Methane to Markets

Preliminary Assessment of the Opportunity for Methane Recovery from Wastewater at the Frigosinú SA Slaughterhouse, Monteria, Cordoba, Colombia

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Executive Summary

The Frigosinu SA slaughterhouse located in Monteria, Cordoba, Colombia was selected by the Methane to Markets program for an evaluation of the potential to reduce methane emissions. Methane is emitted from three lagoons used to pretreat wastewater before discharge to the municipal wastewater collection system. Methane is a greenhouse gas with the heat trapping capacity of approximately 21 times that of carbon dioxide. It appears that replacing the existing lagoons with a covered anaerobic lagoon followed by a settling/polishing pond is the most feasible option. By covering the anaerobic lagoon, methane, can be captured and used in place of natural gas or combusted to generate electricity. This mixture of methane and carbon dioxide that is captured from the lagoon is commonly referred to as biogas.

Considering the constraint of the area available for upgrading the existing lagoon system, we propose a lined and covered lagoon with an operating volume of 23,400 m^3, which would provide a hydraulic retention time (HRT) of 15 days. The covered lagoon would be followed by a lined settling/polishing pond with an operating volume of approximately 15,400 m^3, which would provide an additional HRT of 10 days. The covered lagoon should produce approximately 1,478 m^3 of biogas methane per day with an estimated heating capacity of 48.2 million Btu per day.

Given Frigosinú Monteria's requirements for electricity and natural gas as a boiler fuel, there are three possible options for use of the biogas captured from the covered lagoon. The potential uses are: 1) a boiler fuel in place of natural gas, 2) fuel for an internal combustion engine to generate electricity, or 3) fuel for an internal combustion engine to generate electricity with engine waste heat recovery for preheating water. The results of our preliminary assessment of options for biogas use are summarized below.

Table ES-1. Assessment of Options for Biogas Use at Frigosinú Monteria.

Biogas Use Option	Facility Energy Replacement Potential	Estimated Value, pesos/day
Boiler fuel	~ 50 % of 2008 natural gas use	1,058,500
Electricity generation w/o waste heat recovery	~ 33 % of 2008 electricity use	1,543,828
Electricity generation with waste heat recovery	~33 % of 2008 electricity use and ~22 % of 2008 natural gas use	1,543,828 476,532 2,020,360

This assessment is based on the assumption that all of the biogas can be used as it is produced. Given that it is probable that there are time-of-day and day-of-week variations in the demand for both natural gas and electricity, base load demand will have to be determined. If there are periods of time when the supply of biogas exceeds the demand as a replacement for natural gas, short-term biogas storage could be an option.

Based on the summary presented in Table ES-1, use of biogas to generate electricity with waste heat recovery using a 200 kW engine-generator set appears to be the more attractive option financially. However, interconnection with the electric utility will be necessary so that Frigosinú Monteria can purchase electricity during periods when the biogas fueled engine-generator set is off line for maintenance and repairs, and can sell electricity during periods when electricity generation exceeds on-site demand. Before a decision concerning biogas use can be made, the tradeoff between the added revenue minus the associated operation and maintenance costs and the additional capital cost of the engine-generator set should be analyzed. All biogas use options will require gas processing to reduce the moisture and hydrogen sulfide concentrations prior to combustion.

Introduction

The Frigosinú SA slaughterhouse, located in Monteria, Cordoba, Colombia, is a beef cattle slaughtering operation. Currently, an average of 750 animals is processed per day producing carcass halves, vacuum-packed single cuts, and other products such as tripe. In addition, rendering, blood drying, and hide salting operations are located on-site. There are plans for eventual expansion to allow processing of up to 1,200 animals per day.

Currently, all liquid wastes from the cattle holding pens and the slaughtering, rendering, and blood-drying operations are combined, screened and discharged into a series of three lagoons. The effluent from the final lagoon is discharged into the municipal wastewater collection system for further treatment and disposal. This three-lagoon pretreatment system was designed for a 400 head capacity slaughterhouse without rendering, blood drying, or hide salting operations. When this three-lagoon system was designed, it was intended to be an anaerobic lagoon followed by a facultative lagoon and then an aerobic lagoon. However, increased wastewater-flow resulting from expansion of the size and scope of Frigosinú's Monteria operation has compromised the operation of the system, resulting in the deterioration of effluent quality and an increase in discharge cost. Thus, any further expansion of the Frigosinú Monteria operation is constrained until the existing wastewater pretreatment system is upgraded.

