HDL ENGINEERING Consultants

MEMORANDUM

DATE: November 23, 2016

TO: Matanuska-Susitna Borough

FROM: HDL Engineering Consultants

RE: Talkeetna Wastewater Treatment Facility Upgrades Alternatives

INTRODUCTION

The Matanuska-Susitna Borough's (MSB) Talkeetna Wastewater Treatment Facility (WWTF) is not in compliance with its State-administered wastewater discharge permit. Correspondence from the Alaska Department of Environmental Conservation (ADEC) includes a listing of permit compliance excursions, the most common of which are occurrences of high effluent fecal coliform (FC) counts and low effluent dissolved oxygen (DO) concentrations. Other less common excursions include inadequate biological oxygen demand (BOD_5), inadequate total suspended solids (TSS) removals, and/or excessively high effluent BOD_5 and TSS concentrations. The MSB is seeking to upgrade the WWTF to bring it into regulatory compliance now and into the future.

The purpose of this memo is to screen potential upgrade alternatives to the WWTF and choose two alternatives for further evaluation in a Preliminary Engineering Report (PER).

ASSESSMENT OF EXISTING WWTF

A review of the existing wastewater treatment facility (WWTF) was completed using the following observations, documents and data:

1. A tour of the facility in July of 2016 with operations personnel;
2. Construction project record drawings;
   A. From the construction of the original ponds in 1988;
   B. From construction of the wetland treatment system upgrade in 2003;
3. Lift station flow data from G Street Sewage Lift Station;
4. Talkeetna Sewer and Water Assessment Technical Memorandum, 2014.

Background

The original wastewater lagoon was constructed in 1988 and consisted of a two cell, facultative lagoon with a third percolation cell. A facility upgrade project in 2003 converted the percolation cell to a facultative lagoon (referred to as Cell 3), and installed a constructed wetland treatment area with a discharge pipeline to the Talkeetna Slough. Based on treatment parameters used in the 2003 upgrades, the facility is designed for inflows of 42,000 gallons per day (gpd) with a BOD_5 loading of 70 lb/day. The existing lagoon cells have a combined volume of roughly 9.4 million gallons (MG).

Raw sewage from the community is pumped from the G Street Lift Station directly into Cell 2. From Cell 2 wastewater flows through Cell 1, to Cell 3, and finally through the treatment wetlands. Treated effluent is discharged through a measurement weir and into the Slough. Flow through the entire treatment system, including wetlands is by gravity. Per the facility's ADEC wastewater discharge permit, the facility is permitted to discharge treated effluent from May to October with wastewater being stored in the lagoon cells November through April. **Figure 1** shows the current operational configuration of the WWTF.

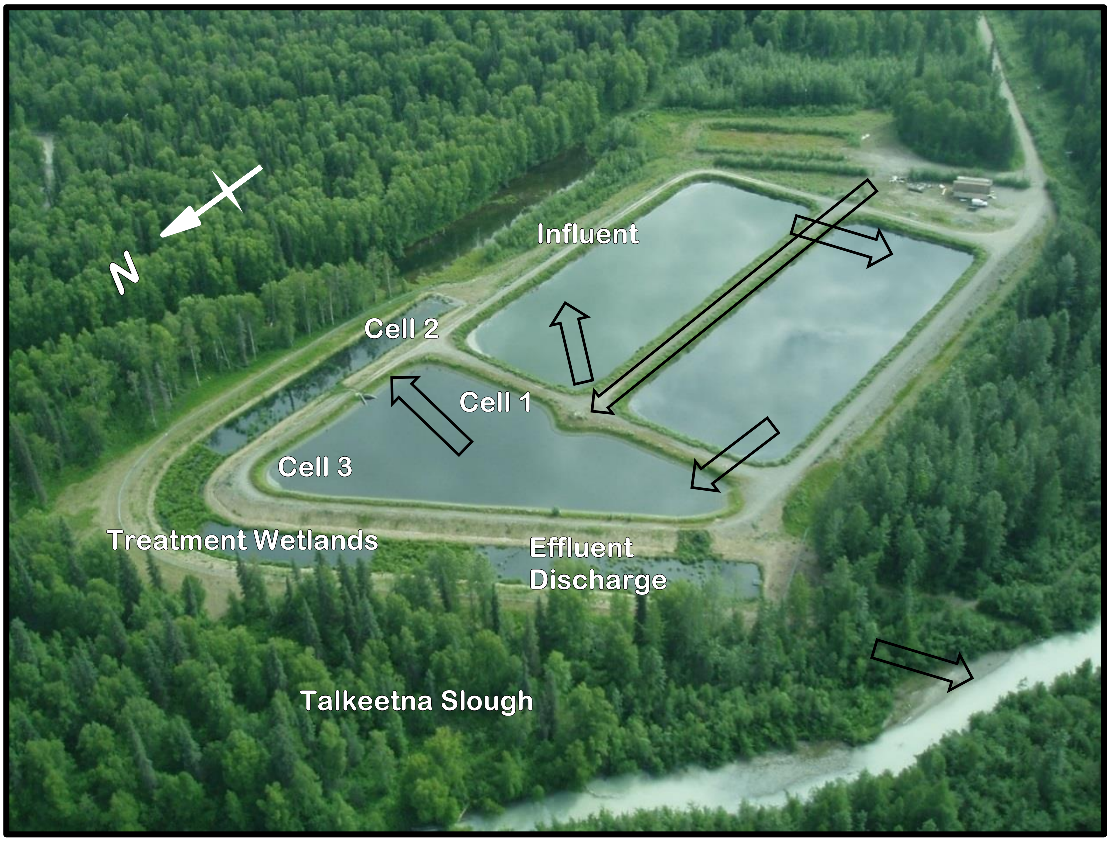

Figure 1: Talkeetna Wastewater Treatment Facility (Photo Taken June 2007)

Influent Flows

Flow volumes entering the treatment system can be inferred from total volume data reported by equipment at the G Street Lift Station as recorded by operations personnel. From those data, flow into the WWTF varies by season with low flows during winter months and significantly higher flows during the summer tourist season. Averaged weekly flows from January through October of 2016 are shown in **Figure 2**.

