Memorandum

Project Name: Resolute Bay WWTF Project #: FRE-00255934-A0 /File No: 62

Date: April 23, 2020

Subject: Resolute Bay Wastewater Treatment Pre-Design Report (Rev 2)

Prepared By: Daryl Burke

Background

The Hamlet of Resolute Bay is located on Cornwallis Island at N74°42' and W94°52'. Resolute Bay has a reported population of approximately 200 as of the 2016 census data. The climate is especially challenging in this community. Average annual temperature is -16.7°C and average annual wind speed is 21 km/hour. The lowest temperature recorded at this site is -52.2°C and the highest recorded hourly wind speed is 142 km/hr. A wind chill temperature as low as -72°C has been observed. The extremely low temperatures are combined with a protracted period of darkness during the winter. The sun does not rise above the horizon between early November and early February. The combination of temperature, high wind and lack of daylight create challenging operating conditions for much of the year.

The Hamlet of Resolute Bay is made up of two development areas: the town site and the airport area. In the late 1970's, the majority of the permanent population of the community were relocated to the current town site area. The town site area was developed with piped water distribution and sewage collection networks. The needs of the Airport area is currently met using a truck service delivery system. There is no current intention to modify this servicing scheme for the airport area. Wastewater will continue to be trucked from the airport but it will be deposited into a manhole upstream of the new treatment plant. The intent is for the existing airport lagoon to be decommissioned. The exact location, elevation, and design of the truck discharge point will be confirmed during detailed design.

While Resolute Bay has been served by a piped water and sewer system since the late 1970's, wastewater treatment has been non-existent, and wastewater from the piped system flows through a macerator unit. The Hamlet requires a wastewater treatment facility that can service the future permanent population as well as seasonal temporary population. The Hamlet requires a system that is simple to operate while being reliable and compact.

Design Flows

Design flows were previously developed by EXP as part of a pre-design study completed in 2012. Population in the Hamlet at that time was approximately 250. The current population is approximately 200 representing a 20% decline in population. However, for the purpose of this updated pre-design report, it is recommended to maintain the design population that was previously used even though there has been a slight decline in recent years. The recommended design population from the 2012 design was 365 people for the Town Site and up to 400 people for the airport site including residents, Polar Continental Shelf, DND, and a New Hotel.

Calculated design flows for the plant are summarized as follows:

- Average Daily Flow (ADF): 4.7 L/s
- Maximum Daily Flow (MDF): 7.6 L/s
- Peak Hourly Flow (PHF): 8.9 L/s

The design flow estimates noted above were calculated based on the following design values:

1. Residential water consumption = 140 L/cap·d for the airport area
2. Residential water consumption = 225 L/cap·d for the town site
3. Design bleed flow allowance = 3.0 L/s (total for Town Site at design population)
4. Maximum day factor = 2.75[1]
5. Peak hourly factor = 4.04[2]

A summary of the flow calculations for design is summarized in Table 1.

EXP reviewed available flow data from the 2017-2019. Annual water volumes were reported as follows as measured at the Char Lake Pump Station:

- 2017: Total Annual Volume = 127,670 m^3 (average flow = 4.05 L/s)
- 2018: Total Annual Volume = 152,062 m^3 (average flow = 4.82 L/s)
- 2019: Total Annual Volume = 191,255 m^3 (average flow = 6.07 L/s)

The data reported does appear to show that current average flow rates may already be at or in excess of the calculated flow for design. There was also a noticeable increase of 26% from 2018 to 2019 which cannot be explained by a corresponding population increase or other obvious change in the community. In discussions with the GN and the Hamlet, the accuracy of the flow meter at the Char Lake Pump Station has been suspect. Prior to 2017, there were also leaks within the water collection and distribution system that inflated the total water usage values. It is the recommendation of EXP that the flowmeter be replaced and properly calibrated so as to provide a higher degree of confidence in the measured values. We are also aware of a flume that is installed at the existing wastewater treatment macerator building. It is the recommendation of EXP that the size and details of this flume be confirmed which could allow for installation of an ultrasonic transmitter to measure wastewater

[1] *Design Guidelines for Drinking Water Systems,* Ontario
[2] Calculated using the Harmon Formula, refer to Table 1 for additional details.

flow. Both of the these initiatives would provide better flow data for comparison to calculated design values. Until this work is completed, the current calculated design flow rates have been used for conceptual design as shown in Table 1.

