SECTION 4.0

SECTION 4.0
EXPANDED INDUSTRIAL WASTE WATER TREATMENT FACILITY

4.1 DESCRIPTION OF EXISTING IWWTF

The effluent from the pretreatment plant is the influent to the existing Industrial Waste Water Treatment Facility (IWWTF); and, the influent quality will be the same going to the improved IWWTF. Table 4.1 illustrates the pretreatment system design effluent parameters.

Table 4.1 Wastewater Pre-treatment Effluent/ Waste Water Treatment Influent Design Parameters

Parameter	Maximum Week	Concentration
Flow	31,200 m^3/wk	-
COD	103,740 kg/wk	3325 mg/l
CBOD5	59,280 kg/wk	1900 mg/l
Total Suspended Solids (TSS)	39,312 kg/wk	1260 mg/l
Total Kjeldahl Nitrogen (TKN)	6,145 kg/wk	197 mg/l
Phosphorous (P)	1,000 kg/wk	32 mg/l
Oil and Grease (O&G)	5,865 kg/wk	188 mg/l

The existing biological treatment facilities consist of a number of stages described below and illustrated in Figure 4.1. The three stages of this facility consist of a covered anaerobic lagoon; an activated sludge system and an effluent disinfection system including a sampling, metering and discharge facility. Each of these stages and their components are described briefly below.

4.1.1 Covered Anaerobic Lagoon

Pretreated process waste water from the Maple Leaf Pork plant is metered with a magnetic flow meter and sampled with a refrigerated flow-composite sampler just before entering the anaerobic lagoon. The flow is split into four anaerobic influent lines. Sanitary sewage is also pumped into the anaerobic lagoon. Additionally, there is a line with a valve from the influent to the anaerobic bypass pump station wet pit. Anaerobic influent design parameters for the slaughter of 54,000 hogs per week during a single-shift kill, six days per week were defined in Table 4.1 previously.

The anaerobic lagoon is lined with a double HDPE liner including a leak detection/collection system. The lagoon is also equipped with an insulated HDPE cover to minimize heat loss and retain biogas under the cover for collection and use. Biogas can be withdrawn by one of four biogas blowers to be flared or used in a dedicated biogas hot water heater at the packing plant to generate hot water. The biogas contains an estimated amount of 75% methane and small concentrations of hydrogen sulfide.

Waste water flow can be pumped around the anaerobic lagoon through a bypass pump station. Flow from the anaerobic influent piping or from two lines from the southeast corner of the anaerobic lagoon can be directed into the wet pit for this pump station. A magnetic flow meter is available in an adjoining pit to meter bypass flow. A portion of the flow is normally bypassed around the lagoon (approximately 2000 m^3/day) as a carbon source for denitrification further along in the process.

The anaerobic bypass flow combines with two effluent lines from the anaerobic lagoon. Simple provisions are available to throttle the flow rate out of the lagoon in an effort to equalize the flow over a seven-day week (since the Maple Leaf Pork plant normally operates on a five- or six-day week). As such, the maximum volume with 0.5 m (1.64 ft) of freeboard is 9,973.6 m^3 (10,560,867 U.S. gallons) and the minimum volume is 30,409.0 m^3 (8,033,265 U.S. gallons). This results in the difference of 9,567.6 m^3 available for flow equalization. A separate high water overflow line to the subsequent anoxic basin is included in case the water level becomes too high in the anaerobic lagoon.

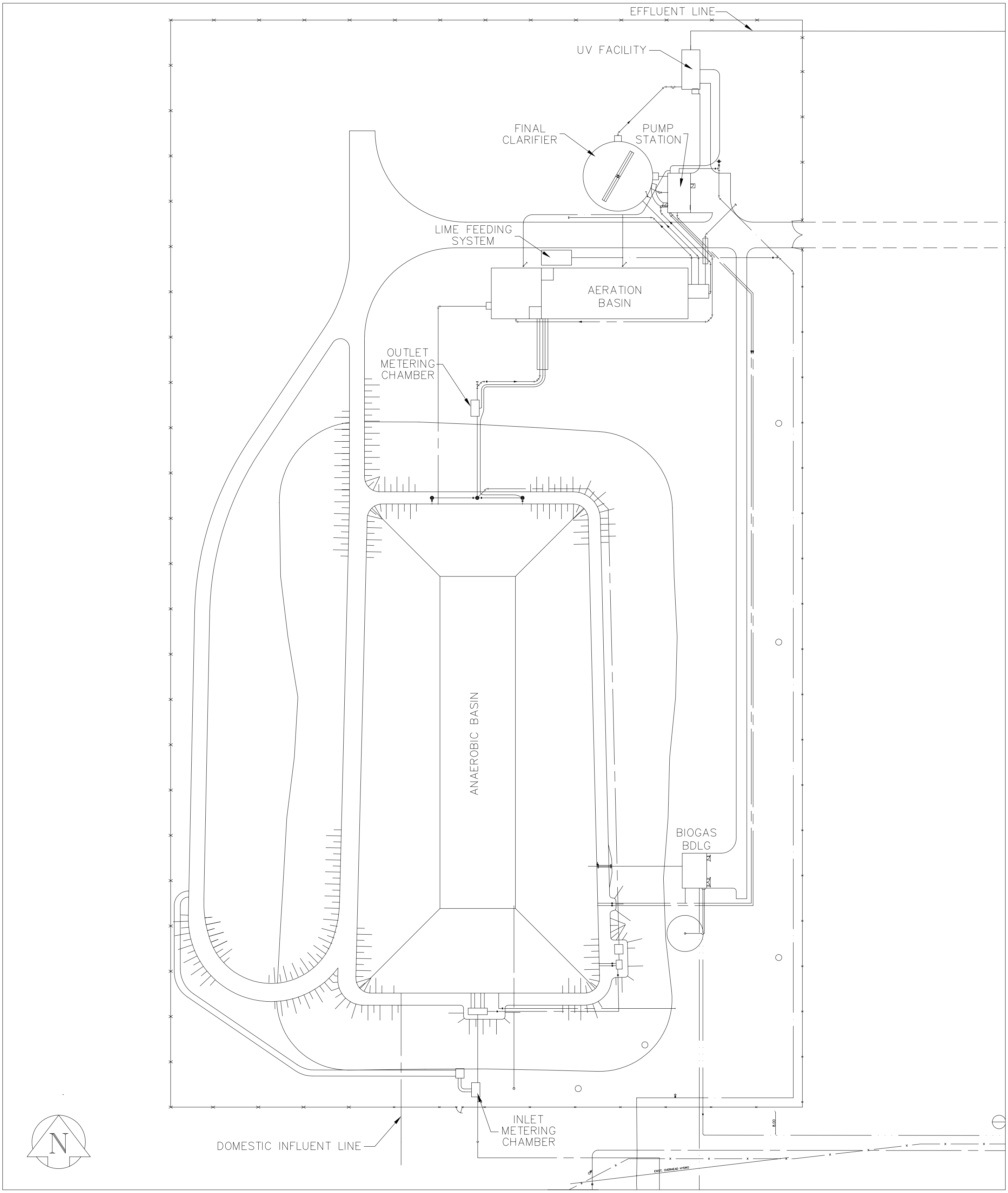
Waste activated sludge (WAS) and scum from the final clarifier are also pumped through separate lines into the anaerobic lagoon for settling, digestion; and, thickening. The anaerobic lagoon is equipped with five 250 mm (10 in) sludge draw-off lines so sludge can periodically be removed from the lagoon and land applied at agronomic rates. The solids content of this sludge has varied from 2.5 to 4 percent when sludge has been removed in the past.

4.1.2 Activated Sludge System

Effluent from the anaerobic lagoon flows by gravity to a subsequent activated sludge system designed to nitrify and denitrify. The activated sludge system consists of a combination anoxic/aeration basin, a final clarifier and sludge and scum pumping facilities.

4.1.2.1 Anoxic Basin

Anaerobically-treated wastes enter the initial anoxic zone of the concrete anoxic/aeration basin. The anoxic cell holds approximately 1152 m^3 (304,360 U.S. gallons) at a water depth of 4.5 m (14.76 ft) and is divided into two halves. Each half is equipped with a 7.5-hp submersible mixer. This basin is intended to recover alkalinity and reuse oxygen while treating BOD. To enhance the recovery by providing more BOD for nitrification, flow can be bypassed around the anaerobic lagoon, as discussed previously. Nitrates are returned to this basin with the Return Activated Sludge (RAS) and by pumping mixed liquor from the end of the subsequent aeration basin back to the inlet end of the anoxic basin with a 420 lps



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General Arrangement of The Existing
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(6660 gpm), 6-hp submersible pump. Dissolved oxygen in the anoxic basin is typically around 0.2 mg/l.

Monthly total nitrogen reductions across the entire treatment system, due to both denitrification and nitrogen uptake in the waste sludge, have been as high as nearly 60 percent and as low as 5.5 percent. Despite alkalinity recovery through denitrification however, alkalinity is still occasionally added to the subsequent aeration basin, although the amount is rather variable. This alkalinity is supplied in the form of unslaked lime stored in a lime silo. This lime silo is equipped with a slaker to hydrate the lime before it is added as slurry.

4.1.2.2 Aeration Basin

After anoxic treatment, the waste water enters the aerated portion of the anoxic/aeration basin for nitrification of the ammonia and further BOD reduction. This aerated cell holds approximately 3456 m^3 (912,979 U.S. gallons) at a water depth of 4.5 m (14.76 feet) and is equipped with three dual-speed 113/150 hp, low-speed surface aerators that promote aeration; and, mixing. Typically, only two aerators are operated. Dissolved oxygen is typically around 4.5 to 5.0 mg/l near the influent end and 2.0 mg/l near the effluent end of this basin. In addition to changing the speed of the aerators, oxygen transfer can be varied by adjusting the submergence of the propellers. From this basin, the mixed liquor enters an adjoining splitter structure that is designed to potentially split the flow between three final clarifiers.

4.1.2.3 Final Clarifier

Currently, mixed liquor enters a single 22.5-m (73.8-foot) diameter final clarifier with inboard launder. This 4.5 m (14.76-foot) deep clarifier is equipped with a Westech double-center well, full-sweep skimmer and sludge scraper mechanism for settled sludge removal. The sludge blanket depth is continuously monitored by a Drexelbrook sludge blanket sensor.

4.1.2.4 Sludge and Scum Handling

Settled sludge is pumped from the clarifier sludge hopper and returned to the anoxic cell with one or two Ingersoll Dresser horizontal centrifugal pumps. This RAS flow is metered with a magnetic flow meter.

Sludge can be wasted from the activated sludge system by either pumping waste activated sludge (WAS) from the final clarifier sludge hopper or by pumping mixed liquor from the influent side of the clarifier splitter structure with one or two Ingersoll Dresser horizontal centrifugal pumps. In either case, this flow is metered with a magnetic flow meter and then pumped back to the southeast corner of the anaerobic lagoon.

From the clarifier skimmings hopper, the scum is deposited into a small concrete scum hopper adjoining the final clarifier wall. Scum is pumped from this hopper with one of two Wemco

Hidrostall pumps back to the southeast corner of the anaerobic lagoon through a forcemain separate from the sludge wasting line.

4.1.3 Effluent Disinfection, Sampling, Metering; and, Discharge Facilities

Before discharge the final effluent is metered and then disinfected with a Trojan 3000 ultra-violet (UV) disinfection system. UV lamps are mounted on four arms that can swing out of the channel for maintenance. A baffle was installed in the UV channel to block off a third of the channel. This baffle can be removed so two more moveable arms with UV lamps can be installed to accommodate future increases in effluent volumes, such as those created by the second shift.

After disinfection, the effluent is sampled with a refrigerated flow composite sampler and discharged through a 375 mm (14.75 in) gravity outfall to the Assiniboine River.