Because of the high strength of meat and poultry processing wastewaters, use of anaerobic pretreatment processes, such as conventional anaerobic lagoons, have been used for many years especially in temperate, subtropical, and tropical climates. Where adequate land is available, conventional anaerobic lagoons are particularly attractive because of relatively low construction and operating costs. However, conventional anaerobic lagoons are a source of methane emissions to the atmosphere. Methane is a greenhouse gas with approximately 21 times the heat trapping capacity of carbon dioxide. With the need to upgrade their wastewater pretreatment system, Frigosinú Monteria has the opportunity to reduce future methane emissions during the anaerobic pretreatment of their wastewater through the capture and use of the methane being produced. In addition, there is the opportunity to reduce purchases of electricity or natural gas or both.

This report was prepared to present an option of upgrading the existing three lagoon system with an ambient temperature covered anaerobic lagoon with biogas capture followed by an open settling/polishing pond. The information used in the development of this report was obtained during a site visit by RCM International and subsequent discussions with Frigosinú Monteria personnel.

Wastewater Sources

At Frigosinú Monteria, wastewaters from the following operations are combined prior to pretreatment:

1. Holding pens
2. Slaughtering
3. Paunch manure solids separation
4. Evisceration and carcass cut-up
5. Rendering
6. Blood drying
7. Sanitary wastes

Holding pen manure and paunch manure collected during evisceration is liquefied and pumped to a screw press for removal of the coarse solids. These solids are then dried and bagged in preparation for sale. The liquid effluent from the screw press is then combined with the other wastewater streams.

In the slaughtering, evisceration, and carcass cutup areas of the Monteria plant, there are screens on floor drains to collect larger particles of soft tissue and bone, which are rendered with other solid wastes from the evisceration and carcass cutup processes. Blood is collected for the production of dried blood but some unavoidable loss occurs and becomes a wastewater constituent. Wastewater from the rendering operation includes water used for equipment and facility sanitation as well as water from a scrubber used for odor control.

Wastewater Volume

Frigosinú Monteria estimates the rate of water use to be 1.1 m^3 per head slaughtered based on the volume purchased from the local municipality. However, data supplied by Frigosinú indicates an average rate of discharge to the municipal wastewater collection system of 1.3 m^3 per head slaughtered (Table 1) with well water used for the odor control scrubber in the rendering area being responsible for the difference. This rate of water use is comparable to average use in similar U.S. slaughterhouses (U.S. Environmental Protection Agency, 2002).

Table 1. Recent Water Use at Frigosinú Monteria.

2008	**Daily Kill**	**Live Weight Killed, kg/day**	**Water Use, m^3 per Day**	**Water Use, m^3 per Head Killed**
June	532	252,700	826.5	1.55
July	679	322,525	794.38	1.17
August	631	299,725	789.23	1.25
September	635	301,625	691.2	1.09
Average	—	—	—	1.27

Frigosinú Monteria reported that as expansion occurred and daily kill increased from 400 to the current 750 head per day, water use per head killed has remained relatively constant to control cost. Therefore, it seems reasonable to assume the water use per head killed will not increase when expansion to the processing capacity of 1,200 head per day eventually occurs.

Wastewater Characteristics

Table 2 provides an overview of Frigosinú Monteria's wastewater characteristics from October 2003 through October 2008. Given the nature of the processes generating this wastewater, the observed degree of variability is not surprising. It is noteworthy that there was no marked change in the wastewater characteristics listed in Table 2 with an increase from 400 to 650 head of cattle slaughtered per day. In comparison with similar U.S. Slaughterhouses (U.S. Environmental Protection Agency, 2002), the five-day biochemical oxygen demand concentrations (BOD_5) are low.

Table 2. Overview of Frigosinú Monteria's Wastewater Characteristics Over Time.