Table 1: Summary of Design Flow Calculations

Line No.	Description	Town Site	Airport	Total (Town + Airport)	Comment/Calculation
(a)	Design Population	365	400	765	Population estimate for design from 2019 draft memo.
(b)	Average Unit Water Consumption (L/cap·d)	225 (1)	140 (2)		Per capita water usage value from published guidelines for Town Site and previous water usage data for Airport Site.
(c)	Average Day Residential Water Consumption (L/s)	0.95	0.65	1.6	Calculation: (a) x (b)
(d)	Total Water Consumption Factor	1.08	1		Calculation: 1.0 + (0.00023 x Pop.) for Town Site
(e)	Average Day Water Consumption (L/s)	1.03	0.65	1.7	Calculation: (c) x (d)
(f)	Peak Day Factor	2.75 (3)	2.75 (3)		
(g)	Peak Day Water Consumption (L/s)	2.83	1.78	4.6	Calculation: (f) x (e)
(h)	Peak Hour Factor	4.04	2.75		Harmon Formula applied for Town Site: M = 1 + 14 / (4 + P^0.5) Where P = population in 1000's
(i)	Peak Hourly Water Consumption (L/s)	4.16	1.78	5.9	Calculation: (h) x (e)
(j)	Bleed Water Flow (L/s)			3.0	Bleed water flow for design referenced in report.
(k)	Average Day Sewage Flow (L/s)			**4.7**	Calculation: (j) + (e)
(l)	Peak Day Sewage Flow (L/s)			**7.6**	Calculation: (j) + (g)
(m)	Peak Hourly Sewage Flow (L/s)			**8.9**	Calculation: (J) + (i)
(n)	Annual Average Water Consumption Without Bleed Water (m^3/year)	32,492	20,440	52,932	Calculation: [(e) x 86,400 s/d x 365 d/year] / 1000 L/m^3
(o)	Annual Average Sewage Flow Including Bleed Water (m^3/year)			147,540	Calculation: [(k) x 86,400 s/d x 365 d/year] / 1000 L/m^3

Notes:

(1) Reference: CSA W203:19 for piped services.

(2) Per-capital water use for airport area based on previous site-specific estimates by EXP (2012).

(3) Reference: Design Guidelines for Drinking Water Systems, Ontario

Wastewater Characteristics for Design and Effluent Limits

The wastewater characteristics for design of the wastewater treatment facility were developed as part of the pre-design study completed in 2012[3]. In summary, the design characteristics on a concentration basis are significantly higher than current wastewater test results indicate. While there are no current plans by the GN or Hamlet to reduce bleed water flow, the design influent concentrations conservatively take into account any possible future initiatives to reduce bleed water flow into the collection system which would significantly increase the wastewater concentrations. The wastewater characteristics that have been developed for design are presented in the following table along with current effluent discharge limits where applicable.

The current effluent limits have been provided as 80 mg/L for $cBOD_5$ and TSS which are based on the current operating permit for the Hamlet. However, there are initiatives underway by the regulatory agencies to better define the discharge objectives for the Far North which may become part of the National Wastewater Systems Effluent Regulations (at the time of this report, Nunavut was excluded from these regulations). Through consultation with the GN on this project, it was felt that a design effluent discharge objective of 25 mg/L for both $cBOD_5$ and TSS should be used for preliminary treatment plant sizing and selection.

