heat exchanger will modulate to maintain the condenser water temperature on the building side (or load side) of the heat exchanger. An example of a typical control sequence is included below:.

- When the building (load side) entering water temperature of the heat exchanger is between 10°C and 18.3°C (50°F and 65°F), the geothermal (source side) control valve to the geothermal loop pumps is closed.
- When building (load side) entering water temperature rises above 18.3°C (65°F), the geothermal (source side) control valve modulates open to maintain building (load side) water temperature at optimal setpoint.

- When building (load side) entering water temperature drops below 10°C (50°F), the geothermal (source side) control valve modulates open to maintain building (load side) water temperature at optimal setpoint.
- The VFD on the geothermal district distribution pumps are staged and will vary speed to maintain constant system pressure. With a single pump operating at minimum speed, the system bypass will bypass flow to maintain constant system pressure.

To accommodate a hybrid system with boilers and/or cooling towers at the building level, capped connections can be provided between the heat exchangers and building level heat pumps. The sizing of the boilers and/or cooling towers is dependent on the design borefield capacity and the long term simulated borefield fluid temperature fluctuation.

6 Technical Analysis and Results

To assess the thermal performance of the district geothermal system, the building thermal load profile is matched against the available geothermal capacity at Robert Street Field. Geothermal numerical simulation software, Ground Loop Design (GLD), is used to perform hourly simulation of the ground temperatures based on the available thermal conductivity results from KCC and annual hourly building thermal load profiles. The geothermal numerical simulation calculates the annual ground loop fluid temperature fluctuation and identify the maximum and minimum fluid temperature over 25-years of operation. Detailed geothermal simulation inputs can be found in Appendix D.

Borefield combinations considered in the report includes three combinations of possible borefield areas. These areas include the playing field, community area, Sussex Mews lands, and the foundation of the SSR (shown in Table 5). The 25-year simulated borefield fluid temperature (condenser water temperature) is presented in figure 24. A full set of simulations can be found in the Appendix D.

A larger borefield comes with a higher capital cost, but the seasonal borefield fluid temperature fluctuation is lowered and remain closer to the deep earth temperature of ~53.5F (12C). Lowered seasonal borefield fluid temperature fluctuation will result in cooler average condenser entering temperature for the heat pump in cooling mode, and hotter average evaporator entering temperature for the heat pump in heating mode, thus reducing compressors' lift and resulting in a more energy efficient operation of the heat pumps. Larger number of boreholes also increase the redundancy of the system.

Likewise, a smaller borefield (with less boreholes) will results in higher seasonal borefield fluid temperature fluctuation, and thus less energy efficient operation of the district system. The increase in max/min fluid temperature would also restrict the number of heat pump technology/manufacturers that are capable to maintain operation in those temperature ranges. The main benefit of a smaller borefield is a reduction of capital cost investment.

Borefield Option	Area Considered	Number of Boreholes	Boreholes Modelled
1	Playing Field (A) and Community Area (B)	216	220
2	Playing Field (A), Community Area (B), and Sussex Mews Land (C)	243	240
3	Playing Field (A), Community Area (B), Sussex Mews Land (C), and SSR Foundation (D)	308	300

Table 6: Peak cooling demand from the third-party buildings

The district energy distribution system peak flow rate is calculated to 2,850 gpm (or 180 L/s). The peak flow rate is based on peak cooling load; this means for a given cooling load, the flowrate in each borehole decreases as the total number of boreholes in the system increases. With greater number of borehole reduces the static pressure of the system, reducing pump power and This means that with larger number of boreholes the flow rate will be reduced in each borehole increasing heat transfer and reducing the effect on field temperature (Figure 24, Appendix D).

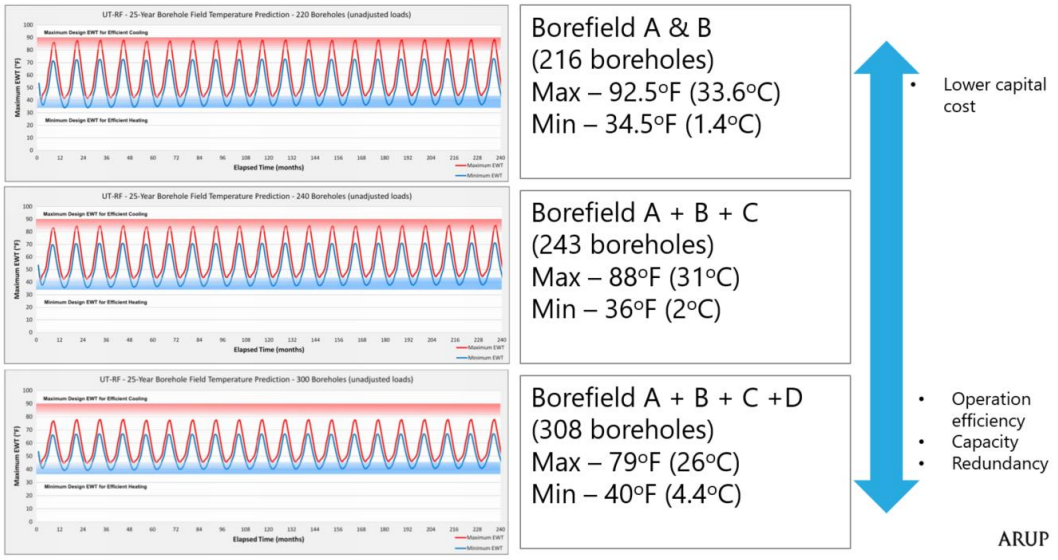


Figure 25: Field Entering Water Temperature (EWT) Analysis

7 Capital Cost Estimates

Class D capital cost estimation for the district energy system is divided into three phases listed below. The scope includes the construction cost of the geothermal borefield, distribution piping, incremental plant cost at the SSR, up to heat transfer stations' heat exchangers in third party buildings and excluded any addition equipment or retrofitting required. The incremental plant cost included the heat pump system and ancillary equipment, minus "business-as-usual" plant cost of boilers, chillers, and cooling towers. Details of the capital cost estimation can be found in Appendix E.

- **Phase 1 – Geothermal Field:** Construction of the geothermal borefield and ground loop distribution system, capped at Sussex Mews land before crossing Sussex Mews and connecting to the SSR.
- **Phase 2 – SSR Mechanical Plant:** Installation of plant equipment within the Spadina-Sussex Student Residence, including connection to capped services for geothermal system across Sussex Mews.

- **Phase 3a – Third Party Site Connection:** Construction of site distribution piping, building connections and terminal heat exchangers for proposed third party buildings. It is assumed that the addition of third-party heat pumps and system retrofit are the responsibility of the third-party properties.

- **Phase 3b – NW Chiller Plant Connection:** Horizontal directional drilling (HDD) beneath Spadina Avenue to connect the NW Chiller Plant with the district geothermal system, including excavation for launch pits, HDPE piping and addition of modular heat pumps at 600 ton (2110 kW_t).

Project Phase	Total Capital Cost			
	90 Boreholes	220 Boreholes	240 Boreholes	300 Boreholes
Phase 1 – Geothermal Borefield	$1,607,417	$3,942,000	$4,300,364	$5,518,800
Phase 2 – Spadina-Sussex Student Residence (SSR)	$1,756,000	$1,756,000	$1,756,000	$1,756,000
Phase 3a – Third-Party Site Distribution		$1,445,000	$1,445,000	$1,445,000
Avoided Cost - Business as Usual SSR	($1,921,000)	($1,921,000)	($1,921,000)	($1,921,000)
Total with Phase 3a	$1,442,417	$5,222,000	$5,580,364	$6,798,800
Phase 3b – NW Chiller Plant Connection		$1,797,573	$1,797,573	$1,797,573
Total with Phase 3b	$1,442,417	$5,574,573	$5,932,937	$7,151,373

Table 7: Capital cost estimates of the 2-pipe district geothermal energy system, divided by project phases

The following cost premiums are not included in the capital cost estimation shown above:

- Geothermal Vault on Sussex Mews land: $214,400
- Inverted trench distribution for third-party site distribution: $1,385,100

Details of the Class D capital cost estimates by construction phases shown above can be found in Appendix E. The capital cost are broken down by different boreholes combination; these are linearly extrapolated based on the budgetary quotation of 308 boreholes from Geosource in Appendix E.

8 Life Cycle Cost Analysis

A lifecycle cost analysis of the district geothermal system is presented below. The simple payback period of the district geothermal energy system is 28 years when compared against a natural-gas based business-as-usual scenario, with condensing boilers at the new residence buildings and rooftop furnace for the JCC. The capital cost of the district pipe distribution and the associated pumping energy reduces the economic viability of the district geothermal energy system considerably. It is worth noting that if the residence buildings are to meet the Toronto Green Standard (TGS) v3 tier 3 requirement, the business-as-usual is electricity-based air-sourced heat pumps sized for 50% of the peak thermal demand with gas topped-up per TGS Zero Emission Building Framework (ZEBF).

	220 boreholes	240 boreholes	300 boreholes
Total Capital cost	$5,222,000	$5,580,364	$6,798,800
Avoided (Added) Energy Cost	$11,283	$16,734	$27,003
Avoided Carbon Tax	$52,550	$52,550	$52,550
Avoided O&M Costs	$125,363	$125,363	$125,363
Net Avoided Costs	$189,196	$194,646	$204,916
Simple Payback (Years)	27.6	28.7	33.2

Table 8: Lifecycle cost analysis of the district 2-pipe geothermal system

The following assumptions were used in the life cycle cost analysis, and a complete list can be found in the appendices.

- Electricity at 13.5 ¢ per kWh and Natural Gas at $0.29 per m^3.
- $50 per ton of CO_2 equivalent based on Pan-Canadian Pricing on Carbon Pollution.
- Chemical treatment $14 per ton cooling.
- Cooling water makeup and sewage (blowdown) at $2.32 per m^3.

9 Green House Gas Emissions Analysis

The proposed district geothermal energy system can eliminate the need to burn natural gas on-site, considerably reducing the amount of equivalent GHG emission. The green house gas emission factors used in the study is based on the emission factor in Ontario Building Code (OBC) SB-10 2016, outlined in Table 8. The following figures show the potential reduction of more than 90% of the overall emissions. This reduction represents between 1150 tons of CO_{2e} annually. The following figures include only CO_{2e} related to heating and cooling of the SSR and third-party buildings and not miscellaneous electricity usage such as lighting, equipment or process.

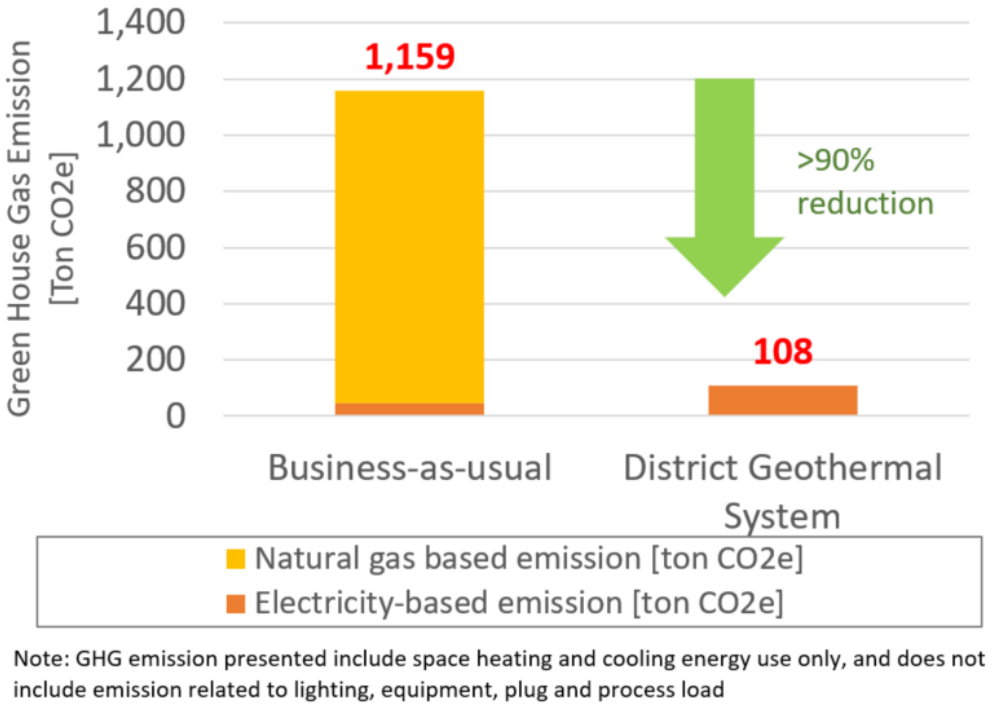


Figure 26 – District geothermal energy system estimated green house gas reduction relative to business-as-usual scenario

Building Energy Source	Emission Factor
Stationary Sources	
Electricity (average for 2014)	0.050 $kgCO_{2e}$ / kWh
Natural Gas	1.899 $kgCO_{2e}$ / m^3
Propane	1.548 $kgCO_{2e}$ / L
Heating Oil	2.755 $kgCO_{2e}$ / L
Column 1	2

Table 9: Ontario's equivalent GHG emission factor (source: OBC SB-10 2016 Table 1.1.2.2)

For the Spadina-Sussex Student Residence (SSR), the district geothermal system can help reduce its whole-building energy use intensity (EUI) and equivalent greenhouse gas emission by 35.6% and 69.2%, reducing the EUI from 118 kWh/m^2-yr to 76 kWh/m^2-yr and reducing the CO_2e from 13 kg CO_2e/m^2-yr to 4 kg CO_2e/m^2-yr. The higher building energy performance and lower building equivalent GHG emission can help the SSR achieve higher LEED certification rating (i.e. LEED Gold) and higher Toronto Green Standards (TGS) tiers. Achieving higher TGS tiers allows the project to obtain partial development charge refunds from the City of Toronto.

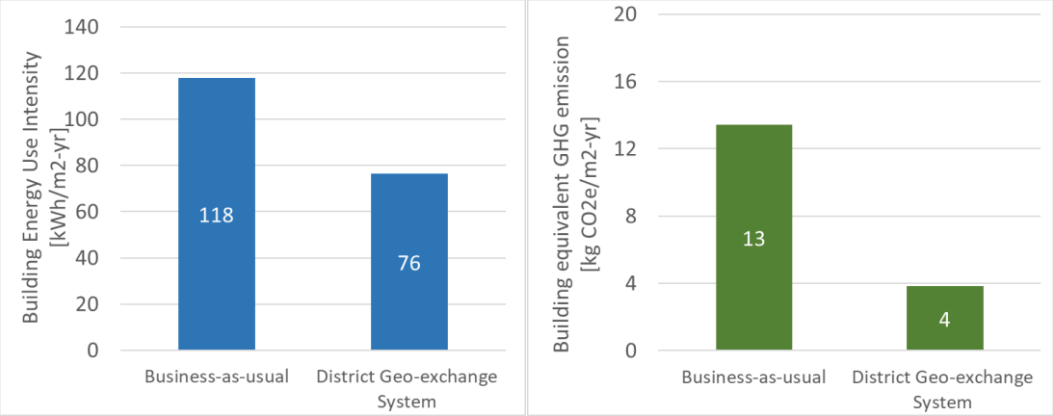


Figure 27 – The Spadina-Sussex Student Residence estimated building energy performance and equivalent green house gas reduction level relative to business-as-usual scenario Green House Gas Reduction

10 Design Alternatives

Various preliminary design alternatives have been presented to the University and feedback were obtained from the biweekly meetings. This section outlines some of the design alternatives that were explored during the feasibility study.

Option 1: Borefield combination

Different borefield combinations have been considered in the feasibility study, including three combinations of possible borefield areas within the Robert Street Field. These areas include the Playing Field, Community Park, Sussex Mews land, and the foundation of the SSR (See Figure 9). A portion of the playing field area (90 boreholes) is also presented as an option of borefield to serve only the SSR (1A), while three area combinations were analyzed to serve the district energy system (1B, C, D). Larger field area allows for more boreholes, increasing heating and cooling capacity, operational efficiency, and field redundancy. These alternatives have been summarized below.

Option	Area Considered	Number of Boreholes	Boreholes Modelled
1A	Portion of Playing Field (A)	90	90 [1]
1B	Playing Field (A) and Community Area (B)	216	220
1C	Playing Field (A), Community Area (B), and Sussex Mews Land (C)	243	240
1D	Playing Field (A), Community Area (B), Sussex Mews Land (C), and SSR Foundation (D)	308	300

Note [1]: Capital cost estimation of 90 borehole field is extrapolated

Table 10: Geothermal borefield area combination evaluated in the feasibility study

Option 1B is the preferred option based on discussions at progress meeting with the University and the plan layout is shown in figure 14. The 90-borehole option is based on the request at Progress meeting #3 from the University to include a scenario of borefield capacity sufficient to serve the SSR only. The borehole number is calculated based on an extrapolation of the district system borehole capacity and building peak cooling load. A plan showing the layout is added in the report in figure 28.

