



IDEA2022

Building Connections

June 6-9 | Sheraton Centre Toronto Hotel | Toronto, ON



INTERNATIONAL
DISTRICT ENERGY
ASSOCIATION

Streamlined Approach Heats Up Site Selection Process For Community-Networked Geothermal Pilot Project

Jagrut Jathal, PE
Jacky Kinson, EIT





Feasibility Screening Analysis and Site Selection

Overall Project Goal: Implement a district-level (“community-networked”) geothermal utility on a pilot-project scale

Initial Phase Objectives:

- Screen candidate sites provided by the client and develop a short-list of feasible sites to install and operate a district-level geothermal utility.
- Assess feasibility of each candidate site through evaluation of a specific set of criteria in an objective, unbiased manner.

Approach:

Screening 1 – “Go/No-Go” Evaluation

Screening 2 – Multi-Criteria Decision Analysis (MCDA)

Screening 3 – Site Selection & Schematic Design

Screening 1 – “Go/No-Go” Evaluation

- 17 sites assigned located across five cities/towns
- Initial screening of each site against 10 “critical” criteria
- “Yes” or “No” Evaluation

Criteria developed with gas utility client input and to meet objectives of the governing Public Utilities agency

Criteria/Metric Name
Site Located in Client’s Gas Service Territory
Existing Natural Gas Distribution Operational Concerns Present
Presence of Delivered Fuel Customers
Mix of Residential and Commercial/Industrial
Minimum of One Low-Income, Multifamily Building
Initial Customer Participation and Willingness
Presence of Environmental Impacts
Public Infrastructure Interference
Right-of-Way (ROW) for Borefield
Building Loads

Screening 1 Criteria (1 of 3 slides)

Criteria/Metric Name	Description
Site Located in Existing Gas Service Territory	The site is within the existing gas service territory.
Existing Natural Gas Distribution Operational Concerns	There would be no negative effect on natural gas delivery infrastructure.
Includes Delivered-Fuel Customer(s)	One or more of the buildings that make up the pilot site include delivered-fuel customer(s).
Mix of Residential and Commercial/Industrial	There is a mix of residential, which can include multifamily, buildings and commercial/industrial buildings. Commercial buildings can include common meter multifamily and municipal buildings.
Minimum of One Low-Income, Multifamily Building	There is at least one low-income, multifamily building within the buildings that make up the pilot site.
Initial Customer Participation and Willingness	
Received a request from the municipality	The municipal government or other officials where the site is located have indicated interest in the geothermal pilot.
Site is located within a U.S. Census-designated metropolitan statistical area	A metropolitan statistical area is defined as a core area containing a sufficient population concentration, combined with nearby communities that are integrated economically and socially with that core. These areas are delineated periodically by the U.S. Census.

Screening 1 Criteria (2 of 3 slides)

Criteria/Metric Name	Description
Environmental Impacts	
Natural Resources On-site (e.g., wetlands, sensitive receptors, and others)	The pilot site borefield area is not located within a wetland or closer to a regulated natural resource or buffer zone per the governing state and local municipal environmental departments that would preclude intrusive activities such as drilling.
Major Environmental Contamination On-site (Federal/State Superfund and Brownfield sites)	The site does not include any properties that are a listed federal or state Superfund site or designated Brownfield site that would require an extensive approval process and limit the extent of intrusive activities (drilling, trenching for pipe installation) on that property.
Public Infrastructure Interference	
Public Transit (Rail) Tunnels	There are no rail tunnels beneath the site or in proximity such that drilling will be precluded by the associated transit agency.
Aboveground Rail Lines	There are no aboveground rail corridors adjoining the site such that drilling will be precluded by the associated transit agency.
Public Drinking Water Tunnels	There are no public drinking water supply tunnels beneath the site or in proximity such that drilling will be precluded by the associated water supplier or agency.


Screening 1 Criteria (3 of 3 slides)

Criteria/Metric Name	Description
Right-of-Way (ROW) for Borefield	
ROW Needed/Available	Presence of sufficient available ROW within the project site to access enough geothermal capacity to meet the site buildings' heating and cooling loads, using up to two lines of closed loops in the sidewalk and/or street in front of the site buildings, public open space (e.g., parking lots, parks/greenspace), and/or in front of adjoining buildings that are not part of the site.
Building Loads	
Diversity of Loads	Aggregated heating and cooling annual loads of the buildings have sufficient diversity to achieve thermal balance within the system and the ground, without the need to add or remove excessive amounts of to/heat from the thermal network over the time of operation.
Load Size	Estimated building load size must be large enough to prove the pilot works in concept, but small enough to stay within the pilot project budget.