The typical treated effluent quality can be seen in Table 4.2.

Table 4.2 Typical Single Shift IWWTF Effluent Quality (Based on November 1, 2002 through January 30, 2003 data)

Parameter	Load	Concentration
Flow	4330 m^3/day	-
$CBOD_5$		13 mg/L (daily max)
Total Suspended Solids (TSS)		21 mg/L (daily max)
Nitrogen (N)	10,578 kg/month (average monthly maximum)	
Phosphorous (P)	1771kg/month (average monthly maximum)	
Oil and Grease (O&G)	(not measured)	-
Total Coliform	-	10 MPN/100 mL
Fecal Coliform	-	18 MPN/100 mL

It is interesting to note that the existing IWWTF became an award-winning project on March 4th, 2003, when the Association of Professional Engineers and Geoscientists of Manitoba awarded the City of Brandon and Earth Tech (Canada) Inc. an Achievement Award. The award was given for the project being on-time and on-budget, as well as meeting and exceeding the effluent standards set for the effluent quality.

4.2 EXPANDED WASTEWATER TREATMENT SYSTEM

4.2.1 Process Selection

As indicated in Section 4.1, the existing IWWTF employs a conventional biological treatment approach for the oxidation of organic contaminants contained in the waste water. Additionally, it is designed to partially remove nitrogen by first oxidizing nitrogen compounds to nitrate nitrogen, followed by biological reduction to nitrogen gas, which is released to the atmosphere as a gas.

While the discharge license granted to the City of Brandon mandates effluent quality for BOD TSS and ammonia, among other things (fecal and total coliform, overall community nitrogen loading, un-ionized nitrogen, and DO), the removal of nitrogen is necessary to preserve water quality in the river. Over the past three years, the existing IWWTF has been able to effectively reduce BOD, TSS and ammonia concentrations to within license limits. Additionally, it has demonstrated the capability to reduce the total nitrogen (TN) and total phosphorus across the treatment plant, resulting in a discharge to the river of between 8,302 and 12,057 kg TN/month and the total phosphorous to between 1266 and 2359 kg TP/month. As a basis for design of the expanded IWWTF, the primary objective of allowing no additional net increase in total nitrogen (TN) or total phosphorous (P) discharge to the river was established (Advice Document, Manitoba Conservation, June, 2002). With the Maple Leaf Pork plant desire to double production, the total mass loading to be treated will almost double.

The treatment of BOD, TSS and ammonia is relatively straightforward, while the integration of new facilities to effect very high levels of TN reduction necessitates that additional process steps be included. In the existing IWWTF, the reduction of nitrate nitrogen to nitrogen gas, a process referred to as denitrification is accomplished by recycling nitrified effluent to an anoxic treatment step. In this step, biomass utilizes oxygen bound in the nitrate for respiration and dissolved organics contained in the waste water as a food source. In the process, nitrate is biochemically reduced to nitrogen gas, which bubbles into the atmosphere as a gas. Any nitrogen contained in the flow that is not recycled to the anoxic step is discharged to the river.

Accordingly, the IWWTF expansion must not only include denitrification as presently practiced in the existing IWWTF, but also must include a post-denitrification step to remove nitrogen contained in the flow that is not recycled to the initial anoxic step. In a post-denitrification step, a separate treatment volume is provided which is mixed, but not aerated. In such an environment, some aerobic biomass will die due to the absence of oxygen. As the cells die, organics will be released into the liquid and become available as a food source for microorganisms for denitrification. With adequate food available, reduction of nitrate will occur in the post-treatment step in the same manner in which it occurs in the initial anoxic step. However, with the inclusion of a post-denitrification step, the overall removal of nitrogen from the wastewater will be greatly enhanced.

While the inclusion of both pre- and post-denitrification steps in a single treatment plant has been demonstrated in many instances, it must be acknowledged that stable plant operation will hinge on reliable and assured retention of biomass within the total system. Conventionally, biomass retention is accomplished by using clarifiers. The existing IWWTF utilizes clarifiers and has demonstrated good success. However, with the higher level of treatment that must, in future, be delivered throughout the year, the use of membranes instead of clarifiers is proposed. Membrane systems can be viewed as an absolute clarifier. As will be discussed later, a membrane system will retain all biomass within the system, unless it is intentionally wasted. Equally important, the high-quality effluent produced by the membranes offers the possibility of reusing this water in the future at the Maple Leaf Pork in selected areas where it could not come in contact with plant products.

Based on the above, the proposed design will meet the treatment objectives duplicating the proven pre-denitrification/aerobic approach currently in practice, augmented by a post-denitrification step followed by a membrane system to assure overall biomass retention.

4.2.2 Pilot Project Testing

Before finalizing any decisions regarding process selection by Maple Leaf Pork and the City of Brandon a pilot plant test was performed in the pretreatment building at the Brandon site. The pilot test set-up was provided by Zenon Environmental Inc. and included all process steps discussed above, as well as a full-scale Zenon membrane system. The goals of the pilot plant test were as follows:

- Validate the process assumptions for the expanded IWWTF design. This involved modeling full-scale treatment volumes for the various process steps, considering appropriate solids and hydraulic retention times.
- Evaluate the effluent quality in terms of BOD, COD, TSS, TN and phosphorus that can be produced on a real time basis, using actual waste water, as produced by the existing processing plant.
- Determine the steady-state design flux rate across the membrane system.
- Determine the quantity and quality of waste sludge that will be produced under the expanded plant conditions.
- Assess the overall system stability in treating actual waste water with naturally occurring variations in strength, volume and other characteristics.
- Develop the basis for a definitive performance guarantee.

The pilot test was performed over a three-month period beginning in late 2002. A schematic diagram of the pilot plant layout is illustrated in Figure 4.2. The treatment volumes used for the various process steps were at a similar scale as those proposed for the IWWTF expansion. As such, in terms of volumetric loading for organics and nitrogen, the pilot project validated the system design. Throughout the test period, the BOD in the final effluent was consistently below the detectable limit of 4 mg/l (City discharge limit is 30 mg/l). The permeate, or final effluent, did not contain TSS, as the pore size in the membrane elements is much smaller than the pore size in the filter paper used to test for TSS. Most importantly, the TN in the treated effluent was consistently below 10 mg/l.

The pilot test also evaluated the effectiveness of chemical addition to precipitate phosphorus. With the objective being to demonstrate the ability to reduce effluent phosphorus concentrations to less than 1.0 mg/l, ferric chloride was added to the pilot system. Once the ferric chloride addition rate was optimized, the pilot system demonstrated the capability to reduce phosphorus in the permeate, or final effluent, to the objective level.

As the existing City IWWTF has run quite well over the past three years, the performance of the pilot plant from a biological standpoint was not unexpected. With the pilot plant including a post-denitrification step, it was adequately demonstrated that this additional process step was effective in generating effluent TN levels below the 10 mg/l objective. Validating this key process aspect is critical to the overall system design objective of not discharging any higher amounts of TN to the river than is currently being discharged.

While the biological performance of the pilot plant met expectations, the pilot test provided important information regarding the performance of the membrane system. The system provided by Zenon can best be characterized as an immersed, hollow fiber, ultrafiltration membrane system. The system functions in an outside-in filtration mode in which the solids are removed from the solids-containing liquid by the membrane barrier with negative pressure inside the membrane provided by a downstream process pump. The energy that must be applied by the process pump is directly related to the filterability of the solids-containing liquid.

An important evaluation criterion for the membrane system is the throughput rate or flux, expressed in m^3/m^2/day (gallons/ft^2/day). By understanding the sustainable flux rate under real time circumstances using the pilot plant test data, the total area of membrane surface required for the expansion can be determined. As with all membrane pilot tests, full-scale membrane elements were used. As such, test results were used directly to establish full-scale system size. Additionally, the energy required to reach a given flux rate is also important. By comparing the flux rate demonstrated and the vacuum maintained on the membranes, a comparison can be made against other operating membrane systems.

Based on the data gathered, the design flux rate was easily achieved and did not deteriorate in any way over the period. Furthermore, the vacuum maintained was very low in comparison to other plants designed by Zenon, and it held steady throughout. The conclusion to be drawn here is that the pretreatment effluent from Maple Leaf Pork in Brandon suits the membrane system very well.

Membrane systems require occasional cleaning to maintain steady performance. Cleaning protocols can take several forms and can occur as often as every two or three weeks or as seldom as twice per year. Pilot tests can provide an approximation of the cleaning interval. The prediction of a long interval between cleanings is another indication of a suitable application for membranes. During the operation of the Maple Leaf Pork pilot project in Brandon, no cleaning of the membrane system was required. Cleaning is performed when the energy required to maintain a design flux rate increases to a given set point measured by pressure differential. Throughout the pilot test, the vacuum across the membrane system remained very low and did not increase; hence, no cleaning was required.

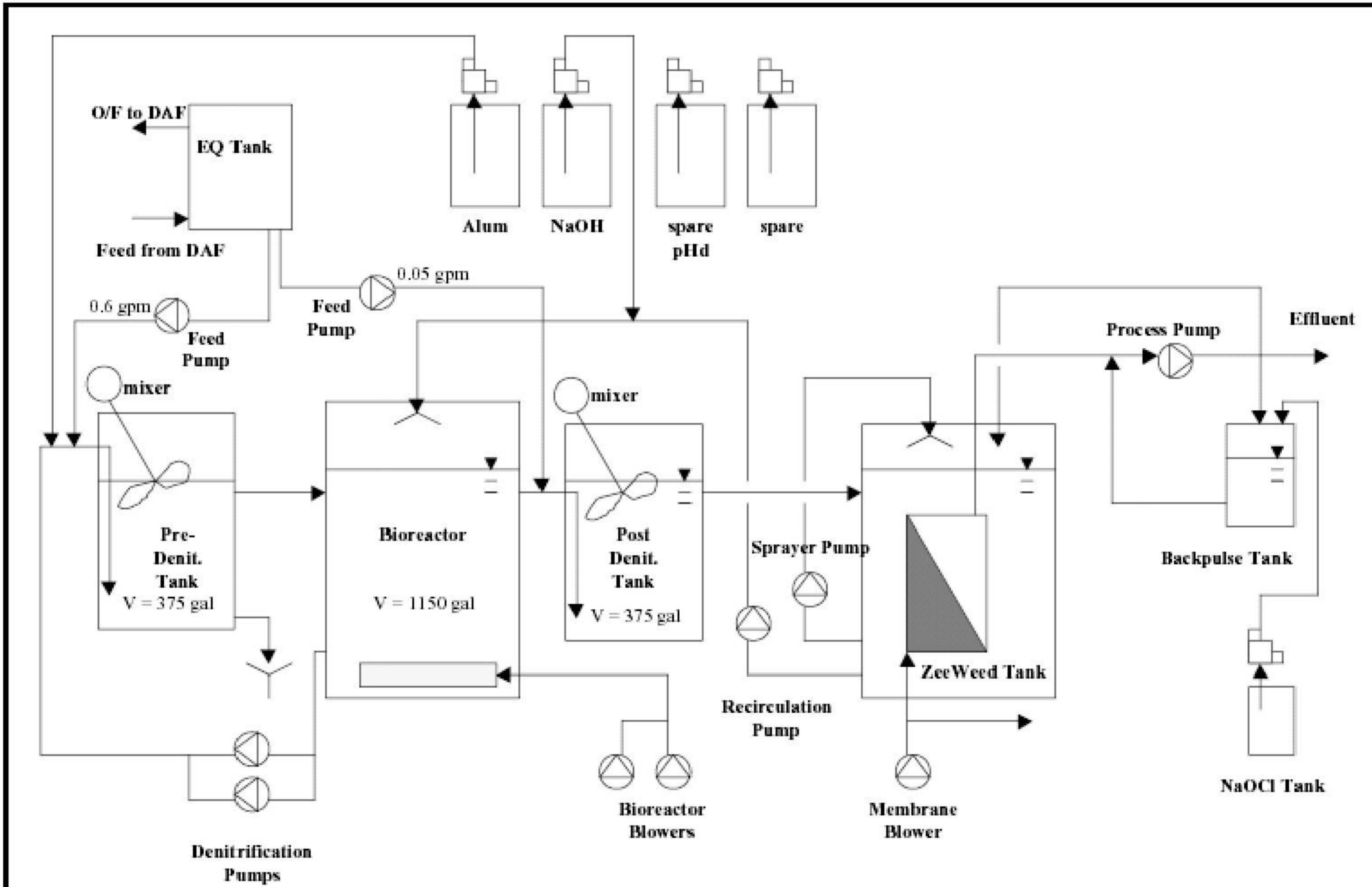
Overall, the pilot plant test validated the conceptual process design, demonstrated the ability to produce permeate that would not result in any additional nutrient loading to the river, and showed that the filtration characteristics of the pretreated waste water are well suited for processing through a Zenon membrane system.