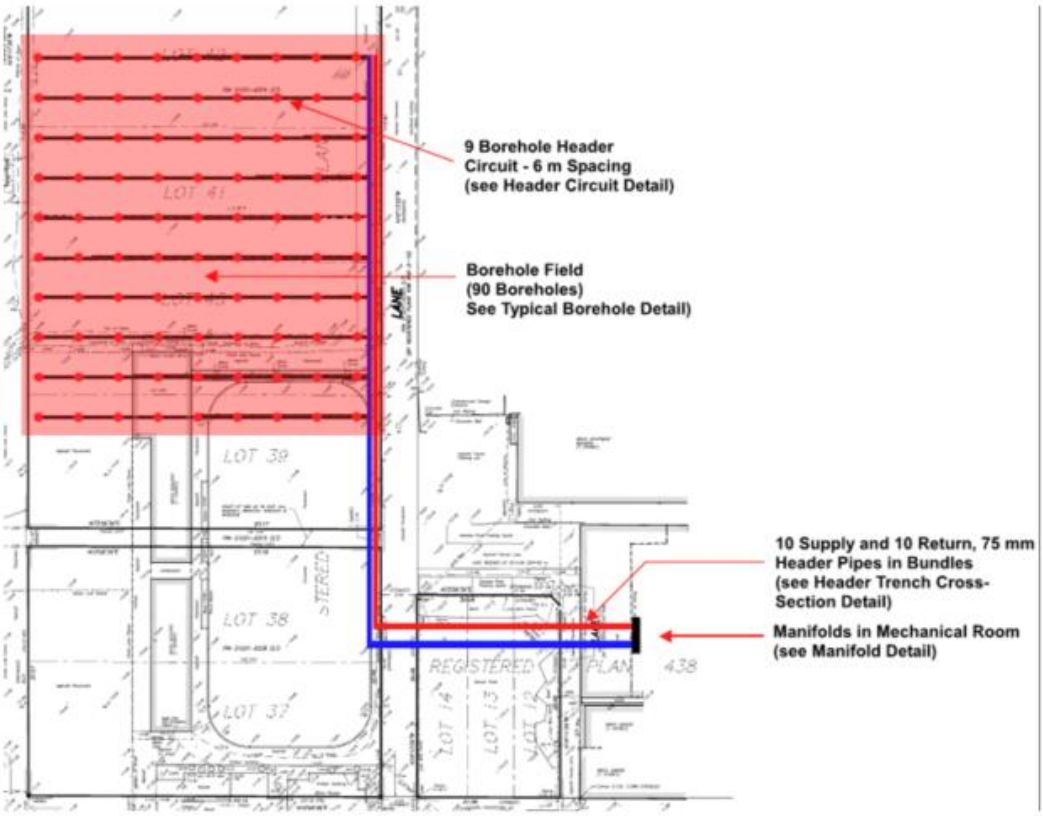


Figure 28: Layout of 90 geothermal borehole

Option 2: Ground Water Loop

The geothermal circuits are collected into a single supply and return main and manifolded. The manifolds can occur at the SSR plant room (bundle piping) or in a pre-fabricated vault.

- **2A - Bundle Piping:** Each circuit is collected into two bundles of multiple pipes for supply and return from the field and travel the distance between the field and the SSR basement mechanical room before reaching a single header (Figure 11 and 12).

- **2B - Geothermal Vault:** A pre-fabricated solution provides a buried enclosure that houses the main geothermal supply and return manifolds within the Sussex Mews land (Figure 29), combining the ground loop circuits into a common supply and return header pipe. From the vault, a supply and return header pipe would go below Sussex Mews and connect to the SSR. While it is a cost premium, this alternative eliminates the need for bundle piping across Sussex Mews and reduces the area requirement in the SSR basement mechanical room.

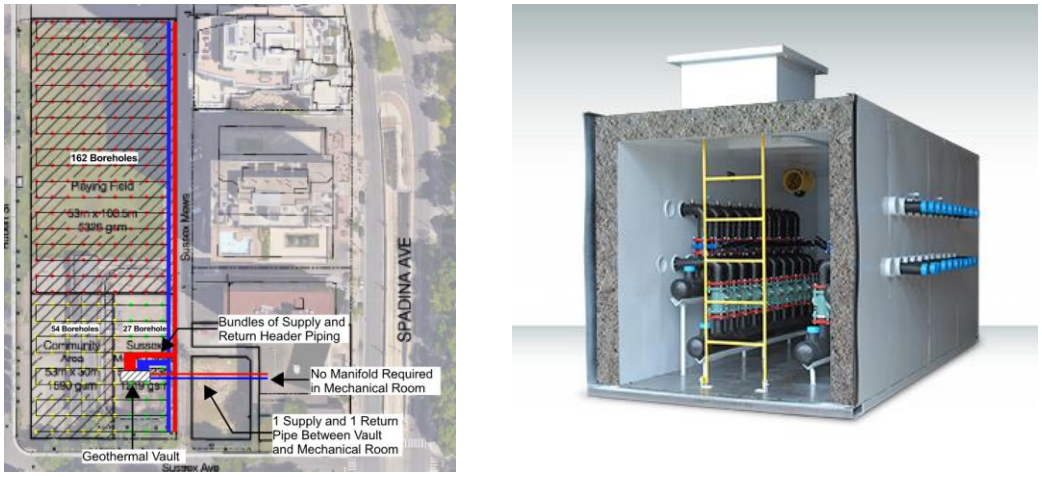


Figure 29 – Geothermal Vault Design and Location

Option 3: Site Distribution

Site distribution piping refers to the supply and return mains that circulates condenser water between the SSR plant room and other third-party buildings. The design of this distribution will have a large impact on maintainability and lifespan of the project. All distribution solutions will be coordinated with existing site services at a minimum of 5ft (1500mm) below grade to avoid seasonable temperature variations.

- **3A - Direct Buried:** High density poly-ethylene (HDPE) piping can be directly buried in the ground with or without insulation due to the temperate temperature of the condenser water. Direct buried piping is commonly used in district energy system due to its low capital cost. It is relatively less accessible for maintenance comparing to other distribution methods.

- **3B - Inverted Trench:** Inverted trench involves a concrete foundation and sections of preformed concrete to enclose the trench (Figure 30). A piping solution that creates a small cavity to house the distribution piping, forming a barrier against the environment, increasing maintainability and lifespan of the distribution system.

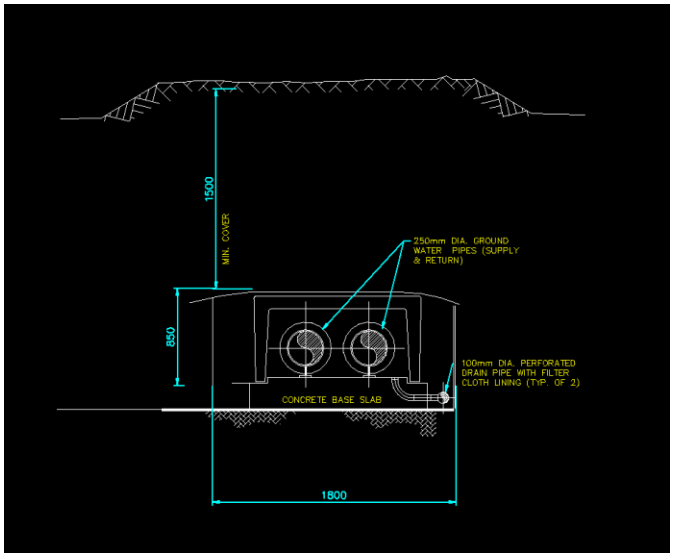


Figure 30 – Section Diagram of Inverted Trench Distribution Piping

Option 4: Borehole depth

The current basis of design includes a borehole depth of 650 ft, which is typically attainable by multiple Ontario geothermal drilling contractors under their ECA restriction. Recently, we are aware of at least one local geothermal contractor who has started to install geothermal borefield at a depth of 800 ft. Limestone bedrock is typically reached at approximately 600 ft (185 m) of depth and beyond locally,

which has a higher thermal conductivity of shale bedrock. The increase in borefield depth from 650 to 800 ft is estimated to increase capital cost by 20% per borehole but is estimated to yield an increase of 30% in geothermal capacity. For a given geothermal borefield capacity, it is more economical to construct a borefield with borehole depth of 800 ft with reduced numbers of boreholes, than to construction a borefield with borehole depth of 650 ft with higher numbers of boreholes.

11 Borefield Construction

The construction timeline is typically determined by borehole drilling. On average, a geothermal drilling rig can complete one 650 feet deep borehole per every 10-hour day. Therefore, a specific project schedule can be met by varying the number of rigs. Distribution piping will be buried in place during borehole drilling, to expedite the construction process. It is expected that 800 feet deep boreholes will have the same drill rate, taking approximately 12 hours to complete. This increased time per bore can be accommodated with additional drilling rigs. To confirm the assumptions used in this study, a site-specific test borehole and thermal conductivity test is recommended, which can be conducted over the span of approximately 2 weeks.

Based on the notes and assumptions above, a preliminary construction implementation schedule of the geothermal borefield is presented below. It should be noted that the design and construction timeline depend on a range of factors such as permitting, availability of geothermal drilling contractors, weather and more. There is currently no permitting guideline from the City of Toronto regarding the installation of the geothermal borefield such as RSF, as geothermal design drawings are typically submitted for the City's approval along with the rest of the building construction documents, but there is no permanent structure within the RSF boundary. The construction implementations schedule presented below is estimated based on Arup's and its subconsultants' knowledge and experiences, and discussion with geothermal contractor; Arup cannot guarantee the construction implementation timeline presented below.

Design & Construction Phases	Date
Consultants procurement and mobilization. Design of the geothermal borefield, including in-situ thermal response testing.	June to August, 2019
Permitting	August to September, 2019
Excavation and demolition of existing structures	September, 2019
Borefield construction (assume 4 rigs) and tie-in	September 2019 to January, 2020
Geothermal borefield commissioning	February to March, 2020
RSF landscaping and site works completion	February to April, 2020

Table 11: Construction implementation schedule for the district geothermal system Phase 1.

12 Other Considerations and Risks

Borehole Field Failure Scenarios

There are two possible failure scenarios in the design of the borehole field, first is a leak in the U-loop piping and the second is a leak in the distribution piping. Both scenarios are highly unlikely and rare, due to the use of high density polyethylene piping with heat fused joints without the use of mechanical connections. Additionally, rigorous installation and testing requirements laid out in the ANSI/CSA/IGSHPA C448 standards further minimize the possibility of failure.

The most common reason for a leak in geothermal piping is damage due to unrelated construction work, for example excavating for unrelated utilities.

If a leak occurred within one of the U-loops, header circuits, or mains, the circuit would be manually isolated at the ground loop header located in the SSR basement mechanical room. This would cause a temporary disruption of the 9 interconnected boreholes on that circuit until the piping can be repaired. For a geothermal system of this size, the temporary loss of 9 boreholes would be insignificant to the operation. A single 9 borehole circuit represents between 3.0 and 4.1% of the total output depending on final field size.

Borefield Design Refinement

A site-specific test borehole and thermal conductivity test is recommended, and test results should be used to refine the design of the geothermal borefield. If the district thermal load is expected to change, i.e. connect to NW chilled water plant, change of third-party building connection, etc., the geothermal system design should be refined to determine the appropriate design parameters (i.e. increase borefield depth to maximize borefield capacity, increase/reduce the number of boreholes to optimize capital cost/performance, hybrid geothermal system approach, etc.)

Micro-Utility for Third Party Loads

There is a level of uncertainty associated with the third-party building connections that should be acknowledged in this feasibility study. It is not certain what are the interests and commitment levels of the third-party buildings towards the proposed low-carbon district energy system. Considering the tight construction timeline of the RSF, the geothermal borefield are required to begin construction quickly, leaving little time to negotiate and agree on a micro-utility agreement. Existing building conditions of the Jewish Community Centre is also not fully understood at this stage, and there may be unforeseen retrofit costs to connect to the JCC. There is also minimal information obtained regarding the new Metro Condominium

Tower; the building base design and its compatibility with a district condenser water system needs to be further investigated.

NW Chiller Plant Connection across Spadina

In lieu of connecting to the proposed third-party buildings noted in this feasibility study, there is the potential utilization of the low-carbon heat source for the University's own existing or planned development across Spadina Avenue.

The approach utilizes Horizontal Directional Drilling (HDD) to run two 350 mm diameter pipes under Spadina Avenue. This will minimize above-grade and below-grade interruption of Spadina Avenue. The drilling will need to be coordinated to avoid all existing services reaching a maximum depth of 5.5 meters below grade between the SSR basement and NW Chiller Plant (Figure 31 and 32). Excavated pits are required on the drill entry side and exit points. Preliminary research suggests that the spatial requirement of the two launch pits are at 40' (12.2m) long x 15' (4.6m) wide x 13' deep (4m), 20' (6.1m) long by x 6' (2m) wide x 13' (4m) deep (Figure 32). There are limited spaces, existing trees and below-grade utilities near the east side of Spadina Avenue for a launch pit. Further investigation and analysis is recommended to confirm the spatial viability of HDD across Spadina. Potential utilization of the excavation of the SSR building foundation for synergies for launch pit should also be explored and coordinated.

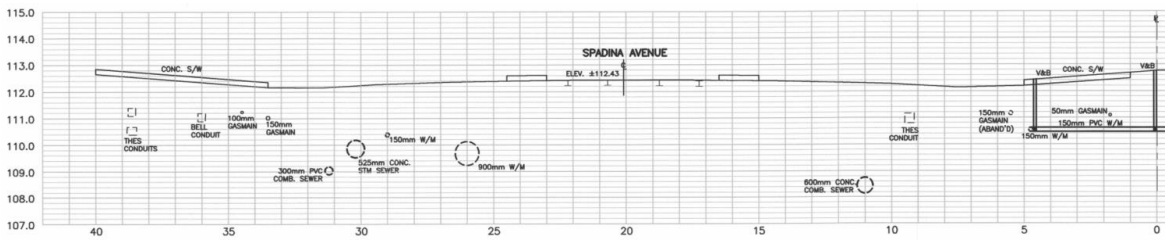


Figure 31 – Section of existing utility underneath Spadina Avenue from Site Servicing Plan dated 2009

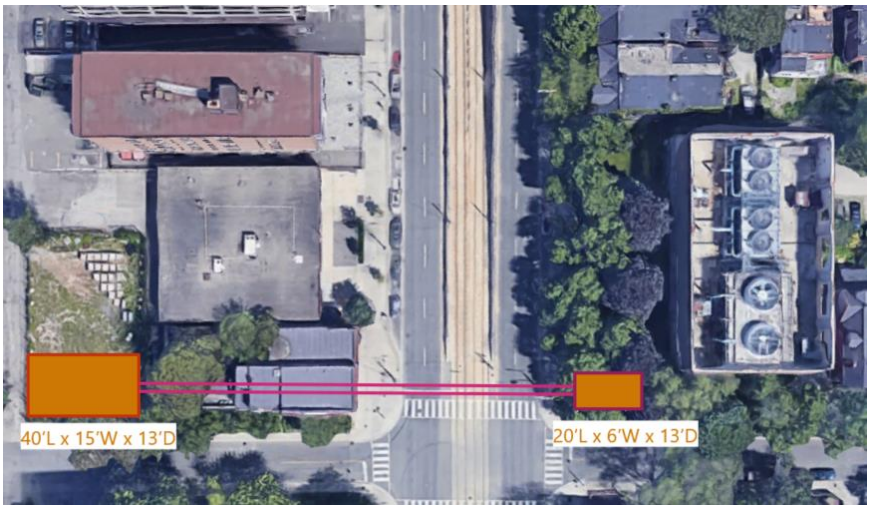


Figure 32 – Indicative layout of the launch pits required for horizontal directional drilling. Not-to-scale.

Drilling under Spadina to the NW Chiller Plant covers a distance of ~50 meters. Preliminary cost estimation of the connection, which include the horizontal directional drilling, excavation, and installation of 600-ton modular heat pumps at the Northwest chilled water plant, is estimated at $1,797,573. There are some technical considerations that need to be further investigated, but the connection of the Northwest chilled water plant and utilizing the low-carbon energy source for planned new development of the University may prove to be more beneficial than to connect to third-party buildings; all the avoided carbon emissions can be claimed for the University's building portfolio and support the University's energy efficiency goals and sustainability commitment to 37% greenhouse gas reduction by 2030.

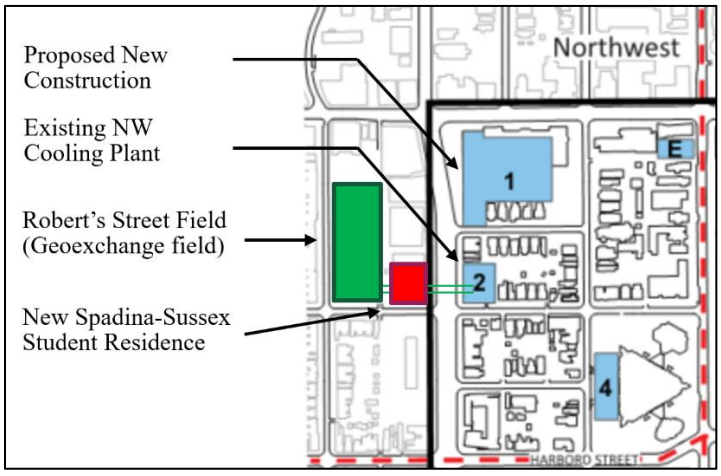


Figure 33 – Robert Street Field District Geothermal System connecting to NW Chiller Plant with potential future development overlaid, based on Campus Master Plan (2011)

Figure 34 presents the main activities that take place during each phase of a Horizontal Directional Drill. The schematic illustrates a watercourse crossing but the main activities are similar - drilling of the pilot hole, reaming and pipe string pull back are illustrated.

