Date: January 28, 2025

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Subject: Desktop Study for Water Reservoir Upgrade for the Savary Shore Improvement District

1. Introduction

MSR Solutions Inc. (MSR) was retained by Savary Shores Improvement District (SSID) to provide a preliminary design and cost estimate for the upgrade of their existing water supply storage reservoirs. This report details the proposed upgrade options and includes recommendations, risks and limitations, preliminary design and Class D cost estimates for each option.

2. Existing System Description and Conditions

The SSID is an improvement district located on Savary Island, BC. It currently includes 171 residential dwellings, or (single-family equivalent units), with the potential to build up to 213 dwellings. The SSID and the whole of Savary Island population is highly season dependant, with a peak occupancy in the summer months reaching around 10 times the winter occupancy. There is no grid supplied electricity on the island. The access to the island is by either a passenger ferry or a vehicle ferry of 1 vehicle capacity.

The SSID water is supplied from two licenced wells, well ID#34152 (built in 2011) and well ID#20738 (built in 1980), each pumping from the aquifer #834, which is a sand and gravel aquifer with high vulnerability. Each well includes a 5 HP submersible well pump (Xylem 55GS50 and 15STG) powered by a generator. The pumps transfer the raw water to two reservoirs up the hill via a 75 mm (3”) PVC pipe and are controlled by switches. A small control building near the wells houses the pump controls and is powered by the generator. There is no treatment on the raw water, it is directly stored in the reservoirs and supplied after being pumped from the wells. There are two diesel generators at the well building, operating on duty standby, one is a 22 kW Kubota D1803-CR, and the other is a 20 kW Kubota QAS 25 KD. Either duty generator runs at approximately 44% capacity when providing power for one of the two pumps (one pump running at a time), control building heating, pipe trace heating and switches.

The SSID water distribution system includes two separate pressure zones. A lower zone includes a 150 mm distribution main, 106 dwellings connections (and potentially up to 132 dwellings at full buildout) and 7 fire hydrants. The upper zone includes a 100 mm distribution main, 65 dwellings (81 potential) and 6 fire hydrants (plus valves, blow-offs and air release valves on both zones).

The two water storage reservoirs include a 182 m^3 capacity (40,000 imp gallons) steel tank reservoir installed at ground level and an elevated steel tank reservoir of 45 m^3 capacity (10,000 imp gallons) installed on a 16 m (55 ft) scaffold tower next to the ground level reservoir. The ground reservoir normally supplies drinking water and fire prevention through a 150 mm (6") PVC gravity main to the SSID lower zone. The elevated reservoir normally supplies water and fire prevention through a 100 mm (4") PVC gravity main to the SSID upper zone

A valve chamber between the two reservoirs enables each reservoir to supply either zone via manual operation. The well pumps normally feed the elevated tank which overflows to the ground tank. The pumps automatically stop when the ground tank reaches high level. There is level switches installed in each tank, powered by the generator down at the well site. The generators also power the pump control switches at the valve chamber and pipe trace heating around the reservoir.

The reservoirs were built in 1976 making them almost 50 years old. Several inspections were performed on the tanks over the years. The upper tank was inspected in 2012 by Brian Callow & Associates Ltd., who reported areas of concern regarding the pipe penetration into and out of the tank, as well as the ladder coating. In 2018, Seaveyors Environmental and Marine Services inspected both tanks and noted the following: the elevated tank had rust build-up on the exterior of the tank and on the flange of the entry hatch while the interior was found to be in a good condition with minimal corrosion. The lower tank's interior was in fair condition due to some corrosion of the internal walls and outlets, while the exterior was found to be in good condition. A more recent 2024 ultrasonic test inspection by JDK Specialty Welding & Repair was performed on the elevated tank. It concluded a high level of external corrosion at the bottom of the tank and the need to replace the tank bottom off site.

The 16 m high elevated tank is not designed for earthquake or post disaster.