4.2.3 System Integration Issues

There are some interesting issues to consider in expanding the IWWTF in terms of system integration. The existing IWWTF includes an anaerobic lagoon system, which biologically treats pretreated waste water before the anoxic/aerobic polishing step that follows prior to discharge. While the anaerobic lagoon is effective at organic removal, it does not remove or convert any appreciable amount of nitrogen. This is characteristic of anaerobic systems in general. As part of the denitrification process, organic matter is consumed as a food source by the biomass, which reduce nitrates to nitrogen gas. Currently, some of the process wastewater is bypassed from one corner of the anaerobic lagoon near the influent to increase organic matter in the denitrification step.

Additionally, the anaerobic lagoon system was sized to provide organic removal and waste sludge digestion simultaneously. As it is planned to discharge waste sludge from the expansion facilities to the anaerobic lagoon, this will impact on the amount of organic removal that can be accomplished in the lagoon.

A further consideration is that the anaerobic lagoon also acts to equalize flow and load to downstream process steps. Biological systems, in general, operate best when fed consistent amounts of flow and load. Under the expanded Maple Leaf Pork operating conditions, the



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Schematic of Pilot Test Facility
Maple Leaf Pork
Brandon, Manitoba

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checked SJB	drawing no. 4.2	rev.
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capacity of the existing anaerobic lagoon is not adequate to equalize total waste water flow and load. As Maple Leaf Pork adds the second shift, it will sometimes operate with two shifts only five days per week. At other times, it will operate two shifts for six days per week. The expanded IWWTF must be able to accommodate the changing needs of Maple Leaf Pork.

Additional flow equalization must be provided. Under the most extreme case for flow equalization, which is a five-day production week, the IWWTF will need to continue to operate for seven days. This will require that wastewater be stored over the five-day production period and fed to the system over the weekend. At the same time, this storage cannot be provided for by the anaerobic system, as it currently exists. A key system integration aspect is to ensure that sufficient organic material is available as food for denitrification. Otherwise, the TN discharge to the river may be compromised over the weekends.

While provisions for additional flow equalization cannot take the form of an anaerobic treatment lagoon, since organic content must be preserved for denitrification, it cannot be stored over an extended period in an aerobic volume either. Maple Leaf Pork wastewater is readily biodegradable. An aerobic flow equalization tank would quickly lead to aerobic degradation of organics prior to denitrification. Additionally, any such activity would generate more waste sludge for disposal.

While these integration issues may seem to be in conflict, certain points are clear:

- The anaerobic lagoon must be utilized for organic removal, but only to a point of insuring that sufficient organics remain for denitrification. At the same time, any organic removal must be accomplished while storing all waste sludge generated by the expanded IWWTF.
- Additional flow equalization must be provided to allow for five or six day production by Maple Leaf Pork. This equalization must be accomplished in such a way that the organics will not be degraded, anaerobically; or, aerobically.
- There is an optimal amount of organics needed for denitrification. Preferably, a ratio of BOD:TKN of 4.5 should be maintained in the flow fed to the anoxic step.

4.2.4 Expanded System Description and Method of Integration with the Existing IWWTF

This section describes the IWWTF expansion and how it will be physically integrated into the existing plant.

In summary, the expanded waste water treatment system will consist of a new equalization basin and a new Zenon membrane system connected in series, but paralleling the existing biological treatment system at the IWWTF. The new general layout arrangement of the existing plant with the integrated Zenon system is shown in Figure 4.3. Effluent from the pretreatment plant located on the Maple Leaf Pork processing site with an average flow of 6700 m^3/day will be split with 4900 m^3/day being pumped to a new equalization basin and 1800 m^3/day being pumped to the existing covered anaerobic lagoon on the City of Brandon's IWWTF site. The new equalization basin, Zenon membrane technology system, and the discharge facilities are discussed in more detail in Sections 4.2.6 through 4.2.8.

Figures 4.4 through 4.6 provide preliminary process flow diagrams for the existing system with added equalization basin, Zenon system, and the UV disinfection system, respectively. Figure 4.7 shows a summary of the projected mass balance through the entire IWWTF.

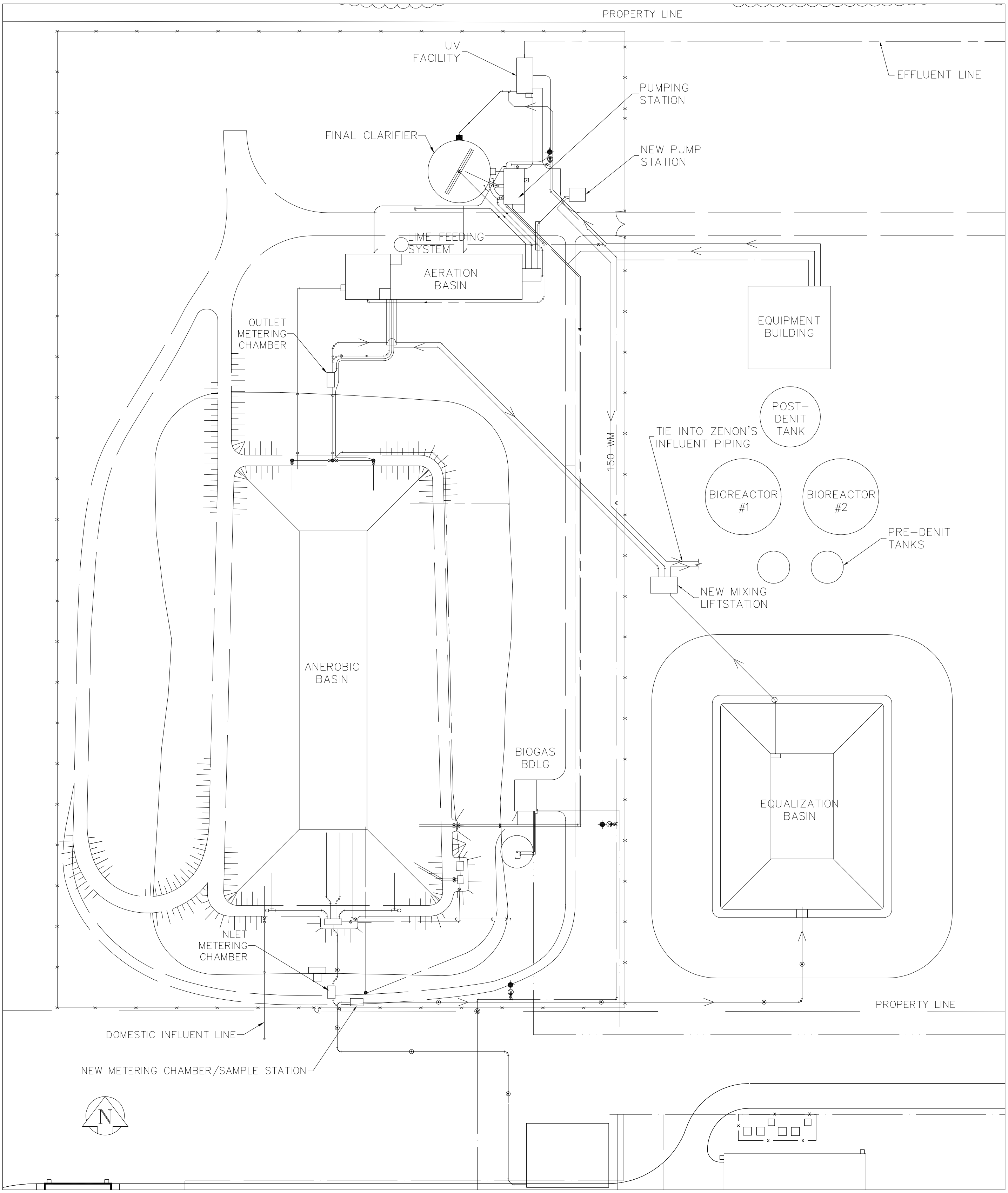
The total facility will be designed to treat up to 6,918 m^3/d. This is the projected total daily average flow for a production week in which two production shifts would be scheduled for six days of the week. This is the highest average flow that the plant would see over the course of a full week.

Of this total, an average of 218 m^3/d of sanitary waste water would be generated. This stream would be sent directly to the anaerobic lagoon, as is presently practiced. As this stream would be part of the equalized flow sent to the existing plant and the expansion, any future recycle of treated waste water back to the Maple Leaf Pork plant from the expansion plant would necessitate pumping this sanitary flow to a nearby waste water line to the City's municipal waste water treatment plant.

Of the 6700 m^3/d of process waste water produced on average each day, 1800 m^3/d would be directed to the anaerobic lagoon. The remaining 4900 m^3/d would be sent to a new flow equalization basin. This flow equalization basin would be either a double-lined earthen basin with a flexible cover, very similar to the existing anaerobic lagoon, or a concrete or steel tank. The volume has been sized for the worst-case scenario of Maple Leaf Pork production only five days per week. In such a case, the goal for this equalization basin would be to incrementally accumulate enough waste water during production days to be able to feed the existing IWWTF and the expansion plant a consistent and equalized flow over the two-day weekend.

The process waste water and sanitary flow treated in the anaerobic lagoon would then be combined with flow from the new equalization basin in a mixing lift station. At this point, it is expected that the waste water would contain a BOD of 1417 mg/l and a TKN of 311 mg/l. The ratio of BOD:TKN in this case would be 4.5:1, the proper ratio to insure that adequate organic matter is available for denitrification.