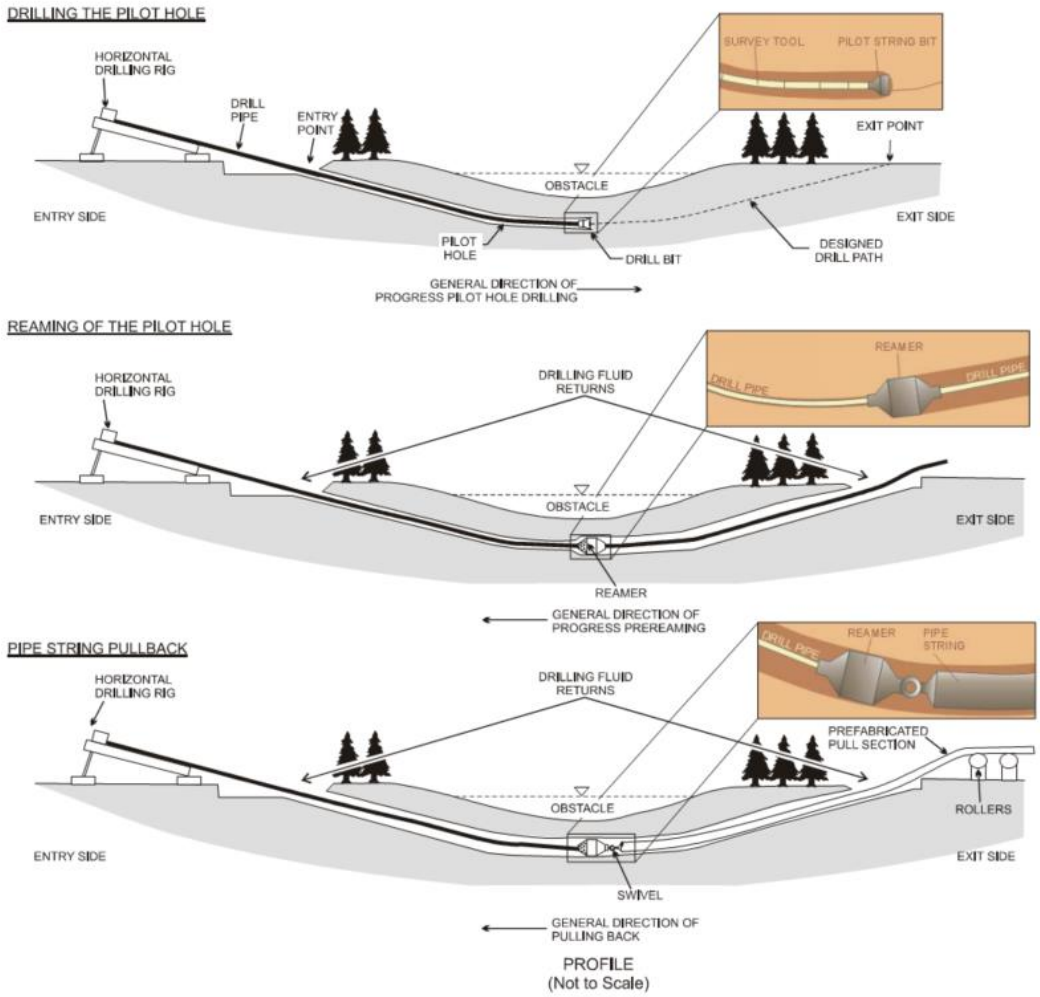


Figure 34 – Main activities of horizontal directional drilling (Source: Canadian Association of Petroleum Producers, 2004)

Solar PV

A Solar PV installation at the SSR will help further reduce carbon emissions and offers a financial payback within 10 to 15 years in the Toronto Area.

Potential for Solar PV panels have been identified at the SSR on the 25th floor roof of the mechanical penthouse. The proposed array has a total of 70 panels (24.1 kW_{AC}), with an estimated annual energy production of 27.4 MWh. This size PV array reduces cost by eliminating the need for a Supervisory Control and Data

Acquisition (SCADA) System by Toronto Hydro for PV installations over 50 kW_{AC}.

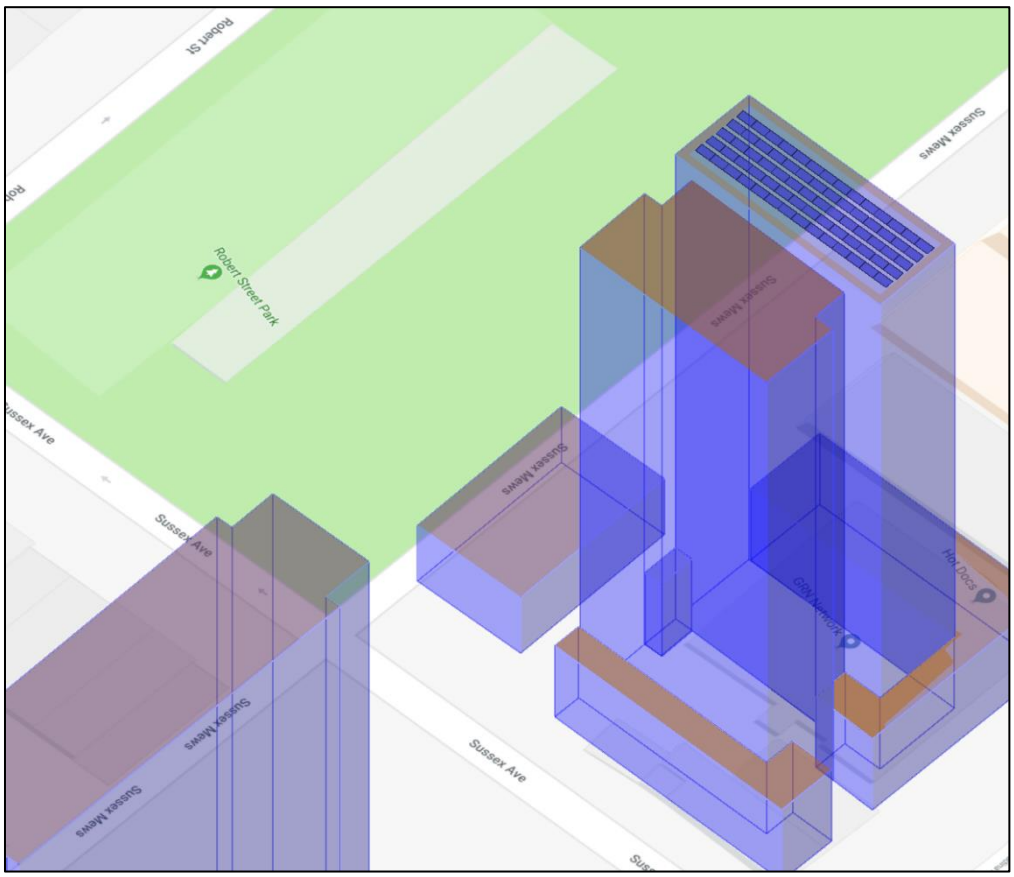


Figure 35 – Proposed Solar PV Array

13 Conclusions and Recommendations

The preliminary design of the Robert Street Field district geothermal system was developed based on the available borefield capacity and district thermal load. Lifecycle cost analysis of different borefield capacities are developed in the feasibility study as well as the capital cost estimation of various design alternatives.

The proposed district geothermal energy system is projected to achieve greenhouse gas emissions reduction by 1050 ton of CO_2e or 90% comparing to a natural-gas based business-as-usual scenario. This greenhouse gas emission reduction is associated with the SSR, the JCC and the new Metro condominium tower. For the Spadina-Sussex Student Residence (SSR), the district geothermal system can help reduce its whole-building energy use intensity (EUI) and equivalent greenhouse gas emission by 35.6% and 69.2%, reducing the EUI from 118 kWh/m^2-yr to 76 kWh/m^2-yr and reducing the CO_2e from 13 kg CO_2e/m^2-yr to 4 kg CO_2e/m^2-yr. The higher building energy performance and lower building equivalent GHG emission

can help the SSR achieve higher LEED certification rating (i.e. LEED Gold) and higher Toronto Green Standards (TGS) tiers. Achieving higher TGS tiers allows the project to obtain partial development charge refunds from the City of Toronto.

Class D capital cost estimates for proposed district geothermal system are presented in the table below.

Project Phase	Total Capital Cost			
	90 Boreholes	220 Boreholes	240 Boreholes	300 Boreholes
Phase 1 – Geothermal Borefield	$1,607,417	$3,942,000	$4,300,364	$5,518,800
Phase 2 – Spadina-Sussex Student Residence (SSR)	$1,756,000	$1,756,000	$1,756,000	$1,756,000
Phase 3a – Third-Party Site Distribution		$1,445,000	$1,445,000	$1,445,000
Avoided Cost - Business as Usual SSR	($1,921,000)	($1,921,000)	($1,921,000)	($1,921,000)
Total with Phase 3a	$1,442,417	$5,222,000	$5,580,364	$6,798,800
Phase 3b – NW Chiller Plant Connection		$1,797,573	$1,797,573	$1,797,573
Total with Phase 3b	$1,442,417	$5,574,573	$5,932,937	$7,151,373

Life cycle cost analysis of the district geothermal system of different borefield capacity are presented below.

	220 boreholes	240 boreholes	300 boreholes
Total Capital cost	$5,222,000	$5,580,364	$6,798,800
Avoided (Added) Energy Cost	$11,283	$16,734	$27,003
Avoided Carbon Tax	$52,550	$52,550	$52,550
Avoided O&M Costs	$125,363	$125,363	$125,363
Net Avoided Costs	$189,196	$194,646	$204,916
Simple Payback (Years)	27.6	28.7	33.2

Equivalent carbon emission reduction with third-party buildings may or may not contribute to the University's carbon portfolio reduction and the University's UC3 carbon reduction target. In lieu of connecting the district geothermal system to third-party buildings, there is the potential to connect the district geothermal borefield to the University's Northwest Chiller Plant and nearby existing/planned development of the University. This will help support the University of Toronto's 2030 goal to reduce campus wide CO_2e by 37%.

To connect the geothermal borefield across Spadina Avenue to the main campus, horizontal direction drilling can be used. Excavated pits are required on the drill entry side and exit point, and there are limited space and existing utilities on the

east side of Spadina near the NW Chiller plant. Further investigation and analysis is recommended to confirm the spatial viability of HDD across Spadina. Potential to utilize the excavation of the SSR building foundation for synergies for launch pit should also be explored and coordinated.

Based on the findings of this feasibility study Arup has the following recommendations:

- Considering the significant carbon emission reduction (avoidance) with the district geothermal system, the University's green house gas reduction pledge, and the limited timeline to perform earthwork at the Robert Street Field, Arup recommends for the University to further pursue a district geothermal system at the Robert Street Field (project phase 1) and proceed to schematic and detailed design stage.

- The third-party loads should be further investigated and analyzed against the district geothermal borefield capacity to determine the seasonal temperature variation and peak (max/min) ground loop temperature. If the third-party loads exceed the district geothermal borefield capacity, a hybrid geothermal system approach can be deployed.

- If the University desires to utilize the area underneath the SSR for geothermal, coordination is recommended as early as possible between the SSR building design team and the district energy system design team related to structural foundation of the SSR, location of the boreholes as well as horizontal direction drilling across Spadina.

- Arup does not recommend cost premium design alternatives including inverted trench and geothermal vault, based on increased financial burden of technically equivalent solutions.

- Arup does not recommend proceeding with third party distribution piping construction until third parties have confirmed participation in district energy network.

- Engage the City of Toronto regarding permitting issues with the implementation of the district geothermal system and utility infrastructure underneath public rights-of-way (across Sussex Mews and Spadina).

- Further analysis is required to confirm the viability of deploying HDD to connect the district geothermal system across Spadina to the main campus. This includes but not limited to confirming the spatial requirement on a launch pit near the Northwest chilled water plant, implications of existing trees and utility infrastructure, permitting issues, coordination with the foundation work of the SSR.

- If the district geothermal borefield is to be connected to the NW chiller plant and adjacent loads, further analysis is recommended to determine how the campus load can be integrated with the low-carbon energy source at RSF.

14 Appendices

Appendix A - Geothermal Model Inputs

Assumptions used by Beatty Geothermal Consulting as GLD software input:

Item	Value
Flow Rate	3.0 GPM/Ton
Fluid Composition	23.5% Propylene Glycol
Specific Heat	0.96BTU/ (°F lbm)
Density	64.0 lb / ft^3
Ground Temperature	53.5 °F
Thermal Conductivity	1.35 BTU / (h ft °F)
Thermal Diffusivity	0.85 ft^2 / day
Pipe Type	1 ¼ in (32mm) SDR 11
Flow Type	Turbulent
U-Tube Configuration	Single
Radial Pipe Placement	Average
Borehole Diameter	4.25 in
Grout Thermal Conductivity	1.00 BTU / (h ft °F)
Borehole Thermal Resistance	0.205 (h ft °F) / BTU

Appendix B - Energy calculation assumptions

Energy Calculations assumptions can be found below:

Item	Value
BAU	
Chiller Magnetic Bearing COP (TGS v3 Tier 2)	7.5
Condensing Boiler Eff.	86%
VFD Coefficient	2.4
Cooling Tower Fan Energy (ASHRAE 90.1 – 2013)	0.0105 kW/kW
Constant Speed Condenser Water Pump (ASHRAE 90.1 – 2013)	310 W / (L/s)
Rooftop Furnace	75%
Rooftop Direct Expansion Cooling COP	4
Geothermal	
Heat Pump Efficiency in Heating	5
Heat Pump Efficiency in Cooling	6.5
Heat Pump Efficiency in Simultaneous Heating and Cooling	6.3
Liquid Heat Capacity	488 BTU/lb °F

Appendix C – Lifecycle cost Analysis Assumptions

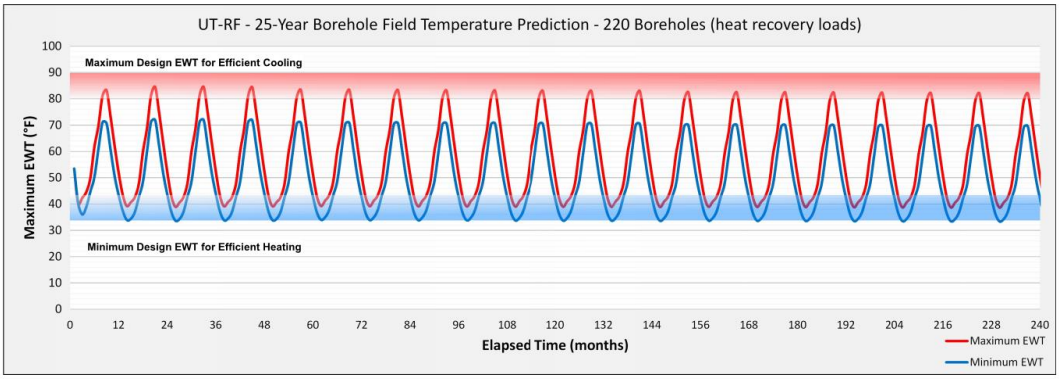
The assumptions used in the financial modelling can be found below:

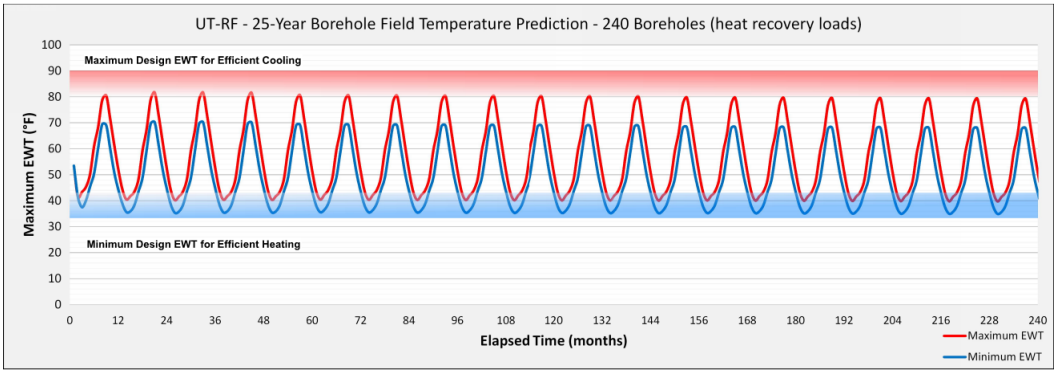
Item	Value
Discount Rate	4.00 %
Energy Escalation	3.00 %
Electricity Rate	13.5 cents / kWh
Natural Gas Rate (cents/Therm)	29 cents / m^3
Chiller & Heat Pump Maintenance	$ 16.6 / kW
Boiler Maintenance	$ 12.54 / kW
Cooling Maintenance	$ 12.50 / kW
Water and Sewage	$ 2.32 per m^3
Carbon Tax	$ 50 / tonne $CO_{2\ equiv.}$

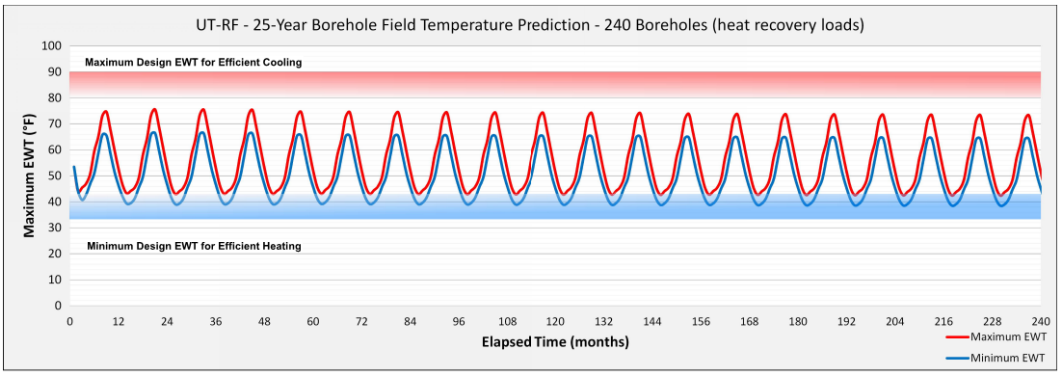
Appendix D – Geothermal Simulation Results

Entering water temperature for the geothermal field have been simulated for 220, 240 and 300 borehole alternatives. Temperature ranges have been tabulated below:

Number of Boreholes	Minimum Temperature	Maximum Temperature
220	34.5 °F / 1.4 °C	92.5 °F / 33.6 °C
240	36 °F / 2.0 °C	88 °F / 31 °C
300	40 °F / 4.4 °C	79 °F / 26 °C







Appendix E – A.W. Hooker Costing Reports

UofT Feasibility Study for Roberts Field Geoexchange
Feasibility Study Class D Estimate R1
May 17, 2019

Report Recipient:
Arup

A.W. Hooker Associates Ltd.
2265 Upper Middle Rd. E., Suite 400, Oakville, ON, CA, L6H 0G5
T 905-823-8111 F 905-823-5111 E info@awhooker.com
awhooker.com

May 17, 2019 Project No. 119148

Arup
2 Bloor Street East, Suite 2400
Toronto, Ontario
M4W 1A8

Attention: Edmund S.W. Wong *PE CEM BEMP LEED-AP* – Senior Consultant, Energy & Sustainability

Re: UofT Feasibility Study for Roberts Field Geoexchange - Class D Estimate R1

Edmund,

Please find enclosed our feasibility estimate for the above project.

This estimate was prepared based on drawings and information provided by Arup received in April 2019.

