TECHNICAL MEMORANDUM

Project:	Captains Tank Conceptual Design		
Project No.:	CA0014219.5332	**Date:**	2026-February-19
To:	Water Distribution Engineering and Planning, Capital Regional District	**From:**	Simon Kras, P.Eng.
Attention:	Katarina Konicek, P.Eng.	**Subject:**	Captains Tank Conceptual Design

INTRODUCTION

As part of the Standing Offer Agreement #2021-679, WSP undertook the conceptual design for the replacement of Captains Tank in the Magic Lakes Estates Water System (MLEWS) on Pender Island.

Project Understanding

CRD is seeking to replace the existing 340 m^3 Captains Tank, located on North Pender Island, which is over 50 years old and in poor condition. The proposed scope of work includes conceptual design and preparation of a Class 'D'[1] construction cost estimate. The Magic Lake Estates (MLE) Water System on North Pender Island is operated by the CRD Electoral Area Service Department (Operations). The system currently relies on two storage tanks for fire and domestic potable water storage (see Water System Map attached for reference):

- Frigate Tank, which was replaced in 2012, is in good condition, and supplies approximately 75% of the system demands, according to Operations. It has a capacity of 770 m^3 based on available record drawings.
- Captains Tank was constructed in 1970, and is in poor condition with visible deterioration, leakage and safety concerns. It has a capacity of 340 m^3 based on available record drawings.

The existing access road is very steep and will require improvements.

The tank's existing shared supply/distribution watermain is a 150 mm PVC pipe extending to the south down a steep slope (approximately 60% grade). The soil cover over the pipe has eroded and the pipe is now exposed. The pipe is currently vulnerable to further erosion, soil movement and mechanical damage. Joint separation is a concern with this pipe type.

Operations have reported occasional water quality concerns within the MLE water system, which could be a result of high residence times. Water quality may be further impacted if the Captains Tank storage volume is increased which would result in additional residence time. However, the CRD Operations have discussed system changes to increase water demand from Captains Tank by allowing the lower pressure zones to be fed from the Tank. Most importantly, these changes would also address low water levels in the Frigate Tank during high demand days.

There are four pressure zones within the MLEWS. Currently Captains Tank feeds one zone and Frigate three zones. Due to high water demand during summer it would be helpful to connect Captains Tank to the three other zones via the existing PRV at Bosun Booster Station. This system change requires additional review by the CRD.

[1] Per Association of Consulting Engineers of Canada guidelines

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Scope of Work

WSP's scope of work for this project included the following:

- Background information review including record drawings, previous reports, operational records, and any available geotechnical information.
- Kickoff meeting with CRD IWS attended by our Project Manager and Assistant Project Engineer. This meeting was hosted virtually on October 8, 2025.
- Conceptual Design Technical Memorandum documenting all calculations, design assumptions and recommended next steps
- Conceptual Site Plan
- Class 'D' construction cost estimate.

CONCEPTUAL DESIGN

Storage Tank Sizing

Tank sizing is based on the demands in the Captains Tank service area. Additional redundancy and overall system resilience would be achieved if Captains Tank is linked to the lower zones through the Bosun PRV.

The tank sizing was based on the BC Design Guidelines[2], which indicates the following:

Storage required = A + B + C

where

A = Balancing Storage = MDD / 4. The Captains Tank service area MDD was used.

B = Fire Storage

C = Equalization Storage = 0.25 x (A + B)

The following assumptions were used for tank sizing:

- Maximum Day Demand (MDD) = 245 m^3/day
  - Estimated future demand for Captains Tank per AECOM report[3]
- Fire Flow = 1.5 hrs @ 67 L/s
  - Based on FUS simplified method[4], Duration based on FUS Table 1.

The system-wide calculations are summarized below:

A = 245 m^3/day / 4 = **61.3 m^3**

B = 67 L/s x 1.5 hrs x 3600 s/hr = 361,800 L = **361.8 m^3**

C = 0.25 x (61.3 m^3 + 361.8 m^3) = **105.8 m^3**

V_{req} (required storage) = A + B + C = 61.3 m^3 + 361.8 m^3 + 105.8 m^3 = 528.9 m^3

A new tank with a 530 m^3 storage capacity is recommended to replace the existing Captains Tank. WSP has reached out to two reputable tank suppliers for quotes. Based on the quotes obtained, the nearest available tank size based on standard panel dimensions is 522.8 m^3, which is close enough to be acceptable for this project, since the shortfall is minimal.