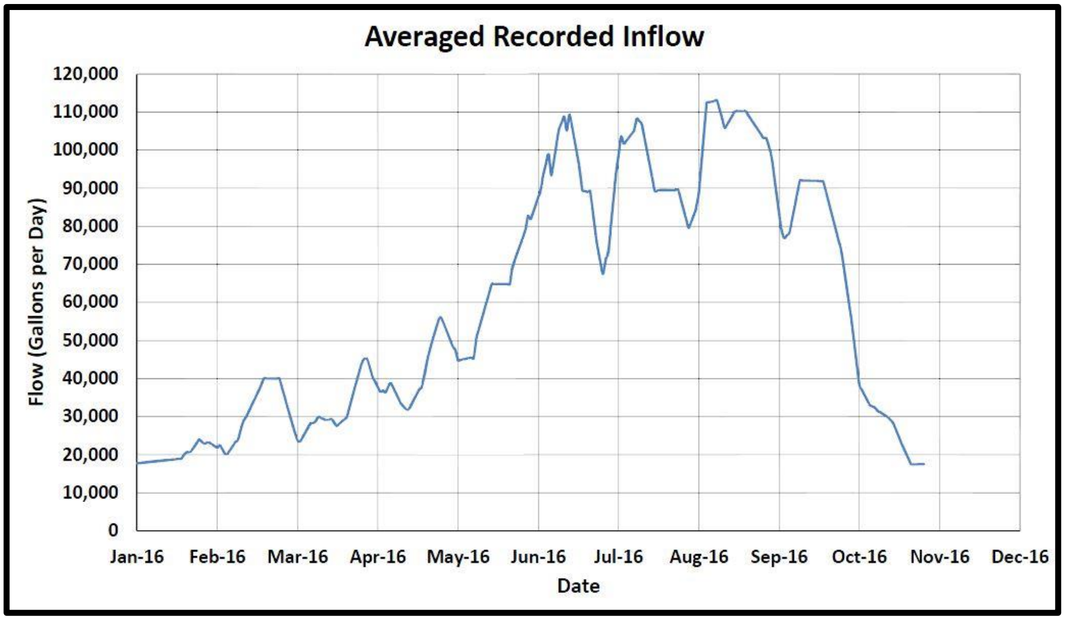

Figure 2: Influent Flows to the WWTF

Contributions to wastewater inflow to the WWTF are assumed to be comprised of two sources. One is the *base inflow* generated by year-round residents of Talkeetna. The other is the *seasonal inflow* generated by both the tourism industry and inflow/infiltration (I/I) from spring melt and rain events. From the data, and for the purpose of this memo, the base inflow will be estimated as 20,000 gallons per day (gpd), and seasonal inflow will be estimated as 90,000 gpd in 2016. Adding the base inflow and seasonal inflow gives a peak inflow of 110,000 gpd for 2016.

Influent Loadings

For this memo, data on solids and/or organic loadings to the treatment facility was limited to monitoring and reporting completed for compliance with the facility's discharge permit. Grab samples for monthly discharge monitoring reports (DMR) are collected for each month the facility discharges to the slough. Available results for these monitoring events from 2014 through 2016, as well as permit limits are provided in **Table 1**. Highlighted cells indicate instances where permit requirements were not met.

To aid in future studies and analysis, MSB collected weekly composite samples of influent wastewater at the G Street Lift Station as well as grab samples from each of the three lagoons. Samples were measured for chemical oxygen demand (COD), biochemical oxygen demand BOD_5, Total Suspended Solids (TSS), dissolved oxygen (DO), ultraviolet transmissivity (UVT), and chlorine demand. Results of these samples will contribute to the design of future upgrades and analysis in the PER.

Table 1: Discharge Monitoring Report Results								
			Analyte					
			DO (mg/l)	BOD_5 (mg/l)	pH	TSS (mg/l)	FC (col/100 ml)
Permit Requirements			7-17	45 Max	6.5-8.5	70 Max	40 Daily Max
Discharge Month	**MAY**	2014	1.11	13.3	7-8	33.3	34
		2015	1.66	24.8	7.23	20.8	62
		2016	3.6	17.4	8.5	18	ND
	JUNE	2014	9.68	40.6	7.5	68.6	14
		2015	5.69	35	7.78	41	510
		2016	11.45	15.4	7.5	12.7	160
	JULY	2014	4.25	35.2	7.94	56	70
		2015	5.96	43.3	7.47	50	290
		2016	8.81	35.2	8.5	ND	410
	AUGUST	2014	2.73	22.9	7.31	42	1,130
		2015	5.7	26.6	7.49	37.9	3,100
		2016	7.13	14.4	7.43	5.5	54
	SEPTEMBER	2014	2.7	29.8	7.6	28	1,050
		2015	11.18	26.2	7.92	41	73
		2016	ND	11.3	ND	17	27
	OCTOBER	2014	ND	ND	ND	ND	ND
		2015	8.19	14	7.68	17	128
		2016	ND	13.3	ND	7	9
							*ND= NO DATA

The Tabulated DMR values indicate the facility is consistently unable to meet permit requirements for fecal coliform and dissolved oxygen. Furthermore, while the table indicates that the effluent typically satisfies BOD_5 and TSS concentration requirements, there were 3 instances between 2014 and 2016 where the facility did not meet the 65 percent removal requirement of the permit. For one of those instances, in June of 2014, the facility did not meet BOD_5 or TSS percent removal.

FUTURE CAPACITY REQUIREMENTS

When addressing the Talkeetna WWTF deficiencies, it is important to consider both population and tourism growth to ensure that potential facility upgrades are capable of meeting existing permit limits.

Projections for year-round population growth of Talkeetna used herein are derived from the Alaska Department of Labor and Workforce Development 2014 report *Alaska Population Projections 2012 to 2042*. That document suggests, as a baseline projection, the statewide population will grow from 770,000 to 897,000 between 2016 and 2036, an increase of approximately 16%. By applying this same increase to the estimated 2016 base wastewater flow, the 2036 base flow can be estimated at approximately 23,000 gpd.

Projections for tourism visitation to Talkeetna are derived from the Talkeetna Community Tourism Plan. Those data report the number of people visiting Talkeetna in 2016 was 248,000. Using a 2.06% growth rate in tourist visitations, which is the average state-wide tourism growth rate reported by the Alaska Visitor Statistics Program, the projected number of visitors to Talkeetna in year 2036 would be 351,000, an increase of 41 percent over the 20-year time interval. By applying this same increase to the estimated 2016 seasonal wastewater flow, the 2036 seasonal inflow is estimated at approximately 127,000 gpd.

Adding the projected base and seasonal flows gives a peak flow of approximately 150,000 gpd in 2036. This compares with year 2016 peak flow of 110,000 gpd and equates to an approximately 36% increase over existing. Existing design flows, actual flows, and 20-year design flows are summarized in **Table 2** below.

Table 2: Peak Influent Flow Rates

	Existing Design	Current Year (2016)	20-Year Design (2036)
Base Flow (Residential)	N/A	20,000 gpd	23,000 gpd
Seasonal Flows (Tourism and I/I)	N/A	90,000 gpd	127,000 gpd
Base Flow + Seasonal Flow	42,000 gpd	110,000 gpd	150,000 gpd

As shown above, the facility is receiving nearly three times the design capacity during peak flow periods. As residential and seasonal visitors increase over time, the system will become increasingly overloaded.

FACILITY LOADINGS

In addition to hydraulic loadings, the ability of the WWTF to routinely comply with regulatory criteria is dependent upon the solids and organic loadings anticipated into the future. Estimates of these future loadings are addressed in the following paragraphs.