This estimate is meant to reflect the fair market value for the construction of this project; it is not intended to be the prediction of the lowest bid and should be representative of the median bid amount received

An allowance of 14% as a design and pricing contingency has been included in our estimate. The contingency is **not** meant to cover significant additional program space or quality modifications, but rather to provide some flexibility as the design develops. An allowance for potential escalation between now and the commencement date has not been included in the estimate. Currently we are seeing escalation at an amount of 4% per annum. Allowances for construction (post contract changes) have also been excluded. *Note: Total total G.C.'s and Contingency is equal to 35% of the contractors cost - this % has been provided by UofT*

It was assumed for the preparation of this estimate that the project would be tendered to a prequalified list of bidders with a standard Lumpsum contract. Pricing is based on competitive tender results with a minimum of four (preferably six tender submissions) at general contractor and major trade level. Pre-qualification with a restrictive list of contractors or subcontractors may result in a higher tendered cost due to the inherent reduction in competitiveness. Tenders receiving two or less submissions (occasionally three) historically tend to have a much higher risk of over an overrun in cost when compared to the budget established in an estimate. Ensuring adequate bonafide bidders is a prerequisite for competitive bidding scenarios, on which the estimate is predicated.

Our estimate excludes the following items:

1. Harmonized Sales Tax (HST)
2. Escalation Allowance
3. Construction Allowance
4. Development charges, permit fees, and expenses
5. Professional fees and expenses including special consultants
6. Legal fees and expenses
7. Other associated soft costs including construction/project management fees
8. “Shared” costs between “Business As Usual” and “Geoexchange” options (costs that are the same in both options). This feasibility study is meant to show the premium costs for the Geoexchange option.
9. Hazardous materials abatement

Various assumptions were made based on the design information available and our experience with projects of a similar nature. Please refer to the specific items within the estimate for the detailed assumptions made.

A.W. Hooker Associates Ltd.
2265 Upper Middle Rd. E., Suite 400, Oakville, ON, CA, L6H 0G5
T 905-823-8111 F 905-823-5111 E info@awhooker.com
awhooker.com

A.W. Hooker Associates Ltd. (HOOKER) cannot control over the cost of labour and materials, the general contractors or any subcontractors' methods of determining prices, or competitive bidding and market conditions. This opinion of probable cost of construction is based on the experience, qualifications, and best judgement of the professional consultant familiar with the construction industry. HOOKER cannot and does not warranty that proposals or actual construction costs will not vary from this or subsequent estimates.

A.W. Hooker Associates Ltd. **recommends** that the owner and/or the design team carefully review the cost estimate report, including line item descriptions, unit price clarifications, exclusions, inclusions and assumptions, contingencies, escalation, and mark-ups. This is to ensure that the design intent is captured within the content of the report. This is especially important at early stage estimates which tend to be based on a lesser level of design completion.

We trust our work will assist in the decision making process and look forward to our continued involvement in this important project.

Yours very truly,

A.W. HOOKER ASSOCIATES LTD.

Greg Babiak, PQS
Partner (Mechanical)

Encl: (Feasibility Study Class D Estimate R1, May 17, 2019)

MULTIPLE ESTIMATE SUMMARY
U OF T FEASIBILITY STUDY FOR ROBERTS FIELD GEOEXCHANGE - BAU

FEASIBILITY STUDY (Rev.1)
MAY 17, 2019

A.W. HOOKER ®
QUANTITY SURVEYORS

	Hard Construction Costs	Estimated Total
1	Business as Usual Case Including Chiller and Boiler Plants	$1,921,000
	Total Estimated Hard Construction Cost - BAU Case	**$1,921,000**
2	Geothermal Field	$6,214,000
3	Student Residence Plant Room	$1,756,000
4	Site Distribution (District Energy)	$1,445,000
	Total Estimated Hard Construction Cost - Geothermal Case	**$9,415,000**
	Variance	**$7,494,000**

Itemized Estimates: (Included Above)

1	Supplementary eletric boiler plant included in Student Residence Plant Room Estimate	$112,000.00

Separate Estimates: (Not Included Above)

1	Premium for Inverted Trench	$1,179,000.00
2	Savings to reduce sand bedding from 3.28' to 1'	-$217,000.00
3	Premium to increase depth of boreholes to 800' + from 650'	$1,242,800.00
4	Savings to increase branch piping from 3" dia. to 4" dia.	No Appreciable Change
5	Savings for 20% ethanol in lieu of 20% glycol	-$124,000.00
6	Digging of HDD and receiving pits to bore across Spadina Ave.	$65,000.00

MASTER ESTIMATE SUMMARY
U OF T FEASIBILITY STUDY FOR ROBERTS FIELD
GEOEXCHANGE - BAU

FEASIBILITY STUDY (Rev.1)
MAY 17, 2019

A.W. HOOKER ®
QUANTITY SURVEYORS

	Hard Construction Costs		GFA (m2)	Unit (Cost/m2)	Sub Total	Estimated Total	% of Total
1	Mechanical		1,000	$1,421.80		$1,421,800	74.0%
	- Plumbing and Drainage			$0.00	$0		
	- Fire Protection			$0.00	$0		
	- Heating, Ventilation, Air Conditioning			$1,371.80	$1,371,800		
	- Controls			$50.00	$50,000		
2	Contractor's General Requirements	10.0%	1,000	$183.20		$183,200	9.5%
3	Contractor's Fees (OH&P)	5.0%	1,000	$80.00		$80,000	4.2%
4	Design & Pricing Contingency	14.0%	1,000	$235.90		$235,900	12.3%
	Sub Total (current dollars)		**1,000**	**$1,921.00**		**$1,921,000**	
5	Escalation Contingency			Excluded			0.0%
	Sub Total (Excluding Escalation)		**1,000**	**$1,921.00**		**$1,921,000**	
6	Construction Contingency (Post Contract Changes)			Excluded			0.0%
	Total Estimated Hard Construction Cost		**1,000**	**$1,921.00**		**$1,921,000**	
	Imperial Conversion		**10,764**	**$178.47**		**Per SF**	

Note: Total total G.C.'s and Contingency is equal to 35% of the contractors cost - this % has been provided by UofT

	Estimated Construction Costs (Breakdown by Major Component)	GFA m2	Unit Cost/m2	Estimated Total	% of Total
1	Building	1,000	$1,921.00	$1,921,000	100.0%
2	Alterations and Demolition	0	$0.00	$0	0.0%
3	Site Work (including M&E site services)	0	$0.00	$0	0.0%
4	Soft Costs	1,000	$0.00	Excluded	0.0%
	Total Estimated Hard and Soft Construction Costs	**1,000**	**$1,921.00**	**$1,921,000**	
	Imperial Conversion	**10,764**	**$178.47**	**Per SF**	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	C1. SERVICES - MECHANICAL					
	C1.1 Plumbing & Drainage					
1	No work required - Not in scope					
	TOTAL FOR MECHANICAL - Plumbing & Drainage	0.00 / 0	m2	$0.00	$0	
	C1.2 Fire Protection					
2	No work required - Not in scope					
	TOTAL FOR MECHANICAL - Fire Protection	0.00 / 0	m2	$0.00	$0	
	C1.3 Heating, Ventilation & Air Conditioning					
	C1.31 - Liquid Heat Transfer (Heating)					$350,000
	Student Residence Plant Room					
3	Premium for mechanical penthouse holding boilers and cooling towers	1	NO	$200,000.00	$200,000	
	Heating Water Circuit					
4	Natural gas fired condensing boilers within rooftop mechanical penthouse - 2,000 MBH capacity	2	NO	$70,000.00	$140,000	
5	Heating water circulation duplex pump package - 200 GPM, 10 HP - Not significantly different from Geothermal case				Info Only	
6	Air control, chemical treatment and expansion tank serving heating water - 80 gallon capacity - Not significantly different from Geothermal case				Info Only	
7	Heating water distribution piping within plant room c/w joints, fittings and supports - 3" dia. - Not significantly different from Geothermal case				Info Only	
8	Thermal insulation to above piping - Not significantly different from Geothermal case				Info Only	
9	Hook-up connection assemblies:					
9.1	- Boilers	2	NO	$5,000.00	$10,000	
9.2	- Pumps - Not significantly different from Geothermal case				Info Only	
	C1.32 - Liquid Heat Transfer (Cooling)					$757,000
	Student Residence Plant Room					
	Condenser Water Circuit					
10	Cooling tower - 200 ton capacity equal to BAC c/w immersion heater	2	NO	$50,000.00	$100,000	
11	Condenser water circulation duplex pump package - 25 HP	2	NO	$12,000.00	$24,000	
12	Cooling tower chemical treatment system	1	NO	$30,000.00	$30,000	
13	Condenser water piping risers, Sch.40 black steel c/w joints, fittings and supports - 8" dia.	300	m	$560.00	$168,000	
14	Thermal insulation to above piping	300	m	$50.00	$15,000	
15	Condenser water distribution piping within plant room c/w joints, fittings and supports - 8" dia. - Not significantly different from Geothermal case				Info Only	
16	Thermal insulation to above piping - Not significantly different from Geothermal case				Info Only	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
17	Hook-up connection assemblies:					
17.1	- Cooling tower	2	NO	$12,000.00	$24,000	
17.2	- Pumps	2	NO	$10,000.00	$20,000	
17.3	- Chillers	2	NO	$10,000.00	$20,000	
	Chilled Water Circuit					
18	High efficency magnetic bearing water-cooled chiller equal to Daikin - 175 ton capacity	2	NO	$175,000.00	$350,000	
19	Chilled water circulation duplex pump package - 20 HP - Not significantly different from Geothermal case				Info Only	
20	Air control, chemical treatment and expansion tank serving chilled water - 40 gallon capacity - Not significantly different from Geothermal case				Info Only	
21	Chilled water distribution piping within plant room, Sch.40 black steel c/w joints, fittings and supports - Not significantly different from Geothermal case				Info Only	
22	Thermal insulation to above piping - Not significantly different from Geothermal case				Info Only	
23	Hook-up connection assemblies:					
23.1	- Chillers	2	NO	$3,000.00	$6,000	
23.2	- Pumps - Not significantly different from Geothermal case				Info Only	
	C1.37 - Support Systems and Works					$35,800
	C1.37.2 - Mechanical Wiring and Starters					$15,800
24	Line and load side power wiring connections from local panels:					
24.1	- Boilers	2	NO	$1,200.00	$2,400	
24.2	- Cooling towers	2	NO	$2,200.00	$4,400	
24.3	- Chillers	2	NO	$3,000.00	$6,000	
24.4	- Pumps	2	NO	$1,500.00	$3,000	
	C1.37.3 - Balancing and Commissioning					$20,000
25	Balancing and commissioning	1	NO	$20,000.00	$20,000	
	C1.38 - Miscellaneous Works and General Accounts					$229,000
	Student Residence Plant Room					
26	Supervision, job set up, clean up, small tools, rentals, poermits & inspections, overhead / profit, etc.	1	NO	$229,000.00	$229,000	
	TOTAL FOR MECHANICAL - HVAC	1.00	1,000 m2	$1,371.80	$1,371,800	

C1.4 MECHANICAL - Controls

	C1.41 - Controls and Automation					$50,000
27	Implement new building automation system to control and monitor equipment including the following:					
27.1	- Boilers	2	NO	$4,000.00	$8,000	
27.2	- Cooling towers	2	NO	$8,000.00	$16,000	
27.3	- Chillers	2	NO	$8,000.00	$16,000	
27.4	- Pumps	2	NO	$5,000.00	$10,000	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	C1.42 - Miscellaneous Works and General Accounts					$0
28	Included in above rates					
	TOTAL FOR MECHANICAL - Controls	1.00 1,000	m2	$50.00	$50,000	
		Total Mech Unit Rate		$1,421.80		

Z. GENERAL REQUIREMENTS & CONTINGENCIES

Z1.1 GENERAL REQUIREMENTS & FEES - General Requirements

Z1.11 - Supervision & Labour Expenses

29	Allowance for the General Contractor's supervision & labour expenses as follows:	1	LS	$142,180	$142,200	10.0%
29.1	- supervision and coordination of subcontractors					
29.2	- site superintendent and vehicle					
29.3	- general labour expenses					

Z1.12 - Temporary Conditions

30	Allowance for the temporary conditions provided by the General Contractor including:				Included in Z1.11	
31	Access to site					
31.1	- traffic control					
31.2	- pedestrian safety					
31.3	- removal of exterior cladding for access					
31.4	- temporary closure panels					
32	Site accommodations:					
32.1	- temporary site office					
32.2	- temporary signage					
32.3	- telephone and fax					
32.4	- stationary supplies and office equipment					
33	Site protection:					
33.1	- hoarding and gates					
33.2	- safety guard rails					
33.3	- fire extinguishers					
33.4	- first aid kits					
33.5	- temporary shoring					
33.6	- temporary stairs and ladders					
33.7	- protection for site elevators and flooring					
34	Temporary utilities:					
34.1	- temporary construction power panels					
34.2	- temporary water source					
35	Site clean up:					
35.1	- daily clean up in addition to the trades					
35.2	- final cleaning					
35.3	- dump bins					
35.4	- dumping charges					
36	Equipment:					
36.1	- material hoisting equipment					
36.2	- cranes and operators					
36.3	- small tool rental					
36.4	- pumps and pumping equipment					

No.	Description	Quant.		Unit	Rate	Sub Total	Total
37	Miscellaneous						
37.1	- CPM scheduling						
37.2	- land surveying						
37.3	- testing and inspections						
37.4	- photography						
	Cash Allowances						**$0**
38	Independent inspection and testing					Excluded	
39	Door hardware supply					Included in B 1.2	
	Z1.13 - Permits, Insurance & Bonds						**$41,000**
40	Building permit			1 LS	$17,000	$17,000	
41	General Liability and Builder's Risk insurance			1 LS	$10,000	$10,000	
42	Labour & Material and Performance bonding			1 LS	$14,000	$14,000	
	TOTAL FOR GEN. REQ'MENTS & FEES - Gen. Req'ments	1.00	1,000	m2	$183.20	$183,200	
	Z1.2 GENERAL REQUIREMENTS & FEES - Fees						
	Z1.21 - General Contractor's Fees						
43	Allowance for the General Contractor's Fees (Head Office Overhead, Profit and Risk). (applied to measured works plus general requirements)			1 LS	$80,250	$80,000	5.0%
	TOTAL FOR GEN. REQ'MENTS & FEES - Fees	1.00	1,000	m2	$80.00	$80,000	
	Z2.1 ALLOWANCES - Design Contingency						
44	Design Contingency as a percentage of the above to cover increases in the overall scope of the design during the remaining stages of the design phase (applied to measured works plus general requirements and fees)						
44.1	- Architectural					Excluded	14.0%
44.2	- Structural					Excluded	14.0%
44.3	- Siteworks					Excluded	14.0%
44.4	- Mechanical Services			1 LS	$235,900	$235,900	14.0%
44.5	- Electrical Services					Excluded	14.0%
	TOTAL FOR ALLOWANCES - Design Contingency	1.00	1,000	m2	$235.90	$235,900	
	Z2.2 ALLOWANCES - Escalation Contingency						
45	Contingency for escalation that might occur between the date of the estimate and the anticipated tender date (applied to measured works plus general requirements, fees and Design Contingency)					Excluded	0.0%
	TOTAL FOR ALLOWANCES - Escalation Contingency	1.00	1,000	m2	$0.00	$0	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	Z2.3 ALLOWANCES - Construction Contingency					
46	Construction Contingency for post contract changes (applied to measured works plus general requirements, fees, Design Contingency and Escalation Contingency)				Excluded	0.0%
	TOTAL FOR ALLOWANCES - Construction Contingency	1.00 1,000	m2	$0.00	$0	

MASTER ESTIMATE SUMMARY
U OF T FEASIBILITY STUDY FOR ROBERTS FIELD
GEOEXCHANGE - GEO FIELD

FEASIBILITY STUDY (Rev.1)
MAY 17, 2019

A.W. HOOKER ®
QUANTITY SURVEYORS

	Hard Construction Costs		GFA (m2)	Unit (Cost/m2)	Sub Total	Estimated Total	% of Total
1	Mechanical		1,000	$4,598.40		$4,598,400	74.0%
	- Plumbing and Drainage			$0.00	$0		
	- Fire Protection			$0.00	$0		
	- Heating, Ventilation, Air Conditioning			$4,598.40	$4,598,400		
	- Controls			$0.00	$0		
2	Contractor's General Requirements	10.0%	1,000	$592.80		$592,800	9.5%
3	Contractor's Fees (OH&P)	5.0%	1,000	$260.00		$260,000	4.2%
4	Design & Pricing Contingency	14.0%	1,000	$763.20		$763,200	12.3%
	Sub Total (current dollars)		**1,000**	**$6,214.00**		**$6,214,000**	
5	Escalation Contingency			Excluded			0.0%
	Sub Total (Excluding Escalation)		**1,000**	**$6,214.00**		**$6,214,000**	
6	Construction Contingency (Post Contract Changes)			Excluded			0.0%
	Total Estimated Hard Construction Cost		**1,000**	**$6,214.00**		**$6,214,000**	
	Imperial Conversion		**10,764**	**$577.29**		**Per SF**	

Note: Total total G.C.'s and Contingency is equal to 35% of the contractors cost - this % has been provided by UofT