Parameter	**Oct-03**	**Dec-05**	**May-06**	**Jun-06**	**Feb-07**	**Nov-07**	**Oct-08**	**Average**
Biochemical oxygen demand, 5- day, mg/L	2,938	5,190	3,765	2,278	852	1,937	1,393	2,622
Chemical oxygen demand, mg/L	5,419	3,032	4,047	4,970	4,003	4,194	4,891	4,365
Total dissolved solids, mg/L	3,341	1,596	5,90	2,100	1,470	1,740	1,642	1,783
Oil and grease, mg/L	—	1,662	239	2,17	1,478	580	3,660	1,306
pH	—	8.0	8.1	8.8	—	—	7.9	8.2
Temperature, °C	34.8	31.4	29.2	—	—	—	35.5	32.7

Current Wastewater Treatment System Performance

The wastewater generated at Frigosinú Monteria's beef cattle slaughterhouse currently is treated in a series of three lagoons before discharge to a municipal wastewater collection system (Figure 1, p. 15). The first lagoon (Picture 1), which was designed to be a conventional anaerobic lagoon, has a design operating volume of 5,777 m^3. The second lagoon, which was designed to operate as facultative lagoon, has an operating volume of 12,905 m^3. The third lagoon, which was designed to operate as an aerobic polishing pond, has an operating volume of 2,806 m^3. Thus, the existing three-lagoon system has a combined operating volume of 21,488 m^3. Assuming a slaughter rate of 650 head per day and a wastewater generation rate of 1.3 m^3 per head slaughtered, the hydraulic retention time (HRT) in the existing treatment system is approximately 25 days. With the anticipated ultimate increase in the slaughter rate to 1,200 head per day, the HRT will be reduced to between 13 and 14 days.

Picture 1: First Lagoon at Frigosinú

Picture 2: Second Lagoon at Frigosinú

Table 3 indicates recent system performance based on results from one day of sample collection and analysis. Before entering the first lagoon, the combined flow of wastewater passes through a stationary screen and grease trap (Picture 3). As shown in this table, the stationary screen and grease trap substantially reduces the concentrations of BOD_5, chemical oxygen demand (COD), suspended solids (SS), and oil and grease (O&G) entering the first lagoon. The overall reductions in BOD_5, COD, SS, and O&G concentrations through the three lagoon system are reasonably good even though the operating volumes of the first and second lagoons, and thus the HRTs, have been reduced substantially due to accumulation of settled solids. With the ultimate expansion of processing capacity to 1,200 head of beef cattle per day, the deterioration of treatment system performance to an unacceptable level is highly probable.

Table 3. Frigosinú Monteria's Wastewater Characteristics from an October 2008 Sampling Episode.

Parameter	**Stationary Screen Influent**	**Primary Lagoon Influent**	**Secondary Lagoon Influent**	**Tertiary Lagoon Influent**	**Tertiary Lagoon Effluent**	**Reduction Through the Three Lagoon System**
Biochemical oxygen demand, 5-day, mg/L	2,511	1,393	312	134	128	91%
Chemical oxygen demand, mg/L	7,192	4,891	1,294	1,942	1,438	71%
Suspended solids, mg/L	2,090	1,642	628	12	228	86%
Nitrate, mg/L	0.34	0.16	<0.02	<0.02	0.1	50%
Orthophosphate, mg/L	7.50	17.5	30.5	23.0	25.0	-43%
Sulfur, mg/L	ND	ND	20.5	ND	ND	—
Oil and grease, mg/L	8,334	3,660	702	1,243	784	79%
Detergent, mg/L	9.56	9.24	4.85	5.11	9.0	3%
pH	—	7.91	6.99	7.66	7.71	—
Temperature, °C	—	35.3	32.6	30.9	31.1	—

Picture 3: Stationary Screen

Options for a Wastewater Treatment System Upgrade

The Frigosinú Monteria wastewater pretreatment system needs to be upgraded to avoid excessive discharge fees in the future. Given the high strength of this wastewater, the continued use of some form of anaerobic treatment is the most attractive general approach. By continuing the use of an anaerobic process, energy requirements and cost will continue to be minimal and the opportunity to capture a usable form of energy, biogas, becomes available. The biogas that is produced during the anaerobic treatment of wastewater is the end product of the microbial degradation of complex organic compounds. It is a mixture of methane and carbon dioxide and can be used to generate electricity or as a boiler fuel in place of a fossil fuel such as natural gas.

