Halifax Water

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April 23, 2024

VIA EMAIL (crystal.henwood@novascotia.ca)
Ms. Crystal Henwood
N.S. Utility and Review Board
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Halifax, NS   B3J 3S3

RE: Mt. Edward 1 Reservoir Replacement

Dear Ms. Henwood:

The Halifax Water Board approved the replacement of the Mt. Edward Reservoir # 1 for total project cost of $23,744,000 on March 28, 2024. Subsequently, Halifax Water is now requesting funding approval from the NS Utility and Review Board with this application and supporting information.

Halifax Water owns and operates 16 above ground reservoirs throughout the distribution system. Nine of the reservoirs are constructed of steel, while the remaining seven reservoirs are concrete. The construction dates for the concrete reservoirs range from 1913 to 2022, with storage volumes ranging from 5.5 million to 36 million liters.

The Mt. Edward Reservoirs (# 1-concrete and #2-steel) are located at 153 Mt. Edward Road in Dartmouth, NS (see Attachments #1 and #2). These reservoirs provide storage for the Dartmouth system and regulate pressure in the Dartmouth 24 East High Zone, which includes Woodlawn, Forest Hills, Colby Village, and subdivisions off Caledonia Road. The Mt. Edward Reservoirs also provide water to the pressure reduced zones in central Dartmouth, Downtown, Woodside and Eastern Passage.

General information for the Mt. Edward Reservoir #1 is as follows:

Mt Edward #1	Type: Pre-stressed Concrete Constructed: 1979 Volume: 21.7 million Liters Diameter: 55m Height: 10.7m (total), 9.1m (above grade)

The reservoir was constructed in 1979. There were multiple exterior leakage repair projects carried out on the Mt Edward Reservoir #1 in the early 1990s. There was also an extensive interior leak-proofing program undertaken in the early 2000s as well as the installation of an exterior post-tensioning cable system for additional structural support.

In 2018, as part of Halifax Water's ongoing Asset Management Program, AECOM, with specialist support from DN Tanks, was retained to carry out an inspection of all the concrete/gunite reservoirs in the water system. The study identified a range of life-cycle issues associated with each reservoir. The AECOM assessment identified that the Mt Edward Reservoir #1 was in satisfactory condition overall and functionally sound, however, the tank was significantly affected by deterioration. The structure was considered marginal in its capacity to prevent leakage. The report included recommendations for remediation work on the wall cracking, floor cracks, vent, hatch, interior cleaning, and the addition of an electric mixing system. The assessment recommended completing the remedial work within the next 5 to 10 years. The assessment was done by conducting visual inspections on the exterior and remote operated vehicles on the interior without taking the reservoir out of service.

In March 2022, Halifax Water Operations staff isolated and drained the Mt Edward Reservoir #1 to perform a more detailed interior and exterior condition inspection of the reservoir. The inspection was completed by Read Jones Christofferson Ltd (RJC), a consulting firm that specializes in concrete condition assessment and rehabilitation projects. The assessment concluded that the structure is in generally fair to poor condition, consistent with its age. The assessment provided guidance for further destructive testing and concrete rehabilitation recommendations, which could extend the service life of the reservoir for 20 years before requiring replacement.

In November 2022, to determine the best value solution, Halifax Water staff issued a Request for Proposals (RFP) to investigate the option of reservoir rehabilitation versus replacement. Two responses were received and CBCL was awarded the project after the proposals were evaluated.

CBCL have since completed their preliminary design report which is summarized in the following discussion section and attached with this application (see Attachment #3 – Mt Edward Preliminary Design Report).

Reservoir Size and Location

As part of their design scope, CBCL completed sizing calculations using population projections included in the 2019 Integrated Master Plan (IMP) as well as known developments in the Dartmouth System that have arisen since the IMP was published. The sizing calculations follow the Atlantic Canada Water and Wastewater Association design guidelines for reservoir sizing. Based on CBCL's analysis, it is their recommendation that a replacement reservoir of the same size (21.7 million Liters) meets current and projected water demands.

Although not part of this design exercise, the preliminary design review confirmed that the Mt. Edward Reservoir site is large enough to accommodate a third reservoir, if additional storage is needed in the future.

Reservoir Material

As noted in the Preliminary Design Report, a glass-lined bolted tank (AWWA D103) alternative was ruled out because the recommended size for the new reservoir exceeds the structural capability of that style of tank.

CBCL considered two suitable material types for the reservoir construction: welded steel (AWWA D100) and pre-cast concrete (AWWA D110 – Type III). CBCL completed a Net Present Value (NPV) analysis over a 100-year lifecycle timeframe on steel and concrete reservoirs, which includes the initial capital cost and assumptions for operation and maintenance costing based on information provided by reservoir builders and Halifax Water's experience. As part of the analysis, CBCL also consulted with four reservoir construction companies (two pre-cast concrete and two welded steel) to gather accurate budget information on the initial capital cost for the reservoir construction. A preliminary project cost estimate for a steel reservoir is attached to this report (see Attachments #5 – Mt Edward Reservoir Preliminary Cost Estimate).

There are advantages and disadvantages with both tank material types. Based on the NPV analysis in the Preliminary Design Report, it was determined that welded steel and pre-cast concrete have an approximately equivalent NPV over the full asset lifecycle. Halifax Water has experience with operating and maintaining welded steel and pre-cast concrete reservoirs. There are reservoirs of both material types that have performed well in their current life cycle. During the Preliminary Design review with Operations and Engineering staff, there was no preference for one type over the other.

Rehabilitation versus Replacement

CBCL also reviewed the recommendations for rehabilitation from the RJC report. The RJC Report indicated that rehabilitation could extend the life of the existing reservoir by 20 years. CBCL compared the option of rehabilitation versus replacing the reservoir. As part of their analysis, CBCL carried out a NPV assessment over a 100-year time frame for all three options (Rehabilitation, replace with steel, Replace with concrete). Based on their NPV analysis of options, and as noted in Preliminary Design Report, it is CBCL's recommendation that the best value for Halifax Water is to replace the Mt. Edward Reservoir #1 when compared to extending the service life by 20 years through a rehabilitation project and then replacing the reservoir.

In discussions with CBCL, they have recommended proceeding with the design work for both the welded steel and the pre-cast concrete reservoirs. Once detailed specifications for each material type are finalized, general contractors (with specialized expertise in steel tanks and concrete tanks) will be invited to pre-qualify for the construction phase. Qualified general contractors will then have an opportunity to submit lump sum pricing proposals to construct a welded steel reservoir and/or pre-cast concrete reservoir. Once the submissions are received, the NPV analyses for each bid/option will be evaluated to determine the preferred lowest NPV bid. Using the NPV analysis approach creates a bidding environment that encourages the lowest initial capital cost investment for either tank material type, and as a result, the best overall value for the Utility. A summary of the operation and maintenance cost assumptions for concrete and steel reservoirs are included as Attachment #4– Mt Edward LCCA Analysis. The assumptions were developed through consultation with industry reservoir builders and Halifax Water's historical experience with operation and maintenance of these tank types.

It is staff's opinion that this procurement method will allow for a competitive bidding environment for the reservoir replacement. As there are limited numbers of qualified tank construction companies, making a final choice for reservoir material at the end of the preliminary design phase would limit competitiveness by reducing the number of qualified bidders. Also, the design and certification of these tanks to AWWA standards is done by the reservoir builders. It is Halifax Water's expectation for CBCL to develop the owner statement of requirements through the initial drawing and specification package and assist in the selection of the best value reservoir material type.

An application to Nova Scotia Environment and Climate Change will be made as part of the project as reservoir replacement is an activity requiring approval based on their regulations.

Funding for this project is as follows:

2022/23 Capital Budget - $150,000

2023/24 Capital Budget - $200,000

2024/25 Capital Budget - $100,000

2025/26 Capital Budget - $23,294,000 (Steel Reservoir Option)

As noted above, the capital budget information shown is based on the steel reservoir cost estimate. Halifax Water staff is requesting this amount based on the higher funding amount option for steel at this time, until more definite costs are obtained through a public solicitation process. If the proposed tendering process identifies the concrete tank as the preferred best value option based on a NPV analysis, the proposed project budget will be revised accordingly.

Since the NPVs are approximately equivalent for both material types, having general contractors submit pricing on both tank types minimizes financial risk and provides best value options for a final decision to be made.

The proposed expenditure meets the "NO REGRETS- UNAVOIDABLE NEEDS" approach of the 2012 Integrated Resource Plan. The proposed work meets the NR-UN criteria of "Directly supports the implementation of the Asset Management program". The project meets these criteria based on the following: The existing asset is failing due to its age and is at the end of life.

PROPOSED PROJECT MILESTONES

- Concept Design Completion – March 13, 2024
- Detailed Design Completion – October 2, 2024
- NSUARB Funding Application - April 2024 with anticipated approval date before October 31, 2024.
- Tender – Issued Mid-October 2024 and close Mid November 2024
- Contract Award – End November 2024
- Final Reservoir Design (by awarded General Contractor) – December 2024 to Spring 2025
- Construction Start – Spring 2025 to Summer/Fall 2026
- Substantial Completion – Fall 2026

Subject to approval, Halifax Water staff are proposing the future deliverables to be submitted to the UARB as supplemental information packages to the original application:

1) Detailed design report including drawings for both reservoir types (Anticipated in October 2024).

2) List of pre-qualified general contractors for the construction of both reservoir types (Mid November 2024).

3) CBCL's NPV analysis based on tender results, recommendation of the preferred reservoir material type and required decrease or increase (if required) in the original requested funding amount (Mid November 2024).

Reservoirs are required for system operation to balance peak demands, provide storage for high flow (emergency) and to operate the system during planned water supply plant shutdowns.

The Mt. Edward Reservoir #1 is reaching the end of its asset life. The Preliminary Design Report has recommended that the replacement of the reservoir is the best value option when compared to rehabilitation.

If the reservoir is not replaced, its condition will continue to deteriorate, and more leaks will develop; potentially leading to a structural failure. Halifax Water invests operational effort into minimizing system leaks wherever possible to reduce the volume of non-revenue water. Also, the reservoir, with its current pipe configuration, is difficult to isolate and bring back into service. There is an opportunity with this project to optimize the inlet, outlet and drain piping to bring it up to current standards.

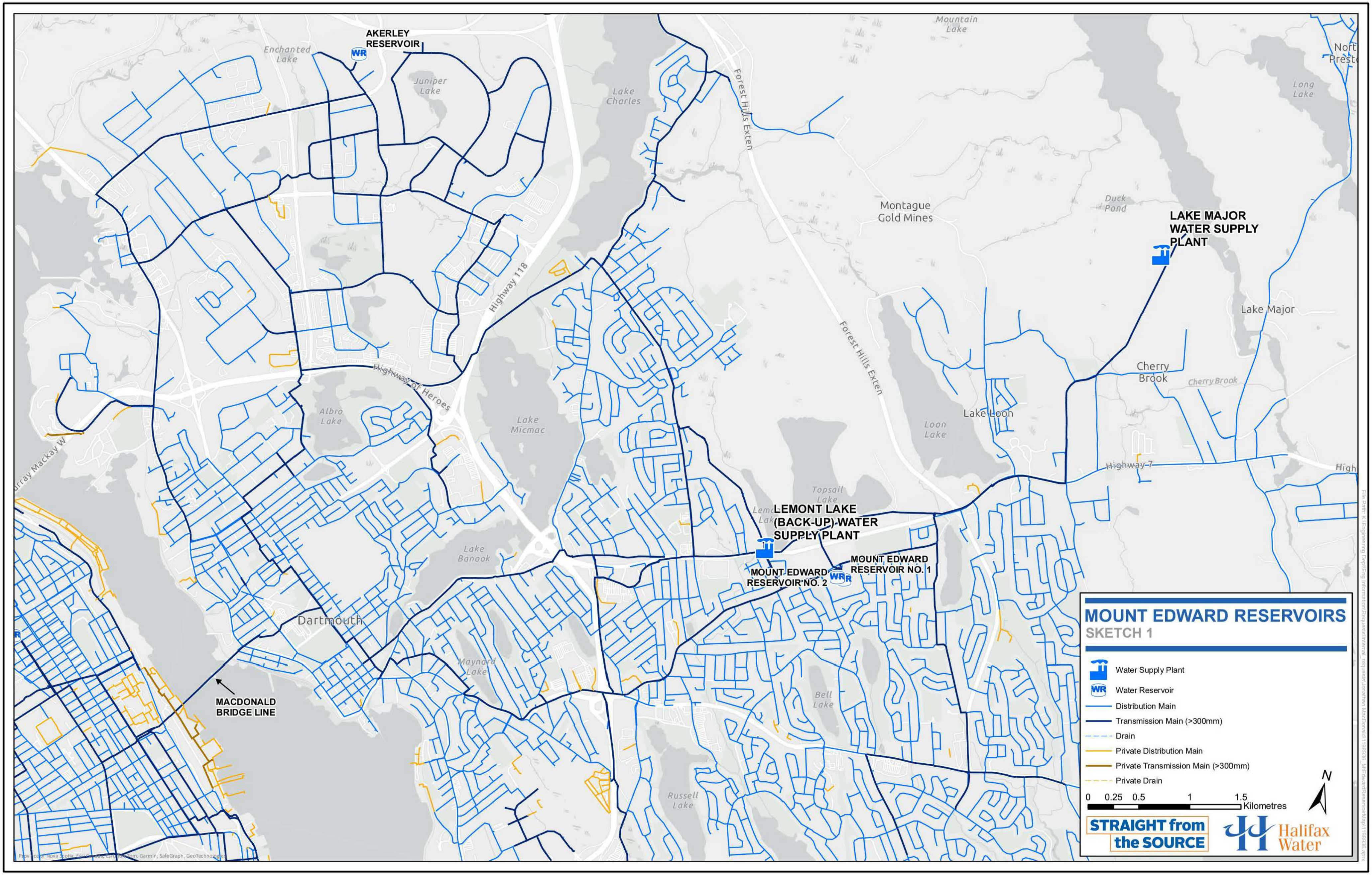
Accordingly, Halifax Water is now requesting approval from the Nova Scotia Utility and Review Board for the Mt. Edward Reservoir #1 project. Please contact me if you have any questions regarding this submission.

Respectfully submitted,

Josh DeYoung, P.Eng.
Director, Engineering & Capital Infrastructure

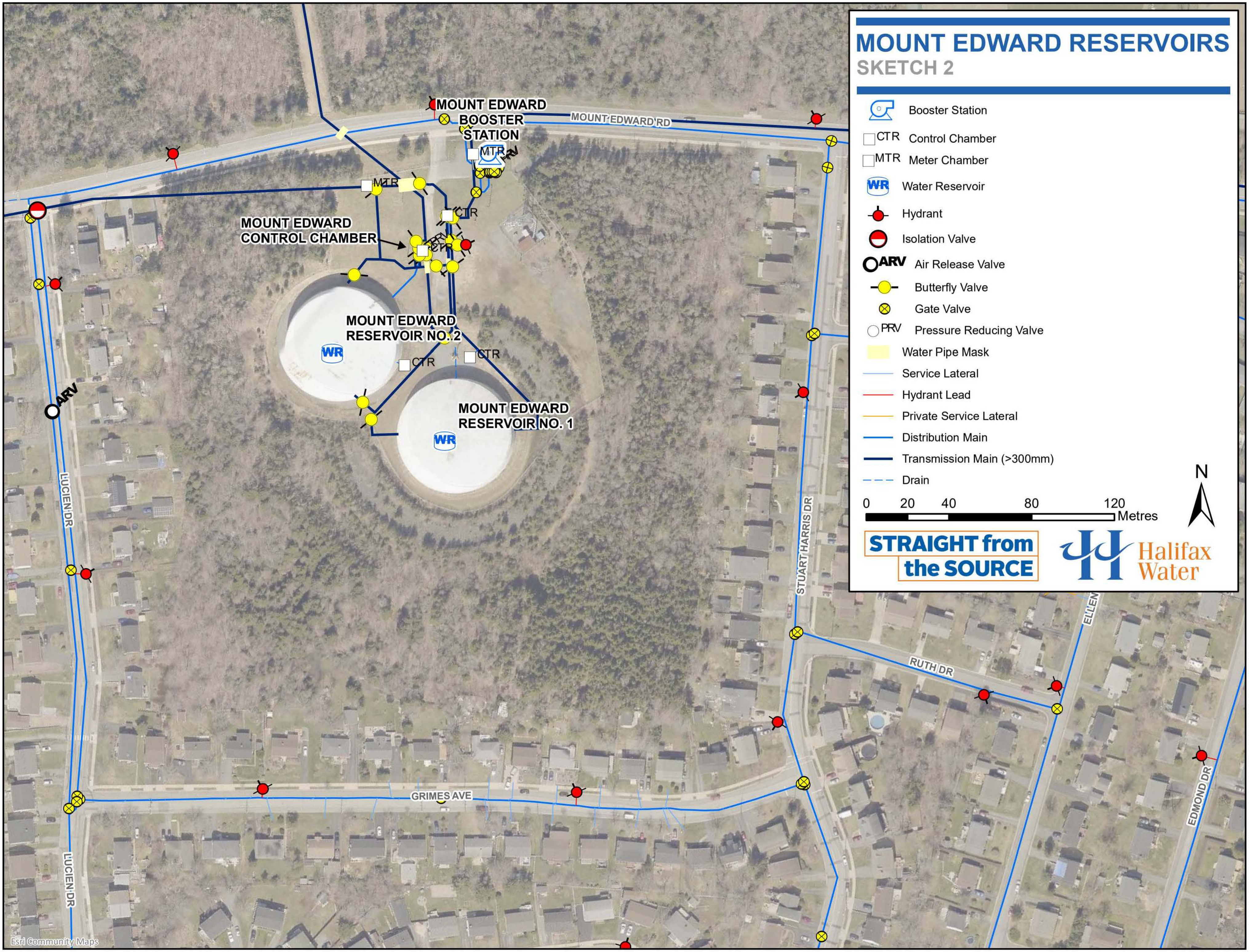
ATTACHMENTS

1. Attachment #1 - Mt Edward Reservoirs - Sketch 1 Lake Major Water Distribution System
2. Attachment #2 - Mt Edward Reservoirs - Sketch 2 Site Plan
3. Attachment #3 - Mt Edward Reservoir Preliminary Cost Estimate
4. Attachment #4 – Mt Edward Reservoir – LCCA Analysis
5. Attachment #5 – Mt Edward Reservoir – Preliminary Design Report



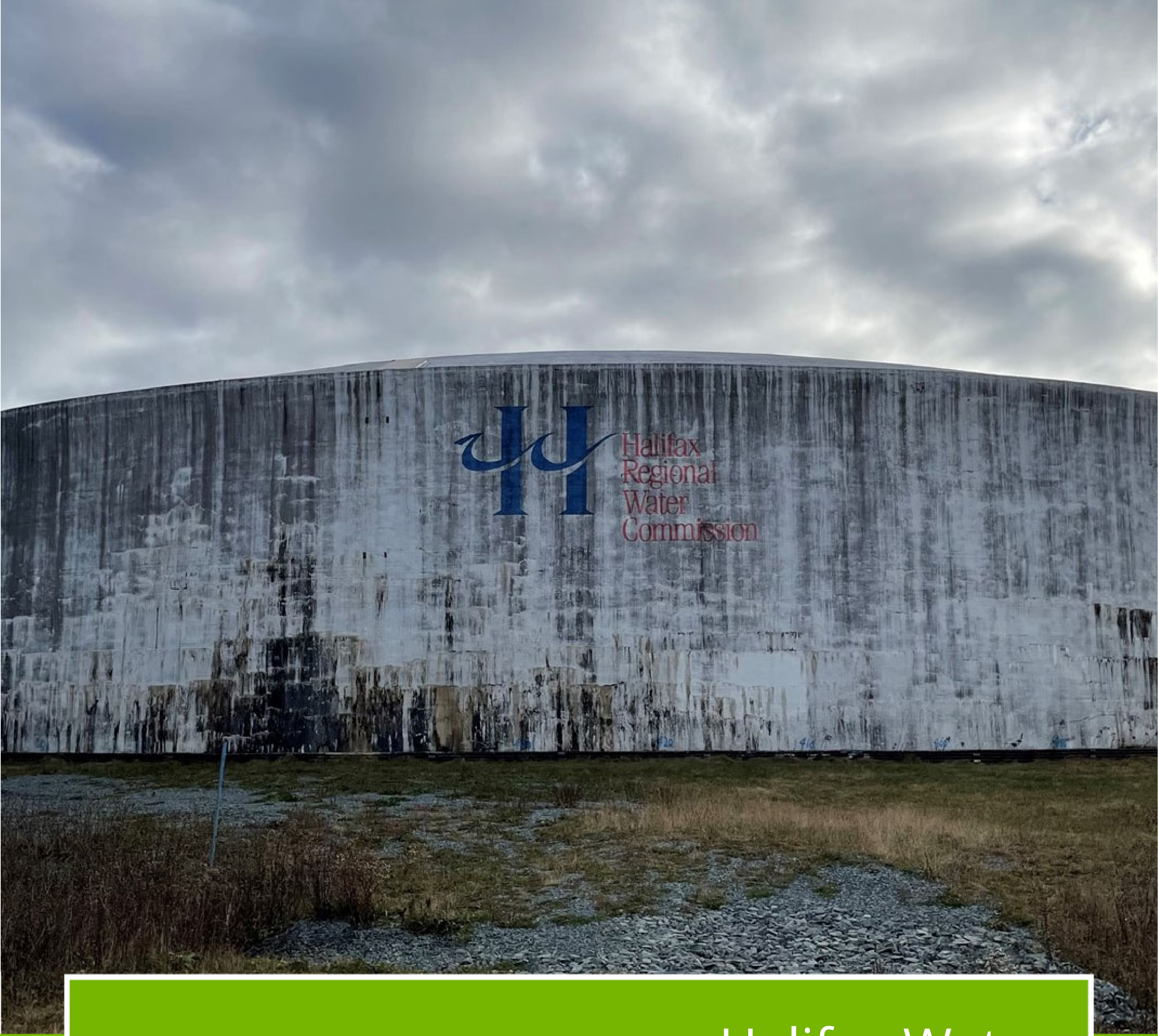
MOUNT EDWARD RESERVOIRS

SKETCH 1



MOUNT EDWARD RESERVOIRS

SKETCH 2



Halifax Water

Mount Edward Reservoir #1 Replacement (P32.2022)

Preliminary Design Report

231007.00 • March 2024

Rev.	Issue	Reviewed By:	Date	Issued By:
2	Final Report		12-Mar-2024	
1	Issued for Draft	K. Murphy	14-Feb-2024	J. Clair

CBCL

REGISTERED PROFESSIONAL ENGINEER
DATE Mar/12/2024
K.J. MURPHY
6222
PROVINCE OF NOVA SCOTIA

Project No. 231007.00

CBCL
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CANADA BEST MANAGED COMPANIES
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March 12, 2024

Jonathan MacDonald, P.Eng.
Halifax Water
450 Cowie Hill Road
PO Box 8388, RPO CSC
Halifax, NS B3K 5M1

Dear Mr. MacDonald:

RE: Mount Edward Reservoir #1 Replacement – Preliminary Design Report

Please find enclosed the final preliminary design report for the Mount Edward #1 Reservoir Replacement project. This report outlines our analysis, assumptions, options, and associated costs for the preliminary design of the Mount Edward #1 Reservoir.

If you have any questions or comments regarding the report, please send to the undersigned at your convenience.

Yours very truly,

CBCL Limited

Prepared by: Jeffrey Clair, P.Eng. Senior Municipal Engineer Direct: 902-421-7241, Ext. 2427 E-Mail: jclair@cbcl.ca	Reviewed by: Kevin Murphy, P.Eng. Senior Project Manager

Project No.: 231007.00

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1 Introduction

1.1 Project Introduction and Report Structure

CBCL Limited (CBCL) was engaged by Halifax Water on February 22, 2023, to provide consultant services for the Mount Edward #1 Reservoir Replacement project. The existing reservoir is in need of rehabilitation for continued and reliable service. However, considering the cost of rehabilitation, replacement may result in a lower total cost of ownership which will be considered in this report.

The report has been structured to summarize the sizing analysis in Chapter 2 and the life cycle analysis in Chapter 3. Chapter 4 outlines the proposed site upgrades while Chapter 5 provides opinions of probable cost, a preliminary schedule and summarizes the implementation, including utility and regulatory approvals.

1.2 Background

The first Mount Edward Reservoir was constructed circa 1979 and is 45 years old. It is located on the higher elevation lands at 155 Mount Edward Road, opposite of Topsail Lake. This reservoir has a nominal storage volume of 21.7 million litres and is constructed of prestressed concrete with precast panel walls. Recent evaluations conducted after leak events concluded that the reservoir is in fair to poor condition, consistent with its age. A second reservoir (Mount Edward #2) was constructed as welded steel in 1998. It is located adjacent to the first reservoir. A transmission main connects the two reservoirs to the Lake Major Water Supply Plant (WSP).

The two existing Mount Edward reservoirs operate together with the same Top Water Level (TWL) of 118.9 m (390 ft) and same nominal volumes. The two reservoirs primarily service lands south of Main Avenue, however, they can service lands to the North (e.g., Burnside High zone), in emergencies. Water is supplied by the Lake Major WSP through a 1,050 mm diameter water transmission main. Flow is directed to the Mount Edward reservoirs and the Akerley reservoir at the Topsail control chamber located on Golf View Drive – adjacent to Topsail Lake. The proximity of the Mount Edward reservoirs to the transmission main allows them to operate inline (as opposed to floating), which supports a higher rate of reservoir turnover.

1.3 Scope of Design

The scope of design generally includes the following activities:

- Review of background information.
- Perform topographic surveys, geotechnical and environmental investigation.
- Liaise with regulatory bodies and apply for approvals.
- Undertake a sizing analysis to determine required reservoir volumes and hydraulic requirements based on current design standards.
- Perform a life cycle analysis to support selection of the tank material.
- Review water quality systems including chlorination and mixing.
- Undertake a reservoir location assessment.
- Prepare preliminary and detailed design reports complete with supporting drawings and opinions of probable cost.
- Undertake the detailed design activities including the preparation of drawings and specifications.

Following the detailed design phase, the project will be tendered, with construction planned for 2025.

1.4 Reference and Supporting Information

The following documents have been referred to, or relied upon, in the development of the preliminary design:

- Infrastructure Master Plan (IMP) (Vol 1 and 2), GM Blueplan Engineering, January 2020.
- Structural Condition Survey Assessment, Mount Edward Reservoir No. 1, RJC Engineers, June 2022.
- Town of Dartmouth: Water System, Mount Edward Reservoir (i.e., Mount Edward Earthen Reservoir), Engineering Service Co Ltd., January 10, 1951.
- Prestressed Concrete Reservoir for Water Storage (i.e. Mount Edward #1 Reservoir) Record Drawings (Revised January 8, 1980), Engineering Service Co. Ltd., March 1979.
- Lake Major Water Treatment Plant, Mount Edward Road Reservoir (i.e. Mount Edward #2 Reservoir) Record Drawings (Revised September 3, 1999), The Tap Group, May 1977.
- Mount Edward Road Booster Station Record Drawings (Revised October 19, 2005), Dillon consulting, July 2002.
- Final Design Brief for the Mount Edward Booster Station Upgrade, Dillon Consulting Ltd., December 2002.
- Design Brief – Mount Edward Reservoir – Emergency Flow Route, CBCL, June 25, 2007.

1.5 Design Criteria

The reservoirs have been designed to conform to the Halifax Water Design Specifications, 2023. A summary of the design parameters common to both reservoirs are as follows:

Average Daily Water Consumption	375 L/cap/d
Maximum Day Factor	1.65
Peak Hour Factor	2.5
Fire Flows:	
– Single Family/Two Family.	3,300 L/min for 1.5 hours
– Townhouse.	4,452 L/min for 1.75 hours
– Multi-Unit High Rise Residential.	13,620 L/min for 3 hours
– Commercial / Industrial/Institutional.	13,620 L/min for 3 hours
Watermain Velocities	1.5 m/s during Peak Hour Demand (PHD) 2.4 m/s during Fire Flow conditions (MDD+FF)

The Atlantic Canada Water and Wastewater Association (ACWWA) Water Supply Guidelines (2022) (herein referred to as the ACWWA Guidelines) provides guidance on reservoir sizing criteria and is based on the following formula:

S = A + B + C

where:
S = Total Storage Requirement, m^3
A = Fire Storage, m^3 (equal to required fire flow over required duration)
B = Peak Balancing Storage, m^3 (25% of Maximum Day Demand)
C = Emergency Storage, m^3 (A minimum of 25% of A + B is recommended)

The above equation will be herein referred to as first principles and is based on a water supply rate to the storage facility equal to Maximum Day Demand (MDD). The guidelines recommend a maximum 72-hour turnover to prevent deterioration of water quality and loss of disinfection residual resulting from water age.

1.6 Geodetic Datum

Throughout this document, elevations are stated in metric units (metres) while imperial units (feet) are also provided for convenience and information. Where imperial elevations are provided, they are in feet and are referenced to the Canadian Geodetic Vertical Datum 1928 (CGVD28). Elevations presented in metres are referenced to Canadian Geodetic Vertical Datum 2013 (CGVD2013). Where elevations (feet or metres) were taken from record or historical information, the elevations were converted to metric units (as required) then were adjusted by -0.613 m.

2 Sizing Analysis

2.1 Service Area, Population and Demands

The Mount Edward reservoirs service both gravity and boosted zones. The gravity fed zones, which include 24 East and Lake Major High, are less sensitive to reservoir levels. The IMP desktop analysis showed that a water level near the base of the Mount Edward Reservoirs of 109.7 m (360 ft) would provide a minimum 22 psi for the zones that they service. The Montague High zone is currently gravity fed; however, it will be transitioned to a boosted zone with the construction of a new booster station in 2024/25.

The Mount Edward Booster Station, located adjacent to the Mount Edward reservoirs, draws from these reservoirs to supply the Mount Edward and Caldwell Road boosted zones. The existing booster station pumps are sensitive to reservoir draw down which is considered in the volume analysis.

2.1.1 Review of Present Day Demand

Present day demands have been determined based on reservoir outflow data provided by Halifax Water for the years 2017 to 2022. The data was analysed to extract Average Day and Maximum Day demands (ADD & MDD) and then calculate a Max Day Factor (MDF). This information is summarized in Table 2.1.

Table 2.1: Existing Reservoir Outflows

Year	ADD (MLD)	MDD (MLD)	MDF
2017	16.7	21.5	1.29
2018	17.3	22.9	1.33
2019	17.6	22.0	1.25
2020	18.5	26.6	1.44
2021	17.3	22.1	1.28
2022	16.7	21.9	1.31
Average	**17.4**	**22.8**	**1.32**

Demands have been relatively consistent between 2017 and 2022, with no noticeable increasing or decreasing trends. Therefore, the average values for these years are carried forward.

We also considered the design values carried in the IMP. The 2016 demands for Mount Edward were not explicitly identified in the IMP. However, using the pressure zones serviced by Mount Edward and their respective demands, (Appendix D of Vol 1 of the IMP) we have calculated an ADD of 20 MLD. We have concluded that an MDD of **33.4 MLD** was used as a basis for the Storage Capacity Desktop Analysis (Table 7 of Volume 2 of the IMP) that reported the 2016 required storage for Mount Edward to be 13.5 MLD. The MDD is 1.65 x ADD (33.4 / 20 = 1.65), thus it appears that the MDD may have been a design value based on the Halifax Water Design Specifications, as opposed to the actual measured value.

Halifax Water has stated that the IMP is to be used as the guide for infrastructure system planning, and that the figures in the IMP are the appropriate values for design. For this report, we carried both forward as two sizing scenarios.

2.1.2 Future Population Growth Estimates

The peak balancing and emergency storage requirements are dependent on the ADD for the Mount Edward service area. Growth areas within the Mount Edward service area and their respective estimated populations from the IMP are shown in Table 2.2. As the expected service life of the Mount Edward reservoir will exceed 50 years – surpassing 2046 – we have included the post 2046 growth identified in the IMP in the sizing analysis.

Table 2.2: IMP Growth Areas and Populations

Year	2046	Post-2046
GA06	1,186	549
GA03	3,422	915
GA08	3,344	2,075
GA13	1,964	
GA14	724	
GA14a	1,853	207
GA16	289	
GA17	1,669	1,339
GA18	1,453	461
GA64	326	65
GA74	5,271	
GA79	3,995	
Totals	**25,496**	**5,611**

The Mount Hope Development (GA13) has recently been approved with a design population of 2,432, which is 468 persons higher than the IMP growth area population of GA13 summarized in Table 2.2. This additional demand has been added to the storage requirement calculations.

HRM recently identified additional growth areas that were not accounted for in the IMP: East Dartmouth (i.e., Morris Lake) and AKOMA lands. These growth areas were outlined in the RFP for the *HRM Future Serviced Communities Background Studies*, issued late 2022. The scope of the HRM study includes different development scenarios with varying densities for these growth areas. The schedule of the HRM project is expected to extend beyond this project, therefore it is assumed that the design population will not be available for this study. These same growth areas were previously studied in the *Greenfield Areas Servicing Analysis* (CBCL, 2004). Design population densities and developable areas in the 2004 study have been utilized in this analysis as shown in Table 2.3. The gross areas for each development in the current HRM study are different than those of the 2004 study. Therefore, the current gross area estimates from the HRM study have been used.

Table 2.3: AKOMA and East Dartmouth (Morris Lake) Lands

	AKOMA	East Dartmouth
Assumed Population Density (CBCL, 2004)	45 persons per developable hectare	
Gross Area (from 2022 HRM RFP)	450 Ha.	500 Ha.
Developable Area (CBCL, 2004)	74%	65%
Design Population	14,985	14,625

The growth area source, populations, and respective demands have been summarized in Table 2.4 based on the design parameters outlined above.

Table 2.4: Summary of Growth and Demands

Source of Growth	Population	ADD (MLD)	MDD (MLD)
IMP Growth to 2046	25,496	9.6	15.8
IMP Growth Post 2046	5,611	2.1	3.5
Additional Growth in GA13 (Mount Hope)	468	0.2	0.3
AKOMA Lands	14,985	5.6	9.3
East Dartmouth	14,625	5.5	9.0
Totals	**61,185**	**22.9**	**37.9**

The total design demands for the Mount Edward Service area are summarized in Table 2.5. The table presents two scenarios for the design demands by using different existing (or baseline) demands:

- The IMP values.
- The historical values from SCADA.

Table 2.5: Design Demands for the Mount Edward Reservoirs

	ADD	MDD	ADD	MDD
Scenario	IMP		Historical (based on SCADA)	
Existing	20.2	33.4	17.4	22.8
Future Growth	22.9	37.9	22.9	37.9
Future Totals	**43.2**	**71.3**	**40.3**	**60.7**

2.2 Mount Edward Low Level Analysis

The Mount Edward booster station draws from the existing storage tanks and is sensitive to reduced operating levels, which limit the useable storage within the tanks. A hydraulic analysis was undertaken to determine a low level that would be appropriate for use in design.

Two conditions were analyzed to establish an acceptable design low water level.

1. A low water level that provides a positive suction pressure at the MDD flow condition when the fire pump is called to run.
2. A low water level that provides a minimum allowable suction pressure of 0 psi at the design flow (MDD+FF) at the start of the design fire.

Design flows are summarized as follows:

- Mount Edward Reservoir (#1 & #2) 2046 MDD: 49.5 MLD.
- Booster Station MDD: 2.5 MLD.
- Design Fire Flow for Boosted Zones: 7,570 L/min (or 10.9 MLD).