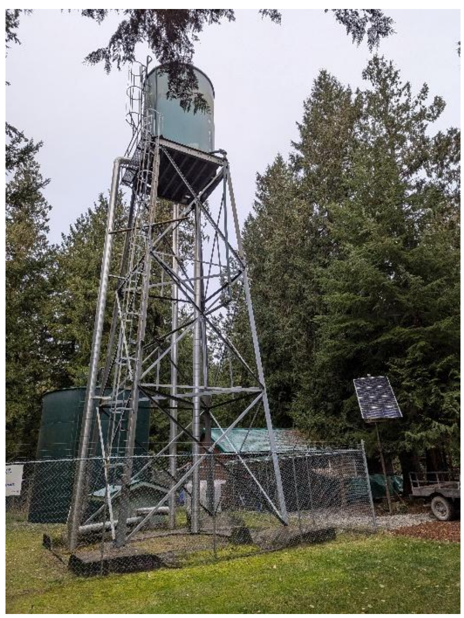

Figure 1. Existing Elevated reservoir (front) and Ground reservoir (back). Valve chamber in Between.

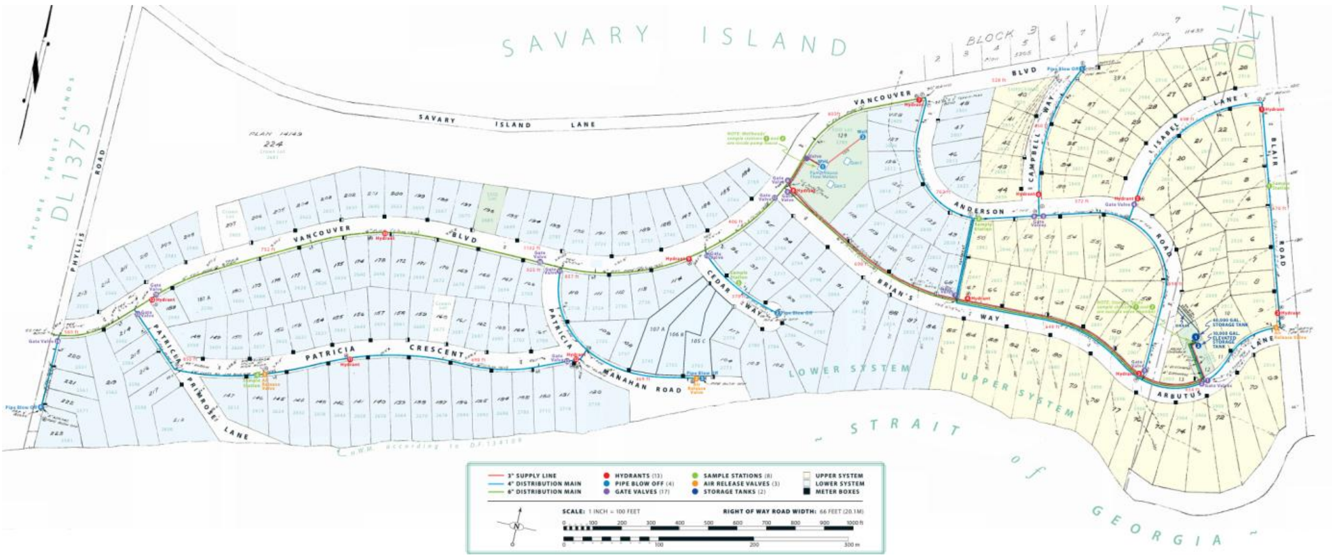

Figure 2. SSID map showing upper zone (in yellow), lower zone (in blue) and water supply and distribution system

3. Regulations

We have identified the SSID water system is operating under a water operating permit signed by Vancouver Coastal Health (VCH). The SSID governance is supported by guidance from the Ministry of Municipal Affairs (Local Government Finance), Ministry of Forests (Groundwater Department), and Ministry of Health (Environmental Health Officer, Drinking Water Officer). and follows the Water Sustainability Act and the Fire Services Act.

However, as an improvement district, and as stipulated by its Bylaw 136 (2023), Part 2, Section 4, it "does not guarantee a specific water pressure, a continuous supply of water or a specific quality of water to any customers or other users of water."