Recommended Influent Wastewater Characteristics for Design

Parameter	Unit	Influent	Effluent Limits[4]	Effluent Design Objective
Carbonaceous BOD_5 Concentration	mg/L	110	80	25
Total Suspended Solids (TSS)	mg/L	125	70	25
Chemical Oxygen Demand (COD)	mg/L	250		
Ammonia-N (NH_3-N)	mg/L	12		
Total Kjeldahl Nitrogen (TKN)	mg/L	20		
Total Phosphorous (TP)	mg/L	4		

Wastewater Treatment Design Considerations

Similar to the previous pre-design report from 2012, EXP recommends a packaged mechanical treatment system for the Hamlet. The previous recommendation for a membrane bioreactor treatment system proved to be cost prohibitive and would have generated a higher quality of effluent than what is required by the effluent discharge limits. While a mechanical system is still recommended, EXP

[3] *Wastewater Treatment Plant – Design Brief,* EXP Services Inc., 2012
[4] *Guidelines for Treated Municipal Wastewater in the Northwest Territories*

believes there are options that would better balance treatment performance with realistic capital costs for the Hamlet.

The revised recommendation is to proceed with a containerized, packaged mechanical treatment system. Numerous technologies and vendors are available that can supply such a system. The advantage is that all or most of the required biological treatment process is pre-built and usually constructed in pods or modules of uniform size, dimension, and capacity. Multiple units can be stacked together in parallel as needed to meet the overall plant capacity. These types of systems are easy to install, relatively cost effective, and would be easy to ship to the site due to their containerized and modular nature. An example would be the BMS Blivet packaged sewage treatment system. The system is a complete packaged treatment plant based on a similar technology to a conventional rotating biological contactor (RBC) treatment process. Large rotating disks are used to mix and aerate the mixed liquor as well as providing a medium for biofilm growth. Inlet and outlet settling zones are included within the containerized process to remove suspended solids.

To illustrate the general design principle, EXP has completed a conceptual design based on the BMS packaged treatment technology. A conceptual Process Flow Diagram has been included in the appendices to this report. For the BMS Blivet, the key sizing criteria to consider are the BOD loading and average day design flow. For conceptual sizing, EXP referred to published sizing data for the various Blivet standard models which has been included in Appendix A of this report. Due to the relatively low strength of the wastewater in this case, the average day flow was the key parameter for sizing of the Blivet units. As can be seen in Appendix A, the largest Blivet model BL4000 can handle up to an average day flow (i.e. dry weather) of 92,000 L/day (1.06 L/s). In order to handle the projected design average day flow of 4.7 L/s, it would require a total of five (5) BL4000 units in parallel. For simplicity of design, an equalization tank has not been included in the design. The Blivet supplier has confirmed that the selection of five units would be able to readily accept the peak hourly design flow of 8.9 L/s without equalization. While the peak day flow did not factor specifically into the design selection for the Blivet, it has been provided for information and could potentially impact on other treatment technology selections during final detailed design.

The proposed BMS Blivet packaged treatment system is modular in nature which also helps to simplify installation of the units on site. The total dry weight of one of the modules is 6800 kg (15,000 lb.) including all components. Major internal components can be installed separately on site from the tank portion of the module to further reduce lifting loads for final placement. It is anticipated that a crane or excavator that would already be on site for other portions of the construction could be used to set the units in place. It is also anticipated that other manufacturers of packaged treatment processes would be of a similar nature in this regard.

EXP would recommend the inclusion of a headworks system upstream of the containerized system. A coarse screen system would be recommended to ensure larger solids in the system are captured for disposal prior to entering the packaged treatment plant. Downstream of the main treatment process, the final effluent will pass through an ultraviolet (UV) disinfection system prior to being discharged to the environment. It is also anticipated that an influent pump station will be required to pump the influent wastewater into the treatment plant. All subsequent flow through the system would be achieved by gravity including flow through the UV system and final outfall.

Due to the continuous growth of the active biomass in the system, waste sludge will be periodically removed from the main process. A waste sludge storage tank will be used to retain the waste sludge prior to dewatering. Dewatering is required to reduce the overall volume of waste sludge sent for disposal. As was recommended in the 2012 design brief, EXP recommends the use GeoTube® filter bags to passively dewater the waste sludge. The GeoTube® will be housed in trailer in an enclosed room of the treatment plant. The water draining from the GeoTube® (identified as filtrate) would be directed from the trailer to the raw wastewater sump and pumped back through the treatment process. The sludge would collect in the GeoTube® until such time as it is full, then the trailer would be removed from the plant, hauled to the landfill site, emptied of the GeoTube® and returned to have a new GeoTube® installed.