Screening 1 – “Go/No-Go” Results

ID	Criteria and Metrics	Site 1	Site 2	Site 3	Site 7	Site 13	Site 14
		Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
101	Existing Gas Service Territory	Y	Y	Y	Y	Y	Y
102	Existing Natural Gas Distribution Operational Concerns	Y	Y	Y	Y	Y	Y
103	Includes Delivered Fuel Customer(s)	Y	Y	Y	Y	N	N
104	Mix of Residential and Commercial/Industrial	Y	Y	Y	Y	Y	Y
105	Minimum of One Low-Income, Multi-Family Building	Y	Y	Y	N	N	N
	Initial Customer Participation and Willingness						
106	<i>Received a request from the municipality</i>	Y	Y	Y	Y	Y	Y
107	<i>Site is located within a Census-designated metropolitan statistical area</i>	Y	Y	Y	Y	Y	Y
	Environmental Impacts						
108	<i>Natural Resources On-Site (e.g., wetlands, sensitive receptors, and others)</i>	N	N	N	N	N	N
109	<i>Major Environmental Contamination On-Site (Federal/State Superfund and/or Brownfield sites)</i>	N	N	N	N	N	N
	Public Infrastructure Interference						
110	<i>Public Transit (Rail) Tunnels</i>	N	N	N	N	N	N
111	<i>Aboveground Rail Lines</i>	N	N	N	N	N	N
112	<i>Public Drinking Water Tunnels</i>	N	N	N	N	N	N
	Right of Way (ROW for Borefield)						
113	<i>ROW Needed/Available</i>	Y	Y	Y	Y	Y	N
	Building Loads						
114	<i>Balanced Energy Demands</i>	Y	Y	Y	Y	Y	N
115	<i>Load Size</i>	Y	Y	Y	Y	Y	N
		PASS	PASS	PASS	FAIL	FAIL	FAIL

Note: Criteria are in bold. Metrics are in italics.



Screening 2 – Multi-Criteria Decision Analysis (MCDA)

- Nine sites passed Screening 1 and advanced to Screening 2
- Comparative Ranking
- 24 criteria and metrics
- Summary criteria weighted based on level of importance to client and CDM Smith team
- Metrics within each summary criterion similarly weighted

Criteria/Metric Name
Site Located in Existing Electrical Service Territory
Viability for Future System Expansion
Customer Participation and Willingness
Geological Conditions & Thermal Conductivity
Environmental Justice Impacts
ROW for Accessibility and Construction
Building Loads
Environmental Impacts

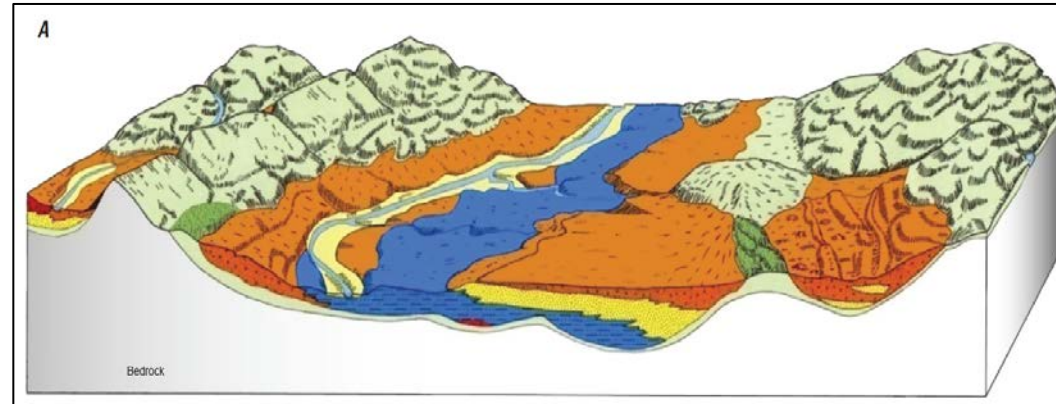
Screening 2 – Customer Willingness

Criteria/Metric Name	Description	Summary Criteria Weights	Metric Weights
Customer Participation and Willingness		20%	--
Relative Level of Community Interest in Geothermal Pilot Project	A desktop assessment of news and social media was performed to identify evidence of community interest in a geothermal pilot project or related topics. Topics considered include interest in sustainability, energy efficiency, and cost-effectiveness and safety of home heating and cooling systems. Each topic was scored on the relative level of community interest. A score of 1 reflected negative community interest on the subject; 5 reflected neutral community interest; 10 reflected positive community interest. The average of these scores determined the overall relative level of community interest ranking.	–	10%
At Least One Government/Municipal Official’s Letter of Support	Support from local government or municipal entities is important to the implementation of the project, i.e., “Geothermal Champion(s).”	–	30%
At Least One Customer’s Letter of Support	Support from potential customers is important to implementation of the project.	–	30%
At Least One Community Organization’s Letter of Support	Support from local community organizations is important to the implementation of the project (additional Geothermal Champions).	–	30%