Nonetheless, it is incumbent upon MSR, in fulfillment of their responsibility and commitment, to propose and design systems that prioritize safety and sustainability for both the public and the environment. Consequently, our design methodology strictly adheres to the best practice guidelines outlined in the Water Sustainability Act, the Fire Services Act and applicable regulations.

4. Scope and Solutions Considered

MSR was asked by SSID to propose replacement solutions for the elevated tank, including preliminary design and cost estimate for a non-earthquake and non-post disaster detailed design and construction of a new reservoir. The options reviewed are surface mounted tank reservoir with a booster pump station, standpipe reservoir, elevated tank and some potential temporary solutions. A potential refurbishment of the elevated tank was also briefly investigated.

5. Population and Design Flow Basis

An estimate of population occupancy and water consumption of SSID was performed using actual recorded values from SSID for the peak months of July and August 20023, showing a average daily flow per person of about 95 L/d during these months. Using the BC Design Guidelines for Rural Residential Community Water Systems (BCDGRRCWS), Theoretical Average Daily Demand (ADD), Maximum Day Demand (MDD), and Peak Hour Demand (PHD) are calculated for the lower zone, upper zone, total existing and full build out of the SSID. Results are compared with actual flow data from the SSID well building flowmeter (average daily flow over monthly readings). Table 1 below summarizes the flows used for design basis.

Table 1. Design flow

SSID Water Supply Flow Demand						
	Value	**Value**	**Value**	**Value**	**Unit**	**Notes**
SSID zone	**upper**	**lower**	**total**	**potential (full buildout)**		
Current Number of dwellings	65	106	171	213	Units	potential upper zone 81 connects
Type of dwellings	SFE	SFE	SFE	SFE		
Dwellings occupancy guidelines	3.5	3.5	3.5	3.5	person/unit	
Selected Occupancy	3.5	3.5	3.5	3.5	person/unit	using average of 3.5 people per unit at peak season
Total population	228	371	599	746	people	
Monthly Average daily flow per person during peak season	92	97	95	95	L/d/capita	Peak Jul-Aug 2023 data 60 upper, 94 lower dwellings USING water
Average Day Demand, ADD	21	36	57	71	m3/d	ADD = average daily fow per person * population
Daily Peak Factor PF1	2	2	2	2	n/a	BC DGRRCWS
Peak Hour Factor PF2	5	5	5	5	n/a	BC DGRRCWS
Maximum Daily Demand, MDD	**42**	**72**	**114**	**142**	**m^3/d**	MDD = ADD*PF1 (BC DGRRCWS)
ADD per dwellings	**320**	**340**	**330**	**330**	**L/d/dwelling**	
Actual ADD per dwelling in July and August 2023	**333**	**333**	**333**	**333**	**L/d/dwelling**	3180 m^3 for 62 days in Jul-Aug 2023, with 154 dwellings using water
Peak Hour Demand, PHD	**4**	**7**	**12**	**15**	**m^3/h**	PHD = (ADD*PF2)/24 (in m^3/h)
Peak Hour Demand, PHD	**1.2**	**2.1**	**3.3**	**4.1**	**L/s**	

- As noted above, the SSID occupancy is highly dependant on the season. The peak season consumption, usually in the months of July and August, is used for the reservoir and booster pump station design. The actual flow data from SSID reports a maximum monthly usage of 3180 m^3 in July and August 2023, with 154 dwellings consuming water during this month. This represents an average daily flow of 333 L/d per dwelling.
- To take into account this figure we chose to use an average occupancy of 3.5 people per dwellings during the high season (illustrated in Table 1). We estimate an average daily demand of about 320 to 340 L/d per dwelling during the peak season. Peak Hour demand is calculated using a peaking factor of 5 compared to Average Day Demand.

