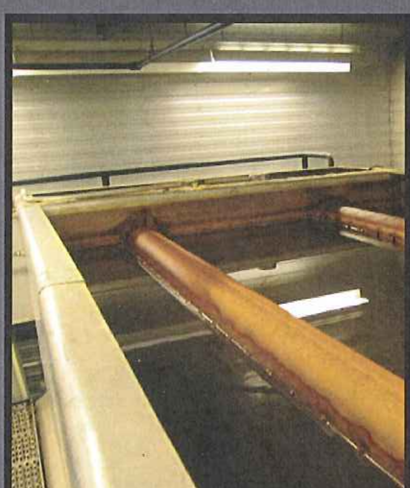
ASHMONT WATER TREATMENT UPGRADE

Pre-Design Draft Report October 2012



URBAN systems

File #: 3144.0003.02
#200 - 10345 -105 Street
Edmonton, AB T5J 1E8
Contact: Christina Fonseca
T: 780 430 4041
cfonseca@urbansystems.ca

urbansystems.ca

Prepared for:

The County of St. Paul
5015 – 49 Avenue
St. Paul, AB T0A 3A4

Prepared by:

Urban Systems Ltd.
#200, 10345 – 105 Street
Edmonton, AB T5J 1E8
T: (780) 430-4041
Email: cfonseca@urbansystems.ca

Attention: Cristina Fonseca, Ph.D., P.Eng.

TABLE OF CONTENTS

APPENDICES

ABBREVIATIONS

µg/L	micrograms/liter
ADD	Average Daily Demand
AESRD	Alberta Environment and Sustainable Resources Development
AO	aesthetic objectives
AT	Alberta Transportation
CFU	Colony Forming Unit
DBP	disinfection by-products
EPEA	Environmental Protection and Enhancement Act
GCDWQ	Guidelines for Canadian Drinking Water Quality (December 2010).
GW	Groundwater
ha	hectares
HAA	Haloacetic Acids
HAA5	haloacetic acids (HAA5; five species)
HDPE	High Density Polyethylene
hp	horsepower
kPa	kilopascals
kwh	kilowatt hour
L/min	Litres per minute
L/s	Litres per second
L/cap/d	Litres per capita per day
m^3/d	cubic metres per day
MAC	maximum acceptable concentrations
MDD	Maximum Daily Demand
mg $CaCO_3/L$	(equivalent) milligrams of Calcium Carbonate per liter
mg/L	milligram per litre
mJ/cm^2	millijoules per square centimeters
mL	millilitre
NDMA	Nitrosodimethylamine
NPV	Net Present Value
NTU	Nephelometric turbidity units
O&M	Operations and Maintenance
OG	Operational Guidance Values
PLC	Programmable Logic Controller
Psi	Pounds per square inches
RO	Reverse Osmosis
RWL	Regional Water Line
SDI	Silt Density Index
T&O	taste and odours
TDH	Total Dynamic Head
TDS	Total Dissolved Solids
THM	Trihalomethanes
TOC	Total Organic carbon
TSS	Total Suspended Solids
TTHM	Total Trihalomethanes
USL	Urban Systems Ltd.
UV	Ultra-violet
UVT	Ultra-violet transmittance
WTP	Water Treatment Plant

EXECUTIVE SUMMARY

The objective of this project is to upgrade the Ashmont water treatment plant (WTP) to meet future demands (i.e., 2036) for the Hamlets of Ashmont, Lottie Lake, and (possibly) Mallaig, and improve finished water quality. The project includes two phases:

- 1st Phase: Ashmont WTP would supply to Ashmont and Lottie Lake. The Ashmont WTP would be connected to the Lottie Lake WTP via a transmission line currently under construction, and new pumps would be added. These pumps were sized to meet either Lottie Lake and/ or Mallaig's supply requirements.

- Expansion: Ashmont WTP would serve as a hub supplying Ashmont, Lottie Lake and Mallaig. Water treatment process units would be added to the Ashmont WTP to meet Mallaig's demand and a new transmission line connecting the Ashmont WTP and Mallaig would be constructed.

The pre-design stage, which includes pilot-scale evaluation of two treatment options, is based on work done previously. The County of St. Paul (County) Regional Water Services Committee engaged Urban Systems Ltd. (Urban) in the Fall of 2011 to complete a feasibility study evaluating potential options to improve water quality and connect the communities of Ashmont and Mallaig (Ashmont WTP Upgrade and Ashmont-Lottie Lake Transmission Main, October 2011). The feasibility study included the following components:

- Conceptual evaluation of treatment alternatives to upgrade the Ashmont WTP to meet all required treatment criteria and in order to support the water demand needs of both Ashmont and Lottie Lake,

- Pre-design of a water transmission line to connect the communities of Ashmont and Lottie Lake.

The design and construction of a new WTP shall be pursued only if it results in favourable life-cycle costs when compared to connecting to the Highway 28/63 Regional Water Services or Regional Water Line (RWL). With that in mind, the objectives for the current project are as follows:

- Evaluate the best approach to upgrade / expand the Ashmont WTP treatment to meet Ashmont and Lottie Lake communities' future water demands and treated water quality standards,
- Evaluation optional treatment processes at pilot-scale,
- Evaluate the potential to direct discharge of treatment process residuals to a surface water receiving body,
- Summarise the treatment process and design criteria proposed for the Ashmont WTP,
- Provide Class C capital cost as well as life-cycle cost estimates, and
- Incorporate the capacity to easily expand the Ashmont WTP to meet Mallaig's future demand.

In summary, the current project goal is to provide the County with an estimate of the capital and life-cycle costs associated with building a new WTP in Ashmont. Moreover, the project also looked at WTP building siting and associated implications with integration between existing and future facilities, as well as residuals disposal.

Due to project time constraints, the pilot-scale study and pre-design work occurred simultaneously. Additionally, the residuals disposal investigation was tied-in with the pilot-scale study and could have a critical impact in process selection. For these reasons, and to maximize resources, it was decided to carry the pre-design only to 30 percent completion. The objective was to be able to recommend a preferred treatment process, size the treatment building, proposed a location for the new WTP, and provide the County with updated capital and life-cycle cost estimates without investing unnecessary funds into the project.

1. DESIGN FLOWS

The design flows were determined during the feasibility study stage for Ashmont and Lottie Lake, and through discussions with Alberta Transportation (AT) and the County for the community of Mallaig. Water demands were based on projected population growth and per capita demand. **Table ES.1** summarizes the design flow rates.

Table ES.1 - Ashmont WTP Design Flows

Communities Serviced	2022 Flow (L/s)		2037 Flow (L/s)	
	ADD	MDD	ADD	MDD
Ashmont and Lottie Lake	3.3	5.9	4.7	8.5
Ashmont, Lottie Lake and Mallaig	5.0	8.9	7.0	12.6

2. PILOT-SCALE TESTING

The approach to pilot-scale testing was developed to identify the best treatment process that would meet the water quality objectives while being cost effective and competitive when compared to connecting to the RWL (i.e. the Highway 28/63 Regional Water Services). Although many options exist to treat water to potable standards, once the connection to a RWL became an option, investing in costly alternatives with significant impact in plant operations and maintenance (O&M) was dismissed. Therefore, two pilot-scale tests were conducted during this phase, Option 1 (Reverse Osmosis (RO) membrane filtration) and Option 2 (Pre-Oxidation / Pressure Filtration / RO membranes).

Figure ES.1 shows a simplified process flow diagram of the direct feed RO membrane filtration pilot-scale trial. Water was pumped from the groundwater well directly to the RO membrane skid. Prior to filtration with the RO membranes, anti-scalant was added into the water stream to minimize membrane fouling and filtered with a 5 μm cartridge filter.

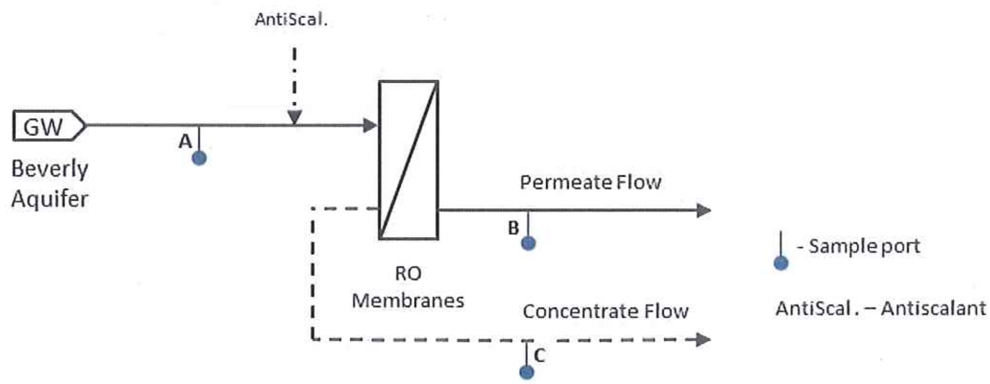


Figure ES.1 - Direct Feed RO Membrane Pilot-Scale Trial Simplified Process Flow Diagram

Figure ES.2 shows a simplified process flow diagram followed for the Pressure Filtration (PF) / RO membrane filtration pilot-scale trail. Water was pumped from the groundwater wells to the treatment skid, consisting of a pressure filter unit followed by RO membranes. An oxidant was injected in the water upstream of the pressure filter (sodium hypochlorite and potassium permanganate were tested) to oxidize iron and manganese and keep the Greensand Plus media operational. Sodium bisulfite was added downstream the pressure filter to quench any remaining oxidant residual. Anti-scalant was added downstream the sodium bisulfite injection location and upstream the 5 µm cartridge filter and RO membrane filtration modules.

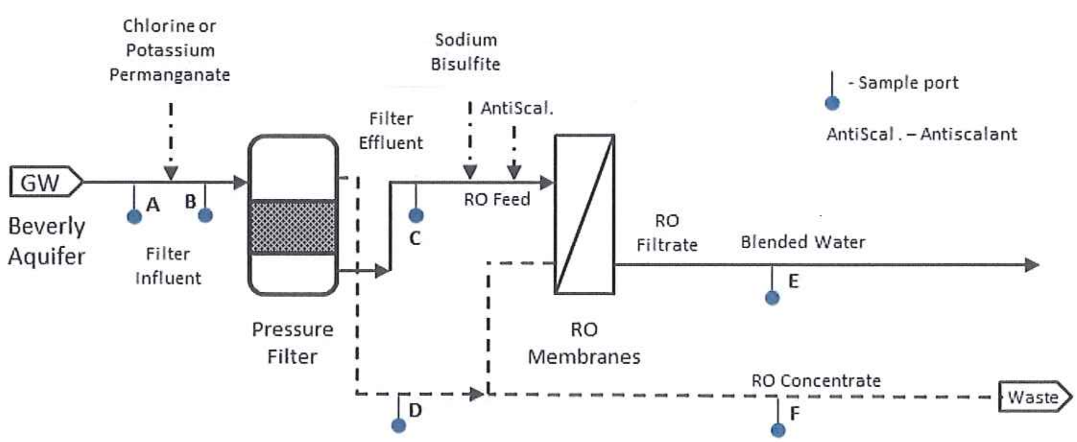


Figure ES.2 – Pressure Filtration / RO Membrane Pilot-Scale Trial Simplified Process Flow Diagram

Based on the pilot-scale testing results, treatment of Beverly Aquifer water directly with RO membranes shows great promise from a contaminant removal and membrane treatment performance perspective. Moreover, the concentrate stream, which corresponds to the process residuals generated during treatment, was not toxic to aquatic life and could potentially be discharged directly to a surface water body.

If this option is selected, it is recommended to prolong testing for another two to three months in order to gain a better understanding of CIP requirements as this may impact chemical systems design. The data collected during testing were not optimal as it is suspected that anti-scalant doses were fed at greater than optimal rates. Additionally, recovery rates were allowed to reach 78 percent, slightly larger than the target 70 percent. This work could be conducted along with the detailed design phase of the project.

Implementation of this option would generate process residual volumes larger than Option 2, i.e., 30 percent as opposed to 17.5 percent, which would require appropriate disposal. Although less sustainable from a water conservation perspective, Option 1 would require the addition of less chemicals during treatment. It would also likely eliminate the requirement for UV disinfection as virus inactivation would be achieved with free chlorine residual instead of UV light.

Option 2 will require some optimization at the pilot-scale level to identify optimal operating conditions. One of the issues remaining to be evaluated is whether contact time must be provided ahead of the pressure filters to improve manganese removal within the pressure filter. It is not uncommon for manganese to require additional contact time, especially when in the presence of high concentration of organic matter (i.e., 10 mg/L TOC) and ammonia. Once optimal conditions are identified, it is expected that the RO membranes would perform equally well or better than in Option 1. Initial water quality test results suggest that contaminants will be removed to the extent anticipated using pressure filters and RO membranes. These results will be confirmed during the next test trial.

Although not a commonly adopted treatment option, direct RO membrane filtration works in situations where contaminants are kept in the dissolved state until they reach the membrane surface. Pilot-scale water quality results indicate that Option 1 is a viable treatment option, provided the finished water pH is adjusted. Wigen Technologies conducted a pilot-scale study in Iowa, between April 20 and July 20, 2011, for Rembrandt Enterprises, Inc. where raw water was fed directly to the RO membranes, similarly to what was tested at Ashmont. This test was also successful in removing iron, arsenic, TDS, among other water contaminants.

Option 2, with pre-treatment ahead of RO membrane filtration is a more common treatment approach. It removes some of the foulants prior to membrane filtration, potentially extending membrane life, and is more robust overall. If either the filtration or the RO membrane process fails, the other can still provide for some level of treatment.

3. WATER TREATMENT PLANT UPGRADES

At this stage two treatment options remain viable for implementation at the Ashmont WTP, from a technical perspective, and were therefore evaluated from a life-cycle costs perspective. **Figures ES.3** and **ES.4** show simplified process flow diagrams (PDF) of each treatment option.

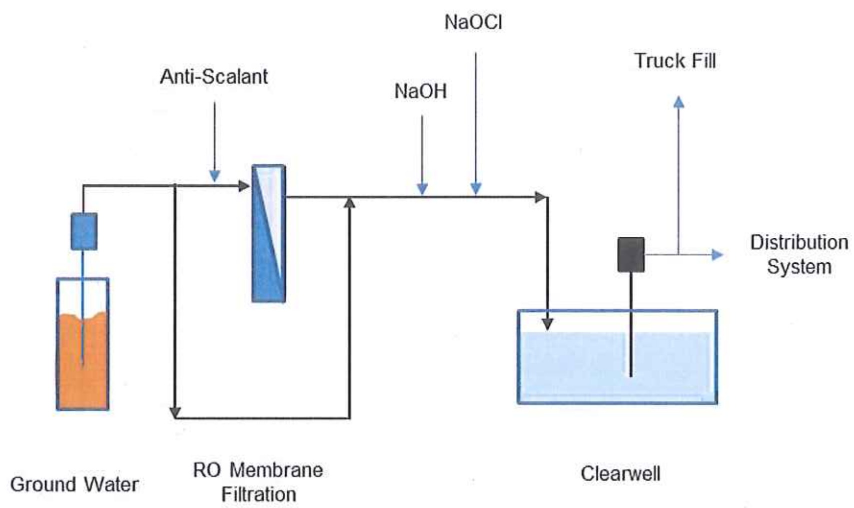
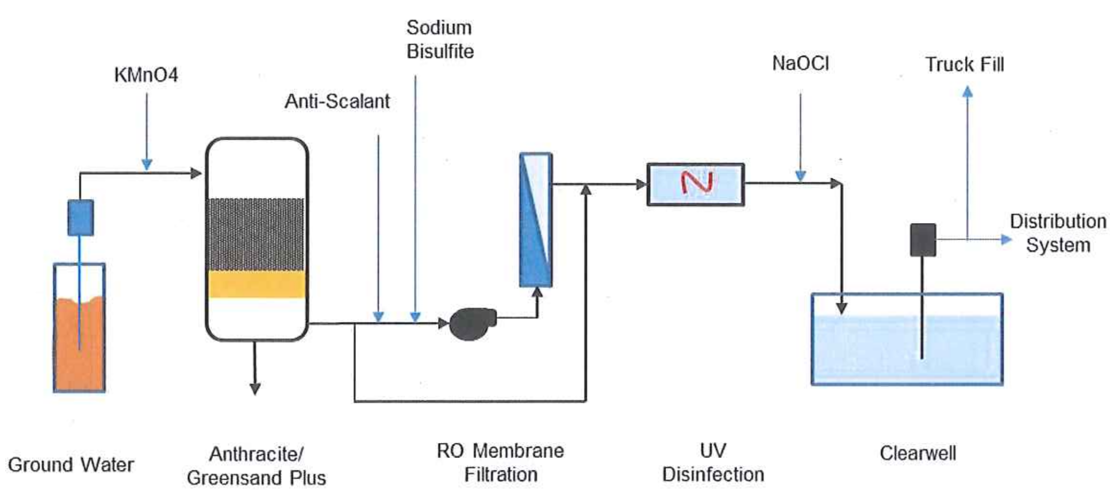


Figure ES.3 – Pressure Filtration / RO Membrane Filtration Treatment Simplified PFD

Option 1 assumes direct filtration of groundwater through RO membranes without any pre-treatment. A fraction of the raw water flow would by-pass the RO membrane process providing for some mineralization / conditioning of the treated water. The fraction of the raw water to be by-passed would be limited by iron and ammonia concentration in the blended water stream.



ES.4 – Direct RO Membrane Filtration Treatment Simplified PFD

Option 2 assumes all flow treated with anthracite / manganese pressure filtration, followed by partial treatment with RO membranes. As agreed with AT during the Feasibility Study phase, only 50 percent of the pressure filtration effluent would undergo RO membrane treatment. Finished water would result from the combination of pressure filter effluent and RO membranes permeate.

The design approach adopted in for the Ashmont WTP upgrade was to size the building to accommodate the final design flow (i.e., 12.6 L/s) but only install the equipment required to meet the first phase design criteria. During detailed design, consideration will be given to modifying the existing WTP building footprint to store chemicals, and keep the new building footprint smaller. Additionally, a connecting vestibule will be built between existing and future buildings allowing the operators to freely move between them without being exposed to the weather.

Figures ES.5 and **ES.6** show layouts for Options 1 and 2, including the connection vestibule to the existing building. These layouts were used as basis to obtain preliminary (pre-engineered) building and mechanical equipment (i.e., HVAC and plumbing) costs. During detailed design the layouts will be improved with input from the architect.

Consideration was given to clearance around process equipment and adequate space requirements to install pipes, flow meters, as well as access from the outside into the WTP building. Connection with the existing building was also included for ease of travel between the two working areas.

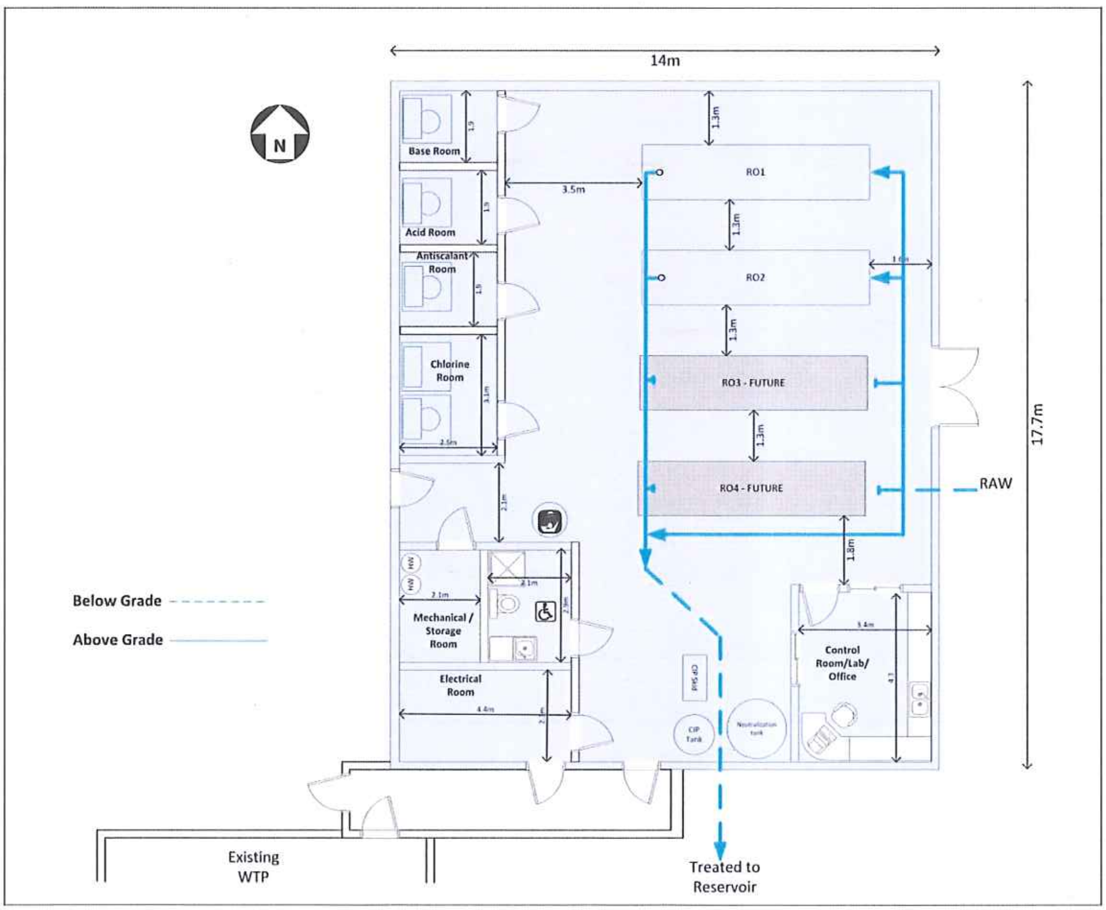


Figure ES.5 –Direct Feed RO Membrane Process Layout (Option 1)

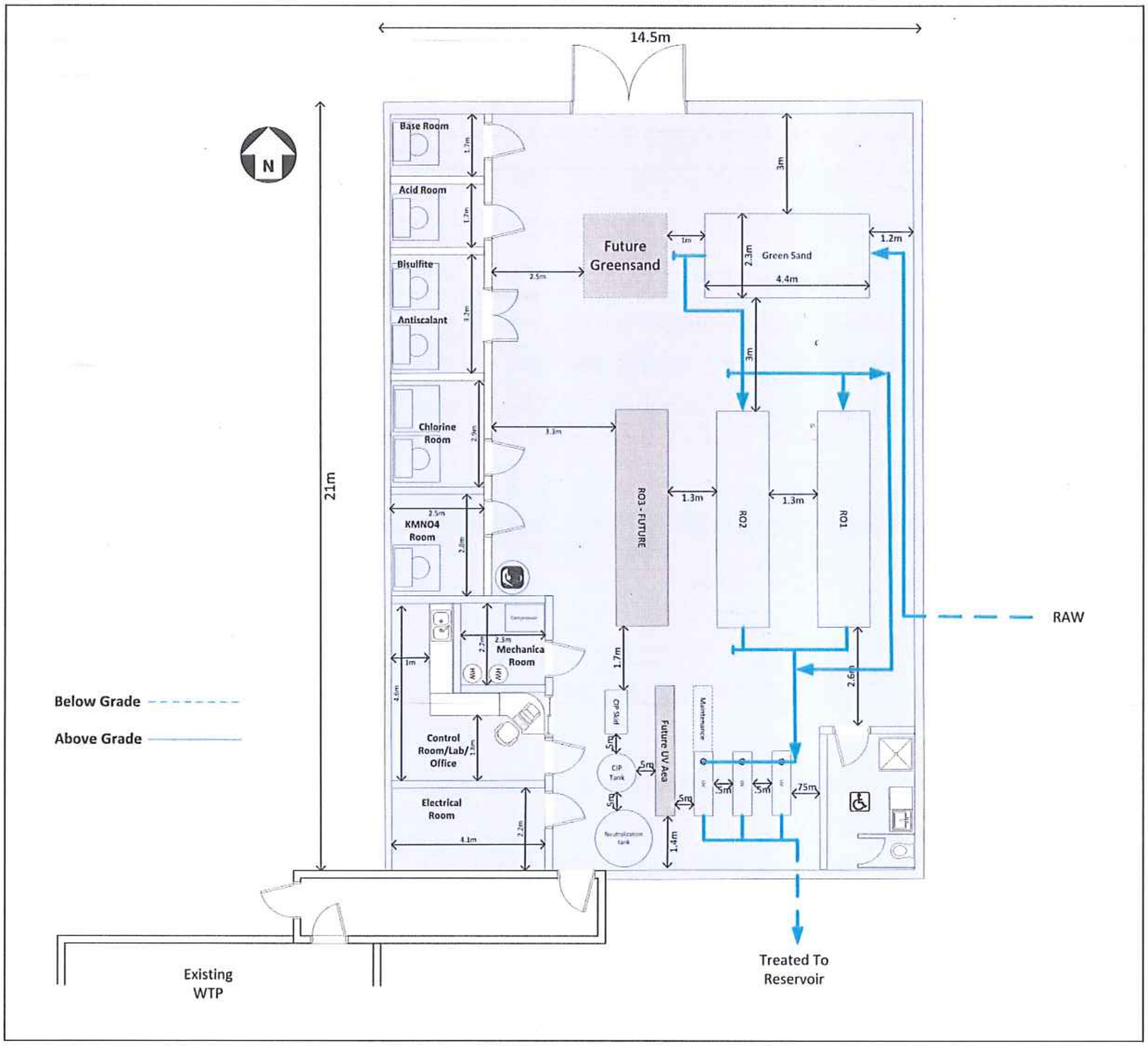


Figure ES.6 –Direct Feed RO Membrane Process Layout (Option 1)

The site layout developed for the Ashmont WTP upgrade is shown in **Drawing C01**in in **Appendix I**. The site was developed to allow easy access to chemical delivery trucks, connection between the existing and future buildings and parking.

4. WATER TREATMENT PROCESS RESIDUALS DISPOSAL

One of the key aspects of the current project was to evaluate residuals generation and disposal. Options associated with process residuals could limit process selection, given that RO membranes produce considerable larger volumes of residuals and the existing sewage lagoons are currently approaching their capacity. The option to release the residuals stream to a surface water was just one approach reviewed in the feasibility stage, and the preliminary indications indicated that this was a potentially viable approach to the management of the residual stream. Within that context, a study was undertaken by Urban (Ashmont Water Treatment Plant Upgrades – Receiving Water Assessment for Residuals Discharge) to evaluate potential discharge options.

The receiving water assessment aimed to evaluate the potential for pursuing a discharge to one of the surface waters in the area and, if the discharge approach appears to be viable, develop suitable discharge criteria which will aim to protect the surface water resources and uses. Batty Lake and the un-named creek were the focus for potential receiving environments. An on-site assessment indicated that there are limited uses for either water course. There are no fish present and the fisheries habitat is low for both the lake and the creek.

The preliminary recommendations are that the preferred discharge approach would be to the lake, unless Alberta Environment and Sustainable Resources Development is willing to allow a release into the creek, in recognition of the limited uses associated with the creek. Storage over the winter period may be required for the creek discharge, but may be reduced for the lake if an outfall can be placed in deep enough water to avoid winter freeze-up. Alternatives to storage over the winter can be considered, such as snow-making.

5. CAPITAL AND O&M COST ESTIMATES AND LIFE-CYCLE COSTS

Capital and O&M cost estimates associated with the upgrade of the existing WTP were developed for both options and are summarized in **Tables ES.2** and **ES.3**. Detailed cost estimate sheets are available in **Appendix J**. Net present values were also calculated for both options at each of the design flows (i.e., 8.5 L/s and 12.6 L/s). The costs presented in **Table ES.2** are total costs and assume that an increase in capacity from 8.5 L/s to 12.6 L/s would require an additional $165,000 and $360,000 for Options 1 and 2, respectively.

Table ES.2 - Ashmont WTP Upgrade Preliminary Capital Cost Estimates[1]

	1st Phase (8.5 L/s)	Expansion (12.6 L/s)
Option 1	$2,110,000	$2,275,000
Option 2	$3,000,000	$3,360,000

1. Cost estimate values are rounded up.

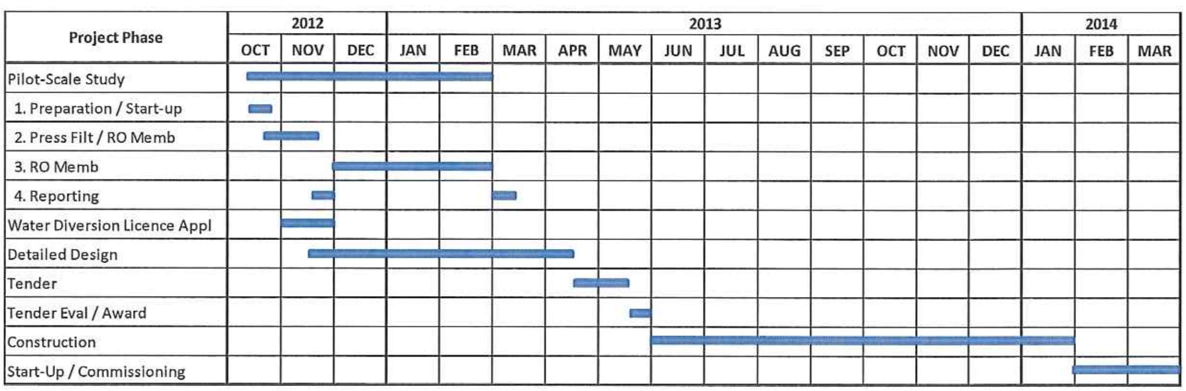
Table ES.3- Ashmont WTP Upgrade Preliminary O&M Cost Estimates[1]

O&M Costs	1st Phase		Expansion	
	Option 1	Option 2	Option 1	Option 2
Variable O&M Costs - $ / Yr - $ / m^3	 $37,000 $0.14	 $38,100 $0.14	 $49,000 0.12	 $57,000 0.14
Fixed O&M Costs - $ / Yr - $ / m^3	 $45,000 $0.17	 $52,600 0.2	 $5,000 $0.11	 $52,600 $0.13
Net Present Value[2] ($)	$3,200,000	$4,250,000	$3,475,000	$4,780,000

1. Cost estimate values are rounded up.
2. NPV estimated based on ADD O&M values at half the project design horizon, i.e., half the O&M calculated for 2036.

6. SCHEDULE

A preliminary schedule for the next phases of the project is shown below, including pilot-scale testing of Option 2, detailed design, tender process and award, construction and start-up and commissioning.



Since there are no large buried structures to be built, e.g., reservoirs, the project schedule will mostly depend on equipment delivery times required from the different suppliers. Generally, shop drawing submittal takes four to six weeks from purchase order (PO) issuance while equipment fabrication may take up to 16 weeks from shop drawing acceptance. Same timelines would be expected for a pre-engineered type building. During detailed design the building will be selected based on costs and also impact on overall schedule if that becomes a deciding factor as the project progresses.

7. CONCLUSIONS AND RECOMMENDATIONS

The objective of the current pre-design work is to recommend the best treatment option to upgrade the existing Ashmont WTP. This work included an evaluation of treatment processes that could meet water quality objectives and design flows rates, assess whether the future WTP would fit in the area adjacent to the existing Ahsmont WTP, and an evaluation of capital, O&M and life-cycle costs. Consideration was given to expanding the Ashmont WTP in the future, to accommodate water supply to Mallaig.

Based on pilot-scale testing and capital, O&M, and life-cycle cost estimates, direct treatment with RO membranes (Option 1) looks extremely promising. The water quality obtained over one month of testing was extremely good with all major water contaminants being removed up to 99 percent of below their detection limits. This option also resulted in lower capital and life-cycle cost estimates with savings of approximately $900,000 in initial capital cost investment and $1,250,000 over the life-cycle of the project. The capital and life-cycle costs estimate for this option were $2,110,000 and $3,200,000, respectively. If the raw water quality conditions are maintained this option could be very well suited for the Ashmont WTP upgrade.

Pressure filtration followed by RO membrane filtration (Option 2) was also tested at pilot-scale; potassium permanganate was identified as the pre-oxidant of choice over sodium hypochlorite based on on-site testing results. However, issues associated with manganese removal during pilot-scale testing of Option 2 limited the amount water quality collected to date. Upgrades to the test set-up (i.e., addition of a contactor ahead of the pressure filters) are currently under way, and testing is anticipated to re-start during the third week of October. Nevertheless, based on the limited data collected to date, good removals of target water quality contaminants were obtained, although to a lesser extent than with direct RO membrane treatment.

Option 2, although more robust from a process redundancy perspective (i.e., pre-treatment ahead of RO membranes), is more expensive in terms of capital, O&M and life-cycle costs, compared to Option 1. The capital and life-cycle costs estimate for this option were $3,000,000 and $4,250,000, respectively. Once the pilot-scale testing re-starts the impact of upfront contact time (with potassium permanganate) on the extent of manganese removal will be determined. Due to the elevated levels of organic matter (measured as TOC, DOC and UV absorbance) and ammonia, manganese removal could be limited.

Based on these results it is recommended to finish Option 2 pilot-scale testing with the goal of evaluating pressure filter performance, i.e., iron, manganese and arsenic removal, as well as backwashing requirements, and RO membrane fouling occurrence.

If Option 1 is selected it is recommended to conduct a three month pilot-scale testing to evaluate RO membrane performance over a longer testing period. Testing can occur in parallel with detailed design stage of the current project. The information gathered during pilot-scale testing would be used to refine the WTP design and provide valuable insight to RO membrane system design and selection.