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[2] British Columbia Design Guidelines for Rural Residential Water Systems, Ministry of Forests, Lands, Natural Resource Operations & Rural Development (MFLNRORD), 2012.

[3] Magic Lake Estates – Pender Island, Water System Review, AECOM, September 2011

[4] Fire Underwriters Survey Water Supply for Public Fire Protection, A Guide to Recommended Practice in Canada, 2019. Simplified Method for One and Two Family Dwellings Up to 450 sq.m.

Water Quality and Future System Operation

Based on the current Captain Tank size of 340m^3 and an ADD of 1.1 L/s, the Hydraulic Residence Time (HRT) in the tank is approximately 3.6 days.

From discussions with Operations, low chlorine levels are a challenge at times. Given this concern, we recommend against further increasing the HRT. To mitigate water quality concerns associated with increasing the storage volume in Captains Tank, WSP recommends feeding the lower zones from the new Captains Tank, which could help to reduce the HRT.

This approach will require a Pressure Reducing Valve (PRV) at the Bosun Booster Station with appropriate piloting, as well as development of an effective control strategy. This approach will improve the overall system redundancy as well as improving turnover in Captains Tank. HRT in the Frigate Tank would be increased with this approach and more frequent sampling should be done to assess water quality during initial implementation to allow for fine tuning of the control strategy.

If it is assumed the new 530 m^3 Captains Tank and 740m^3 Frigate Tank equally share storage volumes for the entire MLEWS area and the total ADD is 5.6L/s[5], then the shared HRT in the tanks would be approximately 2.6 days.

If the new Captains Tank is constructed before the new control strategy is implemented, then the tank could be operated below full capacity if water quality is a concern, provided that system pressures are acceptable.

The CRD has indicated that the Captains Tank currently services lots with elevations between 80 and 156 m, which currently provides a static pressure of 255 kPa (37 psi) at the highest elevation home when the tank is full – not accounting for any head loss in the pipes. WSP notes that this is already slightly lower than the current provincial guidelines[6] which recommend a minimum system pressure of 280 kPa (40 psi) at Peak Hour Demand. System pressures will be a consideration when determining an operating strategy for the reservoir.

System pressures and water quality should be monitored during initial operation of the new tank. This will allow optimization of both water quality and system pressure.

Storage Tank Sizing Confirmation

The conceptual sizing is based on FUS requirements. However, fire protection needs to be balanced against water quality. Moreover, it may not be practical to provide fire flow capacity beyond the needs or capabilities of the fire department. Based on CRD's discussions with the Pender Island Fire Department, we understand that the proposed sizing would be acceptable, and represents a significant improvement to the existing storage volume.

Furthermore, the sizing assumes that the Captains Tank feeds its own zone and only supplements the lower zones during peak flows to allow for recovery of the Frigate Tank. This assessment focuses on the Captains Tank distribution zone and does not consider storage requirements for the lower zones.

Access Road Considerations

The existing access road is approximately 240 m long, climbing from an elevation of 133 m to 174 m (an average slope of 25%). Certain sections of the road are even steeper at slopes of around 35%. Access to the tank is challenging even for a small 4-wheel-drive vehicle. Tracked vehicles are likely to be required for any significant construction activity.

Constructing a new access road at a more reasonable grade is unlikely to be feasible within the scope of the storage tank replacement. A new roadway would need to be approximately 350 m long. It would require significant amounts of clearing and rock blasting. In addition to being expensive, these activities would require community engagement given that the site is on designated parkland.

[5] AECOM, 2011

[6] Design Guidelines for Rural Residential Community Water Systems, 2012, Utility Regulation Section, Water Management Branch, Ministry of Forests, Lands, Natural Resource Operations and Rural Development, Government of British Columbia.

Tank Materials and Shape

Based on the size and location of the proposed new storage tank, a steel tank is the most cost-effective and practical option. Concrete tanks are much more expensive for storage volumes less than 2,000 m^3. Moreover, supplying the required quantities of concrete at this site would be challenging given the extremely steep access road. Steel tank panels are much lighter and easier to transport to site.

Common types of steel tanks are (i) bolted and (ii) lined corrugated steel. Bolted tanks are more suitable for this location because they can be taller and more slender than lined corrugated tanks. Bolted steel tanks coatings can be either (a) glass-fused or (b) epoxy. Glass-Fused Steel (GFS) provides a longer lifespan than Epoxy Coated Steel, especially with the addition of cathodic protection.