6. Reservoir Capacity

- The reservoir sizing is based on the flow demands from Table 1 and the minimum flow recommended by the Canadian Fire Underwriter Survey (FUS) which is a part of the Water Supply for Fire Protection Document. The minimum fire prevention water supply credited by FUS must be capable of delivering not less than 1000 L/min for two hours or 2000 L/min for one hour in addition to any domestic consumption at the maximum daily rate. This means than a minimum of 120 m^3 storage for fire prevention must be available to be credited by the FUS. A minimum pressure of 150 kPa (15.3 m water column, or 22 PSI), at the minimum fire flow is also required at the point of use.
- Standard Reservoir design for fire protection and water supply are based on the following: an equalization storage calculated at 25% of the MDD, a fire prevention storage and an emergency storage. The required reservoir capacity is then the sum of the equalization storage (A), fire protection storage (B) and emergency storage (C = 25% (A+B)). As a minimum, MSR recommends a capacity of equalization storage plus fire protection storage (A+B), to always maintain the fire protection storage.
- Table 2 summarizes the minimum reservoir capacity for either individual zones (upper and lower), or the full SSID (either current or full build out).

Table 2. Reservoir Capacity

SSID zone	Upper	Lower	Total	Full buildout	Unit	Notes
MDD	42	72	114	142	m^3/d	
Equalization Storage, A	10.5	18	28.4	35.4	m^3	A =25% *MDD
Fire Flow Rate	60	60	60	60	m^3/hr	Minimum FUS 1000 lpm for 120 min
Fire Flow Duration	2	2	2	2	hr	
Fire Protection Storage, B	120	120	120	120	m^3	B = determined by FUS calcs
Emergency Storage, C	33	34	37	39	m^3	C = 25% * (A + B)
Reservoir design capacity	163	172	186	194	m^3	A+B+C

From the table we can observe the following points:

- The required reservoir capacity between an individual zone and the whole SSID at full build-out is not significantly different (163 m^3 vs 194 m^3). If minimum pressure can be maintained for both zones, it can be economically beneficial to only use one reservoir.
- The existing elevated reservoir capacity, at 45 m^3, provides only 45 minutes of minimum fire flow when full and therefore does not comply with the FUS requirements. We also understand that the way the reservoir operates, it can reach a low level, therefore reducing furthermore the fire prevention capacity. The recommended capacity for the upper zone would be as a minimum the sum of the fire protection storage and equalization storage which is 130 m^3.
- The existing 182 m^3 ground reservoir has sufficient capacity to provide fire protection, equalization and emergency storage for the lower zone. If connected to both zones (upper and lower), and with an added booster station, it would have enough capacity to provide fire protection and equalization storage at full build out (which requires 155 m^3). This point will be discussed further in our options.

7. System Pressure

- As mentioned above, the FUS usually requires a minimum pressure of 150 kPa (22 PSI) at the minimum fire flowrate (60 m^3/h) at the point of use (hydrant). The elevated reservoir water level is estimated to be between 55 and 65 ft (16.8 to 19.8 m water head) above ground, depending on water level. At fire flows (60 m^3/h or 16.7 L/s), the pressure at the nearest fire hydrant is estimated between 20 and 25 PSI (14 m to 17.5 m water head) which is considered acceptable. The other upper zone fire hydrants are located downhill and meet pressure requirements at fire flows. The 100 mm (4") PVC distribution line in the upper zone can accommodate the minimum fire flow (2.2 m/s at 60 m^3/h).
- Additionally, a minimum water pressure is required for the SSID dwellings water usage at peak flows. Usually, a minimum pressure of 30 PSI is required by health authorities and MSR recommends a minimum of 35 PSI (25 m of water column). The highest dwellings in SSID are situated at approximately the same ground level as the reservoirs and are located nearby (within 100 m). We estimate the maximum pressure for the dwellings located near the reservoir is 23 PSI at peak demand which is considered too low.
- For an elevated reservoir or standpipe option for the upper zone, we recommend a minimum reservoir height of 25 m which is significantly higher than the height of the existing elevated reservoir.

