CBCL LIMITED
Consulting Engineers

January 31, 2020

Mark White, P. Eng.
Manager, Construction Engineering
Planning, Development and Engineering
City of St. John's
P.O. Box 908
St. John's, NL A1C 5M2

Dear Mr. White:

RE: Water Street Infrastructure Improvements, Phase III
Heated Sidewalk Study: Ayre's Cove to Clift's-Baird's Cove
FINAL REPORT

187 Kenmount Road
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In 2015, CBCL was engaged by the City of St. John's to provide engineering services for the Water Street Infrastructure Improvements Project. To date, two phases of this five-phase project have been completed. Phase III, which is scheduled to be completed in 2020, includes the area from Ayre's Cove to Clift's-Baird's Cove.

Removing snow from sidewalks during the wintertime is operationally challenging, especially in the downtown area. As a supplement to snow removal, sidewalks could be heated such that snow melts and runs away as water from sidewalks as opposed to accumulating. Given that there are commercially available snow melt technologies, the City requested that CBCL assess the feasibility of implementing such a technology along Water Street prior to commencing construction between Ayre's Cove and Clift's-Baird's Cove. CBCL has completed this assessment as part of the Phase III preliminary design work.

CBCL's scope of work includes completing a cursory review of the available technologies, assessing two of these technologies in detail and providing capital and power costs for each technology. Case studies of snow melt applications are discussed. An overview of some of the benefits of snow melt systems is provided. We have also provided comments on the practical challenges associated with installing and maintaining a snow melt system.

<u>Technology Overview</u>

There are predominantly two technologies available for melting snow from walking or driving surfaces:

- Electric heat tracing: Electric cable is embedded in the walking or driving surface. An electric current is applied to the heat tracing cable when snow melting is required.
- Hydronic: Piping is placed in the walking or driving surface. A heated water/glycol (antifreeze) mixture is circulated through the piping when snow melting is required.

Other systems include heated pads and conductive concrete which were not considered in detail for Water Street. Heated pads are temporarily placed on walking surfaces during wintertime. CBCL's research indicates that these systems are commercially available for ships and oil platforms; they have also been used for homes and businesses. Conductive concrete, which is concrete with metal shavings in it, is currently being tested as a snow melt technology.

CBCL has reviewed the feasibility of the heat tracing and hydronic systems. For both options, the following is applicable:

- Water Street from Ayre's Cove to Clift's-Baird's Cove is approximately 175 m long.
- The average sidewalk width on the North side of the street is 2.5 m for an approximate surface area of 437.5 m^2.
- The average sidewalk width on the South side of the street is 3 m for an area of 525 m^2.
- The total sidewalk surface area is approximately 962.5 m^2.

The energy required for snow melting varies with air temperature, wind speed, humidity, snow density and the depth of snow. Using historical climate data for St. John's and information provided from manufacturers on the design requirements for snow melt systems, the expected rate of energy consumption, that is, the required snow melt system capacity, can be estimated. For Water Street, the required capacity is estimated to be a maximum of 473 W/m^2 for a total of 455 kW. For conceptual design, 500 kW was selected as the required capacity.

<u>Heat Tracing</u>

An electric heat tracing system has controllers installed in a building which are powered from an electric utility service. Sensors installed outdoors detect ambient temperature and moisture content in the air. Power cables are installed from the service to junction boxes at the sidewalk surface. The junction boxes allow for power cables to be connected to the heat tracing cables which are routed in the sidewalks. Expansion joints in the sidewalks require underground enclosures which allow the heat tracing cables to transition from one sidewalk section to another. These enclosures protect cables from damage due to the effects of thermal expansion of the concrete throughout the year.

A heat tracing system for the section of Water Street from Ayre's Cove to Clift's-Baird's Cove would require the following:

- Electric service including utility transformer, cabling, switchgear/motor control centre and distribution boards.
- ±6,000 m of mineral insulated heat tracing cables that are placed in centre of concrete sidewalks and are spaced at approximately 150 mm.
- Ground grid and ground cables around heat trace.
- Enclosure with controllers and contactors to control all heat trace circuits.
- Sensors for detecting weather and snow.
- Metal enclosures to be installed below sidewalk for heat trace to transition between expansion gaps in sidewalk.
- Field junction boxes to be mounted around the street to provide connection between power cables and heat trace cables and sensors.
- Power cable for feeding heat trace circuits on the street.
- Control cable and conduit for connection to sensors located on the street.