Organic Loading

As previously stated, data from DMRs was used to approximate organic loadings to the WWTF. These data represent grab samples of influent flow collected during the summer months. To aid in development of chosen alternatives during the later stages of this project, HDL assisted MSB with collection of additional treatment data at various points in the WWTF during the latter portion of their 2016 discharge. Due to the timing of this data collection, however, full results were not yet available and the following organic loading assumptions were made:

- **Year-Round Resident Loading -** A value of 0.17 lbs of BOD_5 per capita per day is commonly reported for municipal sewage and is assumed to be the BOD_5 contribution from year-round residents. For a projected year 2036 permanent population of 1,218 people, this equates to a daily resident population loading of 207 pounds of BOD_5 per day.

- **Seasonal Tourist Loading -** A value of 0.06 lbs of BOD_5 per capita per day is assumed to be the BOD_5 contribution from summer visitors to Talkeetna, occurring from June 1st to October 1st. This value represents approximately one third the daily per capita contribution and may be suitable for representing contributions from tourists visiting Talkeetna for only part of a day. For a projected year 2036 tourist visitor count of 351,000 people in 4 months, or an average of 2,925 visitors per day, this equates to a daily visitor loading of 176 pounds of BOD_5 per day during the summer season.

Solids Loading

As with organic loadings, assumptions of solids loadings for both year-round residents and seasonal visitors have been made per the following.

- **Year-Round Resident Loading -** A value of 0.20 lbs of TSS per capita per day is commonly reported for municipal sewage and is assumed to be the solids contribution from year-round residents. For a projected year 2036 permanent population of 1,218 people, this equates to a daily resident population loading of 243 pounds of TSS per day.

- **Seasonal Tourist Loading -** A value of 0.06 lbs of TSS per capita per day is assumed to be the solids contribution from summer visitors to Talkeetna, occurring from June 1st to October 1st. For a projected year 2036 tourist visitor count of 351,000 people in 4 months, or an average of 2,925 visitors per day, this equates to a daily visitor loading of 176 pounds of TSS per day.

Table 3 below summarizes anticipated design organic loadings to the WWTF.

Table 3: Future BOD_5 and TSS Loadings

	Organic Loading		Solids Loading	
	Resident Loading	Seasonal Tourist Loading	Resident Loading	Seasonal Tourist Loading
20-Year Design (2036)	207 lb/day	176 lb/day	243 lb/day	176 lb/day

UPGRADE ALTERNATIVES ANALYSIS

Five possible WWTF upgrade alternatives are presented below. Based on this memo, MSB will select two alternatives to further analyze in a preliminary engineering report. The following section presents candidate upgrades to meet the design criteria listed in the previous sections.

Each alternative must meet the following site constraints:

- ✓ Occupy a footprint small enough to be accommodated on the parcel of land on which the treatment facility is located (Approximately 40 acres);
- ✓ Provide adequate separation distance between the treatment facility and nearby neighbors;
- ✓ Meet regulatory requirements for vertical separation between treatment structures and high groundwater for the area;
- ✓ Have the capability to withstand flood events without loss of functionality.

In addition to the foregoing, each treatment alternative upgrade must meet the following objectives:

- ✓ Meet the regulatory stipulations outlined in the WWTF discharge permit;
- ✓ Discharge seasonally into the slough May through October,
- ✓ Provide treatment for a 20 year planning horizon;
- ✓ Be configured as needed to secure ADEC approval for construction.

Candidate Upgrades

As part of the initial alternative screening process, expanding the existing treatment wetlands was considered as a possible solution. To accommodate projected future flows, recommended hydraulic loading rates for effective wetland treatment require up to 10 times the land area occupied by the existing wetland area. Additionally, wetland treatment for FC removal is highly variable and cannot be counted on to consistently meet the existing limits of 20 and 40 FC/100 mL for monthly average and daily maximum values, respectively, as required by the current discharge permit. Several sources suggest that wetland treatment effluents should not be counted on to consistently produce FC concentrations less than 500 FC/100 mL. Based on these treatment limitations, the following alternatives all include the removal of the existing treatment wetlands.

The five alternative upgrades reviewed for this memorandum include:

1. Expand Facultative Lagoon per ADEC Guidelines;
2. Expand Facultative Lagoon per Canadian Guidelines;
3. Partially Mixed Aerated Lagoon Treatment;
4. Extended Aeration Activated Sludge Lagoon Treatment;
5. Mechanical Treatment Plant.

These options are described further below and compared in a table on Page 18 of this memo.

Alternative 1: Expand Facultative Lagoon per ADEC Lagoon Construction Guidelines

Expanding the existing lagoons will allow for adequate removal of TSS and BOD_5 as population expands and wastewater inflow increases; however, to achieve DO and fecal coliform requirements supplemental aeration and disinfection will also need to be included.

The ADEC Lagoon Construction Guidelines utilize the treatment process currently in place where wastewater is treated using facultative pond cells operating in series. Wastewater flows into the primary pond where solids settle, then flow into the secondary pond where further TSS and BOD_5 removal takes place.

The ADEC Guidelines require the facility be sized for annual retention of influent wastewater with seasonal discharge during summer months. In addition, rain and snow falling on the ponds must be factored into the size of the ponds. Further, the ponds themselves must be sized according to the anticipated organic loading to the WWTF. With the required geometric configurations of earthen embankments and operating water depths, the footprint of the overall treatment facility is approximately 24 acres. This compares to the existing 3-cell facility which is approximately 8 acres (excluding wetland treatment area).

In addition to the physical size of the upgraded lagoon being approximately 3 times larger than the existing facility, the distance from the current lagoon to existing occupied buildings shown in **Figure 3** is less than the ADEC minimum recommended distance of 1,000 feet. Expanding the treatment area to 24 acres would further decrease this separation distance.

Figure 3: Separation Distance Between Existing Lagoon and Occupied Building

Additional Treatment Addressing Effluent DO and FC's

Effluent DO

Because of the nature of facultative lagoons, additional modifications to the treatment process will be required to meet prescribed limits of the existing ADEC discharge permit. Options for corrective action that improve effluent DO values are listed and screened in **Table 4**.

Table 4: Option Screening for DO Compliance

	Option	Advantage	Disadvantage
A	Request a mixing zone in the slough large enough to enable compliance with effluent DO requirements	No mechanical power or equipment required for treatment	River is designated as habitat for salmon and likely unavailable for mixing zone
B	Deploy in-pipeline aeration of effluent	Easy access to mechanical aeration equipment	1. Best done with full pipe flow which is not available with existing outfall 2. Requires mechanical aeration equipment
C	Include reaeration in final cell	Easy access to mechanical equipment.	1. More air supply required for facultative pond effluent than for wetland treatment effluent. 2. Requires seasonal pigging of effluent outfall pipe between third cell and slough

Options B and C in **Table 4** provide compliance with regulatory effluent DO concentrations; however C is the preferred option.

Fecal Coliforms

Consistent regulatory compliance with Talkeetna's existing discharge permit for FCs is likely only possible by deployment of an effluent disinfection process. Options for corrective action that improve effluent FC concentrations are listed and screened in **Table 5**.