WSP recommends a Glass-Fused bolted steel tank to replace the existing aging Captains Tank, with a steel floor, and cathodic protection for all glass-fused steel components including the side and roof access hatches.

Tank Access

The interior of the tank should be accessible from the ground level when the tank is empty through a hinged side-opening hatch designed to provide unrestricted entry.

The roof access hatch should be large enough to accommodate flexible ventilation ducting during confined space entry from the roof. The tank should feature an exterior roof access ladder with suitable safety cage, platforms as required. Safety guardrails and a suitable fall protection anchor should be provided on the roof of the tank to protect workers accessing rooftop features including the vents and the roof access hatch.

Instrumentation and Telemetry

The existing battery-powered wireless level transmitter requires access to the reservoir roof for battery replacement. For the new tank, WSP recommends a wired level transmitter (either pressure or ultrasonic) connected to the kiosk on Captains Crescent.

Hatch alarms can also be wired to the kiosk for security. WSP has not reviewed the existing control panel at the kiosk to confirm that the capacity for additional input/output connections. This should be confirmed during the detailed design phase.

Appurtenances

Appurtenances should include:

1) A check valve chamber to provide dedicated inlet and outlet piping into the storage tank from the shared supply/distribution main, complete with isolation valves to facilitate removal and servicing of the check valves.
2) Sampling stations on the storage tank inlet and outlet lines.

Watermain Connections

The existing watermain is exposed and vulnerable to mechanical damage, further erosion and soil movement in its current condition. The existing watermain alignment is on steep rocky terrain which is difficult to work on and requires harnesses and fall protection for safety. The three options below should be considered further in the preliminary design stage for replacing the watermain:

a) Replacement with a new insulated above-ground HDPE main extending down the slope.

b) Replacement with a new main in a trench along the access road.

c) Above-ground insulated pipe along access road.

Option A: Above-ground Insulated HDPE along existing pipe alignment

This option allows for a shorter watermain installation, without the need for excavation, backfill or imported bedding. This option also does not encumber the storage tank access road with construction activities.

The insulation would be protected with a polyethylene jacket, allowing the insulated pipe the ability to bend slightly, adapting to the contours of the terrain. Insulated pipe is typically ordered pre-insulated with the exception of the ends, which are joined on-site and field insulated. Once the new pipe is constructed, tested and tied in, the existing pipe could be removed if feasible, or else capped and abandoned.

The main consideration with this approach is constructability. The existing watermain connection is approximately 100 m long and will require 6-9 pre-insulated pipe segments to construct. It will likely not be feasible to butt-fuse HDPE on the steep rocky watermain alignment. Other alternative approaches could be considered including pre-fusing the line and either (a) winching the pipe up the slope, or (b) installation by helicopter.

Polyethylene pipe jackets can sometimes be vulnerable to damage from wildlife which can chew through the jacketing material and damage the insulation. Steel jacketing is likely not feasible for this installation because some flexibility is required to conform to the uneven terrain.

Option B: New watermain alignment along access road

Extending a new watermain along the access road would require approximately 240 linear meters of challenging pipe installation up a steep, narrow access road. Careful planning and staging would be required since there is no room to drive around an open trench along this alignment. Additional space may need to be cleared to provide laydown areas. Construction of the watermain would impede vehicle access to the storage tank for Operations during the installation, rendering the tank accessible only by foot.

This option is likely to be more costly than an above-ground pipe but provides a more robust final product. However, if there is a watermain failure along the access road, it could temporarily render the tank inaccessible, making it challenging to manually shut off the water supply and complete a repair.

Option C: Above-ground insulated pipe alongside access road

A hybrid approach would involve an insulated jacketed pipe alongside the access road alignment. The pipe could be aligned to minimize tree removals due to the flexibility of the polyethylene jacketing. This option may be more feasible to construct than Options A or B and allows easier access to the pipe for repairs if required.

