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Mr. Charles F. Soules, P.E.
Public Works Director
City of Lawrence
PO Box 708
Lawrence, KS 66044-0708

2009 Lawrence Municipal Airport
Airport Sanitary Sewer Study Draft Report
Burns & McDonnell Project No. 53324

Dear Mr. Soules:

This report presents the results of the Lawrence Municipal Airport Sanitary Sewer study.

Background

The City of Lawrence (City) airport is currently using septic systems for treatment of the wastewater generated at the facilities. However, because of future airport expansion, the City is considering the implementation of an alternate to septic tanks capable of handling the increased flows. This report presents the results of the evaluation of several treatment alternatives and opinion of probable costs for three of the alternatives.

Purpose and Scope

The purpose of the study was to identify potential treatment alternatives to replace the septic tanks at the City's airport site and to accommodate increased development at the facility. A qualitative evaluation of alternatives was conducted and three of the alternatives were selected for further evaluation including development of opinions of probable construction and operation and maintenance costs. The scope of services included the following tasks:

- Review of existing documents
- Development of flow rate and water quality projections
- Development of alternatives
- Projection of long term costs
- Recommendations

Wastewater Flow

Original evaluations of the potential wastewater flow, presented in Technical Memorandum No. 1 dated July 31, 2009 (attached as Appendix A) and summarized in

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Table 1 below, resulted in relatively high values between approximately 400,000 and 450,000 gallons per day (gpd) projected for year 2020.

Table 1 – Wastewater Design Flow Projections (gpd)

Methodology	Year 2009	Year 2010	Year 2015	Year 2020 (Build Out)
Land Use and Assumed Density	3,576	89,606	220,085	434,049
Land Use and Typical Unit Flow Rate for Type of Development	3,000	88,140	216,300	429,600
KDHE Minimum Design Criteria	3,000	91,000	223,450	443,900
Average	**3,200**	**89,600**	**220,000**	**436,000**

Although these results were consistent using three different calculation methodologies, it was considered an overly conservative number. Initial assumptions used in the calculations were generally taken at the high end of a given range of numbers, resulting in a relatively large uncertainty. Using low end numbers, the results could have been 50% or less of the calculated values. A phone conference held on August 6th, as well as additional data subsequently provided by the City, has been used to provide recalculated values for consideration.

Calculations were performed to develop flow projections based on the revised data provided by the City. The significant changes in calculation presented in Technical Memorandum No. 2, dated August 14, 2009 (attached as Appendix A) were as follows:

- Three different acreage scenarios were investigated
- Two of the three scenarios used fewer acres than previous calculations
- Peaking factors were reduced based on the use of peaking factor tables provided by the City
- A second set of calculations were developed using a procedure used by the City to analyze flows in the area of the East Hills Business Park.

Results from these calculations are presented in Tables 2 and 3.

Table 2 – Revised Calculations with Updated Acreage and Peaking Factors

Total Acreage	Peak Flow (gpd)
30	64,000
37	78,000
45 (Build Out)	93,000

Table 3 – Flow Calculations Projected Using East Hills Method

Total Acreage	Peak Flow (gpd)
30	225,000
37	280,000
45 (Build Out)	342,000

The results shown in both Tables 2 and 3 are significantly less than the projected flows reported in Technical Memorandum No.1 and presented in Table 1. The large difference between results in Tables 2 and 3 is likely due to the key parameter that dictates the results which is the occupancy rate of each building. The parameter can vary significantly and has a direct impact on the flow rate. The raw data used to develop these numbers can be provided at your request.

The previous data indicate that the projection of wastewater flows at a facility such as the Lawrence Airport is very challenging. The final value is highly dependant on the exact nature of the businesses operating at and around the airport, as well as on the condition of the piping network serving the area. Reasonable and industry-standard calculations can arrive at a wide range of potential values. The actual flow rate to be observed when the area is fully built out is therefore very hard to predict.

To address this challenge, the decision was made to provide a design approach that allows for easy expansion as the site fully develops, starting with initial sizing of facilities to handle current flows and up to 100,000 gpd and expandable in modules as needed. If the airport experiences rapid development, additional treatment or pumping facilities would have to be built. However, under that scenario, where activity at the airport would be many times greater than is currently being experienced, airport revenues would be similarly larger, and facility expansion could then be more easily financed compared to current conditions.