Table 5: Option Screening for FC Compliance			
	Option	**Advantage**	**Disadvantage**
A	Effluent disinfection using Chlorination/De-chlorination	1. Effective in controlling regulated pathogens 2. Simple technology and equipment 3. Low power consumption	1. Requires chlorine contact reactor tank and mechanical mixer 2. Requires periodic draining and flushing solids out of contact tank 3. Requires chemicals for chlorination and de-chlorination 4. Requires chemical storage 5. Requires online analyzer instrumentation to monitor and report chlorine residual 6. Requires periodic pigging sample line to online analyzer
B	Effluent disinfection using UV Disinfection	1. Effective in controlling regulated pathogens 2. No chemicals added to effluent 3. No chemical storage required 4. Small footprint as no mechanical mixer or contact tank required	1. Requires electrical power for lamp operation 2. Requires periodic lamp sleeve cleaning, though can be automated 3. Requires periodic lamp replacement

As previously stated, MSB is in the process of performing a variety of data collection efforts, including ultraviolet transmittance testing (UVT) on effluent wastewater from Cell 3. Provided UVT levels are conducive, UV disinfection is the preferred process.

Figure 4 shows a conceptual configuration for this alternative including disinfection and aeration equipment.

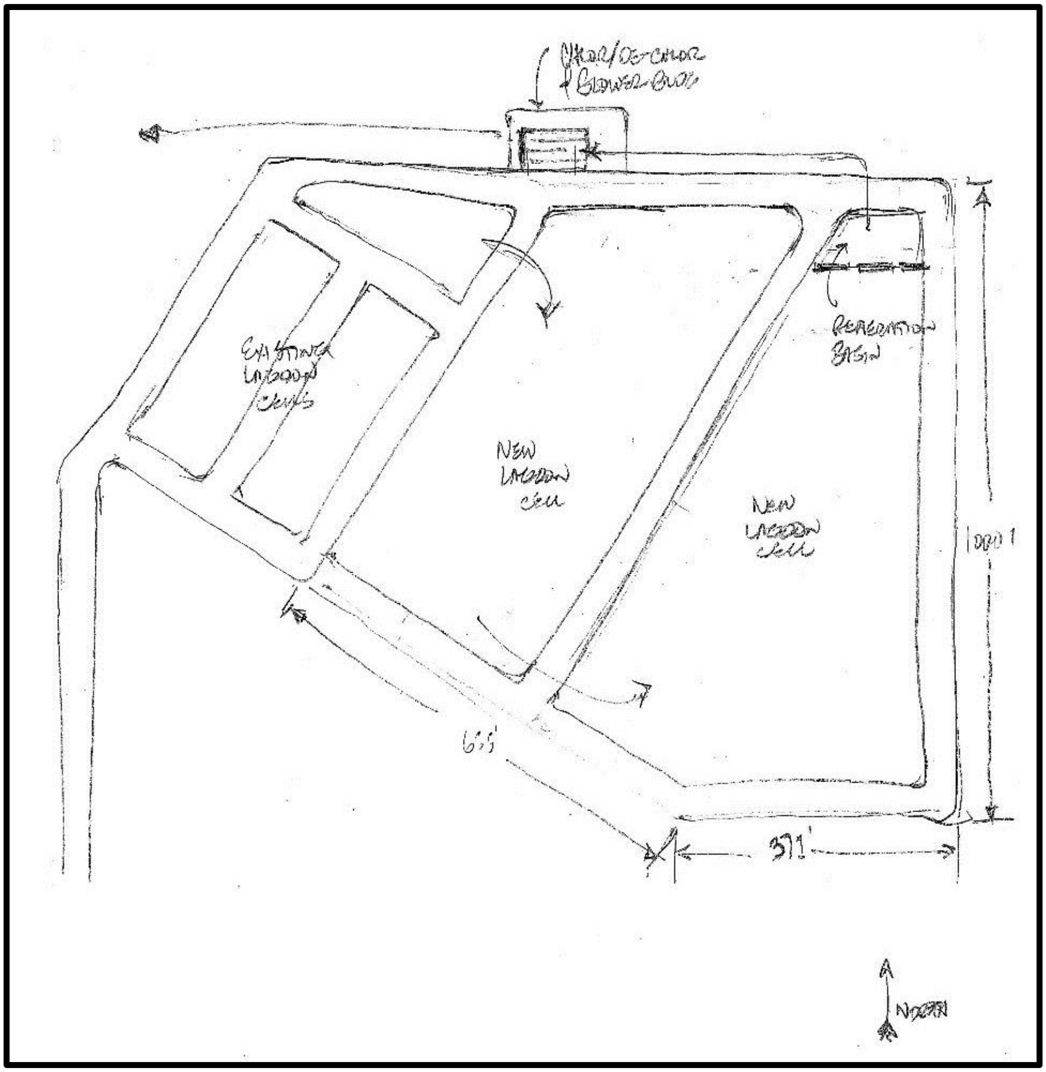

Figure 4: Conceptual Layout for Alternative 1- Lagoon Upgrade per ADEC Guidelines

Alternative 2: Expand Facultative Lagoon Per Canadian Guidelines

The following evaluates the option of upgrading the existing facultative lagoon treatment system utilizing a configuration and operation which complies with Canadian standards, and not necessarily with the ADEC guidelines for lagoon construction.

Since 1982, the Canadian Province of Alberta has been proactive in its research of lagoon performance for 190 facultative lagoons in Alberta operating in climatic environments not dissimilar to that of Talkeetna. The Province's Ministry of Environment and Parks is the agency which maintains and updates design and operational standards for facultative lagoon treatment systems. Based on published data from the University of Alberta, Edmonton, lagoon systems configured and operated according to provincial standards are able to meet Talkeetna's permit limits for BOD_5 and TSS. Effluent FCs are reported to be below 30 most all the time, but with excursions that would require supplemental disinfection. Effluent DO is not addressed by the Canadian research, and it is assumed that effluent reaeration would be needed.

The configuration for this alternative includes the addition of two anerobic lagoon cells, and one storage cell to the existing system, as well as a reaeration basin in the final storage cell and a chlorination/dechlorination building. A conceptual sketch of the configuration and flow process including reaeration and disinfection is shown in **Figure 5.** Water flows into the anerobic cells, then through the existing 3 cells, to the storage cell. From the storage cell treated water is directed to the reaeration basin, then to the disinfection building and finally discharged to the slough. Based on required depths and flow rates through each cell, using 3:1 horizontal to vertical side slopes, the footprint of the facultative lagoon would be approximately 15 acres. Similar to Alternative 1, this alternative would significantly reduce the separation distance between lagoons and the nearest occupied buildings.