Cost comparison

The following table provides a rough order-of-magnitude cost comparison for the two options, not including tie-ins:

Option A: Above-ground insulated HDPE watermain

Item	Unit Price	Qty	Amount
150 mm Insulated Jacketed HDPE supply	$200	100 linear metres	$20,000
Closure kits, couplings and miscellaneous materials	$15,000	Lump Sum	$15,000
Installation	$500	100 linear metres	$50,000
		Subtotal	$85,000
		40% Contingency	$34,000
		Total Excluding GST	**$119,000**

Option B: New watermain along access road

Item	Unit Price	Qty	Amount
150 mm HDPE supply and installation	$500	240 linear metres	$75,000
Access Road Restoration	$20	960 square metres	$19,200
		Subtotal	$94,200
		40% Contingency	$37,680
		Total Excluding GST	**$131,880**

Option C: Shallow-bury or above grade insulated pipe along access road

Item	Unit Price	Qty	Amount
150 mm Insulated Jacketed HDPE supply	$200	250 linear metres	$50,000
Closure kits, couplings and miscellaneous materials	$25,000	Lump Sum	$25,000
Installation	$300	100 linear metres	$30,000
		Subtotal	$105,000
		40% Contingency	$42,000
		Total Excluding GST	**$147,000**

Because the cost for all three options is comparable, the constructability and cost of Options B and C should be investigated further during the preliminary design phase, since they both provide a more robust final product than Option A.

Inlet and Outlet Sizing

The existing Captains Tank has a 150 mm diameter watermain connection which acts as a combined inlet and outlet. This configuration is not optimal for tank circulation and tends to create dead zones in tanks. Separate inlet and outlet pipes on opposite sides of the new tank are proposed.

Based on AECOM's record drawings for the Water Treatment Plant[7], the maximum ultimate flow to distribution from the treatment facility is 24.26 L/s. The existing inlet and outlet pipe sizing of 150 mm is adequate based on the maximum future flows from the WTP and the size of the existing distribution system mains.

[7] Magic Lake Estates Water System Upgrades, General Water Treatment Plant Process Flow Diagram, Issued for Record, AECOM, 2015-03-23

Tank Drainage and Overflow

The existing Captains Tank drain and overflow lines discharge into a common buried 150mm diameter pipe. The pipe outlet could not be located during WSP's site visit but is believed to be directly south of the tank based on the location of the valve box for the drain. Based on the steep terrain, it is likely that the pipe outlet has been covered by debris or vegetation. There is no-dechlorination manhole in the existing system.

The existing drain is problematic because it discharges directly above existing homes located south of Lively Peak Park. CRD Operations have indicated that when the tank needs to be drained for maintenance, it has to be done very slowly to avoid impacting the properties. Current provincial regulations require de-chlorination of water prior to discharge which is not practically feasible with the current system.

The new tank is proposed to drain over the north face of Lively Peak through a new de-chlorination manhole, with a concrete headwall on the rock face at the end of the pipe. Drainage released onto the north slope would flow down the slope into an existing ditch along the Lively Peak Park trail. The ditch is culverted under the trail, leading to a ravine with an ephemeral watercourse. Though care will still need to be taken to control the rate of discharge, this location is considered more suitable than the existing.

Storage Tank Foundation

The existing access road is too steep for concrete trucks, and any concrete delivery would likely require tracked vehicles or a helicopter lift. For this reason, a typical cast-in-place concrete foundation at this site is not practical. The design of bolted steel tanks allows them to be constructed on a gravel foundation. However, a low-profile concrete ring foundation with rock anchors should be considered to resist sliding and overturning forces. The required rock anchor size, spacing and depth should be determined during detailed design based on geotechnical requirements. The foundation should be designed to minimize the concrete volume required.

Geotechnical Considerations

There is a steep slope adjacent to the proposed storage tank site (approximately 38% grade). Slope stability should be assessed during the design of the new tank. Geotechnical exploration is recommended to determine:

- The depth of soil overlying the bedrock at the proposed tank site
- The nature and condition of the bedrock.

The conceptual design assumes blasting to a depth of approximately 0.5-1 m below existing grade to provide space for the tank. The geotechnical investigation at the design stage should comment on any safety and rock stability considerations related to blasting, and on the suitability of the bedrock for rock anchoring.

Because mobilization of drilling equipment to Pender Island is costly, a phased investigation approach is recommended. An initial investigation could be undertaken using an excavator with a pneumatic hammer. If the depth to competent bedrock exceeds the capabilities of the excavator, then a secondary drilling phase could be completed.

Cost Estimate

The Class D cost estimate is provided below.