The results of the analysis are:

- **Condition #1**: A minimum tank level of 111.2 m (367 ft) would provide a minimum of 1 psi dynamic suction pressure to the fire pump during a design MDD scenario.
- **Condition #2:** A minimum tank level of 112.0 m (369 ft) would provide a minimum of 0 psi dynamic suction pressure to the fire pump at the start of the design fire flow.

Condition #2 governs and is, therefore, considered the minimum allowable low level for emergency or Lake Major WSP shutdowns. Historically, Halifax Water would not permit draw down of the tanks below 113.69 m (375 ft), which provides a 5 psi static suction pressure at the inlet of both the booster and fire pumps (elevation 110.11 m). We don’t see why this would change for day-to-day operation.

2.3 Existing Reservoirs

The Mount Edward reservoirs are an integral part of Halifax Water's East Region Water System and, according to the IMP, account for approximately two-thirds of the East Region's water storage capacity. The operation of the Mount Edward storage facility is outlined below:

- Flow to Mount Edward is controlled by the Topsail control chamber which directs flow from the Lake Major WSP to the Mount Edward and Akerley reservoirs.
- The Mount Edward reservoirs operate inline with the transmission main, (as opposed to floating), which results in continuous reservoir turnover.
- Mount Edward services lands in Dartmouth, primarily south of Main Avenue, however, land to the north (e.g., Burnside High), can be serviced by Mount Edward in emergencies.
- Mount Edward supplies flow to the North Preston and Shearwater storage tanks.

2.3.1 Dimensions and Volumes

The tank dimensions and theoretical operating volumes for the existing Mount Edward reservoirs are summarized below in Table 2.6.

Table 2.6: Existing Mount Edward Storage Dimensions and Volumes

Tank Dimensions	
Top Water Level (TWL)	118.28 m (390 ft)
Overflow Level	118.72 m (391.5 ft)
Freeboard (TWL – Overflow Level)	0.5 m
Tank Floor	109.22 m (360 ft)
Diameter	2 @ 55.0 m (180.5 ft)
Design Water Height (TWL – Tank Floor)	9.14 m
Total volume (Mount Edward #1 + #2)	**43.5 ML**
Low Water Level	112.0 m (369 ft)
Accessible Volume for Design	30.0 ML

The TWL for the Mount Edward reservoirs was shown as the overflow elevation on the record drawings but has historically been established as 118.28 (390 ft). The resulting freeboard (TWL to Overflow) is 0.45 m so there appears to be an opportunity to increase the tank level by up to 0.30 m, to 118.59 m (391 ft) to gain an additional 2.8 ML. However, this is not considered in the sizing analysis.

2.4 East Region Emergency Volume Analysis

The emergency volume requirement as per the first principles calculation, is based on an absence of clear information. However, ACWWA Guidelines suggest the emergency storage is not rigidly defined, but rather a function of risk and redundancy in the system.

Emergency scenarios were developed for this analysis to help understand the duration that storage can be relied upon to supply the system during a shutdown of the WSP, or a break in the transmission main. Relying on system storage for shutdowns, can occur at any time and may be planned or unplanned. In addition, shutdowns of the Lake Major WSP will be required for the Water Supply Enhancement Program (WSEP). The details of these shutdowns are not yet known and, as such, a minimum required shutdown duration cannot be assigned.

For this analysis, we consider two shutdown scenarios:

- Unplanned shutdown.
- Planned shutdown.

For an unplanned shutdown:

- There is limited or no notice for interruption of water supply from Lake Major WSP.
- The bridge line is not activated.
- The tank levels are at 70% of the typical operating range. This is consistent with the IMP.

For a planned shutdown:

- There is advanced notice and opportunity to plan for the shutdown.
- The bridge line is activated.
- The tank levels are at TWL.

There are three storage tanks in the East Region considered in this analysis: Mount Edward #1 and #2 and Akerley. There are two additional storage tanks, Preston and Shearwater, that service relatively small areas and have been excluded from the analysis. Available storage volume for the shutdown scenarios is calculated from the design low operating level, less the fire volume, and is summarized in Table 2.7.

Table 2.7: Storage Volumes in East Region for Shutdown Scenarios

Shutdown	Unplanned		Planned	
Tank	Mount Edward #1 & #2	Akerley	Mount Edward #1 & #2	Akerley
Starting Level (m)	118.0	117.0[1]	118.9	118.9
Low Level (m)	112.6	107.0	112.6	107.0
Volume (ML)	25.6	19.7	30.0	23.4
Fire Volume (ML)	2.45	2.45	2.45	2.45
Remaining Volume (ML)	23.2	17.3	27.6	20.9
Shutdown Volume (ML)	**40.5**		**48.6**	

1. The starting level 117.0 m (384 ft) for the Akerley tank is taken from Table 5, Volume 2 of the IMP.

2.4.1 East Region System Demands

The present (2016) and future (2046) average day demands for the East Region, were considered in the analysis. Demands were taken from the integrated water model prepared for the IMP and are summarized as follows:

- Present (2016): 34.1 MLD.
- Future (2046): 64.2 MLD.

The ‘present’ demands are considered current to 2016, however, as of 2019, ADD has decreased to 32.4 MLD.

2.4.2 Intersystem Supplies

The Pockwock and East Region water systems are connected via a 600 mm watermain on the MacDonald Bridge (the “Bridge Line”). The capacity of the Bridge Line is defined below.

The IMP has also identified a future interconnection (prior to 2046) to supplement the Bridge Line which is referred to as the Bedford to Burnside Connector. This connector is intended to provide redundancy to the East Region and to supplement a predicted source water deficit at Lake Major. CBCL has been engaged by Halifax Water in a separate project to establish capacities and constraints of this connection. The project is not complete and connector capacity and constraints have not been fully defined.

The rated capacity of the Bridge Line is 25 MLD (5.5 MIGD), however, conveyance from Pockwock to the East Region will be constrained by the capacity of the Lyle Street Booster Station. As well there are hydraulic constraints that limit the ability to move the water within the East Region. Lyle Street Booster Station is being upgraded (or is planned for an upgrade) in the future. Water from the Bridge Line is pumped into the Dartmouth Intermediate West Zone which cannot fully utilize the flow at all times. To address this, a new booster station at Leaman Drive is being designed to pump water from the Dartmouth Intermediate West Zone into the Burnside High Zone. Therefore, excess flow from the Bridge Line not consumed in the Intermediate Zone can be pumped into the Burnside High Zone to fully utilize the available capacity of the Bridge Line. It is also possible for water to flow from the Intermediate West to the Intermediate East Zone via Pine Street, however, the system hydraulics limit the amount of flow that can be conveyed in that direction.

Presently, the capacity of the Lyle Street Booster Station is 9 MLD, but the station was originally designed for 18 MLD. In the future (2046) it is assumed that the capacity will be increased to 25 MLD, consistent with the value carried in the IMP. The current design flow rate for Leamen Street pump station is 11.8 MLD.

2.4.3 Present Day Shutdowns

For an unplanned shutdown of the Lake Major WSP, both Mount Edward tanks and the Akerley tank can supply water to the East Region for an expected duration of 28.5 hours.

For a planned shutdown of the Lake Major WSP, the duration that the tanks can supply the East Region varies from 39 hours to 68 hours, with the Bridge Line flow varying from 4.5 to 17 MLD, respectively. Bridge line flows in excess of 9.9 MLD would require increased pumping capacity at Lyle Street and construction of the Leaman Drive booster station.

The duration of the unplanned shutdown is reduced to 18 hours if one of the two Mount Edward tanks were to be taken offline for construction of the Mount Edward #1 replacement. The duration of the planned shutdown is adjusted to 27 to 47 hours, with the Bridge Line flow varying from 4.5 to 17 MLD (1 MIGD to 3.7 MIGD), respectively. Alternatively, if a new tank is constructed adjacent to Mount Edward #1, while the existing tank (Mount Edward #1) remains in service (a total of three tanks active), the duration of the unplanned shutdown is increased to 39 hours, while the planned shutdown is increased to 51 to 88 hours.

2.4.4 2046 Shutdowns

For the 2046 scenario, existing storage for both the planned and unplanned shutdown events is 29 hours and 15 hours, respectively. While no standard of emergency volume requirements exists, it is reasonable to provide at least 24 hours of storage in the system to reduce risk of service interruption in an unplanned shutdown. Therefore, additional storage of at least 24 ML appears warranted in the future to reduce the risk of service interruptions.

2.5 Reservoir Sizing

The first principles sizing, as outlined in Section 1.5, is summarized in Table 2.8. Sizing scenarios for present and future demands are presented. As per Table 2.5, volumes for both the IMP and historical demand scenarios are presented.

Table 2.8: Design Storage Volumes for the Mount Edward Reservoirs

Storage Volumes	Sizing Scenario		
	Existing, or Present-Day	Future	
		IMP	Historical
Design MDD	22.8 MLD	71.3 MLD	60.7 MLD
Peak Balancing (25% of MDD)	5.7 ML	17.8 ML	15.2 ML
Fire Volume (13,620 L/min for 3 hours)	2.5 ML	2.5 ML	2.5 ML
Emergency (25% of Peak Balancing + Fire)	2.1 ML	5.1 ML	4.4 ML
Totals	**10.3 ML**	**25.3 ML**	**22.1 ML**

The present-day storage at Mount Edward is 30 ML (Table 2.7) and satisfies the first principles sizing for future demands. While there is some excess storage (4.7 – 7.9 ML) in the future based on this analysis, the emergency volume analysis (Section 2.4), shows that, in a shutdown scenario, more storage is needed. Therefore, we recommend that the replacement tank should have the same active volume as the existing Mount Edward #1.

A portion of the storage falls below the present day allowable low water level and could be considered dead volume. Raising the floor would reduce the initial capital costs and total volume of the tank, however the available volume would remain unchanged. The allowable low level is driven by the hydraulics of the existing booster station. The station is nearing 20 years of service and will require replacement within the life of the new tank. The new station could be designed to permit full draw down of the tank, to fully utilize the tank volume, thereby eliminating the dead volume. While there is an apparent cost reduction now, consideration should be given to potential volume requirements in the future when it is needed.

An alternative to maintaining the same volume as present day, is to increase the tank diameter if the floor is raised. However, the capital cost will be greater for a larger diameter, driven primarily by the cost of the roof. As well, there will be additional costs to prepare the site for the larger diameter tank. Tank geometry alternatives will be explored further in Chapter 3 and 4.

3 Life Cycle Cost Analysis and Tank Material Selection

This section summarizes an evaluation of the materials used in tank construction and their respective design standards. Each material option has unique maintenance requirements, service life, and differing capital costs that can affect to total life cycle cost. The life cycle cost analysis attempts to consider these variables using a net present value calculation to support the material selection decision.

3.1 Tank Materials

To meet Halifax Water requirements, storage tanks must conform to the latest edition of the American Water Works Association (AWWA) standards. Materials of construction are a vital consideration for any water storage project. Welded steel, glass-lined bolted steel, and prestressed concrete tanks are the primary construction methods, and have their own specific characteristics and AWWA standards.

3.1.1 Welded Steel Tanks

Welded steel tanks designed and constructed to the AWWA D100 standard have been used for water storage since the 1930's and completely replaced riveted construction by the 1950's. Welded steel tanks have historically been the most widely selected construction type in Atlantic Canada and have generally been very successful. With proper maintenance, particularly with keeping the coating systems in good condition and providing cathodic protection, welded steel tanks can have very long service lives. According to the AWWA Manual M42 – Steel Water Storage Tanks, there are tanks with service lives exceeding 100 years.

These tanks are made of steel plates that comprise the welded wall sections, floor, and roof segments (where a steel roof is specified). The foundation consists of a concrete ring foundation under the wall plates, while the floor plates are founded on an inert soil or crushed rook, such as limestone, to reduce the risk of soil side corrosion. Roofs are commonly of steel construction and can be self-supporting in smaller diameters. In larger diameter tanks, roofs are supported on steel beams and columns and are referred to as Cone Roof Tank (CRT). Aluminum geodesic domes can also be used, and can be more cost effective than CRT roofs, depending on diameter. For the Mount Edward tank, an aluminium geodesic dome is more cost effective and has been assumed for this analysis.

3.1.2 Prestressed Concrete Tanks

Prestressed, wire-wound concrete tanks combine the benefits of the compressive strength of concrete together with the high tensile strength and water tightness of steel. The AWWA D110, Type III standard, provides a more durable finished structure as opposed to the older “gunite” style tanks and are recommended by the tank contractors for cold climates. Although the standard was published in 1986, these tanks have been constructed for over 50 years. Tank contractors claim the expected service life of these tanks to be over 80 years, though this claim is difficult to substantiate. We have assumed a service life of 60 years for this tank material.

AWWA D110, Type III tanks are constructed of multi-layered, high tensile strength wire wound prestressing around segmented precast concrete wall panels finished with a shotcrete cover. Wall panels are precast on-site in custom made casting beds formed to the curvature of the tank. An embedded steel diaphragm acts as a water barrier to prevent water migration through the tank wall. Roofs are freestanding reinforced concrete dome construction, with either segmented precast panels or cast monolithically. Tank floors are reinforced concrete and cast monolithically on site.

3.1.3 Glass Lined Bolted Steel Tank

A Glass-lined Bolted Steel Tank (AWWA D103) configuration was not considered since the size of the Mount Edward tank is larger than the maximum sizing parameters that can be constructed with this style of tank.

3.2 Life Cycle Cost Analysis

The lifecycle cost (LCC) of an asset is defined as the total cost, in Net Present Value (NPV), that includes the initial construction costs, maintenance, repairs, and rehabilitation costs over the specified design life cycle. The following outlines the key assumptions utilized in the NPV:

Initial Tank Construction Costs

Construction costs for the tank options are based on pricing provided by tank contractors who were contacted to obtain budgetary construction and maintenance costs. The initial tank costs are based on the same geometry of the existing tank. The costs are budgetary and may change as detailed design progresses.

Costs for a welded steel tank were obtained from two separate tank contractors that have had history with tank construction in Nova Scotia. Of these two contractors, one constructed the newest welded steel reservoir in Halifax, Hemlock, in 2020-2021. The bid price for the Hemlock project fell within the project budget which was based on pricing provided by the same two tank contractors. Therefore, we have carried average tank price based on the two quotes provided by the tank contractors for the NPV.

We also received costs for the prestressed concrete tank from two reputable tank contractors located in the United States. One cost was significantly lower than the other. The lower cost was provided by a tank contractor who has not recently worked in Canada. The higher cost was the provided by the tank contractor that has recently completed the Cowie Hill Reservoir. The Cowie Hill Reservoir bid price exceeded the project budget, so there is a risk that when tendered, the cost for this tank material will be higher than the quoted price. To mitigate this risk, we have selected the higher of the two quotes for this analysis. It is assumed that the higher cost reflects the probable tank cost as it was provided by the tank contractor with the familiarity with working in the Canadian contracting environment.

The initial capital cost for the NPV for both tank materials is:

- Welded Steel Tank (D100) with Aluminum Dome Roof: $10,850,000.
- Prestressed Concrete (D110 Type III): $8,160,000.

Costs were also obtained for a welded steel tank with a column-supported cone roof. However, the capital cost is greater than the aluminum dome and was not included in the NPV.

Maintenance and Rehabilitation Costs

Maintenance and rehabilitation costs are based on information provided by the manufacturers and history.

Maintenance for prestressed concrete tanks includes exterior cleaning and recoating. The cleaning and recoating work is done to restore the original exterior tank appearance and remove environmental dirt, staining and efflorescence. The estimate cost for the cleaning and recoating is estimated to be $7 per square foot and is expected to occur every 20 years. Minor exterior rehabilitation is included to cover miscellaneous repairs if required, to restore any deterioration of the shotcrete exterior cover coat. We have also allowed for major repairs to be performed every 20 years, with an assumed cost being 15% of the construction cost. This is based on a historical review undertaken by Halifax Water and is thought to be representative of their experience with the “gunite” style of tank construction that preceded the present-day standard of construction.

Welded steel tanks have interior and exterior coatings requiring maintenance throughout the life of the tank. Full removal and replacement of the system will occur every 40 years, with touch-up and overcoat applied 20 years after each removal and replacement. Costs are based on $31 per square foot for full removal and replacement on both interior and exterior surfaces (based on a recent Halifax Water project), and $8 and $7 per square foot for touch-up and overcoat application for interior and exterior surfaces, respectively. An allowance for environmental containment costs is included for removal and replacement cycles.

For a welded steel tank with an aluminum geodesic dome, the dome itself will not require a protective coating, therefore the re-coating costs and maintenance for the aluminum roof are less than the steel roof. However, the aluminum dome will require periodic maintenance of gaskets and seals and are budgeted for every 20 years. We have included a cost of replacement for the aluminum geodesic dome at year 60 based on the current budgetary cost of the aluminum dome.

Rehabilitation of the existing Mount Edward #1 tank, as outlined in the Structural Condition Survey Assessment report (RJC, 2022), is stated to extend the service life of the existing Mount Edward #1 tank by 20 years. Maintenance of this tank during the extended service life would include inspection every 5 years. After 20 years, we assume that the tank will be replaced with a prestressed concrete tank or steel tank and will follow the maintenance schedule outlined for the new tank. In addition to the Opinion of Probable Cost (OPC) for rehabilitation in the report, we included the following additional costs:

- Costs for overhead and profit.
- Inflation.
- An allowance to cover potential repairs to the external post tensioning system.

Replacement Costs and Residual Value

Where the service life is less than the NPV forecast year, the replacement cost is the NPV of the initial capital cost for the year it is constructed. The residual value of a tank is calculated based on the expected service life remaining at the NPV forecast year. The residual value is calculated from a straight-line depreciation of its construction cost for that service life cycle.

3.2.1 Net Present Value

The NPV was calculated over a 100-year forecast considering annual interest rates of both 6.0% and 4.0%, with a constant annual inflation rate of 2.5%. Results of the NPV for the Mount Edward #1 reservoir are presented in Table 3.1 and Figure 3.1.

A replacement cost for the prestressed concrete tank was included during year 60 of the analysis. A shorter NPV forecast horizon of 60 years could also be considered. It can be seen in Figure 3.1 that the concrete tank NPV with a 60-year forecast is less than the steel tank, including the residual value of the steel tank. The 60-year NPV is also not as sensitive to the interest rate variable.

Table 3.1: NPV Summary for 100-year Forecast

Tank Material Option	6.0% Interest	4.0% Interest
	Total Cost (NPV)	Total Cost (NPV)
Prestressed Concrete (AWWA D110 Type III)	$10,500,000	$13,900,000
Welded Steel (AWWA D100) With Aluminum Dome Roof	$12,200,000	$14,000,000

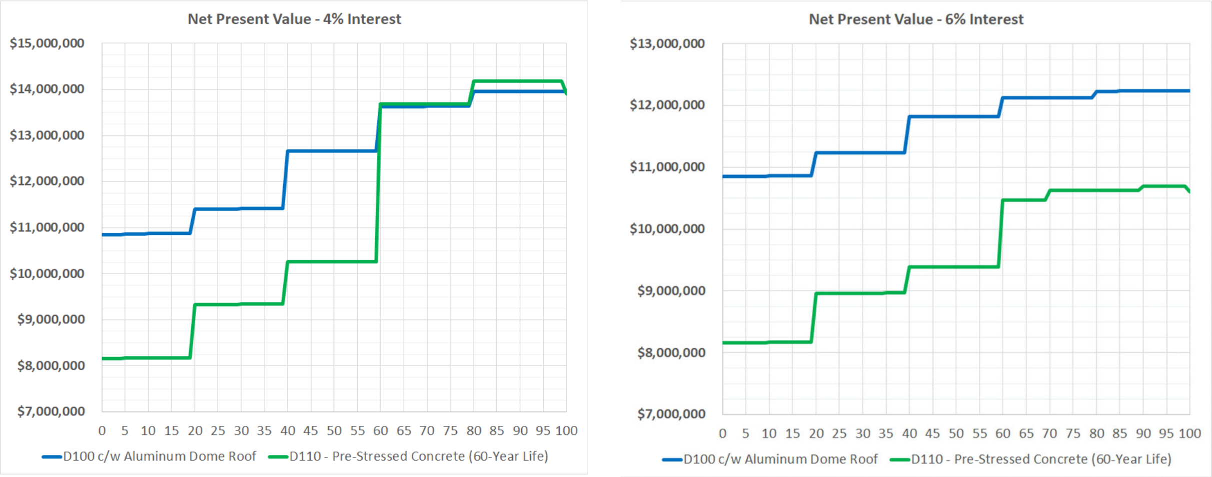


Figure 3.1: Net Present Value for 4% and 6% Interest Rates.

As part of a sensitivity analysis, we also varied the prestressed concrete tank service life using both 50 and 80 years, and major repair assumption from 10%– 20%, respectively. The results are similar to above. At a 6% interest rate, the NPV was less than welded steel by more than 10%. However, using a 4.0% interest rate, the concrete tank with an 80-year service life was less than welded steel by 6% while with a 50-year life, the concrete tank was more than welded steel by 3%.

While neither tank had a lower NPV for all variables that were considered, what can be concluded is that the concrete tank life cycle cost is similar, or less than, that of a steel tank.

3.2.2 Potential Alternatives

The cost reduction to raise the floor by 1.2 m was provided by the tank manufacturers and is shown in Table 3.2. Raising the floor from the present-day elevation will require additional structural fill, which will offset some of the savings and is also shown in the table. There is a significant range of apparent capital cost reduction for both tanks, therefore, it is difficult to conclude that these savings will ultimately be realized.

Table 3.2: Apparent Cost Reduction for A Raised Floor Level

Tank Material	Reduction in Tank Cost for a Raised Floor	Additional Structural Fill Cost	Net Reduction to Raise Floor
Concrete	$400,000 - $950,000	$214,000	$186,000 - $736,000
Steel	$224,000 - $450,000	$214,000	$10,000 - $236,000

Note: Tank costs excluding markup and all costs exclude contingencies.

The concrete tank has the lowest NPV for both interest rates assuming the maximum reduction for both tank materials. Otherwise, the results are similar to those above. It is recommended that the same floor elevation as the existing tank is brought forward to the next stage of design. The cost/benefit can be thoroughly evaluated at that time.

3.3 Rehabilitation of Mount Edward #1

Rehabilitation of the Mount Edward #1 tank is outlined in the Structural Condition Survey Assessment report (RJC, 2022). The report includes a description of the recommended methods for rehabilitation of the tank which involves: dewatering of the reservoir, repair of concrete with low-permeability silica fume repair material, potential repair of reinforcement, removal and replacement of interior wall and floor slab waterproofing systems, crack sealing, and new coating system on exterior walls.

The rehabilitation work is recommended to include further engineering review and analysis including destructive testing to determine the extent of the reinforcing repairs needed. Therefore, the scope of the rehabilitation work could increase. The report states that the condition of the tank could be improved from a Halifax Water Grade 3 or 4 (fair to poor) condition to Grade 2 (good) to extend the life of the tank. The report states that the effective service life would be extended for 20 years or more.

For this assessment we have assumed that the rehabilitated tank would be replaced with a prestressed concrete tank (AWWA D110 – Type III) or a welded steel tank (AWWA D100) at year 20. The costs associated with the site preparation, reinstatement and yard piping are not immediately needed if the existing reservoir is rehabilitated. However, these costs will apply for immediate replacement and have been incorporated in the analysis.

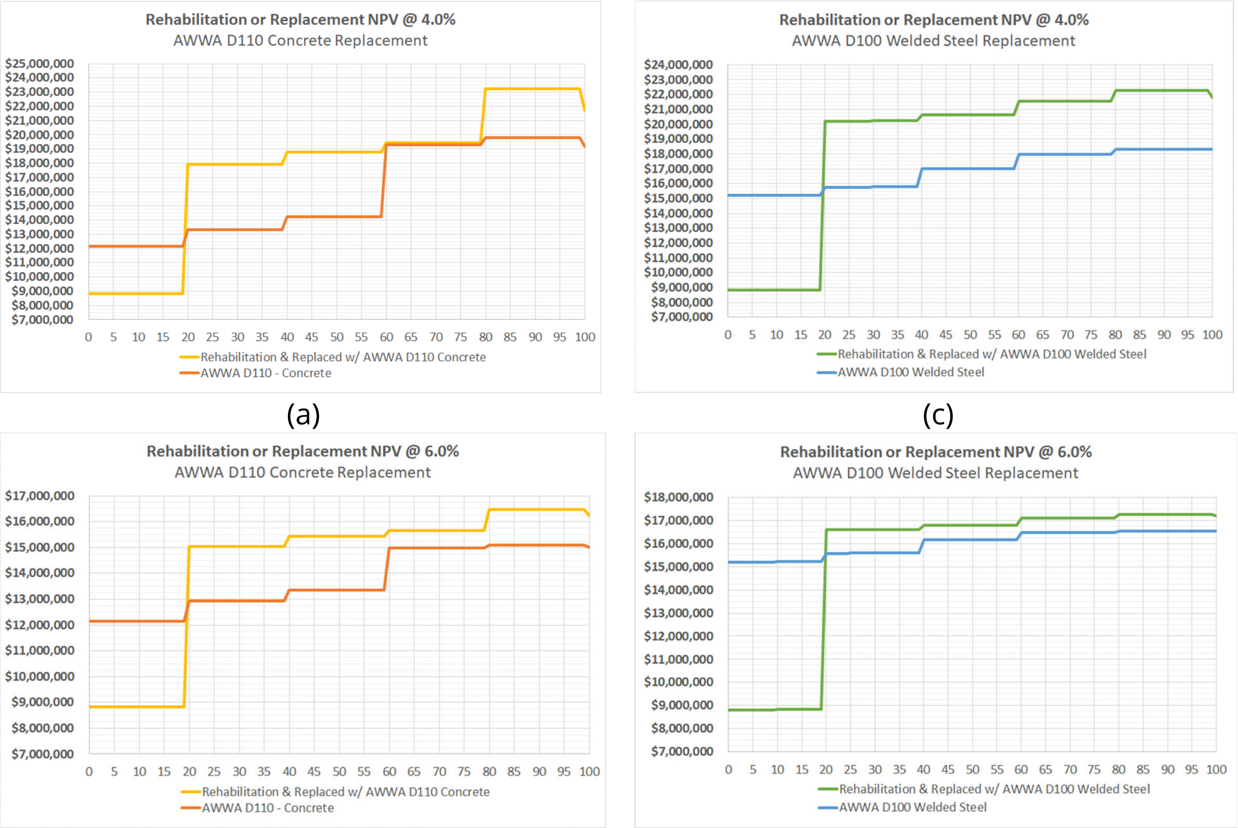
Maintenance of this tank during the extended service life would include inspection every 5 years. After 20 years, we assume that the tank will be replaced with a prestressed concrete tank or steel tank and will follow the maintenance schedule outlined for the new tank. In addition to the OPC for rehabilitation in the 2022 report, we included the following additional costs:

- Costs for overhead and profit.
- Inflation.
- An allowance to cover potential repairs to the external post tensioning system.

3.3.1 Net Present Value

A NPV analysis was carried out for a 100-year forecast for both 4.0% and 6.0% interest rates for either welded steel replacement or concrete replacement. The initial capital cost to immediately replace the reservoir is higher, however these costs will be outpaced by the rehabilitation options after 20 years when replacement is finally needed, for either interest rate. The results of the NPV are presented in Figure 3.2.

Based on the NPV, it is recommended that Halifax Water proceed with immediate replacement of the Mount Edward #1 reservoir.



(a) (c)

(b) (d)

Figure 3.2: Life Cycle Cost Analysis – Rehabilitation vs Immediate Replacement; (a) and (b) show the NPV for the AWWA D110 concrete tank replacement while for 4% and 6% interest rate, respectively; (c) and (d) show the AWWA D100 welded steel tank replacement for 4% and 6% interest rate, respectively.

4 Site Upgrades

This chapter discusses the major components of the site upgrades and modifications to accommodate the new reservoir. Preliminary drawings have been included in Appendix A.

4.1 Reservoir Location

The Halifax Water property for which the existing Mount Edward reservoirs are located is large enough to accommodate one or more tanks in addition to the two existing reservoirs. In discussions with Halifax Water, we evaluated two (2) tank location options as follows:

Option 1 – Construct the New Reservoir in the Same Location as the Existing Mount Edward #1 Reservoir

Option 2 – Construct the New Reservoir Adjacent to the Existing Mount Edward #1 Reservoir

The two location options are shown in Figure 4.1. The advantages and disadvantages for each option are summarized as follows:

Option 1

- Reduced geotechnical risk as it replaces the existing reservoir in the same location with the same top water level.
- Limited yard piping modifications.
- Present day drainage issues can be addressed with drainage improvements.
- Reduces available system storage during construction.

Option 2

- Geotechnical boreholes and record drawings show a large quantity of fill within the proposed location.
- Increased risk of differential settlement and/or slope stability issues, as the existing ground has not been consolidated.
- Greater yard piping modifications, relative to Option 1.
- Available system storage during construction remains the same.
- Continued use of the existing Mount Edward #1 throughout construction may warrant some remedial work.

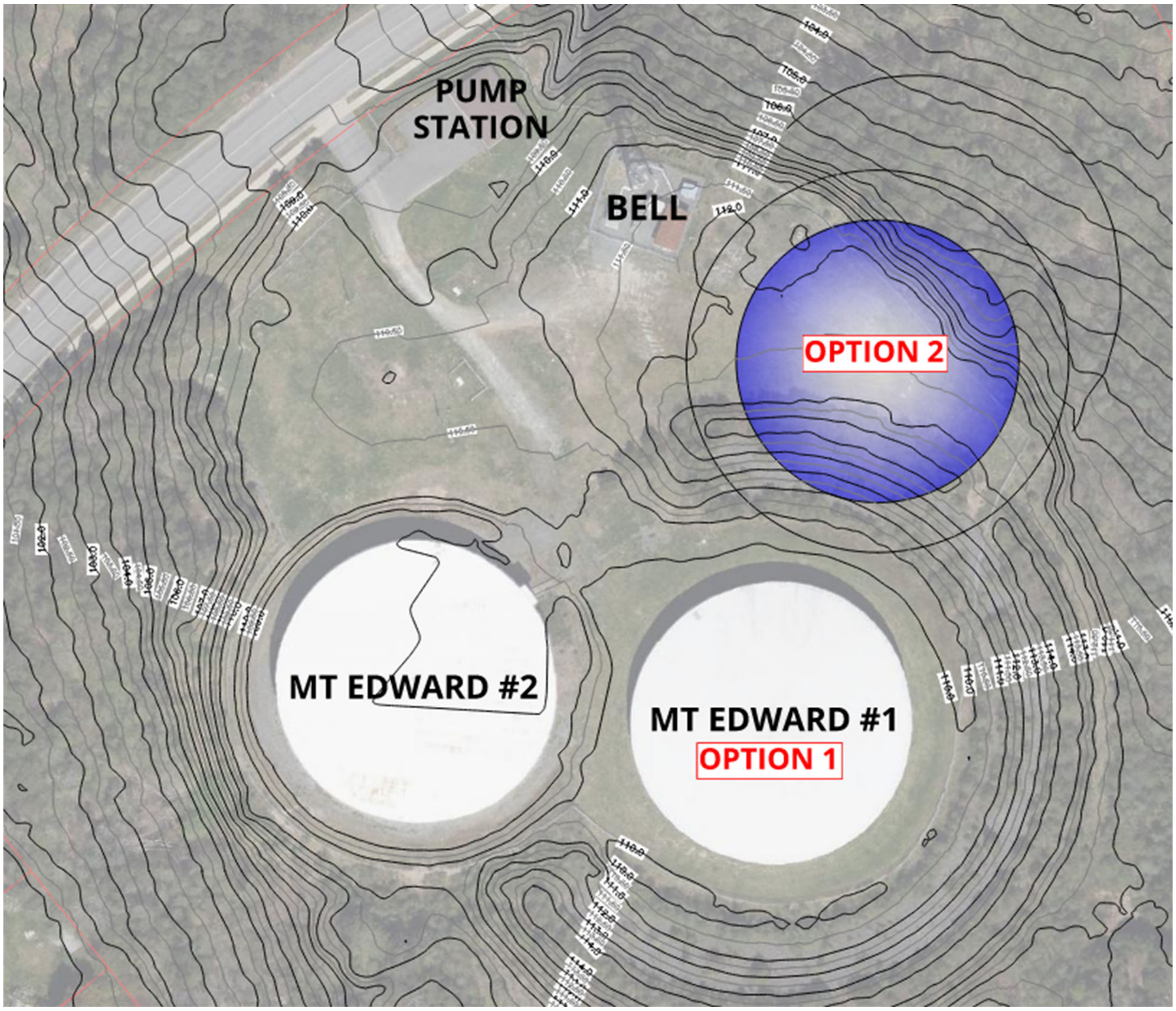


Figure 4.1: Reservoir Location Options.

The additional cost for Option 2 is estimated to be $840,000 (excl. HST), and is due, primarily, to the earthworks and yard piping requirements.

The primary advantage of Option 2 is maintaining the present-day level of storage for emergencies during construction. The Akerley reservoir (a greater volume than Mount Edward #1) was offline for a period exceeding one year during its recoating process. The reduced storage for that project was necessary but deemed acceptable by Halifax Water. In consideration of the above, it is our opinion that this storage advantage does not outweigh the additional costs for Option 2.

Given the additional cost and greater risk associated with Option 2, we recommend that Option 1 is selected as the preferred location of the new reservoir.

The remainder of report is written under the assumption that the tank will be constructed in the same location as the existing Mount Edward #1 Reservoir.

4.2 Yard Piping Modifications

The fill and drain piping for the existing Mount Edward #1 reservoir will be reused which will minimize the yard piping modifications. No modifications are proposed for the existing reservoir inlet flow control. A new sensing line will be brought back from the reservoir and will be used for monitoring reservoir levels via a level transmitter connected to SCADA.

The existing reservoir has an overflow but does not have a dedicated drain, which has caused some challenges during maintenance. The new tank will be provided both with an overflow and a dedicated drain. As the tank is to be identical to the existing tank, and there are no known changes to the inflows, it is anticipated that the existing tank drainage system is sufficient and can be reused for the new reservoir. We have assumed that the Overflow will be directed to the same drainage path as the existing reservoir.

Adequate flow metering already exists, and no new flow meters are proposed under this project.

4.3 Control Chamber Access Retrofit

The Mount Edward #2 control chamber access retrofit is driven by the desire to change the classification of the chamber from a confined space to a restricted space. To address this, a new stairway will be constructed. This has been successfully carried out on several chambers in the Halifax Water system. Removal of valves within the chamber will be partially impeded by the new stairway. However, Halifax Water operations indicated that in the rare event that a valve requires replacement, the stairway could be temporarily removed.

4.4 Water Quality Management

An active mixing system will be specified for the Mount Edward #1 Reservoir. The mixing system will address thermal stratification to reduce risk of interior ice damage and will help to maintain water quality. Tank turnover is sufficient (< 3 days) such that the risk of ice formation is minimal, hence, further mitigation of ice formation does not appear warranted.

Based on the historical performance of the two reservoirs, chlorine maintenance will not be required. The two tanks operate in line and are supplied directly from the Lake Major WSP therefore, water age is quite low.

4.5 Drainage Study

Stormwater generated within the berms around the reservoirs follows the downstream drainage paths that convey flows to Mount Edward Road ditching, and then to the north, towards Main Street through an open channel. The flows are directed to the Main Street ditch, where a portion of the design flows are conveyed east to Cranberry Lake, while the remaining flows are conveyed north to Topsail Lake. Drainage studies were previously completed by CBCL for the Mount Edward site, and drainage retrofits were undertaken at that time for the design flows and flow paths. The Design Flow for the drainage system was 1 m^3/s, which was consistent with the estimated flow that could be delivered by the overflows if the altitude valve was to fail open and the pumps at Lake Major were to continue to run. Peak runoff flows, resulting from extreme rainfall events, including the 1 in 100 year event, were estimated at that time to be much less than 1 m^3/s, and the downstream conveyance system was therefore designed for a flow rate of 1 m^3/s.