For the capital cost estimate, it was assumed that a small building would be constructed adjacent to the Law Society Building on Water Street to house the electrical equipment. An alternative option is to install a concrete chamber for the equipment in Water Street. This option is mainly limited by the presence of existing infrastructure in Water Street.

Based on historical climate data for St. John's and Newfoundland Power's rates for a General Service (110kVA to 1000kVA), the cost to operate the heat tracing system was estimated. This estimate is based on an average number of snow days of 78 and operating for a period of 12 hours per day.

Item	Cost
Heat tracing capital cost	$1,538,000
Annual power cost	$69,000

The detailed capital cost estimate is contained in Appendix A and assumes that the snow melt system is constructed independent of the Phase III work.

Hydronic System

The water/glycol mixture in a hydronic system is heated and then pumped through piping in a walking or driving surface to melt snow. The hydronic system is controlled by a digital controls system that uses snow sensors as well as outside air temperature sensors to determine when, and at what capacity, the snowmelt system is required. During operation, a pump is enabled and the fluid is heated to meet the demand. Since the fluid is a water/ glycol mixture, the system can be turned off when not needed.

In the absence of a waste heat source, either boilers or heat pumps are used to heat the fluid. The boiler can be electric- or oil-powered (an alternative fuel such as propane can also be used). An oil-powered boiler adds additional complexity to the system as equipment for fuel storage, fuel delivery, and handling exhaust gases are required. An electric boiler is a simpler option but the associated power costs can be very high. A heat pump would generally give a coefficient of performance (COP) above 2.0 which would save 50% of the power compared to an electric boiler. A combination of heat pumps and an electric boiler is another option if it could be shown that the heat pumps would run most of the time and electric boiler would only be necessary at certain peak times. The hydronic system becomes more cost-effective when there is a source of waste heat available that is used to provide heat to the system. Currently, there is not an adequate source of waste heat to use for Water Street. For the purposes of this study a heat-pump-only system was explored.

A hydronic system for the section of Water Street from Ayre's Cove to Clift's-Baird's Cove would require the following:

- Electric service including utility transformer, cabling, switchgear/motor control centre, and distribution boards.
- ±5,500 m of 19 mm diameter cross-linked polyethylene (PEX) piping spaced at 200 mm and placed in centre of concrete sidewalks; the 19 mm piping is looped to a 150 mm diameter header pipe.
- Heat pump layout, along with a mechanical and electrical building, requires approximately 20 m x 6 m of space.
- Heat pumps proposed are Mitsubishi Zubadan CAHV air-to-water heat; 15 heat pumps are required.
- Mechanical building with a floor area of approximately 9.3 m^2 containing:
    - One in-line pump with a capacity of 28 L/s.

 - Glycol fill and mixing tank.
 - Controls and electrical equipment.
- Fluid is a solution of 50% propylene glycol and 50% water.

For the capital cost estimate, it was assumed that an outside area large enough for the heat pumps is available. Again, it was assumed that the land adjacent to the Law Society Building could be used.

Based on historical climate data for St. John's and Newfoundland Power's rates for a General Service (110kVA to 1000kVA), the cost to operate the hydronic system was estimated. This estimate is based on an average number of snow days of 78 and operating for a period of 12 hours per day.

Item	Cost
Hydronic system capital cost	$3,475,000
Hydronic system annual power cost	$70,000

The detailed capital cost estimate is contained in Appendix A and assumes that the snow melt system is constructed independent of the Phase III work.

For the hydronic system, it is possible to also consider water-to-water heat pumps using the harbour water as a heat source. The location of Water Street in relation to the harbour means that the capital cost for a water-to-water heat pump system would be higher than the air-to-water system due to the additional piping and pumps required to circulate the water from the harbour to Water Street. The efficiency gained in using water-to-water heat pumps, if any, would not offset the additional capital costs.

<u>Case Studies</u>
Our preliminary research indicates that successful implementation of hydronic snow melt systems such as those in Reykjavik, Iceland and Holland, Michigan rely on an inexpensive heat source for the water/glycol mixture. Canadian cities, including Montreal and Saskatoon, have considered snow melt systems, but have not installed them.

Reykjavik, Iceland
Iceland's National Energy Authority notes on its website (https://nea.is/geothermal/direct-utilization/snow-melting) that geothermal water (water heated through tectonic plate and volcanic activity) is used to heat 9 out of 10 homes in Iceland. In downtown Reykjavik, a snow-melting system has been installed under the sidewalks and streets over an area of 50,000 m^2. This system is designed for a heat output of 180 W/m^2 of surface area.