Item	Cost
530 m^3 Glass-fused-steel tank with cathodic protection and steel floor	700,000
Rock Blasting (~170 m3)	70,000
Site Grading and Civil Works	80,000
10 x #18 Rock anchors	101,000
150mm HDPE watermain and access road restoration (Option C)	105,000
Check valve chamber	50,000
2 x 50 mm conduits to existing kiosk	50,000
150mm PVC drain, dechlorination manhole and headwall	30,000
Existing Tank and Watermain decommissioning	100,000
Electrical and Instrumentation	50,000
Subtotal	**$1,336,000**
40% Contingency	$534,400
20% Engineering	$267,200
Total Excluding GST	**$2,137,600**

Additional Cost for Increased Reservoir Size

Based on WSP's discussions with tank suppliers, the cost to upsize to a 622 m^3 tank (one size up) would be $28,000. The total additional project cost including contingencies would be approximately $50,000. This would provide approximately 18% more storage.

NEXT STEPS

WSP understands that delivery of this project will be subject to available funding. The following preliminary schedule is provided as an overview for discussion and planning purposes:

Spring 2026:

- Conduct a geotechnical investigation to assess bedrock conditions and slope stability.
- Identify environmental and archaeological requirements.
- Identify stakeholders to be engaged which might include Pender Island Parks.
- Expose existing storm drain outlet on slope.

Spring/Summer 2026:

- Detailed topographic survey of existing storage tank site, including existing watermain where exposed.
- Complete design, incorporating findings from investigations.

Fall/Winter 2026:

- Construction of new tank.
- Monitor water quality and during commissioning to fine tune optimal TWL and setpoints.
- Develop a control strategy and pilot a new PRV at the Bosun pressure station.

Prepared by:

PROFESSIONAL PROVINCE OF BRITISH COLUMBIA ENGINEER S. M. KRAS # 40183

2026-02-20

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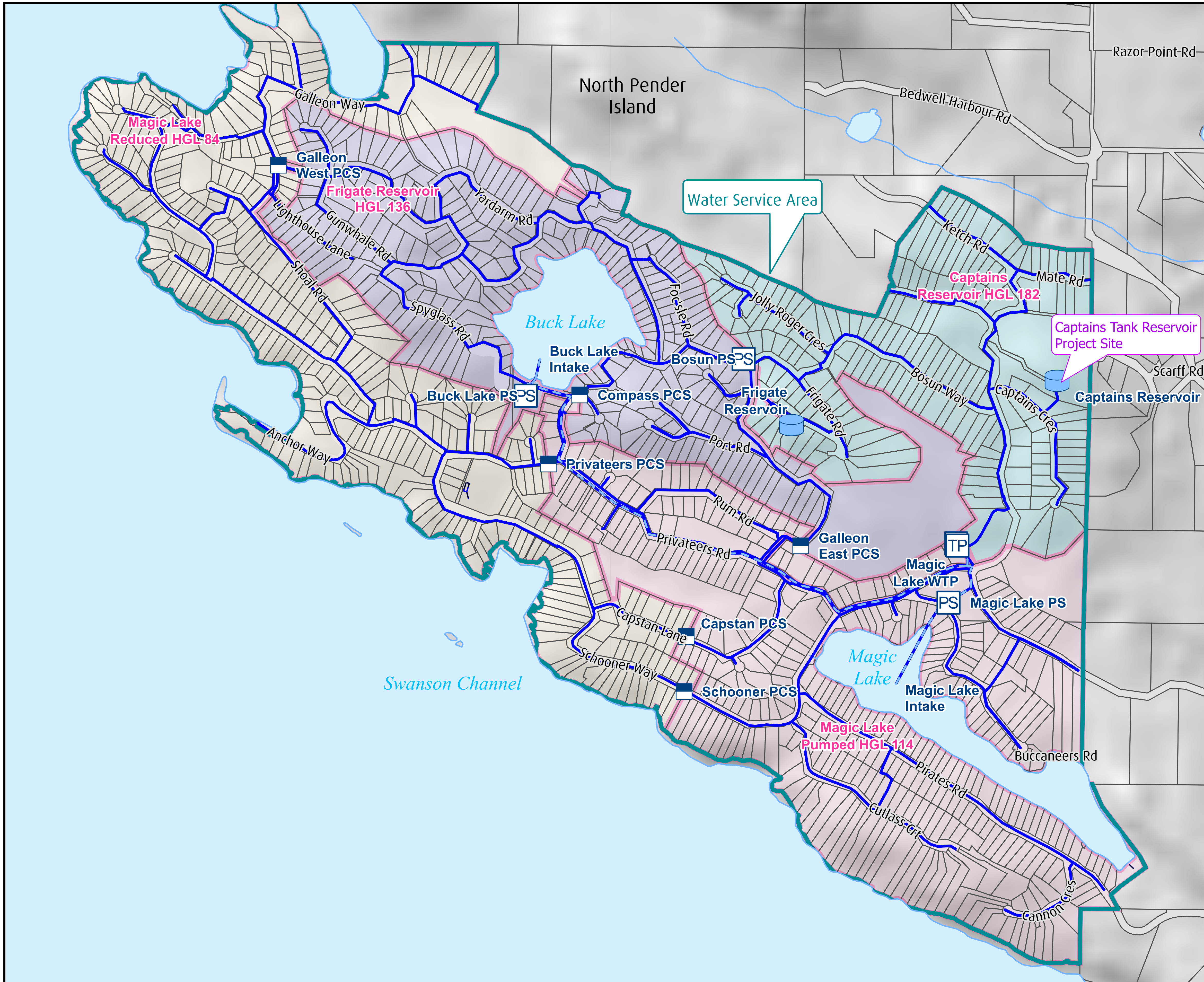
Attachments