8. Upgrade Solutions

8.1. Solution 1. Surface Mounted Reservoir plus Booster Pump Station

- Considering the points above regarding current states of both the low reservoir and the elevated reservoir, MSR recommends building a surface mounted reservoir of a minimum 194 m^3 capacity that could effectively replace both reservoirs.
- In comparison having only one new reservoir of 163 m^3 for the upper zone would be at a really similar price range and would not provide a solution for a potential replacement of the existing ground reservoir.
- The reservoir will be a glass fused steel reservoir featuring a concrete base ring foundation and will not be designed for post disaster or earthquake resilience. The selected diameter is 7 m and reservoir height of

6.5 m. It will be located on the current reservoir property, next to the existing tanks. Trees and shrubs clearing, ground leveling and sub base installation will take place before reservoir installation.

- The reservoir steel plates can be shipped on site and transported on a small trailer to the reservoir site. The reservoir installation doesn't require specific large equipment, each reservoir rings are manually assembled and lifted with small hydraulic jacks.
- Reservoir will include drain and overflow pipe, inspection and maintenance hatches, level gauge, level switches and tideflex mixing system in the feed pipe. Exposed piping will be trace heated.
- The reservoir will require a ground load geotechnical assessment prior to detailed design.
- We requested prices from two manufacturers of bolted, glass fused steel tanks which are Greatario and H2flow. Both companies have extensive experience in design and installation of this type of tank in BC.
- To accommodate for pressure in the upper zone, we propose to build a small booster pump station near the new reservoir which will connect to the upper zone distribution line. The pump station will include two peak-hour-demand pumps (centrifugal multistage or single stage with Variable Speed Drive) and one larger pump used for fire demand. The pumps will be installed in a small building. The pump station will be powered by a 20-kW generator installed next to the building. The generator will require an electric box (ATS) to connect the appliances. The pump building will be heated. It will include motor control centres (MCCs), pumps, valves and instrumentation.
- The new reservoir will be fed by the well pumps and be connected to the lower zone system by gravity and to the upper zone system via the pump station. This system will provide sufficient flow and pressure to meet fire prevention requirements and water usage requirements for the whole SSID at full build out.
- The connections of the reservoir and pump station to the existing distribution and supply line will be done with the possibility to keep the existing reservoirs in use if required after the new reservoir is in operation. Performing The connections themselves with require half a day of water supply shutdown per connection.
- The preliminary design drawings for this solution are attached with this report.

8.2. Solution 2. Standpipe

- An alternative to a surface mounted reservoir is a standpipe or an elevated reservoir. However, a 163 m^3 (upper zone only) to 194 m^3 (full buildout) reservoir elevated on a 20 m scaffold was disregarded due to higher costs and lower practicality. Only the standpipe option is therefore proposed.
- Like the surface mounted reservoir, the standpipe reservoir will be a glass fused bolted steel reservoir. Its usable water capacity will be 194 m^3 but it will include 1000 m^3 of "dead volume" below the 20 m level. To provide sufficient pressure for the users, the tank will be 8 m diameter and 25 m high. The reservoir will be connected to both the upper zone and lower zone and provide sufficient flow and pressure to meet fire prevention requirements and water usage for the whole SSID at full build out. It will include drain and overflow pipe, inspection and maintenance hatches, access ladder, measurement gauge and level switches. The level switches and trace heating for the exterior piping can be powered by the existing generator using the current electrical cabling at the reservoir site. The tank mixing will be done with a tideflex mixing system on the feed pipe.
- The tank will likely require a significant amount of foundation which will be assessed after ground load assessment and structural design. While this option has the advantage of not relying on a new source of power, it requires a structure of a considerable size with possible high visual impact.

- Standpipe Tank prices (design, shipping, and installation) are provided by Greatario and used for the cost estimate.