A number of options are available for the anaerobic pretreatment of slaughterhouse wastewater. The options considered are an upflow anaerobic sludge blanket (USAB) and similar processes, conventional anaerobic lagoon, and covered anaerobic lagoons. Although the USAB and similar processes can be used to successfully pretreat slaughterhouse and other high strength wastewaters, the costs of construction and operation are higher than those for lagoons. In addition, USAB and similar processes are more operationally complex and require a more intensive management. Thus, the upgrading of the Frigosinú Monteria's wastewater pretreatment system by replacing the existing three-lagoon system with a covered anaerobic lagoon followed by a combination settling and polishing pond appears to be the most feasible option given that the necessary land is available. See Figure 2 for an overview of the proposed system upgrade.

Covered Lagoon Preliminary Process Design

Assumptions

Temperature—In temperate and subtropical climates heating anaerobic waste treatment reactors often is desirable to increase the rate of microbial degradation of complex organic compounds to biogas and thus reduces required reactor volume and cost. However, the tropical climate of Monteria and the temperature of the wastewater being generated (Tables 2 and 3) make the option of covered lagoon heating unnecessary.

Wastewater Volume and Characteristics—Although it is unclear when the final expansion of the capacity of the Frigosinú Monteria slaughterhouse to 1,200 head of beef cattle per day will occur, we recommend upgrading the current wastewater pretreatment system assuming that final expansion will occur. As discussed earlier, it appears reasonable to assume that the current wastewater generation rate of 1.3 m^3 per head slaughtered will not increase with any further increase in processing capacity. It also seems reasonable to assume that for preliminary design purposes the current wastewater characteristics will persist after the expansion. The assumptions regarding wastewater volume and characteristics and other process design parameters are summarized below.

Table 4. Assumed Values for the Preliminary Design of a Covered Anaerobic Lagoon for the Frigosinú Monteria Slaughterhouse Operation.

Design Parameter	Assumed Value
Maximum slaughter rate	1,200 beef cattle per day
Wastewater generation rate	1.3 m^3 per head slaughtered
Wastewater flow rate	1,560 m^3 per day
Average wastewater BOD_5 concentration	3 kg per m^3
Mass BOD_5 loading	4,680 kg per day
Wastewater temperature	30 °C
Covered lagoon temperature	30 °C
Design BOD_5 loading rate	0.32 kg BOD_5 per m^3-day
Design hydraulic retention time	15 days

The design BOD_5 loading rate is typical for anaerobic waste treatment processes in warm temperate to tropical climates. The design HRT is conservative providing a safety factor of 2.5.

Proposed Covered Lagoon Specifications

To provide an HRT of 15 days at the wastewater flow rate of 1,560 m^3 per day, a covered lagoon with an operating volume of 23,400 m^3 will be required. We propose a two-cell covered lagoon with a length to width ratio of approximately four-to-one to minimize short-circuiting of the lagoon influent. The two cells will be equal in volume and will be separated with an internal wall installed after the placement of the HDPE line. The design specifications and preliminary dimensions are listed in Table 5.

Table 5. Design Specifications and Preliminary Dimensions for a Covered Anaerobic Lagoon for the Frigosinú Monteria Slaughterhouse Operation.

Specifications	
Length to width	~4:1
Operating depth	6 m
Freeboard	0.5 m
Side slope	2 m horizontal per m vertical
Liner and cover	HPDE
Cover type	Bank-to-bank
Preliminary Dimensions	
Top width	38 m
Bottom width	14 m
Top length	160 m
Bottom length	137.6 m
Operating volume	23,376 m^3
Cover area	~6,080 m^2

Proposed Settling/Polishing Pond Specifications

Based on information provided by RCM International, it appears that space is available also to construct a 15,408 m^3 combination settling and polishing lagoon for addition treatment prior to wastewater discharge to the municipal system (see Figure 3). This lagoon, which will be uncovered, will have a HRT of approximately 10 days. The preliminary dimensions are listed in Table 6.

Table 6. Preliminary Specifications and Dimensions for a Combination Settling and Polishing Lagoon for the Frigosinú Monteria Slaughterhouse Operation.