- Attachment 01: Water System Map
- Attachment 02: Conceptual Site Plan
- Attachment 03: Conceptual Section



Magic Lake Estate Water System Overview

Figure 1

CRD
Making a difference...together

1:11,000

0 100 200 400 600 Metres

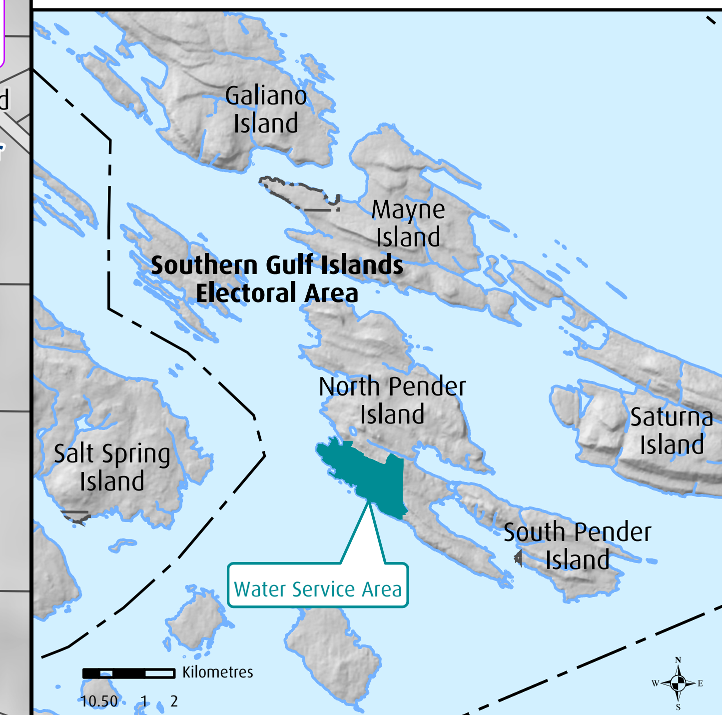
UTM Zone 10N NAD 1983

N E S W

DISCLAIMER

Important This map is for general information purposes only. The Capital Regional District (**CRD**) makes no representations or warranties regarding the accuracy or completeness of this map or the suitability of the map for any purpose. **This map is not for navigation.** The CRD **will not be liable** for any damage, loss or injury resulting from the use of the map or information on the map and the map may be changed by the CRD at any time.

August 2025 | Captains Tank Reservoir.mxd | helpdesk@crd.bc.ca



Legend
Water Service Area
Distribution Main
Untreated Supply Main
TP Treatment Plant
Reservoir (Storage Tank)
PS Pump Station
Pressure Control Station
Captains Reservoir Zone - HGL 182
Magic Lake Pumped Zone - HGL 114
Magic Lake Reduced Zone - HGL 84
Frigate Reservoir Zone - HGL 136

1:200

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PROJECT NUMBER: CA0014219.5332