Since this study shows that the existing Mount Edward #1 Reservoir can be replaced with a new reservoir with the same dimensions and volume, the Design Flow for the downstream drainage system remains at 1 m^3/s. The rainfall inputs were updated to estimate the peak runoff flows from extreme rainfall events that incorporate climate change, and to evaluate the validity of the design parameters established in the previous drainage studies.

4.5.1 Rainfall Inputs

Rainfall inputs were derived from the Halifax Water 2023 Design Specifications and Supplementary Standard Specifications, which provides the Intensity-Duration-Frequency (IDF) curves parameters based on the projected changes in the intensities for short-period storm events in 2080. The IDF curve parameters for the 1 in 5 year and 1 in 100 year design events are presented in Table 4.1. The Chicago Distribution was used to derive the hyetographs for the design storm events, as presented in Figure 4.2, and these rainfall time series were used as the updated rainfall inputs in the hydrologic and hydraulic model to estimate the peak runoff flows under the climate change conditions.

Table 4.1: Intensity-Duration-Frequency (IDF) Curves Parameters

Strom Event Return Periods	A	B	C
1 in 5 year	31.196	0.03178	0.565
1 in 100 year	47.924	0.00594	0.544

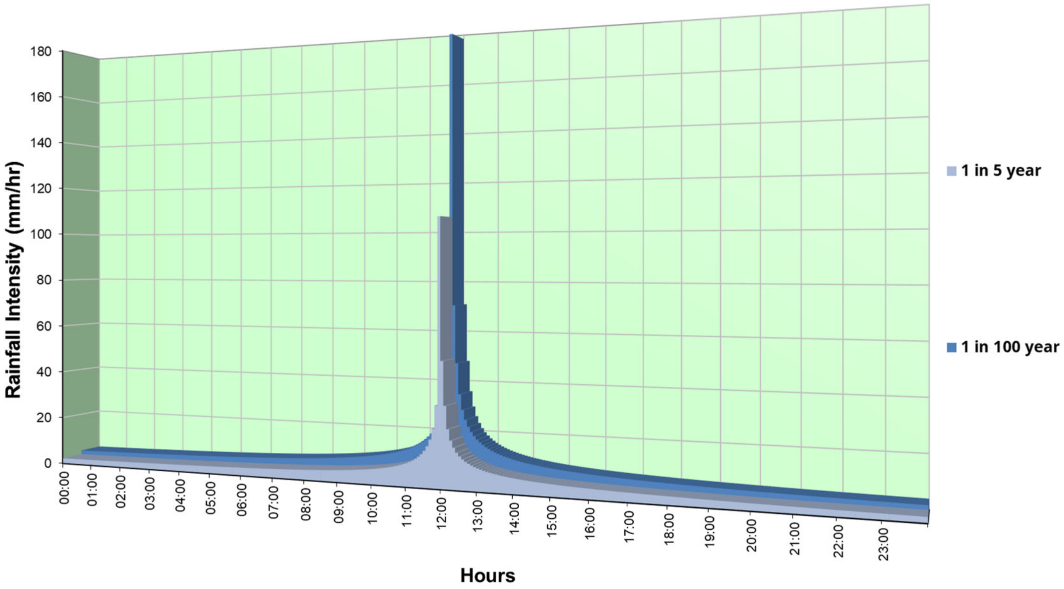


Figure 4.2: Design Storm Hyetographs.

4.5.2 Model Domain

Stormwater generated within the berms around the reservoirs is directed to a catch basin manhole, then through a stormwater pipe to an open ditch that crosses the remainder of the site, and discharges to an open ditch adjacent Mount Edward Road. A hydrologic and hydraulic model was set up to estimate the peak runoff flows that would be discharged to the open ditch on the site. The model domain is as presented in Figure 4.3.

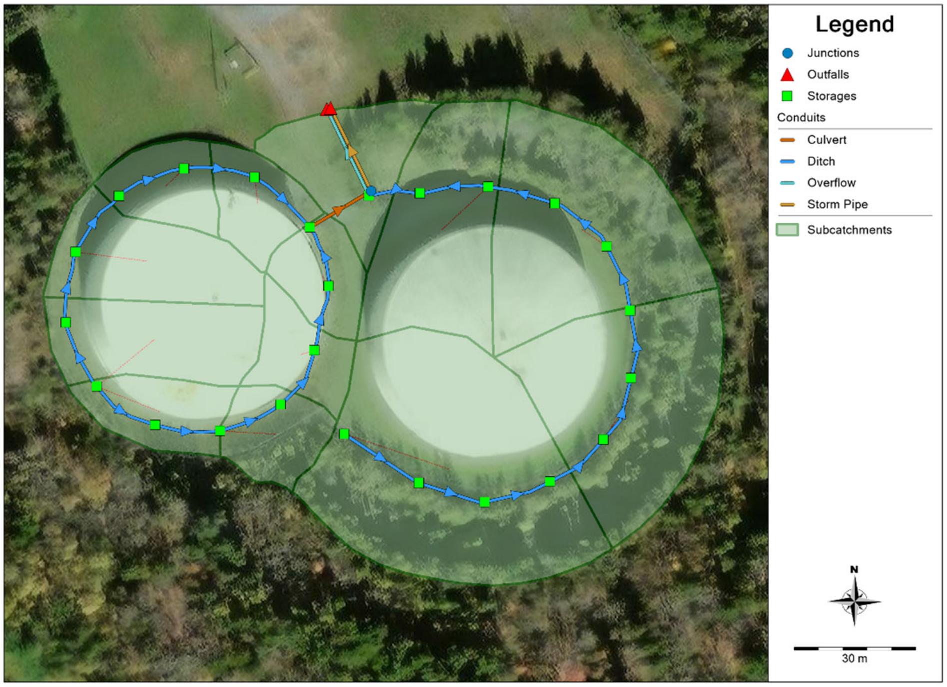


Figure 4.3: Model Domain.

4.5.3 Peak Runoff Flows

The modelled peak runoff flows for the 1 in 5 year and 1 in 100 year storm events in 2080, incorporating climate change, are presented in Figure 4.2.

Table 4.2: Peak Runoff Flows for Design Events in 2080s

Strom Event Return Periods	Peak Runoff Flows (m^3/s)
1 in 5 year	0.18
1 in 100 year	0.25

Since the peak runoff flows, resulting from 1 in 5 year and 1 in 100 year design storm events under climate change conditions, were estimated to still be much less than the design flow of 1 m^3/s – design parameters established in the previous drainage studies remain valid, and no upgrade would be required for the downstream conveyance system.

4.6 Geotechnical Conditions

The Mount Edward #1 Reservoir geotechnical report is included in Appendix B. A total of eight (8) boreholes were drilled under this program of which four (4) boreholes were drilled around the perimeter of the existing reservoir. For the boreholes around the existing tank, fill varying from 1.5 – 2.1 m was encountered, however, this was expected based on the record drawings. Below the fill is the clay till, which has a thickness that exceeds the depth of the borehole. No bedrock was encountered. Of the eight boreholes, one was drilled to bedrock and was encountered at an elevation of 95.5 m, which is 13.6 m below the tank floor.

The ground conditions below the existing reservoir will need to be verified after the tank has been removed. The existing structural fill below the reservoir identified on the record drawings will be removed to expose the native material. The existing soils will need to be tested for suitability prior to placing any new material. Following inspection, Structural Engineered Fill (SEF) will be placed between the suitable subgrade and the underside of the tank foundation and floor. A minimum of 500 mm of SEF will be required below the footing. A foundation drain will be incorporated into the design drawings to reduce the risk of uplift on the tank floor.

4.7 Environmental Investigation

An environmental investigation was undertaken and consisted of standard environmental soil sampling in conjunction with the geotechnical borehole drilling program. One sample from each of the eight boreholes was collected, screened for volatile gases, and submitted for lab analysis of petroleum hydrocarbons (PHCs), metals, and polycyclic aromatic hydrocarbons (PAHs).

Based on the information gathered and on observations made, it was found that all PHC, metals and PAH parameters were reported below the NSE Tier 1 EQS and NSE Tier 2 PSS (direct contact/ingestion) guidelines for a non-potable, industrial property with coarse-grained soil in all submitted borehole soil samples collected from the seven geotechnical boreholes. The Environmental Report is included in Appendix C.

5 Cost, Schedule & Implementation

The following chapter discusses cost, implementation, scheduling, and regulatory approval requirements.

5.1 Opinion of Probable Cost

An Opinion of Probable Cost (OPC) for both a D100 Welded Steel tank and a AWWA D110 Type III Pre-stressed concrete tank has been prepared and are included in Appendix D. OPC's are considered Class 3 and include 20% contingency. We have included 4.0% inflation to account for the planned construction year of 2025. The OPCs are based on the prices provided by the tank contractors as follows:

- AWWA D100 Welded Steel Tank: **$12,300,000**.
- AWWA D110 Type III pre-stressed concrete tank: $6,000,000 in US dollars. At the time of the quote, the exchange rate was 1.36 resulting in a price of **$8,160,000** in Canadian dollars. Over the past year, the exchange rate has varied from 1.31 to 1.39 and is presently 1.36 (As of February 13, 2024).

A 10% markup has been added to the tank prices. The OPC for the two tank materials is shown in Table 5.1.

Table 5.1: Class 3 OPCs (excl. HST)

AWWA D100 – Welded Steel	AWWA D110 Type III – Pre-stressed Concrete
$21,027,000	**$15,187,000**

This type of tank construction is specialized and, while a number of tank contractors were engaged for the preliminary design, it is not clear how many bids can be expected when the project is tendered. Two quotes were submitted by two separate tank contractors for each tank material (four quotes total). The two quotes for each tank material varied by more than 20%. For the purpose of budgeting, the higher of the quotes were used for the OPC. However, given the pricing variance, we are unable to recommend a tank material based on OPC or NPV. It is recommended that Halifax Water proceed into the detailed design phase based on a AWWA D110 Type III Pre-stressed Concrete tank given its lower cost. However, the tender should include a add/deduct for an AWWA D100 Welded Steel tank material. With the competitively bid tank prices, a choice can be made at that time as to the tank material that will have the lowest life cycle cost.

Opinions of probable cost are presented on the basis of experience, qualifications, and best judgement. They have been prepared in accordance with acceptable principles and practices. Sudden market trends, non-competitive bidding situations, unforeseen labour and material adjustments, and the like are beyond the control of CBCL. It is not a prediction of low price. As such, we cannot warrant or guarantee that the actual costs will not vary from the opinion provided.

5.2 Project Schedule

The overall project schedule is presented at the end of this Chapter. Construction scheduling has been based on discussions with both steel and concrete tank contractors.

5.3 Regulatory Approvals

The application for approval of the Mount Edward #1 reservoir replacement will be prepared and submitted to NSE following the 60% detailed design development. The drawings and specification will be submitted in support of the application in advance of the tender phase.

The Utility and Review Board will be provided a copy of this preliminary design report and will be engaged throughout the design process.

5.4 Implementation

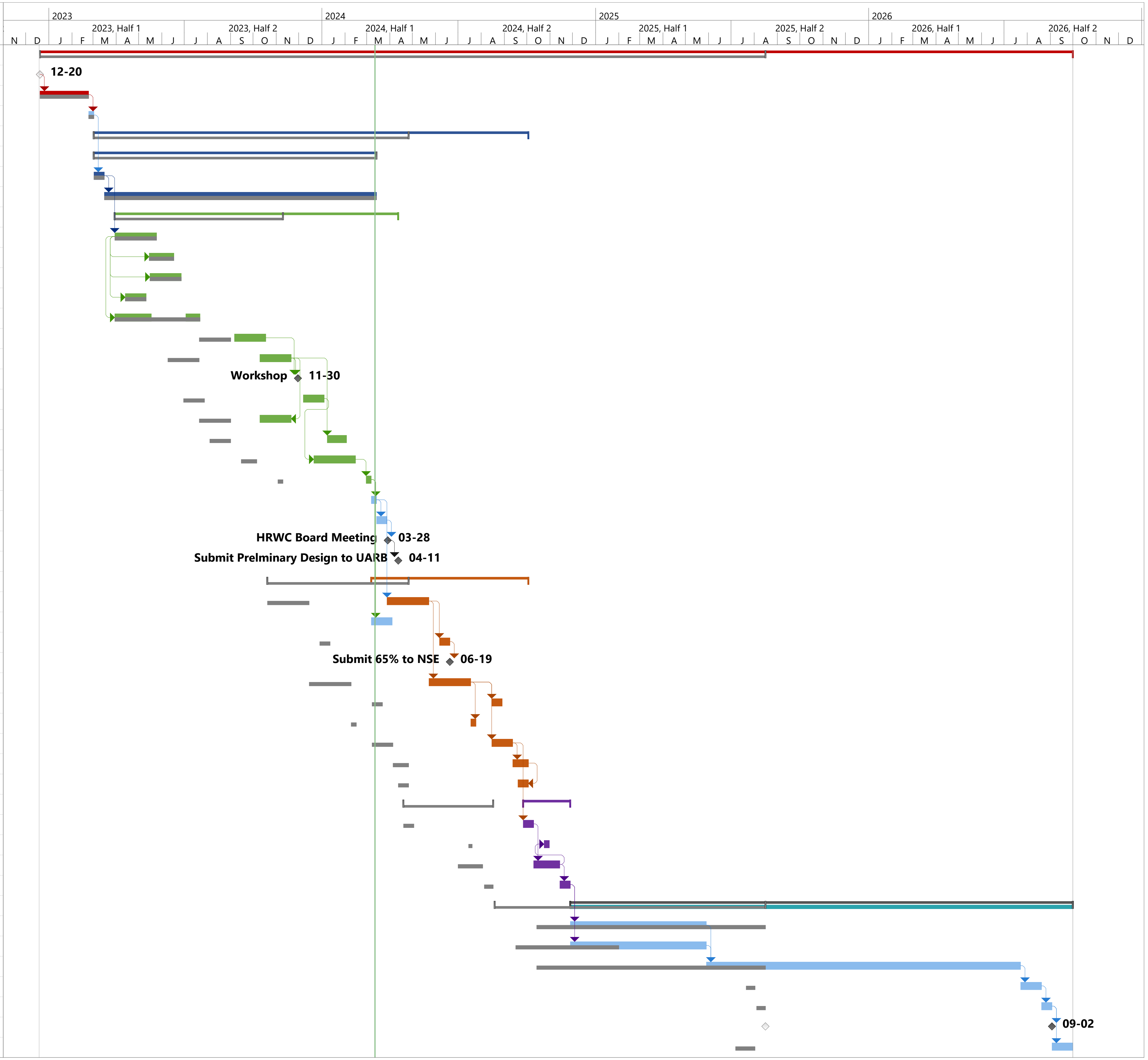
Halifax Water anticipates that the existing Mount Edward #1 reservoir can be taken offline for the duration of construction. Mount Edward #2 will remain online to continue to supply the service area. The Mount Edward Booster Station will remain available (except for approved shutdowns) and will draw from Mount Edward #2 to supply the high zones.

Halifax Water

Mount Edward #1 Reservoir Replacement

P32.2022

WBS	Task Name	Duration	Start	Finish	Predecessors
0	**P32.2022 - Mount Edward Reservoir**	**985 days**	**2022-12-20**	**2026-09-30**	
0.1	Proposal Submission	0 days	2022-12-20	2022-12-20	
0.2	Halifax Water Review of Submissions	45 days	2022-12-20	2023-02-22	2
0.3	Contract Negotiations / Award	5 days	2023-02-23	2023-03-01	3
Phase 1	**Design Phase**	**415 days**	**2023-03-02**	**2024-10-02**	
Phase 1A	Project Management	270 days	2023-03-02	2024-03-13	
101	Project Initiation	2 wks	2023-03-02	2023-03-15	4
102	Project Management Execution	52 wks	2023-03-16	2024-03-13	7
Phase 1B	Concept Design	271 days	2023-03-30	2024-04-11	
201	Information Retrieval & Review	8 wks	2023-03-30	2023-05-24	7FS+2 wks
202	Topographic Survey & Legal Description	5 wks	2023-05-15	2023-06-16	17SS+4 wks
203	Geotechnical Investigation	6 wks	2023-05-16	2023-06-26	17SS+2 wks
205	Reservoir Rehabilitation or Replacement	4 wks	2023-04-13	2023-05-10	17SS+2 wks
206	Reservoir Design Parameters	10 wks	2023-03-30	2023-07-21	17SS
207	Material Analysis & Life Cycle Cost Evaluation	6 wks	2023-09-06	2023-10-17	
208	Reservoir Location Analysis	6 wks	2023-10-10	2023-11-20	
1.1	Workshop	0 days	2023-11-30	2023-11-30	23,24
209	Control Chamber Access Upgrades	4 wks	2023-12-07	2024-01-03	
210	Yard Piping Optimization	6 wks	2023-10-10	2023-11-20	24FF
211	Drainage Study	4 wks	2024-01-08	2024-02-02	24FS+2 wks
213	Preliminary Design Report & Cost Estimate	8 wks	2023-12-21	2024-02-14	26FS-2 wks
214	Preliminary Design Review Meeting	1 wk	2024-02-29	2024-03-06	29FS+2 wks
1.2	Final Preliminary Design Report	1 wk	2024-03-07	2024-03-13	30
1.3	HRWC Board Review & Approval	2 wks	2024-03-14	2024-03-27	31
1.4	HRWC Board Meeting	0 days	2024-03-28	2024-03-28	32FS+1 day
1.5	Submit Prelminary Design to UARB	0 days	2024-04-11	2024-04-11	33FS+2 wks
Phase 1C	Detailed Design	150 days	2024-03-07	2024-10-02	
301	Detailed Design Development (65%)	8 wks	2024-03-28	2024-05-22	31FS+2 wks
212	Water Quality & CFD Analysis	4 wks	2024-03-07	2024-04-03	30
302	65% Design Review Meeting	2 wks	2024-06-06	2024-06-19	36FS+2 wks
1.6	Submit 65% to NSE	0 days	2024-06-19	2024-06-19	38
303	Detailed Drawings & Specifications (95%)	8 wks	2024-05-23	2024-07-17	36
304	95% Design Review Meeting	2 wks	2024-08-15	2024-08-28	40FS+4 wks
305	Regulatory Approval Applications	1 wk	2024-07-18	2024-07-24	40
306	Detailed Drawings & Specifications (100%)	4 wks	2024-08-15	2024-09-11	40FS+4 wks
307	Detailed Design Report	3 wks	2024-09-12	2024-10-02	43
308	Pre-Tender Construction Cost Estimate	2 wks	2024-09-19	2024-10-02	44FF
Phase 2	**Tender Phase**	**45 days**	**2024-09-26**	**2024-11-27**	
401	Finalize Tender Documents	2 wks	2024-09-26	2024-10-09	43FS+2 wks
402	Contractor Information Support	1 wk	2024-10-24	2024-10-30	49FS-3 wks
403	Tender Period Technical Support	5 wks	2024-10-10	2024-11-13	47
404	Review of Tender Submittals	2 wks	2024-11-14	2024-11-27	49
Phase 3	**Construction Phase**	**480 days**	**2024-11-28**	**2026-09-30**	
3.1	Engineering, Procurement & Fabrication	26 wks	2024-11-28	2025-05-28	50
3.2	Demolition, Yard Piping & Site Preparation	26 wks	2024-11-28	2025-05-28	50
3.3	Tank Construction	60 wks	2025-05-29	2026-07-22	53,52
507	Facility Start-up & Commissioning	4 wks	2026-07-23	2026-08-19	54
508	Facility Training	2 wks	2026-08-20	2026-09-02	55
509	Start of Warranty Period Services (1 year)	0 wks	2026-09-02	2026-09-02	56
510	Record Information Package	4 wks	2026-09-03	2026-09-30	56



5.5 Commissioning

Commissioning of the reservoir will include testing and chlorinating of the reservoirs and piping. The reservoir will be cleaned and chlorinated in accordance with AWWA C652. Chlorination Method 3 outlined in C652 could be utilized by the tank contractors as it does not require disposing of highly chlorinated water or applying a high concentration of chlorine solution to the tank coatings. Chlorination Method 3 involves filling 5% of the total volume with a chlorine residual of not less than 50 ppm for a period of 6 hours. Following the holding period, the reservoir will then be filled to overflow level with a chlorine residual of not less than 2 ppm and held for 24 hours. During the filling process, the control systems will be tested, and the full reservoir can also be used for leakage testing. Following the holding period and successful testing, drain piping will be purged and samples will be taken for bacteriological testing. If results are satisfactory, the reservoir can be put into service, and water delivered to customers.

The reservoir water supply and outlet piping will be cleaned, pressure tested and chlorinated in accordance with Halifax Water Specifications for Watermains.

6 Closure

The existing Mount Edward #1 Reservoir is approaching the end of its service life and will be replaced. Based on the sizing analysis presented herein, a replacement reservoir with the same dimensions as existing will satisfy growth for several years into the future. A NPV analysis did not show conclusively that one tank material will have a lower life cycle cost than another. However, the NPV did show that, throughout the NPV horizon, immediate replacement has a lower NPV than rehabilitation.

To maintain water quality, an active tank mixing system is recommended. Required yard piping upgrades are minimal as the new reservoir will be put in the same location as the existing reservoir.

The construction of the Mount Edward #1 Reservoir Replacement is scheduled for 2025.

Prepared by:
Jeffrey Clair, P.Eng.
Senior Municipal Engineer

Reviewed by:
Kevin Murphy, P.Eng.
Senior Project Manager

APPENDIX A

Preliminary Design Drawings

Contract No. P32.2022

Sheet List Table	
Sheet Number	Sheet Title
C00	COVER
C101	EXISTING CONDITIONS AND REMOVALS
C102	PROPOSED SITE PLAN
C103	RESERVOIR PLAN AND SECTION
C104	RESERVOIR DETAILS
C105	RESERVOIR PIPING DETAILS
C105	MISCELLANEOUS DETAILS
C107	TYPICAL DETAILS
S101	CONTROL CHAMBER ACCESS RETROFITS
S102	TANK PLATFORM AND DETAILS
E101	SITE PLAN
E102	DETAILS, SCHEDULES, IO AND WIRING DIAGRAM

HALIFAX WATER

MOUNT EDWARD #1 RESERVOIR REPLACEMENT

Halifax Water

CBCL

ISSUED FOR
PRELIMINARY
DESIGN

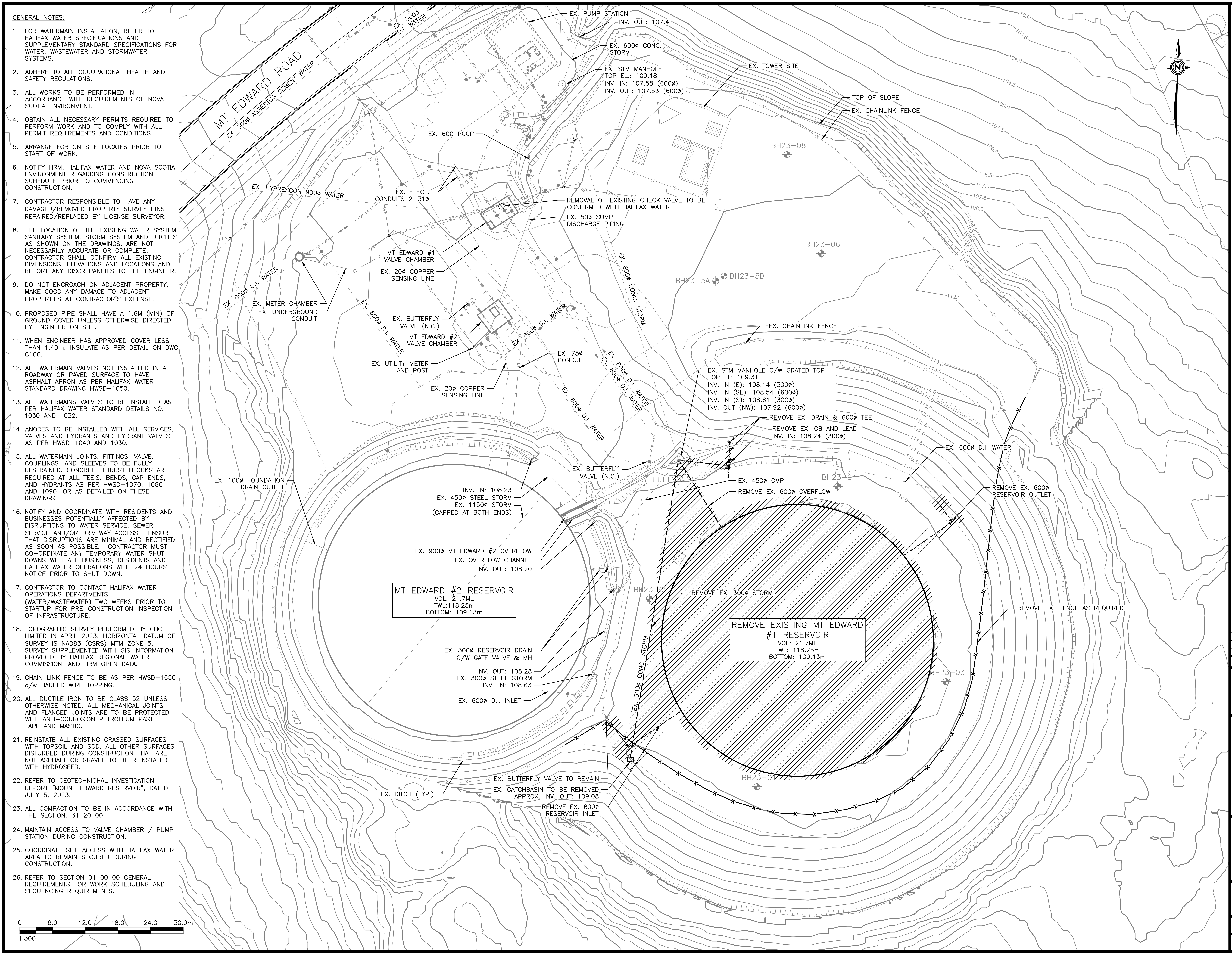
FEBRUARY 14 2024

DRAWING NAME: \\CBCL.LAN\CBCL\HALIFAX\DATA\PROJECTS\2023\231007.00 HW MOUNT EDWARD 1 RESERVOIR\44 CAD\01 CIVIL\03 DRAWING SHEETS\231007.00 – COVER.DWG LAYOUT NAME: C00 COVER PLOT DATE: Wednesday, February 14, 2024 3:49:34 PM CAD OPERATOR: KLINEHAN

DRAWING NAME: \\CBCL.LAN\CBCL\HALIFAX\DATA\PROJECTS\2023\231007.00 HW MOUNT EDWARD 1 RESERVOIR\44 CAD\01 CIVIL\03 DRAWING SHEETS\231007.00 EXISTING AND PROP CONDITIONS SHEET.DWG LAYOUT NAME: C101 EXISTING CONDITIONS AND REMOVALS PLOT DATE: Wednesday, February 14, 2024 4:11:13 PM CAD OPERATOR: KLINEHAN

GENERAL NOTES:

1. FOR WATERMAIN INSTALLATION, REFER TO HALIFAX WATER SPECIFICATIONS AND SUPPLEMENTARY STANDARD SPECIFICATIONS FOR WATER, WASTEWATER AND STORMWATER SYSTEMS.
2. ADHERE TO ALL OCCUPATIONAL HEALTH AND SAFETY REGULATIONS.
3. ALL WORKS TO BE PERFORMED IN ACCORDANCE WITH REQUIREMENTS OF NOVA SCOTIA ENVIRONMENT.
4. OBTAIN ALL NECESSARY PERMITS REQUIRED TO PERFORM WORK AND TO COMPLY WITH ALL PERMIT REQUIREMENTS AND CONDITIONS.
5. ARRANGE FOR ON SITE LOCATES PRIOR TO START OF WORK.
6. NOTIFY HRM, HALIFAX WATER AND NOVA SCOTIA ENVIRONMENT REGARDING CONSTRUCTION SCHEDULE PRIOR TO COMMENCING CONSTRUCTION.
7. CONTRACTOR RESPONSIBLE TO HAVE ANY DAMAGED/REMOVED PROPERTY SURVEY PINS REPAIRED/REPLACED BY LICENSE SURVEYOR.
8. THE LOCATION OF THE EXISTING WATER SYSTEM, SANITARY SYSTEM, STORM SYSTEM AND DITCHES AS SHOWN ON THE DRAWINGS, ARE NOT NECESSARILY ACCURATE OR COMPLETE. CONTRACTOR SHALL CONFIRM ALL EXISTING DIMENSIONS, ELEVATIONS AND LOCATIONS AND REPORT ANY DISCREPANCIES TO THE ENGINEER.
9. DO NOT ENCROACH ON ADJACENT PROPERTY, MAKE GOOD ANY DAMAGE TO ADJACENT PROPERTIES AT CONTRACTOR'S EXPENSE.
10. PROPOSED PIPE SHALL HAVE A 1.6M (MIN) OF GROUND COVER UNLESS OTHERWISE DIRECTED BY ENGINEER ON SITE.
11. WHEN ENGINEER HAS APPROVED COVER LESS THAN 1.40m, INSULATE AS PER DETAIL ON DWG C106.
12. ALL WATERMAIN VALVES NOT INSTALLED IN A ROADWAY OR PAVED SURFACE TO HAVE ASPHALT APRON AS PER HALIFAX WATER STANDARD DRAWING HWSD–1050.
13. ALL WATERMAINS VALVES TO BE INSTALLED AS PER HALIFAX WATER STANDARD DETAILS NO. 1030 AND 1032.
14. ANODES TO BE INSTALLED WITH ALL SERVICES, VALVES AND HYDRANTS AND HYDRANT VALVES AS PER HWSD–1040 AND 1030.
15. ALL WATERMAIN JOINTS, FITTINGS, VALVE, COUPLINGS, AND SLEEVES TO BE FULLY RESTRAINED. CONCRETE THRUST BLOCKS ARE REQUIRED AT ALL TEE'S. BENDS, CAP ENDS, AND HYDRANTS AS PER HWSD–1070, 1080 AND 1090, OR AS DETAILED ON THESE DRAWINGS.
16. NOTIFY AND COORDINATE WITH RESIDENTS AND BUSINESSES POTENTIALLY AFFECTED BY DISRUPTIONS TO WATER SERVICE, SEWER SERVICE AND/OR DRIVEWAY ACCESS. ENSURE THAT DISRUPTIONS ARE MINIMAL AND RECTIFIED AS SOON AS POSSIBLE. CONTRACTOR MUST CO–ORDINATE ANY TEMPORARY WATER SHUT DOWNS WITH ALL BUSINESS, RESIDENTS AND HALIFAX WATER OPERATIONS WITH 24 HOURS NOTICE PRIOR TO SHUT DOWN.
17. CONTRACTOR TO CONTACT HALIFAX WATER OPERATIONS DEPARTMENTS (WATER/WASTEWATER) TWO WEEKS PRIOR TO STARTUP FOR PRE–CONSTRUCTION INSPECTION OF INFRASTRUCTURE.
18. TOPOGRAPHIC SURVEY PERFORMED BY CBCL LIMITED IN APRIL 2023. HORIZONTAL DATUM OF SURVEY IS NAD83 (CSRS) MTM ZONE 5. SURVEY SUPPLEMENTED WITH GIS INFORMATION PROVIDED BY HALIFAX REGIONAL WATER COMMISSION, AND HRM OPEN DATA.
19. CHAIN LINK FENCE TO BE AS PER HWSD–1650 c/w BARBED WIRE TOPPING.
20. ALL DUCTILE IRON TO BE CLASS 52 UNLESS OTHERWISE NOTED. ALL MECHANICAL JOINTS AND FLANGED JOINTS ARE TO BE PROTECTED WITH ANTI–CORROSION PETROLEUM PASTE, TAPE AND MASTIC.
21. REINSTATE ALL EXISTING GRASSED SURFACES WITH TOPSOIL AND SOD. ALL OTHER SURFACES DISTURBED DURING CONSTRUCTION THAT ARE NOT ASPHALT OR GRAVEL TO BE REINSTATED WITH HYDROSEED.
22. REFER TO GEOTECHNICHAL INVESTIGATION REPORT "MOUNT EDWARD RESERVOIR", DATED JULY 5, 2023.
23. ALL COMPACTION TO BE IN ACCORDANCE WITH THE SECTION. 31 20 00.
24. MAINTAIN ACCESS TO VALVE CHAMBER / PUMP STATION DURING CONSTRUCTION.
25. COORDINATE SITE ACCESS WITH HALIFAX WATER AREA TO REMAIN SECURED DURING CONSTRUCTION.
26. REFER TO SECTION 01 00 00 GENERAL REQUIREMENTS FOR WORK SCHEDULING AND SEQUENCING REQUIREMENTS.