Screening 2 – Geological Conditions

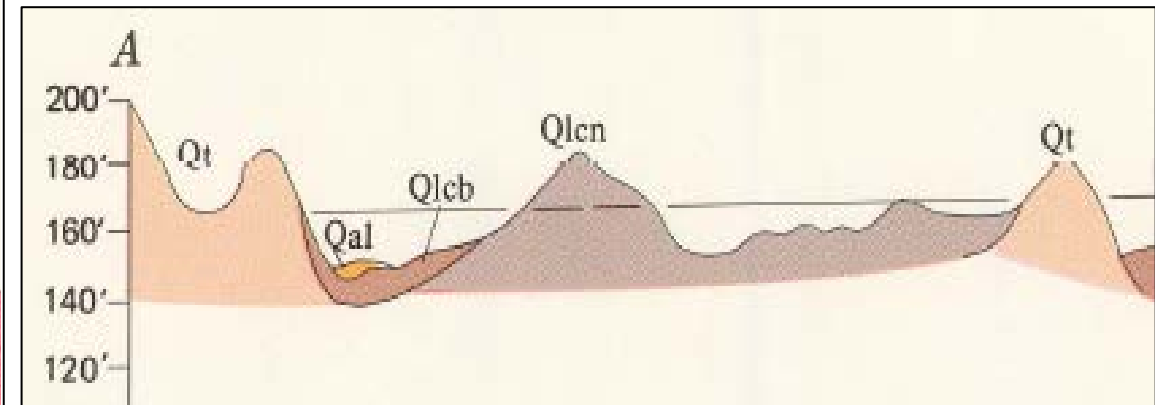
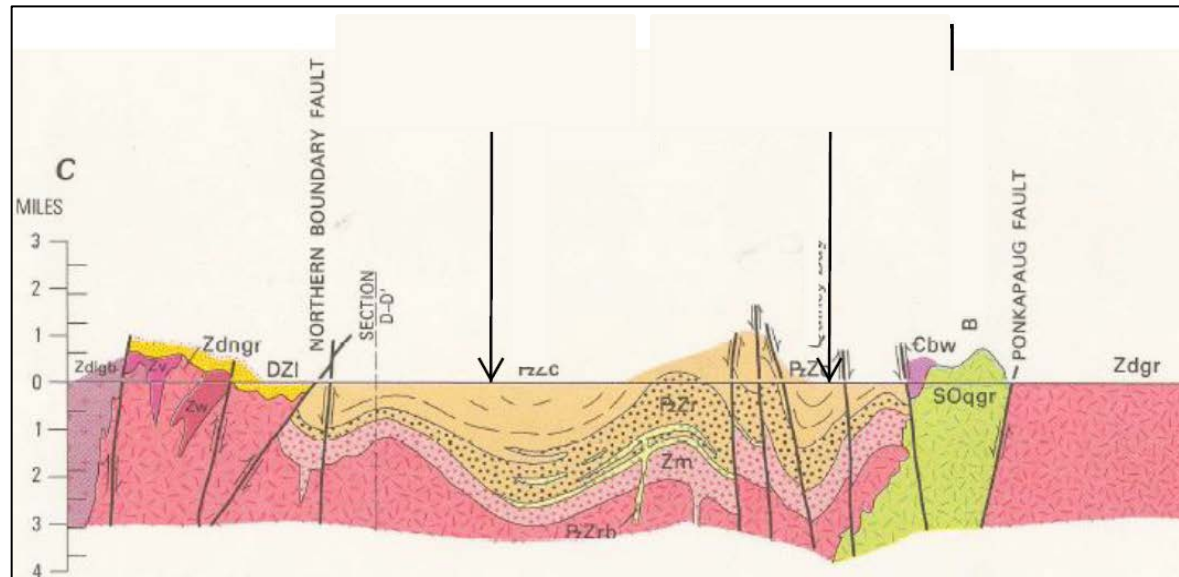
Criteria/Metric Name	Description	Summary Criteria Weights	Metric Weights
Regional Geologic Conditions and Thermal Conductivity		20%	–
Depth to Bedrock	Shallow bedrock is desirable to minimize the need for and costs associated with steel casing to support the overburden. This metric ranks from deepest to shallowest depth to bedrock.	–	40%
Bedrock Conditions/ Drillability	Drilling conditions within various bedrock formations can vary. This metric ranking ranges from “competent” to “fractured/unstable,” meaning the borehole walls may not be able to be supported long enough to install a loop and/or cannot be drilled to desired depth.	–	20%
Groundwater-Producing Formation(s)	The amount and quality of groundwater encountered that must be managed and disposed varies by the type of bedrock formation and location. This metric reflects the amount of effort, support equipment and pumps, and associated costs needed to manage and dispose of groundwater generated during drilling.	–	20%
Overburden-Type Drillability	The density and thickness of coarse-grained materials (e.g., boulders, cobbles, and large rock pieces) determines how quickly and easily it is to drill through the shallow geologic materials (i.e., “overburden”). This metric ranges from the hardest to drill to the easiest, based on the anticipated or known type of overburden present.	–	10%
Thermal Conductivity	Thermal conductivity is a measure of how easily heat moves through the ground. Higher thermal conductivity improves the efficiency of and reduces the size of a geothermal system, minimizing capital cost. This metric ranges from lowest to highest thermal conductivity.	–	10%