	Estimated Construction Costs (Breakdown by Major Component)	GFA m2	Unit Cost/m2	Estimated Total	% of Total
1	Building	1,000	$6,214.00	$6,214,000	100.0%
2	Alterations and Demolition	0	$0.00	$0	0.0%
3	Site Work (including M&E site services)	0	$0.00	$0	0.0%
4	Soft Costs	1,000	$0.00	Excluded	0.0%
	Total Estimated Hard and Soft Construction Costs	**1,000**	**$6,214.00**	**$6,214,000**	
	Imperial Conversion	**10,764**	**$577.29**	**Per SF**	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	C1. SERVICES - MECHANICAL					
	C1.1 Plumbing & Drainage					
1	No work required - Not in scope					
	TOTAL FOR MECHANICAL - Plumbing & Drainage	0.00 / 0	m2	$0.00	$0	
	C1.2 Fire Protection					
2	No work required - Not in scope					
	TOTAL FOR MECHANICAL - Fire Protection	0.00 / 0	m2	$0.00	$0	
	C1.3 Heating, Ventilation & Air Conditioning					
	C1.31 - Liquid Heat Transfer (Heating)					$3,998,400
	Geothermal Field					
3	Geothermal borehole field, holes drilled to 650 ft deep c/w flexible piping, thermally enhanced grout, tie-in's, etc. equal to Geosource					
3.1	- Field A	162	NO	$12,300.00	$1,992,600	
3.2	- Field B	54	NO	$12,300.00	$664,200	
3.3	- Field C	27	NO	$12,300.00	$332,100	
3.4	- Field D	65	NO	$12,300.00	$799,500	
4	Ground loop distribution piping from borefields to Sussex Mews via direct bury				Included above	
5	Test hole c/w thermal conductivity test	1	NO	$30,000.00	$30,000	
6	Automatic glycol fill for 20% glycol c/w initial charge for Susterra 1,3 Propanediol glycol	1	NO	$180,000.00	$180,000	
	Note: Surface restoration is excluded - assumed by others					
	C1.32 - Liquid Heat Transfer (Cooling)					$0
7	No work required					
	C1.38 - Miscellaneous Works and General Accounts					$600,000
	Geothermal Field					
8	Supervision, job set up, clean up, small tools, rentals, poermits & inspections, overhead / profit, etc.	1	NO	$600,000.00	$600,000	
	TOTAL FOR MECHANICAL - HVAC	1.00 / 1,000	m2	$4,598.40	$4,598,400	
	C1.4 MECHANICAL - Controls					
	C1.41 - Controls and Automation					$0
9	No work required					

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	C1.42 - Miscellaneous Works and General Accounts					$0
10	Included in above rates					
	TOTAL FOR MECHANICAL - Controls	0.00 0	m2	$0.00	$0	
		Total Mech Unit Rate		$4,598.40		

Z. GENERAL REQUIREMENTS & CONTINGENCIES

Z1.1 GENERAL REQUIREMENTS & FEES - General Requirements

Z1.11 - Supervision & Labour Expenses

11	Allowance for the General Contractor's supervision & labour expenses as follows:	1	LS	$459,840	$459,800	10.0%
11.1	- supervision and coordination of subcontractors					
11.2	- site superintendent and vehicle					
11.3	- general labour expenses					

Z1.12 - Temporary Conditions

12	Allowance for the temporary conditions provided by the General Contractor including:				Included in Z1.11	
13	Access to site					
13.1	- traffic control					
13.2	- pedestrian safety					
13.3	- removal of exterior cladding for access					
13.4	- temporary closure panels					
14	Site accommodations:					
14.1	- temporary site office					
14.2	- temporary signage					
14.3	- telephone and fax					
14.4	- stationary supplies and office equipment					
15	Site protection:					
15.1	- hoarding and gates					
15.2	- safety guard rails					
15.3	- fire extinguishers					
15.4	- first aid kits					
15.5	- temporary shoring					
15.6	- temporary stairs and ladders					
15.7	- protection for site elevators and flooring					
16	Temporary utilities:					
16.1	- temporary construction power panels					
16.2	- temporary water source					
17	Site clean up:					
17.1	- daily clean up in addition to the trades					
17.2	- final cleaning					
17.3	- dump bins					
17.4	- dumping charges					
18	Equipment:					
18.1	- material hoisting equipment					
18.2	- cranes and operators					
18.3	- small tool rental					
18.4	- pumps and pumping equipment					

No.	Description	Quant.	Unit	Rate	Sub Total	Total
19	Miscellaneous					
19.1	- CPM scheduling					
19.2	- land surveying					
19.3	- testing and inspections					
19.4	- photography					
	Cash Allowances					$0
20	Independent inspection and testing				Excluded	
21	Door hardware supply				Included in B 1.2	
	Z1.13 - Permits, Insurance & Bonds					$133,000
22	Building permit	1	LS	$55,000	$55,000	
23	General Liability and Builder's Risk insurance	1	LS	$32,000	$32,000	
24	Labour & Material and Performance bonding	1	LS	$46,000	$46,000	
	TOTAL FOR GEN. REQ'MENTS & FEES - Gen. Req'ments	1.00 1,000	m2	$592.80	$592,800	
	Z1.2 GENERAL REQUIREMENTS & FEES - Fees					
	Z1.21 - General Contractor's Fees					
25	Allowance for the General Contractor's Fees (Head Office Overhead, Profit and Risk). (applied to measured works plus general requirements)	1	LS	$259,560	$260,000	5.0%
	TOTAL FOR GEN. REQ'MENTS & FEES - Fees	1.00 1,000	m2	$260.00	$260,000	
	Z2.1 ALLOWANCES - Design Contingency					
26	Design Contingency as a percentage of the above to cover increases in the overall scope of the design during the remaining stages of the design phase (applied to measured works plus general requirements and fees)					
26.1	- Architectural				Excluded	14.0%
26.2	- Structural				Excluded	14.0%
26.3	- Siteworks				Excluded	14.0%
26.4	- Mechanical Services	1	LS	$763,200	$763,200	14.0%
26.5	- Electrical Services				Excluded	14.0%
	TOTAL FOR ALLOWANCES - Design Contingency	1.00 1,000	m2	$763.20	$763,200	
	Z2.2 ALLOWANCES - Escalation Contingency					
27	Contingency for escalation that might occur between the date of the estimate and the anticipated tender date (applied to measured works plus general requirements, fees and Design Contingency)				Excluded	0.0%
	TOTAL FOR ALLOWANCES - Escalation Contingency	1.00 1,000	m2	$0.00	$0	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	Z2.3 ALLOWANCES - Construction Contingency					
28	Construction Contingency for post contract changes (applied to measured works plus general requirements, fees, Design Contingency and Escalation Contingency)				Excluded	0.0%
	TOTAL FOR ALLOWANCES - Construction Contingency	1.00 1,000	m2	$0.00	$0	

MASTER ESTIMATE SUMMARY
U OF T FEASIBILITY STUDY FOR ROBERTS FIELD
GEOEXCHANGE - PLANT ROOM

FEASIBILITY STUDY (Rev.1)
MAY 17, 2019

A.W. HOOKER ®
QUANTITY SURVEYORS

	Hard Construction Costs		GFA (m2)	Unit (Cost/m2)	Sub Total	Estimated Total	% of Total
1	Mechanical		1,000	$1,347.70		$1,347,700	76.7%
	- Plumbing and Drainage			$0.00	$0		
	- Fire Protection			$0.00	$0		
	- Heating, Ventilation, Air Conditioning			$1,258.70	$1,258,700		
	- Controls			$89.00	$89,000		
2	Contractor's General Requirements	10.0%	1,000	$172.80		$172,800	9.8%
3	Contractor's Fees (OH&P)	5.0%	1,000	$76.00		$76,000	4.3%
4	Design & Pricing Contingency	10.0%	1,000	$159.70		$159,700	9.1%
	Sub Total (current dollars)		**1,000**	**$1,756.00**		**$1,756,000**	
5	Escalation Contingency			Excluded			0.0%
	Sub Total (Excluding Escalation)		**1,000**	**$1,756.00**		**$1,756,000**	
6	Construction Contingency (Post Contract Changes)			Excluded			0.0%
	Total Estimated Hard Construction Cost		**1,000**	**$1,756.00**		**$1,756,000**	
	Imperial Conversion		**10,764**	**$163.14**		**Per SF**	

Note: Total total G.C.'s and Contingency is equal to 35% of the contractors cost - this % has been provided by UofT

	Estimated Construction Costs (Breakdown by Major Component)	GFA m2	Unit Cost/m2	Estimated Total	% of Total
1	Building	1,000	$1,756.00	$1,756,000	100.0%
2	Alterations and Demolition	0	$0.00	$0	0.0%
3	Site Work (including M&E site services)	0	$0.00	$0	0.0%
4	Soft Costs	1,000	$0.00	Excluded	0.0%
	Total Estimated Hard and Soft Construction Costs	**1,000**	**$1,756.00**	**$1,756,000**	
	Imperial Conversion	**10,764**	**$163.14**	**Per SF**	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	C1. SERVICES - MECHANICAL					
	C1.1 Plumbing & Drainage					
1	No work required - Not in scope					
	TOTAL FOR MECHANICAL - Plumbing & Drainage	0.00 / 0	m2	$0.00	$0	
	C1.2 Fire Protection					
2	No work required - Not in scope					
	TOTAL FOR MECHANICAL - Fire Protection	0.00 / 0	m2	$0.00	$0	
	C1.3 Heating, Ventilation & Air Conditioning					
	C1.31 - Liquid Heat Transfer (Heating)					$936,000
	Student Residence Plant Room					
3	Modular heat pumps equal to Multistack - 300 tons total	4	NO	$110,000.00	$440,000	
4	Student residence ground source loop to condenser water heat exchanger - 300 tons, 800 GPM	1	NO	$40,000.00	$40,000	
5	OPTIONAL Electric boiler - 1,330 MBH capacity	1	NO	$47,000.00	$47,000	
6	OPTIONAL Boiler circulation duplex pump package "P-7" - 130 GPM, 2 HP	1	NO	$4,000.00	$4,000	
7	Heating water circulation duplex pump package "P-4" - 400 GPM, 10 HP - Not significantly different from BAU case				Info Only	
8	Ground source circulation pump package "P-1A,B,C & D" - 1,318 GPM per pump (3,954 GPM total), 100 HP	4	NO	$25,000.00	$100,000	
9	Air control, chemical treatment and expansion tank serving heating water - 80 gallon capacity - Not significantly different from BAU case				Info Only	
10	Air control, chemical treatment and expansion tank serving geothermal water - 100 gallon capacity	1	NO	$2,000.00	$2,000	
11	Geothermal header manifold - 34 pipe connections	1	NO	$130,000.00	$130,000	
12	Ground loop distribution piping within plant room c/w joints, fittings and supports - 12" dia.	10	m	$1,600.00	$16,000	
13	Thermal insulation to above piping	10	m	$300.00	$3,000	
14	Ground loop distribution piping from plant room to Sussex Mews via direct bury - 3" dia.	1,360	m	$75.00	$102,000	
15	Hook-up connection assemblies:					
15.1	- Manifold	1	NO	$12,000.00	$12,000	
15.2	- Heat pumps	4	NO	$3,000.00	$12,000	
15.3	- Pumps	4	NO	$3,000.00	$12,000	
15.4	- OPTIONAL Boiler	1	NO	$4,000.00	$4,000	
15.5	- OPTIONAL Pumps - Boiler pumpsets	1	NO	$4,000.00	$4,000	
15.6	- Heat exchanger (geothermal to condenser - geo side only)	1	NO	$8,000.00	$8,000	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	C1.32 - Liquid Heat Transfer (Cooling)					$70,000
	Student Residence Plant Room					
	Condenser Water Circuit					
16	Condenser water circulation duplex pump package "P-3" - 800 GPM, 7.5 HP	2	NO	$10,000.00	$20,000	
17	Condenser water distribution piping within plant room c/w joints, fittings and supports - 8" dia. - Not significantly different from BAU case				Info Only	
18	Thermal insulation to above piping - Not significantly different from BAU case				Info Only	
19	Hook-up connection assemblies:					
19.1	- Heat pumps	4	NO	$3,000.00	$12,000	
19.2	- Pumps	2	NO	$8,000.00	$16,000	
19.3	- Heat exchanger (geothermal to condenser - condenser side only)	1	NO	$10,000.00	$10,000	
	Chilled Water Circuit					
20	Chilled water circulation duplex pump package "P-5" - 800 GPM, 20 HP - Not significantly different from BAU case				Info Only	
21	Air control, chemical treatment and expansion tank serving chilled water - 40 gallon capacity - Not significantly different from BAU case				Info Only	
22	Chilled water distribution piping within plant room, Sch.40 black steel c/w joints, fittings and supports - Not significantly different from BAU case				Info Only	
23	Thermal insulation to above piping - Not significantly different from BAU case				Info Only	
24	Hook-up connection assemblies:					
24.1	- Heat pumps	4	NO	$3,000.00	$12,000	
24.2	- Pumps - Not significantly different from BAU case				Info Only	
	C1.37 - Support Systems and Works					$42,700
	C1.37.2 - Mechanical Wiring and Starters					$22,700
25	Line and load side power wiring connections from local panels:					
25.1	- Heat pumps	4	NO	$2,200.00	$8,800	
25.2	- Heat exchanger	1	NO	$2,200.00	$2,200	
25.3	- OPTIONAL Boiler	1	NO	$1,200.00	$1,200	
25.4	- Pumps	6	NO	$1,500.00	$9,000	
25.5	- OPTIONAL Boiler pump	1	NO	$1,500.00	$1,500	
	C1.37.3 - Balancing and Commissioning					$20,000
26	Balancing and commissioning	1	NO	$20,000.00	$20,000	
	C1.38 - Miscellaneous Works and General Accounts					$210,000
	Student Residence Plant Room					
27	Supervision, job set up, clean up, small tools, rentals, poermits & inspections, overhead / profit, etc.	1	NO	$210,000.00	$210,000	
	TOTAL FOR MECHANICAL - HVAC	1.00	1,000 m2	$1,258.70	$1,258,700	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	C1.4 MECHANICAL - Controls					
	C1.41 - Controls and Automation					$89,000
28	Implement new building automation system to control and monitor equipment including the following:					
28.1	- Heat pumps	4	NO	$10,000.00	$40,000	
28.2	- Heat exchanger	1	NO	$10,000.00	$10,000	
28.3	- OPTIONAL Boiler	1	NO	$4,000.00	$4,000	
28.4	- Pumps	6	NO	$5,000.00	$30,000	
28.5	- OPTIONAL Boiler pump	1	NO	$5,000.00	$5,000	
	C1.42 - Miscellaneous Works and General Accounts					$0
29	Included in above rates					
	TOTAL FOR MECHANICAL - Controls	1.00 / 1,000	m2	$89.00	$89,000	
		Total Mech Unit Rate		$1,347.70		

Z. GENERAL REQUIREMENTS & CONTINGENCIES

Z1.1 GENERAL REQUIREMENTS & FEES - General Requirements

Z1.11 - Supervision & Labour Expenses

30	Allowance for the General Contractor's supervision & labour expenses as follows:	1	LS	$134,770	$134,800	10.0%
30.1	- supervision and coordination of subcontractors					
30.2	- site superintendent and vehicle					
30.3	- general labour expenses					

Z1.12 - Temporary Conditions

31	Allowance for the temporary conditions provided by the General Contractor including:				Included in Z1.11	
32	Access to site					
32.1	- traffic control					
32.2	- pedestrian safety					
32.3	- removal of exterior cladding for access					
32.4	- temporary closure panels					
33	Site accommodations:					
33.1	- temporary site office					
33.2	- temporary signage					
33.3	- telephone and fax					
33.4	- stationary supplies and office equipment					
34	Site protection:					
34.1	- hoarding and gates					
34.2	- safety guard rails					
34.3	- fire extinguishers					
34.4	- first aid kits					
34.5	- temporary shoring					
34.6	- temporary stairs and ladders					
34.7	- protection for site elevators and flooring					
35	Temporary utilities:					
35.1	- temporary construction power panels					
35.2	- temporary water source					

No.	Description	Quant.		Unit	Rate	Sub Total	Total
36	Site clean up:						
36.1	- daily clean up in addition to the trades						
36.2	- final cleaning						
36.3	- dump bins						
36.4	- dumping charges						
37	Equipment:						
37.1	- material hoisting equipment						
37.2	- cranes and operators						
37.3	- small tool rental						
37.4	- pumps and pumping equipment						
38	Miscellaneous						
38.1	- CPM scheduling						
38.2	- land surveying						
38.3	- testing and inspections						
38.4	- photography						
	Cash Allowances						**$0**
39	Independent inspection and testing					Excluded	
40	Door hardware supply					Included in B 1.2	
	Z1.13 - Permits, Insurance & Bonds						**$38,000**
41	Building permit		1	LS	$16,000	$16,000	
42	General Liability and Builder's Risk insurance		1	LS	$9,000	$9,000	
43	Labour & Material and Performance bonding		1	LS	$13,000	$13,000	
	TOTAL FOR GEN. REQ'MENTS & FEES - Gen. Req'ments	1.00	1,000	m2	$172.80	$172,800	
	Z1.2 GENERAL REQUIREMENTS & FEES - Fees						
	Z1.21 - General Contractor's Fees						
44	Allowance for the General Contractor's Fees (Head Office Overhead, Profit and Risk). (applied to measured works plus general requirements)		1	LS	$76,025	$76,000	5.0%
	TOTAL FOR GEN. REQ'MENTS & FEES - Fees	1.00	1,000	m2	$76.00	$76,000	
	Z2.1 ALLOWANCES - Design Contingency						
45	Design Contingency as a percentage of the above to cover increases in the overall scope of the design during the remaining stages of the design phase (applied to measured works plus general requirements and fees)						
45.1	- Architectural					Excluded	10.0%
45.2	- Structural					Excluded	10.0%
45.3	- Siteworks					Excluded	10.0%
45.4	- Mechanical Services		1	LS	$159,700	$159,700	10.0%
45.5	- Electrical Services					Excluded	10.0%
	TOTAL FOR ALLOWANCES - Design Contingency	1.00	1,000	m2	$159.70	$159,700	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	Z2.2 ALLOWANCES - Escalation Contingency					
46	Contingency for escalation that might occur between the date of the estimate and the anticipated tender date (applied to measured works plus general requirements, fees and Design Contingency)				Excluded	0.0%
	TOTAL FOR ALLOWANCES - Escalation Contingency	1.00 1,000	m2	$0.00	$0	
	Z2.3 ALLOWANCES - Construction Contingency					
47	Construction Contingency for post contract changes (applied to measured works plus general requirements, fees, Design Contingency and Escalation Contingency)				Excluded	0.0%
	TOTAL FOR ALLOWANCES - Construction Contingency	1.00 1,000	m2	$0.00	$0	