8.3. Solution 3. Booster Pump Station Only

- In the case the SSID plan is to replace only the elevated reservoir and to keep the ground reservoir as of now, one potential solution is to use it for both zones and to build a booster pump station for the upper zone only.
- The current reservoir capacity is 182 m^3 which is sufficient for fire prevention and equalization storage for the whole SSID at full build out. Note that this capacity will not provide an emergency storage, but we believe this can be managed with a contingency plan. The current reservoir valve chamber can be arranged for the ground reservoir to feed both upper and lower zones. A pump station can then be connected to the upper zone distribution piping.
- To accommodate for pressure in the upper zone, the pump station will include two peak hour demand pumps (centrifugal multistage or single stage with Variable Speed Drive) and one larger pump used for fire demand installed in a small building. The pump station will be powered by a 20-kW generator installed next to the building. The generator will require an electric box (ATS) to connect the appliances. The pump building will be heated.
- This solution could be an interim solution before installing a new ground surface reservoir that would replace both existing reservoirs. Space can be allocated for the future reservoir and its connection to the booster pump station.

8.4. Solution 4. Pressure Tanks

- As for solution 3, it is possible to use the existing ground reservoir for water storage of both upper and lower zones. The issue is it cannot provide sufficient pressure for water usage and fire prevention in the upper zones.
- One solution is to use the well pumps to feed the upper zone directly and to provide a buffer capacity in between to prevent the pumps from stopping and starting too frequently. According to the pumps curve, one well pump should have enough capacity to provide peak demand flow in the upper zone at a pressure of 35 PSI at the reservoir site. This however needs further assessment of actual peak flow during the high occupancy months.
- Either bladder or diaphragm tanks can be installed at the reservoir site and connect to the elevated reservoir feed line. The advantage of these tanks is they don't require a compressor like a pneumatic tank and therefore no need for power and there is no noise generated by a compressor.
- One well pump will fill up the existing reservoir for the upper zone and the pressure tanks for the lower zone simultaneously. Control switches in both the reservoir and at the pressure tank will control the pumps. We propose 5 tanks of 120 gallons capacity each, with a total drawdown capacity of about 200 gallons (757 L). At peak demand, this represents a buffer time of about 3 to 4 min and would leave enough time fo the well pump to cool down. The relatively small tanks would be easy to supply and install. The tanks could be installed in a small building and switches and building heating could be powered with the existing electrical facility.

- For fire prevention in the upper zone, the fire department would need to connect a pump to the fire hydrant, powered by a portable generator to achieve the minimum pressure at fire flow.
- This solution is not recommended until further assessment of the well pumps capacity, fire department capabilities and possible impact on the aquifers if the pumps require frequent start and stop.
- Additionally, we note that the existing water is not treated and doesn't require disinfection under the current permit. This could change within the future if regulations become more stringent or if the well water quality were to change. Disinfection would then require chlorine and a minimum contact time downstream which would then require a reservoir for the upper zone.

8.5. Solution 5. Elevated Tank Refurbishment

A potential refurbishment of the tank can also be considered. This would entail dismounting the tank, transporting it off site for repair and reinstalling it on top of the scaffold. We disregarded this solution for the following reasons.

- As mentioned previously the current elevated tank doesn't comply with minimum FUS requirements in terms of capacity. It also provides relatively low water pressure to the closest users (below 30 PSI).
- The tank, piping, scaffold and ladder is almost 50 years old. Replacing the tank bottom off site would be considered a potentially costly short term solution.
- Repairing the tank off site entails not having pressure for the upper zone for several months and would require the implementation of Solution 3 or 4 . If the upper zone pressure issue is solved, the low ground reservoir has then sufficient capacity for both zones and the upper tank refurbishment becomes redundant.
- Finally, the elevated tank and scaffold are not designed to withstand post-disaster or earthquake conditions, and the base of the 20-meter-high structure is located less than 10 meters from the nearest dwelling. This poses a potential risk, and MSR recommends further investigation to determine the risk and possible mitigation measures, such as installing guide wires to prevent the structure from collapsing onto the dwelling.

9. Costs estimates

Table 3 below summarizes the Class D costs estimates (35% contingency) for the proposed solutions described above. A larger format table is also attached with this report.