Specifications	
Operating depth	6 m
Operating depth	6 m
Freeboard	0.5 m
Side slope	2 m horizontal per m vertical
Liner	HPDE
Preliminary Dimensions	
Top width	30 m
Bottom width	6 m
Top length	140 m
Bottom length	128 m
Operating volume	15,408 m^3
Surface area	4,200 m^2

Methane Production Potential

Assuming a covered lagoon BOD_5 loading rate of 4,680 kg per day and a 90 percent reduction in BOD_5 to methane, we estimate a methane production rate of approximately 1,478 m^3 (52,188 ft^3) per day. This estimate is based on the assumption of a methane production rate of 0.35 m^3 per kg (5.62 ft^3 per lb) of BOD removed anaerobically, as derived from process stoichiometry. Assuming a lower heating value for biogas of 32,591 Btu per m^3 (923 Btu per ft^3), this is equivalent to the production of approximately 48.2 million Btu per day.

Biogas Utilization

Energy Demand and Cost

In the Frigosinú Monteria slaughterhouse operation, electricity is used for lighting, refrigeration, and the operation of machinery while natural gas is used to provide heat for hot water for sanitation and for rendering and blood drying. Electricity and natural gas use and cost for 2008 are summarized in Tables 7 and 8. Costs are in Colombian pesos and the assumed cost for natural gas in 2008 was 21,960 pesos per mm Btu.

Table 7. Monthly Electricity Demand and Cost at the Frigosinú Monteria Slaughterhouse Operation in 2008.

Month	Demand, kWh	Cost, Peso	Cost, peso/kWh
January	369,104	103,936,960	281.59
February	452,333	140,158,620	309.86
March	420,348	131,910,040	313.81
April	396,051	119,956,910	302.88
May	426,626	130,658,800	306.26
June	454,205	141,177,150	310.82
July	454,062	165,508,360	364.51
August	498,641	157,577,750	316.01
September	483,876	157,389,400	325.27
October	460,560	157,389,400	341.73
November	460,560	157,389,400	341.73
December	460,560	157,389,400	341.73
Total	5,336,926	1,720,442,190	—

Table 7. Monthly Natural Gas Demand and Cost at the Frigosinú Monteria Slaughterhouse Operation in 2008.

Month	Demand, m^3	Demand, mm Btu	Cost, peso
January	89,266	3,039	66,725,704
February	90,893	3,094	67,941,875
March	73,113	2,489	54,651,450
April	72,526	2,496	54,212,672
May	78,418	2,669	58,616,900
June	85,677	2,916	64,042,951
July	98,136	3,340	73,355,966
August	98,128	3,340	73,349,986
September	100,493	3,421	75,117,807
October	93,417	3,180	69,828,547
November	95,866	3,263	71,659,157
December	95,866	3,263	71,659,157
Total	1,071,797	36,486	801,160,676

Biogas Utilization Options

There are three options for methane use at Frigosinú Monteria: 1) use as a boiler fuel in place of natural gas, 2) use as a fuel to generate electricity, or 3) use as a fuel to generate electricity with waste heat recovery to reduce natural gas consumption. Each of these options would require biogas processing to remove moisture and reduce the concentration of hydrogen sulfide.

A covered lagoon for a slaughter rate of 1,200 head of beef cattle per day has the potential of producing 48.2 million Btu of energy per day in the form of biogas methane. Average daily demand and cost for natural gas and electricity at Frigosinú Monteria are summarized in Table 8.

Table 8. Average Daily Demand and Cost for Natural Gas and Electricity at Frigosinú Monteria.

	Demand	Cost, Pesos
Natural gas	99.95 million Btu	2,194,961
Electricity	14,622 kWh	4,713,540

The potential of 48.2 million Btu in biogas energy production is approximately 50 percent of the average natural gas consumption of 99.95 mm Btu per day (Table 8) and would reduce the cost of purchased natural gas by 1,058,500 pesos per day. The biogas produced during anaerobic digestion is a mixture of gases with methane and carbon dioxide being the principal constituents. Methane normally constitutes 60 to 70 percent by volume of the mixture. Thus, biogas has a lower heating value that natural gas, which is primarily methane but also can contain small amounts of longer chain hydrocarbons such as ethane and butane. Assuming a lower heating value of methane of 32,951 Btu per m^3, the lower heating value of biogas containing 65 percent methane is 21,418 Btu per m^3. Thus, the Frigosinú Monteria boilers would have to be retrofitted to provide dual fuel (natural gas and biogas) combustion capability.