Beyond this point, waste water would be pumped to the existing IWWTF and the expansion facilities, which would essentially operate as parallel treatment trains. The existing plant



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General Arrangement of The City of Brandon Expanded IWWTF

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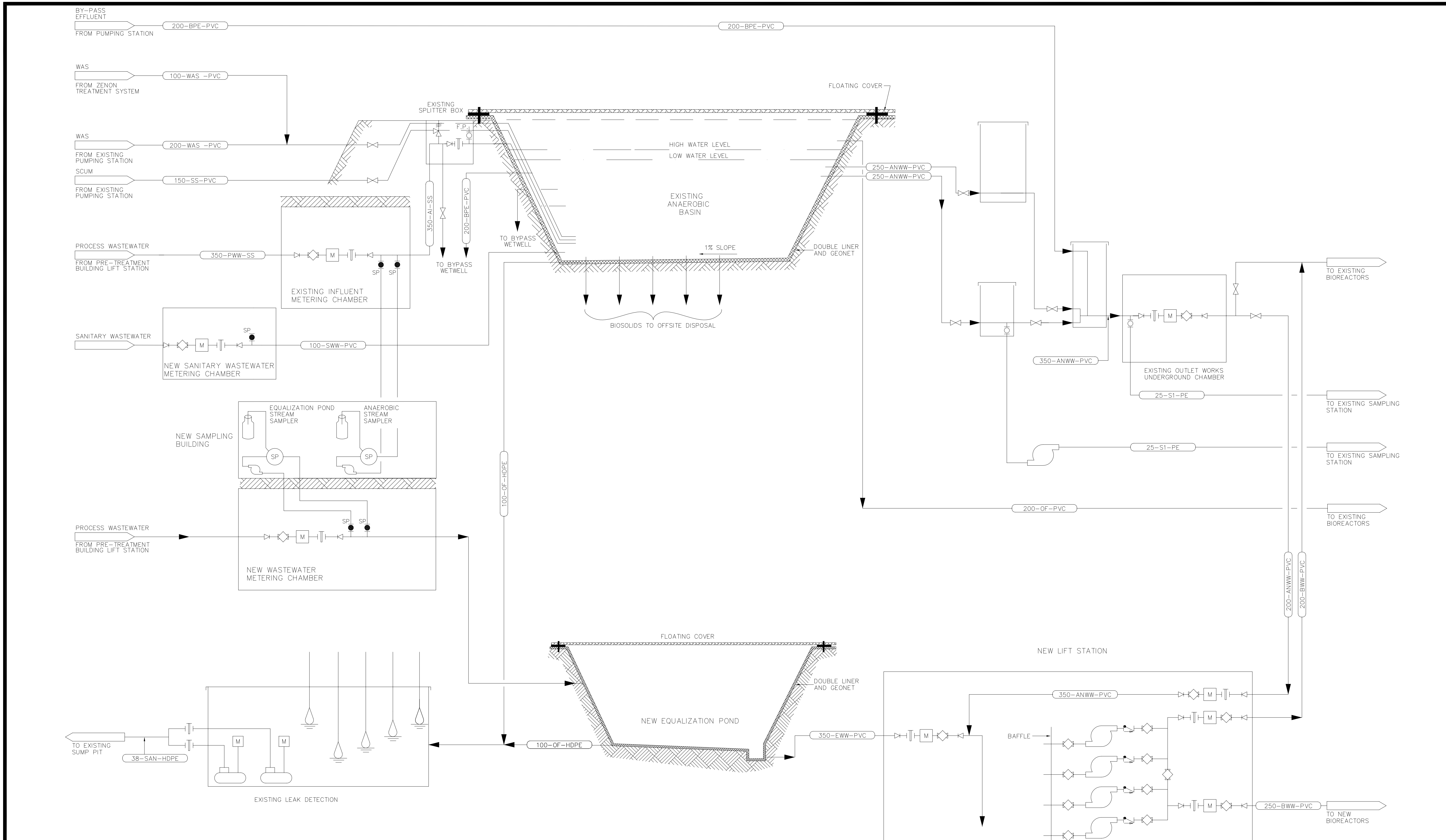

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Process Flow Diagram of The City of Brandon Expanded IWWTF Equalization Basin

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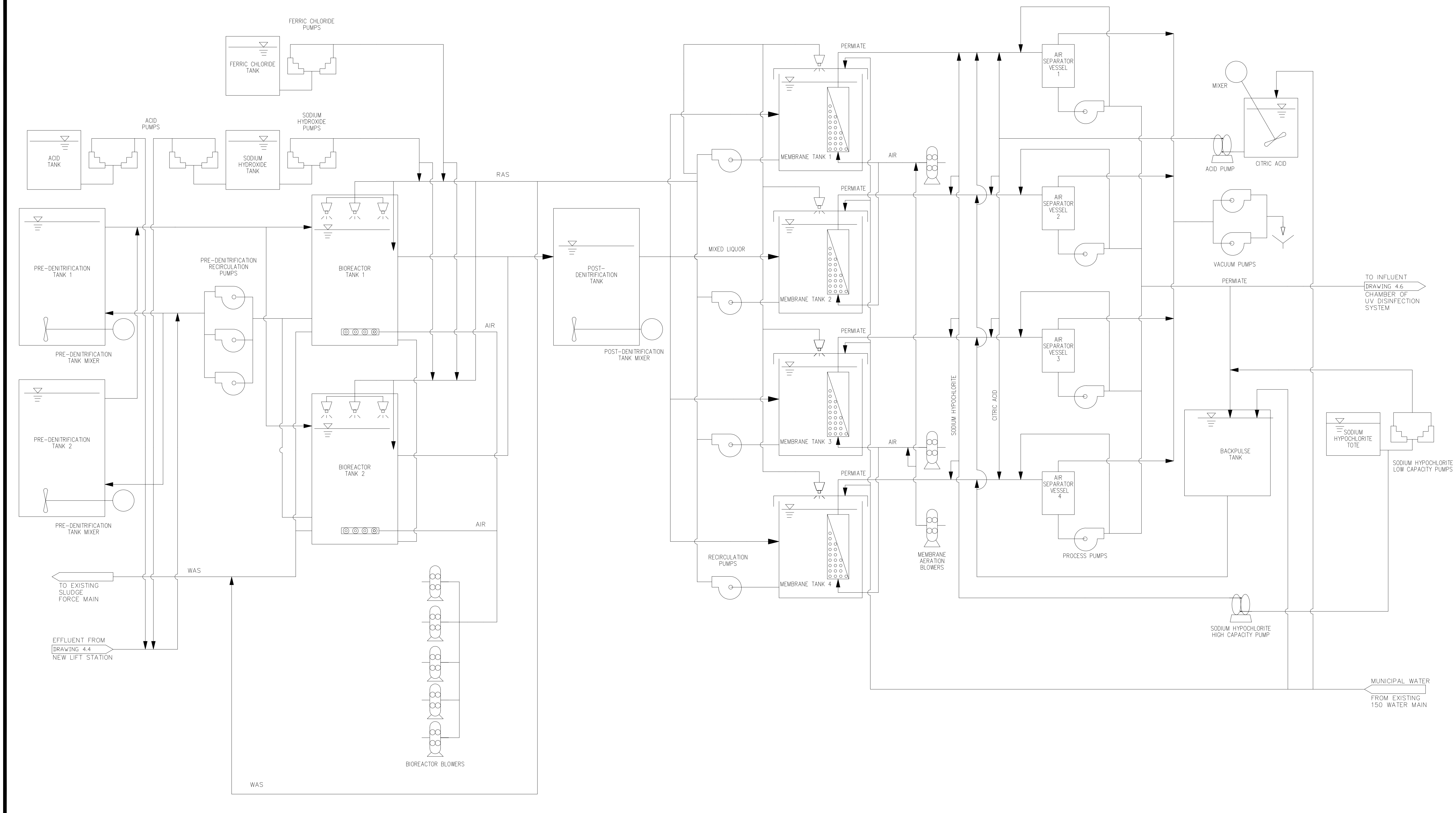

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Process Flow Diagram of The Zenon System at The City of Brandon Expanded IWWTF

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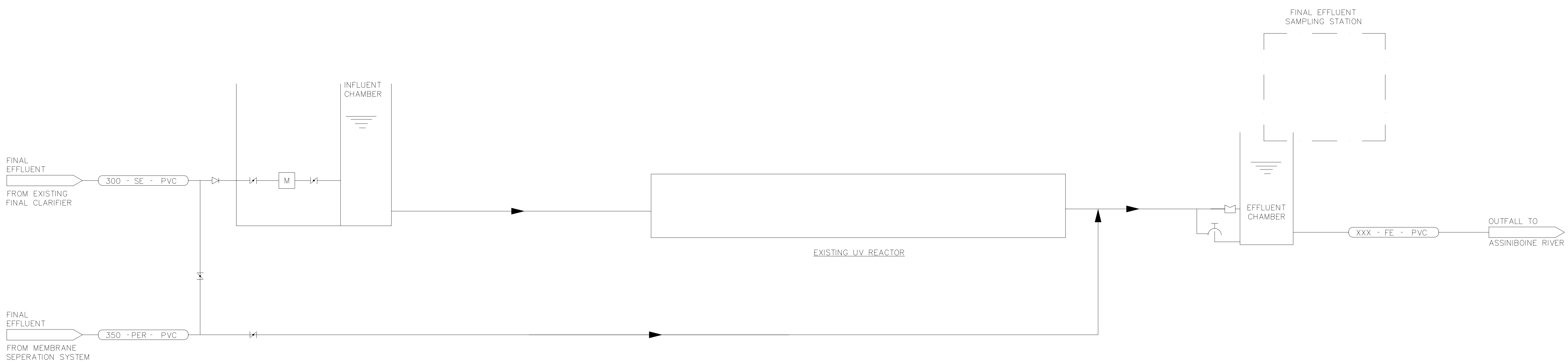

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Process Flow Diagram of The UV Disinfection System at The City of Brandon Expanded IWWTF

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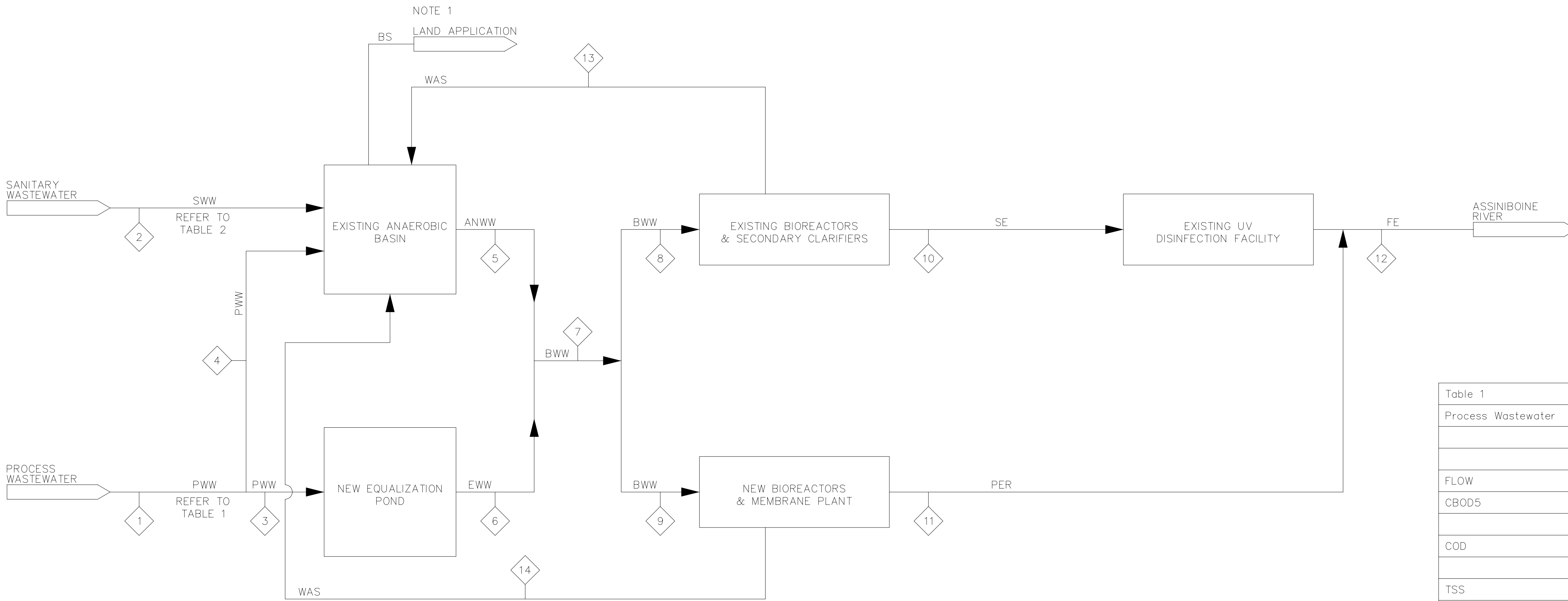