PLAN LEGEND

EXISTING		PROPOSED
	WATER MAIN	
⊗	WATER VALVE	⊗
	FIRE HYDRANT	
19mmC ▼	SERVICE CONNECTIONS	
	COMBINED MANHOLE & PIPE	
	STORM MANHOLE & PIPE	
	SANITARY MANHOLE & PIPE	
	CATCH BASIN	
ET ET ET	U/G CONDUIT	ET ET ET
O/H O/H O/H O/H	OVERHEAD POWERLINE	O/H O/H O/H O/H
X X	FENCE LINE	
	PROPERTY LINE	
	TOP OF SLOPE	
	BOTTOM OF SLOPE	
99.0	MAJOR CONTOUR	
98.75	MINOR CONTOUR	
	SITE BOUNDARY	
○	WATER CHAMBER	○
	LIGHT POLE	
○UP	UTILITY POLE	
//////	REMOVAL	
	ABANDONMENTS	
▨	BUILDING	

No.	DESCRIPTION	DATE	BY	CHKD
A	ISSUED FOR PRELIMINARY REVIEW	FEB 14/24		

CBCL

Halifax Water

ENGINEERING DEPARTMENT

PROJECT
MOUNT EDWARD #1 RESERVOIR
REPLACEMENT
EXISTING CONDITIONS AND REMOVALS

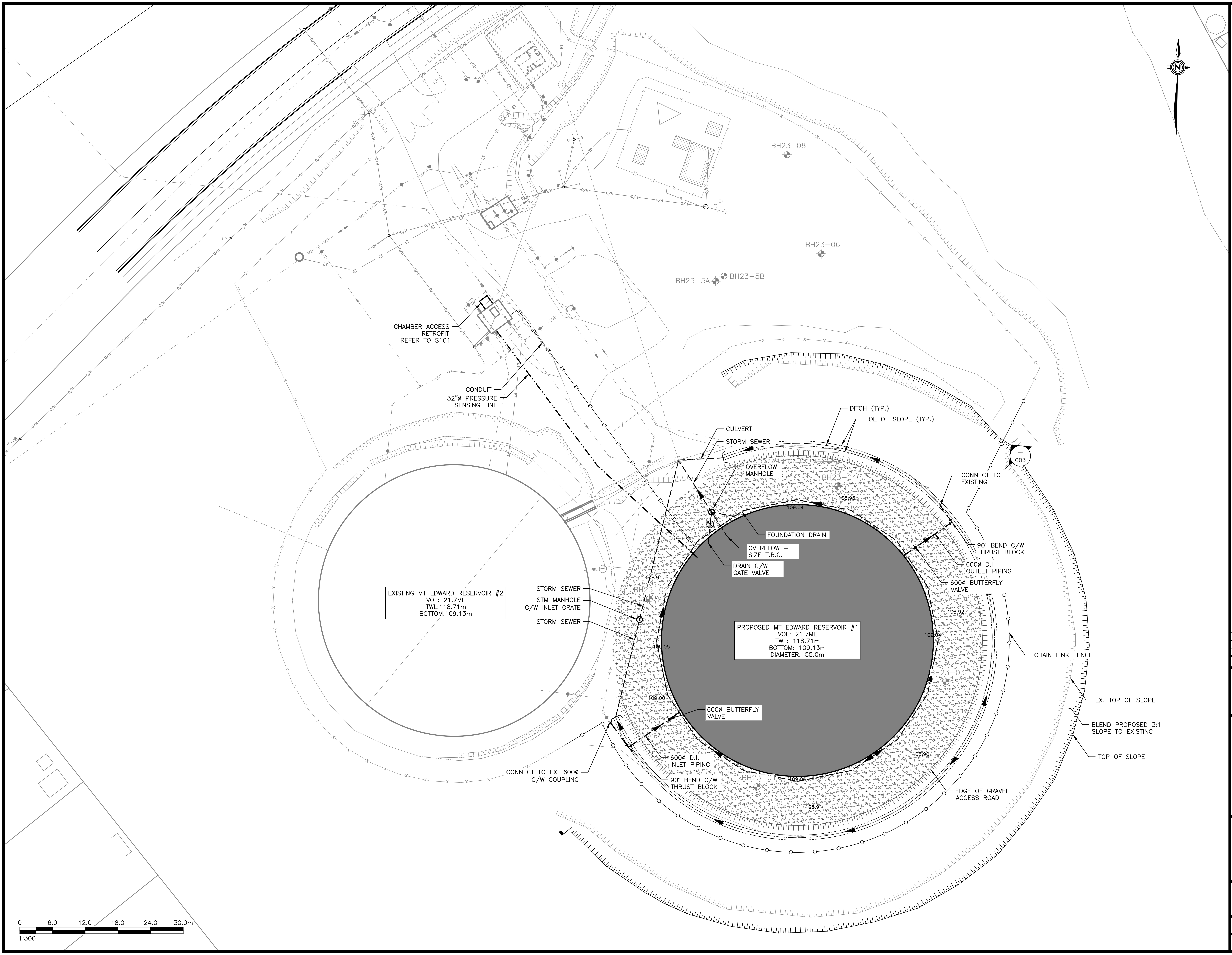
DRAWN	KL	SCALE (PLAN)	AS NOTED
CHECKED	SP	SCALE (PROFILE)	AS NOTED
APPROVED	JC	DATE	FEB 14/24

PROJECT No. P32.2022

DWG. No. C101

CBCL No. 231007.00

DRAWING NAME: \\CBCL.LAN\CBCL\HALIFAX\DATA\PROJECTS\2023\231007.00 HW MOUNT EDWARD 1 RESERVOIR\44 CAD\01 CIVIL\03 DRAWING SHEETS\231007.00 EXISTING AND PROP CONDITIONS SHEET.DWG LAYOUT NAME: C102 PROPOSED SITE PLAN PLOT DATE: Wednesday, February 14, 2024 4:25:42 PM CAD OPERATOR: KLINEHAN



PLAN LEGEND

EXISTING		PROPOSED
—▷—··—	WATER MAIN	━••━▶━••━
⊗	WATER GATE VALVE	⊗
✛	FIRE HYDRANT	✛
19mmC ▼	SERVICE CONNECTIONS	
⊗	STORM GATE VALVE	⊗
—▷—○—	STORM MANHOLE & PIPE	—▶—○—
—□—	SANITARY MANHOLE & PIPE	—■—
—▷—□—	CATCH BASIN & PIPE	—▶—□—
— ET — ET — ET —	U/G CONDUIT	— ET — ET — ET —
— O/H — O/H — O/H — O/H —	OVERHEAD POWERLINE	— O/H — O/H — O/H — O/H —
—X—X—	FENCE LINE	—x—x—x—x—x—x—
━ ━ ━	PROPERTY LINE	
┬┬┬┬┬┬┬┬	TOP OF SLOPE	
━━━━	BOTTOM OF SLOPE	
—99.0—	MAJOR CONTOUR	
—98.75—	MINOR CONTOUR	
	SITE BOUNDARY	
○	WATER CHAMBER	○
○—□	LIGHT POLE	
○UP	UTILITY POLE	
//////	REMOVAL	
▨	BUILDING	

NOTES:
1. SEE DRAWING C01 FOR GENERAL NOTES.

No.	DESCRIPTION	DATE	BY	CHKD
A	ISSUED FOR PRELIMINARY REVIEW	FEB 14/24		

CBCL

Halifax
Water

ENGINEERING DEPARTMENT

PROJECT
MOUNT EDWARD #1 RESERVOIR
REPLACEMENT
PROPOSED SITE PLAN
WELDED STEEL TANK

DRAWN	KL	SCALE (PLAN)	AS NOTED
CHECKED	SP	SCALE (PROFILE)	AS NOTED
APPROVED	JC	DATE	FEB 14/24

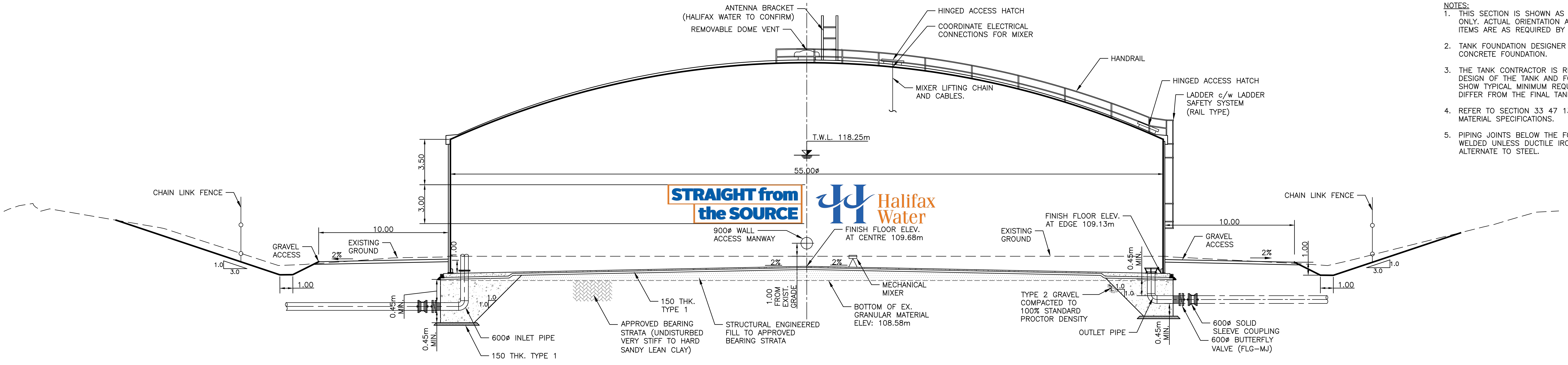
PROJECT No. P32.2022

DWG. No. C102

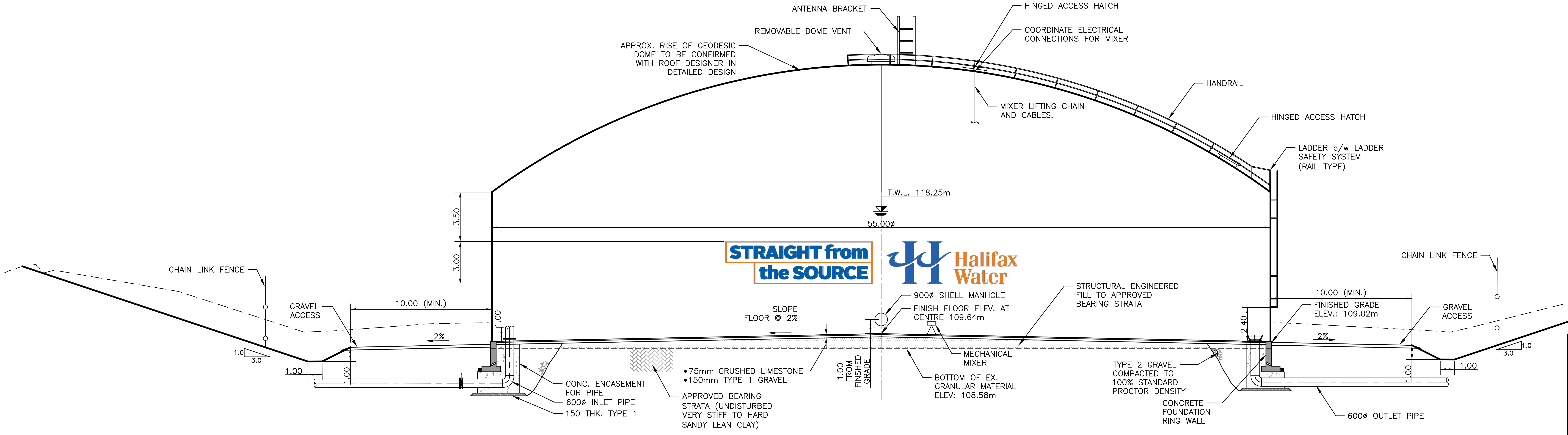
CBCL No. 231007.00

NOTES:

1. THIS SECTION IS SHOWN AS A SCHEMATIC DIAGRAM ONLY. ACTUAL ORIENTATION AND LOCATIONS FOR ALL ITEMS ARE AS REQUIRED BY THE TANK CONTRACTOR.
2. TANK FOUNDATION DESIGNER TO CONFIRM DETAILS OF CONCRETE FOUNDATION.
3. THE TANK CONTRACTOR IS RESPONSIBLE FOR THE DESIGN OF THE TANK AND FOUNDATIONS. DRAWINGS SHOW TYPICAL MINIMUM REQUIREMENTS AND MAY DIFFER FROM THE FINAL TANK DESIGN.
4. REFER TO SECTION 33 47 13 FOR DESIGN AND MATERIAL SPECIFICATIONS.
5. PIPING JOINTS BELOW THE FOUNDATION SHALL BE WELDED UNLESS DUCTILE IRON IS ACCEPTED AS AN ALTERNATE TO STEEL.



SECTION–PRE-STRESSED CONCRETE TANK
1:150



SECTION–WELDED STEEL TANK
1:150

No.	DESCRIPTION	DATE	BY	CHKD
A	ISSUED FOR PRELIMINARY DESIGN	JAN 14/24		

CBCL

Halifax Water

ENGINEERING DEPARTMENT

PROJECT
MOUNT EDWARD #1 RESERVOIR
REPLACEMENT
RESERVOIR PLAN AND SECTION

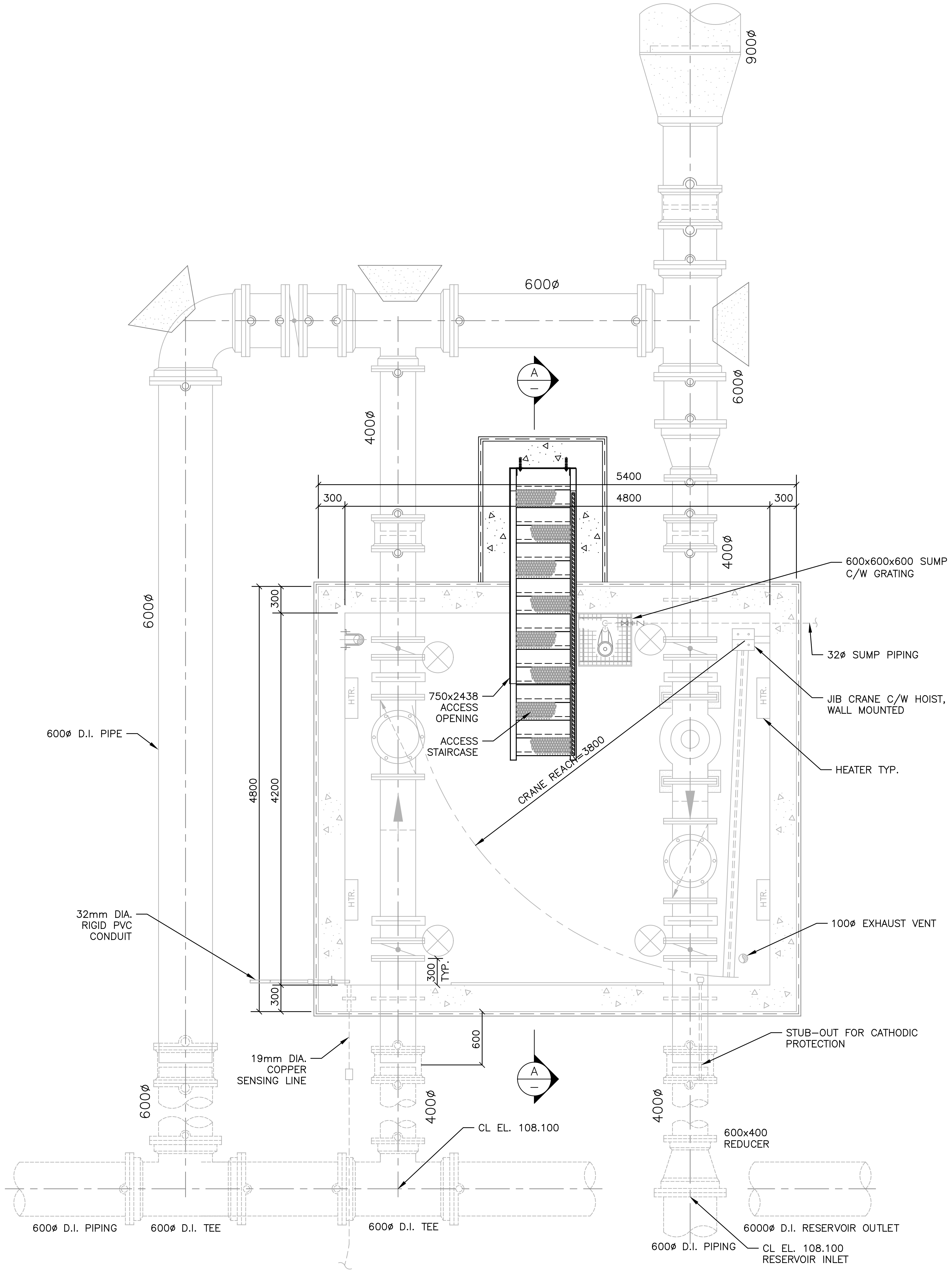
DRAWN	KL	SCALE (PLAN)	AS NOTED
CHECKED	SP	SCALE (PROFILE)	AS NOTED
APPROVED	JC	DATE	FEB 14/24

PROJECT No. P32.2022

DWG. No. C103

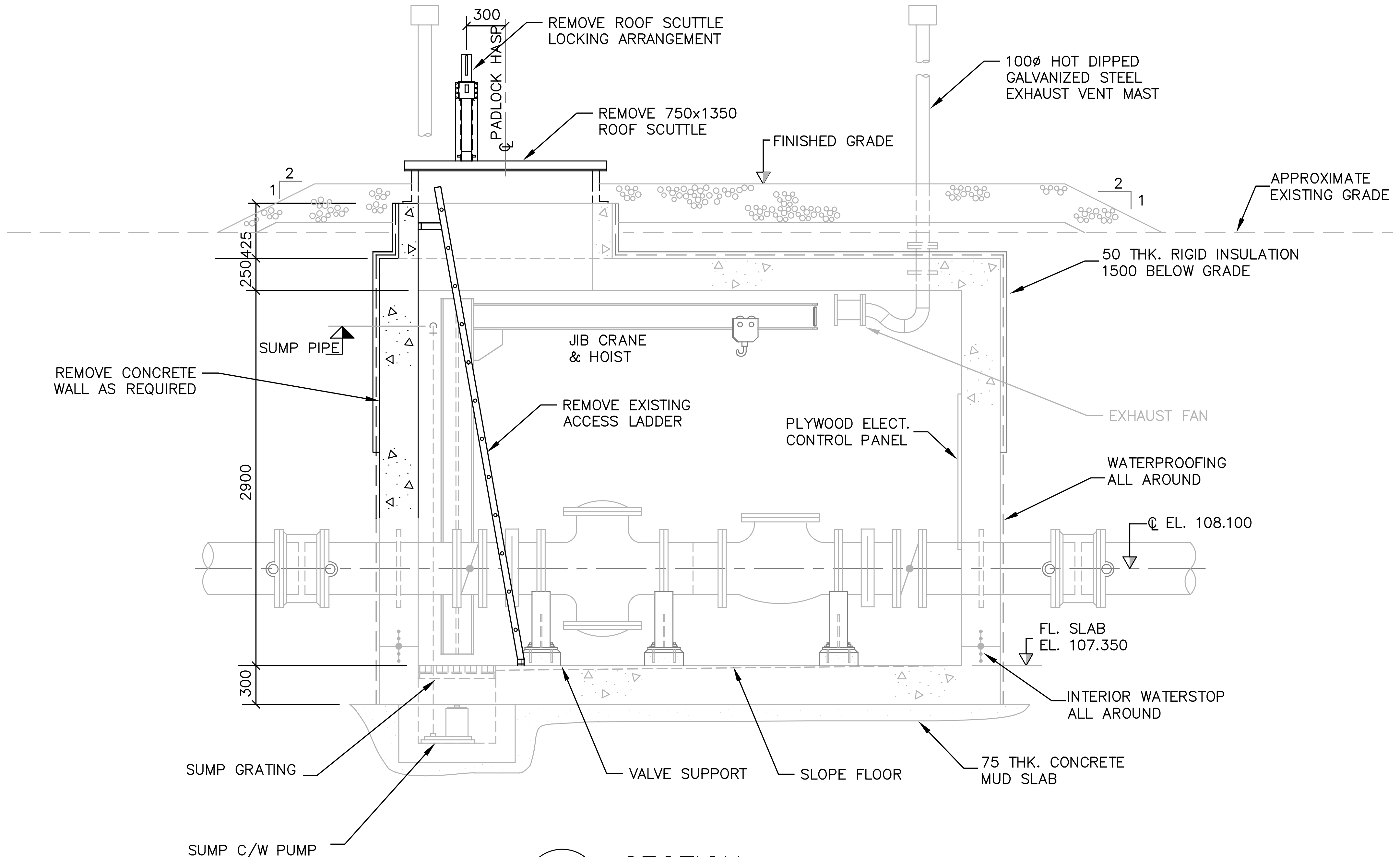
CBCL No. 213007.00

DRAWING NAME: \\CBCL.LAN\CBCL\HALIFAX\DATA\PROJECTS\2023\231007.00 HW MOUNT EDWARD 1 RESERVOIR\44 CAD\01 CIVIL\03 DRAWING SHEETS\231007.00 – RESERVOIR SECTIONS.DWG LAYOUT NAME: C103 RESERVOIR PLAN AND SECTION PLOT DATE: Wednesday, February 14, 2024 4:12:52 PM CAD OPERATOR: KLINEHAN



PLAN–FLOW CONTROL CHAMBER

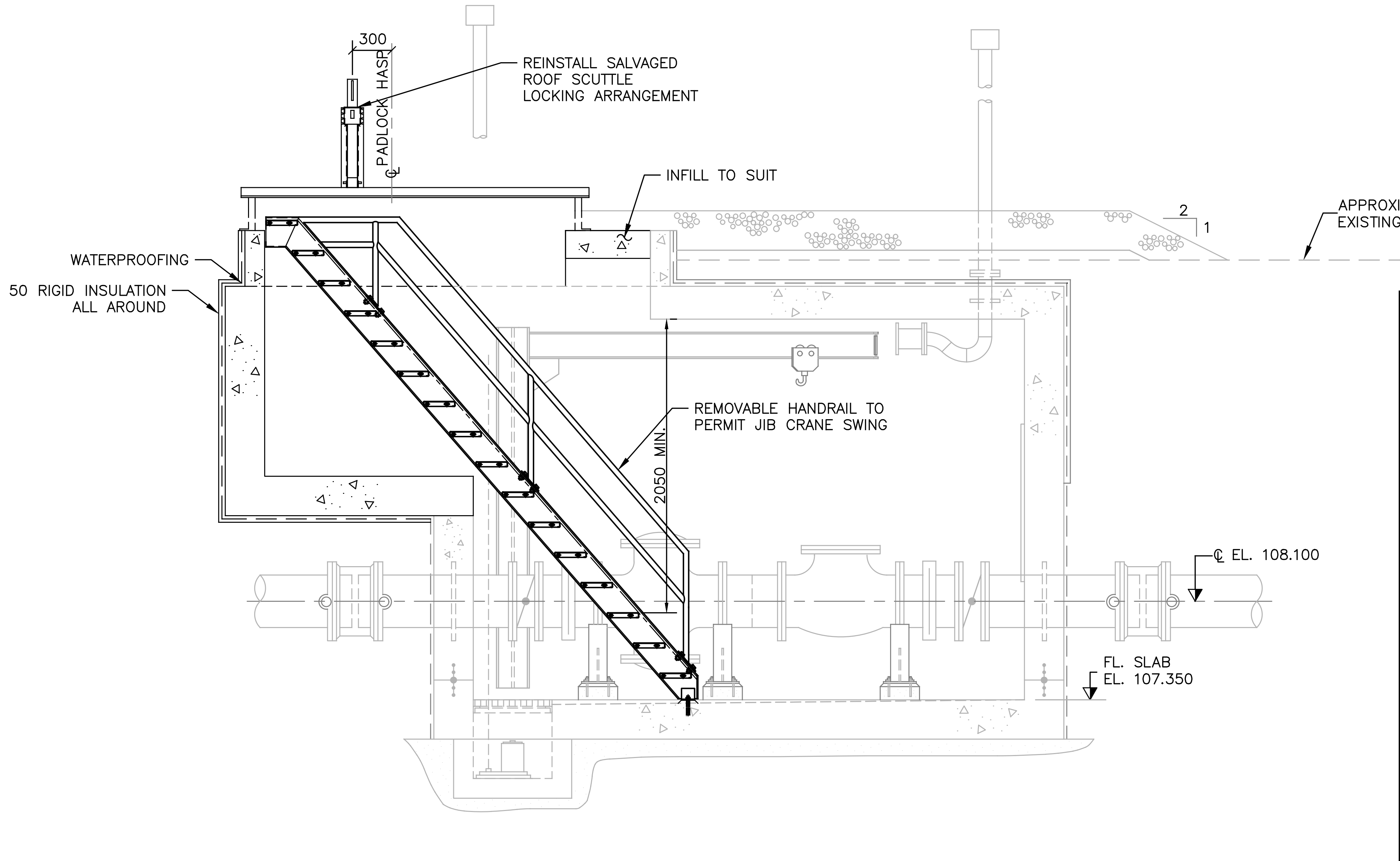
1:30



A

SECTION–EXISTING AND REMOVALS

1:30 NOTE: REMOVALS ARE BOLD THIS SECTION



B

SECTION–RETROFITS

1:30

No.	DESCRIPTION	DATE	BY	CHKD
A	ISSUED FOR PRELIMINARY DESIGN	FEB 14/24		

CBCL

Halifax Water

ENGINEERING DEPARTMENT

PROJECT
MOUNT EDWARD #1 RESERVOIR
REPLACEMENT
CONTROL CHAMBER ACCESS RETROFITS

DRAWN KL
CHECKED SP
APPROVED JC
SCALE (PLAN) AS NOTED
SCALE (PROFILE) AS NOTED
DATE FEB 14/24
PROJECT No. P32.2022
DWG. No. S101

CBCL No. 213007.00

APPENDIX B

Geotechnical Report

Geotechnical Investigation (Rev. 3)

Halifax Water

Mount Edward Reservoir

Project 231007.00 • September 1, 2023

Rev.	Issue	Reviewed By:	Date	Issued By:
3	Report Rev. 3	KL	1-Sep-2023	MA
2	Report Rev. 2	KL	31-Jul-2023	MA
1	Final Report	KL	5-Jul-2023	MA

CBCL

REGISTERED PROFESSIONAL ENGINEER
Date: 2023-09-01
M. Ashari Ghomi
20200547
PROVINCE OF NOVA SCOTIA

Project No. 231007.00

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C Laboratory Test Results

1 Introduction

CBCL Limited (CBCL) has conducted a geotechnical investigation for the replacement or relocation of an existing water reservoir tank located on Mount Edward Road, in Dartmouth, NS. The site is located within the boundaries of PID 00196360. The purpose of the geotechnical investigation was to observe the subsurface conditions at the location of the reservoir tank and provide geotechnical recommendations for foundation design.

Between May 17th and 19th, 2023, CBCL conducted a geotechnical investigation for the proposed water reservoir tank structures on the property. The site's location is shown in Borehole Location Plan, Appendix A.

This report has been prepared for the sole benefit of Halifax Water and was prepared specifically for the subject site. The findings and recommendations contained in this report should not be extrapolated beyond the area investigated.

2 Site Description and Geology

The site is located on Mount Edward Rd, in Dartmouth, Nova Scotia, as shown in Borehole Location Plan, Appendix A.

Currently, two water reservoir tanks are located on the subject site. One of the reservoir tanks (the tank on the east) shows signs of structural cracks and is planned to be replaced. The replacement tank is proposed to be placed either at the existing tank location or moved to the North of the existing tank location.

Based on geological mapping, the site's bedrock geology is mapped as part of the Meguma Group, Halifax Formation. The formation consists of slope-outer slate, siltstone, minor sandstone and Fe-Mn nodules (Keppie 2000). The site is located at the boundary of two geological soil units, Silty Till Plain and Stony Till Plain. The Silty Till Plain is described as silty compact material derived from local and distant sources. The Stony Till Plain is described as a stony and sandy matrix with material derived from local bedrock sources (Stea et al., 1992).

3 Fieldwork Procedure

The field program consisted of drilling eight (8) boreholes (BH23-01 to BH23-04, BH23-05A, BH23-05B, BH23-06 and BH23-08) at seven (7) locations and installation of one (1) monitoring well at the location of BH23-06. Pipes were laid out in the field at and around the proposed location of BH23-07 (4948211 m E, 459583 m N), and the drill could not access that location. Boreholes were drilled, and the monitoring well was installed between May 17th to May 19th, 2023. The approximate borehole locations and the preliminary location of the proposed structures are shown in Borehole Location Plan, Appendix A.

Borehole drilling was performed by Nova Drilling Group of Mount Uniacke, Nova Scotia, using a CME-45 drill rig mounted on a trailer. Upon drilling completion, boreholes were backfilled to the surface using sand and drill cuttings.

Borehole locations were selected based on the proposed location of the reservoir tank and located using Trimble surveying equipment with 0.1 m accuracy. The borehole and monitoring well coordinates, elevations and final depths are provided in Table 3.1 below.

Table 3.1 Borehole Locations and Depths

Location	Northing[1] (m)	Easting[1] (m)	Ground Elevation[2] (m)	Borehole Depth (m)
BH23-01	4948126.3	459529.9	110.5	5.2
BH23-02	4948165.0	459508.7	110.3	6.1
BH23-03	4948147.0	459568.8	110.6	7.3
BH23-04	4948187.2	459547.5	110.3	6.4
BH23-05A	4948229.5	459523.4	112.0	3.1
BH23-05B	4948230.5	459525.1	112.0	8.3
BH23-06	4948234.7	459545.0	112.2	18.4
BH23-08	4948255.0	459538.4	111.9	8.9

Notes: [1] Coordinate System: NAD83, UTM Zone 20T
[2] Geodetic Datum: CGVD13

Sampling in overburden soils consisted of split-spoon sampling (51-mm outer sampler diameter) with Standard Penetration Testing (SPT) based on the procedures discussed in ASTM D1586.

The soil samples were classified and logged in the field by visual examination according to the Standard Practice for Description and Identification of Soils (Visual-Manual Procedures), ASTM D2488. Groundwater levels were observed in the monitoring well. Detailed descriptions of the soil and rock encountered are provided in the attached Borehole Records, Appendix B.

Following completion of the fieldwork, the soil and rock core samples were returned to our laboratory in Bedford, where additional testing and evaluation was carried out. The soil samples will be stored in the laboratory for a maximum of three months after this report's date and then discarded.

4 Summarized Subsurface Conditions

The soil classification methodology used on the Borehole Records is based on visual-manual field observations and laboratory testing in general accordance with American Society for Testing and Materials (ASTM) standard test methods D2488 and D2487. These methods provide for a descriptive classification of soils based on engineering properties and which is referenced in many geotechnical engineering design approaches and literature.

The subsurface conditions encountered in the boreholes are summarized in Table 4.1 and presented in the Borehole Records in Appendix B.

Table 4.1 Summary of Starta Encountered

Location	Fill Thickness (m)	Till Thickness (m)	Top of Till Elevation (m)	Top of Bedrock Elevation (m)
BH23-01	1.5[1]	>3.7[2]	109.0	-
BH23-02	1.5[1]	>4.6[2]	108.8	-
BH23-03	1.5[1]	>5.8[2]	109.1	-
BH23-04	2.1[1]	>4.3[2]	108.2	-
BH23-05A	3.1	-	-	-
BH23-05B	-	>5.2[2]	108.9	-
BH23-06	4.7	12.0	107.5	95.5
BH23-08	4.7	>4.2[2]	107.2	-

Notes: [1] Includes a 0.1 m layer of Topsoil
[2] A thicknesses shown with a greater than sign (>) means the borehole was terminated within this strata

Borehole Records (Appendix B) and Table 4.1 represent our interpretation of the soil conditions based on observations of the samples obtained and the drilling methods. Stratification lines on the Borehole Records and Table 4.1 represent approximate boundaries between the soil types. The actual boundaries may be different, and/or there may be a gradual transition between the soil layers.

The following paragraphs provide further discussion on the strata encountered.

4.1 Fill

At all borehole locations, a layer of fill, 1.5 m to 4.7 m thick, was observed at the ground surface. This layer was between 1.5 m to 2.1 m around the existing tank location and increased in thickness (3.1 m to 4.7 m) at the locations of BH23-05A to BH23-08. A thin layer of topsoil (0.1 m thick) was observed near the surface around the existing tank location. The fill was generally described as compact silty SAND with gravel to very stiff to hard sandy lean CLAY with gravel, reddish brown in colour and dry to moist with trace amounts of cobbles and/or boulders.

Moisture content tests were conducted on thirteen (13) samples in this layer. The average moisture content from the laboratory results for this layer is 10.9% with a minimum of 4.3% and a maximum of 23.3%. The moisture content results are shown on the appended Borehole Records.

4.2 Till

Under the fill layer, a layer of till was encountered in all borehole locations. This layer generally consisted of hard, moist, brown sandy lean CLAY with gravel. Trace amount of cobbles and/or boulders were observed in this layer. Most boreholes were terminated in this layer. Borehole BH23-06 was advanced past this layer into the bedrock and recorded a layer thickness of 12.0 m.

Four sieve analysis tests conducted on this layer showed 3% to 17% gravel, 32% to 39% sand, and 52% to 58% fines. Atterberg limits test conducted on four samples of this layer showed a Liquid Limit of 23 to 26 and a Plastic Limit of 13 to 14. The corresponding Plasticity Index is between 9 to 13. The results are indicative of low plasticity or sandy lean CLAY with gravel which were consistent with our visual observations.

Moisture content tests were conducted on thirty (30) samples in this layer. The average moisture content from the laboratory results for this layer is 10.3% with a minimum of 7.7% and a maximum of 13.1%. The moisture content results are shown on the appended Borehole Records.

4.3 Bedrock

Bedrock was encountered at BH23-06 at the depth of 16.8 m. The bedrock was described as weak to medium strong, slightly to moderately weathered, very severely fractured, grey SILTSTONE.

4.4 Groundwater

Groundwater was measured in the monitoring well at the location of BH23-06. The groundwater was recorded at 5.9 mbgs (metres below ground surface) on May 18th, 2023. Groundwater levels should be expected to fluctuate seasonally, with precipitation, site development, and/or construction activity.

5 Discussions and Recommendations

5.1 Main Findings

It is understood that a new water reservoir tank is being proposed at the subject site. The replacement tank will be the same size as the existing tank. The location of the replacement tank will be either at the exact location of the existing tank or North of the existing tank. Also, the elevation of the proposed tank will be the same as the existing tanks, so if the tank is placed north of the existing tanks, the existing grade should be lowered. We request to be contacted to make appropriate changes to our recommendations based on the final size, material type and location of the reservoir tank.

Generally, a reservoir tank placed on a layer of Structural Engineered Fill (SEF) over the native till should be appropriate in this area. However, other factors, such as ground slope, should be considered in the final geotechnical design of the reservoir tank.

The following sections outline further our preliminary geotechnical recommendations for site preparation and geotechnical design.

5.2 Earthworks

Earthworks for this project will involve excavating the top layer of fill, followed by reinstatement using SEF to the design grade. The excavation footprint should extend beyond the tank's perimeter by an amount equivalent to the thickness of the SEF plus two meters.

5.2.1 Surface Water and Erosion Control

Prior to excavations, surface water drainage controls should be provided to minimize run-off onto exposed soils and/or into excavations. Suitable erosion and sedimentation control measures should be employed. These may include silt fences, check dams in ditches, and granular working pads.

5.2.2 Excavation

Within the proposed excavation footprint, the top fill layer should be removed down to the very stiff to hard sandy lean CLAY till layer. Any additional softened areas that manifest during construction should also be excavated. The base of the excavation should extend laterally beyond the outside perimeter of the tank foundation to accommodate a 45-degree splay. Replace excavated soils with SEF to the underside of the tank ring wall footings and the underside of the tank floor. SEF materials should be placed and compacted in thin lifts using the materials recommended in the relevant SEF section of this report.

Since the existing tank is not showing any sign of geotechnical failure, the fill underneath it might consist of suitable material and compaction. However, we are not able to investigate the fill underneath before the demolition of the tank. We might be able to reduce the excavation and reinstatement effort by investigating the fill after the demolition.

The trench depth for the watermain system should accommodate a minimum cover of 1.5 m over the pipe from finished grade or equivalent insulation provided for frost protection. Compacted Type1 Gravel pipe bedding should be provided below the pipe invert and extend up to the spring line. The pipe bedding should extend 300 mm beyond the pipe surface. Backfill over the pipe should be select material generally having a grain size less than 50 mm unless otherwise approved by the pipe manufacturer. The trench should be backfilled with appropriate material and compacted in a way that does not damage the pipe.

Temporary excavated side slopes above the depth of the groundwater table should be stable at one horizontal to one vertical (1H:1V) for excavations not more than 2 m in depth. Excavations below the groundwater level or deeper than 2 m should be reviewed during construction and flattened as needed to safely accommodate site conditions. Once the final location of the tank is determined, we wish to review the temporary slopes and adjust our recommendations.

5.2.3 Dewatering of Excavations

The contractor undertaking the earthworks must be prepared to dewater excavations. Footings and structural engineered fill should not be placed in standing water, slough, or over softened bearing soils.

Discharge from the dewatering activities must be carried out in strict accordance with environmental regulations.

5.2.4 Structural Fill Placement and Compaction

Structural engineered fill will be required for the proposed structures and is recommended to consist of well-graded clean sand/gravel materials obtained from:

- approved, imported rockfill/gravel, or;
- approved, imported sand and gravel pit run.

Approval of selected SEF material should be carried out by a geotechnical engineer before proceeding with construction. The department of public works has specifications for many acceptable materials.

It is recommended to place SEF at or near the optimum moisture content and compact to 100% of the standard Proctor maximum dry density (ASTM D698). Placing SEF at moisture contents much more than the optimum value often results in material that has zero air voids, making it susceptible to softening and potential frost heave if freezing follows shortly after it is placed.