Instrumentation and Control

A Programmable Logic Controller (PLC) will be required for automatic operation of the facility. The main PLC would be provided with the packaged treatment plant with a separate PLC provided to control the influent pump station, grinder/macerator units, and sludge dewatering system. The PLC's will control functions as well as monitor online instrumentation. Each PLC will have a local operator interface to allow local control and monitoring. All PLC's will be connected to a plant-wide SCADA system to allow for central monitoring and control from a Windows based computer in the main office/control room.

The following is a preliminary list of functions that the wastewater treatment PLC/SCADA will control:

- Flow measurement (inlet of plant, plant effluent and waste sludge);
- Operation of the raw wastewater pumps and grinder/macerator units;
- Monitoring the packaged treatment system for status/alarms;
- Various "FAULT" and "STATUS" indications for auxiliary equipment:
    - Pumps (Circulation and Chemical Feed)
    - Diesel Generator
    - Boilers
    - HVAC

Building Design

All treatment processes including the influent pump station, grinder/macerator units, packaged treatment plant, UV disinfection, and sludge storage and dewatering will be contained within a single building space. Additional building spaces are recommended for the following supporting functional spaces:

- Laboratory
- Office/control room
- Electrical/MCC room

- Mechanical/Boiler Room
- Washroom
- Maintenance/storage room

A conceptual building layout plan has been included in the appendices of this report.

The building foundation design will be carried out in accordance with the geotechnical report recommendations. It is anticipated that the foundation will be a cast-in-place concrete mat with rigid insulation, granular base and thermosyphon system.

The building structure will be a steel pre-engineered building system which is well suited and commonly used in the north. The framing will consist of steel rigid frames spanning the narrow dimension of the building which will support cold formed roof purlins, liner, insulation and metal roofing. The wall structure will consist of horizontal cold formed girts, liner, insulation and exterior metal cladding.

Recommendations

The main recommendation from this conceptual design study is to take steps to improve the accuracy of measured flow data. EXP recommends the replacement of the flow meter at the Char Lake Pump Station and the installation of an ultrasonic transmitter capable of measuring flow in the existing flume at the wastewater macerator building. With more reliable flow data available, this could be reviewed against the calculated design values and adjustments to the design flows could be made if necessary.

Submitted by:

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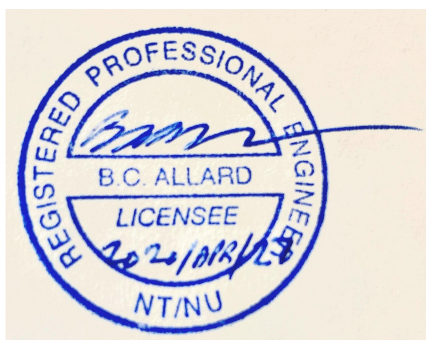
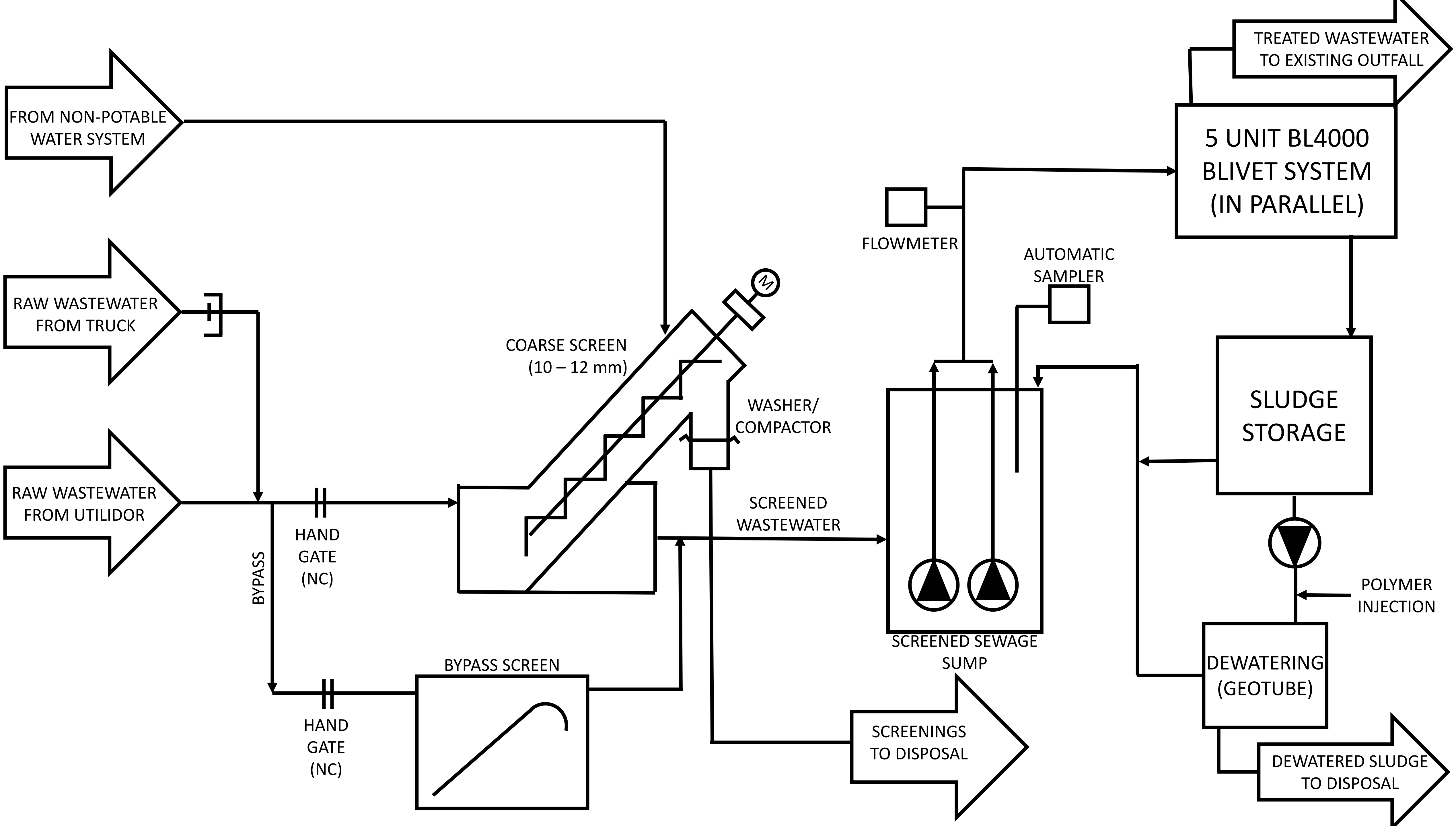
EXP Services Inc.