NOTES:

1. BIOSOLIDS REMOVED SEASONALLY
2. 1202 kg/d TSS DUE TO 'P' REMOVAL WITH FERRIC

LEGEND	
ANWW	ANAEROBIC WASTEWATER
BS	BIOSOLIDS
BWW	BLENDED WASTEWATER
EWW	EQUALIZED WASTEWATER
FE	DISINFECTED FINAL EFFLUENT
PER	PERMEATE
PWW	PROCESS WASTEWATER
SE	SECONDARY EFFLUENT
SWW	SANITARY WASTEWATER
WAS	WASTE ACTIVATED SLUDGE

Table 1

Process Wastewater

	Units	Mon–Fri	Sat	Sun	Average
FLOW	m3/d	7665	7325	1250	6700
CBOD5	kg/d	15286	14606	2493	13360
	mg/l	1994	1994	1994	1994
COD	kg/d	28370	27110	4626	24797
	mg/l	3701	3701	3701	3701
TSS	kg/d	8908	8512	1453	7785
	mg/l	1162	1162	1162	1162
FOG	kg/d	2630.0	2512	429	2298
	mg/l	343	343	343	343
TKN	kg/d	2665	2549	435	2332
	mg/l	348	348	348	348
TP	kg/d	332	317	54	290
	mg/l	43.3	43.3	43.3	43.3

TABLE 3

Mass Balance

Stream No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Stream Type		PWW	SWW	PWW	PWW	ANWW	EWW	BWW	BWW	BWW	SE	PER	DFE	WAS(SE)	WAS(PER)
Flow	m3/d	6700	218	4900	1800	2477	4900	7377	2077	5300	1910	5008	6918	167	292
CBOD5	kg/d	13360	105	9771	3589	681	9771	10452	2943	7509	15	20	35	418	704
	mg/L	1994	480	1994	1994	275	1994	1417	1417	1417	8	4	5.1	2500	2411
COD	kg/d	24797	261	18135	6662	2043	18135	20178	5681	14497	478	200	678	1847	3178
	mg/L	3701	1200	3701	3701	825	3701	2735	2735	2735	250	40	98	11060	10884
TSS	kg/d	7785	105	5694	2092	743	5694	6437	1812	4625	53	0	53	1703	4380 (NOTE 2)
	mg/L	1162	480	1162	1162	300	1162	873	873	873	28	0	7.7	10200	15000
TKN	kg/d	2298	7.0	1681	617	611	1681	2292	645	1646	6.9	1.3	8.1	132	245
	mg/L	343	32	343	343	247	343	311	311	311	3.6	0.25	1.2	790	839
FOG	kg/d	2332	21.8	1705	626	186	1705	1891	532	1359	0	0	0	0	0
	mg/L	348	100	348	348	75	348	256	256	256	0	0	0	0	0
TP	kg/d	290	2.6	212	78	92	212	304	86	218	39.2	5	44.2	46	102
	mg/L	43.3	12	43.3	43.3	37.0	43.3	41	41	41	20.5	1	6.4	275	349
TN	kg/d	–	–	–	–	–	–	–	–	–	110	50	160	–	–
	mg/L	–	–	–	–	–	–	–	–	–	57.5	10	23.1	–	–

Table 2

Sanitary Wastewater

	Units	Kill Day	Non–Kill Day	Average
FLOW	m3/d	250	25	218
CBOD5	kg/d	120	12	105
	mg/l	480	480	480
COD	kg/d	300	30	261
	mg/l	1200	1200	1200
TSS	kg/d	120	12	105
	mg/l	480	480	480
TKN	kg/d	8	0.8	7.0
	mg/l	32	32	32
FOG	kg/d	25	0.25	21.8
	mg/l	100	100	100
TP	kg/d	3	0.3	2.6
	mg/l	12	12	12

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Mass Balance of The City of Brandon Expanded IWWTF

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SJB	4.7	
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would receive 2,077 m^3/d and expansion facilities would receive 5,300 m^3/d. Thereafter, the existing IWWTF would operate in the same manner as it does today with no modification. It is anticipated that, after sludge wasting of 167 m^3/d, a treated effluent flow from the existing IWWTF of 1,910 m^3/d would be produced which would contain 57.5 mg/l of TN or 110 kg/d of TN for river discharge.

The balance of the equalized flow would be sent to the expansion facilities. As can be seen from the plant layout drawing contained elsewhere in this document, the expansion facilities would basically include a series of five tanks followed by the membrane system.

An equalized flow of 5,300 m^3/d would be first fed to two parallel anoxic pre-denitrification tanks. These tanks would be above-ground bolted steel tanks. They would be covered for heat retention and the tank contents would be mixed, but not aerated. In addition to receiving equalized flow, aerobically treated flow would also be recycled back into these tanks. With this recycled flow, nitrates produced by the following aerobic step are blended with organics in the presence of denitrifying biomass. The result is denitrification, which will occur in a manner similar to that in the existing IWWTF.

Following the anoxic tanks, two aerobic bioreactor tanks would be built. These tanks would operate in parallel, and would again be above-ground, covered, bolted steel tanks. These tanks would contain fine-bubble aeration diffusers to maintain an aerobic environment. In these tanks, organic matter (BOD) would be oxidized to CO_2 and water. Additionally, by virtue of the solids retention time maintained, nitrogen compounds would be oxidized to nitrate nitrogen.

From the aerobic bioreactor tanks, a large recycle flow would be recycled back to the anoxic tanks for denitrification. The forward flow would pass on to a post-denitrification tank. This tank would be similar in form to the other tanks, but would be mixed and not aerated. In this process step, some aerobic biomass will die and provide a source of organic matter for additional denitrification. The key operating parameter in this step is to ensure that incoming dissolved oxygen levels remain low, so that denitrification can proceed smoothly.

Following the post-dentrification tank, treated effluent would flow to the membrane system. Membrane cassettes would be contained in four parallel membrane process tanks. Each tank would be a rectangular steel vessel with a dedicated process pump to pull treated permeate, or final effluent, through the membrane elements.

During the pilot test, the membrane system was operated at a flux rate of 0.30 m^3/m^2/day (9.6 U.S. gallons/ft^2/d). The full-scale plant has been sized at flux rate of 0.35 m^3/m^2/day (8.6 U.S. gallons/ft^2/d). Zenon experience indicates that flux rate data from pilot operations is directly scalable to full scale design. Additionally, numerous membrane systems on similar applications operate at higher flux rates over extended periods of time. It is typical for membrane systems to operate at up to 0.61 m^3/m^2/day (15 U.S. gallons/ft^2/d) over extended periods of time.

As mentioned, the membrane system will require occasional cleaning. In such an event, one membrane train would be shut down, with all flow being treated by the remaining three trains. In operating only three trains and treating full flow, the flux rate would increase to 0.47 m^3/m^2/day (11.6 U.S. gallons/ft^2/d). This is still a very conservative flux rate. Additionally, with four membrane trains in operation, it would be possible to treat the entire flow from the Maple Leaf Pork plant for some period of time, as the flux rate to treat full flow would be 0.49 m^3/m^2/day (11.9 U.S. gallons/ft^2/d).

From the membrane process tanks, the biosolids retained by the membranes will be re-circulated back to the aerobic bioreactor tanks, except for about 292 m^3/d that would be wasted to the anaerobic lagoon. This recycle would be analogous to the recycle of clarifier underflow to the aeration tanks at the existing IWWTF, except that the membrane system acts as an absolute solids barrier, thus producing a treated effluent without TSS.

Beyond this point, the permeate, or final effluent, from the membrane tanks, with a flow of 5,008 m^3/d, will contain less than 10 mg/l of TN or only 50 kg/d. This permeate would then be blended with the effluent from the existing IWWTF. The combined treated flow would then pass through the existing UV disinfection step prior to discharge to the Assiniboine River. With the higher flow, the existing UV facility will be upgraded with additional UV lamps in order to provide proper disinfection of the increased flow.

With the existing system treating 1,910 m^3/d of flow and reducing TN to 110 kg/d and the expansion facilities treating 5,008 m^3/d and reducing TN to 50 kg/d, the combined discharge could contain as little as 160 kg/d TN. Over a 31-day month, this will result in as little as 4,960 kg/month TN discharged to the river. This TN amount is 53.9% less than the current average monthly maximums of 10,758 kg/month discharged by the existing IWWTF with Maple Leaf Pork operating one shift only. Additionally, this scenario is based on production assuming two shifts per day, six-days per week and the most conservative wastewater design criteria.

In a similar review of phosphorous, the existing system should reduce phosphorous in the effluent to approximately 20.5 mg/l or 39.2 kg/day. With ferric chloride addition, as tested in the pilot study, the expansion facilities were shown to be capable of reducing effluent phosphorous concentrations to 1.0 mg/l or 5.0 kg/day in the discharge in the discharge for this flow. The combined phosphorous discharged to the Assiniboine River is projected to be 44.2 kg/day during maximum pork plant production periods or about 1370 kg during a 31-day month, which is 22.7% less than the current average monthly maximum of 1771 kg/month.

In short, implementation of the expanded IWWTF will result in less nutrients discharged to the Assiniboine River.

As mentioned, waste sludge from the existing IWWTF and the expansion facilities will be discharged to the anaerobic lagoon. As the process conditions that will be maintained in the existing and expanded treatment trains will be very similar to operating conditions presently practiced, it is not anticipated that the waste sludge will impact lagoon performance, aside from the fact that greater amounts of solids will be held in storage. However, this additional solid storage will be offset by the reduced waste water influent loading to the lagoon under future operating conditions.

From a conceptual viewpoint, there are a number of key points, which illustrate that a conservative and flexible approach has been taken:

- New equalization capacity will be added based on only five-day per week production by Maple Leaf Pork, the most conservative case. However, the loadings to all other treatment units are based on a six-day week, which is the most conservative case for these units.
- While organic loading to the anaerobic lagoon will be controlled such that the proper BOD:TKN ratio can be maintained for denitrification, the lagoon will have additional organic removal capacity in place, should it be needed.
- By adding equalization and blending with anaerobic effluent, the forward feed to the existing IWWTF and the expanded facilities will be identical.
- Significant system redundancy has been included as a part of the proposed expansion:
  - All process pumps and blowers include on-line spares.
  - Two aeration and two anoxic tanks of 50% capacity each instead of one larger tank will be supplied for ease of maintenance, thereby minimizing downtime.
  - The membrane system is conservatively sized, with space to add additional membrane cassettes in the future.

4.2.5Membrane System Security

As previously mentioned, the flux rate across the membrane system is a key process design parameter. As the membrane system represents an absolute barrier for biomass retention, it is critical that a conservative flux rate be selected. As currently envisioned, 28 membrane cassettes will be provided in four parallel treatment trains of seven cassettes each. With an equalized flow of 5,300 m^3/d to the expanded facility, the flux rate across the membrane system will be 0.37 m^3/m^2/day (9.1U.S. gallons/ft^2/day). This flux rate was readily demonstrated during the pilot plant test. Additionally, other full-scale facilities have consistently demonstrated the capability to operate at flux rates up to 0.61 m^3/m^2/day (15.0 U.S. gallons/ft^2/day) over extended periods of time.

When one membrane train requires cleaning or maintenance, flow to the train to be serviced will be stopped and all flow will be processed by the remaining three trains. The resulting flux rate under such a condition would be only 0.47 m^3/m^2/day (11.6 U.S. gallons/ft^2/day).