The lift thickness used during the placement of SEF must be compatible with the compaction equipment and the material type to ensure the specified density is achieved throughout. For preliminary consideration, the lift thickness should not exceed approximately 300 mm for mass filling and 200 mm for trench work. The maximum particle size should be no larger than ⅔ of the lift thickness. These criteria can be reviewed at the time of construction and adjusted to suit the prevailing site conditions and construction equipment/methods.

Ideally, foundation walls should be backfilled on both sides simultaneously to prevent unbalanced earth pressures that would damage the wall. Otherwise, foundation walls should be designed to account for lateral earth and compaction equipment pressures.

To prevent the migration of fines from the native clay soils into granular SEF backfills, it is recommended to separate dissimilarly graded soils using a filter fabric such as Terrafix 270R or equivalent.

5.2.5 Winter Construction

Earthworks undertaken during freezing conditions result in a higher risk of poor work quality than earthworks carried out during more favourable non-winter conditions. Special procedures and precautions should be exercised to mitigate quality issues. Even with the best intentions and when typical construction practices are followed, problems (to varying degrees) related to freezing soils are experienced. The best practice is to carry out earthworks in dry conditions during seasons that have continuous ambient temperatures above zero degrees Celsius. Impacts on earthworks and foundations constructed in the winter are practically unavoidable.

Should the construction of this project be undertaken in the winter, please contact us to discuss mitigation measures to be considered.

5.2.6 Inspection and Testing

It is recommended that inspection of all bearing surfaces be conducted by experienced geotechnical personnel prior to placement of concrete and tank floor. Inspection and testing are also recommended during site grading and backfilling operations.

5.3 Foundations

A foundation system consisting of a circular strip foundation system for the reservoir founded on structural engineered fill would be suitable.

5.3.1 Reservoir Foundation System

It is our understanding that the existing tank is cylindrical in shape with a diameter of 55.4 m and an approximate water height of 10 m. The proposed replacement tank is expected to be the same size and built at the same elevation of the existing tanks. Two candidate locations are chosen for the replacement tank. One is the current location of the existing tank, and the other is the North of the existing tanks. It is assumed the perimeter of the proposed tank is placed on a concrete ring-wall on a spread footing. It is recommended that the fill under the footing be removed and reinstated by SEF compacted to 100% of the standard Proctor maximum dry density (ASTM D698). The sub-excavation and reinstatement are assumed to extend radially beyond the tank perimeter by an amount equivalent to the thickness of the SEF plus two meters. If a new location is chosen for the tank, we will need to adjust our recommendations based on the soil properties in the new location and the size and elevation of the tank.

The recommended excavation under the reservoir tank floor and perimeter ring-wall should be backfilled with approved backfill material, as discussed in section 5.2.4. Further to the discussion of the section, a minimum of 150 mm of Type 1 (or similar) is recommended directly under the tank floor unless otherwise recommended by the tank manufacturer.

The predicted settlement of the tank after the initial tank filling (immediate elastic settlement), the post-filling long-term settlement (immediate settlement plus primary consolidation) and the differential settlement between the centre and permitter of the tank are shown in Table 5.1 and Table 5.2. The estimated settlement values in Table 5.1 are based on the assumption that a tank of a similar size, replaces the existing tank in the same location. The estimated settlement values in Table 5.2 are based on the assumption that a tank of similar size will be placed at the same elevation as the existing tanks but located to the North of the existing tanks, which means the grade should be lowered by 2 m in this area (2 m of fill is excavated). We request to be contacted to review the final design to check our assumptions.

Table 5.1 Estimated Settlement Values at Existing Tank Location

Estimated Immediate Elastic Settlement	Estimated Immediate Settlement and Primary Consolidation	Estimated Differential Settlement (Between Centre and Perimeter)
70 mm @ centre 30 mm @ perimeter	70 mm @ centre 30 mm @ perimeter	Immediate: 40 mm Long-Term: 40 mm

Note: Assumed soil has gone through long-term settlement (consolidation) at this location.

Table 5.2 Estimated Settlement Values North of Existing Tank Location

Estimated Immediate Elastic Settlement	Estimated Immediate Settlement and Primary Consolidation	Estimated Differential Settlement (Between Centre and Perimeter)
70 mm @ centre 30 mm @ perimeter	105 mm @ centre 50 mm @ perimeter	Immediate: 40 mm Long-Term: 55 mm

The factored geotechnical bearing resistance of the ring-wall footings should be limited to 225 kPa, assuming:

- the bearing layer to be ≥500 mm of SEF over undisturbed very stiff to hard sandy lean CLAY;
- minimum footing width of 600 mm;
- concentric loading; and,
- minimum of 1.5 m of embedment below ground surface.

The clay layer will be susceptible to softening and it may be required to cover it immediately after being exposed. Covering clay with a nominal layer of well-graded gravel or lean concrete can help mitigate the potential for being disturbed by construction activity.

5.3.2 Modulus of Subgrade Reaction

As long as subgrade of the tank is prepared according to 5.3.1, a modulus of subgrade reaction, k, of 100 MPa/m may be used for the tank design. This modulus corresponds to a 300 mm x 300 mm square bearing plate. The modulus of subgrade reaction adjusted for the effective area of the tank is 25 MPa/m.

5.4 Seismic Classification

The site classification for seismic site response was based on our geotechnical investigation.

The recommended site classification for seismic site response, as per Table 4.1.8.4.A of NBCC 2015, is Site Class D.

5.5 Additional Geotechnical Services

It is recommended that inspection of the footing bearing surfaces be conducted by a geotechnical engineer prior to placement of concrete. Inspection and testing are recommended during site grading and backfilling operations and road construction.

6 Closure

This report has been prepared for the sole benefit of the Client. All information, documentation, or other material contained in, attached to, or forming part of this report reflects CBCL's opinion and best judgment based on the information available to us at the time of preparation. Any use or reliance on this report by the Client in circumstances where there has been a change in site conditions or for any purpose not expressly intended by or delineated in this report shall be the sole responsibility of the Client and CBCL accepts no liability for such use or reliance. Any use or reliance on this report by any third party, without CBCL's prior express written consent, shall be the sole responsibility of that third party. CBCL accepts no liability whatsoever for such use or reliance.

The information and conclusions contained in this report are generally consistent with professional standards for engineering and scientific professionals providing similar services at the same time, in similar locations, and under similar circumstances.

A geotechnical field investigation is a limited sampling of a site. Some variation between sampling locations should be expected. The conclusions presented in this report represent the technical judgment of CBCL, based on the data obtained from the work and on CBCL's understanding of the project. The data obtained by CBCL is specific to the time the work was performed at the specific testing and/or sampling locations and can only be extrapolated to an undefined limited area surrounding these locations. The extent of the limited area depends on the soil and groundwater conditions, as well as the history of the site reflecting natural, construction, and other activities. Due to the nature of the investigation and the limited data available, CBCL cannot and does not warrant that undiscovered environmental liabilities and/or undetected subsurface conditions may not arise.

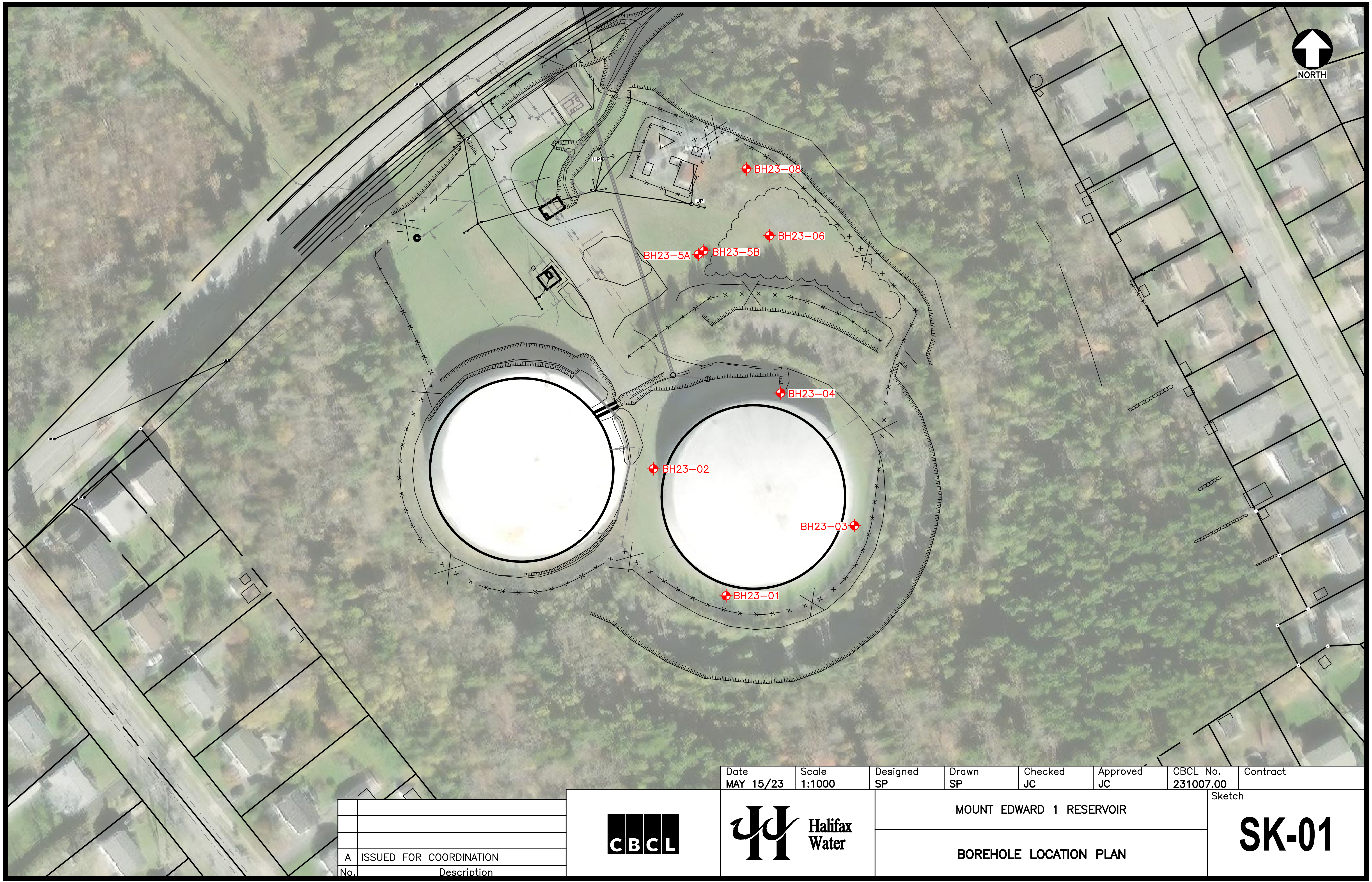
We trust this is the information you require at this time. We are available to discuss the contents of this report at your convenience. This report was prepared by Mohammad Ashari, M.A.Sc., P.Eng. and reviewed by Kris LeClair, P.Eng.

Respectfully submitted,

CBCL Limited

APPENDIX A

Borehole Location Plan



Date	Scale	Designed	Drawn	Checked	Approved	CBCL No.	Contract
MAY 15/23	1:1000	SP	SP	JC	JC	231007.00	

CBCL

Halifax Water

MOUNT EDWARD 1 RESERVOIR

BOREHOLE LOCATION PLAN

Sketch

SK-01

A	ISSUED FOR COORDINATION
No.	Description

DRAWING NAME: Y:\HALIFAX\DATA\PROJECTS\2023\231007.00 HW MOUNT EDWARD 1 RESERVOIR\44 CAD\01 CIVIL\04 SKETCHES\231007.00 – BOREHOLE LOCATION PLAN.DWG LAYOUT NAME: SK–01 PLOT DATE:June 27, 2023 10:17:41 AM CAD OPERATOR: MURRAYC

APPENDIX B

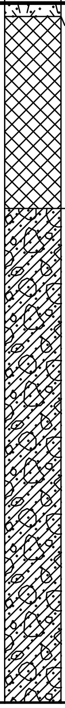
Borehole Records

RECORD OF BOREHOLE: BH23-01

PAGE 1 OF 1

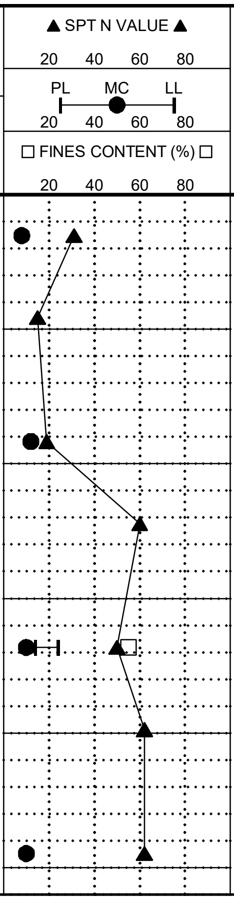
CLIENT Halifax Water
PROJECT NUMBER 231007.00
BORING START DATE 5/17/2023
BORING END DATE 5/17/2023
BORING CONTRACTOR Nova Drilling Inc.
BORING METHOD Solid Stem Auger

PROJECT NAME Mount Edward 1 Reservoir
PROJECT LOCATION Dartmouth, NS
GROUND ELEVATION 110.5 m **GWT DATE** -
DATUM CGVD2013
COORDINATES 4948126.3 m N; 459529.9 m E
LOGGED BY AS **CHECKED BY** MA



DEPTH SCALE (m)	WATER LEVEL(m)	GRAPHIC LOG	ELEVATION (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY SOIL (mm) ROCK (%)	SOIL ("N" VALUE) ROCK (RQD (%))	GRAIN SIZE DISTRIBUTION			WELL DIAGRAM
									Gravel (%)	Sand (%)	Fines (%)	
			110.5									
			110.4	Loose, brown, ROOTMAT and TOPSOIL								
				Compact/Very stiff to hard, brown, silty SAND with gravel to sandy lean CLAY with gravel: FILL - Dry to moist - Trace cobbles and/or boulders	SS	1	280	31				
1					SS	2	0	15				
			109.0									
2				Very stiff to hard, brown, sandy lean CLAY, trace gravel to sandy lean CLAY with gravel: TILL - Moist - Trace cobbles and/or boulders	SS	3	610	19				
					SS	4	410	60				
3												
					SS	5	610	50	5	39	55	
4					SS	6	320	62				
5			105.3		SS	7	340	62				

End of borehole at 5.2 m



RECORD OF BOREHOLE: BH23-02

PAGE 1 OF 1

CLIENT Halifax Water

PROJECT NAME Mount Edward 1 Reservoir

PROJECT NUMBER 231007.00

PROJECT LOCATION Dartmouth, NS

BORING START DATE 5/17/2023

GROUND ELEVATION 110.3 m **GWT DATE** -

BORING END DATE 5/17/2023

DATUM CGVD2013

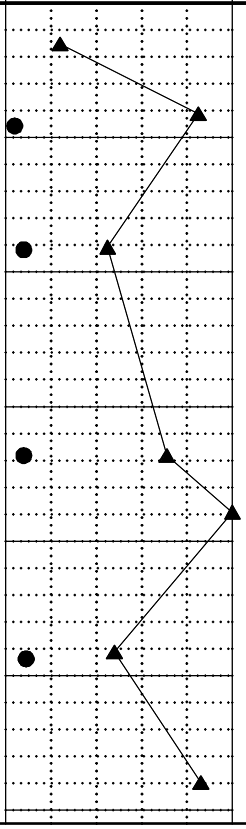
BORING CONTRACTOR Nova Drilling Inc.

COORDINATES 4948165.0 m N; 459508.7 m E

BORING METHOD Solid Stem Auger

LOGGED BY AS **CHECKED BY** MA

DEPTH SCALE (m)	WATER LEVEL(m)	GRAPHIC LOG	ELEVATION (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY SOIL (mm) ROCK (%)	SOIL ("N" VALUE) ROCK (RQD (%))	GRAIN SIZE DISTRIBUTION Gravel (%)	Sand (%)	Fines (%)	▲ SPT N VALUE ▲ 20 40 60 80 PL MC LL 20 40 60 80 ☐ FINES CONTENT (%) ☐ 20 40 60 80	WELL DIAGRAM
			110.3										
			110.2	Loose, brown, ROOTMAT and TOPSOIL									
				Compact/Very stiff to hard, reddish brown, silty SAND with gravel to sandy lean CLAY with gravel: FILL - Dry to moist - Trace cobbles and/or boulders - Trace organics	SS	1	250	24					
1					SS	2	290	85					
			108.8										
2				Hard, brown, sandy lean CLAY, trace gravel to sandy lean CLAY with gravel: TILL - Moist - Trace cobbles and/or boulders	SS	3	570	45					
3													
					SS	4	610	71					
4					SS	5	230	SSR					
5					SS	6	510	48					
6			104.2		SS	7	100	86					



End of borehole at 6.1 m

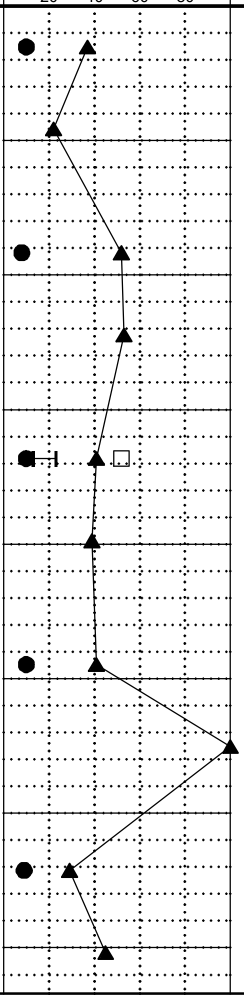
CBCL

RECORD OF BOREHOLE: BH23-03

PAGE 1 OF 1

CLIENT Halifax Water
PROJECT NAME Mount Edward 1 Reservoir
PROJECT NUMBER 231007.00
PROJECT LOCATION Dartmouth, NS
BORING START DATE 5/17/2023
GROUND ELEVATION 110.6 m **GWT DATE** -
BORING END DATE 5/17/2023
DATUM CGVD2013
BORING CONTRACTOR Nova Drilling Inc.
COORDINATES 4948147.0 m N; 459568.8 m E
BORING METHOD Solid Stem Auger
LOGGED BY AS **CHECKED BY** MA

DEPTH SCALE (m)	WATER LEVEL(m)	GRAPHIC LOG	ELEVATION (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY SOIL (mm) ROCK (%)	SOIL ("N" VALUE) ROCK (RQD (%))	GRAIN SIZE DISTRIBUTION Gravel (%)	GRAIN SIZE DISTRIBUTION Sand (%)	GRAIN SIZE DISTRIBUTION Fines (%)	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / ☐ FINES CONTENT (%) ☐ 20 40 60 80	WELL DIAGRAM
			110.6 110.5	Loose, brown, ROOTMAT and TOPSOIL									
				Compact/Very stiff to hard, reddish brown, silty SAND with gravel to sandy lean CLAY with gravel: FILL - Dry to moist - Trace cobbles and/or boulders - Trace organics	SS	1	350	37					
1					SS	2	0	22					
			109.1										
2				Hard, brown, sandy lean CLAY, trace gravel to sandy lean CLAY with gravel: TILL - Moist - Frequent cobbles and/or boulders	SS	3	610	52					
					SS	4	610	53					
3													
					SS	5	610	41	17	32	52		
4					SS	6	610	39					
5					SS	7	330	41					
					SS	8	500	100					
6													
					SS	9	610	29					
7			103.3		SS	10	610	45					



End of borehole at 7.3 m

RECORD OF BOREHOLE: BH23-04

PAGE 1 OF 1

CLIENT Halifax Water

PROJECT NUMBER 231007.00

BORING START DATE 5/17/2023

BORING END DATE 5/17/2023

BORING CONTRACTOR Nova Drilling Inc.

BORING METHOD Solid Stem Auger

PROJECT NAME Mount Edward 1 Reservoir

PROJECT LOCATION Dartmouth, NS

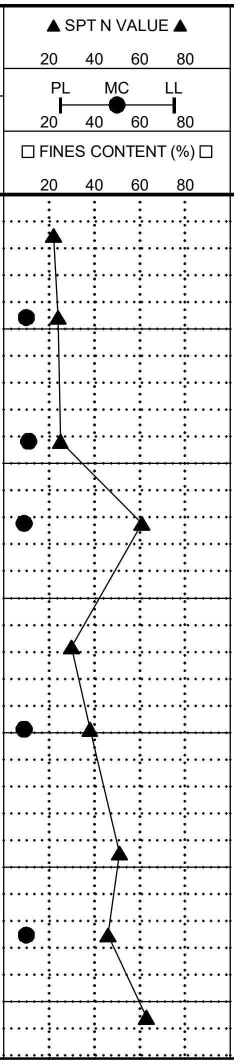
GROUND ELEVATION 110.3 m **GWT DATE** -

DATUM CGVD2013

COORDINATES 4948187.2 m N; 459547.5 m E

LOGGED BY AS **CHECKED BY** MA

DEPTH SCALE (m)	WATER LEVEL(m)	GRAPHIC LOG	ELEVATION (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY SOIL (mm) ROCK (%)	SOIL ("N" VALUE) ROCK (RQD (%))	GRAIN SIZE DISTRIBUTION			WELL DIAGRAM
									Gravel (%)	Sand (%)	Fines (%)	
			110.3									
			110.2	Loose, brown, ROOTMAT and TOPSOIL								
				Compact/Very stiff, reddish brown, silty SAND with gravel to sandy lean CLAY with gravel: FILL - Dry to moist	SS	1	330	22				
1					SS	2	610	24				
2					SS	3	610	25				
			108.2	Hard, brown, sandy lean CLAY, trace gravel to sandy lean CLAY with gravel: TILL - Moist - Frequent cobbles and/or boulders	SS	4	610	61				
3												
					SS	5	610	30				
4					SS	6	610	38				
5					SS	7	430	51				
					SS	8	610	46				
6					SS	9	610	63				
			103.9									



End of borehole at 6.4 m

RECORD OF BOREHOLE: BH23-05A

PAGE 1 OF 1

CLIENT Halifax Water

PROJECT NUMBER 231007.00

BORING START DATE 5/19/2023

BORING END DATE 5/19/2023

BORING CONTRACTOR Nova Drilling Inc.

BORING METHOD Rotary Diamond

PROJECT NAME Mount Edward 1 Reservoir

PROJECT LOCATION Dartmouth, NS

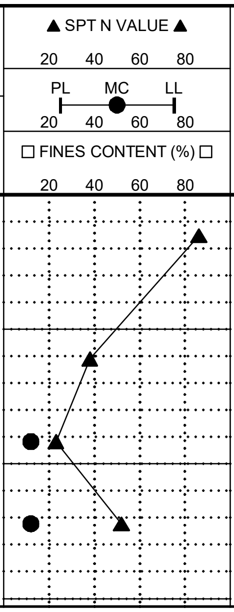
GROUND ELEVATION 112.0 m **GWT DATE** -

DATUM CGVD2013

COORDINATES 4948229.5 m N; 459523.4 m E

LOGGED BY AS **CHECKED BY** MA

DEPTH SCALE (m)	WATER LEVEL(m)	GRAPHIC LOG	ELEVATION (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY SOIL (mm) ROCK (%)	SOIL ("N" VALUE) ROCK (RQD (%))	GRAIN SIZE DISTRIBUTION Gravel (%)	Sand (%)	Fines (%)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐	WELL DIAGRAM
			112.0 111.9	Grey, poorly graded GRAVEL with silt and sand: FILL	SS	1	280	86					
1				Compact to very dense/Very stiff to hard, reddish brown, silty SAND with gravel to sandy lean CLAY, trace gravel to sandy lean CLAY with gravel: FILL - Moist - Trace cobbles and/or boulders - Trace organcis	SS	2	0	38					
2					SS	3	610	23					
					SS	4	610	52					
3			108.9										



End of borehole at 3.1 m

RECORD OF BOREHOLE: BH23-05B

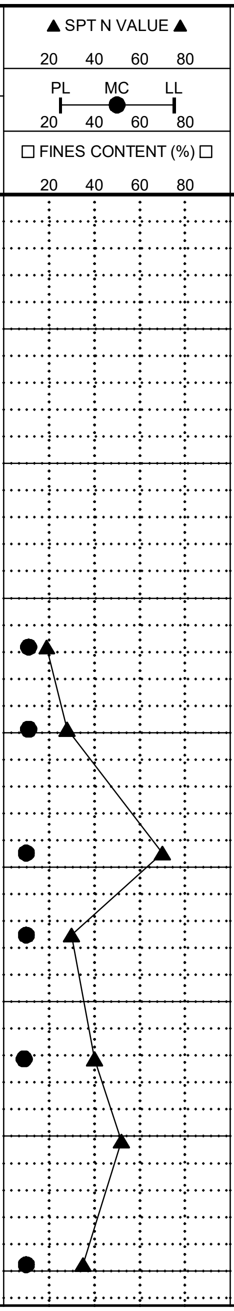
PAGE 1 OF 1

CLIENT Halifax Water
PROJECT NUMBER 231007.00
BORING START DATE 5/19/2023
BORING END DATE 5/19/2023
BORING CONTRACTOR Nova Drilling Inc.
BORING METHOD Rotary Diamond

PROJECT NAME Mount Edward 1 Reservoir
PROJECT LOCATION Dartmouth, NS
GROUND ELEVATION 112.0 m **GWT DATE** -
DATUM CGVD2013
COORDINATES 4948230.5 m N; 459525.1 m E
LOGGED BY AS **CHECKED BY** MA

DEPTH SCALE (m)	ELEVATION (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY SOIL (mm) ROCK (%)	SOIL ("N" VALUE) ROCK (RQD (%))	GRAIN SIZE DISTRIBUTION Gravel (%)	Sand (%)	Fines (%)
0	112.0	See BH23-05A							
3	108.9	Very stiff to hard, brown, sandy lean CLAY, trace gravel to sandy lean CLAY with gravel: TILL - Moist - Trace cobbles and/or boulders	SS	1	610	19			
4			SS	2	610	28			
5			SS	3	610	70			
			SS	4	610	30			
6			SS	5	610	40			
7			SS	6	610	52			
8	103.7		SS	7	610	35			

End of borehole at 8.3 m



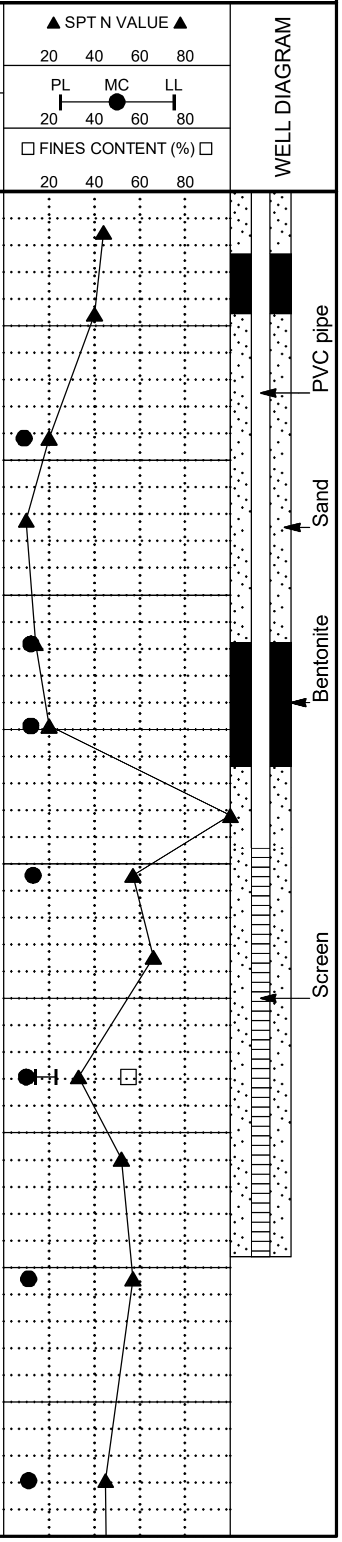
WELL DIAGRAM

RECORD OF BOREHOLE: BH23-06

CLIENT	Halifax Water	**PROJECT NAME**	Mount Edward 1 Reservoir
PROJECT NUMBER	231007.00	**PROJECT LOCATION**	Dartmouth, NS
BORING START DATE	5/18/2023	**GROUND ELEVATION**	112.2 m
		GWT DATE	5/18/2023
BORING END DATE	5/18/2023	**DATUM**	CGVD2013
BORING CONTRACTOR	Nova Drilling Inc.	**COORDINATES**	4948234.7 m N; 459545.0 m E
BORING METHOD	Rotary Diamond	**LOGGED BY**	AS
		CHECKED BY	MA

ELEVATION (m)	MATERIAL DESCRIPTION
112.2	
112.1	Grey, poorly graded GRAVEL with silt and sand: FILL
	Compact to very dense/Very stiff to hard, reddish brown, silty SAND with gravel to sandy lean CLAY with gravel: FILL - Dry to wet - Trace cobbles and/or boulders - Trace wood and coal pieces - Trace organcis
107.5	Hard, brown, sandy lean CLAY, trace gravel to sandy lean CLAY with gravel: TILL - Moist - Frequent cobbles and/or boulders

SAMPLE TYPE	SAMPLE NUMBER	RECOVERY SOIL (mm) ROCK (%)	SOIL ("N" VALUE) ROCK (RQD (%))	GRAIN SIZE DISTRIBUTION Gravel (%)	Sand (%)	Fines (%)
SS	1	490	44			
SS	2	420	40			
SS	3	240	20			
SS	4	400	10			
SS	5	610	14			
SS	6	610	20			
SS	7	100	SSR			
SS	8	610	57			
SS	9	430	66			
SS	10	610	33	10	36	55
SS	11	470	52			
SS	12	440	57			
SS	13	360	45			



(Continued Next Page)

RECORD OF BOREHOLE: BH23-06

PAGE 2 OF 2

CLIENT Halifax Water

PROJECT NAME Mount Edward 1 Reservoir

PROJECT NUMBER 231007.00

PROJECT LOCATION Dartmouth, NS

BORING START DATE 5/18/2023

GROUND ELEVATION 112.2 m **GWT DATE** 5/18/2023

BORING END DATE 5/18/2023

DATUM CGVD2013

BORING CONTRACTOR Nova Drilling Inc.

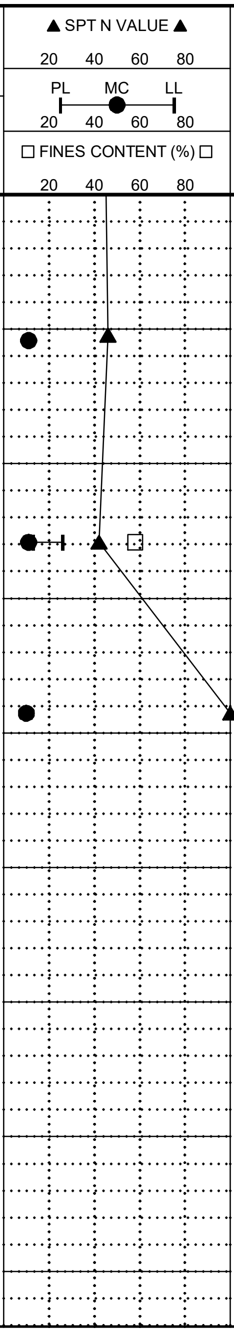
COORDINATES 4948234.7 m N; 459545.0 m E

BORING METHOD Rotary Diamond

LOGGED BY AS **CHECKED BY** MA

DEPTH SCALE (m)	WATER LEVEL(m)	GRAPHIC LOG	ELEVATION (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY SOIL (mm) ROCK (%)	SOIL ("N" VALUE) ROCK (RQD (%))	GRAIN SIZE DISTRIBUTION Gravel (%)	Sand (%)	Fines (%)	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐	WELL DIAGRAM
11				Hard, brown, sandy lean CLAY, trace gravel to sandy lean CLAY with gravel: TILL - Moist - Frequent cobbles and/or boulders *(continued)*	SS	14	420	46					
12													
13					SS	15	610	42	3	39	58		
14					SS	16	150	SSR					
15													
16			95.5										
17				Weak to medium strong, slightly to moderately weathered, very severely fractured, grey, SILTSTONE BEDROCK	HQ	1	100	0					
					HQ	2	32	0					
18			93.8		HQ	3	100	0					

End of borehole at 18.4 m



RECORD OF BOREHOLE: BH23-08

PAGE 1 OF 1

CLIENT Halifax Water

PROJECT NAME Mount Edward 1 Reservoir

PROJECT NUMBER 231007.00

PROJECT LOCATION Dartmouth, NS

BORING START DATE 5/19/2023

GROUND ELEVATION 111.9 m **GWT DATE** -

BORING END DATE 5/19/2023

DATUM CGVD2013

BORING CONTRACTOR Nova Drilling Inc.