Regional and Site Geological Conditions



Cross-section view

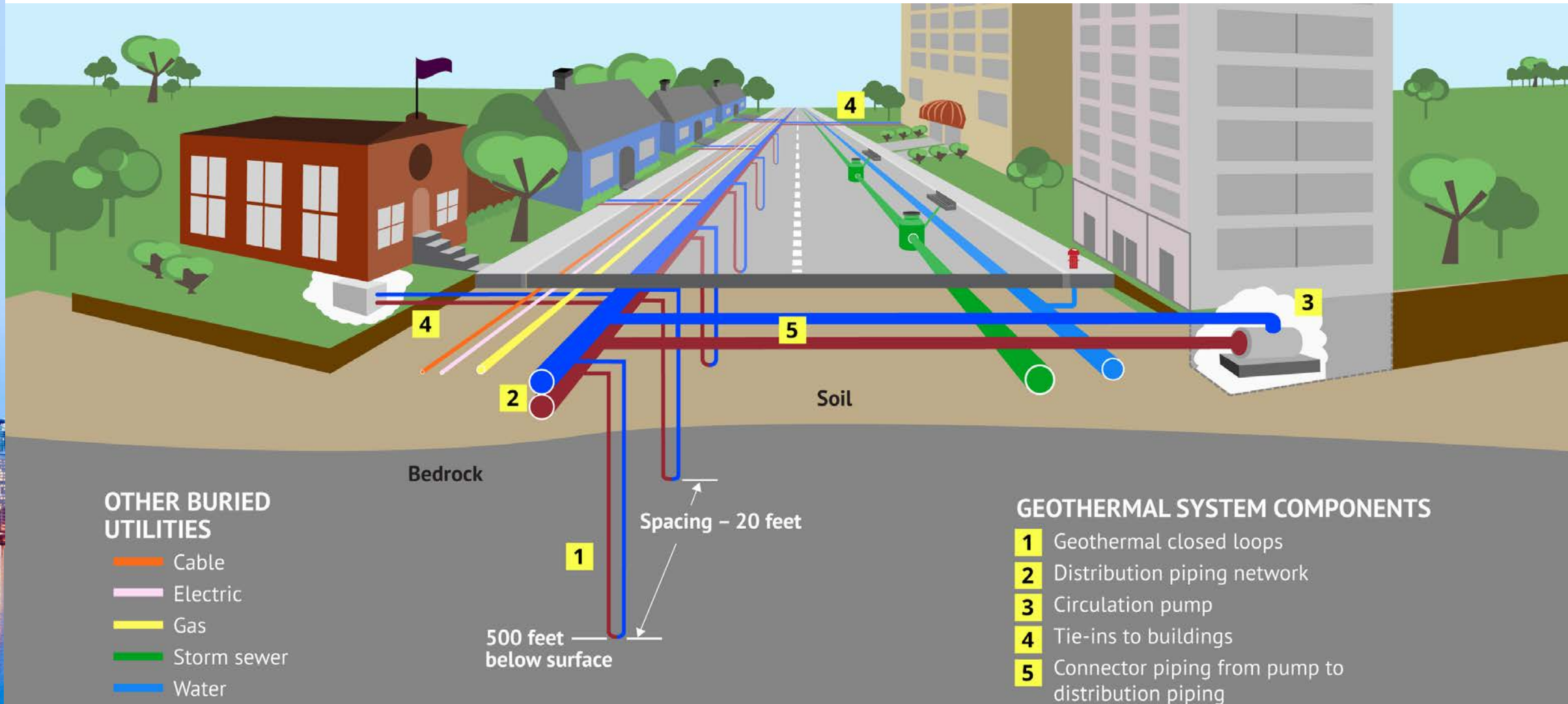
- Gravel deposits
- Sand and gravel deposits
- Sand deposits
- Fine sand, silt, and clay deposits
- Till



Screening 2 – Right of Way

Criteria/Metric Name	Description	Summary Criteria Weights	Metric Weights
ROW for Accessibility and Construction		20%	–
Borefield Work Area Accessibility	The cost of the geothermal pilot will depend on how accessible the work is to locate the drill rigs, support equipment, and material storage, and to perform the work safely and efficiently. This metric ranks the site from the most expensive and difficult to drill (less desirable) to the least expensive and easiest to drill (more desirable).	–	30%
Concentration of Utilities (Buried/Overhead)	Drilling and installation of the geothermal system piping is complicated and slowed down by the presence of buried and overhead utilities, and it increases the project cost. This metric ranks the site from the highest to the lowest concentration of utilities within the borefield area.	–	20%
Buildings Adjoining or Separated	Buildings within the pilot site are connected to the borefield and to each other via buried piping that is installed in excavated trenches, backfilled, and re-surfaced. The cost of the pilot project will be lower if the buildings are adjoining and/or close to one another on the same block, compared to buildings separated by large distances and requiring road crossings. This metric ranks the pilot site from the largest areal spread of the buildings to the closest concentration of buildings located on the same block.	–	20%
Density of Pedestrian Usage	Drilling of the borefield will disrupt and require diversion of pedestrian and vehicular traffic within the ROW. This metric ranks the site from the highest to lowest concentration of pedestrian/vehicular traffic that will be disrupted and need to be diverted during construction.	–	10%
Ease of Procuring Easement (if required)	Some pilot sites may have private property or other public property available to locate a portion of the borefield instead of solely using the ROW. Assumptions are that the work would be easier in these areas than the public ROWs, and that obtaining easements is easier for public than private parties. This metric ranks the site from the greatest to lowest anticipated difficulty to secure any easements from the associated private or public entity or entities.	–	10%
Number of Building Owners for Negotiation	Gaining approval and negotiating and coordinating access to work in front of the multiple and varied customers' buildings that will be part of the pilot will be a challenge. This metric ranks the site from the highest to lowest number of building owners involved in negotiating the work schedule, access, and logistics.	–	10%