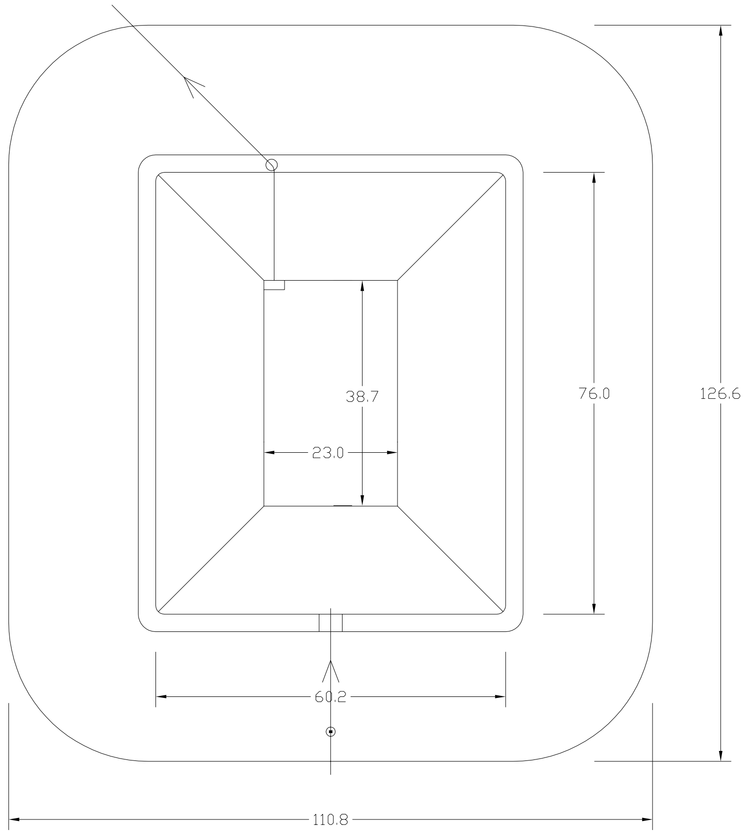
In the unlikely event of a shutdown of the existing IWWTF, processing the entire wastewater flow of 6,918 m^3/d through the membrane system would result in a flux rate of only 0.48 m^3/m^2/day (11.9 U.S. gallons/ft^2/day). So, for example, if an operational issue would develop regarding the secondary clarifier at the existing IWWTF, the membrane system could be utilized to provide clarification prior to final discharge of treated wastewater.

In terms of membrane integrity, each membrane process train will be equipped with on-line turbidity monitoring. Under normal operation, membrane permeate will have a turbidity of less than 0.3 NTU. In the event of any malfunction of one membrane cassette, turbidity will increase. Any increased turbidity will trigger an alarm to inform the operator of the problem. Thereafter, the operator will be able to easily locate and isolate the damaged cassette. Cassettes can be isolated and removed from the system while normal operation continues. Replacement cassettes can be provided to the plant site within 24 hours of notification.

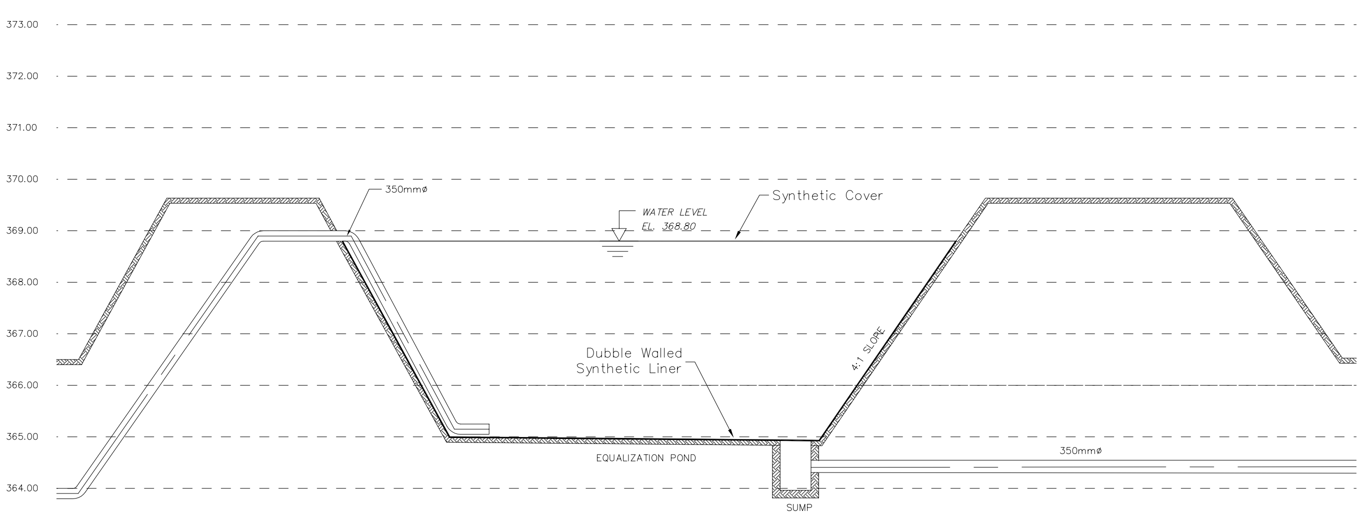
4.2.6 Preliminary Design of New Equalization Basin

The new equalization basin is required to equalize the flow from the five-day plus kill-and-cut second-shift pork processing operation to a seven-day operation of the expanded IWWTF including the Zenon system. The details of the equalization basin are shown in Figure 4.8. During the workweek, incremental portions of the effluent from the pretreatment plant will be retained in the new equalization basin. The majority of the effluent will continuously flow through to the Zenon system, but some will be retained daily in the new equalization basin. The equalization basin will be essentially full by the end of the week (5, 5.5 or 6 days) and it will be drawn down over the following weekend (Saturday and/or Sunday). Depending on the length of the workweek (5, 5.5 or 6 days), the effluent will be pumped at a predetermined rate through to the Zenon system on the weekend. In this way, the treated effluent leaving the expanded IWWTF will be at a near-constant strength throughout the week.

The equalization basin as shown in Figure 4.8 will be about one-quarter of the size of the existing anaerobic lagoon, and very similar in design. It is anticipated to be an earthen structure, lined with a double HDPE liner including a leak detection/collection system, and equipped with an insulated HDPE cover to minimize heat loss. It will have a footprint of about 4575 m^2 (50,000 ft^2) being about 76 m (250 ft) long and 60.2 m (200 ft wide). The water



Plan of Equilzation Basin



Cross Section of Equilzation Basin

(Not to Scale)

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General Details of the Equalization Basin at The City of Brandon Expanded IWWTF

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depth will be about 3.8 m (12.5 ft) with an assumed 0.9 m of freeboard providing a total storage volume of 7660 m^3. The interior and exterior side slopes will be 4:1 and a ramp will be provided for access to the top. There will be no provision for sludge removal nor for methane gas collection because sludge will be continuously removed; and, little or no methane gas will be produced because the retention time will be so short. In addition, because of the near-continuous flow-through of the equalization basin, little or no aerobic or anaerobic treatment will take place in the equalization basin. This is desirable because all of the BOD will be required for the denitrification process within the Zenon membrane system.

The double-liner of this earth filled embankment structure will be sloped to provide drainage of the interstice of the liners to one corner where a sampling well will provide monitoring and sampling capability for potential leak detection. This system has been used on the anaerobic lagoon with success.

The preliminary design has focused on providing an earthen basin for flow equalization, but during detailed design, options such as steel or concrete tankage(s) will be investigated.

4.2.7 Preliminary Design of Zenon Membrane System

The membrane system proposed for the City of Brandon's expanded IWWTF is based largely on the Pilot Plant Test carried out in the pretreatment building at Maple Leaf Pork plant and on Zenon's patented ZeeWeed outside-in membrane. Details of the process design of Zenon system proposed for the City of Brandon's expanded IWWTF can be found in Appendix B. Effluent from the new equalization basin will be pumped directly to the pre-denitrification tanks via a 203 mm (8-inch) pipe, the first step in the membrane system. Figure 4.9 shows the general layout of the Zenon tanks and building. These two anoxic pre-denitrification tanks are used to receive equalized flow and recycled aerobically treated flow from the downstream aerobic reactors. The purpose of this recycling is to denitrify aerobically produced nitrates. It is from these pre-denitrification tanks that the largest amount of nitrogen gas is emitted. Both tanks are 11.9 m (39 ft) in diameter and 9.75 m (32 ft) high. From these two 1068 m^3 (37,697 ft^3) tanks, the effluent continues in two streams each flowing to one of two bioreactors. These aerobic tanks or bioreactors are each 28 m (92 ft) in diameter and 9.75 m (32 ft) high. Each of these 6057 m^3 (213,889 ft^3) tanks is used to oxidize the effluent and from each the flow is directed to a post-denitrifiation tank. This post-denitrification tank has a volume of 2854 m^3 (100,795 ft^3) and is 22.25 m (73 ft) in diameter and about 7.3 m (24 ft) high. This post-denitrification tank is also an anoxic operation similar to the pre-denitrifiation tanks, and is used to "polish"; that is, it converts most of the remaining nitrites to nitrogen gas.

All of the tanks described above will be constructed outdoors and are not insulated due to the heat entering with the waste water even though the lowest ambient minimum temperature recorded in Brandon is -46.7^{o}C. The tanks are designed for –50 ^{o}C and a steam injection system will be provided to the influent line for added protection. Tank exteriors will be inspected at least annually for any sign of deterioration; and, tanks will be properly maintained including routine maintenance to provide the longest life possible. As interior tank components require servicing in future years, the tank interiors will be inspected internally. Should significant deterioration become evident a program of component replacement (bolted steel tanks) or complete replacement will be undertaken.

The partially treated effluent from the post-denitrification tank then enters the equipment building (Figure 4.10) that houses the membrane tanks, the air blower system and the control room and the laboratory. The equipment building has a rough footprint of 930 m^2 (30.5 m x 30.5 m), and a height of approximately 6 m (20 ft). The membrane tanks will be arranged in four (4) trains, each with a capacity to hold up to nine (9) membrane units (cassettes), although initially only seven (7) will be installed in each. The membrane units will be about 2 m (6 ft) in height standing in a tank of approximately 3 m (10 ft). There will be four (4) membrane tanks in total, with a maximum of up to 28 filter cassettes capable of operating at any one time. The total hydraulic capacity of the Zenon system with all 28 filter cassettes operating is more than 6918 m^3/day (the maximum seven-day average flow of the pretreatment plant under second-shift operation of the Maple Leaf Pork processing plant).

Figures 4.11 through 4.14 show hydraulic profiles of the various components of the expanded IWWTF, including reference to the existing IWWTF hydraulic profile.