CLIENT: CAPITAL REGIONAL DISTRICT

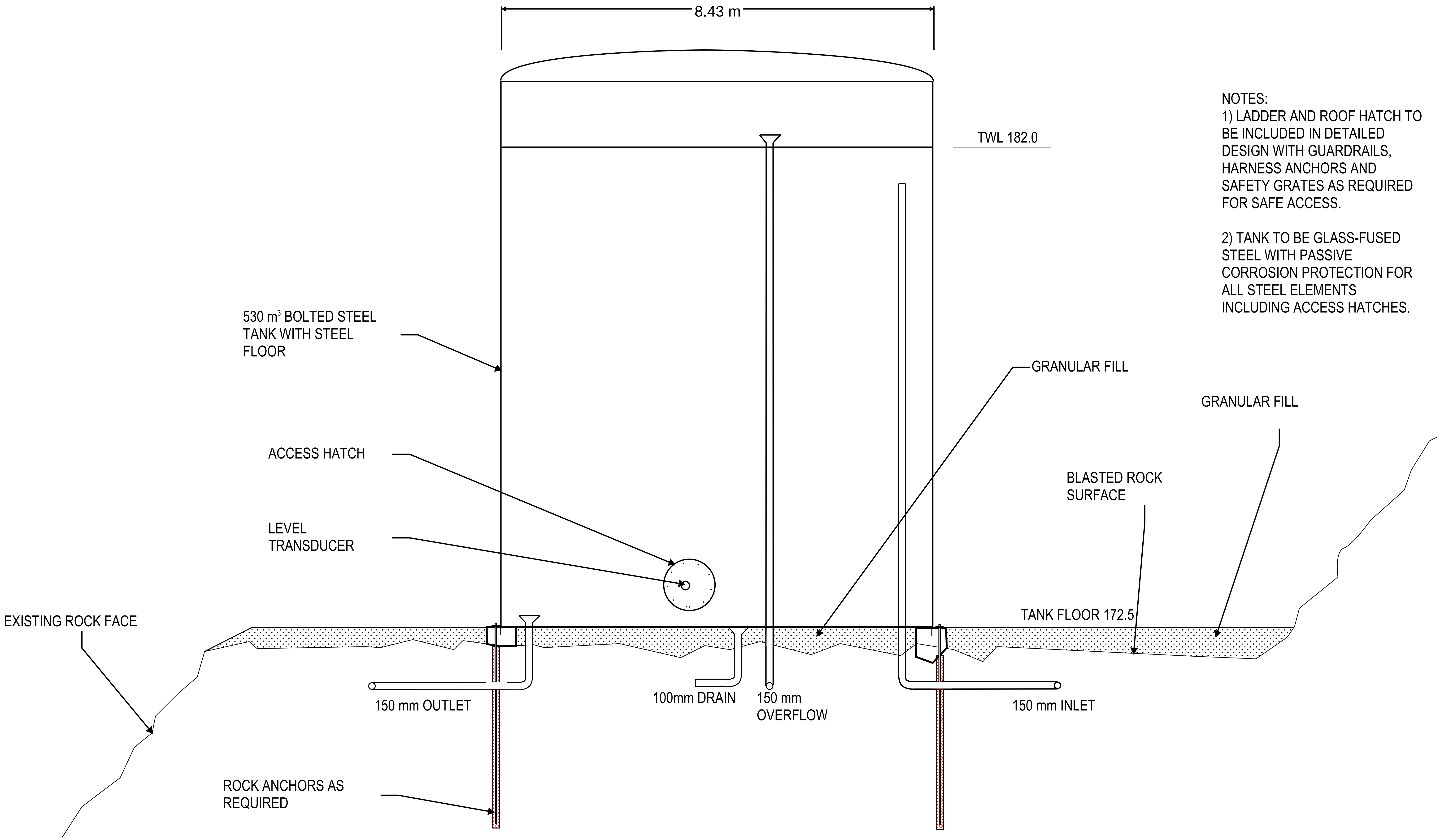
CLIENT REF. #: --

TITLE: SITE PLAN
CAPTAINS TANK

PROJECT: CRD CAPTAINS TANK

DRAWING NUMBER: C-XXX

REV.: X



NOTES:
1) LADDER AND ROOF HATCH TO BE INCLUDED IN DETAILED DESIGN WITH GUARDRAILS, HARNESS ANCHORS AND SAFETY GRATES AS REQUIRED FOR SAFE ACCESS.

2) TANK TO BE GLASS-FUSED STEEL WITH PASSIVE CORROSION PROTECTION FOR ALL STEEL ELEMENTS INCLUDING ACCESS HATCHES.