Utility-Scale Geothermal Conceptual Layout



Screening 2 – Building Loads

Criteria/Metric Name	Description	Summary Criteria Weights	Metric Weights
Building Loads		15%	–
Additional Land Area Required	Possible sites with diverse building occupancies will have more balanced annual loads. Does the ROW have enough area to accommodate both the heating and cooling annual loads of the buildings or must heat be added or removed from the ground to keep the system thermally balanced? An ROW area that can accommodate both is more desirable.	–	50%
Load Size	Does the possible site contain enough potential buildings if customers decide against joining the pilot study? If some customers decide against joining the pilot study, would the possible site still achieve a diverse load profile and total load to prove the pilot works in concept, but small enough to stay within the project budget?	–	50%

Screening 2 Results (examples)

Criteria and Metrics ^{1,4}	Criteria Weights ²	Metric Weights ³	Site 1			Site 3A			Site 10		
			Metric Score	Weighted Metric Score	Weighted Criteria Score	Metric Score	Weighted Metric Score	Weighted Criteria Score	Metric Score	Weighted Metric Score	Weighted Criteria Score
Existing Electrical Territory	5%	100%	1	1	1	10	10	5	10	10	5
Viability for Future System Expansion	5%	100%	10	10	5	10	10	5	0	0	0
Customer Participation and Willingness	20%			6.7	13		5.85	12		0.7	1
Relative level of community interest in geothermal		10%	7	0.7		6	0.6		7	0.7	
At least one government/municipal official has issued a letter of support for the project		30%	10	3		7.5	2.25		0	0	
At least one customer has issued a letter of support for the project		30%	0	0		5	1.5		0	0	
At least one community organization has issued a letter of support for the project		30%	10	3		5	1.5		0	0	
Geological Conditions & Thermal Conductivity	20%			7	14		7.6	15		2.8	6
Depth to Bedrock		40%	7	2.8		7	2.8		3	1.2	
Bedrock Conditions/Drillability		20%	10	2		10	2		3	0.6	
Groundwater-Producing Formation(s)		20%	5	1		7	1.4		0	0	
Overburden Type Drillability		10%	7	0.7		7	0.7		3	0.3	
Thermal Conductivity		10%	5	0.5		7	0.7		7	0.7	
Environmental Justice Impacts	10%			10	10		7.5	8		5	5
Presence on Site on GIS Mapping		100%	10	10		7.5	7.5		5	5	
Right of Way (ROW) for Accessibility and Construction	20%			2.9	6		6.4	13		7.5	15
Borefield Work Area Accessibility		30%	0	0		5	1.5		10	3	
Concentration of Utilities (Buried/Overhead)		20%	5	1		5	1		5	1	
Buildings Adjoining or Separated		20%	0	0		10	2		10	2	
Density of Pedestrian Usage		10%	5	0.5		5	0.5		0	0	
Ease of Procuring Easement (if required)		10%	6	0.6		8	0.8		6	0.6	
No. of Building Owners for Negotiation		10%	8	0.8		6	0.6		9	0.9	
Building Loads	15%			1.5	2		10	15		0.5	1
Additional Land Area Required		50%	0	0		10	5		0	0	
Load Size		50%	3	1.5		10	5		1	0.5	
Environmental Impacts	5%			8	4		5.5	3		7	4
Proximity to Wetlands / Permitted Jurisdictions		40%	10	4		5	2		10	4	
Proximity of Borefield Areas to Subsurface Environmental Contamination (Federal/State Superfund or Brownfield Sites, etc.)		40%	5	2		5	2		5	2	
Proximity to Classified Aquifers or Regulated Surface Water Bodies		10%	10	1		5	0.5		10	1	
Proximity to Municipal / Private Drinking Water Supply Wells and/or Associated Regulated Areas		10%	10	1		10	1		0	0	
Notes: 1) Criteria are in bold, Metrics are in italics, 2) Green cells potentially large cost impacts to project.			Site Score		55	Site Score		75	Site Score		36

Screening 3 – Site Selection

Four sites passed Screening 2 and advanced to Screening 3
Iteratively refined the four remaining sites based on:

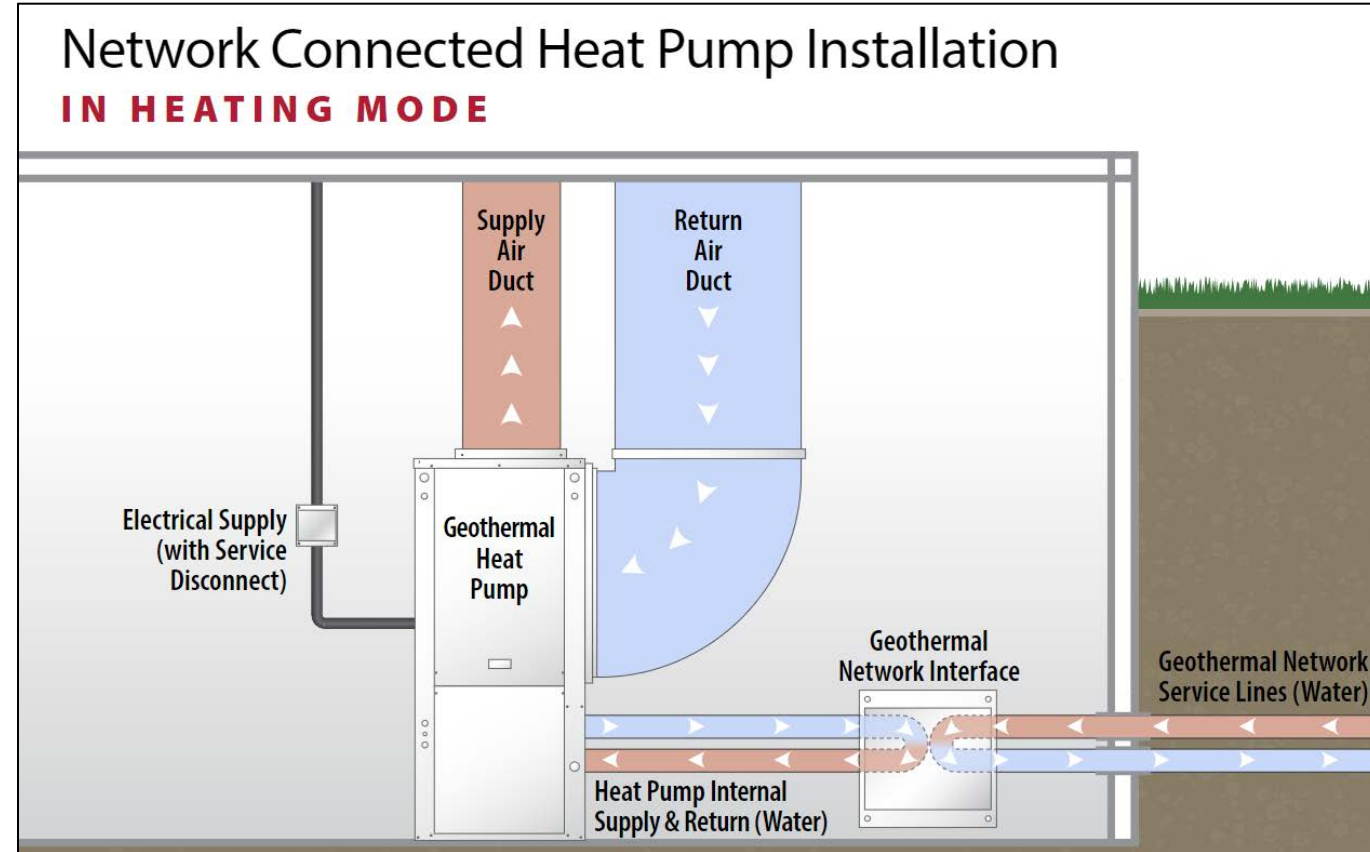
- Customer Willingness
- Physical Settings
- Geological, Environmental & Permitting Considerations
- Refined Heating and Cooling Loads
- Distribution Network Sizing and Configuration
- Geothermal Borefield Modeling

Site	Screening 1	Screening 2
Site 1	PASS	55
Site 2	PASS	49
Site 3	PASS	60
Site 4	PASS	70
Site 5	PASS	67
Site 6	PASS	69
Site 3A	PASS	75
Site 4A	PASS	70
Site 5A	PASS	70
Site 6A	PASS	76
Site 7	FAIL	Not Evaluated
Site 8	FAIL	Not Evaluated
Site 9	PASS	Not Evaluated
Site 10	FAIL	36
Site 11	FAIL	Not Evaluated
Site 12	FAIL	Not Evaluated
Site 13	FAIL	Not Evaluated
Site 14	FAIL	Not Evaluated
Site 15	PASS	46
Site 16	PASS	56
Site 17	FAIL	Not Evaluated

Screening 3 – Customer Willingness

Canvassing Objectives:

- Inform homeowners and business owners of the geothermal project
- Gather information about the existing HVAC equipment, electrical service & other conversion requirements
- Prepared and issued surveys to potential customers
- Stakeholder mapping exercise to ensure appropriate stakeholders were engaged



Flyers, a brochure including a project description and graphics, FAQ sheets, letters of support from the City and other resources were prepared to distribute during canvassing efforts.