MASTER ESTIMATE SUMMARY
U OF T FEASIBILITY STUDY FOR ROBERTS FIELD
GEOEXCHANGE - SITE DISTRIBUTION

FEASIBILITY STUDY (Rev.1)
MAY 17, 2019

A.W. HOOKER ®
QUANTITY SURVEYORS

	Hard Construction Costs		GFA (m2)	Unit (Cost/m2)	Sub Total	Estimated Total	% of Total
1	Mechanical		1,000	$1,069.95		$1,069,950	74.0%
	- Plumbing and Drainage			$0.00	$0		
	- Fire Protection			$0.00	$0		
	- Heating, Ventilation, Air Conditioning			$1,049.95	$1,049,950		
	- Controls			$20.00	$20,000		
2	Contractor's General Requirements	10.0%	1,000	$138.00		$138,000	9.6%
3	Contractor's Fees (OH&P)	5.0%	1,000	$60.00		$60,000	4.2%
4	Design & Pricing Contingency	14.0%	1,000	$177.50		$177,500	12.3%
	Sub Total (current dollars)		**1,000**	**$1,445.00**		**$1,445,000**	
5	Escalation Contingency			Excluded			0.0%
	Sub Total (Excluding Escalation)		**1,000**	**$1,445.00**		**$1,445,000**	
6	Construction Contingency (Post Contract Changes)			Excluded			0.0%
	Total Estimated Hard Construction Cost		**1,000**	**$1,445.00**		**$1,445,000**	
	Imperial Conversion		**10,764**	**$134.24**		**Per SF**	

Note: Total total G.C.'s and Contingency is equal to 35% of the contractors cost - this % has been provided by UofT

	Estimated Construction Costs (Breakdown by Major Component)	GFA m2	Unit Cost/m2	Estimated Total	% of Total
1	Building	1,000	$1,445.00	$1,445,000	100.0%
2	Alterations and Demolition	0	$0.00	$0	0.0%
3	Site Work (including M&E site services)	0	$0.00	$0	0.0%
4	Soft Costs	1,000	$0.00	Excluded	0.0%
	Total Estimated Hard and Soft Construction Costs	**1,000**	**$1,445.00**	**$1,445,000**	
	Imperial Conversion	**10,764**	**$134.24**	**Per SF**	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	C1. SERVICES - MECHANICAL					
	C1.1 Plumbing & Drainage					
1	No work required - Not in scope					
	TOTAL FOR MECHANICAL - Plumbing & Drainage	0.00 / 0	m2	$0.00	$0	
	C1.2 Fire Protection					
2	No work required - Not in scope					
	TOTAL FOR MECHANICAL - Fire Protection	0.00 / 0	m2	$0.00	$0	
	C1.3 Heating, Ventilation & Air Conditioning					
	C1.31 - Liquid Heat Transfer (Heating)					$867,550
	Site Distribution and Terminal Heat Transfer Stations					
3	District Energy heat exchanger - 620 tons, 1,650 GPM	1	NO	$45,000.00	$45,000	
4	District Energy heat exchanger - 280 tons, 750 GPM	1	NO	$35,000.00	$35,000	
5	Provisional sum allowance for architectural cutting, coring and patching modifications to existing foundation walls	2	NO	$15,000.00	$30,000	
6	Ground loop distribution piping within plant room c/w joints, fittings and supports - 10" dia.	30	m	$450.00	$13,500	
7	Thermal insulation to above piping	30	m	$235.00	$7,050	
8	Ground loop distribution piping from plant room to District Energy Buildings via direct bury - 10" dia.	560	m	$1,200.00	$672,000	
9	Valve and cap connecttion for future expansion - in chamber	1	NO	$25,000.00	$25,000	
10	Energy metering	2	NO	$10,000.00	$20,000	
11 11.1	Hook-up connection assemblies: - Heat exchangers (geothermal to District Energy water - geo side only)	2	NO	$10,000.00	$20,000	
	C1.32 - Liquid Heat Transfer (Cooling)					$0
12	No work required					
	C1.37 - Support Systems and Works					$7,400
	C1.37.2 - Mechanical Wiring and Starters					$2,400
13 13.1	Line and load side power wiring connections from local panels: - District heat exchangers including energy flow meters	2	NO	$1,200.00	$2,400	
	C1.37.3 - Balancing and Commissioning					$5,000
14	Balancing and commissioning	1	NO	$5,000.00	$5,000	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	C1.38 - Miscellaneous Works and General Accounts					$175,000
	Site Distribution and Terminal Heat Transfer Stations					
15	Supervision, job set up, clean up, small tools, rentals, poermits & inspections, overhead / profit, etc.	1	NO	$175,000.00	$175,000	
	TOTAL FOR MECHANICAL - HVAC	1.00 1,000	m2	$1,049.95	$1,049,950	
	C1.4 MECHANICAL - Controls					
	C1.41 - Controls and Automation					$20,000
16	Implement new building automation system to control and monitor equipment including the following:					
16.1	- District heat exchangers including energy flow meters	2	NO	$10,000.00	$20,000	
	C1.42 - Miscellaneous Works and General Accounts					$0
17	Included in above rates					
	TOTAL FOR MECHANICAL - Controls	1.00 1,000	m2	$20.00	$20,000	
		Total Mech Unit Rate		$1,069.95		
	Z. GENERAL REQUIREMENTS & CONTINGENCIES					
	Z1.1 GENERAL REQUIREMENTS & FEES - General Requirements					
	Z1.11 - Supervision & Labour Expenses					
18	Allowance for the General Contractor's supervision & labour expenses as follows:	1	LS	$106,995	$107,000	10.0%
18.1	- supervision and coordination of subcontractors					
18.2	- site superintendent and vehicle					
18.3	- general labour expenses					
	Z1.12 - Temporary Conditions					
19	Allowance for the temporary conditions provided by the General Contractor including:				Included in Z1.11	
20	Access to site					
20.1	- traffic control					
20.2	- pedestrian safety					
20.3	- removal of exterior cladding for access					
20.4	- temporary closure panels					
21	Site accommodations:					
21.1	- temporary site office					
21.2	- temporary signage					
21.3	- telephone and fax					
21.4	- stationary supplies and office equipment					

No.	Description	Quant.	Unit	Rate	Sub Total	Total
22	Site protection:					
22.1	- hoarding and gates					
22.2	- safety guard rails					
22.3	- fire extinguishers					
22.4	- first aid kits					
22.5	- temporary shoring					
22.6	- temporary stairs and ladders					
22.7	- protection for site elevators and flooring					
23	Temporary utilities:					
23.1	- temporary construction power panels					
23.2	- temporary water source					
24	Site clean up:					
24.1	- daily clean up in addition to the trades					
24.2	- final cleaning					
24.3	- dump bins					
24.4	- dumping charges					
25	Equipment:					
25.1	- material hoisting equipment					
25.2	- cranes and operators					
25.3	- small tool rental					
25.4	- pumps and pumping equipment					
26	Miscellaneous					
26.1	- CPM scheduling					
26.2	- land surveying					
26.3	- testing and inspections					
26.4	- photography					
	Cash Allowances					**$0**
27	Independent inspection and testing				Excluded	
28	Door hardware supply				Included in B 1.2	
	Z1.13 - Permits, Insurance & Bonds					**$31,000**
29	Building permit	1	LS	$13,000	$13,000	
30	General Liability and Builder's Risk insurance	1	LS	$7,000	$7,000	
31	Labour & Material and Performance bonding	1	LS	$11,000	$11,000	
	TOTAL FOR GEN. REQ'MENTS & FEES - Gen. Req'ments	1.00 / 1,000	m2	$138.00	$138,000	
	Z1.2 GENERAL REQUIREMENTS & FEES - Fees					
	Z1.21 - General Contractor's Fees					
32	Allowance for the General Contractor's Fees (Head Office Overhead, Profit and Risk). (applied to measured works plus general requirements)	1	LS	$60,398	$60,000	5.0%
	TOTAL FOR GEN. REQ'MENTS & FEES - Fees	1.00 / 1,000	m2	$60.00	$60,000	

No.	Description	Quant.	Unit	Rate	Sub Total	Total
	Z2.1 ALLOWANCES - Design Contingency					
33	Design Contingency as a percentage of the above to cover increases in the overall scope of the design during the remaining stages of the design phase					
	(applied to measured works plus general requirements and fees)					
33.1	- Architectural				Excluded	14.0%
33.2	- Structural				Excluded	14.0%
33.3	- Siteworks				Excluded	14.0%
33.4	- Mechanical Services	1	LS	$177,500	$177,500	14.0%
33.5	- Electrical Services				Excluded	14.0%
	TOTAL FOR ALLOWANCES - Design Contingency	1.00 1,000	m2	$177.50	$177,500	
	Z2.2 ALLOWANCES - Escalation Contingency					
34	Contingency for escalation that might occur between the date of the estimate and the anticipated tender date (applied to measured works plus general requirements, fees and Design Contingency)				Excluded	0.0%
	TOTAL FOR ALLOWANCES - Escalation Contingency	1.00 1,000	m2	$0.00	$0	
	Z2.3 ALLOWANCES - Construction Contingency					
35	Construction Contingency for post contract changes (applied to measured works plus general requirements, fees, Design Contingency and Escalation Contingency)				Excluded	0.0%
	TOTAL FOR ALLOWANCES - Construction Contingency	1.00 1,000	m2	$0.00	$0	

Geosource Energy Inc
1508 Highway 54
Caledonia On N3W 2G9
T: 905-765-6950
E: office@geosourceenergy.com

QUOTE

Prepared by,
Stanley Reitsma

Quote Valid Until: July 2, 2019

Date Quoted:	May 3, 2019		Quote/Job #	**19 931**	
Client/Customer:	A.W. Hooker Associates Ltd.				
Billing Address:	2265 Upper Middle Rd E, Suite 400		Oakville, ON		L6H 0G5
	Address & Suite #		City & Province		Postal Code
Contact Person:	Greg Babiak	Tel:	905 399 0870	Email:	gbabiak@awhooker.com
Project Name:	Downtown Toronto TBD			Project Address	TBD
Description:	308 Boreholes to 650' Rev1			Facility Type	

Not a Valid Quote - Strictly for Budget & Discussion Purposes Only

Total Quote + HST:		**$4,088,000.00**
Phase 1	+HST	$3,775,974.67
Phase 2	+HST	$312,025.33

The Scope Of Work, Additional Costs, Additional Work, Exclusions, Invoicing & Payments, Terms and Condtions as outlined below and included in this Quote form part of this Quote and the Agreement in the event this Quote is accepted.

GEOSOURCE
ENERGY INC

SCOPE OF WORK Geosource Energy Inc. will provide the following work and services:

Phase 1

- Completion of 308 Boreholes to 650' (655' from current surface)
- 32 mm SDR11 4710 prefabricated geothermal loops as per specification (200 psi rating)
- Thermally enhanced bentonite grout (K=1.0 btu/ft.hr.F)
- Containment of drill cuttings and water
- Tie-in of loops into mechanical room including all excavation, backfill, compaction where required
- Sand bedding around piping as required
- Tracer devices
- Rough site grading
- Shop drawings for all material used
- As-built drawings of borehole field and pressure report for final pressure test only.

Exclusions - Phase 1

- Aggregate for backfill material if necessary other than bedding sand
- Asphalt/Concrete disposal or Remediation
- Disposal of extra site material
- Disposal of drill cuttings or other drill waste
- Third party backfill compaction testing or other inspection
- Site preparation including tree, fence or garbage removal
- Water for Drilling (Approx 10m3 per hole)
- Fencing
- Parking (Company and Personal Vehicles)
- 10" Mains in Green
- Concrete work including coring, sleeve installation, etc

Phase 2

- 100 mm flanged transition fittings in mechanical room
- HDPE manifold in mechanical room c/w balancing valves (Supply to building side only), isolation valves, ports
- Geothermal loop purge and fill
- Antifreeze including 1 extra drum of at 20% propylene glycol and inhibitor
- Shop drawing of antifreeze

Exclusions - Phase 2

- Insulation on mechanical room manifolds

Notes & Optional Items (if applicable):

Adequate Water Supply to be Supplied for Phase 1 Work
Drill spoils to remain on site, pit for spoils must be supplied to us at no cost close to boreholes.
If spoils are required to be removed, it will be at a cost of $1,200 per hole.
Parking for company and personal vehicles must be provided free of charge

Additional Costs:

- If drilling is impeded due to access, scheduling or any other reason beyond the control of Geosource, a stand-by charge of $400.00 per hour per drill rig/crew will be charged.
- If lateral borehole tie-in is impeded due to access, scheduling or any other reason beyond the control of Geosource, a stand-by charge of $230.00 per hour per crew will be charged.
- In the event Geosource has an unanticipated demobilization and/or remobilization as a result of a delay or inability by Geosource to complete the work as a result of any reason beyond the control of Geosource, a demobilization fee of $5,000.00 per drill rig and a remobilization fee of $5,000.00 per drill rig will be charged.

Additional Work:

- Any additional work undertaken that is not included with the original Scope of Work shall be an extra to the contract and charged and invoiced separately. Geosource will only perform additional work providing it has received a written authorization to do so detailing the additional work to be performed for an agreed-upon lump-sum amount, plus HST or alternatively to be charged on a time and material basis. In the event the additional work is to be completed on the basis of time and materials, hourly rates to be charged for the additional work shall be paid as follows;
- Project Manager/Coordinator $200.00 per hour
- Field Technician $110.00 per hour
- Any subcontractors and/or materials required to complete the additional work shall be charged at cost plus 15% for overhead and profit.
- No additional work shall be undertaken until a signed authorization is provided by the client.
- In the event of any conflict or ambiguity with respect to the Quote and the Terms and Conditions attached hereto the Quote shall prevail.

Invoicing and Payment:

Geosource will render invoices monthly payable within thirty days from the date of the invoice for each phase of the Work. Interest on overdue accounts will be charged at the rate of 2% per month (24% per annum).

Holdback:

Geosource's work under this agreement will be completed well in advance of the eventual substantial completion of the overall project. Geosource will render a holdback invoice after completion of the Work under this Agreement. Pursuant to Section 33 of the Construction Lien Act, the contractor shall request the payment certifier to determine if this subcontract has been completed and if so, the payment certifier shall certify the subcontract in the prescribed form and provide a copy to Geosource; alternatively the owner and contractor may jointly make the declaration and certify completion in the prescribed forms and provide a copy to Geosource. Upon receipt of the certificate, the payer upon the subcontract will make payment of the holdback when all liens that may have been claimed against that holdback have expired pursuant to Section 26 of the Construction Lien Act (i.e. 45 days after the date of certification of the subcontract).

Harnessing The Power Of The Earth

SCHEDULE OF VALUES

Schedule of Contract Values (Excluding HST)		
Job Number	**Project**	
19 931	**Downtown Toronto TBD**	
ITEM #	**DESCRIPTION**	**CONTRACT AMOUNT**
	Phase 1	
1	Drilling	$2,300,274.81
2	Geothermal pipe	$372,865.99
3	Thermally enhanced grout	$291,429.85
4	Mobilization	$7,429.35
5	Tie-In	$803,974.67
	Phase 1	**$3,775,974.67**
	Phase 2	
1	Antifreeze	$170,449.28
2	Flush and Fill	$11,576.05
3	Manifolds	$130,000.00
4	Other Item	$0.00
5	Other Item	$0.00
	Phase 2	**$312,025.33**
	Total Contract Amount	**$4,088,000.00**

Quote Authorized and Accepted by: (Not Valid without the Authorizer's Signature)

Unsigned

X_____

Stanley Reitsma,
CEO, Geosource Energy
DATE: May 3, 2019

ACCEPTANCE

We hereby authorize and direct Geosource Energy Inc. to proceed to complete the Scope of Work as outlined in each Phase herein for the stipulated price on the Terms and Conditions attached hereto.

I have authority to bind the corporation

_____
Print Name of Authorized Representative

_____
Company and or Corporation Name

X_____
Signature of Authorized Representative

Date: _____
Month Day Year

TERMS AND CONDITIONS

Geosource Energy Inc. (Geosource) agrees to perform the services described in the Work Order attached. Together the work order and these terms and conditions constitute the Agreement between Geosource and the Client.

1. Article

1.1 Geosource will perform the services described in the Agreement in accordance with the applicable building code requirements and using the degree and skill ordinarily exercised by members of the profession providing such services.

1.2 Geosource will provide all equipment, personnel, materials and services to perform a geothermal drilling services (Work) as required from time to time as set out in the work order. The general Scope of Work may be amended to accommodate project requirements but any such amendment must be in writing signed by both Geosource and the Client.

1.3 If Geosource is delayed at any time in the progress of the Work by the Client's actions (or the actions of the Client's subcontractors, suppliers, or consultants), the time for performance of the Work shall be extended for such reasonable time as Geosource may determine, acting reasonably, and any additional costs resulting from the delays shall be determined and the Work Order amended accordingly.

1.4 Geosource will take reasonable precautions to assist the Client to avoid damage to existing utilities and other man-made objects at the project identified by the Client. The Client acknowledges and agrees that Geosource shall not be liable for any limited movement and/or settlement of structure nor for any loss or damage to existing utilities and other underground services not located and identified for Geosource prior to commencement of its services.

1.5 Geosource will submit supporting data required to secure permits for the project. However, unless specified in the work order, such submissions will be considered additional work to the work order.

1.6 No warranty, collateral warranty or guarantee as expressed, implied or intended herein save that Geosource warrants its services will be provided with reasonable skill and care in accordance with paragraph 1.1 above.

1.7 Geosource will be and operate as an independent contractor in the performance of the Work. Geosource shall perform the Work in accordance with its own methods in an orderly and workmanlike manner and shall have complete control over and responsibility for all personnel performing the Work. In no event shall the client be authorized to enter into any agreements or undertakings for or on behalf of Geosource or to act as or be an agent or employee of Geosource. Alternatively, in no event shall Geosource be authorized to enter into any agreements or undertakings for or on behalf of the client or to act as an agent or employee of the client.

1.8 There are no other terms and conditions of the Agreement save and except those expressed herein. Alternatively, the Terms and Conditions herein as set out in this Agreement supersede any other terms and conditions, governing, or purporting to govern, the relationship between the Client and Geosource.