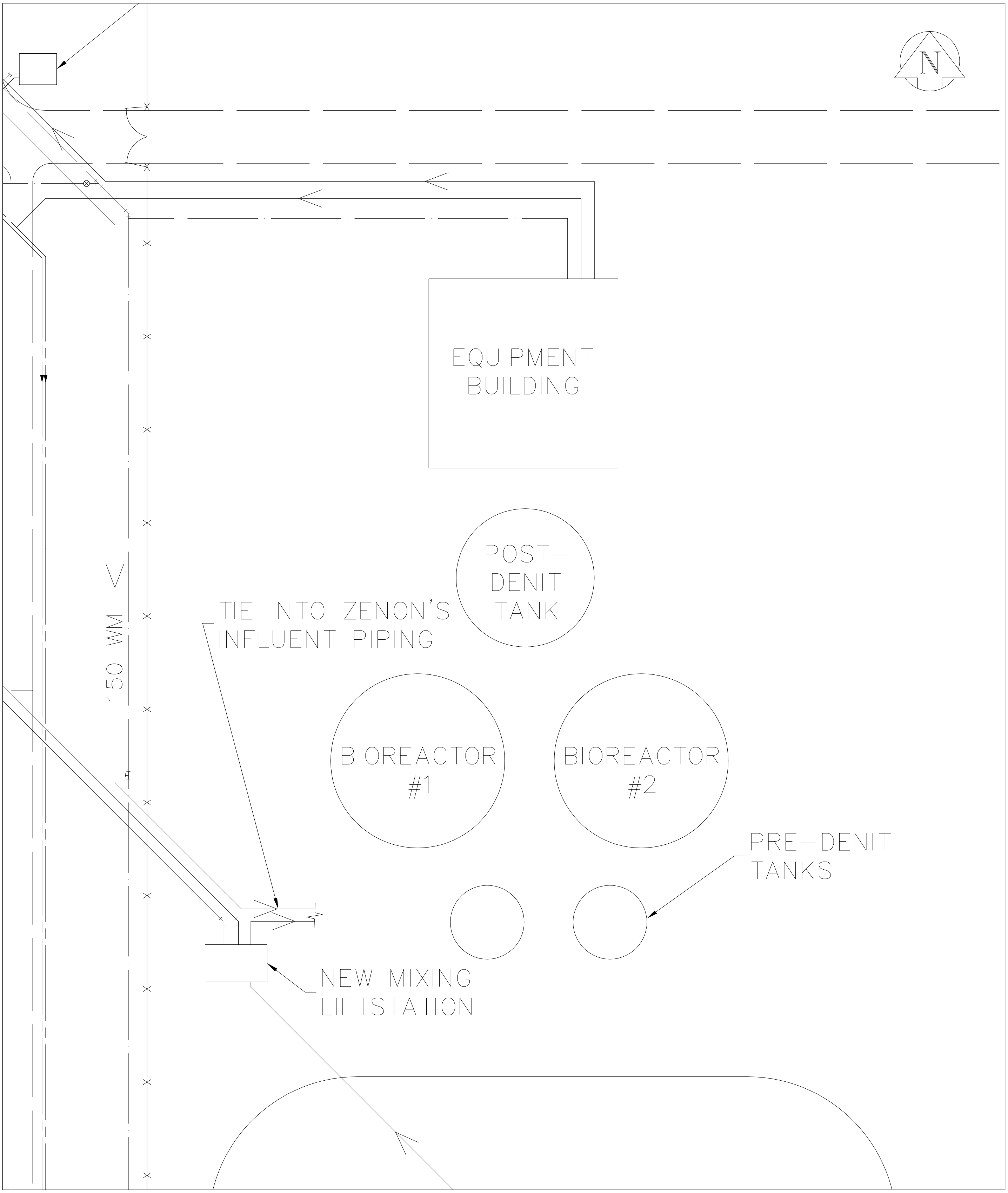
The excess capacity of the Zenon system allows down time for cleaning and replacement of cassettes. Each cassette can be isolated from the others for removal and cleaning. Special cleaning tanks are provided for cleaning the filters. Cassettes are lifted out by overhead crane, moved by monorail over the cleaning tank and immersed in a weak acid solution.

Blowers contained within the equipment building will have silencers on both the intake and outlets.

Sludge from the membrane tanks will be re-circulated back to the two bioreactors. This sludge plus sludge from the bioreactors themselves will be fed back to the anaerobic lagoon for further digestion and eventual removal and disposal to land as part of the City of Brandon's Biosolids Management Program.

Total sludge production after digestion together with the plant-available nutrients of the second-shift plus one clean-up shift from the Maple Leaf Pork processing plant is based on the maximum annual kill of 5,058,000 hogs/yr. Annual sludge production, including: sludge generated by anaerobic treatment, WAS from the existing plant and the new Zenon plant; and, sludge from the chemical precipitation of phosphorus are as follows:

- Dry Solids = 1,853,750 kg/yr



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General Layout of the Treatment Tanks of The City of Brandon Expanded IWWTF

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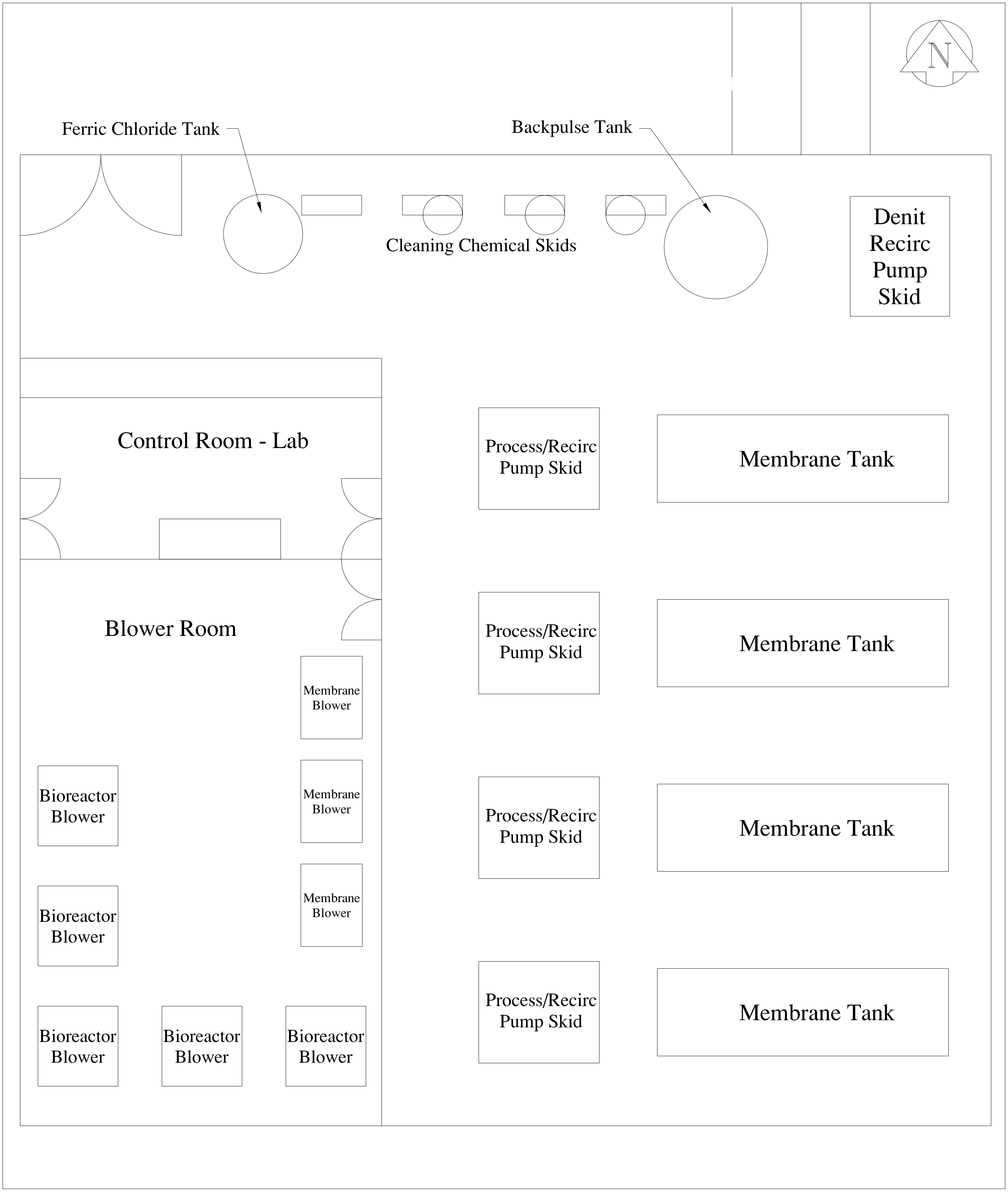

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General Layout of the Equipment Building of The City of Brandon Expanded IWWTF

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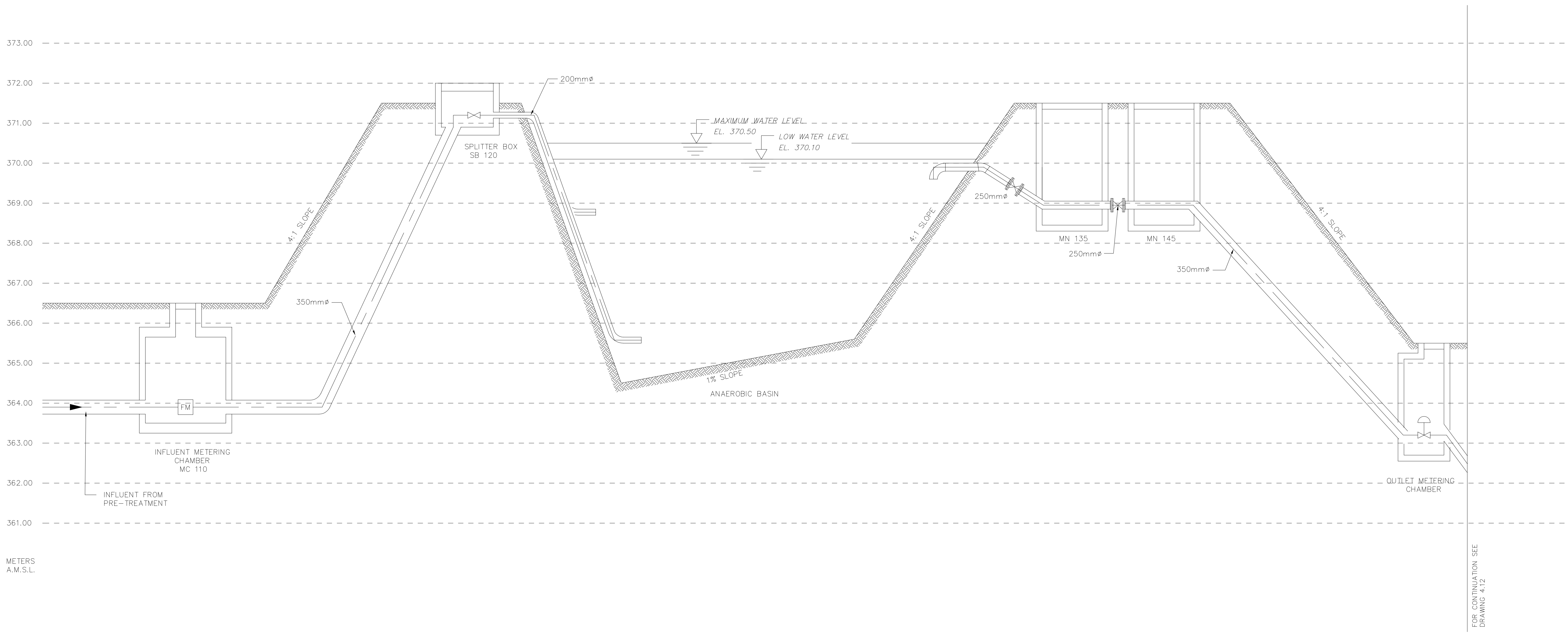

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Hydraulic Profile for the Existing Anaerobic Lagoon at The City of Brandon Expanded IWWTF