A vertical strip on the left side of the slide shows a night view of the Toronto skyline, with the CN Tower and other skyscrapers illuminated and reflected in the water.

Screening 3 – Site-Specific Environmental, Geological & Permitting Considerations

Geological Considerations

- Review publicly-available test borings and wells database
- Consultations with local drilling companies
- Previous drilling experience from nearby project sites
- Confirm drilling and spoils disposal is manageable and within project budget

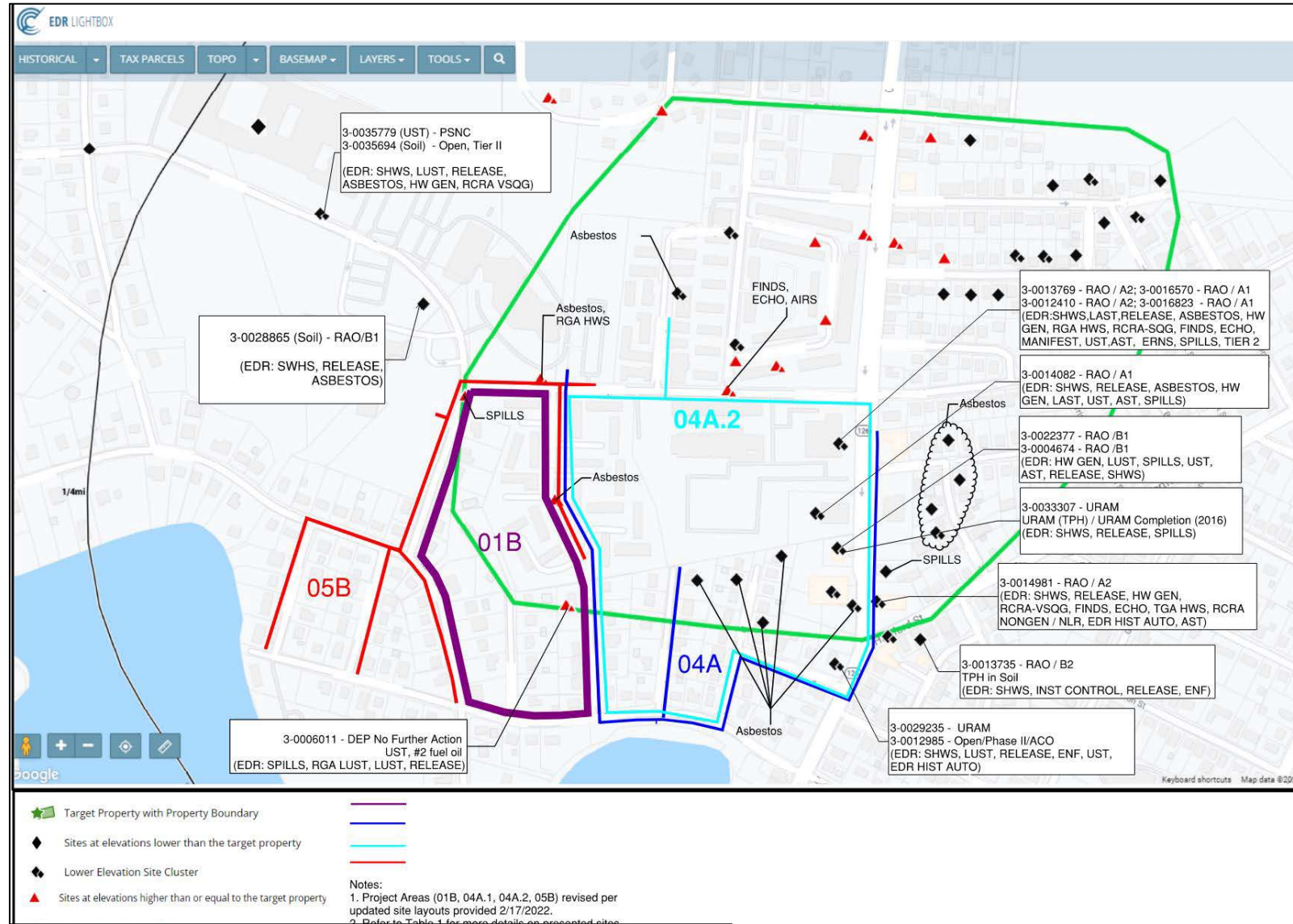
Environmental Contamination Assessment

- Urban environments have potential for subsurface contamination
- Assess risks due to nearby documented environmental sites, e.g., leaking storage tanks, spills, etc.