Wastewater Quality

Similar to the wastewater flow projections, the wastewater quality projections are also a challenging task since it is highly dependent on the type of industry to be operating at the airport. However, the final effluent quality to be met by any industrial or commercial facility operating at the airport would have to comply with the City's pretreatment program. The pretreatment regulations are found in the City of Lawrence Code, Chapter 19, Article 6. Compliance with other articles in Chapter 19 is also required. A summary of the main parameters and limits in the City's Code are presented in Table 4. Certain type of industries may require additional limits for specific parameters not included in the City Code.

Table 4 – Summary of City Code Parameters of Compliance

Parameter	Value*
5-Day Biochemical Oxygen Demand (BOD_5), mg/L	300
Total Suspended Solids (TSS), mg/L	300
pH, SU	5.5 – 10.5
Fat, Oil, and Grease (FOG), mg/L	100
Temperature, °F	<104
Total Arsenic, lbs/day (mg/L)	1.64 (1.97)
Total Cadmium, lbs/day (mg/L)	0.81 (0.97)
Total Chromium, lbs/day (mg/L)	6.90 (8.27)
Total Copper, lbs/day (mg/L)	20.99 (25.17)
Total Cyanide, lbs/day (mg/L)	1.49 (1.79)
Total Lead, lbs/day (mg/L)	6.40 (7.67)
Total Mercury, lbs/day (mg/L)	0.06 (0.07)
Total Nickel, lbs/day (mg/L)	10.91 (13.08)
Total Silver, lbs/day (mg/L)	8.17 (9.80)
Total Zinc, lbs/day (mg/L)	25.11 (30.11)

*Concentrations calculated for a flow rate of 100,000 gallons/day

In case the final disposal is to an on-site treatment facility operated by the City, the same compliance requirements included in the City Code would apply to each facility operating at the airport. The on-site treatment facility would have to comply with limits set by the Kansas Department of Health and Environment (KDHE) before discharge to Mud Creek. The on-site treatment facility would require a National Pollutant Discharge Elimination System (NPDES) permit indicating the discharge limits.

Development of Alternatives

In order to select the best disposal alternative for the wastewater to be generated at the airport because of planned future expansion, a number of alternatives were identified in conjunction with the City and are presented in this section.

The following potential alternatives were identified and are briefly discussed in the following paragraphs:

1. Septage holding well and hauling to an existing wastewater treatment plant
2. Lift station and force main to existing sewer system
3. Constructed wetland
4. Conventional package treatment system
5. Tree farm

The discussion of alternatives and qualitative comparison were based on the following parameters:

- Ability to handle projected wastewater characteristics
- Ability to operate without complication at a municipal airport
- Expandability of alternative
- Installed base of system (how many units successfully operating)
- Operational complexity of system
- Ease of permitting
- Applicability for short-term and long-term use

Alternative 1 – Septage Holding Well and Hauling to an Existing Wastewater Treatment Plant

This alternative consists of a holding well or tank to store wastewater and haul it to an existing wastewater treatment plant (WWTP) as needed. The frequency of hauling will depend on the amount of wastewater generated at the airport facilities. Aeration and some type of odor control may be required to minimize odors (both are included in the opinions of cost).

Some of the main advantages of this alternative include:

- No on-site treatment required
- Small footprint
- Ease of operation
- Low operation and maintenance cost
- Does not require KDHE discharge permit
- It can be considered as a temporary alternative to handle current flows and, with proper design, it can be converted to a lift station when required due to increased flow rates in the future

The main disadvantage of this option is potential for high frequency of hauling and odor generation.

An aerated holding well that can be easily converted to a lift station is recommended. Odor control such as activated carbon canisters connected to the vent of the well may be required. Aeration would be provided by a blower and a coarse bubble diffusers array. Level elements for level indication and future pump controls would also be provided. Preliminary sizing of the well indicates that a concrete (cast-in-place) 10,000-gallon well (working volume) can be used and would provide a holding capacity of approximately 10 days at the current flow rate of 1,000 gpd. As the flow rate increases in the future the holding capacity would decrease, requiring an increase in hauling frequency. The pedestals for future submersible pumps would be provided, as well as pipe and penetrations, hatches sized for pump removal, and trash baskets.