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SJB	4.11	
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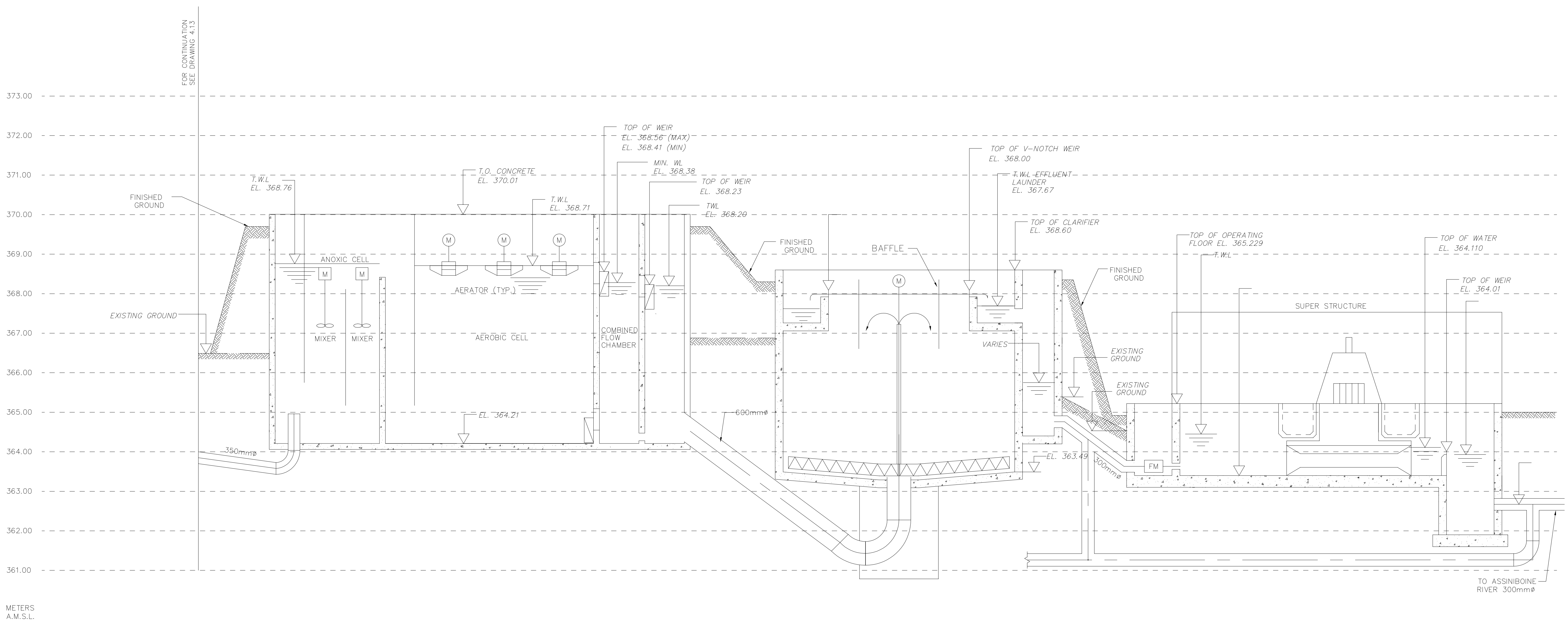

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Hydraulic Profile for the Existing Treatment Train at The City of Brandon Expanded IWWTF

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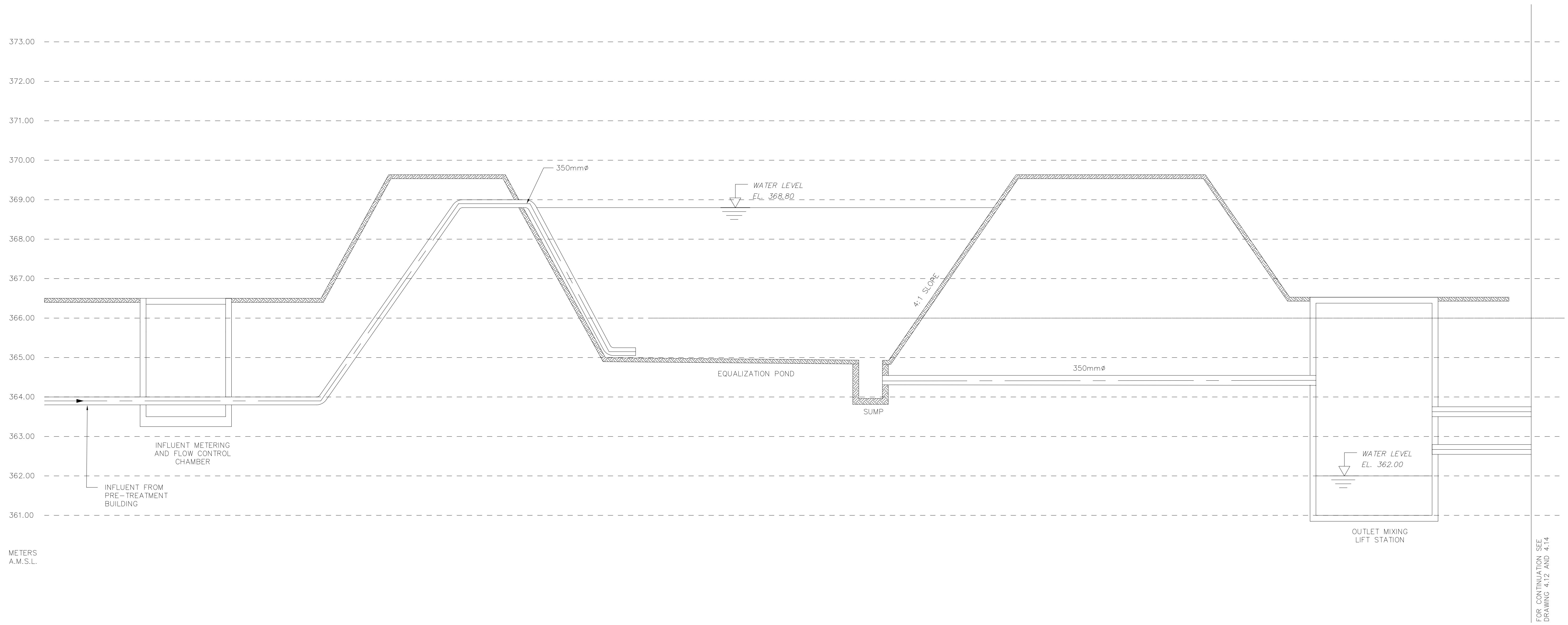

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Hydraulic Profile Through the Equalization Basin at The City of Brandon Expanded IWWTF

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HDR

designed	scale	yyyy/mm/dd
CB	N.T.S.	2003/03/16
drawn	project no.	
CB	57730	
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SJB	4.13	
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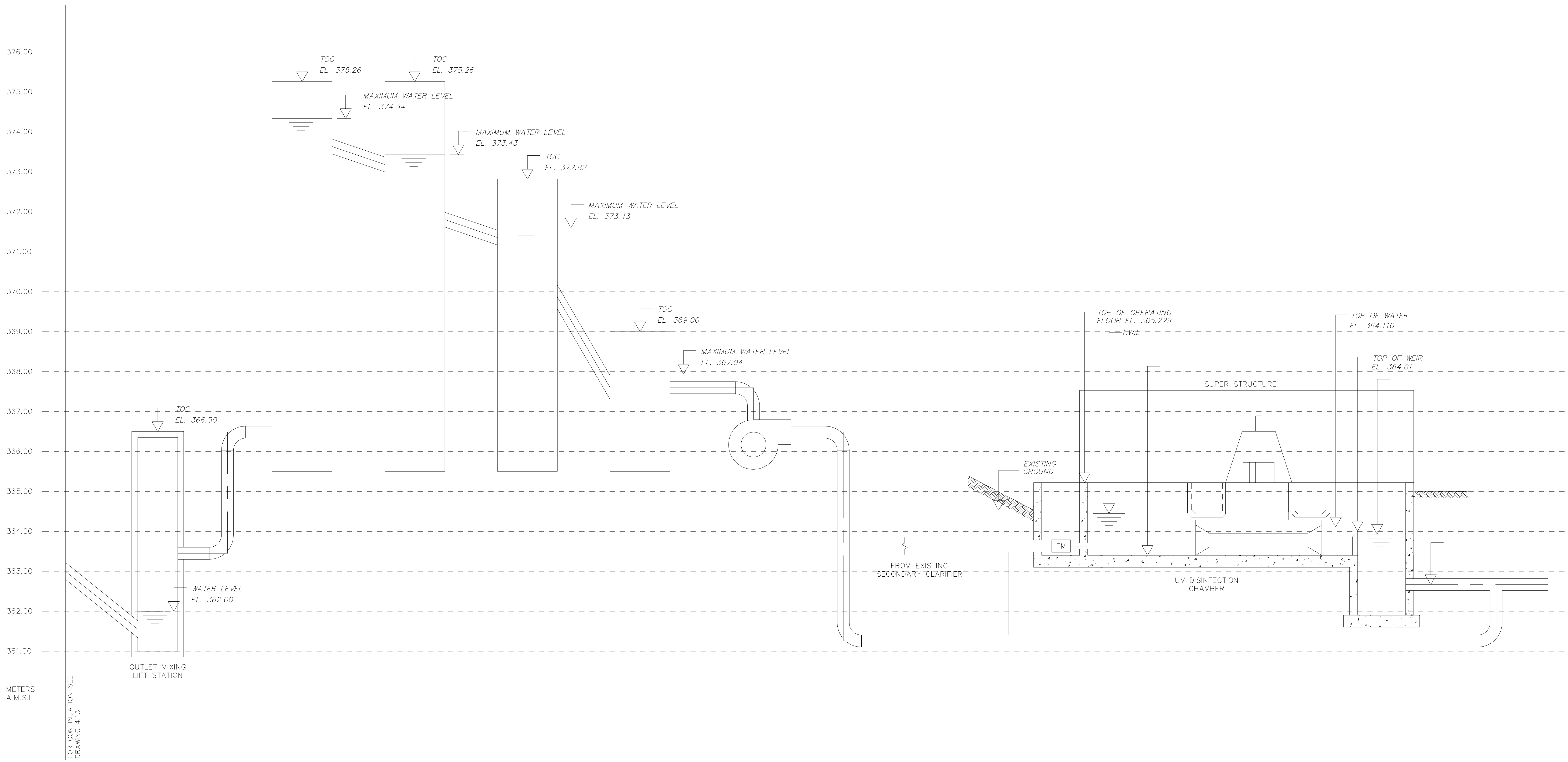

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Hydraulic Profile Through the Zenon Treatment System at The City of Brandon Expanded IWWTF

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ZENON Water for the World
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checked	drawing no.	rev.
SJB	4.14	
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FORM 11x17
REV. 2002/12/18

- Wet Solids @ 3.75 % TSS = 49,433,333 kg/yr
  = 49,433 m3/yr
- Total Kjeldahl Nitrogen = 112,260 kg/yr
- Plant-Available Phosphorus = 43,850 kg/yr

The maximum volume of the existing anaerobic lagoon is 39,973.6 m^3. Of that volume, 11,504 m^3 will be required for anaerobic treatment of the sanitary waste and the portion of the process waste discharged to this lagoon. Another 2805 m^3 of volume will be required to equalize these flows under the worst-case scenario of five kill days per week. This leaves 25,664.6 m^3 of available volume for digestion, thickening; and, storage of the sludges sent to this lagoon. Since the annual design sludge production is nearly double the remaining capacity of the existing anaerobic lagoon, sludge will have to be withdrawn for land application at least twice a year. It should be noted however, that this calculation assumed a very high level of annual sludge production, which will not occur the first few years of double-shift operation.

4.2.8 Effluent Sampling, Metering, Disinfection and Discharge Facilities

Before discharge the final effluent will continue to be sampled and metered with existing equipment. The baffle that currently blocks off a third of the UV channel will be removed and two more moveable arms with Trojan 3000 UV lamps will be installed to operate in conjunction with the four existing arms. After passing through the UV disinfection system, the final treated effluent will flow by gravity through the existing 0.6-m (24-inch) diameter discharge pipe to the Assiniboine River.

REFERENCES:

Advice Document, Manitoba Conservation, June 2002. Advice Document for the Preparation of an Environmental Act Proposal and Environmental Assessment for an Alteration to the City of Brandon's Industrial Wastewater Treatment Facility. Manitoba Conservation, Winnipeg. (Available at: http://www.gov.mb.ca/conservation/envapprovals/publs/mlf-advice.html)