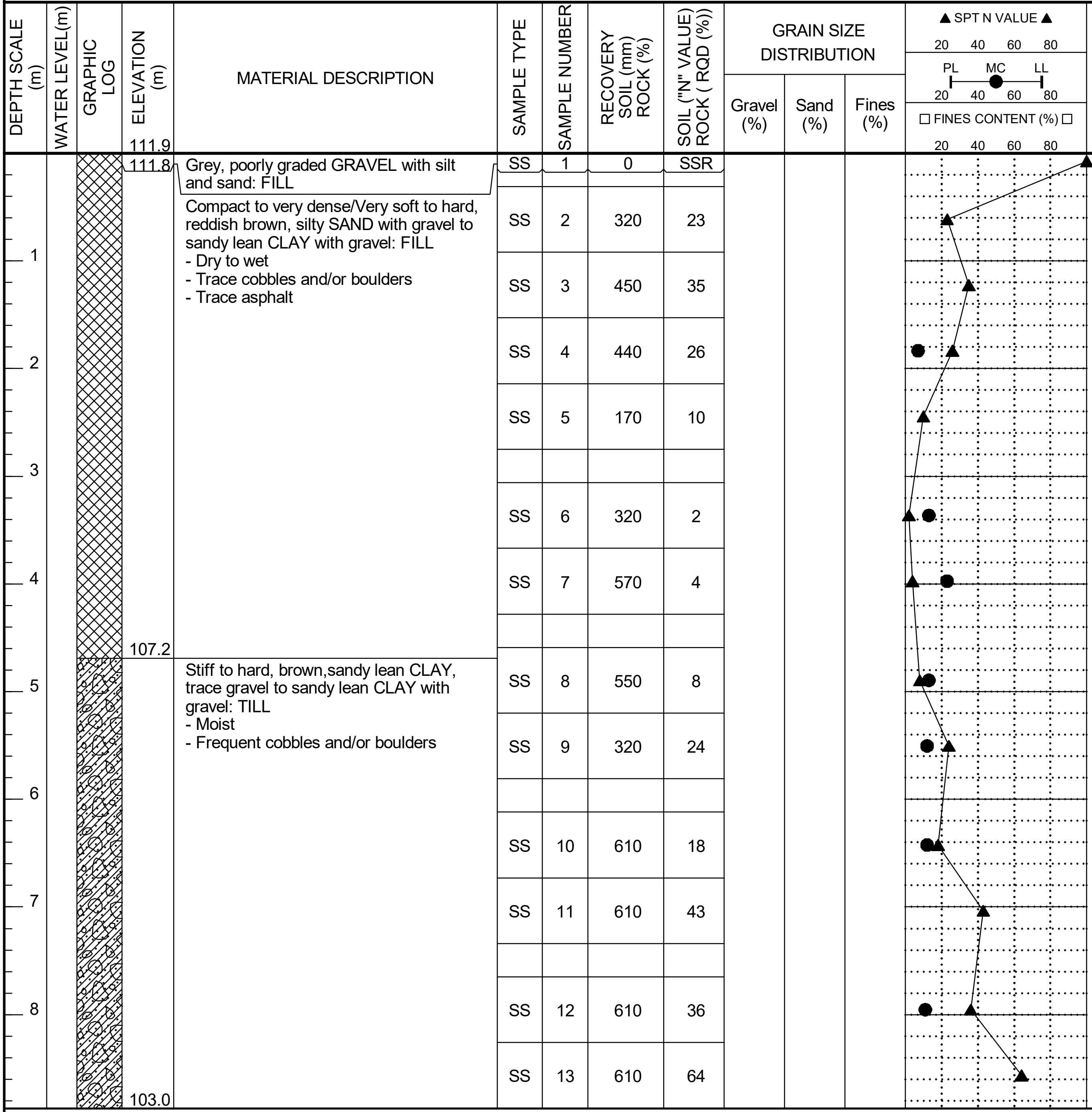
COORDINATES 4948255.0 m N; 459538.4 m E

BORING METHOD Rotary Diamond

LOGGED BY AS **CHECKED BY** MA

ELEVATION (m)	MATERIAL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	RECOVERY SOIL (mm) ROCK (%)	SOIL ("N" VALUE) ROCK (RQD (%))	GRAIN SIZE DISTRIBUTION Gravel (%)	Sand (%)	Fines (%)
111.9								
111.8	Grey, poorly graded GRAVEL with silt and sand: FILL	SS	1	0	SSR			
	Compact to very dense/Very soft to hard, reddish brown, silty SAND with gravel to sandy lean CLAY with gravel: FILL - Dry to wet - Trace cobbles and/or boulders - Trace asphalt	SS	2	320	23			
		SS	3	450	35			
		SS	4	440	26			
		SS	5	170	10			
		SS	6	320	2			
		SS	7	570	4			
107.2	Stiff to hard, brown,sandy lean CLAY, trace gravel to sandy lean CLAY with gravel: TILL - Moist - Frequent cobbles and/or boulders	SS	8	550	8			
		SS	9	320	24			
		SS	10	610	18			
		SS	11	610	43			
		SS	12	610	36			
103.0		SS	13	610	64			

End of borehole at 8.9 m



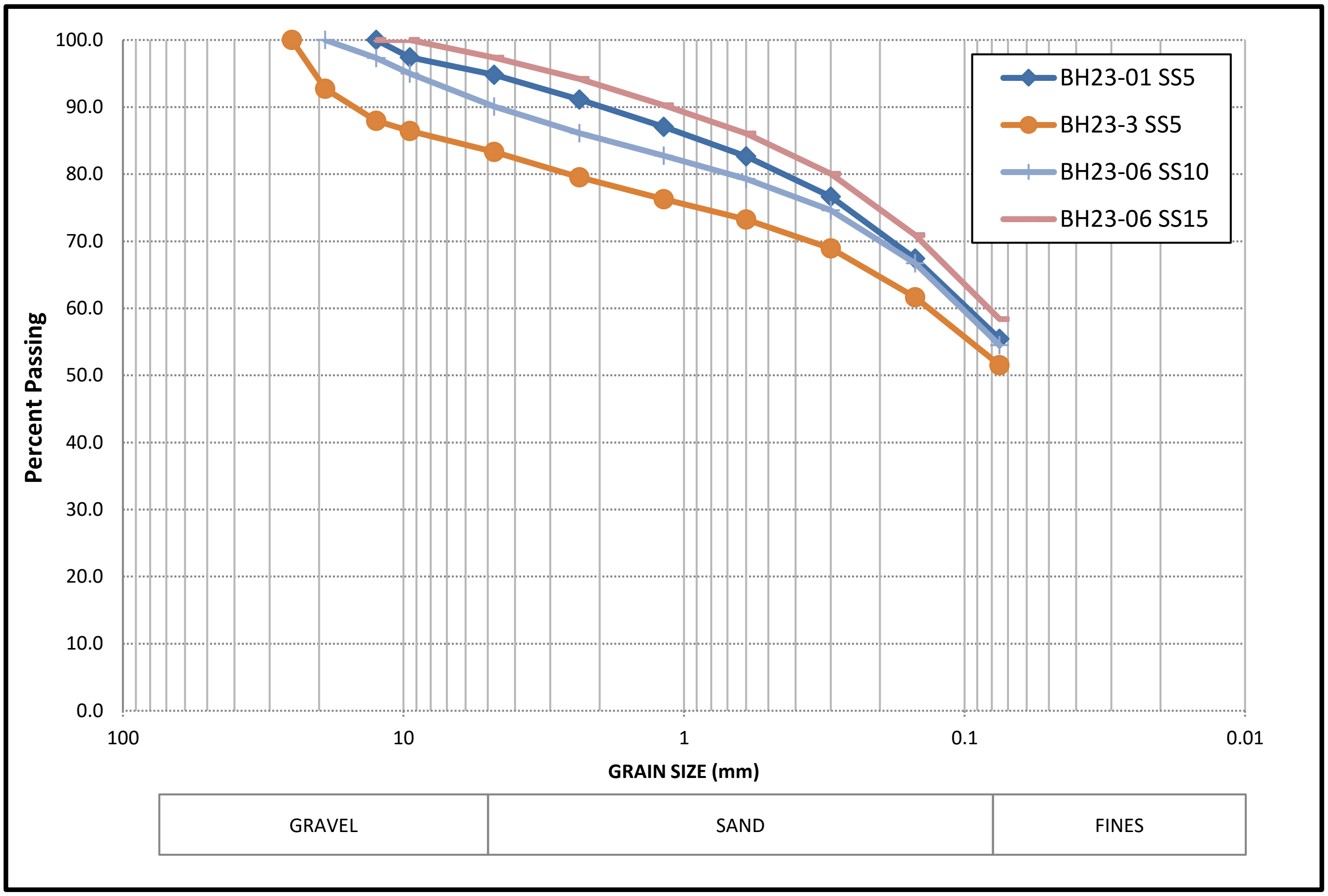
APPENDIX C

Laboratory Test Results

GRAIN SIZE REPORT

Project: Mount Edward 1 Reservoir
Client: Halifax Water
Project No: 231007.00

GRAIN SIZE DISTRIBUTION PLOT



SOIL CLASSIFICATION

Sample No	Depth(m)	Classification	Moisture Content (%)	Gravel (%)	Sand (%)	Silt and Clay (%)
BH23-01 SS5	3.4	Sandy lean clay (CL)	10.3%	5	39	55
BH23-3 SS5	3.4	Sandy lean clay with gravel (CL)	9.6%	17	32	52
BH23-06 SS10	6.6	Sandy lean clay (CL)	10.3%	10	36	55
BH23-06 SS15	12.6	Sandy lean clay(CL)	10.9%	3	39	58

CBCL Limited

348 Bluewater Road, Bedford, NS B4B 1J6
Office (902) 835-7313 • Fax (902) 835-1260

Comments:

Figure 1

CBCL

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APPENDIX C

Environmental Report

CBCL
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Maritime Centre, 1505 Barrington Street, Suite 901, Box 606, Halifax, NS,
B3J 2R7 | 902-421-7241 | CBCL.ca | info@CBCL.ca

June 21, 2023

Mr. Jonathan MacDonald
Halifax Water
450 Cowie Hill Road
Halifax, NS B3K 5M1

Dear Mr. MacDonald:

RE: Mount Edward Reservoir, Environmental Report, 155 Mount Edward Road, Dartmouth Nova Scotia – Consultant Services (P32.2022)

CBCL Limited is pleased to provide the attached Report which presents the findings of our environmental soil sampling program at 155 Mount Edward Road, Dartmouth, Nova Scotia.

Thank you for the opportunity to complete this project.

Yours very truly,

CBCL Limited

Brad Trask

Brad Trask, P. Eng.
Manager, Environmental Science & Engineering
Direct: 902-421-7241 ext. 2253
E-Mail: bradt@cbcl.ca

Project No.: 231007.00

Contents

1 Introduction 1
1.1 Background 1
1.2 Objectives 1
1.3 Scope of Work 2
1.4 Regulatory Framework 2
1.4.1 Soil 2
1.5 Soil Sampling Program Methodology 2
1.6 Labratory Program 3
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2.1.1 Soil Analytical Results 4
3 Conclusions and Recommendations 6
4 Closure 7

Attachments

A Figures
B Analytical Tables
C Laboratory Certificates

1 Introduction

CBCL Limited (CBCL) was retained by Halifax Water to conduct an environmental soil sampling program as part of a geotechnical investigation to assess the conditions of and facilitate the ultimate replacement of one of the two existing Mount Edward water storage reservoirs located at 155 Mount Edward Road, Dartmouth, Nova Scotia (herein referred to as the 'site'). This report outlines the scope, methodology and findings of the environmental program.

1.1 Background

The first Mount Edward Reservoir (Mount Edward 1) was constructed circa 1979, is 44 years old, and is located on the higher elevation lands at 155 Mount Edward Road. Recent evaluations conducted after leak events concluded that the reservoir is in fair to poor condition, consistent with its age and requires repair and retrofits. A second reservoir (Mount Edward 2) was constructed in 1998, it is located adjacent to the first reservoir in conjunction with a new transmission main to connect the two reservoirs to the Lake Major Water Treatment Plant. Halifax Water faces a decision of rehabilitation or replacement for Mound Edward 1.

A sound foundation with suitable subsurface soil conditions is a critical factor for a successful reservoir project. For that reason, a geotechnical drilling program was required to assess the site conditions in the Concept Design phase. As part of the geotechnical program an environmental program should also be completed to assess subsurface soils for potential contamination.

1.2 Objectives

The objective of the environmental scope was to:

- Conduct environmental sampling in conjunction with the geotechnical investigation at the Mount Edward Reservoir to assess subsurface soil for potential environmental impacts.

1.3 Scope of Work

The scope of work for the environmental sampling consisted of the following:

- Conduct standard environmental soil sampling in conjunction with the geotechnical borehole drilling program. One sample from each of the eight boreholes will be collected, screened for volatile gases, and submitted for lab analysis of petroleum hydrocarbons (PHCs), metals, and polycyclic aromatic hydrocarbons (PAHs).
- Prepare a summary report following the field program.

1.4 Regulatory Framework

The Province of Nova Scotia via Nova Scotia Environment and Climate Change (NSECC) established regulations and associated protocols related to contaminated sites in July 2013, referred to as the 'Nova Scotia Contaminated Sites Regulations (NSCSR)' (N.S. Reg 64/2012, effective July 6, 2013, and amended October 2022). The purpose of the regulations is to clarify the procedures around contaminated sites and ensure assessments and cleanups are consistent province wide. The NSECC Tier 1 Environmental Quality Standards (EQS) promulgated by NSECC were used to identify contaminants of potential concern (COPCs) in soil.

1.4.1 Soil

Analytical results for PHCs, metals, and PAHs in soil have been compared to the NSECC Tier I EQS for Soil at a non-potable site with coarse-grained soils for Industrial land use (October 2022). For remediation purposes, the valid Tier 2 PSS guidelines (Table 3D) for direct contact/ingestion of soil (Industrial, coarse-grained soil) will be used for this site.

The classification of "non-potable, industrial" was chosen for the subject site due to the accessibility of municipal drinking water on site (non-potable), as well as site activities and access being restricted to the public at the site (Industrial). A conservative assumption of coarse-grained soils was determined due to insufficient data of soil grain size and porosity at the site.

1.5 Soil Sampling Program Methodology

During the environmental sampling program, a total of seven borehole soil samples were submitted to the laboratory for analysis of PHCs, metals, and PAHs. The scope of work proposed that eight boreholes be drilled, but due to an obstruction in the proposed location at BH23-07, it was removed from the program, and the seven remaining boreholes were completed (BH23-01 to BH23-06, and BH23-08).

Soil samples were chosen based on a variety of factors, which include but are not limited to, proximity to water table, visible signs of potential contamination, and volatile soil vapour screening results.

Soils were collected in sample bags from each location. The bags were approximately half-filled with soil to allow adequate headspace for the accumulation of vapours. Soil sample headspace was then aspirated in each sample bag for volatile and combustible vapours using a MiniRAE 3000 portable photoionization detector. Soil vapour field screening measurements in parts per million (ppm) for each borehole ranged from 0.1 to 1.7. There are no regulatory criteria for combustible soil vapours, however, elevated vapour concentrations (greater than 500 ppm) are generally indicative of the presence of volatile petroleum products (i.e., gasoline, and, to a lesser extent, diesel and fuel oil). Concentrations vary with both hydrocarbon type and age, and it should be noted that the readings are intended as a field screening tool to provide only a qualitative indication of hydrocarbon levels.

1.6 Labratory Program

Samples from the field program were submitted to Bureau Veritas for analysis. Bureau Veritas is accredited by the Standards Council of Canada (SCC) to criteria set by the Canadian Association for Laboratory Accreditation (CALA) for each of the analytical methods utilized and has in-house QA/QC protocols to govern sample analysis, including replicates. All analysis performed by Bureau Veritas are accredited to ISO/IEC 17025 standards (and subsequent revisions). Analytical results are tabulated in Attachment B and laboratory certificates are provided in Attachment C.

2 Results

Field observations and analytical results from the environmental sampling field program are discussed in the following sections. The sample locations are presented on the site figure in Attachment A.

2.1 Soil

2.1.1 Soil Analytical Results

During the environmental sampling program, a total of seven borehole soil samples were submitted to the laboratory for analysis of PHCs, metals, and PAHs.

Tables showing the analytical results for soil compared to applicable guidelines are provided in Attachment B. Copies of the Laboratory Certificates of Analysis are provided in Attachment C.

2.1.1.1 PHCs

A total of seven soil samples collected from boreholes were submitted for laboratory analysis of PHCs. Results are summarized as follows:

- All PHC parameters were either reported below the laboratory detection limits and/or below the NSE Tier 1 EQS in all the analyzed soil samples.

The analytical results for PHCs in soil are provided in Table 1 in Attachment B.

2.1.1.2 Metals

A total of seven soil samples were submitted for laboratory analysis of metals. Results are summarized as follows:

- All metals parameters were either reported below the laboratory detection limits and/or below the NSE Tier 1 EQS in all the analyzed soil samples.

The analytical results for metals in soil are provided in Table 2 in Attachment B.

2.1.1.3 PAHs

A total of seven soil samples were submitted for laboratory analysis of PAHs. Results are summarized as follows:

- All PAH parameters were either reported below the laboratory detection limits and/or below the NSE Tier 1 EQS in all the analyzed soil samples.

The analytical results for PAHs in soil are provided in Table 3 in Attachment B.

3 Conclusions and Recommendations

Based on the information gathered and on observations made during the environmental sampling program conducted at the site, the following conclusions are presented:

- All PHC, metals and PAH parameters were reported below the NSE Tier 1 EQS and NSE Tier 2 PSS (direct contact/ingestion) guidelines for a non-potable, industrial property with coarse-grained soil in all submitted borehole soil samples collected from the seven geotechnical boreholes.

4 Closure

This report has been prepared for the sole benefit of Halifax Water. The report may not be relied upon by any other person or entity without the express written consent of CBCL Limited, and Halifax Water.

The environmental sampling conclusions are based on results from specific testing and/or sampling locations and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions, as well as the history of the site reflecting natural, construction and other activities. In addition, analysis has been carried out for a limited number of chemical parameters, and it should not be inferred that other chemical species are not present.

The conclusions presented in this report are indicative of observations recorded at the time and place noted and represent our professional opinion, in light of the terms of reference, scope of work, and any limiting conditions noted herein. If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

Any use that a third party makes of this report, or any reliance on, or decisions to be made based upon it, are the responsibility of such third parties. CBCL Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based upon this report.

Respectfully Submitted,

CBCL Limited

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Brad Trask

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Attachment A

Site Figure

Document Path: K:\Projects\2023\231007.00 HW Mount Edward 1 Reservoir\44 CAD\07 ENVIRO\PRO\231007_HW_MountEdwardReservoir.aprx - sfewkes - 12/Jun/2023

KEY MAP

LEGEND

BH_ID

- ⊕ Borehole Sampling Location
- ⊕ Borehole Not Sampled as Part of Environmental Sampling Program
- 🟥 Subject Property
- ☐ Property Boundary

CBCL

MOUNT EDWARD 1 RESERVOIR
CONSULTING SERVICES

BOREHOLE LOCATION PLAN

DATE: 2023-06-12	PROJ N°: 231007	FIGURE: **1**
DRAWN BY: SF	CHECKED BY: DM	APPROVED: BT

NOTES:
- Inset Imagery Date: 21APR22

0 15 30 60 m

SCALE: 1:1,500 @ 11 X 17

Coordinate System: NAD 1983 UTM Zone 20N
Units: Meter

Attachment B

Analytical Tables

TABLE 1
PHCs IN SOIL
Halifax Water - Mt. Edward Resevoir
Project No. 231007.00

Sample Location:	**RDL[1]**	**NSECC Tier I EQS[2]**	**NSECC Tier II PSS[3]**	**BH23-01**	**BH23-02**	**BH23-03**	**BH23-04**	**BH23-05A**	**BH23-06**	**BH23-08**
Sample ID:		Industrial, Non-Potable, Coarse-Grained Soils	Industrial, Soil Contact / Ingestion (all soil types)	BH23-01 SS3	BH23-02 SS6	BH23-03 SS10	BH23-04 SS9	BH23-05A SS5	BH23-06 SS8	BH23-08 SS7
Lab Sample ID:				VWO004	VWO005	VWO006	VWO007	VWO008	VWO009	VWO010
Sample Date:				17-May-23	17-May-23	17-May-23	17-May-23	19-May-23	18-May-23	19-May-23
Sample Depth (mbgs):				1.53 - 2.14	4.57 - 5.08	6.73 - 7.34	5.81 - 6.42	6.12 - 6.73	4.78 - 5.39	3.67 - 4.28
Units:	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
BTEX Parameters										
Benzene	0.005	0.52	980	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Toluene	0.05	4700	4700	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Ethylbenzene	0.01	10000	11000	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Xylenes	0.05	60	6300	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Petroleum Hydrocarbon Fraction Concentrations										
C_6-C_{10} (less BTEX)	2.5	-	-	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
>C_{10}-C_{16}	10	-	-	<10	<10	<10	<10	<10	<10	<10
>C_{16}-C_{21}	10	-	-	<10	<10	<10	<10	<10	<10	<10
>C_{21}-C_{32}	15	-	-	<15	<15	<15	<15	<15	<15	38
Modified TPH (Gas)	15	2,000	77,000	<15	<15	<15	<15	<15	<15	38
Modified TPH (Fuel Oil)		10,000	47,000							
Modified TPH (Lube Oil)		10,000	74,000							
Reached Baseline at C_{32}	-	-	-	NA	NA	NA	NA	NA	NA	Yes
Resemblance	-	-	-	-	-	-	-	-	-	Lube oil fraction.

Notes:
-' = no guideline available or parameter not analyzed; <X: Below RDL; mgbs = metres below grade surface; NA = Not Applicable; nd = not detected (laboratory
> RES means no soil criteria are shown as residual soil saturation limits may be
1. RDL = Reportable Detection Limit
2. Nova Scotia Environment and Climate Change (NSECC) Tier I Environmental Quality Standards (EQS) for Soil at a Non-Potable Site (Table 1B, October 2022); Industrial land use and coarse-grained soils.
3. NSECC Tier II PSS for Industrial Land Use (Table 3D, September 2021); Direct Soil

Shaded results indicate an exceedance of the NSECC Tier I EQS Guidelines

Bold results indicate an exceedance of the NSECC Tier II PSS Soil Contact / Ingestion Guidelines

TABLE 2
METALS IN SOIL
Halifax Water - Mt. Edward Resevoir
Project No. 231007.00

Sample Location:		**NSECC Tier I EQS[3]**	**NSECC Tier II EQS[4]**	**BH23-01**	**BH23-02**	**BH23-03**	**BH23-04**	**BH23-05A**	**BH23-06**	**BH23-08**
Sample ID:		Industrial, Non-Potable, Coarse-Grained Soils	Industrial, Soil Contact / Ingestion (all soil types)	BH23-01 SS3	BH23-02 SS6	BH23-03 SS10	BH23-04 SS9	BH23-05A SS5	BH23-06 SS8	BH23-08 SS7
Lab Sample ID:	**RDL[1]**			VWO004	VWO005	VWO006	VWO007	VWO008	VWO009	VWO010
Sample Date:				17-May-23	17-May-23	17-May-23	17-May-23	19-May-23	18-May-23	19-May-23
Sample Depth (mbgs):				1.53 - 2.14	4.57 - 5.08	6.73 - 7.34	5.81 - 6.42	6.12 - 6.73	4.78 - 5.39	3.67 - 4.28
Units:	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Metal Parameters										
Aluminum (Al)	10	220000	220000	11000	11000	11000	10000	11000	10000	14000
Antimony (Sb)	2.0	63	63	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Arsenic (As)	2.0	31	31	11	7.6	8.3	9.1	8.6	7.6	10
Barium (Ba)	5.0	96000	130000	90	85	88	79	110	70	45
Beryllium (Be)	1.0	1100	1400	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Bismuth (Bi)	2.0	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Boron (B)	50	24000	24000	<50	<50	<50	<50	<50	<50	<50
Cadmium (Cd)	0.30	192	2090	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Chromium (Cr)	2.0	2300	6700	21	96	17	18	20	19	19
Cobalt (Co)	1.0	250	250	10	9.9	8.8	8.9	10	8.5	11
Copper (Cu)	2.0	16000	20000	18	20	17	21	18	17	15
Iron (Fe)	50	164000	164000	24000	22000	22000	22000	22000	21000	22000
Lead (Pb)	0.50	740	8200	11	8.9	11	9.2	9.9	8.6	15
Lithium (Li)	2.0	-	-	22	22	22	21	22	20	22
Manganese (Mn)	2.0	5200	5200	640	640	620	610	1100	580	760
Mercury (Hg)	0.10	99	690	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Molybdenum (Mo)	2.0	1200	1200	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Nickel (Ni)	2.0	2500	5100	23	22	20	20	21	19	16
Rubidium (Rb)	2.0	-	-	8.9	8.6	7.7	7	7.9	6.9	10
Selenium (Se)	0.50	1135	4050	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.9
Silver (Ag)	0.50	490	490	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Strontium (Sr)	5.0	140000	140000	16	17	20	16	13	8.5	6.7
Thallium (Tl)	0.10	1	1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.11
Tin (Sn)	1.0	140000	140000	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Uranium (U)	0.10	300	510	0.55	0.63	0.75	0.67	0.54	0.46	0.62
Vanadium (V)	2.0	160	160	18	16	17	16	16	15	23
Zinc (Zn)	5.0	140000	270000	52	46	47	45	49	44	45

Notes:

-' = no guideline available or parameter not analyzed; <X: Below RDL; mgbs = metres below grade surface

1. RDL = Reportable Detection Limit
2. NSE Landfill Disposal = Nova Scotia Environment Guidelines for the Disposal of Contaminated Solids in Landfills, Attachment B - Acceptance Parameters for Contaminated Soil (Total Analysis), May 2016.
3. Nova Scotia Environment and Climate Change (NSECC) Tier I Environmental Quality Standards (EQS) for Soil at a Non-Potable Site (Table 1B, October 2022); Industrial land use and coarse-grained soils.
4. NSECC Tier II PSS for Industrial Land Use (Table 3D, September 2021); Direct Soil Contact / Ingestion (all soil types).

Shaded results indicate an exceedance of the Commercial NSECC Tier I EQS and Commercial NSE Tier 2 PSS (Soil Contact/Ingestion) Guidelines

TABLE 3
POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) IN SOIL

Halifax Water - Mt. Edward Resevoir

Project No. 231007.00

Sample Location:	RDL[1]	**NSECC Tier I EQS[2]** Industrial, Non-Potable, Coarse-Grained Soils	**NSECC Tier II PSS[3]**, Industrial, Soil Contact / Ingestion (all soil types)	**BH23-01**	**BH23-02**	**BH23-03**	**BH23-04**	**BH23-05A**	**BH23-06**	**BH23-08**
Sample ID:				BH23-01 SS3	BH23-02 SS6	BH23-03 SS10	BH23-04 SS9	BH23-05A SS5	BH23-06 SS8	BH23-08 SS7
Lab Sample ID:				VWO004	VWO005	VWO006	VWO007	VWO008	VWO009	VWO010
Sample Date:				17-May-23	17-May-23	17-May-23	17-May-23	19-May-23	18-May-23	19-May-23
Sample Depth (mbgs):				1.53 - 2.14	4.57 - 5.08	6.73 - 7.34	5.81 - 6.42	6.12 - 6.73	4.78 - 5.39	3.67 - 4.28
Units:	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Non-Carcinogenic PAHs										
1-Methylnaphthalene	0.005	560	560	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
2-Methylnaphthalene	0.005	560	560	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Acenaphthene	0.005	43000	75000	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Acenaphthylene	0.005	66	96	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Anthracene	0.005	300000	300000	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Fluoranthene	0.005	50000	50000	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Fluorene	0.005	39000	46000	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Naphthalene	0.005	25	34000	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Perylene	0.005	-	-	<0.0050	0.012	0.0069	0.0079	<0.0050	<0.0050	<0.0050
Phenanthrene	0.005	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Pyrene	0.005	30000	34000	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Carcinogenic PAHs										
Benzo(a)anthracene	0.005	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(a)pyrene	0.005	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b)fluoranthene	0.003	-	-	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Benzo(b/j)fluoranthene	0.005	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo[k]fluoranthene	0.005	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(j)fluoranthene	0.003	-	-	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Benzo[ghi]perylene	0.005	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Chrysene	0.005	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Dibenz[a,h]anthracene	0.005	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Indeno[1,2,3-cd]pyrene	0.005	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Total PAHs[4]				0.039	0.039	0.039	0.039	0.039	0.039	0.039
Benzo[a]pyrene Total Potency Equivalents (Human Health)[5]		5.3	5.3	0.019	0.019	0.019	0.019	0.019	0.019	0.019

Notes:

-' = no guideline available or parameter not analyzed; <X: Below RDL; mgbs = metres below grade surface; FD = Field Duplicate

1. RDL = Reportable Detection Limit
2. Nova Scotia Environment and Climate Change (NSECC) Tier I Environmental Quality Standards (EQS) for Soil at a Non-Potable Site (Table 1B, October 2022); Industrial land use and coarse-grained soils.
3. NSECC Tier II PSS for Industrial Land Use (Table 3D, September 2021); Direct Soil Contact / Ingestion (all soil types).
4. Total PAH calculation based on the sum of 16 individual PAH compounds (acenapthene, acenapthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene,
5. The B[a]pyrene Total Potency Equivalent (B[a]P TPE) is calculated by multiplying concentrations in soil by the Potency Equivalence Factors as outlined in the CCME Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health.

Shaded results indicate an exceedance of the commercial NSECC Tier I EQS

Bold results indicate an exceedance of the commercial NSECC Tier II PSS Soil

Attachment C

Laboratory Certificates

Your Project #: 231007.00
Site Location: MT EDWARD ROAD
Your C.O.C. #: N/A

Attention: Brad Trask

CBCL Limited
Halifax - Standing offer
1505 Barrington Street
Suite 901 / PO Box 606
Halifax, NS
CANADA B3J 3Y6

Report Date: 2023/05/31
Report #: R7651026
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3E5752
Received: 2023/05/19, 14:40

Sample Matrix: Soil
Samples Received: 7

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
TEH in Soil (PIRI) (2)	6	2023/05/25	2023/05/25	ATL SOP 00111	Atl. RBCA v3.1 m
TEH in Soil (PIRI) (2)	1	2023/05/29	2023/05/30	ATL SOP 00111	Atl. RBCA v3.1 m
Metals Solids Acid Extr. ICPMS	5	2023/05/26	2023/05/26	ATL SOP 00058	EPA 6020B R2 m
Metals Solids Acid Extr. ICPMS	2	2023/05/26	2023/05/27	ATL SOP 00058	EPA 6020B R2 m
Moisture	7	N/A	2023/05/25	ATL SOP 00001	OMOE Handbook 1983 m
PAH Compounds in Soil by GC/MS (SIM) (1)	7	2023/05/29	2023/05/30	CAM SOP-00318	EPA 8270E
ModTPH (T1) Calc. for Soil	7	N/A	2023/05/30	N/A	Atl. RBCA v3.1 m
VPH in Soil (PIRI) - Field Preserved (3)	7	N/A	2023/05/26	ATL SOP 00119	Atl. RBCA v3.1 m

Remarks:

Bureau Veritas is accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Bureau Veritas are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCCFP, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Bureau Veritas' profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Bureau Veritas in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

Bureau Veritas liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Bureau Veritas has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Bureau Veritas, unless otherwise agreed in writing. Bureau Veritas is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by Bureau Veritas, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by Bureau Veritas Mississauga, 6740 Campobello Rd , Mississauga, ON, L5N 2L8
(2) Soils are reported on a dry weight basis unless otherwise specified.

Your Project #: 231007.00
Site Location: MT EDWARD ROAD
Your C.O.C. #: N/A

Attention: Brad Trask

CBCL Limited
Halifax - Standing offer
1505 Barrington Street
Suite 901 / PO Box 606
Halifax, NS
CANADA B3J 3Y6

Report Date: 2023/05/31
Report #: R7651026
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BUREAU VERITAS JOB #: C3E5752
Received: 2023/05/19, 14:40

(3) No lab extraction date is given for C6-C10/BTEX and VOC samples that are field preserved with methanol. Extraction date is date sampled unless otherwise stated.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to:
Keri Mackay, Customer Experience Team Lead
Email: Keri.MACKAY@bureauveritas.com
Phone# (902)420-0203 Ext:294
==
This report has been generated and distributed using a secure automated process.
Bureau Veritas has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports. For Service Group specific validation, please refer to the Validation Signatures page if included, otherwise available by request. For Department specific Analyst/Supervisor validation names, please refer to the Test Summary section if included, otherwise available by request. This report is authorized by Suzanne Rogers, General Manager responsible for Nova Scotia Environmental laboratory operations.

RBCA HYDROCARBONS IN SOIL (FIELD PRES.)

Bureau Veritas ID		VWO004	VWO005	VWO006	VWO007	VWO008		
Sampling Date		2023/05/17 10:00	2023/05/17 12:00	2023/05/17 14:00	2023/05/17 16:30	2023/05/19 13:00		
COC Number		N/A	N/A	N/A	N/A	N/A		
	UNITS	**BH23-01 SS3**	**BH23-02 SS6**	**BH23-03 SS10**	**BH23-04 SS9**	**BH23-05A SS5**	**RDL**	**QC Batch**
Petroleum Hydrocarbons								
Benzene	mg/kg	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8686754
Toluene	mg/kg	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	8686754
Ethylbenzene	mg/kg	<0.010	<0.010	<0.010	<0.010	<0.010	0.010	8686754
Total Xylenes	mg/kg	<0.050	<0.050	<0.050	<0.050	<0.050	0.050	8686754
C6 - C10 (less BTEX)	mg/kg	<2.5	<2.5	<2.5	<2.5	<2.5	2.5	8686754
>C10-C16 Hydrocarbons	mg/kg	<10	<10	<10	<10	<10	10	8683575
>C16-C21 Hydrocarbons	mg/kg	<10	<10	<10	<10	<10	10	8683575
>C21-<C32 Hydrocarbons	mg/kg	<15	<15	<15	<15	<15	15	8683575
Modified TPH (Tier1)	mg/kg	<15	<15	<15	<15	<15	15	8678990
Reached Baseline at C32	mg/kg	NA	NA	NA	NA	NA	N/A	8683575
Hydrocarbon Resemblance	mg/kg	NA	NA	NA	NA	NA	N/A	8683575
Surrogate Recovery (%)								
Isobutylbenzene - Extractable	%	112	98	111	111	100		8683575
n-Dotriacontane - Extractable	%	99	94	107	103	95		8683575
Isobutylbenzene - Volatile	%	118	118	106	122	101		8686754

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable

RBCA HYDROCARBONS IN SOIL (FIELD PRES.)

Bureau Veritas ID		VWO009		VWO010			VWO010		
Sampling Date		2023/05/18 11:00		2023/05/19 11:00			2023/05/19 11:00		
COC Number		N/A		N/A			N/A		
	UNITS	**BH23-06 SS8**	**QC Batch**	**BH23-08 SS7**	**RDL**	**QC Batch**	**BH23-08 SS7 Lab-Dup**	**RDL**	**QC Batch**
Petroleum Hydrocarbons									
Benzene	mg/kg	<0.0050	8686754	<0.0050	0.0050	8686754			
Toluene	mg/kg	<0.050	8686754	<0.050	0.050	8686754			
Ethylbenzene	mg/kg	<0.010	8686754	<0.010	0.010	8686754			
Total Xylenes	mg/kg	<0.050	8686754	<0.050	0.050	8686754			
C6 - C10 (less BTEX)	mg/kg	<2.5	8686754	<2.5	2.5	8686754			
>C10-C16 Hydrocarbons	mg/kg	<10	8684106	<10	10	8690359	<10	10	8690359
>C16-C21 Hydrocarbons	mg/kg	<10	8684106	<10	10	8690359	10	10	8690359
>C21-<C32 Hydrocarbons	mg/kg	<15	8684106	38	15	8690359	56	15	8690359
Modified TPH (Tier1)	mg/kg	<15	8678990	38	15	8678990			
Reached Baseline at C32	mg/kg	NA	8684106	Yes	N/A	8690359			
Hydrocarbon Resemblance	mg/kg	NA	8684106	COMMENT (1)	N/A	8690359			
Surrogate Recovery (%)									
Isobutylbenzene - Extractable	%	91	8684106	92		8690359	98		8690359
n-Dotriacontane - Extractable	%	101	8684106	108		8690359	116		8690359
Isobutylbenzene - Volatile	%	100	8686754	128		8686754			

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
N/A = Not Applicable
(1) Possible lube oil fraction.