Holland, Michigan
According to the City of Holland's website (https://www.holland.org/snow-free-holland), water is heated and circulated through 120 miles (193 km) of plastic tubing underneath the streets and sidewalks by using waste heat from power generation. There are currently 4.9 miles (7.9 km) and 10.5 acres (4.3 ha) of heated streets and sidewalks. With the water heating up to 95 °F (35 °C), the system can melt 1 inch (25 mm) of snow per hour - even at 20 °F (-7 °C) with 10 mile/hr (16 km/hr) winds . Photos are courtesy of the City of Holland's website.

Hydronic piping Snow free street and sidewalks

Montreal, Quebec
The City of Montreal had planned to include heated sidewalks in its Ste-Catherine Street revitalization project. However, the City has since decided not to pursue heated sidewalks because it has been judged too expensive, potentially prone to costly breakdowns and could delay the first phase of the infrastructure overhaul. (https://montrealgazette.com/news/local-news/montreal-ices-plan-to-heat-ste-catherine-st-sidewalks).

Saskatoon, Saskatchewan
Waste heat from the National Research Council (NRC) Building in Saskatoon is used to heat sidewalks at the building's main entranceway. The City of Saskatoon has reviewed the use of snow melt systems in its plans to redevelop the city core, but officials were not pursuing it as of 2017. (https://toronto.citynews.ca/2019/01/30/a-new-canadian-city-flirts-with-the-dream-heated-downtown-sidewalks/).

Benefits
While there are significant challenges associated with providing snow free sidewalks along Water Street, there are also benefits, including:
- Improved access to businesses during the wintertime.
- Improved safety through an anticipated reduction in slips and falls.
- Potential to increase tourism by promoting snow free streets to recreational users.
- No equipment on sidewalks for snow fall events that do not exceed the capacity of the snow melt system.

Other Considerations
Some additional challenges associated with implementing a snow melt system for Water Street sidewalks include:
- Snow melt systems are not designed to melt a thick layer of snow. Therefore, snow clearing operations would need to be carried out such that snow is not placed on sidewalks. Also, intense snow storms may result in the accumulation of snow on sidewalks at a rate that exceeds the melt rate; therefore, sidewalk snow clearing would still be required at times.
- It is critical that melted snow or ice (water) be permitted to freely drain from the sidewalk. Accumulated snow on the road side of the curb and gutter could result in blocking the drainage of water from the sidewalk. Therefore, snow would need to

be removed from the street immediately following a snow fall to ensure that water can freely drain from the sidewalks.

- There is limited space available for the installation of mechanical and electrical equipment.
- Compaction under sidewalks will be critical as concrete cracking may result in damage to electric cables or piping system.
- Excavation of water and sewer services for maintenance purposes would result in having to remove and replace sections of the snow melt system.
- The sidewalks on Water Street are cleared by a contractor. The unit cost for an entire winter season is currently $10.34/m, HST included. For the section from Ayre's Cove to Clift's-Baird's Cove, the total snow clearing cost for the winter season is $3,619, HST included.

Yours truly,

CBCL Limited

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Project Manager
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Attachments: Appendix A

Project No: 153051.00

APPENDIX A

Opinion of Probable Construction Costs

City of St. John's

Water Street Infrastructure Improvements, Phase III

Heated Sidewalks Study

DATE:	January 27, 2020
CBCL FILE No.:	153051.00
PREPARED BY:	John K./Greg S.
EST. DESCRIPTION :	Class D

No.	DESCRIPTION		COST	RATIO
	CONSTRUCTION COSTS			
1	Mobilization, Bonds, Insurance, Permits, Pre-Construction Management		$11,000	1.1%
2	Site Power Feed Upgrade		$96,000	9.7%
3	Electrical Equipment		$354,000	35.9%
4	Buried Cables, Control cables, Grounding and Conduit		$234,000	23.8%
5	Sidewalk Removal and Reinstatement		$241,000	24.5%
6	Asphalt Removal and Reinstatement		$3,000	0.3%
7	Excavation and Bedding		$1,000	0.1%
8	Site Work		$5,000	0.5%
9	Electrical Building		$40,000	4.1%
10				
11				
12				
13				
14				
15				
	SUB-TOTAL COSTS (Excluding below contingencies, allowance and factors)		**$985,000**	
	General Contractor, Fees, Overheads and Profit	0%	$0	Included
	Escalation / Inflation	0%	$0	Not Included
	Location Factor	1.00	$0	N/A
	Construction Contingency	15%	$147,750	
		CONSTRUCTION COSTS (A)	**$1,133,000**	
	ENGINEERING and OTHER COSTS			
	Engineering	15%	$169,950	
	Design Development Contingency	20%	$33,990	
		ENGINEERING and OTHER COSTS (B)	**$204,000**	
		TOTAL PROJECT COST (A + B)	**$1,337,000**	
	Taxes	15%	$200,550	
		TOTAL ESTIMATE OF PROBABLE COST	**$1,538,000**	
	ESTIMATED YEARLY OPERATION COSTS (NOT INCLUDED IN TOTAL)			
	Electric Power Costs		$69,000	