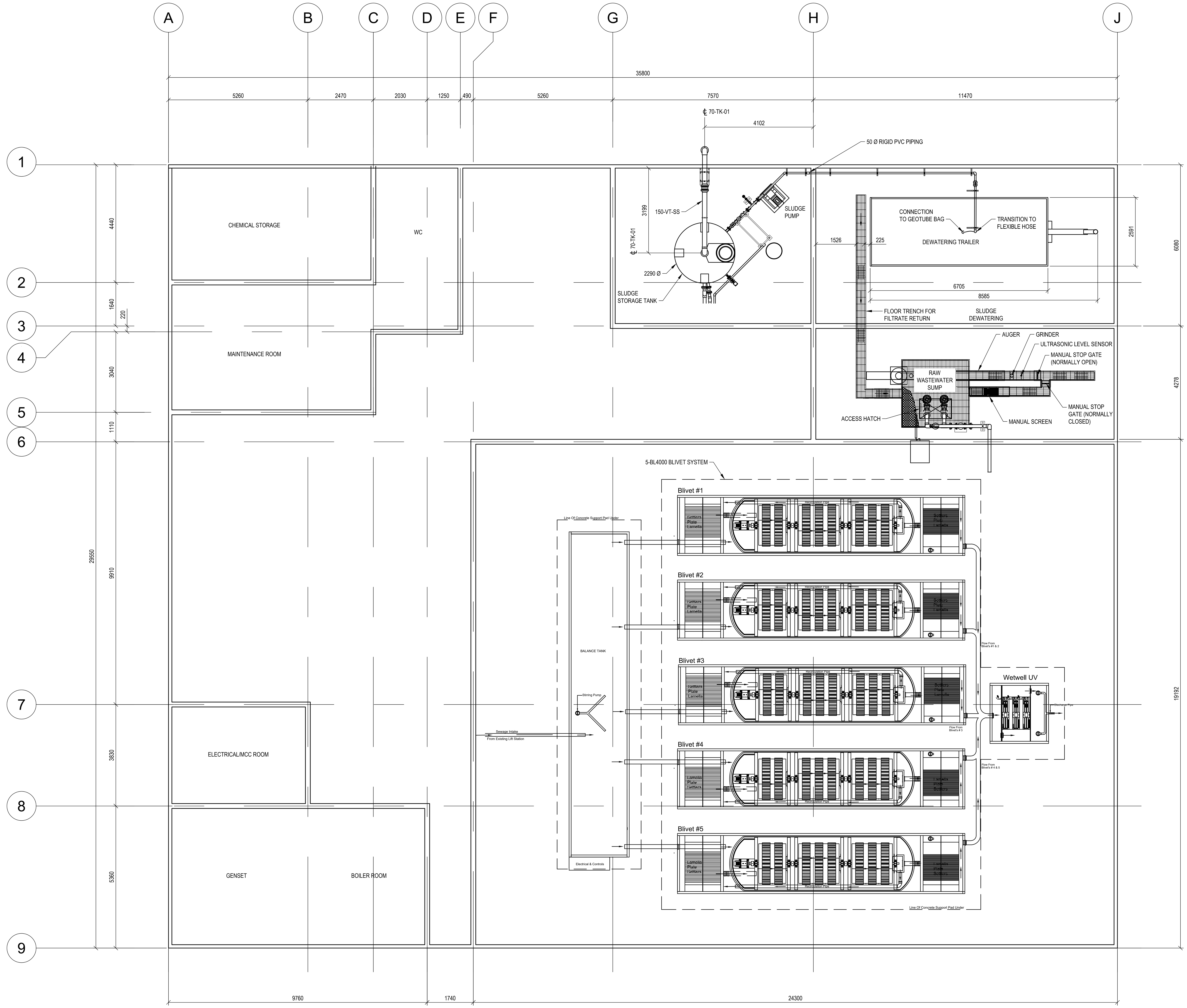


Appendix A – Conceptual Process Flow Diagram



FROM NON-POTABLE WATER SYSTEM
RAW WASTEWATER FROM TRUCK
RAW WASTEWATER FROM UTILIDOR
BYPASS
HAND GATE (NC)
HAND GATE (NC)
BYPASS SCREEN
COARSE SCREEN (10 – 12 mm)
M
WASHER/ COMPACTOR
SCREENED WASTEWATER
SCREENINGS TO DISPOSAL
FLOWMETER
AUTOMATIC SAMPLER
SCREENED SEWAGE SUMP
5 UNIT BL4000 BLIVET SYSTEM (IN PARALLEL)
TREATED WASTEWATER TO EXISTING OUTFALL
SLUDGE STORAGE
POLYMER INJECTION
DEWATERING (GEOTUBE)
DEWATERED SLUDGE TO DISPOSAL

Appendix B – Conceptual Wastewater Equipment Plan



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No.	Issue	Date

No.	Revision	Date

PRELIMINARY

Professional Seal(s)