2. Client Responsibilities

2.1 Client will:

a) Make available to Geosource, prior to commencement of the Work all information and documents available to the Client and provide assistance necessary or reasonably expected by Geosource, including plans, specifications, drawings, site history, geotechnical reports, thermal conductivity reports, environmental reports, and the test results of soil conditions ("Reference Records") in order to enable Geosource to perform the Work in a good and workmanlike manner;

b) Make decisions, provide approvals, and obtain all necessary authorizations, licenses and permits required in order for Geosource to provide timely performance of the Work;

c) Notify Geosource if it becomes aware of any matter that may reasonably be anticipated to change the scope, timing, order or complexity of the Work; and

d) Act reasonably and in good faith in all respects in connection with the agreement.

2.2 The Client is responsible for the accuracy of the Reference Records and Geosource shall not be liable for damages arising as a result of inaccuracies or omissions in the Reference Records.

2.3 The Client shall provide to Geosource all information available to the Client in relation to the location of utilities, adjacent utilities, underground services, and adjacent structures. The Client is responsible to update information about the location of the utilities. Geosource shall not be liable for any loss or damage arising as a result of inaccuracies in the records save and except for damage caused as a result of the negligence of Geosource. Geosource is not responsible for actual verification of the utilities prior to construction; The Client is responsible for the actual verification of the utility location prior to construction in accordance with OHSA.

2.4 a) Geosource is not responsible for any claims, additional costs or delays due to unknown site conditions, including but without limiting changes to any design or construction and any resulting delay due to change in site conditions, including varying soil conditions, rock formation or fractures, high groundwater flow, artesian conditions pre- or post-building excavation, shale gas, archeological artifacts, underground structures, and/or utilities. More specifically, the Client acknowledges and agrees that Geosource shall not be liable for any loss, damage, injury or delay occurring as a result of unknown site conditions on the project lands or adjacent lands. The Client waives any claim against Geosource, in contract, tort, equity or any other cause of action in law arising from unknown site conditions and agrees to indemnify and hold Geosource harmless from any such claims by any third party;

2.4 b) If the geological conditions differ significantly from any test bore hole logs provided by the client or its agents/subcontractors or if the actual site geological differs significantly during bore-field drilling performed by Geosource or its subcontractors, Geosource expressly reserves the right to;

- Cease drilling operations and submit an adjusted drilling price to the client for approval to reflect the change in drilling conditions, supported by appropriate documentation; and/or

- Cease drilling operations entirely and provide notice of termination of the contract if in the sole discretion of Geosource, drilling conditions are determined to be unviable and/or an adjusted drilling price cannot be agreed upon between Geosource and the client. In such event Geosource will render final invoices for the work performed to the date of notice of termination in accordance with the provisions of this Agreement.

2.4 c) Geosource is not responsible for undetected hazardous materials including but without limiting groundwater contamination, or flooding of the project lands or adjacent lands. Discovery of hazardous materials, contamination or flooding shall constitute a change site condition and may result in a change in the Work and/or delay in the completion of the Work. In such event, Geosource shall immediately notify the Client and seek immediate instructions from the Client to take all appropriate measures to preserve and protect the health and safety of the public and of its employees and subcontractors. Client agrees to compensate Geosource for the costs of such measures taken as instructed by the Client. The Client further agrees to waive any claim against Geosource, in contract, tort, equity or any other cause of action in law and agrees to indemnify and hold Geosource harmless against any such claims by any third party.

2.4 d) Where severe weather conditions result in flooding or render the geo-exchange field unsuitable for drilling or tie-in on an extended basis, Geosource will make every attempt to mitigate costs and complete the project as scheduled. However as with geological conditions, Geosource reserves the right to;

- Submit an adjusted drilling/tie-in price to reflect the impact of extended severe weather conditions, supported by appropriate documentation to the client; and/or cease operations entirely and terminate the Agreement if in the sole discretion of Geosource field conditions are determined to be unviable and/or an adjusted price cannot be agreed upon between Geosource and the client. In such event Geosource will render invoices for the work completed to the date of the notice of termination in accordance with the provisions of this Agreement.

2.5 The Client agrees to obtain and pay for all required consents, approvals, licenses and permits as required save and except as specifically referenced in the work order.

2.6 The Client will designate a representative with authority to transmit instructions to, and receive information from Geosource. The Client agrees to advise Geosource in advance if the representative is to be changed.

2.7 The Client acknowledges and agrees that Geosource's designs for temporary structures for use in the course of construction are intended to be temporary and have a limited design life. The Client acknowledges and agrees that it is responsible for the potential consequences of failing to replace temporary structures with permanent structures in a timely manner.

2.8 The Client agrees to provide Geosource time and space required when necessary to address issues arising from unknown or problematic site conditions without assigning costs related to other aspects of construction.

3. Termination

3.1 The Client may be considered in default of this Agreement if:

a) An invoice is not paid when due as per this Agreement; or
b) It refuses or fails to comply with or perform any of the provisions of this Agreement; or
c) It makes any false representations or statements; or
d) It becomes either insolvent or the subject of a notice or petition in bankruptcy, whether voluntary or involuntary, or become subject to any other proceeding under any bankruptcy, insolvency, or receivership law, or makes an assignment for the benefit of creditors (the Client shall immediately notify Geosource in writing of such event).

3.2 If the Client is in default, then Geosource may, at its option, terminate this Agreement effective immediately by providing written notice of same to the Client. In the event of such termination, the Client is not relieved of their obligations herein, including but not limited to all invoices and expenses chargeable up to the date to termination.

3.3 Either party may terminate this Agreement at any time by giving the other party written notice of such termination effective seven (7) days from the date of the written notice (effective date of termination). In the event of such termination, Geosource shall be paid for all Work completed as of the effective date of termination, and be compensated for all obligations, monetary or otherwise, that Geosource have incurred prior to the effective date of termination. Said payment obligations shall be paid to Geosource within twenty-one days from the effective date of termination.

3.4 Upon receipt of any notice of termination from the client, Geosource may immediately stop performance of the Work. In no event shall Geosource be liable for any loss of revenue or profit incurred by the Client as a result of any termination. The rights and obligations created by this Agreement shall survive the completion, termination or cancellation of this Agreement.

3.5 Any notice required or permitted to be given hereunder, by either party, shall be in writing and shall be delivered in person, sent by email, facsimile, or regular mail, property addressed and stamped with the required postage to the intended recipient at the address and to the attention of the person specified below:

If to Geosource :
Geosource Energy Inc.
1508 Highway #54
Caledonia, Ontario N3W 2G9
Attention: Stan Reitsma

If to Client:
A.W. Hooker Associates Ltd.
2265 Upper Middle Rd E, Suite 400
Oakville, ON L6H 0G5
Attention: Greg Babiak

Either party may from time to time change such address by giving the other party notice of such change in accordance with the above requirements.

4. Insurance

4.1 Geosource will have in effect for the duration of the services the following insurance:

a) Workers' Compensation;
b) Comprehensive general liability ($5,000,000.00 per occurrence/aggregate);
c) Automobile liability ($2,000,000.00 per occurrence/aggregate); and

4.2 During the period in which services are being performed by Geosource, the Client will, at its own expense, maintain comprehensive general liability and professional indemnity insurance of not less than $5,000,000.00 per occurrence/aggregate.

5. Indemnification and Limitation of Liability

5.1 The Client expressly acknowledges and agrees that Geosource's employees, officers, directors and agents shall have no personal liability to it in respect of any claim whatsoever whether in contract, tort, equity and/or any other cause of action in law except for acts of gross negligence or willful misconduct. Accordingly, the Client expressly agrees that it will bring no proceedings whatsoever and take no action in any Court of law, arbitration or similar proceeding against any of Geosource's employees, officer, directors, or agents in their personal capacity except as provided herein.

5.2 In addition to the provisions set out in paragraph 2.4 of this Agreement, the Client shall defend and indemnify Geosource and its subcontractors, consultants, agents, officers and directors and employees against all claims (including but not limited to reasonable lawyer's fees and related costs) made by any party arising out of the Work, unless such claims are caused or contributed to by Geosource's own negligent acts, errors, or omissions or the negligent acts, errors or omissions of Geosource's subcontractors, consultants, agents, officer and directors and employees. The Client's agreement to defend and indemnify shall be limited to the maximum amount of available insurance at the time of the loss but in no event shall the available insurance limits be less than $2,000,000.00 per occurrence/aggregate.

5.3 Geosource shall defend and indemnify the Client and its subcontractors, consultants, agents, officers, directors and employees against all claims (including but not limited to reasonable lawyers' fees and related costs) made by any party arising out of the services provided by Geosource, unless such claims are caused or contributed to by the Client's own negligence acts, errors, or omissions or the negligent acts, errors or omissions of the Client's subcontractors, consultants, agents, officers, directors and employees. Geosource's agreement to defend and indemnify shall be limited to the maximum amount of available insurance at the time of the loss but in no event shall the available insurance limits be less than $2,000,000.00 per occurrence/aggregate.

5.4 Under no circumstances shall Geosource be liable for indirect or consequential damages, including without limitation, damages for loss of business, loss of income, loss profits, loss of opportunity, business interruption, loss of bonus payments, overhead expenses, labour escalation costs, or for aggravation, mental anguish, penalties, punitive or exemplary damages, or costs. This provision survives the expiration or termination of this Agreement.

6. Fees

6.1 The Client shall pay Geosource's fees and expenses as rendered within thirty days of the invoices being rendered. Generally invoices are issued on a monthly basis or upon completion of milestones or phases of work. Outstanding balances shall be subject to interest charges of 2% per month (24% per annum). Geosource shall be paid in full for all of its services under this Agreement, including any extension of services or additional services authorized by the Client. Geosource shall advise the Client in advance if any prior estimates of fees and expenses are to be exceeded and receive the Client's written authorization to proceed. The Client shall advise Geosource within thirty days of receipt that it disputes any invoice. The Client shall pay in full the undisputed portion of the invoice promptly. Failure to dispute the invoice within thirty days will be construed as acceptance.

6.2 Geosource expressly reserves its right to terminate this Agreement immediately in accordance with provisions of paragraph 3.1(a) of this Agreement in the event of any one of its accounts remains unpaid for more than thirty days.

6.3 Under no circumstances will Geosource accept pay-when-paid provisions.

7. General Conditions

7.1 Geosource is responsible only for the activities of its own employees and subcontractors. Geosource has no responsibility for general job safety save that Geosource must comply with safety policy and regulations of the project site as they pertain to its own employees and subcontractors and to the extent that Geosource's conduct or services cause or contribute to harm to others.

7.2 All designs, drawings and specifications prepared by Geosource are prepared on the agreement that all Reference Records are supplied by the Client or on behalf of the Client are accurate and complete and intended to be relied on by Geosource in discharging its duties under this agreement. In the event Geosource becomes aware, or reasonably concludes the information may not be accurate or complete, Geosource will immediately notify the Client in writing.

7.3 All drawings, designs, specifications and documents prepared by Geosource are and shall remain the property of Geosource. The client is granted a nonexclusive license to use for the project and agrees not to disclose to any 3rd party or use the drawing design specifications and documents for the development or construction of any other project without the prior written consent of Geosource.

7.4 Geosource shall not be responsible or liable for damages or delays in the performance of services caused by acts or omissions attributable to the Client, regulatory authorities, civil or labour unrests, acts of God, nature, or terror, and/or disruptions in telecommunications.

7.5 Geosource has no control over the contractor's means, methods, sequence, technique or procedures in construction in constructing the Work. Geosource has no responsibility and no liability for construction deficiencies arising from poor and/or negligent construction. Geosource has no responsibility for dewatering/unwatering at the site and has no liability for problems arising from poor and/or negligent dewatering/unwatering design, execution or workmanship.

7.6 The Client shall not delegate, assign or transfer any interest in this Agreement including to subsidiaries or related development corporations without prior written consent.

7.7 This Agreement constitutes the entire agreement between the parties and supersedes any prior understanding and agreements between the parties. There are no representations, warranties, forms, conditions, undertakings or collateral agreements, expressed or implied, or statutory between the parties other than as expressly set out in the Agreement. Any terms appearing on any purchase order or other documents produced by or on behalf of the Client are excluded. All additional Work carried out on this Project will be governed by the terms of the Agreement.

7.8 The parties agree that this Agreement will be governed by the laws of the Province of Ontario and that any dispute arising from this Agreement which requires adjudication will be adjudicated by the Ontario Superior Courts of Justice and the Client thereby consents to the exclusive jurisdiction of the Ontario Superior Courts of Justice.

Harnessing The Power Of The Earth

CLIENT INFORMATION FOR THIS PROJECT:

Job # 931 Project Name: Downtown Toronto TBD Location: TBD

This Form MUST be completed and returned PRIOR to commencing work. *Email completed form to office@geosourceenergy.com*

Project Name & Address: _____

Project Owner Info

Company Name: _____

Address: _____

Contact Name: _____ Email: _____ Tel: _____

General Contractor / Project Manager

Company Name: _____

Address: _____

Contact Name: _____ Email: _____ Tel: _____

Billing Details for Invoicing + Accounts Payable

Please Specify exactly who the invoice is to be made out to and any 'care of' details

Company Name: _____

c/o: _____

Address: _____

A/P Contact : _____ Email: _____ Tel: _____

Choose an Invoice Delivery Method: Regular Mail Email Both

Email Invoice(s) to: _____

CC to: _____

Complete the items below if your company requires us to provide them to you.

Liability Insurance Certificate Details

Name to be Insured: _____

Address _____

Additional to be Insured: _____

Address _____

W.S.I.B Clearance Certificates

Name of the Principle _____

Principle's WSIB account # _____

Please Return this Form via Email to:
office@geosourceenergy.com

Geosource Energy Inc
1508 Highway 54
Caledonia On N3W 2G9
T: 905-765-6950
E: office@geosourceenergy.com

QUOTE

Prepared by,
Stanley Reitsma

Quote Valid Until: July 2, 2019

Date Quoted:	May 3, 2019		Quote/Job #	**19 931**	
Client/Customer:	A.W. Hooker Associates Ltd.				
Billing Address:	2265 Upper Middle Rd E, Suite 400		Oakville, ON		L6H 0G5
	Address & Suite #		City & Province		Postal Code
Contact Person:	Greg Babiak	Tel:	905 399 0870	Email:	gbabiak@awhooker.com
Project Name:	Downtown Toronto TBD			Project Address	TBD
Description:	308 Boreholes to 800' Rev1			Facility Type	

Not a Valid Quote - Strictly for Budget & Discussion Purposes Only

Total Quote + HST:		**$4,923,000.00**
Phase 1	+HST	$4,583,416.57
Phase 2	+HST	$339,583.43

The Scope Of Work, Additional Costs, Additional Work, Exclusions, Invoicing & Payments, Terms and Condtions as outlined below and included in this Quote form part of this Quote and the Agreement in the event this Quote is accepted.

SCOPE OF WORK Geosource Energy Inc. will provide the following work and services:

Phase 1

- Completion of 308 Boreholes to 800' (805' from current surface)
- 38 mm SDR11 4710 prefabricated geothermal loops as per specification (200 psi rating)
- Thermally enhanced bentonite grout (K=1.0 btu/ft.hr.F)
- Containment of drill cuttings and water
- Tie-in of loops into mechanical room including all excavation, backfill, compaction where required
- Sand bedding around piping as required
- Tracer devices
- Rough site grading
- Shop drawings for all material used
- As-built drawings of borehole field and pressure report for final pressure test only.

Exclusions - Phase 1

- Aggregate for backfill material if necessary other than bedding sand
- Asphalt/Concrete disposal or Remediation
- Disposal of extra site material
- Disposal of drill cuttings or other drill waste
- Third party backfill compaction testing or other inspection
- Site preparation including tree, fence or garbage removal
- Water for Drilling (Approx 10m3 per hole)
- Fencing
- Parking (Company and Personal Vehicles)
- 10" Mains in Green
- Concrete work including coring, sleeve installation, etc

Phase 2

- 100 mm flanged transition fittings in mechanical room
- HDPE manifold in mechanical room c/w balancing valves (Supply to building side only), isolation valves, ports
- Geothermal loop purge and fill
- Antifreeze including 1 extra drum of at 20% propylene glycol and inhibitor
- Shop drawing of antifreeze

Exclusions - Phase 2

- Insulation on mechanical room manifolds

Notes & Optional Items (if applicable):

Adequate Water Supply to be Supplied for Phase 1 Work
Drill spoils to remain on site, pit for spoils must be supplied to us at no cost close to boreholes.
If spoils are required to be removed, it will be at a cost of $1,500 per hole.
Parking for company and personal vehicles must be provided free of charge

Additional Costs:

- If drilling is impeded due to access, scheduling or any other reason beyond the control of Geosource, a stand-by charge of $400.00 per hour per drill rig/crew will be charged.
- If lateral borehole tie-in is impeded due to access, scheduling or any other reason beyond the control of Geosource, a stand-by charge of $230.00 per hour per crew will be charged.
- In the event Geosource has an unanticipated demobilization and/or remobilization as a result of a delay or inability by Geosource to complete the work as a result of any reason beyond the control of Geosource, a demobilization fee of $5,000.00 per drill rig and a remobilization fee of $5,000.00 per drill rig will be charged.

Additional Work:

- Any additional work undertaken that is not included with the original Scope of Work shall be an extra to the contract and charged and invoiced separately. Geosource will only perform additional work providing it has received a written authorization to do so detailing the additional work to be performed for an agreed-upon lump-sum amount, plus HST or alternatively to be charged on a time and material basis. In the event the additional work is to be completed on the basis of time and materials, hourly rates to be charged for the additional work shall be paid as follows;
- Project Manager/Coordinator $200.00 per hour
- Field Technician $110.00 per hour
- Any subcontractors and/or materials required to complete the additional work shall be charged at cost plus 15% for overhead and profit.
- No additional work shall be undertaken until a signed authorization is provided by the client.
- In the event of any conflict or ambiguity with respect to the Quote and the Terms and Conditions attached hereto the Quote shall prevail.