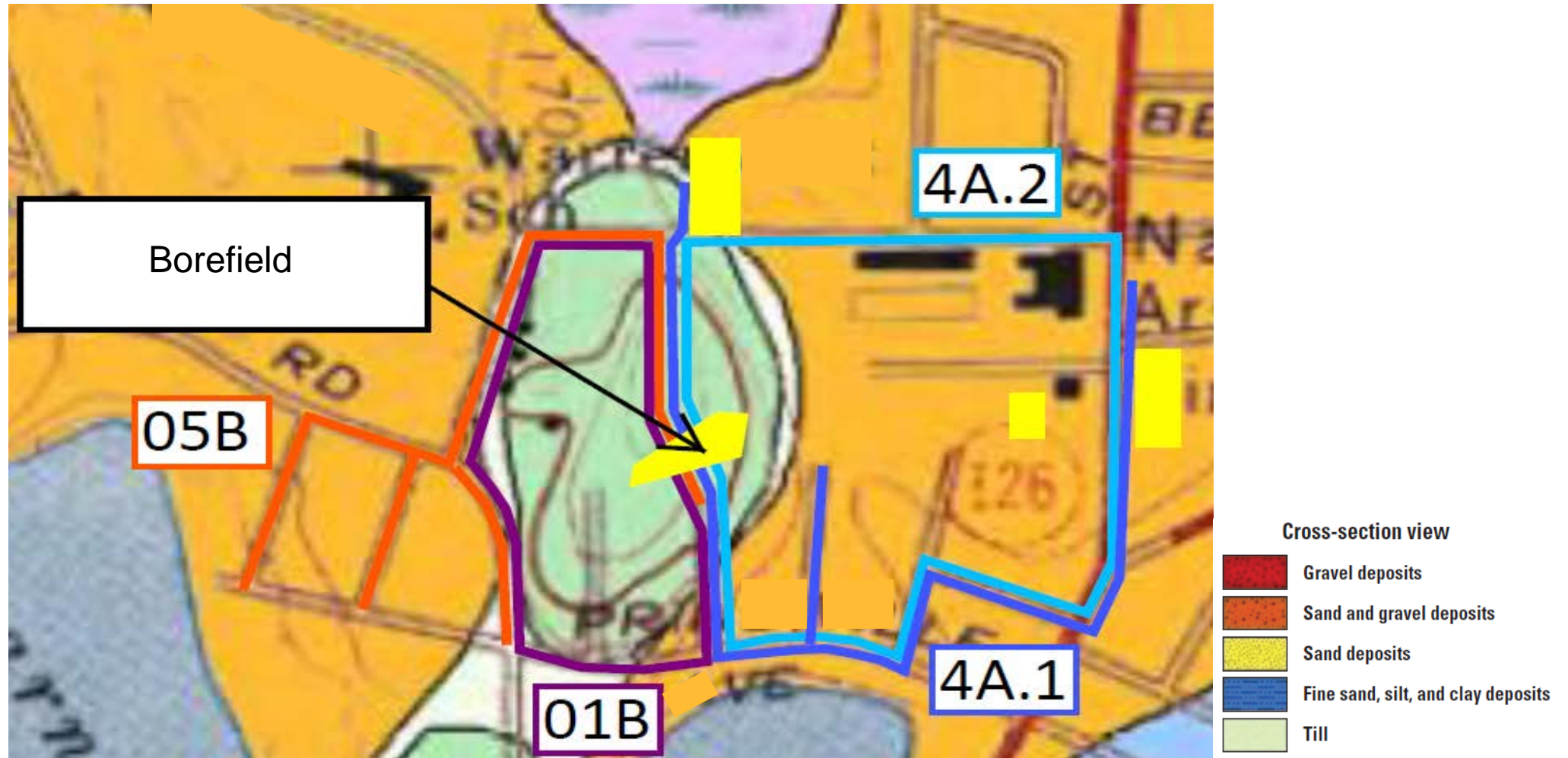
Permitting Considerations

- Confirm local permitting for borehole drilling and geothermal system construction is not required or will not cause excessive costs or schedule impacts
- Wetland or natural resources regulation potentially applicable

Screening 3 – Environmental Assessment



Screening 3 – Geological Assessment



Screening 3 – Engineering Feasibility

Refined Heating and Cooling Loads

- Further developed from previous screenings
- 8760-energy model to simulate building performance
- Sites iteratively refined to add/delete buildings within the area to build a site with a peak heating and cooling capacity of 300 tons

Geothermal Distribution Network Sizing and Configuration

- 20% propylene glycol solution
- One-pipe vs. two-pipe distribution networks
- Central Pump Station & Borefield(s)

Ground Loop Design Modeling

- Sized borefield at each site based on constraints





Final Recommendations & Next Steps

- Identified four site configurations
- Consultations with stakeholders
- “Town Hall” meeting with customers from the selected site configuration
- Final site selection will be made by Client in conjunction with public services agency
- Test loop installation and thermal testing
- Detailed engineering



Lessons Learned

- Multi-disciplinary project benefits from well-organized, up-front process for data gathering, evaluation and documentation
- Evolution of screening process from structured matrices to re-configuring highest-ranking sites
- Ready access to publicly-available database
- Ideal if utility provides both gas and electric service to community
- Benefit of input from motivated and well-informed stakeholder group
- Usefulness of social media research and *Boots-on-the-Ground* canvassing efforts
- Importance of a *Geothermal Champion* to educate and influence multiple stakeholders
- Customer Unexpected overwhelming positive response from community
- willingness and sign-up a critical factor in final site selection

Thank You!

Jagrut Jathal, PE
Jacky Kinson, EIT