REGISTERED PROFESSIONAL ENGINEER
B.C. ALLARD
LICENSEE
NT/NU

Drawn By:	ARL
Dwg Standards Ckd By:	
Designed By:	MF
Design Checked By:	
Scale:	1:75

Project Title

RESOLUTE BAY WASTEWATER TREATMENT CONCEPT

Dwg. Title

PIPING AND EQUIPMENT PLAN

Project No. FRE-00255934-A0

Dwg. No. **SK-1**

Rev. No. ----

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AL LAWRENCE

Appendix C – BMS Blivet Data Sheet

B M S ***(North America) Ltd.*** *P.O. Box 915, Mount Pearl, NL A1N 3C8*
Phone: (709) 747-1444 Fax: (709) 747-1430 E-mail: info@bmsna.com Web: www.bmsna.com

February 2010

BMS Blivet™ - Specifications

Blivet™	PE[1] Nominal	Houses Served[2]	BOD/Day (Average)	Flow/Day (Dry Weather)	Size Imp. (m)	Weight Empty	Motor Size
BL500	50	12	2.75kg	11,500 liters (2,530 gal.) 0.133 l/sec	16'-1" (4.9m) L 7'-5" (2.3m) W	3 Tonne 3.3 ton 6,600 lbs	1ph. 0.37kw 3ph. 0.37kw (½hp)
BL1000	100	25	5.50kg	23,000 liters (5,059 gal.) 0.266 l/sec	17'-8" (5.4m) L 7'-5" (2.3m) W	3.35 Tonne 3.7 ton 7,400 lbs	1ph. 0.37kw 3ph. 0.37kw (½hp)
BL1500	150	37	8.25kg	34,500 liters (7,588 gal.) 0.400 l/sec	21'-0" (6.4m) L 7'-5" (2.3m) W	4 Tonne 4.4 ton 8,800 lbs	1ph. 0.37kw 3ph. 0.55kw (½ & ¾hp)
BL2000	200	50	11.00kg	46,000 liters (10,118 gal.) 0.532 l/sec	24'-8" (7.5m) L 7'-5" (2.3m) W	4.7 Tonne 5.2 ton 10,400 lbs	1ph. 0.55kw 3ph. 0.55kw (¾hp)
BL3000	250	62	13.75kg	57,500 liters (12,648 gal.) 0.666 l/sec	30'-6" (9.3m) L 7'-5" (2.3m) W	5.85 Tonne 6.45 ton 12,900 lbs	1ph. 0.75kw 3ph. 0.75kw (¾hp)
BL3500	325	81	17.87kg	74,750 liters (16,442 gal.) 0.865 l/sec	33'-1" 10m) L 7'-5" (2.3m) W	6.3 Tonne 6.95 ton 13,900 lbs	1ph. 0.75kw 3ph. 0.75kw (1 hp)
BL4000	400	100	22.00kg	92,000 liters (20,237 gal.) 1.065 l/sec	35'-9"(10.9m) L 7'-5" (2.3m) W	6.8 Tonne 7.5 ton 15,000 lbs	1ph. 1.1kw 3ph. 1.1kw (1½hp)

[1]PE - Population Equivalent. For quick reference one (1) PE approximates one (1) person. Note, the selection of unit(s) may vary for the final effluent quality required. Nominal PE number shown is to produce final effluent quality of 20mg/litre BOD and 30mg/litre TSS, from influent raw sewage of 250mg/litre BOD and 300mg/litre TSS.

[2]Houses Served - based on an average of four (4) persons per house.

Notes:

A. As the costs of sewage treatment is site specific, BMS would require information of the area served to provide a quote.
B. Units may be placed in multiples (parallel arrangement using a distribution chamber) for larger populations.
C. Terms of Purchase: Standard conditions are 50% down payment with order to commence manufacture, 40% when unit ready for shipment and final payment when unit is operational or within one month.
D. Discounts for units purchased in any 3-month period are: 2 units less 5%; 3-5 units less 7%; and over 5 units less 10%.

Due to a policy of continuous research and development, specifications are subject to change without prior notice.

BMS Blivet™ - *Innovation for an Unspoiled Environment*