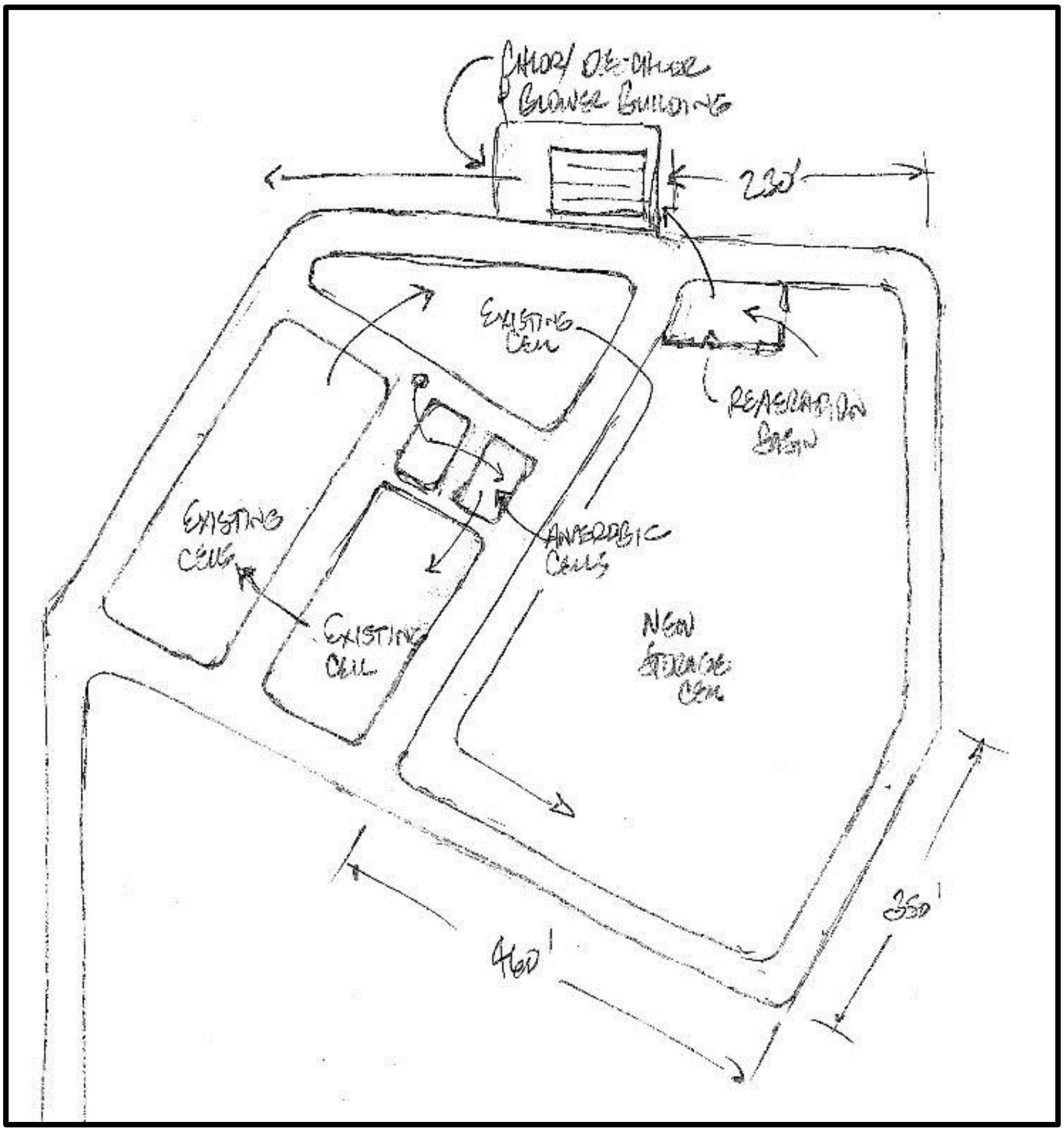

Figure 5: Conceptual Layout for Alternative 2 - Lagoon Upgrade per Canadian Guidelines

Alternative 3: Partially Mixed Aerated Lagoon Treatment

Another treatment option is deployment of a partially mixed aerated facultative lagoon treatment system. These types of treatment facilities are in use within Alaska operating on municipal wastewater at Palmer, Wasilla, Nome, and North Pole.

In summary, for this process raw sewage would be directed in series to a sequence of aerated lagoon cells prior to effluent disinfection and seasonal discharge to the slough. Properly sized, configured, and maintained with periodic sludge solids removal, these types of facilities are able to routinely achieve the effluent quality stipulated in the current Talkeetna APDES permit. This alternative requires periodic sludge removal once every 5-10 years. Sludge removal is typically accomplished with floating dredges discharging sludge into either a mechanical dewatering process or a geotube.

To minimize the introduction of large debris into the lagoon cells, preliminary treatment equipment may be included upstream of the first lagoon cell. The location of this pretreatment equipment is often referred to as the headworks of the treatment system. The advantage of including headworks treatment is that sludge accumulation in the cells is slower and not hampered by large debris at the bottom of the cells.

Seasonal aeration of partially mixed lagoons can result in release of both odors and foam. Surface foam can be captured by the wind and transported off site. Foam formation is a product of oxidation of anoxic organic material released into the water column by aeration and/or seasonal pond turnovers. Odors released may last between several days to a few weeks depending upon the amount of sludge accumulated on the bottom of the aerated cells and the volume of air introduced for aeration. Continuous aeration would eliminate the odor issue.

Using 2036 loading criteria established previously and the foregoing configuration criteria, the footprint of a partially mixed facultative aerated lagoon system would be approximately 8 acres. Mechanical aeration blowers sized for 2036 loadings would be a pair of duty/redundant 30Hp blowers with VFD motor control equipment. While this alternative will also likely reduce the distance between lagoons and occupied buildings, it would be significantly less than Alternatives 1 and 2. A schematic of how this alternative could be configured for the existing site is illustrated in **Figure 6**.