Table 3. Solutions cost estimates

Item	Description	Solution 1	Solution 2	Solution 3	Solution 4	Notes
	Solution	Surface Mounted Reservoir + Booster Station	Standpipe Reservoir	Booster pump station only	Pressure tanks	
0.1	Mobilization and Demobilization	$59,920	$123,270	$17,150	$7,700	Estimated at 7% of construction cost
0.2	Insurance and Bonding	$25,680	$52,830	$7,350	$3,300	Estimated at 3% of construction costs.
1	Reservoir (sub-total)	$606,000	$1,741,000			
1.1	*reservoir/fire storage (supply/shipping/installation)*	*$490,000*	*$1,340,000*			Includes design, supply (equipment transport via barge, estimated $90,000) and construction. Includes ringwall foundation
1.2	*mixing system*	*$30,000*	*$60,000*			Tideflex mixing system
1.3	*switches and instrumentation*	*$6,000*	*$6,000*			Reservoir Level gauge (float and board), level switches
1.4	*piping*	*$20,000*	*$25,000*			Reservoir piping includes drain and overflow pipe, feed pipe, insulation and trace heating
1.5	*tree cutting and shrubbing, excavation,grading,base layer*	*$30,000*	*$30,000*			
1.6	*geotechnical report*	*$30,000*	*$30,000*			ground load assessment and report
1.7	*additional foundations and excavation*	*$0*	*$250,000*			only base ring for low ground reservoir. Standpipe will require foundation design and construction.
2	Booster Pump Station (sub-total)	$230,000		$230,000		
2.1	*building*	*$50,000*		*$50,000*		small building
2.2	*pumps*	*$40,000*		*$40,000*		2 pHD pumps and 1 fire demand pump. Quote at 20,000 from CAC + taxes + freight + installation/commissioning from contractor
2.3	*mechanical*	*$30,000*		*$30,000*		piping, valves and small instrumentation + installation
2.4	*electrical*	*$30,000*		*$30,000*		cabling, control panels Installation/connections
2.5	*generator*	*$50,000*		*$50,000*		generator + supply + electrical boxes and installation
2.6	*spare*	*$30,000*		*$30,000*		spare pumps, valves and ancillaries
3	Pressure tanks (sub-total)				$95,000	
3.1	*Tanks (supply/shipping/installation)*				*$30,000*	5x115 gallons tanks set in parallel. Quote at $15,000 from CAC + + taxes + freight + installation/commissioning
3.2	*building*				*$50,000*	require portable gas heating in building
3.3	*piping, valves and instrumentation*				*$15,000*	
4	Connection to existing supply and distribution line	$10,000	$10,000	$10,000	$10,000	tees, valves, boxes + installation
5	Fencing	$10,000	$10,000	$5,000	$5,000	fencing around reservoir/building
	Subtotal Construction Cost	**$941,600**	**$1,937,100**	**$269,500**	**$121,000**	
	Engineering Design and Construction (12%)	$112,992	$232,452	$32,340	$14,520	12% of subtotal construction costs
	Regulatory Approval Processes (3%)	$28,248	$58,113	$8,085	$3,630	3% of subtotal construction costs
	Commissioning, Verification and Training	$15,000	$15,000	$10,000	$5,000	1 to 3 days on site plus call support
	Contingency allowance (35%)	$329,560	$677,985	$94,325	$42,350	35%
	Total Cost (excluding GST)	**$1,427,000**	**$2,921,000**	**$414,000**	**$187,000**	excluding GST . Costs based on 2025 figures

10. Cumulative Costs

- In general, we estimate annual costs for operation/maintenance, consumables and capital replacement to each be 2% of capital cost (6% total). However in this case consumables are minimal and it is not expected that the current maintenance done on the existing reservoir, generators and pump station will increase significantly with either solution. Reservoir and piping estimated lifespan is 40 to 50 years, pumps about 25 years and instrumentation 10 to 15 years.

11. Summary

As noted above, different options are proposed for the reservoir upgrade with their associated costs. The costs vary significantly depending on the solutions proposed. MSR recommends Solution 1 as a long term solution.

Attachments:

- Preliminary Design Drawing for Solution 1
- Cost estimate table

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