PAH IN SOIL TO MISSISSAUGA (SOIL)

Bureau Veritas ID		VWO004	VWO005	VWO006	VWO007	VWO008	VWO009		
Sampling Date		2023/05/17 10:00	2023/05/17 12:00	2023/05/17 14:00	2023/05/17 16:30	2023/05/19 13:00	2023/05/18 11:00		
COC Number		N/A	N/A	N/A	N/A	N/A	N/A		
	UNITS	**BH23-01 SS3**	**BH23-02 SS6**	**BH23-03 SS10**	**BH23-04 SS9**	**BH23-05A SS5**	**BH23-06 SS8**	**RDL**	**QC Batch**
Polyaromatic Hydrocarbons									
Acenaphthene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Acenaphthylene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Anthracene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Benzo(a)anthracene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Benzo(a)pyrene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Benzo(b/j)fluoranthene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Benzo(g,h,i)perylene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Benzo(k)fluoranthene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Chrysene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Dibenzo(a,h)anthracene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Fluoranthene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Fluorene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Indeno(1,2,3-cd)pyrene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
1-Methylnaphthalene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
2-Methylnaphthalene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Naphthalene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Phenanthrene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Pyrene	ug/g	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0050	8689764
Benzo(b)fluoranthene	ug/g	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0030	8689764
Perylene	ug/g	<0.0050	0.012	0.0069	0.0079	<0.0050	<0.0050	0.0050	8689764
Benzo(j)fluoranthene	ug/g	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0030	8689764
Surrogate Recovery (%)									
D10-Anthracene	%	92	96	96	96	96	97		8689764
D14-Terphenyl (FS)	%	92	97	97	98	97	97		8689764
D8-Acenaphthylene	%	82	86	86	88	81	78		8689764

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

PAH IN SOIL TO MISSISSAUGA (SOIL)

Bureau Veritas ID		VWO010		
Sampling Date		2023/05/19 11:00		
COC Number		N/A		
	UNITS	**BH23-08 SS7**	**RDL**	**QC Batch**
Polyaromatic Hydrocarbons				
Acenaphthene	ug/g	<0.0050	0.0050	8689764
Acenaphthylene	ug/g	<0.0050	0.0050	8689764
Anthracene	ug/g	<0.0050	0.0050	8689764
Benzo(a)anthracene	ug/g	<0.0050	0.0050	8689764
Benzo(a)pyrene	ug/g	<0.0050	0.0050	8689764
Benzo(b/j)fluoranthene	ug/g	<0.0050	0.0050	8689764
Benzo(g,h,i)perylene	ug/g	<0.0050	0.0050	8689764
Benzo(k)fluoranthene	ug/g	<0.0050	0.0050	8689764
Chrysene	ug/g	<0.0050	0.0050	8689764
Dibenzo(a,h)anthracene	ug/g	<0.0050	0.0050	8689764
Fluoranthene	ug/g	<0.0050	0.0050	8689764
Fluorene	ug/g	<0.0050	0.0050	8689764
Indeno(1,2,3-cd)pyrene	ug/g	<0.0050	0.0050	8689764
1-Methylnaphthalene	ug/g	<0.0050	0.0050	8689764
2-Methylnaphthalene	ug/g	<0.0050	0.0050	8689764
Naphthalene	ug/g	<0.0050	0.0050	8689764
Phenanthrene	ug/g	<0.0050	0.0050	8689764
Pyrene	ug/g	<0.0050	0.0050	8689764
Benzo(b)fluoranthene	ug/g	<0.0030	0.0030	8689764
Perylene	ug/g	<0.0050	0.0050	8689764
Benzo(j)fluoranthene	ug/g	<0.0030	0.0030	8689764
Surrogate Recovery (%)				
D10-Anthracene	%	95		8689764
D14-Terphenyl (FS)	%	96		8689764
D8-Acenaphthylene	%	89		8689764

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

RESULTS OF ANALYSES OF SOIL

Bureau Veritas ID		VWO004	VWO004	VWO005	VWO006	VWO007	VWO008		
Sampling Date		2023/05/17 10:00	2023/05/17 10:00	2023/05/17 12:00	2023/05/17 14:00	2023/05/17 16:30	2023/05/19 13:00		
COC Number		N/A	N/A	N/A	N/A	N/A	N/A		
	UNITS	**BH23-01 SS3**	**BH23-01 SS3 Lab-Dup**	**BH23-02 SS6**	**BH23-03 SS10**	**BH23-04 SS9**	**BH23-05A SS5**	**RDL**	**QC Batch**
Inorganics									
Moisture	%	11	9.5	9.3	9.8	11	9.6	1.0	8680840

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate

Bureau Veritas ID		VWO009	VWO010		
Sampling Date		2023/05/18 11:00	2023/05/19 11:00		
COC Number		N/A	N/A		
	UNITS	**BH23-06 SS8**	**BH23-08 SS7**	**RDL**	**QC Batch**
Inorganics					
Moisture	%	12	29	1.0	8680840

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Bureau Veritas ID		VWO004	VWO005		VWO006	VWO007		
Sampling Date		2023/05/17 10:00	2023/05/17 12:00		2023/05/17 14:00	2023/05/17 16:30		
COC Number		N/A	N/A		N/A	N/A		
	UNITS	**BH23-01 SS3**	**BH23-02 SS6**	**QC Batch**	**BH23-03 SS10**	**BH23-04 SS9**	**RDL**	**QC Batch**
Metals								
Acid Extractable Aluminum (Al)	mg/kg	11000	11000	8686021	11000	10000	10	8686233
Acid Extractable Antimony (Sb)	mg/kg	<2.0	<2.0	8686021	<2.0	<2.0	2.0	8686233
Acid Extractable Arsenic (As)	mg/kg	11	7.6	8686021	8.3	9.1	2.0	8686233
Acid Extractable Barium (Ba)	mg/kg	90	85	8686021	88	79	5.0	8686233
Acid Extractable Beryllium (Be)	mg/kg	<1.0	<1.0	8686021	<1.0	<1.0	1.0	8686233
Acid Extractable Bismuth (Bi)	mg/kg	<2.0	<2.0	8686021	<2.0	<2.0	2.0	8686233
Acid Extractable Boron (B)	mg/kg	<50	<50	8686021	<50	<50	50	8686233
Acid Extractable Cadmium (Cd)	mg/kg	<0.30	<0.30	8686021	<0.30	<0.30	0.30	8686233
Acid Extractable Chromium (Cr)	mg/kg	21	96	8686021	17	18	2.0	8686233
Acid Extractable Cobalt (Co)	mg/kg	10	9.9	8686021	8.8	8.9	1.0	8686233
Acid Extractable Copper (Cu)	mg/kg	18	20	8686021	17	21	2.0	8686233
Acid Extractable Iron (Fe)	mg/kg	24000	22000	8686021	22000	22000	50	8686233
Acid Extractable Lead (Pb)	mg/kg	11	8.9	8686021	11	9.2	0.50	8686233
Acid Extractable Lithium (Li)	mg/kg	22	22	8686021	22	21	2.0	8686233
Acid Extractable Manganese (Mn)	mg/kg	640	640	8686021	620	610	2.0	8686233
Acid Extractable Mercury (Hg)	mg/kg	<0.10	<0.10	8686021	<0.10	<0.10	0.10	8686233
Acid Extractable Molybdenum (Mo)	mg/kg	<2.0	<2.0	8686021	<2.0	<2.0	2.0	8686233
Acid Extractable Nickel (Ni)	mg/kg	23	22	8686021	20	20	2.0	8686233
Acid Extractable Rubidium (Rb)	mg/kg	8.9	8.6	8686021	7.7	7.0	2.0	8686233
Acid Extractable Selenium (Se)	mg/kg	<0.50	<0.50	8686021	<0.50	<0.50	0.50	8686233
Acid Extractable Silver (Ag)	mg/kg	<0.50	<0.50	8686021	<0.50	<0.50	0.50	8686233
Acid Extractable Strontium (Sr)	mg/kg	16	17	8686021	20	16	5.0	8686233
Acid Extractable Thallium (Tl)	mg/kg	<0.10	<0.10	8686021	<0.10	<0.10	0.10	8686233
Acid Extractable Tin (Sn)	mg/kg	<1.0	<1.0	8686021	<1.0	<1.0	1.0	8686233
Acid Extractable Uranium (U)	mg/kg	0.55	0.63	8686021	0.75	0.67	0.10	8686233
Acid Extractable Vanadium (V)	mg/kg	18	16	8686021	17	16	2.0	8686233
Acid Extractable Zinc (Zn)	mg/kg	52	46	8686021	47	45	5.0	8686233

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Bureau Veritas ID		VWO008	VWO009	VWO010		
Sampling Date		2023/05/19 13:00	2023/05/18 11:00	2023/05/19 11:00		
COC Number		N/A	N/A	N/A		
	UNITS	**BH23-05A SS5**	**BH23-06 SS8**	**BH23-08 SS7**	**RDL**	**QC Batch**
Metals						
Acid Extractable Aluminum (Al)	mg/kg	11000	10000	14000	10	8686021
Acid Extractable Antimony (Sb)	mg/kg	<2.0	<2.0	<2.0	2.0	8686021
Acid Extractable Arsenic (As)	mg/kg	8.6	7.6	10	2.0	8686021
Acid Extractable Barium (Ba)	mg/kg	110	70	45	5.0	8686021
Acid Extractable Beryllium (Be)	mg/kg	<1.0	<1.0	<1.0	1.0	8686021
Acid Extractable Bismuth (Bi)	mg/kg	<2.0	<2.0	<2.0	2.0	8686021
Acid Extractable Boron (B)	mg/kg	<50	<50	<50	50	8686021
Acid Extractable Cadmium (Cd)	mg/kg	<0.30	<0.30	<0.30	0.30	8686021
Acid Extractable Chromium (Cr)	mg/kg	20	19	19	2.0	8686021
Acid Extractable Cobalt (Co)	mg/kg	10	8.5	11	1.0	8686021
Acid Extractable Copper (Cu)	mg/kg	18	17	15	2.0	8686021
Acid Extractable Iron (Fe)	mg/kg	22000	21000	22000	50	8686021
Acid Extractable Lead (Pb)	mg/kg	9.9	8.6	15	0.50	8686021
Acid Extractable Lithium (Li)	mg/kg	22	20	22	2.0	8686021
Acid Extractable Manganese (Mn)	mg/kg	1100	580	760	2.0	8686021
Acid Extractable Mercury (Hg)	mg/kg	<0.10	<0.10	<0.10	0.10	8686021
Acid Extractable Molybdenum (Mo)	mg/kg	<2.0	<2.0	<2.0	2.0	8686021
Acid Extractable Nickel (Ni)	mg/kg	21	19	16	2.0	8686021
Acid Extractable Rubidium (Rb)	mg/kg	7.9	6.9	10	2.0	8686021
Acid Extractable Selenium (Se)	mg/kg	<0.50	<0.50	0.90	0.50	8686021
Acid Extractable Silver (Ag)	mg/kg	<0.50	<0.50	<0.50	0.50	8686021
Acid Extractable Strontium (Sr)	mg/kg	13	8.5	6.7	5.0	8686021
Acid Extractable Thallium (Tl)	mg/kg	<0.10	<0.10	0.11	0.10	8686021
Acid Extractable Tin (Sn)	mg/kg	<1.0	<1.0	<1.0	1.0	8686021
Acid Extractable Uranium (U)	mg/kg	0.54	0.46	0.62	0.10	8686021
Acid Extractable Vanadium (V)	mg/kg	16	15	23	2.0	8686021
Acid Extractable Zinc (Zn)	mg/kg	49	44	45	5.0	8686021

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	3.7°C

Results relate only to the items tested.

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
8680840	KCS	RPD [VWO004-01]	Moisture	2023/05/25	11		%	25
8683575	MGN	Matrix Spike	Isobutylbenzene - Extractable	2023/05/25		98	%	60 - 130
			n-Dotriacontane - Extractable	2023/05/25		90	%	60 - 130
			>C10-C16 Hydrocarbons	2023/05/25		90	%	30 - 130
			>C16-C21 Hydrocarbons	2023/05/25		86	%	30 - 130
			>C21-<C32 Hydrocarbons	2023/05/25		74	%	30 - 130
8683575	MGN	Spiked Blank	Isobutylbenzene - Extractable	2023/05/25		98	%	60 - 130
			n-Dotriacontane - Extractable	2023/05/25		91	%	60 - 130
			>C10-C16 Hydrocarbons	2023/05/25		93	%	60 - 130
			>C16-C21 Hydrocarbons	2023/05/25		87	%	60 - 130
			>C21-<C32 Hydrocarbons	2023/05/25		79	%	60 - 130
8683575	MGN	Method Blank	Isobutylbenzene - Extractable	2023/05/25		96	%	60 - 130
			n-Dotriacontane - Extractable	2023/05/25		90	%	60 - 130
			>C10-C16 Hydrocarbons	2023/05/25	<10		mg/kg	
			>C16-C21 Hydrocarbons	2023/05/25	<10		mg/kg	
			>C21-<C32 Hydrocarbons	2023/05/25	<15		mg/kg	
8683575	MGN	RPD	>C10-C16 Hydrocarbons	2023/05/25	NC		%	50
			>C16-C21 Hydrocarbons	2023/05/25	NC		%	50
			>C21-<C32 Hydrocarbons	2023/05/25	NC		%	50
8684106	MSK	Matrix Spike	Isobutylbenzene - Extractable	2023/05/25		95	%	60 - 130
			n-Dotriacontane - Extractable	2023/05/25		106	%	60 - 130
			>C10-C16 Hydrocarbons	2023/05/25		99	%	30 - 130
			>C16-C21 Hydrocarbons	2023/05/25		99	%	30 - 130
			>C21-<C32 Hydrocarbons	2023/05/25		91	%	30 - 130
8684106	MSK	Spiked Blank	Isobutylbenzene - Extractable	2023/05/25		95	%	60 - 130
			n-Dotriacontane - Extractable	2023/05/25		105	%	60 - 130
			>C10-C16 Hydrocarbons	2023/05/25		100	%	60 - 130
			>C16-C21 Hydrocarbons	2023/05/25		100	%	60 - 130
			>C21-<C32 Hydrocarbons	2023/05/25		94	%	60 - 130
8684106	MSK	Method Blank	Isobutylbenzene - Extractable	2023/05/25		95	%	60 - 130
			n-Dotriacontane - Extractable	2023/05/25		104	%	60 - 130
			>C10-C16 Hydrocarbons	2023/05/25	<10		mg/kg	
			>C16-C21 Hydrocarbons	2023/05/25	<10		mg/kg	
			>C21-<C32 Hydrocarbons	2023/05/25	<15		mg/kg	
8684106	MSK	RPD	>C10-C16 Hydrocarbons	2023/05/25	NC		%	50
			>C16-C21 Hydrocarbons	2023/05/25	NC		%	50
			>C21-<C32 Hydrocarbons	2023/05/25	NC		%	50
8686021	BCZ	Matrix Spike	Acid Extractable Antimony (Sb)	2023/05/26		82	%	75 - 125
			Acid Extractable Arsenic (As)	2023/05/26		89	%	75 - 125
			Acid Extractable Barium (Ba)	2023/05/26		97	%	75 - 125
			Acid Extractable Beryllium (Be)	2023/05/26		92	%	75 - 125
			Acid Extractable Bismuth (Bi)	2023/05/26		91	%	75 - 125
			Acid Extractable Boron (B)	2023/05/26		73 (1)	%	75 - 125
			Acid Extractable Cadmium (Cd)	2023/05/26		92	%	75 - 125
			Acid Extractable Chromium (Cr)	2023/05/26		90	%	75 - 125
			Acid Extractable Cobalt (Co)	2023/05/26		91	%	75 - 125
			Acid Extractable Copper (Cu)	2023/05/26		91	%	75 - 125
			Acid Extractable Lead (Pb)	2023/05/26		93	%	75 - 125
			Acid Extractable Lithium (Li)	2023/05/26		90	%	75 - 125
			Acid Extractable Manganese (Mn)	2023/05/26		NC	%	75 - 125
			Acid Extractable Mercury (Hg)	2023/05/26		87	%	75 - 125
			Acid Extractable Molybdenum (Mo)	2023/05/26		91	%	75 - 125
			Acid Extractable Nickel (Ni)	2023/05/26		88	%	75 - 125

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Acid Extractable Rubidium (Rb)	2023/05/26		86	%	75 - 125
			Acid Extractable Selenium (Se)	2023/05/26		92	%	75 - 125
			Acid Extractable Silver (Ag)	2023/05/26		90	%	75 - 125
			Acid Extractable Strontium (Sr)	2023/05/26		91	%	75 - 125
			Acid Extractable Thallium (Tl)	2023/05/26		93	%	75 - 125
			Acid Extractable Tin (Sn)	2023/05/26		91	%	75 - 125
			Acid Extractable Uranium (U)	2023/05/26		95	%	75 - 125
			Acid Extractable Vanadium (V)	2023/05/26		92	%	75 - 125
			Acid Extractable Zinc (Zn)	2023/05/26		NC	%	75 - 125
8686021	BCZ	Spiked Blank	Acid Extractable Antimony (Sb)	2023/05/26		101	%	75 - 125
			Acid Extractable Arsenic (As)	2023/05/26		96	%	75 - 125
			Acid Extractable Barium (Ba)	2023/05/26		99	%	75 - 125
			Acid Extractable Beryllium (Be)	2023/05/26		96	%	75 - 125
			Acid Extractable Bismuth (Bi)	2023/05/26		97	%	75 - 125
			Acid Extractable Boron (B)	2023/05/26		110	%	75 - 125
			Acid Extractable Cadmium (Cd)	2023/05/26		98	%	75 - 125
			Acid Extractable Chromium (Cr)	2023/05/26		96	%	75 - 125
			Acid Extractable Cobalt (Co)	2023/05/26		96	%	75 - 125
			Acid Extractable Copper (Cu)	2023/05/26		95	%	75 - 125
			Acid Extractable Lead (Pb)	2023/05/26		98	%	75 - 125
			Acid Extractable Lithium (Li)	2023/05/26		95	%	75 - 125
			Acid Extractable Manganese (Mn)	2023/05/26		99	%	75 - 125
			Acid Extractable Mercury (Hg)	2023/05/26		93	%	75 - 125
			Acid Extractable Molybdenum (Mo)	2023/05/26		97	%	75 - 125
			Acid Extractable Nickel (Ni)	2023/05/26		95	%	75 - 125
			Acid Extractable Rubidium (Rb)	2023/05/26		93	%	75 - 125
			Acid Extractable Selenium (Se)	2023/05/26		100	%	75 - 125
			Acid Extractable Silver (Ag)	2023/05/26		94	%	75 - 125
			Acid Extractable Strontium (Sr)	2023/05/26		96	%	75 - 125
			Acid Extractable Thallium (Tl)	2023/05/26		97	%	75 - 125
			Acid Extractable Tin (Sn)	2023/05/26		102	%	75 - 125
			Acid Extractable Uranium (U)	2023/05/26		99	%	75 - 125
			Acid Extractable Vanadium (V)	2023/05/26		97	%	75 - 125
			Acid Extractable Zinc (Zn)	2023/05/26		97	%	75 - 125
8686021	BCZ	Method Blank	Acid Extractable Aluminum (Al)	2023/05/26	<10		mg/kg	
			Acid Extractable Antimony (Sb)	2023/05/26	<2.0		mg/kg	
			Acid Extractable Arsenic (As)	2023/05/26	<2.0		mg/kg	
			Acid Extractable Barium (Ba)	2023/05/26	<5.0		mg/kg	
			Acid Extractable Beryllium (Be)	2023/05/26	<1.0		mg/kg	
			Acid Extractable Bismuth (Bi)	2023/05/26	<2.0		mg/kg	
			Acid Extractable Boron (B)	2023/05/26	<50		mg/kg	
			Acid Extractable Cadmium (Cd)	2023/05/26	<0.30		mg/kg	
			Acid Extractable Chromium (Cr)	2023/05/26	<2.0		mg/kg	
			Acid Extractable Cobalt (Co)	2023/05/26	<1.0		mg/kg	
			Acid Extractable Copper (Cu)	2023/05/26	<2.0		mg/kg	
			Acid Extractable Iron (Fe)	2023/05/26	<50		mg/kg	
			Acid Extractable Lead (Pb)	2023/05/26	<0.50		mg/kg	
			Acid Extractable Lithium (Li)	2023/05/26	<2.0		mg/kg	
			Acid Extractable Manganese (Mn)	2023/05/26	<2.0		mg/kg	
			Acid Extractable Mercury (Hg)	2023/05/26	<0.10		mg/kg	
			Acid Extractable Molybdenum (Mo)	2023/05/26	<2.0		mg/kg	
			Acid Extractable Nickel (Ni)	2023/05/26	<2.0		mg/kg	
			Acid Extractable Rubidium (Rb)	2023/05/26	<2.0		mg/kg	

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Acid Extractable Selenium (Se)	2023/05/26	<0.50		mg/kg	
			Acid Extractable Silver (Ag)	2023/05/26	<0.50		mg/kg	
			Acid Extractable Strontium (Sr)	2023/05/26	<5.0		mg/kg	
			Acid Extractable Thallium (Tl)	2023/05/26	<0.10		mg/kg	
			Acid Extractable Tin (Sn)	2023/05/26	<1.0		mg/kg	
			Acid Extractable Uranium (U)	2023/05/26	<0.10		mg/kg	
			Acid Extractable Vanadium (V)	2023/05/26	<2.0		mg/kg	
			Acid Extractable Zinc (Zn)	2023/05/26	<5.0		mg/kg	
8686021	BCZ	RPD	Acid Extractable Aluminum (Al)	2023/05/26	5.6		%	35
			Acid Extractable Antimony (Sb)	2023/05/26	NC		%	35
			Acid Extractable Arsenic (As)	2023/05/26	5.4		%	35
			Acid Extractable Barium (Ba)	2023/05/26	2.5		%	35
			Acid Extractable Beryllium (Be)	2023/05/26	NC		%	35
			Acid Extractable Bismuth (Bi)	2023/05/26	NC		%	35
			Acid Extractable Boron (B)	2023/05/26	NC		%	35
			Acid Extractable Cadmium (Cd)	2023/05/26	NC		%	35
			Acid Extractable Chromium (Cr)	2023/05/26	2.9		%	35
			Acid Extractable Cobalt (Co)	2023/05/26	2.5		%	35
			Acid Extractable Copper (Cu)	2023/05/26	3.1		%	35
			Acid Extractable Iron (Fe)	2023/05/26	0.46		%	35
			Acid Extractable Lead (Pb)	2023/05/26	1.6		%	35
			Acid Extractable Lithium (Li)	2023/05/26	5.2		%	35
			Acid Extractable Manganese (Mn)	2023/05/26	2.3		%	35
			Acid Extractable Mercury (Hg)	2023/05/26	NC		%	35
			Acid Extractable Molybdenum (Mo)	2023/05/26	NC		%	35
			Acid Extractable Nickel (Ni)	2023/05/26	4.1		%	35
			Acid Extractable Rubidium (Rb)	2023/05/26	5.1		%	35
			Acid Extractable Selenium (Se)	2023/05/26	9.4		%	35
			Acid Extractable Silver (Ag)	2023/05/26	NC		%	35
			Acid Extractable Strontium (Sr)	2023/05/26	2.0		%	35
			Acid Extractable Thallium (Tl)	2023/05/26	3.3		%	35
			Acid Extractable Tin (Sn)	2023/05/26	NC		%	35
			Acid Extractable Uranium (U)	2023/05/26	1.8		%	35
			Acid Extractable Vanadium (V)	2023/05/26	2.2		%	35
			Acid Extractable Zinc (Zn)	2023/05/26	2.5		%	35
8686233	BCZ	Matrix Spike	Acid Extractable Antimony (Sb)	2023/05/27		95	%	75 - 125
			Acid Extractable Arsenic (As)	2023/05/27		93	%	75 - 125
			Acid Extractable Barium (Ba)	2023/05/27		102	%	75 - 125
			Acid Extractable Beryllium (Be)	2023/05/27		96	%	75 - 125
			Acid Extractable Bismuth (Bi)	2023/05/27		97	%	75 - 125
			Acid Extractable Boron (B)	2023/05/27		83	%	75 - 125
			Acid Extractable Cadmium (Cd)	2023/05/27		97	%	75 - 125
			Acid Extractable Chromium (Cr)	2023/05/27		98	%	75 - 125
			Acid Extractable Cobalt (Co)	2023/05/27		95	%	75 - 125
			Acid Extractable Copper (Cu)	2023/05/27		95	%	75 - 125
			Acid Extractable Lead (Pb)	2023/05/27		97	%	75 - 125
			Acid Extractable Lithium (Li)	2023/05/27		99	%	75 - 125
			Acid Extractable Manganese (Mn)	2023/05/27		NC	%	75 - 125
			Acid Extractable Mercury (Hg)	2023/05/27		91	%	75 - 125
			Acid Extractable Molybdenum (Mo)	2023/05/27		99	%	75 - 125
			Acid Extractable Nickel (Ni)	2023/05/27		96	%	75 - 125
			Acid Extractable Rubidium (Rb)	2023/05/27		94	%	75 - 125
			Acid Extractable Selenium (Se)	2023/05/27		99	%	75 - 125

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Acid Extractable Silver (Ag)	2023/05/27		94	%	75 - 125
			Acid Extractable Strontium (Sr)	2023/05/27		96	%	75 - 125
			Acid Extractable Thallium (Tl)	2023/05/27		97	%	75 - 125
			Acid Extractable Tin (Sn)	2023/05/27		98	%	75 - 125
			Acid Extractable Uranium (U)	2023/05/27		100	%	75 - 125
			Acid Extractable Vanadium (V)	2023/05/27		93	%	75 - 125
			Acid Extractable Zinc (Zn)	2023/05/27		96	%	75 - 125
8686233	BCZ	Spiked Blank	Acid Extractable Antimony (Sb)	2023/05/27		101	%	75 - 125
			Acid Extractable Arsenic (As)	2023/05/27		94	%	75 - 125
			Acid Extractable Barium (Ba)	2023/05/27		101	%	75 - 125
			Acid Extractable Beryllium (Be)	2023/05/27		96	%	75 - 125
			Acid Extractable Bismuth (Bi)	2023/05/27		96	%	75 - 125
			Acid Extractable Boron (B)	2023/05/27		105	%	75 - 125
			Acid Extractable Cadmium (Cd)	2023/05/27		96	%	75 - 125
			Acid Extractable Chromium (Cr)	2023/05/27		97	%	75 - 125
			Acid Extractable Cobalt (Co)	2023/05/27		94	%	75 - 125
			Acid Extractable Copper (Cu)	2023/05/27		93	%	75 - 125
			Acid Extractable Lead (Pb)	2023/05/27		98	%	75 - 125
			Acid Extractable Lithium (Li)	2023/05/27		96	%	75 - 125
			Acid Extractable Manganese (Mn)	2023/05/27		100	%	75 - 125
			Acid Extractable Mercury (Hg)	2023/05/27		94	%	75 - 125
			Acid Extractable Molybdenum (Mo)	2023/05/27		99	%	75 - 125
			Acid Extractable Nickel (Ni)	2023/05/27		93	%	75 - 125
			Acid Extractable Rubidium (Rb)	2023/05/27		95	%	75 - 125
			Acid Extractable Selenium (Se)	2023/05/27		99	%	75 - 125
			Acid Extractable Silver (Ag)	2023/05/27		93	%	75 - 125
			Acid Extractable Strontium (Sr)	2023/05/27		94	%	75 - 125
			Acid Extractable Thallium (Tl)	2023/05/27		98	%	75 - 125
			Acid Extractable Tin (Sn)	2023/05/27		98	%	75 - 125
			Acid Extractable Uranium (U)	2023/05/27		100	%	75 - 125
			Acid Extractable Vanadium (V)	2023/05/27		96	%	75 - 125
			Acid Extractable Zinc (Zn)	2023/05/27		98	%	75 - 125
8686233	BCZ	Method Blank	Acid Extractable Aluminum (Al)	2023/05/27	<10		mg/kg	
			Acid Extractable Antimony (Sb)	2023/05/27	<2.0		mg/kg	
			Acid Extractable Arsenic (As)	2023/05/27	<2.0		mg/kg	
			Acid Extractable Barium (Ba)	2023/05/27	<5.0		mg/kg	
			Acid Extractable Beryllium (Be)	2023/05/27	<1.0		mg/kg	
			Acid Extractable Bismuth (Bi)	2023/05/27	<2.0		mg/kg	
			Acid Extractable Boron (B)	2023/05/27	<50		mg/kg	
			Acid Extractable Cadmium (Cd)	2023/05/27	<0.30		mg/kg	
			Acid Extractable Chromium (Cr)	2023/05/27	<2.0		mg/kg	
			Acid Extractable Cobalt (Co)	2023/05/27	<1.0		mg/kg	
			Acid Extractable Copper (Cu)	2023/05/27	<2.0		mg/kg	
			Acid Extractable Iron (Fe)	2023/05/27	<50		mg/kg	
			Acid Extractable Lead (Pb)	2023/05/27	<0.50		mg/kg	
			Acid Extractable Lithium (Li)	2023/05/27	<2.0		mg/kg	
			Acid Extractable Manganese (Mn)	2023/05/27	<2.0		mg/kg	
			Acid Extractable Mercury (Hg)	2023/05/27	<0.10		mg/kg	
			Acid Extractable Molybdenum (Mo)	2023/05/27	<2.0		mg/kg	
			Acid Extractable Nickel (Ni)	2023/05/27	<2.0		mg/kg	
			Acid Extractable Rubidium (Rb)	2023/05/27	<2.0		mg/kg	
			Acid Extractable Selenium (Se)	2023/05/27	<0.50		mg/kg	
			Acid Extractable Silver (Ag)	2023/05/27	<0.50		mg/kg	

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Acid Extractable Strontium (Sr)	2023/05/27	<5.0		mg/kg	
			Acid Extractable Thallium (Tl)	2023/05/27	<0.10		mg/kg	
			Acid Extractable Tin (Sn)	2023/05/27	<1.0		mg/kg	
			Acid Extractable Uranium (U)	2023/05/27	<0.10		mg/kg	
			Acid Extractable Vanadium (V)	2023/05/27	<2.0		mg/kg	
			Acid Extractable Zinc (Zn)	2023/05/27	<5.0		mg/kg	
8686233	BCZ	RPD	Acid Extractable Aluminum (Al)	2023/05/27	11		%	35
			Acid Extractable Antimony (Sb)	2023/05/27	NC		%	35
			Acid Extractable Arsenic (As)	2023/05/27	9.4		%	35
			Acid Extractable Barium (Ba)	2023/05/27	15		%	35
			Acid Extractable Beryllium (Be)	2023/05/27	NC		%	35
			Acid Extractable Bismuth (Bi)	2023/05/27	NC		%	35
			Acid Extractable Boron (B)	2023/05/27	NC		%	35
			Acid Extractable Cadmium (Cd)	2023/05/27	NC		%	35
			Acid Extractable Chromium (Cr)	2023/05/27	15		%	35
			Acid Extractable Cobalt (Co)	2023/05/27	6.3		%	35
			Acid Extractable Copper (Cu)	2023/05/27	20		%	35
			Acid Extractable Iron (Fe)	2023/05/27	11		%	35
			Acid Extractable Lead (Pb)	2023/05/27	14		%	35
			Acid Extractable Lithium (Li)	2023/05/27	8.6		%	35
			Acid Extractable Manganese (Mn)	2023/05/27	21		%	35
			Acid Extractable Mercury (Hg)	2023/05/27	11		%	35
			Acid Extractable Molybdenum (Mo)	2023/05/27	NC		%	35
			Acid Extractable Nickel (Ni)	2023/05/27	22		%	35
			Acid Extractable Rubidium (Rb)	2023/05/27	14		%	35
			Acid Extractable Selenium (Se)	2023/05/27	4.0		%	35
			Acid Extractable Silver (Ag)	2023/05/27	NC		%	35
			Acid Extractable Strontium (Sr)	2023/05/27	NC		%	35
			Acid Extractable Thallium (Tl)	2023/05/27	NC		%	35
			Acid Extractable Tin (Sn)	2023/05/27	12		%	35
			Acid Extractable Uranium (U)	2023/05/27	0.55		%	35
			Acid Extractable Vanadium (V)	2023/05/27	5.8		%	35
			Acid Extractable Zinc (Zn)	2023/05/27	22		%	35
8686754	A1M	Matrix Spike	Isobutylbenzene - Volatile	2023/05/26		110	%	60 - 130
			Benzene	2023/05/26		106	%	60 - 130
			Toluene	2023/05/26		101	%	60 - 130
			Ethylbenzene	2023/05/26		108	%	60 - 130
			Total Xylenes	2023/05/26		105	%	60 - 130
8686754	A1M	Spiked Blank	Isobutylbenzene - Volatile	2023/05/26		101	%	60 - 130
			Benzene	2023/05/26		93	%	60 - 140
			Toluene	2023/05/26		96	%	60 - 140
			Ethylbenzene	2023/05/26		102	%	60 - 140
			Total Xylenes	2023/05/26		101	%	60 - 140
8686754	A1M	Method Blank	Isobutylbenzene - Volatile	2023/05/26		104	%	60 - 130
			Benzene	2023/05/26	<0.0050		mg/kg	
			Toluene	2023/05/26	<0.050		mg/kg	
			Ethylbenzene	2023/05/26	<0.010		mg/kg	
			Total Xylenes	2023/05/26	<0.050		mg/kg	
			C6 - C10 (less BTEX)	2023/05/26	<2.5		mg/kg	
8686754	A1M	RPD	Benzene	2023/05/26	NC		%	50
			Toluene	2023/05/26	NC		%	50
			Ethylbenzene	2023/05/26	NC		%	50
			Total Xylenes	2023/05/26	NC		%	50

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			C6 - C10 (less BTEX)	2023/05/26	NC		%	50
8689764	RAJ	Matrix Spike	D10-Anthracene	2023/05/30		101	%	50 - 130
			D14-Terphenyl (FS)	2023/05/30		102	%	50 - 130
			D8-Acenaphthylene	2023/05/30		89	%	50 - 130
			Acenaphthene	2023/05/30		97	%	50 - 130
			Acenaphthylene	2023/05/30		90	%	50 - 130
			Anthracene	2023/05/30		95	%	50 - 130
			Benzo(a)anthracene	2023/05/30		95	%	50 - 130
			Benzo(a)pyrene	2023/05/30		93	%	50 - 130
			Benzo(b/j)fluoranthene	2023/05/30		92	%	50 - 130
			Benzo(g,h,i)perylene	2023/05/30		101	%	50 - 130
			Benzo(k)fluoranthene	2023/05/30		96	%	50 - 130
			Chrysene	2023/05/30		94	%	50 - 130
			Dibenzo(a,h)anthracene	2023/05/30		105	%	50 - 130
			Fluoranthene	2023/05/30		95	%	50 - 130
			Fluorene	2023/05/30		104	%	50 - 130
			Indeno(1,2,3-cd)pyrene	2023/05/30		101	%	50 - 130
			1-Methylnaphthalene	2023/05/30		96	%	50 - 130
			2-Methylnaphthalene	2023/05/30		89	%	50 - 130
			Naphthalene	2023/05/30		83	%	50 - 130
			Phenanthrene	2023/05/30		91	%	50 - 130
			Pyrene	2023/05/30		95	%	50 - 130
			Benzo(b)fluoranthene	2023/05/30		93	%	50 - 130
			Perylene	2023/05/30		100	%	50 - 130
			Benzo(j)fluoranthene	2023/05/30		91	%	50 - 130
8689764	RAJ	Spiked Blank	D10-Anthracene	2023/05/30		95	%	50 - 130
			D14-Terphenyl (FS)	2023/05/30		98	%	50 - 130
			D8-Acenaphthylene	2023/05/30		91	%	50 - 130
			Acenaphthene	2023/05/30		91	%	50 - 130
			Acenaphthylene	2023/05/30		87	%	50 - 130
			Anthracene	2023/05/30		92	%	50 - 130
			Benzo(a)anthracene	2023/05/30		89	%	50 - 130
			Benzo(a)pyrene	2023/05/30		88	%	50 - 130
			Benzo(b/j)fluoranthene	2023/05/30		88	%	50 - 130
			Benzo(g,h,i)perylene	2023/05/30		96	%	50 - 130
			Benzo(k)fluoranthene	2023/05/30		91	%	50 - 130
			Chrysene	2023/05/30		90	%	50 - 130
			Dibenzo(a,h)anthracene	2023/05/30		98	%	50 - 130
			Fluoranthene	2023/05/30		91	%	50 - 130
			Fluorene	2023/05/30		99	%	50 - 130
			Indeno(1,2,3-cd)pyrene	2023/05/30		96	%	50 - 130
			1-Methylnaphthalene	2023/05/30		93	%	50 - 130
			2-Methylnaphthalene	2023/05/30		87	%	50 - 130
			Naphthalene	2023/05/30		85	%	50 - 130
			Phenanthrene	2023/05/30		87	%	50 - 130
			Pyrene	2023/05/30		92	%	50 - 130
			Benzo(b)fluoranthene	2023/05/30		87	%	50 - 130
			Perylene	2023/05/30		96	%	50 - 130
			Benzo(j)fluoranthene	2023/05/30		89	%	50 - 130
8689764	RAJ	Method Blank	D10-Anthracene	2023/05/30		95	%	50 - 130
			D14-Terphenyl (FS)	2023/05/30		99	%	50 - 130
			D8-Acenaphthylene	2023/05/30		91	%	50 - 130
			Acenaphthene	2023/05/30	<0.0050		ug/g	

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Acenaphthylene	2023/05/30	<0.0050		ug/g	
			Anthracene	2023/05/30	<0.0050		ug/g	
			Benzo(a)anthracene	2023/05/30	<0.0050		ug/g	
			Benzo(a)pyrene	2023/05/30	<0.0050		ug/g	
			Benzo(b/j)fluoranthene	2023/05/30	<0.0050		ug/g	
			Benzo(g,h,i)perylene	2023/05/30	<0.0050		ug/g	
			Benzo(k)fluoranthene	2023/05/30	<0.0050		ug/g	
			Chrysene	2023/05/30	<0.0050		ug/g	
			Dibenzo(a,h)anthracene	2023/05/30	<0.0050		ug/g	
			Fluoranthene	2023/05/30	<0.0050		ug/g	
			Fluorene	2023/05/30	<0.0050		ug/g	
			Indeno(1,2,3-cd)pyrene	2023/05/30	<0.0050		ug/g	
			1-Methylnaphthalene	2023/05/30	<0.0050		ug/g	
			2-Methylnaphthalene	2023/05/30	<0.0050		ug/g	
			Naphthalene	2023/05/30	<0.0050		ug/g	
			Phenanthrene	2023/05/30	<0.0050		ug/g	
			Pyrene	2023/05/30	<0.0050		ug/g	
			Benzo(b)fluoranthene	2023/05/30	<0.0030		ug/g	
			Perylene	2023/05/30	<0.0050		ug/g	
			Benzo(j)fluoranthene	2023/05/30	<0.0030		ug/g	
8689764	RAJ	RPD	Acenaphthene	2023/05/30	NC		%	40
			Acenaphthylene	2023/05/30	NC		%	40
			Anthracene	2023/05/30	NC		%	40
			Benzo(a)anthracene	2023/05/30	NC		%	40
			Benzo(a)pyrene	2023/05/30	NC		%	40
			Benzo(b/j)fluoranthene	2023/05/30	NC		%	40
			Benzo(g,h,i)perylene	2023/05/30	NC		%	40
			Benzo(k)fluoranthene	2023/05/30	NC		%	40
			Chrysene	2023/05/30	NC		%	40
			Dibenzo(a,h)anthracene	2023/05/30	NC		%	40
			Fluoranthene	2023/05/30	NC		%	40
			Fluorene	2023/05/30	NC		%	40
			Indeno(1,2,3-cd)pyrene	2023/05/30	NC		%	40
			1-Methylnaphthalene	2023/05/30	NC		%	40
			2-Methylnaphthalene	2023/05/30	NC		%	40
			Naphthalene	2023/05/30	NC		%	40
			Phenanthrene	2023/05/30	NC		%	40
			Pyrene	2023/05/30	NC		%	40
8690359	SPY	Matrix Spike [VWO010-01]	Isobutylbenzene - Extractable	2023/05/30		98	%	60 - 130
			n-Dotriacontane - Extractable	2023/05/30		116	%	60 - 130
			>C10-C16 Hydrocarbons	2023/05/30		101	%	30 - 130
			>C16-C21 Hydrocarbons	2023/05/30		103	%	30 - 130
			>C21-<C32 Hydrocarbons	2023/05/30		101	%	30 - 130
8690359	SPY	Spiked Blank	Isobutylbenzene - Extractable	2023/05/30		102	%	60 - 130
			n-Dotriacontane - Extractable	2023/05/30		116	%	60 - 130
			>C10-C16 Hydrocarbons	2023/05/30		112	%	60 - 130
			>C16-C21 Hydrocarbons	2023/05/30		115	%	60 - 130
			>C21-<C32 Hydrocarbons	2023/05/30		112	%	60 - 130
8690359	SPY	Method Blank	Isobutylbenzene - Extractable	2023/05/30		104	%	60 - 130
			n-Dotriacontane - Extractable	2023/05/30		113	%	60 - 130
			>C10-C16 Hydrocarbons	2023/05/30	<10		mg/kg	
			>C16-C21 Hydrocarbons	2023/05/30	<10		mg/kg	

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			>C21-<C32 Hydrocarbons	2023/05/30	<15		mg/kg	
8690359	SPY	RPD [VWO010-01]	>C10-C16 Hydrocarbons	2023/05/30	NC		%	50
			>C16-C21 Hydrocarbons	2023/05/30	1.2		%	50
			>C21-<C32 Hydrocarbons	2023/05/30	39		%	50

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Recovery is within QC acceptance limits. < 10 % of compounds in multi-component analysis in violation.