Invoicing and Payment:

Geosource will render invoices monthly payable within thirty days from the date of the invoice for each phase of the Work. Interest on overdue accounts will be charged at the rate of 2% per month (24% per annum).

Holdback:

Geosource's work under this agreement will be completed well in advance of the eventual substantial completion of the overall project. Geosource will render a holdback invoice after completion of the Work under this Agreement. Pursuant to Section 33 of the Construction Lien Act, the contractor shall request the payment certifier to determine if this subcontract has been completed and if so, the payment certifier shall certify the subcontract in the prescribed form and provide a copy to Geosource; alternatively the owner and contractor may jointly make the declaration and certify completion in the prescribed forms and provide a copy to Geosource. Upon receipt of the certificate, the payer upon the subcontract will make payment of the holdback when all liens that may have been claimed against that holdback have expired pursuant to Section 26 of the Construction Lien Act (i.e. 45 days after the date of certification of the subcontract).

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SCHEDULE OF VALUES

Schedule of Contract Values (Excluding HST)		
Job Number	**Project**	
19 931	**Downtown Toronto TBD**	
ITEM #	**DESCRIPTION**	**CONTRACT AMOUNT**
	Phase 1	
1	Drilling	$2,780,984.12
2	Geothermal pipe	$580,744.57
3	Thermally enhanced grout	$398,841.18
4	Mobilization	$7,430.13
5	Tie-In	$815,416.57
	Phase 1	**$4,583,416.57**
	Phase 2	
1	Antifreeze	$198,011.97
2	Flush and Fill	$11,571.46
3	Manifolds	$130,000.00
4	Other Item	$0.00
5	Other Item	$0.00
	Phase 2	**$339,583.43**
	Total Contract Amount	**$4,923,000.00**

Quote Authorized and Accepted by: (Not Valid without the Authorizer's Signature)

Unsigned

X_____

Stanley Reitsma,
CEO, Geosource Energy
DATE: May 3, 2019

ACCEPTANCE

We hereby authorize and direct Geosource Energy Inc. to proceed to complete the Scope of Work as outlined in each Phase herein for the stipulated price on the Terms and Conditions attached hereto.

I have authority to bind the corporation

_____
Print Name of Authorized Representative

_____
Company and or Corporation Name

X_____
Signature of Authorized Representative

Date: _____
Month Day Year

TERMS AND CONDITIONS

Geosource Energy Inc. (Geosource) agrees to perform the services described in the Work Order attached. Together the work order and these terms and conditions constitute the Agreement between Geosource and the Client.

1. Article

1.1 Geosource will perform the services described in the Agreement in accordance with the applicable building code requirements and using the degree and skill ordinarily exercised by members of the profession providing such services.

1.2 Geosource will provide all equipment, personnel, materials and services to perform a geothermal drilling services (Work) as required from time to time as set out in the work order. The general Scope of Work may be amended to accommodate project requirements but any such amendment must be in writing signed by both Geosource and the Client.

1.3 If Geosource is delayed at any time in the progress of the Work by the Client's actions (or the actions of the Client's subcontractors, suppliers, or consultants), the time for performance of the Work shall be extended for such reasonable time as Geosource may determine, acting reasonably, and any additional costs resulting from the delays shall be determined and the Work Order amended accordingly.

1.4 Geosource will take reasonable precautions to assist the Client to avoid damage to existing utilities and other man-made objects at the project identified by the Client. The Client acknowledges and agrees that Geosource shall not be liable for any limited movement and/or settlement of structure nor for any loss or damage to existing utilities and other underground services not located and identified for Geosource prior to commencement of its services.

1.5 Geosource will submit supporting data required to secure permits for the project. However, unless specified in the work order, such submissions will be considered additional work to the work order.

1.6 No warranty, collateral warranty or guarantee as expressed, implied or intended herein save that Geosource warrants its services will be provided with reasonable skill and care in accordance with paragraph 1.1 above.

1.7 Geosource will be and operate as an independent contractor in the performance of the Work. Geosource shall perform the Work in accordance with its own methods in an orderly and workmanlike manner and shall have complete control over and responsibility for all personnel performing the Work. In no event shall the client be authorized to enter into any agreements or undertakings for or on behalf of Geosource or to act as or be an agent or employee of Geosource. Alternatively, in no event shall Geosource be authorized to enter into any agreements or undertakings for or on behalf of the client or to act as an agent or employee of the client.

1.8 There are no other terms and conditions of the Agreement save and except those expressed herein. Alternatively, the Terms and Conditions herein as set out in this Agreement supersede any other terms and conditions, governing, or purporting to govern, the relationship between the Client and Geosource.

2. Client Responsibilities

2.1 Client will:

a) Make available to Geosource, prior to commencement of the Work all information and documents available to the Client and provide assistance necessary or reasonably expected by Geosource, including plans, specifications, drawings, site history, geotechnical reports, thermal conductivity reports, environmental reports, and the test results of soil conditions ("Reference Records") in order to enable Geosource to perform the Work in a good and workmanlike manner;

b) Make decisions, provide approvals, and obtain all necessary authorizations, licenses and permits required in order for Geosource to provide timely performance of the Work;

c) Notify Geosource if it becomes aware of any matter that may reasonably be anticipated to change the scope, timing, order or complexity of the Work; and

d) Act reasonably and in good faith in all respects in connection with the agreement.

2.2 The Client is responsible for the accuracy of the Reference Records and Geosource shall not be liable for damages arising as a result of inaccuracies or omissions in the Reference Records.

2.3 The Client shall provide to Geosource all information available to the Client in relation to the location of utilities, adjacent utilities, underground services, and adjacent structures. The Client is responsible to update information about the location of the utilities. Geosource shall not be liable for any loss or damage arising as a result of inaccuracies in the records save and except for damage caused as a result of the negligence of Geosource. Geosource is not responsible for actual verification of the utilities prior to construction; The Client is responsible for the actual verification of the utility location prior to construction in accordance with OHSA.

2.4 a) Geosource is not responsible for any claims, additional costs or delays due to unknown site conditions, including but without limiting changes to any design or construction and any resulting delay due to change in site conditions, including varying soil conditions, rock formation or fractures, high groundwater flow, artesian conditions pre- or post-building excavation, shale gas, archeological artifacts, underground structures, and/or utilities. More specifically, the Client acknowledges and agrees that Geosource shall not be liable for any loss, damage, injury or delay occurring as a result of unknown site conditions on the project lands or adjacent lands. The Client waives any claim against Geosource, in contract, tort, equity or any other cause of action in law arising from unknown site conditions and agrees to indemnify and hold Geosource harmless from any such claims by any third party;

2.4 b) If the geological conditions differ significantly from any test bore hole logs provided by the client or its agents/subcontractors or if the actual site geological differs significantly during bore-field drilling performed by Geosource or its subcontractors, Geosource expressly reserves the right to;

- Cease drilling operations and submit an adjusted drilling price to the client for approval to reflect the change in drilling conditions, supported by appropriate documentation; and/or

- Cease drilling operations entirely and provide notice of termination of the contract if in the sole discretion of Geosource, drilling conditions are determined to be unviable and/or an adjusted drilling price cannot be agreed upon between Geosource and the client. In such event Geosource will render final invoices for the work performed to the date of notice of termination in accordance with the provisions of this Agreement.

2.4 c) Geosource is not responsible for undetected hazardous materials including but without limiting groundwater contamination, or flooding of the project lands or adjacent lands. Discovery of hazardous materials, contamination or flooding shall constitute a change site condition and may result in a change in the Work and/or delay in the completion of the Work. In such event, Geosource shall immediately notify the Client and seek immediate instructions from the Client to take all appropriate measures to preserve and protect the health and safety of the public and of its employees and subcontractors. Client agrees to compensate Geosource for the costs of such measures taken as instructed by the Client. The Client further agrees to waive any claim against Geosource, in contract, tort, equity or any other cause of action in law and agrees to indemnify and hold Geosource harmless against any such claims by any third party.

2.4 d) Where severe weather conditions result in flooding or render the geo-exchange field unsuitable for drilling or tie-in on an extended basis, Geosource will make every attempt to mitigate costs and complete the project as scheduled. However as with geological conditions, Geosource reserves the right to;

- Submit an adjusted drilling/tie-in price to reflect the impact of extended severe weather conditions, supported by appropriate documentation to the client; and/or cease operations entirely and terminate the Agreement if in the sole discretion of Geosource field conditions are determined to be unviable and/or an adjusted price cannot be agreed upon between Geosource and the client. In such event Geosource will render invoices for the work completed to the date of the notice of termination in accordance with the provisions of this Agreement.

2.5 The Client agrees to obtain and pay for all required consents, approvals, licenses and permits as required save and except as specifically referenced in the work order.

2.6 The Client will designate a representative with authority to transmit instructions to, and receive information from Geosource. The Client agrees to advise Geosource in advance if the representative is to be changed.

2.7 The Client acknowledges and agrees that Geosource's designs for temporary structures for use in the course of construction are intended to be temporary and have a limited design life. The Client acknowledges and agrees that it is responsible for the potential consequences of failing to replace temporary structures with permanent structures in a timely manner.

2.8 The Client agrees to provide Geosource time and space required when necessary to address issues arising from unknown or problematic site conditions without assigning costs related to other aspects of construction.

3. Termination

3.1 The Client may be considered in default of this Agreement if:

a) An invoice is not paid when due as per this Agreement; or
b) It refuses or fails to comply with or perform any of the provisions of this Agreement; or
c) It makes any false representations or statements; or
d) It becomes either insolvent or the subject of a notice or petition in bankruptcy, whether voluntary or involuntary, or become subject to any other proceeding under any bankruptcy, insolvency, or receivership law, or makes an assignment for the benefit of creditors (the Client shall immediately notify Geosource in writing of such event).

3.2 If the Client is in default, then Geosource may, at its option, terminate this Agreement effective immediately by providing written notice of same to the Client. In the event of such termination, the Client is not relieved of their obligations herein, including but not limited to all invoices and expenses chargeable up to the date to termination.

3.3 Either party may terminate this Agreement at any time by giving the other party written notice of such termination effective seven (7) days from the date of the written notice (effective date of termination). In the event of such termination, Geosource shall be paid for all Work completed as of the effective date of termination, and be compensated for all obligations, monetary or otherwise, that Geosource have incurred prior to the effective date of termination. Said payment obligations shall be paid to Geosource within twenty-one days from the effective date of termination.

3.4 Upon receipt of any notice of termination from the client, Geosource may immediately stop performance of the Work. In no event shall Geosource be liable for any loss of revenue or profit incurred by the Client as a result of any termination. The rights and obligations created by this Agreement shall survive the completion, termination or cancellation of this Agreement.

3.5 Any notice required or permitted to be given hereunder, by either party, shall be in writing and shall be delivered in person, sent by email, facsimile, or regular mail, property addressed and stamped with the required postage to the intended recipient at the address and to the attention of the person specified below:

If to Geosource :
Geosource Energy Inc.
1508 Highway #54
Caledonia, Ontario N3W 2G9
Attention: Stan Reitsma

If to Client:
A.W. Hooker Associates Ltd.
2265 Upper Middle Rd E, Suite 400
Oakville, ON L6H 0G5
Attention: Greg Babiak

Either party may from time to time change such address by giving the other party notice of such change in accordance with the above requirements.

4. Insurance

4.1 Geosource will have in effect for the duration of the services the following insurance:

a) Workers' Compensation;
b) Comprehensive general liability ($5,000,000.00 per occurrence/aggregate);
c) Automobile liability ($2,000,000.00 per occurrence/aggregate); and

4.2 During the period in which services are being performed by Geosource, the Client will, at its own expense, maintain comprehensive general liability and professional indemnity insurance of not less than $5,000,000.00 per occurrence/aggregate.

5. Indemnification and Limitation of Liability

5.1 The Client expressly acknowledges and agrees that Geosource's employees, officers, directors and agents shall have no personal liability to it in respect of any claim whatsoever whether in contract, tort, equity and/or any other cause of action in law except for acts of gross negligence or willful misconduct. Accordingly, the Client expressly agrees that it will bring no proceedings whatsoever and take no action in any Court of law, arbitration or similar proceeding against any of Geosource's employees, officer, directors, or agents in their personal capacity except as provided herein.

5.2 In addition to the provisions set out in paragraph 2.4 of this Agreement, the Client shall defend and indemnify Geosource and its subcontractors, consultants, agents, officers and directors and employees against all claims (including but not limited to reasonable lawyer's fees and related costs) made by any party arising out of the Work, unless such claims are caused or contributed to by Geosource's own negligent acts, errors, or omissions or the negligent acts, errors or omissions of Geosource's subcontractors, consultants, agents, officer and directors and employees. The Client's agreement to defend and indemnify shall be limited to the maximum amount of available insurance at the time of the loss but in no event shall the available insurance limits be less than $2,000,000.00 per occurrence/aggregate.

5.3 Geosource shall defend and indemnify the Client and its subcontractors, consultants, agents, officers, directors and employees against all claims (including but not limited to reasonable lawyers' fees and related costs) made by any party arising out of the services provided by Geosource, unless such claims are caused or contributed to by the Client's own negligence acts, errors, or omissions or the negligent acts, errors or omissions of the Client's subcontractors, consultants, agents, officers, directors and employees. Geosource's agreement to defend and indemnify shall be limited to the maximum amount of available insurance at the time of the loss but in no event shall the available insurance limits be less than $2,000,000.00 per occurrence/aggregate.

5.4 Under no circumstances shall Geosource be liable for indirect or consequential damages, including without limitation, damages for loss of business, loss of income, loss profits, loss of opportunity, business interruption, loss of bonus payments, overhead expenses, labour escalation costs, or for aggravation, mental anguish, penalties, punitive or exemplary damages, or costs. This provision survives the expiration or termination of this Agreement.

6. Fees

6.1 The Client shall pay Geosource's fees and expenses as rendered within thirty days of the invoices being rendered. Generally invoices are issued on a monthly basis or upon completion of milestones or phases of work. Outstanding balances shall be subject to interest charges of 2% per month (24% per annum). Geosource shall be paid in full for all of its services under this Agreement, including any extension of services or additional services authorized by the Client. Geosource shall advise the Client in advance if any prior estimates of fees and expenses are to be exceeded and receive the Client's written authorization to proceed. The Client shall advise Geosource within thirty days of receipt that it disputes any invoice. The Client shall pay in full the undisputed portion of the invoice promptly. Failure to dispute the invoice within thirty days will be construed as acceptance.

6.2 Geosource expressly reserves its right to terminate this Agreement immediately in accordance with provisions of paragraph 3.1(a) of this Agreement in the event of any one of its accounts remains unpaid for more than thirty days.

6.3 Under no circumstances will Geosource accept pay-when-paid provisions.

7. General Conditions

7.1 Geosource is responsible only for the activities of its own employees and subcontractors. Geosource has no responsibility for general job safety save that Geosource must comply with safety policy and regulations of the project site as they pertain to its own employees and subcontractors and to the extent that Geosource's conduct or services cause or contribute to harm to others.

7.2 All designs, drawings and specifications prepared by Geosource are prepared on the agreement that all Reference Records are supplied by the Client or on behalf of the Client are accurate and complete and intended to be relied on by Geosource in discharging its duties under this agreement. In the event Geosource becomes aware, or reasonably concludes the information may not be accurate or complete, Geosource will immediately notify the Client in writing.

7.3 All drawings, designs, specifications and documents prepared by Geosource are and shall remain the property of Geosource. The client is granted a nonexclusive license to use for the project and agrees not to disclose to any 3rd party or use the drawing design specifications and documents for the development or construction of any other project without the prior written consent of Geosource.

7.4 Geosource shall not be responsible or liable for damages or delays in the performance of services caused by acts or omissions attributable to the Client, regulatory authorities, civil or labour unrests, acts of God, nature, or terror, and/or disruptions in telecommunications.

7.5 Geosource has no control over the contractor's means, methods, sequence, technique or procedures in construction in constructing the Work. Geosource has no responsibility and no liability for construction deficiencies arising from poor and/or negligent construction. Geosource has no responsibility for dewatering/unwatering at the site and has no liability for problems arising from poor and/or negligent dewatering/unwatering design, execution or workmanship.

7.6 The Client shall not delegate, assign or transfer any interest in this Agreement including to subsidiaries or related development corporations without prior written consent.

7.7 This Agreement constitutes the entire agreement between the parties and supersedes any prior understanding and agreements between the parties. There are no representations, warranties, forms, conditions, undertakings or collateral agreements, expressed or implied, or statutory between the parties other than as expressly set out in the Agreement. Any terms appearing on any purchase order or other documents produced by or on behalf of the Client are excluded. All additional Work carried out on this Project will be governed by the terms of the Agreement.

7.8 The parties agree that this Agreement will be governed by the laws of the Province of Ontario and that any dispute arising from this Agreement which requires adjudication will be adjudicated by the Ontario Superior Courts of Justice and the Client thereby consents to the exclusive jurisdiction of the Ontario Superior Courts of Justice.

Harnessing The Power Of The Earth

CLIENT INFORMATION FOR THIS PROJECT:

Job # 931 Project Name: Downtown Toronto TBD Location: TBD

This Form MUST be completed and returned PRIOR to commencing work. *Email completed form to office@geosourceenergy.com*

Project Name & Address: _____

Project Owner Info

Company Name: _____

Address: _____

Contact Name: _____ Email: _____ Tel: _____

General Contractor / Project Manager

Company Name: _____

Address: _____

Contact Name: _____ Email: _____ Tel: _____

Billing Details for Invoicing + Accounts Payable

Please Specify exactly who the invoice is to be made out to and any 'care of' details

Company Name: _____

c/o: _____

Address: _____

A/P Contact : _____ Email: _____ Tel: _____

Choose an Invoice Delivery Method: Regular Mail Email Both

Email Invoice(s) to: _____

CC to: _____

Complete the items below if your company requires us to provide them to you.

Liability Insurance Certificate Details

Name to be Insured: _____

Address _____

Additional to be Insured: _____

Address _____

W.S.I.B Clearance Certificates

Name of the Principle _____

Principle's WSIB account # _____

Please Return this Form via Email to:
office@geosourceenergy.com