THIS OPINION OF PROBABLE COSTS IS PRESENTED ON THE BASIS OF EXPERIENCE, QUALIFICATIONS, AND BEST JUDGEMENT. IT HAS BEEN PREPARED IN ACCORDANCE WITH ACCEPTABLE PRINCIPLES AND PRACTICES. MARKET TRENDS, NON-COMPETITIVE BIDDING SITUATIONS, UNFORESEEN LABOUR AND MATERIAL ADJUSTMENTS AND THE LIKE ARE BEYOND THE CONTROL OF CBCL LIMITED. AS SUCH WE CANNOT WARRANT OR GUARANTEE THAT ACTUAL COSTS WILL NOT VARY FROM THE OPINION PROVIDED.

Form CBCL 035.Rev 1

Opinion of Probable Construction Costs

City of St. John's

Water Street Infrastructure Improvements, Phase III

Heated Sidewalks Study

CBCL LIMITED
Consulting Engineers

DATE:	January 17, 2020
CBCL FILE No.:	153051.00
PREPARED BY:	John K./Chris R./Greg S.
EST. DESCRIPTION :	Class D

No.	DESCRIPTION		COST	RATIO
	CONSTRUCTION COSTS			
1	Mobilization, Bonds, Insurance, Permits, Pre-Construction Management		$28,000	1.3%
2	Site Power Feed Upgrade		$96,000	4.3%
3	Heat Pumps, Glycol System and Piping		$1,119,000	50.3%
4	Electrical Equipment		$319,000	14.3%
5	Buried Cables, Control cables, Grounding and Conduit		$329,000	14.8%
6	Sidewalk Removal and Reinstatement		$241,000	10.8%
7	Asphalt Removal and Reinstatement		$3,000	0.1%
8	Excavation and Bedding		$1,000	0.0%
9	Site Work		$15,000	0.7%
10	Mechnical and Electrical Building		$75,000	3.4%
11				
12				
13				
14				
15				
	SUB-TOTAL COSTS (Excluding below contingencies, allowance and factors)		**$2,226,000**	
	General Contractor, Fees, Overheads and Profit	0%	$0	Included
	Escalation / Inflation	0%	$0	Not Included
	Location Factor	1.00	$0	N/A
	Construction Contingency	15%	$333,900	
	CONSTRUCTION COSTS (A)		**$2,560,000**	
	ENGINEERING and OTHER COSTS			
	Engineering	15%	$384,000	
	Design Development Contingency	20%	$76,800	
	ENGINEERING and OTHER COSTS (B)		**$461,000**	
	TOTAL PROJECT COST (A + B)		**$3,021,000**	
	Taxes	15%	$453,150	
	TOTAL ESTIMATE OF PROBABLE COST		**$3,475,000**	
	ESTIMATED YEARLY OPERATION COSTS (NOT INCLUDED IN TOTAL)			
	Electric Power Costs		$70,000	

THIS OPINION OF PROBABLE COSTS IS PRESENTED ON THE BASIS OF EXPERIENCE, QUALIFICATIONS, AND BEST JUDGEMENT. IT HAS BEEN PREPARED IN ACCORDANCE WITH ACCEPTABLE PRINCIPLES AND PRACTICES. MARKET TRENDS, NON-COMPETITIVE BIDDING SITUATIONS, UNFORESEEN LABOUR AND MATERIAL ADJUSTMENTS AND THE LIKE ARE BEYOND THE CONTROL OF CBCL LIMITED. AS SUCH WE CANNOT WARRANT OR GUARANTEE THAT ACTUAL COSTS WILL NOT VARY FROM THE OPINION PROVIDED.

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