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by:

Anastassia Hamanov, Scientific Specialist

Janah M. Rhyno

Janah Rhyno, Metals Supervisor-Bedford

Philippe Deveau

Phil Deveau, Scientific Specialist (Organics)

APPENDIX D

Opinion of Probable Cost

OPINION of PROBABLE CONSTRUCTION COSTS
PROJECT NAME: Halifax Water Mount Edward #1 Reservoir
Reservoir Location Option 1 - Concrete Tank
Dartmouth, NS
SUMMARY

(Based on Mount Edward Dartmouth Drawings February 2024)

DATE:	09-02-2024
CBCL No:	213007.00
Prepared by:	PG
Reviewed by:	AT
Budget Class:	Class 3

SCHEDULE OF QUANTITIES AND UNIT PRICES

Item	Description	Unit	Est. Qty.	Unit Price	Total Price
1	**Mobilization, Bonds, Insurance, PCM**	LS	1	$ 347,000	$ 347,000
2	**EXISTING RESERVOIR DEMOLITION & REINSTATEMENT**	LS	1	$ 392,000	$ 392,000
3	**EARTHWORKS**	LS	1	$ 254,567	$ 254,567
4	**REMOVALS**	LS	1	$ 32,490	$ 32,490
5	**WATER RESERVOIR (c/w Logo, Mixing, etc.)**	LS	1	$ 9,958,000	$ 9,958,000
6	**WATER SYSTEMS**	LS	1	$ 431,287	$ 431,287
7	**STORM SYSTEMS**	LS	1	$ 232,199	$ 232,199
8	**ROADWORK & REINSTATEMENT**	LS	1	$ 236,050	$ 236,050
9	**LANDSCAPING**	LS	1	$ 41,479	$ 41,479
10	**ELECTRICAL**	LS	1	$ 208,250	$ 208,250
11	**ENVIRONMENTAL PROTECTION (c/w Noise and Dust Monitoring)**	LS	1	$ 35,403	$ 35,403
12	**CONTINGENCY**		20.0%		$ 2,433,745
13	**ESCALATION / INFLATION (to 2025 Construction Year) - *Note 1***		4.0%		$ 584,099
14	**OPINION OF PROBABLE CONSTRUCTION COST (excl. HST)**				**$ 15,187,000**
15	**Net HST**		4.286%		$ 650,920
16	**OPINION OF PROBABLE CONSTRUCTION COST**				**$ 15,838,000**

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. SUDDEN MARKET TREND CHANGES, NON-COMPETITIVE BIDDING SITUATIONS, UNFORESEEN LABOUR AND MATERIAL ADJUSTMENTS, UNFORESEEN SITE CONDITIONS, AND THE LIKE ARE BEYOND THE CONTROL OF CBCL LIMITED. IT IS NOT A PREDICTION OF LOW PRICE. AS SUCH WE CANNOT WARRANT OR GUARANTEE THAT ACTUAL COSTS WILL NOT VARY FROM THE OPINION PROVIDED. IT IS BASED ON THE DATE OF THIS BUDGET.

Note 1 This Allowance is for increases in construction costs from the time of budget development to Tender Call.

CBCL Form P3-TMP-NS-001 Rev0

OPINION of PROBABLE CONSTRUCTION COSTS
PROJECT NAME: Halifax Water Mount Edward #1 Reservoir
Reservoir Location Option 1 - Welded Steel Tank
Dartmouth, NS
SUMMARY

(Based on Mount Edward Dartmouth Drawings February 2024)

DATE:	09-02-2024
CBCL No:	213007.00
Prepared by:	PG
Reviewed by:	AT
Budget Class:	Class 3

SCHEDULE OF QUANTITIES AND UNIT PRICES

Item	Description	Unit	Est. Qty.	Unit Price	Total Price
1	**Mobilization, Bonds, Insurance, PCM**	LS	1	$ 508,000	$ 508,000
2	**EXISTING RESERVOIR DEMOLITION & REINSTATEMENT**	LS	1	$ 392,000	$ 392,000
3	**EARTHWORKS**	LS	1	$ 445,175	$ 445,175
4	**REMOVALS**	LS	1	$ 32,490	$ 32,490
5	**WATER RESERVOIR (c/w Logo, Mixing, etc.)**	LS	1	$ 14,194,000	$ 14,194,000
6	**WATER SYSTEMS**	LS	1	$ 431,287	$ 431,287
7	**STORM SYSTEMS**	LS	1	$ 232,199	$ 232,199
8	**ROADWORK & REINSTATEMENT**	LS	1	$ 236,050	$ 236,050
9	**LANDSCAPING**	LS	1	$ 109,760	$ 109,760
10	**ELECTRICAL**	LS	1	$ 208,250	$ 208,250
11	**ENVIRONMENTAL PROTECTION (c/w Noise and Dust Monitoring)**	LS	1	$ 59,290	$ 59,290
12	**CONTINGENCY**		20.0%		$ 3,369,700
13	**ESCALATION / INFLATION (to 2025 Construction Year) - *Note 1***		4.0%		$ 808,728
14	**OPINION OF PROBABLE CONSTRUCTION COST (excl. HST)**				**$ 21,027,000**
15	**Net HST**		4.286%		$ 901,220
16	**OPINION OF PROBABLE CONSTRUCTION COST**				**$ 21,928,300**

Note 1 This Allowance is for increases in construction costs from the time of budget development to Tender Call.

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April 11, 2024

Jonathan MacDonald, P.Eng.
Project Engineer
Halifax Water
450 Cowie Hill Road
Halifax, NS B3K 5M1

Mr. MacDonald:

RE: Mount Edward #1 Life Cycle Analysis – Supplemental Information

Introduction

This letter expands on the life cycle analysis presented in the *Mount Edward Reservoir #1 Replacement (P32.2022) Preliminary Design Report* prepared by CBCL Limited (CBCL) (March 2024). The three options that were chosen for evaluation were the following:

- Replacement with a Welded Steel Tank (AWWA D100).
- Replacement with a Prestressed Concrete Tanks (AWWA D110 – Type III).
- Rehabilitation of Mount Edward #1 followed by replacement with a new tank after 20 years.

Replacement with a Glass-lined Bolted Steel Tank (AWWA D103) was not considered since the size of the Mount Edward tank is larger than the maximum sizing parameters that can be constructed with this style of tank.

Tank Materials

To meet Halifax Water requirements, storage tanks must conform to the latest edition of the American Water Works Association (AWWA) standards. Materials of construction are a vital consideration for any water storage project. Welded steel, and prestressed concrete tanks are the primary construction methods for this size of tank and have their own specific characteristics and AWWA standards.

Welded Steel Tanks

Welded steel tanks designed and constructed to the AWWA D100 standard have been used for water storage since the 1930's, and completely replaced riveted construction by the 1950's. Welded steel tanks have historically been the most widely selected construction type in Atlantic Canada and have generally been very successful. With proper maintenance, particularly with keeping the coating systems in good condition and providing cathodic protection, welded steel tanks can have very long service lives. According to the AWWA Manual *M42 – Steel Water Storage Tanks*, there are tanks with service lives exceeding 100 years.

These tanks are made of steel plates that comprise the welded wall sections, floor, and roof segments (where a steel roof is specified). The foundation consists of a concrete ring foundation under the wall plates, while the floor plates are founded on an inert soil or crushed rock, such as limestone, to reduce the risk of soil side corrosion. Roofs are commonly of steel construction and can be self-supporting in smaller diameters. In larger diameter tanks, roofs are supported on steel beams and columns, and are referred to as Cone Roof Tank (CRT). Aluminum geodesic domes can also be used and can be more cost effective than CRT roofs, depending on diameter. For the Mount Edward tank, an aluminium geodesic dome is more cost effective and has been assumed for this analysis.

One of the primary challenges with welded steel tanks is the ability to adequately coat the surfaces between the roof and rafter supports for a column support cone roof, or between the roof shell and the reinforcing of the umbrella style roof. This affects the overall quality of coating. Improperly coated surfaces can result in premature adhesion failure, requiring maintenance in advance of the expected coating cycle. The experience of the coating contractor and inspector is critical to ensure a properly applied coating system. Proper preparation, basecoat, and topcoat application, and testing of the coating system is required during constructions. Coatings not properly applied can result in pinholes, called holidays, in the coating system, permitting corrosion to occur. Costs of paint coating systems has increased in recent years, due to increasingly stringent volatile organic compounds (VOCs) requirements. This has resulted in coatings requiring cleaner surfaces, and strict occupational procedures to protect worker health, the environment, and stray particulates during application.

Modifications or repairs to welded tanks are relatively easy to perform and can be done by local qualified welders; however, any work that affects the interior or exterior protective coatings will require the services of trained coating applicators.

Table 1: Welded Steel Tanks – Advantages and Disadvantages

Advantages	Disadvantages
Design flexibility can be custom designed for any height and diameter, paint schemes, and accessories. Multiple roof styles are available – including lightweight geodesic domes. Easy to add accessories or attachments.	High maintenance cost due to coating requirements. The initial coating will require a touch-up or the application of a full overcoat after approximately 20 years. At the end of 40 years the coating system is expected to need full removal and replacement.
Zero leakage allowed by AWWA D100 standard.	Cathodic protection system is recommended. Anodes will need to be inspected periodically and will require replacement approximately every 10 to 20 years.
Structural problems are visually evident due to staining or rust. Corrective measures are relatively easy to perform.	Interior coating susceptible to ice damage. Formation of ice caused by insufficient water turnover in epoxy coated welded tanks can reduce the life of the coating due to ice abrasion.
Less susceptible to structural vandalism.	Cannot be backfilled.
Flexible, watertight structure.	Construction can be limited by environmental factors during field erection and field-coating.
Long service life provided the tank coating is maintained.	High construction cost.

Prestressed Concrete Tanks

Prestressed, wire-wound concrete tanks combine the benefits of the compressive strength of concrete with the high tensile strength and water tightness of steel. The AWWA D110, Type III standard, provides a more durable finished structure, as opposed to the older “gunite” style tanks, and are recommended by the tank contractors for cold climates. Although the standard was published in 1986, these tanks have been constructed for over 50 years. Tank contractors claim the expected service life of these tanks to be over 80 years, though this claim is difficult to substantiate. We have assumed a service life of 60 years for this tank material.

AWWA D110, Type III tanks are constructed of multi-layered, high tensile strength wire wound prestressing around segmented precast concrete wall panels finished with a shotcrete cover. Wall panels are precast on-site in custom made casting beds formed to the curvature of the tank. An embedded steel diaphragm acts as a water barrier to prevent water migration through the tank wall. Roofs are freestanding reinforced concrete dome construction, with either segmented precast panels or cast monolithically. Tank floors are reinforced concrete and cast monolithically on site.

Wall panels are precast on-site in custom made casting beds formed to the curvature of the tank. The embedded steel diaphragm acts as a water barrier to prevent water migration through the tank wall. The dome cab to be cast either monolithically or as a series of concentric rows of individual dome panels, curved radially and circumferentially to form a freestanding, spherical dome with no interior columns. Tank floors are monolithically cast on site.

Prestressed concrete tanks allow reduced wall thickness by adding high strength tensile wire in addition to conventional reinforcing steel. The horizontal prestressed reinforcement of the tank wall is accomplished by application of helically wound high-tensile-stress wire, or strand under controlled tension on the surface core wall protected by shotcrete cover coats. The total prestressing requirements are determined for each tank to provide initial and residual compression. A final shotcrete cover coat is applied over the prestressed wire layers.

Tanks of the AWWA D110, Type III construction method have been constructed in cold climate areas (Ontario, New England, etc.) for nearly 40 years with favourable results. The Cowie Hill Reservoir was constructed for Halifax Water in 2022. A concern with concrete tanks in our climate is the frequency of freeze-thaw cycles, and the potential of damaging the exterior shotcrete coating – resulting in corrosion of the prestressing wires. Historically, concrete tanks constructed in advance of the AWWA D110 standard have been problematic in Canada. Mount Edward #1 was constructed in 1979, it is 44 years old, leaking and requires significant work to rehabilitate the structure. As the Cowie Hill Reservoir has just been completed, the long-term performance of a tank constructed to the AWWA D110 Type III standard is not known. The AWWA D110 standard notes that due to the wide range of site-specific environments, foundation conditions, loadings, and construction conditions throughout North America, the standard should not be expected to apply universally, and the structure's expected service life should be adapted to the actual conditions that are anticipated.

Prestressed concrete tanks do not require internal linings or a cathodic protection system. Repairs may include epoxy injection for minor seepage in the wall if it were to occur. This would need to be done by a qualified tank technician trained to do this work on prestressed concrete tanks. Future modifications such as manway installations or pipe penetrations, etc. would be specialty work.

Table 2: Prestressed Concrete Tanks – Advantages and Disadvantages

Advantages	Disadvantages
Cathodic protection not required.	Moderate to high construction cost.
Can be designed for backfilled conditions.	AWWA D110 standard has an allowable leakage rate (0.05%).
Tank exterior is resistant to impact damage and vandalism.	Concrete spalling on exterior wall may expose prestressing wires.
Some structural rehabilitation can be performed while the tank is in service.	Specialized equipment necessary for the prestressing of the exterior circumferential strands.
Structure is designed to resist forces and actions of ice formation in the tank.	Clearance around the tank perimeter required during construction.
Exterior architectural treatments available including facades, pilasters, etc..	Susceptible to cracking under temperature gradients such as warm ambient temperatures against cold stored water temperature.
	Concrete is porous, allowing potential discoloration from mold and mildew.
	Performance history of these tanks in this climate is limited. The tank will be subject to severe conditions due to freeze thaw cycles which will result in increased stress on the shotcrete coating.

Lifecycle Cost Analysis

The lifecycle cost of an asset is defined as the total cost, in present value, that includes the initial construction costs, maintenance, repairs, and rehabilitation costs over the specified design life cycle, and is performed by considering the Net Present Value (NPV) of the total life cycle cost for each tank material. A summary of the associated costs considered in the NPV is presented in Table 4 on the following pages.

Initial Construction Costs

Construction costs for the tank options are based on pricing provided by tank contractors who were contacted to obtain budgetary construction and maintenance costs. The initial tank costs are based on the same geometry of the existing tank. The costs are budgetary and may change as detailed design progresses.

Costs for a welded steel tank were obtained from two separate tank contractors who have had history with tank construction in Nova Scotia. Of these two contractors, one constructed the newest welded steel reservoir in Halifax, Hemlock, in 2020-2021. The bid price for the Hemlock project fell within the project budget which was based on pricing provided by the same two tank contractors. Therefore, we have carried average tank price based on the two quotes provided by the tank contractors for the NPV.

We also received costs for the prestressed concrete tank from two reputable tank contractors located in the United States. One cost was significantly lower than the other. The lower cost was provided by a tank contractor who has not recently worked in Canada. The higher cost was provided by the tank contractor who has recently completed the Cowie Hill Reservoir. The Cowie Hill Reservoir bid price exceeded the project budget, so there is a risk that when tendered, the cost for this tank material will be higher than the quoted price. To mitigate this risk, we have selected the higher of the two quotes for this analysis. It is assumed that the higher cost reflects the probable tank cost as it was provided by the tank contractor with the familiarity with working in the Canadian contracting environment.

The initial capital cost for the NPV for both tank materials is:

- Welded Steel Tank (D100) with Aluminum Dome Roof: $10,850,000.
- Prestressed Concrete (D110 Type III): $8,160,000.

Costs were also obtained for a welded steel tank with a column-supported cone roof. However, the capital cost is greater than the aluminum dome and was not included in the NPV.

Maintenance and Rehabilitation Costs

Maintenance and rehabilitation costs are based on information provided by the manufacturers’ and Halifax Water’s historical experience with these tanks.

Maintenance for prestressed concrete tanks includes exterior cleaning and recoating. The cleaning and recoating work is done to restore the original exterior tank appearance and remove environmental dirt, staining and efflorescence. The estimate cost for the cleaning and recoating is estimated to be $7 per square foot and is expected to occur every 20 years. Minor exterior rehabilitation is included to cover miscellaneous repairs if required and to restore any deterioration of the shotcrete exterior cover coat. We have also allowed for major repairs to be performed every 20 years, with an assumed cost being 15% of the construction cost. This is based on a historical review undertaken by Halifax Water and is thought to be representative of their experience with the “gunite” style of tank construction that preceded the present-day standard of construction.

Welded steel tanks have interior and exterior coatings requiring maintenance throughout the life of the tank. Full removal and replacement of the system will occur every 40 years, with touch-up and overcoat applied 20 years after each removal and replacement. Costs are based on $31 per square foot for full removal and replacement on both interior and exterior surfaces (based on a recent Halifax Water project), and $8 and $7 per square foot for touch-up and overcoat application for interior and exterior surfaces, respectively. An allowance for environmental containment costs is included for removal and replacement cycles.

For a welded steel tank with an aluminum geodesic dome, the dome itself will not require a protective coating, therefore the re-coating costs and maintenance for the aluminum roof are less than the steel roof. However, the aluminum dome will require periodic maintenance of gaskets and seals and are budgeted for every 20 years. We have included a cost of replacement for the aluminum geodesic dome at year 60, based on the current budgetary cost of the aluminum dome.

Rehabilitation of the existing Mount Edward #1 tank, as outlined in the Structural Condition Survey Assessment report (RJC, 2022), is stated to extend the service life of the existing Mount Edward #1 tank by 20 years. Maintenance of this tank during the extended service life would include inspection every 5 years. After 20 years, we assume that the tank will be replaced with a prestressed concrete tank or steel tank and will follow the maintenance schedule outlined for the new tank. In addition to the Opinion of Probable Cost (OPC) for rehabilitation in the report, we included the following additional costs:

- Costs for overhead and profit.
- Inflation.
- An allowance to cover potential repairs to the external post tensioning system.

Replacement Costs and Residual Value

Where the service life is less than the NPV forecast year, the replacement cost is the NPV of the initial capital cost for the year it is constructed. The residual value of a tank is calculated based on the expected service life remaining at the NPV forecast year. The residual value is calculated from a straight-line depreciation of its construction cost for that service life cycle.

Table 3: Typical O&M Activities – Mount Edward #1 Tank Replacement Options

Tank Option	Typical O&M Activities	Frequency	Cost
Prestressed Concrete (AWWA D110 Type III)	Tank Inspection	Every 5 Years	$5,000
	Pressure Wash and Acrylic Coat Exterior	Every 20 Years	$322,000
	Major Repairs	Every 20 Years	$1,224,000
	Exterior Rehabilitation	Every 40 Years	$50,000
	Tank Replacement	At 60 years	$8,160,000
Welded Steel (AWWA D100)	Tank Inspection	Every 5 Years	$5,000
	Replacement of Cathodic Protection Anodes	Every 10 Years	$12,000

Tank Option	Typical O&M Activities	Frequency	Cost
with Aluminum Dome Roof	Interior Coating Spot Repair and Full Overcoat	20 Years After Full Coating Replacement	$350,000
	Exterior Coating Spot Repair and Full Overcoat	20 Years After Full Coating Replacement	$125,000
	Interior Coating Full Removal and Replacement	Every 40 Years	$1,350,000
	Exterior Coating Full Removal and Replacement	Every 40 Years	$555,000
	Environmental Controls (Containment)	Every 40 Years	$75,000
	Aluminum Dome Repairs	Every 20 Years	$220,000
	Aluminum Dome Roof Replacement	At 60 Years	$1,800,000

Net Present Value

The NPV was calculated over a 100-year forecast – considering annual interest rates of both 6.0% and 4.0%, with a constant annual inflation rate of 2.5%. Results of the NPV for the Mount Edward #1 reservoir are presented in Table 4 and Figure 1.

A replacement cost for the prestressed concrete tank was included during year 60 of the analysis. A shorter NPV forecast horizon of 60 years could also be considered. It can be seen in Figure 1 that the concrete tank NPV with a 60-year forecast is less than the steel tank, including the residual value of the steel tank. The 60-year NPV is also not as sensitive to the interest rate variable.

Table 4: NPV Summary for 100-year Forecast

Tank Material Option	6.0% Interest	4.0% Interest
	Total Cost (NPV)	Total Cost (NPV)
Prestressed Concrete (AWWA D110 Type III)	$10,500,000	$13,900,000
Welded Steel (AWWA D100) With Aluminum Dome Roof	$12,200,000	$14,000,000

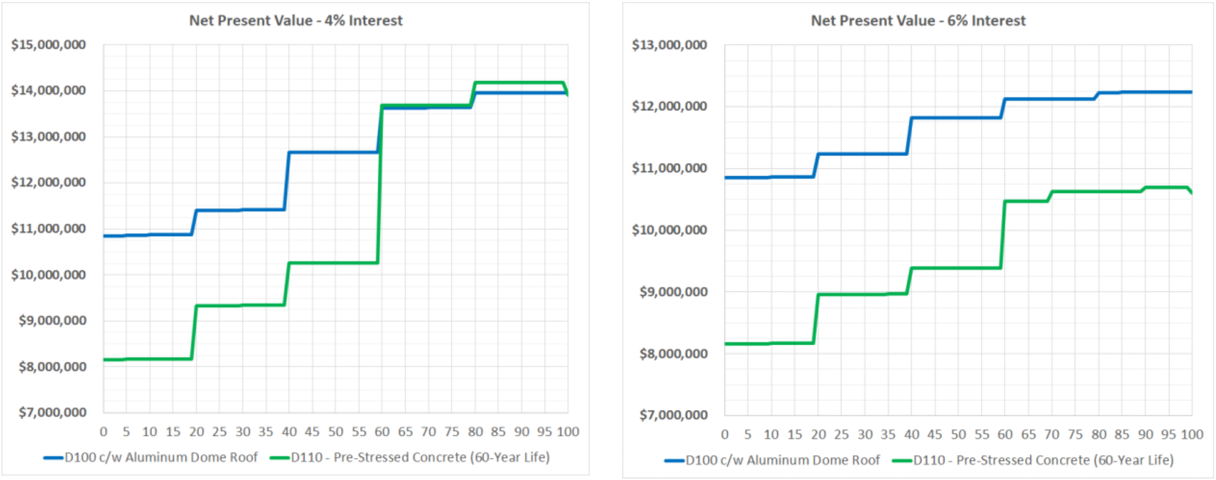


Figure 1: Net Present Value for 4% and 6% Interest Rates.

As part of a sensitivity analysis, we also varied the prestressed concrete tank service life using both 50 and 80 years, and major repair assumption from 10%– 20%, respectively. The results are similar to those above. At a 6% interest rate, the NPV was less than welded steel by more than 10%. However, using a 4.0% interest rate, the concrete tank with an 80-year service life was less than welded steel by 6%, while with a 50-year life, the concrete tank was more than welded steel by 3%.

While neither tank had a lower NPV for all variables that were considered, what can be concluded is that the concrete tank life cycle cost is similar, or less than, that of a steel tank.

Potential Alternatives

The cost reduction to raise the floor by 1.2 m was provided by the tank manufacturers and is shown in Table 5. Raising the floor from the present-day elevation will require additional structural fill, which will offset some of the savings and is also shown in the table. There is a significant range of apparent capital cost reduction for both tanks, therefore, it is difficult to conclude that these savings will ultimately be realized.

Table 5: Apparent Cost Reduction for A Raised Floor Level

Tank Material	Reduction in Tank Cost for a Raised Floor	Additional Structural Fill Cost	Net Reduction to Raise Floor
Concrete	$400,000 – $950,000	$214,000	$186,000 – $736,000
Steel	$224,000 – $450,000	$214,000	$10,000 – $236,000

Note: Tank costs excluding markup and all costs exclude contingencies.

The concrete tank has the lowest NPV for both interest rates assuming the maximum reduction for both tank materials. Otherwise, the results are similar to those above. It is recommended that the same floor elevation as the existing tank is brought forward to the next stage of design. The cost/benefit can be thoroughly evaluated at that time.

Rehabilitation of Mount Edward #1

Rehabilitation of the Mount Edward #1 tank is outlined in the Structural Condition Survey Assessment report (RJC, 2022). The report includes a description of the recommended methods for rehabilitation of the tank which involves dewatering of the reservoir, repair of concrete with low-permeability silica fume repair material, potential repair of reinforcement, removal and replacement of interior wall and floor slab waterproofing systems, crack sealing, and new coating system on exterior walls.

The rehabilitation work is recommended to include further engineering review and analysis including destructive testing to determine the extent of the reinforcing repairs needed. Therefore, the scope of the rehabilitation work could increase. The report states that the condition of the tank could be improved from a Halifax Water Grade 3 or 4 (fair to poor) condition to Grade 2 (good) to extend the life of the tank. The report states that the effective service life would be extended for 20 years or more.

For this assessment we have assumed that the rehabilitated tank would be replaced with a prestressed concrete tank (AWWA D110 – Type III) or a welded steel tank (AWWA D100) at year 20. The costs associated with the site preparation, reinstatement and yard piping are not immediately needed if the existing reservoir is rehabilitated. However, these costs will apply for immediate replacement and have been incorporated in the analysis.

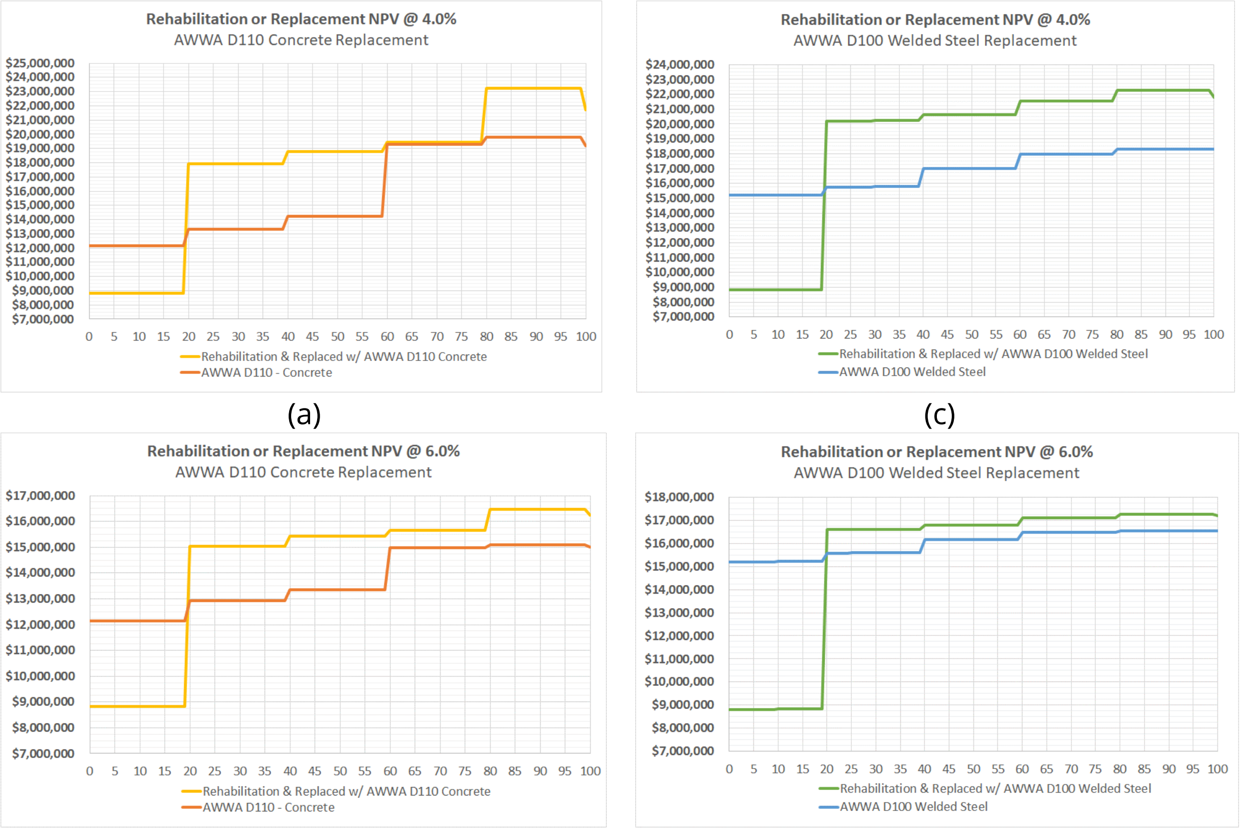
Maintenance of this tank during the extended service life would include inspection every 5 years. After 20 years, we assume that the tank will be replaced with a prestressed concrete tank or steel tank and will follow the maintenance schedule outlined for the new tank. In addition to the OPC for rehabilitation in the 2022 report, we included the following additional costs:

- Costs for overhead and profit.
- Inflation.
- An allowance to cover potential repairs to the external post tensioning system.

Net Present Value

A NPV analysis was carried out for a 100-year forecast for both 4.0% and 6.0% interest rates for either welded steel replacement or concrete replacement. The initial capital cost to immediately replace the reservoir is higher, however these costs will be outpaced by the rehabilitation options after 20 years when replacement is finally needed, for either interest rate. The results of the NPV are presented in Figure.

Based on the NPV, it is recommended that Halifax Water proceed with immediate replacement of the Mount Edward #1 reservoir.



(a) (c)

(b) (d)

Figure 2: Life Cycle Cost Analysis – Rehabilitation vs Immediate Replacement; (a) and (b) show the NPV for the AWWA D110 concrete tank replacement while for 4% and 6% interest rate, respectively; (c) and (d) show the AWWA D100 welded steel tank replacement for 4% and 6% interest rate, respectively.

Closing

The existing Mount Edward #1 Reservoir is approaching the end of its service life and will be replaced. A NPV analysis did not show conclusively that one tank material will have a lower life cycle cost than another. However, the NPV did show that, throughout the NPV horizon, immediate replacement has a lower NPV than rehabilitation. Therefore, replacement is recommended.

A Life Cycle Analysis cost should not be the only factor considered when selecting tank design. Familiarity with tank designs and ease of maintenance are qualitative factors that should be discussed with Halifax Water to better inform the decision.

Yours very truly,

CBCL Limited

Jeffrey Clair

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Project No: 231007.00

Mt Edward Reservoir - Preliminary Cost Estimate - Steel Reservoir
March 14, 2024

Description	Amount
Estimated Construction Cost Welded Steel Reservoir - CBCL Preliminary Design Report (Class 3) Estimate includes 20% Contingency and 4% Inflation for 2025 Construction Year	$21,027,000.00
Sub-Total	**$21,027,000.00**
Internal Halifax Water Costs (Project Management)	$30,000.00
QA/QC Testing - Audit	$50,000.00
Consultant Cost (CBCL) - Detailed Design & Tender Phase	$217,295.50
Consultant Cost (CBCL) - Construction Phase Services (72 weeks)	$1,066,242.00
Halifax Water Internal Cost to Date	$7,500.00
CBCL Cost to date (Project Management, Concept Design, Survey & Geotechnical)	$153,955.00
Grand Total	**$22,551,992.50**
Net HST (4.286%)	**$966,578.40**
Overhead/Interest (1%)	**$225,519.93**
Total Estimated Project Cost	**$23,744,090.82**

Total Estimated Project Cost (Rounded)	**$23,744,000.00**
Previous Funding (22/23 Capital Budget)	**$150,000.00**
Previous Funding (23/24 Capital Budget)	**$200,000.00**
24/25 Capital Budget Funding Required (detailed design and tendering)	**$100,000.00**
25/26 Capital Budget Funding Required (construction phase)	**$23,294,000.00**

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