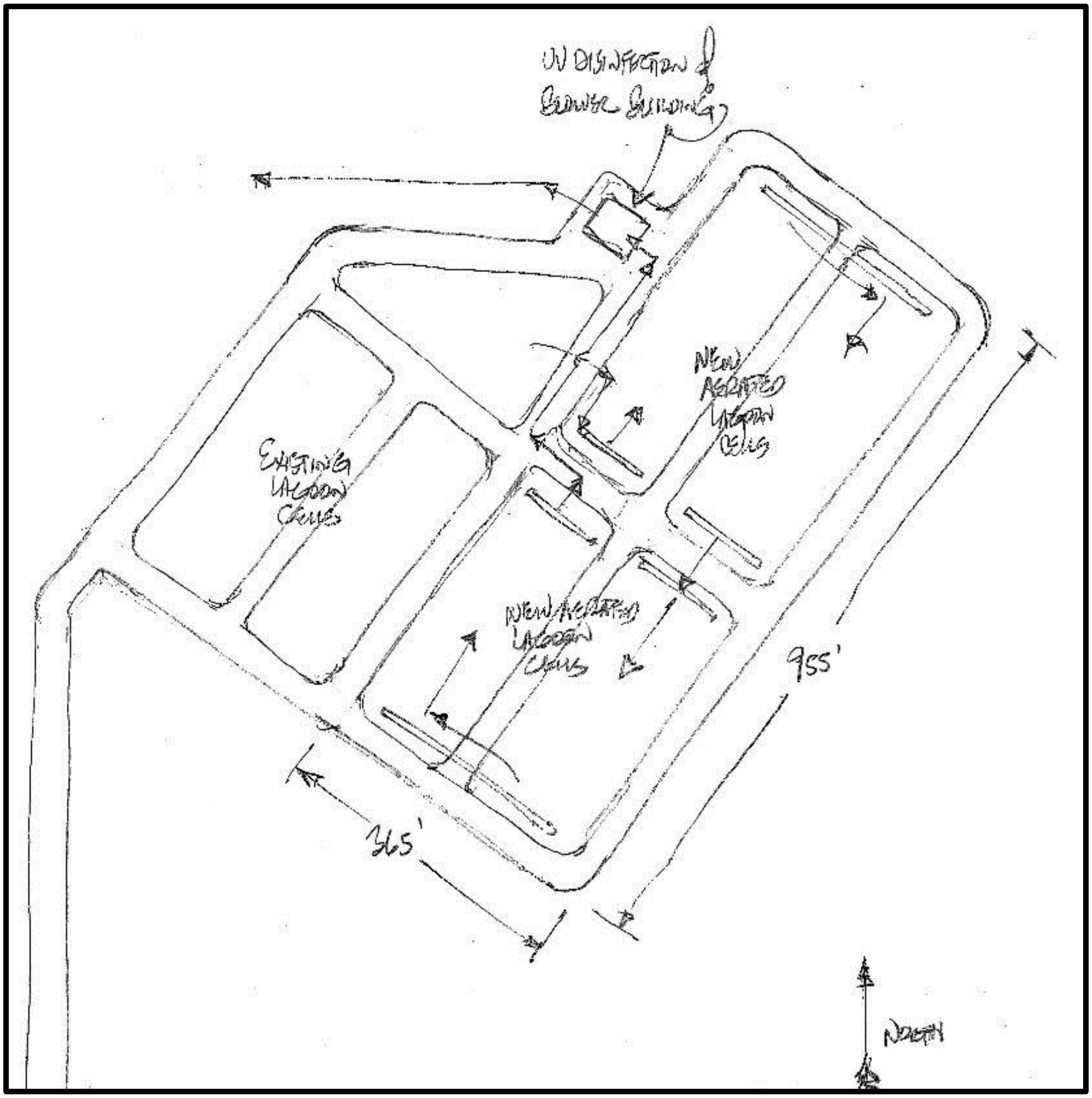

Figure 6: Conceptual Layout for Alternative 3 - Partially Mixed Aerated Lagoon Upgrade

Alternative 4: Extended Aeration AS Lagoon Treatment

Another wastewater treatment alternative for Talkeetna would be conversion of the existing facultative pond treatment system to a seasonally operated extended aeration activated sludge (AS) lagoon treatment system including effluent disinfection.

This treatment system would make use of a portion of one of the existing earthen diked ponds as a biological treatment reactor basin for an extended aeration AS process. The remainder of the existing ponds would be used to capture and store influent wastewater for subsequent seasonal treatment and discharge during the summer.

Instead of using the ponds for a combination of biological stabilization and sedimentation of solids, the lagoon AS process would use a separate clarifier for solids separation and return a portion of settled sludge to the aerated basin as required by the AS process. A conceptual drawing of the site configuration is shown in **Figure 7.**

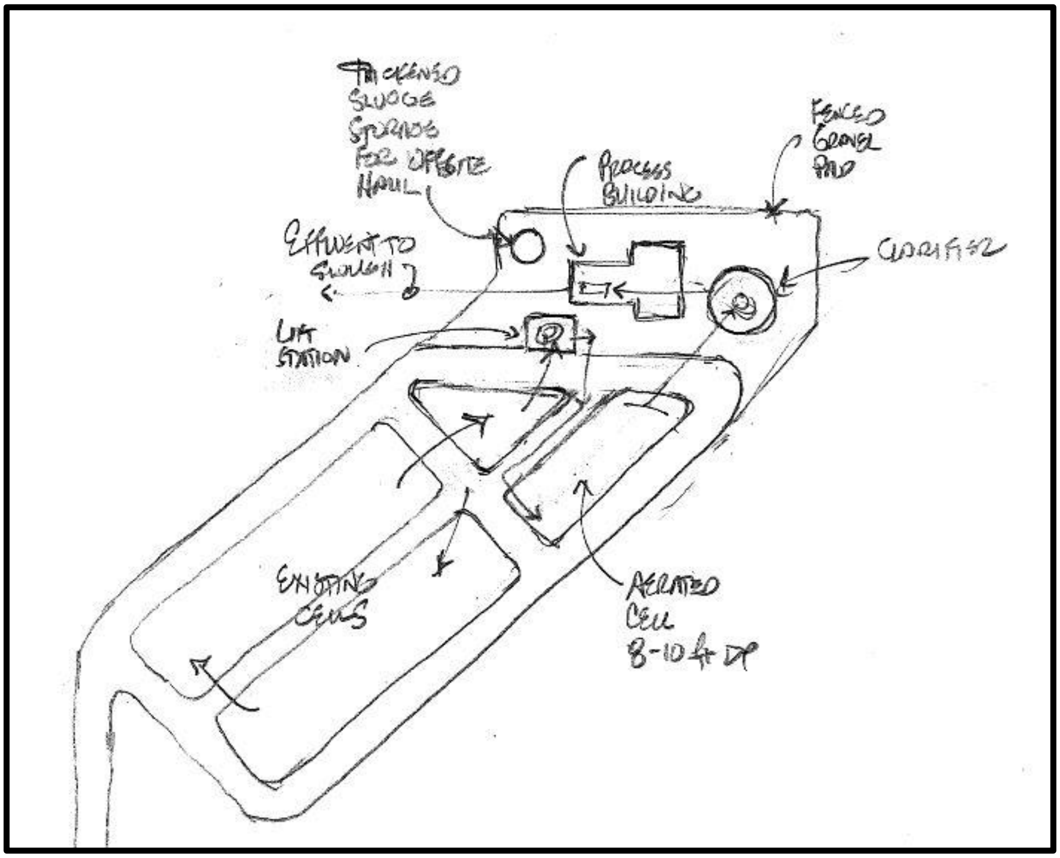

Figure 7: Conceptual Layout for Alternative 4 - Extended Air Activated Sludge Process

A schematic process flow diagram for this process is provided in **Figure 8** below.

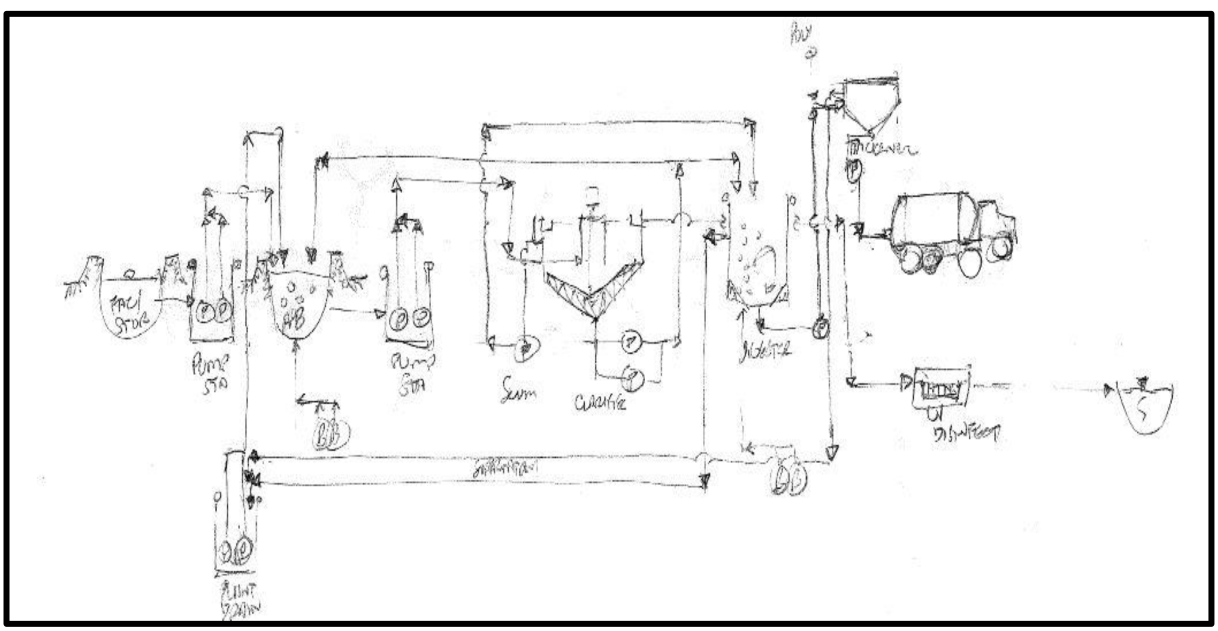

Figure 8: Schematic Flow Diagram for Alternative 4 - Extended Air Activated Sludge Process

For the foregoing treatment process, the footprint of the existing lagoon cells would remain the same and a new 3,500 square foot process building would be added. Additionally, a new circular clarifier and a small pump station to transfer wastewater to the new extended aeration treatment system would be needed. A conceptual building layout is provided in **Figure 9** below.

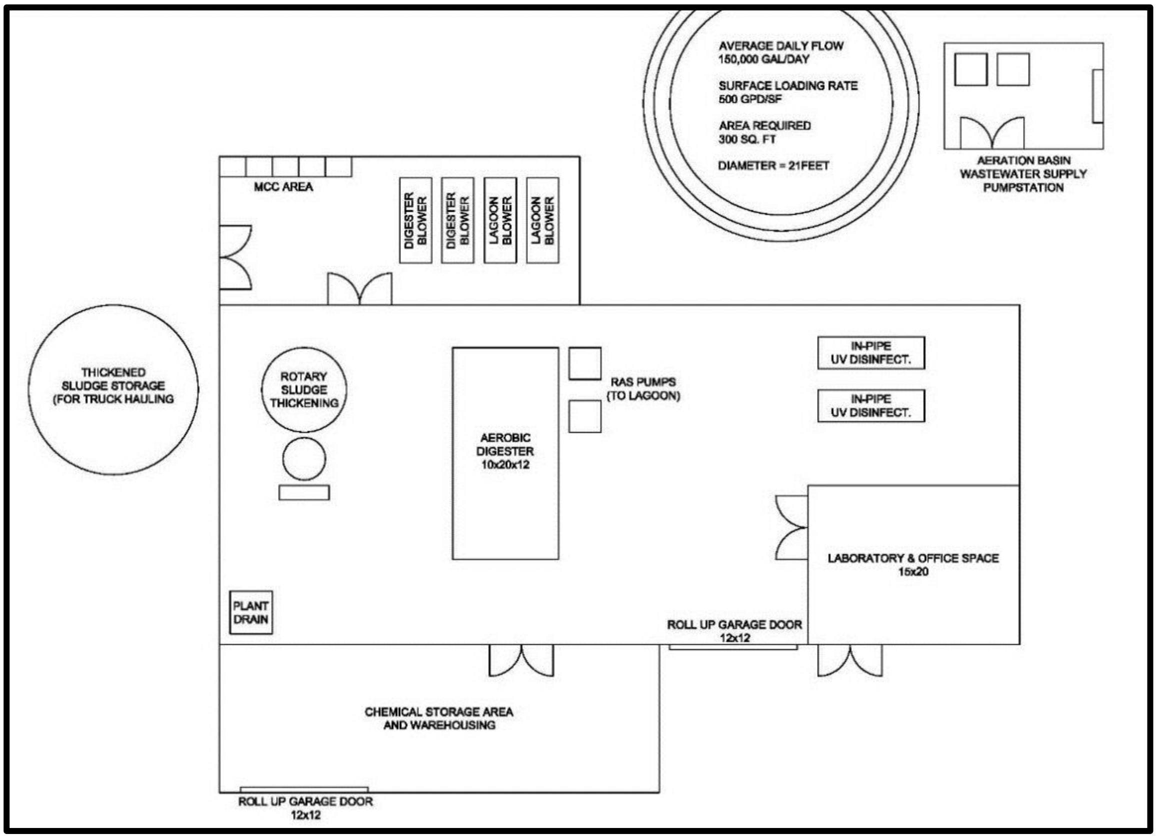

Figure 9: Conceptual Building Layout for Alternative 4 - Extended Air Activated Sludge Process

Alternative 5: Mechanical Treatment Plant

As with Alternative 4, this treatment alternative is also a seasonally operated system. Wastewater generated throughout the year would be directed to the existing three lagoon pond cells for storage. In summer, following ice melt and pond warming, stored wastewater would be withdrawn for treatment in a mechanical treatment plant. The mechanical treatment plant would be a membrane bioreactor (MBR) and includes disinfection and aeration. The MBR process occupies a smaller footprint relative to other mechanical processes, and can be largely automated to operate without continuous operator supervision. A schematic process flow diagram for this process is provided in **Figure 10**.

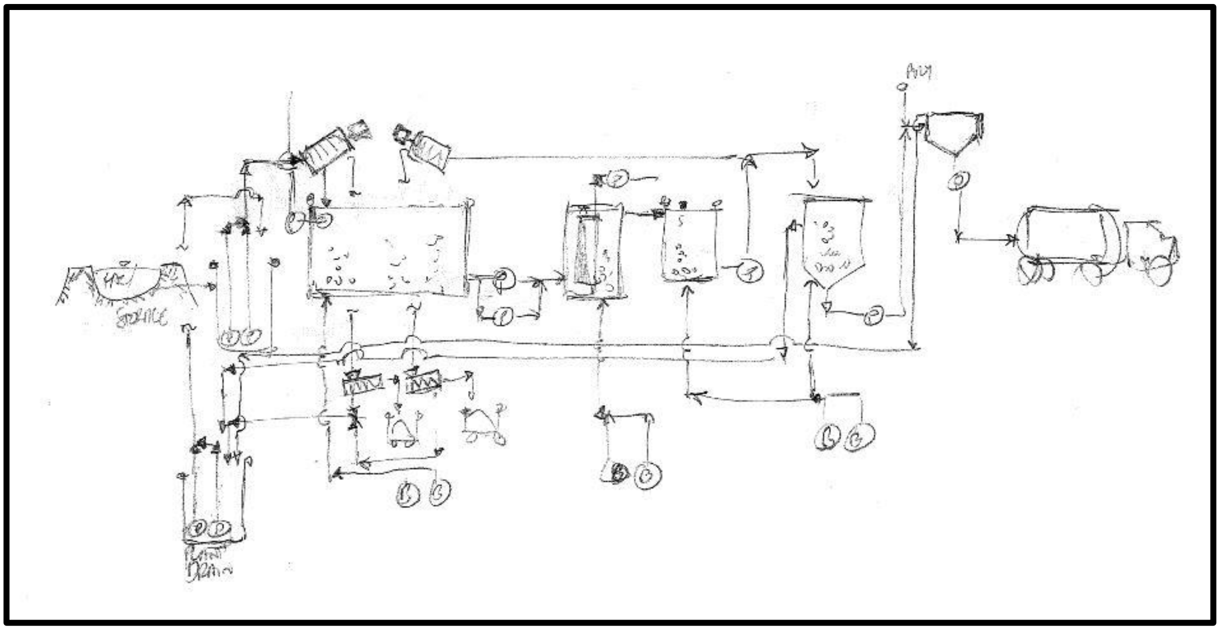

Figure 10: Schematic Flow Diagram for Alternative 5 - MBR Treatment Plant

For the foregoing treatment process, the footprint of the existing lagoon cells would remain the same. A new 5,000 square feet process building would be added to house the new MBR treatment system. A conceptual building layout is provided in **Figure 11**.

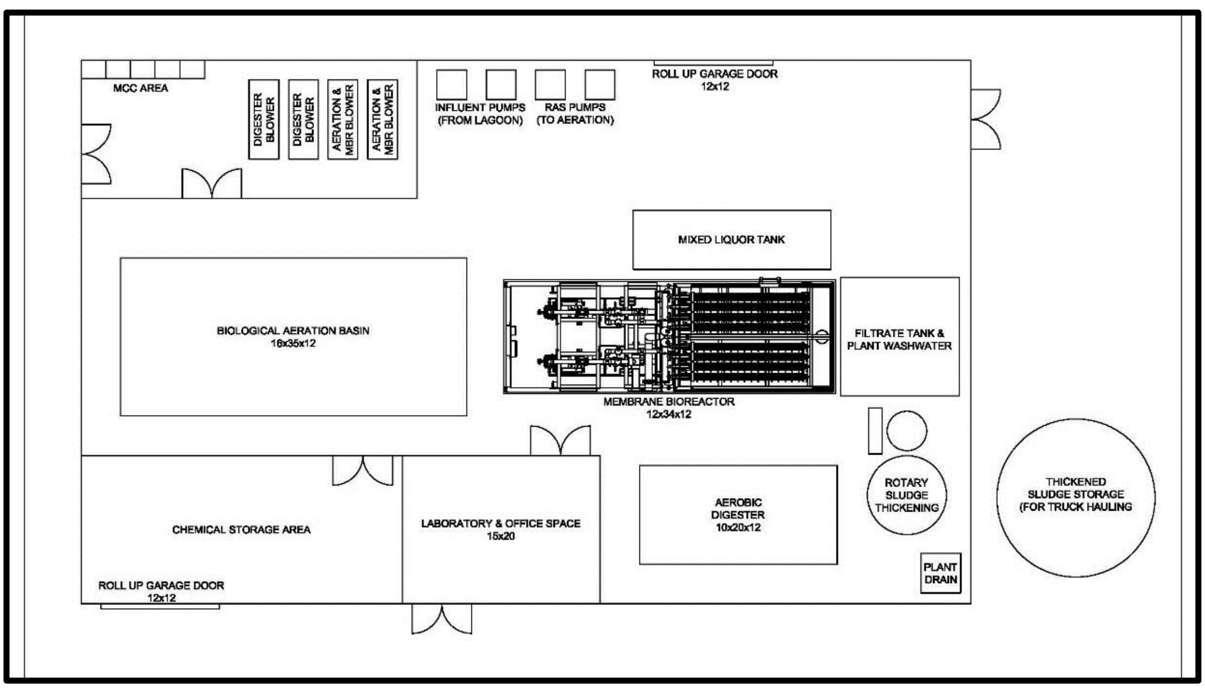

Figure 11: Conceptual Building Layout for Alternative 5 - MBR Treatment Plant

ALTERNATIVES COMPARISON

Table 6: Alternatives Comparison

	Alternative				
	1-Expand Facultative Lagoon per ADEC Guidelines	**2-Expand Facultative Lagoon per Canadian Guidelines**	**3-Partially mixed Aerated Lagoon Treatment**	**4-Extended Aeration Activated Sludge Lagoon Treatment**	**5-Mechanical Treatment Plant**
Footprint	29 Acres	15 Acres	8 Acres	No Change to Lagoon Basin Size, 3,500 SF Building	No Change to Lagoon Basin Size, 5,000 SF Building
Requires Supplemental Disinfection	Yes	Yes	Yes	Yes	No
Requires Supplemental Aeration	Yes	Yes	No	No	No
Operability	Same Process as existing, requires routine checks on aeration and disinfection equipment	Same process as existing, requires routine checks on aeration/disinfection equip	Less Intensive Than Option 4	Operator Intensive	Can be mostly automated, likely requires higher operator level
Constructability	Easy, unless wetland encroachment	Easy, unless wetland encroachment	Difficult	Moderate	Easy
Requires 3 Phase Power	No	No	Yes	Yes	Yes
Requires Solids Removal	No	No	YES (Dredge every 5-10 Years)	Yes	Yes
Construction Cost Ranking (1=Lowest 5=Highest)	3	2	1	4	5
O&M Cost	Low	Low	Mid	High	High

UPGRADE RECOMMENDATIONS

HDL presented upgrade alternatives to MSB staff in October 2016 upon which MSB directed HDL to further evaluate Alternatives 2 and 3. Furthermore, MSB has asked HDL to explore phasing options for each alternative, with the primary objective of the first phase to address dissolved oxygen and fecal coliform violations.

Chosen alternatives and possible phasing plans, complete with estimated construction and operation and maintenance costs will be further evaluated in a PER following United States Department of Agriculture, Rural Utilities Service Bulletin 1780-2 requirements.