The potential for generating electricity from biogas at Frigosinú Monteria is 4,803 kWh per day assuming a thermal conversion efficiency of biogas to electricity of 34 percent. A 200 kW engine-generator set would be required. A generator of this size would generate about 33 percent of the daily electricity demand and would have a potential value of 1,543,828 pesos per day. In addition, the potential will exist to recover up to 45 percent of the waste heat (21.7 million Btu per day) from the cooling system and engine exhaust of the engine-generator set. This heat could be used for preheating water. Thus, if electricity is generated, the potential also exists for a reduction in the purchase of natural gas.

Reduction in Greenhouse Gas Emissions

The upgrading of the Frigosinú Monteria wastewater pretreatment system by replacing the three existing lagoons with a new covered lagoon followed by a combination uncovered settling and polishing pond will essentially eliminate the emission of methane to the atmosphere. If the biogas is used to produce energy, there would be an additional reduction in carbon dioxide emissions due to the reduced demand for electricity or heat energy that is generated using fossil fuels.

The expected reduction in methane emissions can be estimated based on the expected rate of methane production of 1,478 m^3 per day from the upgraded system. Assuming 300 days of operation per year, the emission of 442,260 m^3 or 296,314 kg of methane will be avoided annually. This is equivalent to a reduction of approximately 6,226 metric tons annually of carbon dioxide emissions.

If biogas were used solely to reduce consumption of natural gas by 48.2 million Btu per day, the additional reduction in carbon dioxide emissions from the displacement of fossil fuels would be 1,039 metric tons annually. If biogas were used to generate electricity without waste heat recovery, the additional reduction in carbon dioxide emissions would be 1,068 metric tons annually. With waste heat recovery, the estimated additional reduction in carbon dioxide emissions would be 1,536 metric ton annually.

In summary, it appears that upgrading the existing wastewater pretreatment system at Frigosinú Monteria has the potential of reducing greenhouse gas emissions on a carbon dioxide equivalent basis by as much as 7,762 tonnes annually. However, actual reduction may be somewhat lower due to methane leakage and other factors that have to be considered in the analysis for the Clean Development Mechanism project registration process.

Cost Estimate

A preliminary estimate of the cost of upgrading the existing Frigosinú Monteria wastewater pretreatment system with a covered anaerobic lagoon followed by a settling/polishing pond is presented in Table 9. This estimate does not include the possible cost of items such as relocating existing wastewater piping and a construction of a building to house the biogas processing equipment and engine-generator set. These costs will have to be determined after the general site plan is finalized.

Table 9. Preliminary Estimate of the Cost of Upgrading the Existing Frigosinú Monteria Wastewater Pretreatment System.

Component	U.S. $	Colombian Pesos*
Earth work	250,000	500,000,000
Covered lagoon and settling/polishing pond materials including liners, cover, and gas gathering piping	155,000	310,000,000
Piping—wastewater and biogas	50,000	100,000,000
Gas metering and processing equipment and flare	55,000	110,000,000
Engineering and construction supervision	125,000	250,000,000
Shipping of materials	25,000	50,000,000
Subtotal—Covered lagoon and settling/polishing pond	660,000	1,320,000,000
200 kW engine-generator set with switch gear, water-to-water and exhaust gas-to-water heat exchangers	225,000	450,000,000
Hydrogen sulfide removal unit	55,000	110,000,000
Subtotal—Biogas utilization to generate electricity	280,000	560,000,000
Total	940,000	1,880,000,000

*At the exchange rate of 2,000 Colombian pesos per $1.00

Next Steps

If Frigosinú Monteria is interested in pursuing this approach for upgrading the existing wastewater pretreatment system, the following next steps are recommended:

1. Review current practices in the cattle holding, slaughtering, and rendering components of the operation to identify possible opportunities for reducing wastewater flow and pollutant content.
2. Review current practices for separating coarse fiber from holding pen and paunch manure and identify possible opportunities for improvement of removal efficiency.
3. Evaluate the possibility of directly discharging water (used to reduce odor from the rendering operation) from the water scrubber to the municipal wastewater collection system.
4. Determine the time-of-day and day-of-week usage patterns of natural gas and electricity to identify base loads.
5. Discuss with the local electric utility the requirements for interconnection and the possibility of an agreement for the purchase of any excess electricity.
6. Analyze the option (instead of a settling/polishing pond) of installing a secondary clarifier and increasing the covered lagoon volume to provide a 20-day HRT.
7. Confirm the accuracy of the assumptions about the rate of wastewater flow and its physical and chemical characteristics.
8. Determine the feasibility and cost of converting the existing boilers for duel fuel capability (natural gas or biogas).

9. Analyze the tradeoff between the added revenue minus the associated operation and maintenance costs for using biogas to generate electricity and the additional capital cost.

References

U.S. Environmental Protection Agency. 2002. Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Meat and Poultry Products Point Source category (40 CFR 432), EPA-821-B-01-007. Office of Water, Washington, DC.

Figure 1. Current Wastewater Pretreatment System.