Alternative 2 – Lift Station and Force Main to Existing Sewer System
This alternative consists of a lift station at the airport site and a force main to discharge to the existing City's collection and treatment system. The lift station will be designed and constructed in a way that can be easily expanded once the flow rate generated at the airport exceeds the design flow rate of 100,000 gpd. The force main will also be designed to accommodate a given range of flow rates to maintain recommended velocities and avoid solids settling in the line.

Some of the main advantages of this alternative include:

- No on-site treatment required
- Ease of operation
- Small footprint
- Low operation and maintenance cost
- Does not require KDHE discharge permit
- Easily expandable

The main disadvantage of this alternative may be the difficulty of finding a pipeline size able to handle a desired range of flow rates required to maintain recommended velocities. Also, it requires the acquisition by the City of right of way for the force main layout.

As discussed in the Alternative Selection section, the Septage Holding Well could be converted to a lift station, so the size of the lift station will be approximately 10,000 gallons. Removal of the diffused air system could be required. Installation of two submersible pumps, valve vault, and pump controls will be part of the implementation of this alternative.

Figure 1 presents two preliminary routes for the force main and a location of the lift station. The longest route was used for cost estimating purposes.

Alternative 3 – Constructed Wetland

Constructed wetlands are treatment units that use natural systems such as vegetation, soils, and associated microbial population for removal of pollutants from wastewater. Constructed wetlands replicate natural systems and are widely used for wastewater treatment. They can be built outdoors or inside greenhouses. This alternative also requires a lift station, screening, and UV disinfection of the effluent. It was assumed that the constructed wetland would be located in the vicinity of the point of gravity discharge to Mud Creek. Implementation of this alternative will depend on KDHE approval of discharge to Mud Creek. This alternative assumes a system utilizing non-wetland plants to avoid attraction of waterfowl which creates a safety issue for the airport operation. During the study, the constructed wetland manufacturer indicated that the system would not require enclosure during winter months. If an enclosure was desired, the analysis performed here would have to include the costs for the enclosure or building, as well as lighting and heat for the interior space.

Some of the main advantages of this alternative include:

- Low operation and maintenance cost
- Can easily achieve organic matter and nitrogen removal
- Aesthetically pleasant
- May promote water reuse

Some of the main disadvantages of this alternative include:

- May require larger footprint compared to other alternatives
- Requires significant operator attention compared to a lift station
- Likely requires plant management and involvement of City staff outside of the Utilities Department
- Requires KDHE discharge permit
- Little operator control compared to a mechanical treatment system
- Susceptibility to failure due to industrial slug loads
- Potential reduction in performance during the winter

Two different types of constructed wetlands were reviewed and investigated and the Tidal Wetland ® Living Machine System provided by Worrell Water Technologies (WWT) was selected for further evaluation. The system consists of screening followed by the Recirculating Tidal Wetland System. For the entire 100,000 gpd flow the system footprint would be approximately 14,000 sq. ft. Appendix B includes information provided by WWT. The WWT wetland system was selected for further analysis because they were very responsive to our request for information and also very interested and excited about the project. Ecological Engineering was not responsive to our request for information.

Most of Burns & McDonnell's experience using wetlands has been as a polishing step prior to direct discharge or for stormwater management. Application as the primary treatment system would require consistent compliance year round with final effluent discharge permit limits especially biochemical oxygen demand (BOD_5) and nutrients during the winter time. Figure 1 present a preliminary location for the wetlands.

Alternative 4 – Conventional Package Treatment System
This alternative consists of a lift station followed by a package treatment system and final discharge to Mud Creek. It was assumed that the package treatment system be located in the vicinity of the point of discharge and gravity discharge to Mud Creek. Implementation of this alternative will depend on KDHE approval to discharge to Mud Creek. Typical package treatment units include screening, equalization, aeration, sedimentation, sludge digestion and/or storage, and disinfection. UV disinfection would be preferred over chlorination since chlorination would typically require de-chlorination.

Some of the main advantages of this alternative include:

- Can achieve organic matter and nutrients (nitrogen and phosphorus) removal
- Small footprint compared to constructed wetlands
- Operational flexibility and operator control
- Easily expandable
- Proven technology widely used for wastewater treatment

Some of the main disadvantages of this alternative include:

- Requires significant operator attention compared to a lift station
- