Development of an Integrated Leachate Treatment Solution for the Port Granby Waste Management Facility - 12429

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ABSTRACT

The Port Granby Project (the Project) is located near the north shore of Lake Ontario in the Municipality of Clarington, Ontario, Canada. The Project consists of relocating approximately 450,000 m^3 of historic Low-Level Radioactive Waste (LLRW) and contaminated soil from the existing Port Granby Waste Management Facility (WMF) to a proposed Long-Term Waste Management Facility (LTWMF) located adjacent to the WMF. The LTWMF will include an engineered waste containment facility, a Wastewater Treatment Plant (WTP), and other ancillary facilities. A series of bench- and pilot-scale test programs have been conducted to identify preferred treatment processes to be incorporated into the WTP to treat wastewater generated during the construction, closure and post-closure periods at the WMF/LTWMF.

INTRODUCTION

The Port Granby WMF was operated as a waste site for Port Hope-based Eldorado Nuclear Limited (Eldorado) between 1955 and 1988. In 1988, Eldorado merged with a provincial Crown corporation, Saskatchewan Mining and Development Corporation, to form Cameco Corporation (Cameco). Since the merger, Cameco has managed the Port Granby WMF. Under the terms of the agreement that created Cameco, the federal government took responsibility for the LLRW located at the Port Granby WMF, while Cameco agreed to manage the facility on behalf of the Crown until such time that an acceptable means of dealing with the waste for the long term was identified. With a 2001 legal agreement between the federal government and the Municipality of Clarington, and the subsequent launch of the Port Hope Area Initiative (PHAI), progress towards the long-term disposition of all LLRW associated with the Port Granby WMF has steadily advanced.

Atomic Energy of Canada Limited (AECL) is providing project management services for the Port Granby Project, which is now well advanced. A federal Environmental Assessment (EA) has been completed [1] and AECL is pursuing the licensing of the Project with the Canadian Nuclear Safety Commission (CNSC). This licensing decision will trigger the transfer of the ownership of the Port Granby WMF property from Cameco to the Crown. It is further expected that AECL will provide overall management for the Port Granby WMF on behalf of Canada, i.e., AECL will be the licensee for the Port Granby WMF and the subsequent new LTWMF.

Contaminated water collection and treatment facilities have been in place and operating at the existing Port Granby WMF since 1977. However, it is expected that with the start of the waste excavation process, both the volume and contaminant loading of the collected waters will increase compared to current conditions. Further, at the new LTWMF the waste will be subject to contact with atmospheric water (precipitation) up to the time the final cover system has been completed. Lastly, once the new LTWMF is closed, residual seepage flows from the remediated WMF and leachate from the facility will require on-going collection and treatment for some period of time.

During the EA process, various regulatory agency staff indicated that they expect expanded treatment capability than currently exists. It was expected that treatment would address the full suite of Contaminants of Potential Concern (COPC) identified during the EA process and associated with the wastes and leachate from the site. Secondly, high removal efficiency for the primary COPCs was expected. As a result, AECL commissioned the *Assessment of Water Treatment Requirements and Options* (*Water Treatment Requirements Study)* [2] for the Project to identify feasible concepts for the required treatment. This work identified a preferred concept using a Best Available Technology (BAT) approach. The BAT process is well known in the United States, and is defined in the Clean Water Act (CWA) [3], as follows:

> *Best Available Technology Economically Achievable (BAT) is defined at Section 304(b)(2) of the CWA. In general, Best Available Technology Economically Achievable (BAT) represents the best available economically achievable performance of plants in the industrial subcategory or category. The factors considered in assessing BAT include the cost of achieving BAT effluent reductions, the age of equipment and facilities involved, the process employed, potential process changes, non-water quality environmental impacts, including energy requirements and other such factors as the EPA Administrator deems appropriate*

The "economically achievable" portion of the BAT approach is often overlooked. It has been generally realized by regulatory agencies that any wastewater can be treated to achieve a very pure effluent if enough money is spent. However, the United States Supreme Court in 1980 [4] and again in 2009 [5] upheld that the EPA can in fact consider economic reasonableness and cost benefit analysis approaches as applied to effluent permitting.

METHOD

There are multiple sources of wastewater that will be treated in the WTP as follows [6]:

- Leachate at the WMF is currently collected at two locations (East Gorge and West Gorge Reservoirs). These Reservoirs are strategically located to collect leachate from the buried waste areas as well as general impacted surface water. The East and West Gorge Reservoirs will remain in service throughout the waste excavation process at the WMF.

- Precipitation and dust suppression water will come into contact with uncovered waste materials as excavation at the WMF progresses. Temporary collection ponds will likely be constructed during this period to collect this wastewater. This active construction period is estimated to require six years.

- At the completion of the waste excavation the WMF will be closed. Minor amounts of potentially impacted leachate will continue to be collected by the East Gorge Collection System which will replace the current Reservoirs.

- Once excavated wastes are disposed of at the new LTWMF they will be subject to contact with precipitation and dust suppression water until final capping takes place. Temporary ponds will likely be constructed during this period to collect this wastewater.

- At the completion of construction the LTWMF will be capped and closed. Relatively minor quantities of leachate will be produced after LTWMF closure that will continue to be collected and treated in the WTP.

The projected WTP influent flow rates and water quality for the Project were presented as a section of the *Water Treatment Requirements Study*, and is summarized in Table I.

Table I – Projected Water Quality and Quantity

Parameter	Units	Existing WMF		Projected LTWMF	
		Lower Bound	**Upper Bound**	**Lower Bound**	**Upper Bound**
Influent Flow - Average	m^3/month	2,300	6,200	4,750	4,750
Influent Flow - Peak	m^3/month	13,400	13,400	12,180	12,180
pH	Units	6.5	8.8	7.5	12
Total Dissolved Solids	mg/L	400	8,633	-	-
Alkalinity	mg/L $CaCO_3$	125	311	500	1,000
Chloride	mg/L	3	26	<10	4
Sulphate	mg/L	290	2,200	100	4,000
Ammonia	mg/L as N	0.03	72	5	150
Arsenic	mg/L	1	10	0.1	10
Calcium	mg/L	85	785	100	1,000
Cadmium	mg/L	<0.0001	0.0002	<0.005	0.03
Cobalt	mg/L	0.0001	1	0.01	1
Copper	mg/L	<0.005	0.13	0.01	1
Iron	mg/L	<0.03	37	0.01	0.1
Lead	mg/L	<0.0005	0.02	<0.02	0.03
Magnesium	mg/L	15	975	10	1,000
Manganese	mg/L	0.018	1	<0.1	-
Molybdenum	mg/L	0.003	5	<1	-
Nickel	mg/L	0.001	0.30	<0.1	-
Nitrate	mg/L as N	60	900	100	2,000
Nitrite	mg/L as N	0.3	31	-	-
Phosphorus	mg/L	<0.05	4	<10	-
Potassium	mg/L	11	357	10	300
Radium-226	Bq/L	0.2	22	4	75
Sodium	mg/L	17	2,100	-	-
Silicon	mg/L	3	5	-	-
Uranium	mg/L	1	9	1	20
Vanadium	mg/L	<0.00005	1	-	-

The COPC were identified during the EA process. The *Water Treatment Requirements Study* lists the identified COPC from those studies. These constituents are shown on Table II, with separate lists for the existing WMF collection system and construction water and leachate from the new LTWMF.

Table II – Constituents of Potential Concern

Treatment System	Parameters	
Existing WMF	Ammonia-N	Nickel
	Arsenic	Nitrate-N
	Calcium	Nitrite-N
	Cobalt	Phosphorus
	Copper	Potassium
	Fluoride	Radium-226
	Iron	Selenium
	Lead	Uranium
	Magnesium	Vanadium
	Molybdenum	
Projected for LTWMF	Ammonia-N	Lead
	Arsenic	Magnesium
	Cadmium	Nitrate-N
	Calcium	Phosphorus
	Cobalt	Potassium
	Copper	Radium-226
	Fluoride	Uranium

The nitrogen species (ammonia, nitrate, and nitrite) were identified as a major COPC for both the WMF and LTWMF. In addition, several metals (arsenic, cobalt, copper, lead, and magnesium), radionuclides (uranium, radium-226) and general dissolved solids (calcium, fluoride, phosphorous, and potassium) were also identified as COPC for both the WMF and LTWMF.

Based on the previous efforts several important challenges were identified that needed to be addressed in the subsequent test programs and the final design of the overall integrated treatment process. These challenges included the following:

- **Treatment facility hydraulic capacity.** Significant swings in influent flow are expected over the life of the Project. The flows will be impacted by a combination of site activities under way at any particular time as well as seasonal events (spring/summer rains and winter snow). The challenge is to properly balance capital cost for treatment capacity versus equalization capacity to reduce the impact of peak flow events.

- **Treatment process flexibility.** While data exists on current WMF leachate, the characteristics of water that will contact exposed waste materials during excavation at the WMF and placement at the LTWMF are unknown and difficult to predict. Depending on the specific characteristics of waste materials at any point in time, these characteristics would be subject to change over time as well. The challenge is to select and design unit operations that can operate effectively over a range in contaminant concentration.

- **Environmental conditions.** The Project site is located on the shores of Lake Ontario, and is subject to potential winter weather conditions including snow and prolonged periods of sub-zero temperatures.

- **Project duration.** The main construction phase of the project is projected to be six years. Process development and resulting equipment design needs to consider this relatively short project duration.

RESULTS

Bench Test Program Summary

An initial bench-scale test program was performed in 2009 to evaluate the removal efficiency for specific contaminants and the impacts of the water matrix on that efficiency. In addition, the bench-scale studies evaluated pretreatment conditions that could improve efficiency of processes for the COPC and residuals management requirements and options. Preliminary design parameters such as chemical usage, sludge production, and operational parameters were also assessed.

The results of the bench-scale treatability studies demonstrated that 90 percent or greater removal efficiency could be achieved for all COPC over a range of concentrations and influent flow rates [7]. However, even at these high removal efficiencies, the residual concentrations of some COPC were elevated due to the high concentrations present in the Port Granby water. The problematic constituents that drove the design and process selection for developing long-term water treatment solutions were primarily nitrate, nitrite, ammonia, and total dissolved solids (TDS), which include sulphate, alkalinity, calcium, magnesium, and potassium.

Based on the results of the bench-scale testing, the proposed water treatment system consisted of the following primary unit operations:

- **Equalization** – Storing collected site water in ponds equalizes spikes in contaminant concentration or flow and promotes removal of suspended sediment.

- **Biological Pretreatment** – Biological pretreatment focused on ammonia, nitrate, and nitrite removal. The biological pretreatment step was not originally identified for evaluation during the bench-scale test program. While biological treatment was not evaluated during the bench-scale testing the results of the bench-scale testing indicated that these species had a considerable impact on other treatment processes due to their high concentrations. The high ammonia, nitrate, and nitrite concentrations, coupled with the high TDS (sulphate, calcium, magnesium, alkalinity, and potassium), make other conventional BAT processes less effective. Therefore, supplemental bench testing was completed for biological treatment using flask tests to assess the overall amenability of the Port Granby water to biological treatment for nitrogen removal. Based on favourable results pilot testing was identified as required to determine design parameters and performance.

- **Reverse Osmosis (RO)** – Reverse osmosis was identified as a primary treatment technology for COPC capable of producing a high-quality permeate (treated water) stream for discharge and a concentrated secondary waste stream (brine). The concentrate or brine stream was projected to be approximately 25 percent of the influent volume and require further treatment to produce a stabilized waste for disposal.

- **Secondary Waste (Brine) Management** – The brine stream from the reverse osmosis system will contain uranium, radium-226, metals, and dissolved constituents (sulphate, calcium, magnesium, alkalinity, and potassium) at concentrations approximately four times greater than the influent water. Treatment of the brine stream by conventional chemical precipitation processes can reduce the dissolved concentrations of metals, uranium, and radium, and produce a stable sludge that can be disposed. The brine stream volume can be further reduced using an evaporation system.

- **Effluent Polishing** – Provisions were included in the preliminary design to polish the effluent (permeate) from the reverse osmosis system using BAT processes for ammonia (zeolite absorption) and nitrate/nitrite (ion exchange).

Pilot Test Program Design

The key processes evaluated during the pilot-scale test program included biological treatment and reverse osmosis. The biological treatment pilot testing was intended to demonstrate the effectiveness of removal of ammonia, nitrate, and nitrite, and the potential removal of other species, such as metals. The reverse osmosis system pilot test work was intended to evaluate operational issues associated with membrane scaling, membrane fouling, and cleaning regimes.

Based on previous evaluations and the bench-test program there were several specific challenges and issues that were incorporated in the design of the pilot test program [8].

- Biological treatment is a temperature sensitive process. Since the pilot program was conducted during early to mid-fall there was the opportunity to conduct a portion of the test program at colder temperatures.

- Biological treatment systems require several weeks or more to start up due to the need to establish a viable microbiological population from an initial inoculum. Part of the focus of the pilot program was to use a locally sourced inoculum from a domestic wastewater treatment facility that could be quickly sourced during actual operations as required.

- There will be multiple sources of wastewater that may exhibit a range of contaminant types and concentrations over the course of the Project. One of the goals of the pilot program was to operate on different “mixes” of the available wastewater sources.

The biological treatment process pilot effort was focused on ammonia and nitrate reduction and was intended to evaluate design parameters such as hydraulic retention time (HRT), solids retention time (SRT), mixed liquor concentrations in the bioreactors, and residual ammonia and nitrate levels. The biological treatment system was capable of treating 16.2 m^3/day (2.98 gpm) on an average 24-hour basis based on hydraulic and level controls that combined gravity overflow, pump timers, and level controls. Due to the limited time available for the pilot testing program there was insufficient time to evaluate a wide range of HRT’s.

The reverse osmosis system pilot effort was intended to evaluate operational issues associated with membrane scaling, membrane fouling, and cleaning regimes. The bench-scale testing results and modeling results indicated that a reverse osmosis system could be operated with a recovery of 75 percent; however, the impact of this recovery rate on membrane fouling and cleaning effectiveness could not be determined by bench-scale testing or modeling.

Figure 1 presents a flow schematic for the pilot system setup and Figure 2 photographs of the field setup.

Pilot Test Program Results

The pilot system operated for approximately two months in the summer/fall of 2010 and treated over 413 m^3 (109,000 gallons) of wastewater. West Gorge water was initially treated in the system. The source water was switched to a 1:1 blend of West and East Gorge water part way through the program in order to obtain data over a range of water qualities. Table III summarizes the influent chemistry over the course of the program. Comparison of this table to the projected range of influent concentrations in Table I indicates that the pilot program influent water quality was generally representative of that expected in the full-scale system.

Table III – Pilot System Influent Water Quality Summary

Water Source	Units	Minimum	Average	Maximum	95% Confidence Interval
pH	s.u.	7.49	7.82	8.24	0.10
Alkalinity	mg/L $CaCO_3$	92	174	233	31
TDS	mg/L	1,700	3,259	3,990	346
Sulphate	mg/L	840	1,146	1,400	106
Chloride	mg/L	41	108.8	260	51.8
Ammonia	mg/L as N	64.9	112.5	1,450	16.58
Arsenic	mg/L	0.95	1.1	1.25	0.063
Calcium	mg/L	170	202	2320	11.6
Cadmium	mg/L	0.00008	0.0006	0.0016	0.00024
Cobalt	mg/L	0.012	0.028	0.036	0.0038
Copper	mg/L	0.0062	0.012	0.029	0.0041
Fluoride	mg/L	0.41	1.35	2.46	0.67
Iron	mg/L	0.002	0.029	0.206	0.031
Lead	mg/L	0.00002	0.00016	0.00052	0.00009
Magnesium	mg/L	81.6	109.9	138	12.21
Manganese	mg/L	0.051	0.13	0.16	0.015
Molybdenum	mg/L	0.64	0.89	1.1	0.099
Nickel	mg/L	0.046	0.071	0.087	0.0076
Nitrite	mg/L N	2.16	3.47	5.03	0.46
Nitrate	mg/L N	1,840	272	3,270	31.3
Phosphorous	mg/L	0.05	0.14	0.58	0.07
Potassium	mg/L	206	274	304	14.1
Radium-226	Bq/L	0.4	0.82	1.10	0.34
Sodium	mg/L	102	276	3,820	50.7
Silicon	mg/L	3.3	5.64	7.94	0.86
Uranium	mg/L	4.5	6.1	7.44	0.59
Vanadium	mg/L	0.0017	0.0037	0.0066	0.00098
Zinc	mg/L	0.006	0.015	0.024	0.003

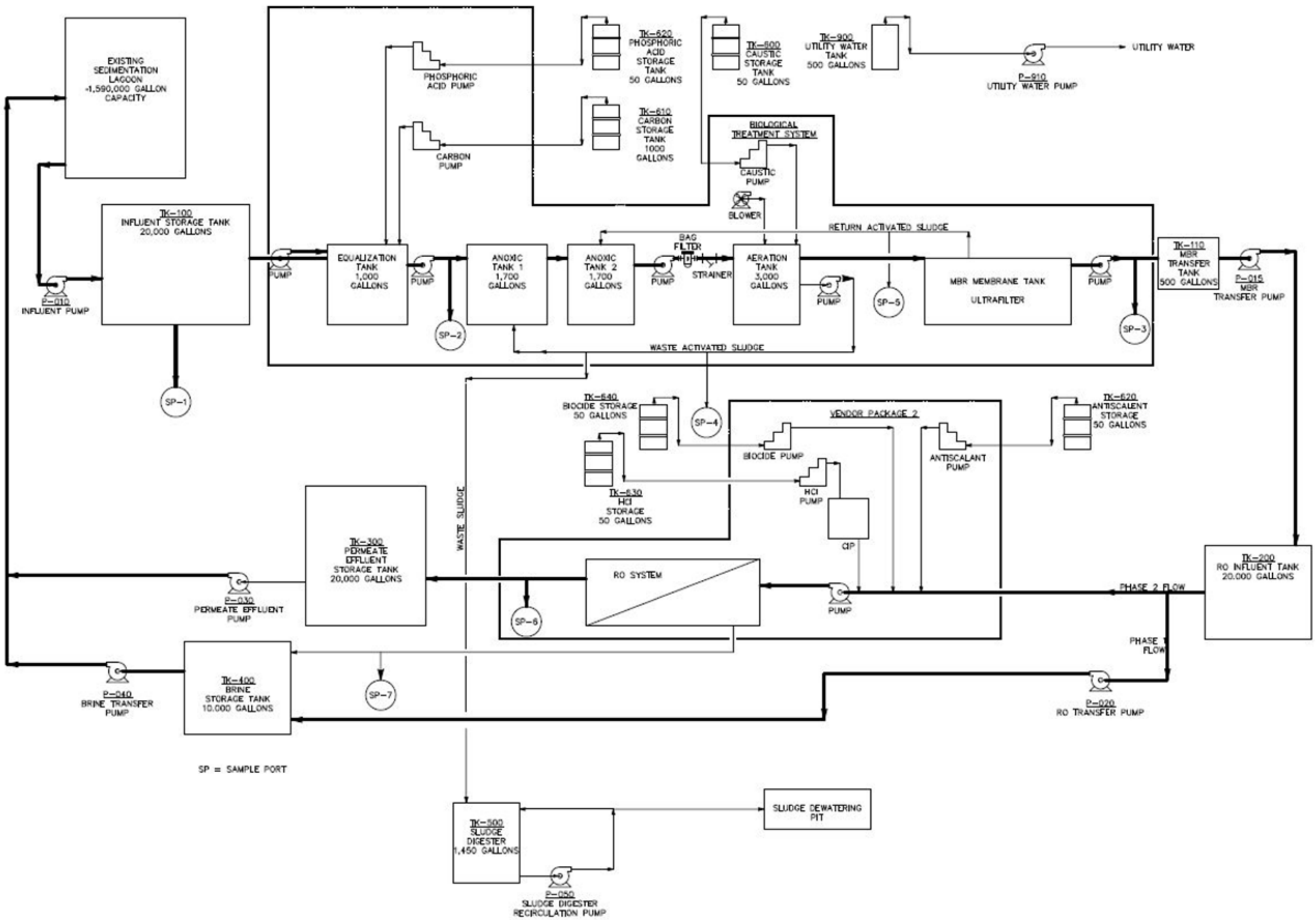
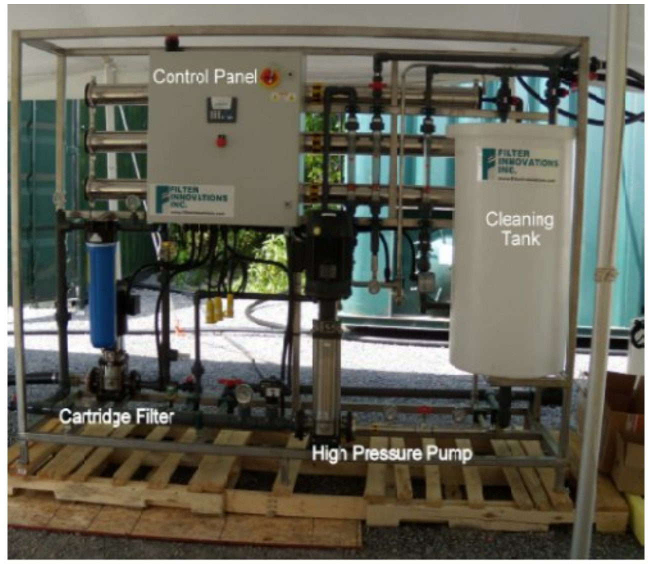


Figure 1 – Pilot Plant Schematic

Site trailers and overview



Reverse osmosis system

Water storage and main process area

Biological treatment tanks

Figure 2 – Pilot Plant Photographs

Table IV summarizes the overall performance of the pilot plant over the course of the test program. The projected effluent quality will be used to establish final discharge criteria in the WTP operating license.

Table IV – Pilot Plant Performance Results

Parameter	**Units**	**Pilot Plant Removal Efficiency**		**Influent for Concentration Upper Bound mg/L**	**Projected Effluent Concentrations**	
		Minimum % Removal	**Average % Removal**		**Minimum Removal mg/L**	**Average Removal mg/L**
Ammonia	mg/L as N	99.8	99.9	150	0.23	0.15
Arsenic	mg/L	96.9	98.5	10	0.31	0.15
Calcium	mg/L	94.2	98.6	1,000	57.65	13.80
Cadmium	mg/L	90.8	96.2	0.03	0.003	0.001
Cobalt	mg/L	99.3	99.7	0.1	0.001	0.0003
Copper	mg/L	47.4	83.4	1	0.53	0.17
Fluoride	mg/L	85.4	91.7	45	6.59	3.72
Iron	mg/L	36.5	89.2	37	23.50	4.01
Lead	mg/L	71.8	86.3	0.03	0.01	0.0041
Magnesium	mg/L	97.2	98.8	1,000	27.54	11.70
Molybdenum	mg/L	97.1	98.2	5	0.14	0.09
Nickel	mg/L	98.9	99.3	0.3	0.003	0.002
Nitrate	mg/L as N	94.8	98.3	2,000	103.41	33.08
Nitrite	mg/L as N	14.9	90.0	31	26.38	3.10
Phosphorous	mg/L	44.4	68.7	4	2.22	1.25
Potassium	mg/L	91.3	96.2	357	31.05	13.46
Ra-226	Bq/L	97.5	98.5	75	1.88	1.09
Selenium	mg/L	62.5	81.1	0.15	0.06	0.03
Uranium	mg/L	97.9	98.9	20	0.41	0.22
Vanadium	mg/L	79.5	95.9	1	0.20	0.04

DISCUSSION

Figure 3 presents the updated Process Flow Diagram for the full-scale system. Table V summarizes the primary design criteria developed from the pilot program for use in final design.

Table V – Summary of Major Design Criteria

Item	**Requirement**
Influent Flow Rate	
Construction Phase	327 m^3/day to 872 m^3/day (60 to 160 gpm), peak flows are expected to last approximately one month
LTWMF Maintenance and Monitoring Phase	27 m^3/day to 82 m^3/day (5 to 15 gpm)
Influent Water Quality	
Water Quality	See Table I
Contaminants of Concern	See Table II

Item	Requirement
Effluent Goals	
Discharge criteria	See Table IV
Equalization	
Storage of peak flows	Three weeks storage preferred
Gross suspended solids removal	Storage capacity for 6 years of influent suspended solids or routine removal. Suspended solids in the site water during construction may be variable and high depending on the construction activities and precipitation
Prefiltration	
Gross screen, mechanically self cleaning	6 to 9 mm
Fine screen, mechanically self cleaning	1 to 2 mm
MBR	
Type	SND MLE MBR
Membrane	Flat plate cartridge, 0.04 micron, external to aeration tank
SRT (based on pilot conditions)	Aerobic – 13 days, Total system – 23 days
HRT (based on pilot conditions)	Anoxic – 16.3 hrs, Aerobic – 15.5 hrs
Reverse Osmosis	
Recovery (based on pilot conditions)	75 percent (82 percent was achieved in limited pilot operations),
Chemical Addition	Ability to add acid to reduce pH and control scale, antiscalent, and biocide
Cleaning Skid	Complete with ability to clean at high or low pH and elevated temperatures (50ºC)
Brine Management	
Reaction Tank/Mixer, Lime Feed System, Iron Feed, Soda Ash Feed	Ability to add lime and other chemicals as required by the brine quality to reduce metals and radionuclides in the brine.
Microfiltration System	Filtration of 0.1 micron or less
Evaporator	Capability to manage up to (15 gpm)

Equalization

Storing collected site water equalizes spikes in contaminant concentration or flow. Both water quality and flow depend on precipitation and the site activities. Water quality can change depending on the area of the site being remediated and the precipitation events occurring when particular areas are exposed. Therefore, the equalization will be an important part of the treatment process train, particularly during the construction activities.

Pre-Treatment

Due to the predicted variable influent concentrations, effective screening is essential. Dual screening, with an upstream larger opening screen, (typically 6 - 9 mm) to remove larger materials was recommended. A downstream fine screen (typically 1-2 mm) will provide operational flexibility and protection of the treatment processes from sediment in the site waters.

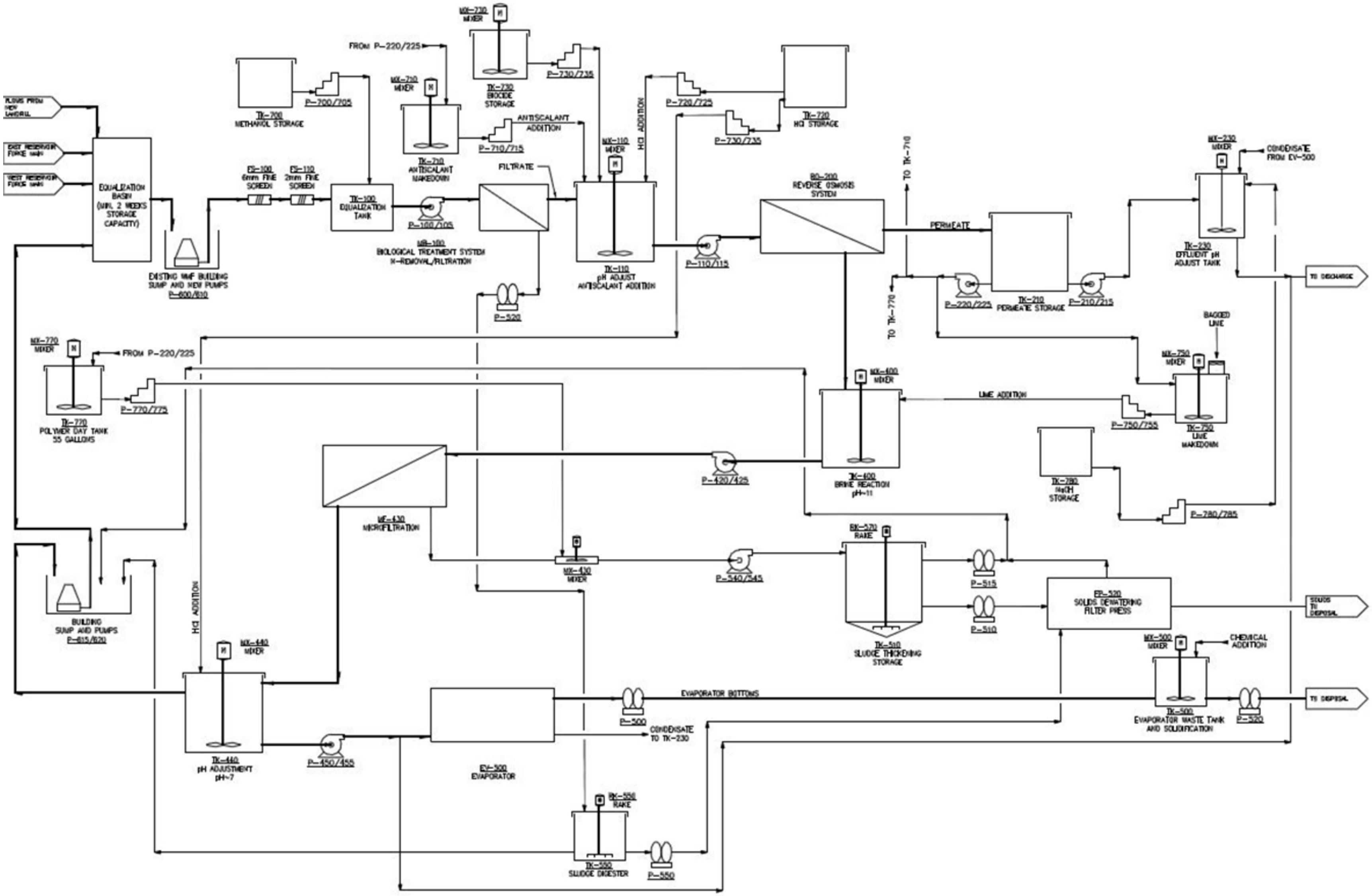


Figure 3 – Full Scale System Process Flow Diagram

Biological Treatment

Biological treatment is considered to be BAT for the treatment of nitrogen compounds such as ammonia, nitrate, and nitrite in wastewater. Several configurations of nitrification-denitrification systems are available, however, for this application a Membrane Bioreactor (MBR) has been used for full-scale design. The membrane component of an MBR is an ultrafiltration step which will provide excellent prefiltration of biological and other solids prior to the reverse osmosis step. MBR also allows operation at variable mixed liquor suspended solids (MLSS) values which provides flexibility to accommodate potential variability and range of influent water qualities.

The MBR pilot system was a variation of the MBR design and specifically was a simultaneous nitrification/denitrification (SND) modified Ludzak-Ettinger (MLE) system. This variant on the biological treatment system has further advantages for an application like the LTWMF in providing flexibility. The MLE design component allows for operations flexibility of internal recycle of the MLSS from the aeration zones which is conducive for high nitrogen removal. The SND portion addresses both the influent ammonia and nitrite by nitrification and nitrate in the denitrification portion in a single system.

Lessons learned on biological treatment during the pilot test program included the following:

- Foam was present during start-up of the system in the MBR membrane tank when operating in the semi-batch mode. A sprayer system was not installed on the pilot for control of foam and an antifoam agent was used. During continuous operations foam was observed during the first week and antifoam was used to control foaming. As the biological treatment system stabilized with regard to the acclimation of the activated sludge to the site water quality excessive foaming was not observed, however, antifoam addition was maintained to assure that foaming was not an issue during unattended operations.

- Submerged flat plate membrane modules with automatic air scouring to extend the periods between cleaning cycles and provide flexibility to treat a range of water qualities may provide an advantage for this application. As construction proceeds the TSS and other foreign material in the influent may increase and the solids handling capability of the MBR will be important.

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Reverse Osmosis

The results of the bench and pilot scale testing indicated that a one-pass reverse osmosis system is an effective treatment following the biological treatment process to obtain greater than 90 percent removal for most COPC present in the blended water. This is based on the water quality present at the site currently. The reverse osmosis system design includes the cleaning skid and provision is included to heat the reverse osmosis membrane cleaning solutions. Flexibility to add antiscalent, biocides, and pH adjustment for scale control are also provided.

The lessons learned from the pilot scale operations included the following:

- The scale formed is reversible with the appropriate cleaning cycles. For the water treated in the pilot test, both an inorganic scale and bioscale appeared to be present so a two step (low pH followed by high pH) cleaning regime was recommended.

- High recovery can be achieved on the water tested, although, the design of the full-scale system must provide the flexibility to treat water at higher influent TDS than that treated in the pilot-scale system.

- Higher than typical membrane replacement costs should be included in the project budget as frequent cleaning may be required. For the relatively short-term of the construction phase, membrane replacement may be less expensive and more convenient than pretreatment and softening upstream of the reverse osmosis system.

Permeate Polishing

The preliminary full-scale water treatment system design included an optional polishing step for the reverse osmosis permeate using an ion exchange system for specific removal of nitrate and other anions and a sorption column (zeolite) or cation exchange resin to remove ammonia and other cations. Permeate polishing was included at the completion of bench testing because the efficiency of biological treatment on the Port Granby water matrix was unknown at that time. Based on the pilot-scale system operating results the polishing processes has been eliminated from the Process Flow Diagram as the ammonia, nitrate and nitrite removal exceeded the projections used for the bench-scale evaluations.

The permeate also may require pH adjustment prior to final discharge depending on the final effluent limits. Provision has been included for final pH adjustment.

Brine Treatment by Chemical Precipitation

Brine treatment includes a combination of gross metals removal by chemical precipitation clarification, and dewatering. Chemical precipitation will be used to decrease the concentrations of uranium, radium, scaling compounds, and metals present in the reverse osmosis brine. Bench-scale treatability tests conducted on the reverse osmosis brine from the pilot tests indicated that increasing the pH to approximately 11, coupled with solids separation, provided significant reduction in concentrations of scaling compounds, target metals and radionuclides.

Evaporator

An evaporator is included to treat a slip stream of the precipitated brine to control salt content in the system. The majority of the chemically treated brine can be returned to the Equalization Pond, however, a slip stream must be removed to prevent salt build-up in the system. Manufacturer’s models will be used to design the evaporator. Based on the bench-scale treatability and pilot study testing an evaporator sized to treat 10 to 15 gpm of brine would allow control of salt content in the system during the construction phase.

Biological Sludge

Biological sludge will be managed by mechanical sludge dewatering. Pilot results indicate good dewatering of the biosolids without digestion, however, a sludge digestion system could be used to reduce the quantity of biological solids. The pilot testing was conducted on water with ammonia levels at the upper end of the projected influent range and nitrate at the lower end of the projected influent range. However, the projected nitrate levels are much higher than the ammonia levels. A digestion step may be warranted to reduce sludge levels if the influent water is consistently at the higher end of the nitrate levels and larger volumes of sludge are produced.

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