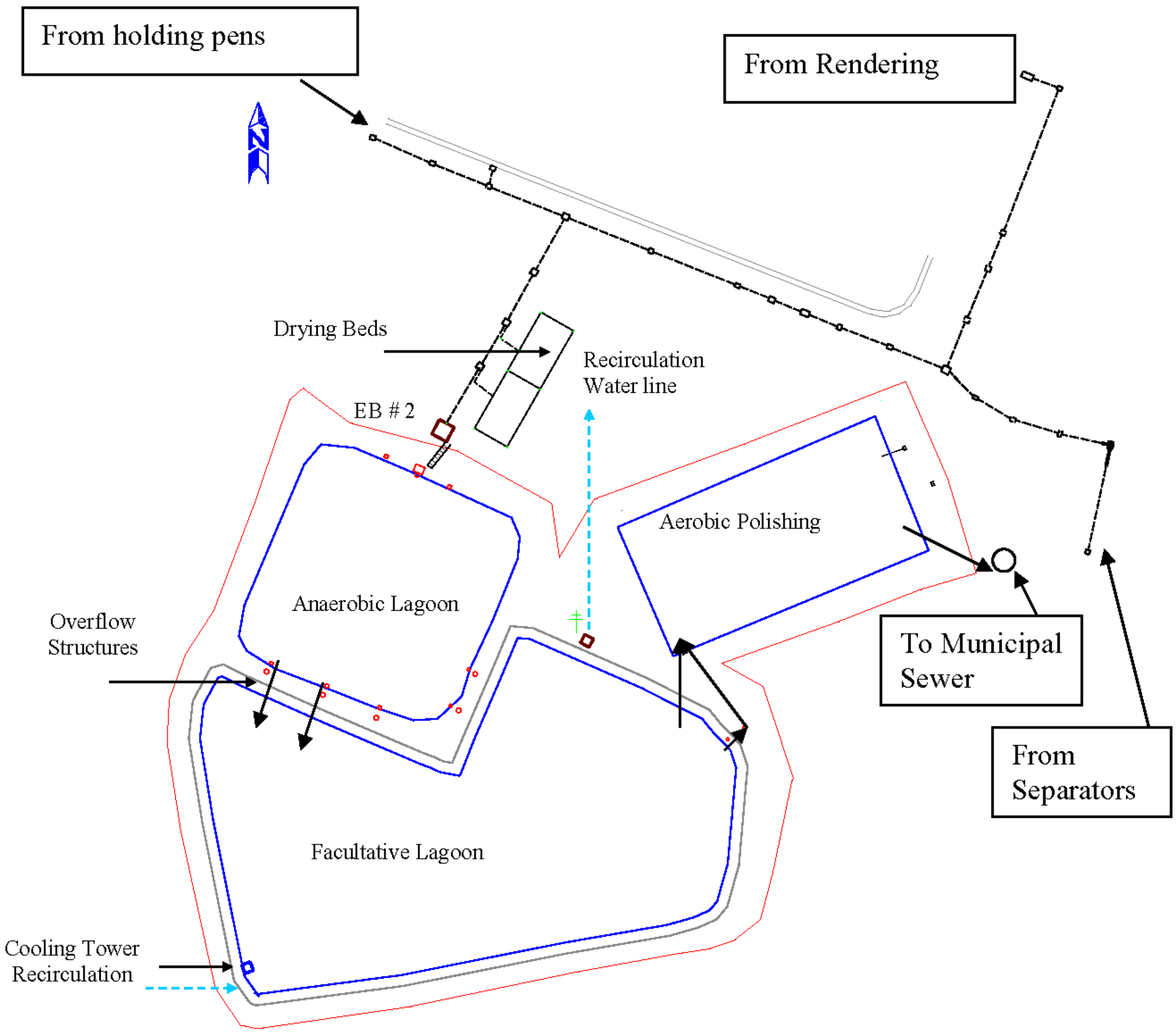

Figure 2. Process Flow Diagram for a Covered Lagoon with Methane Utilization

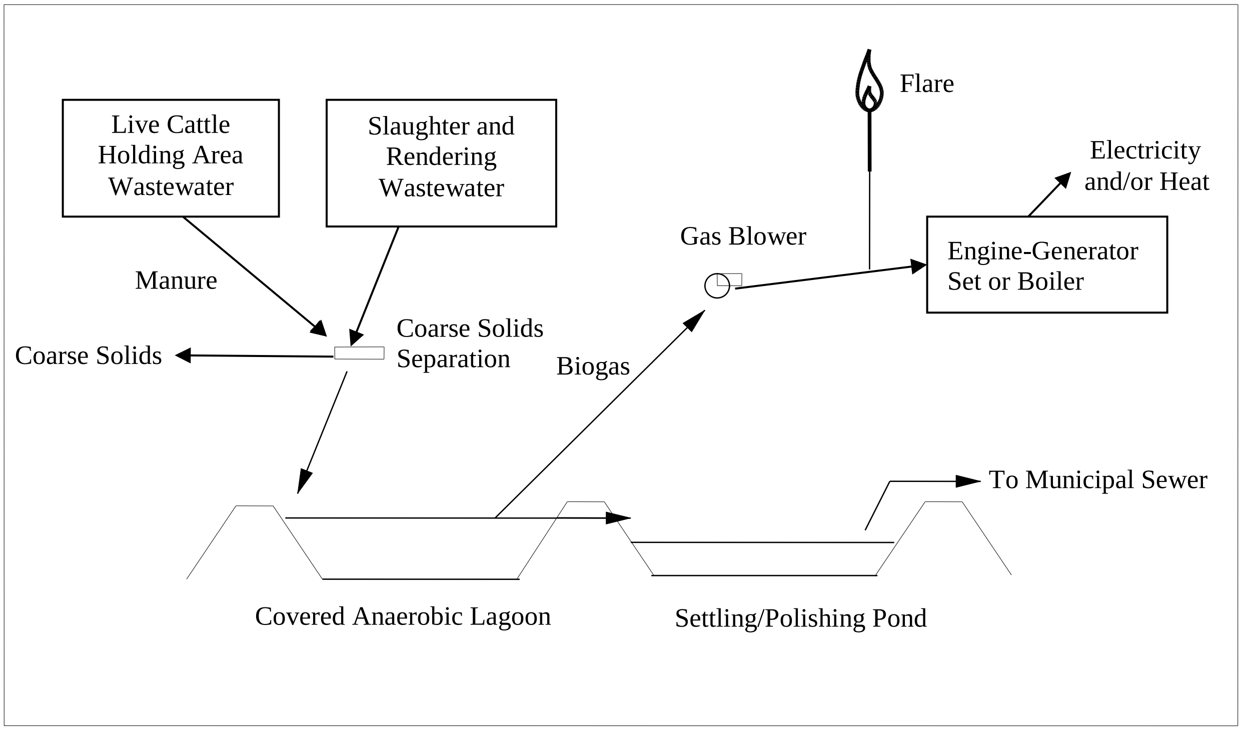

Figure 3. Site Plan Showing the General Location of a New Covered Lagoon and Settling/Polishing Pond.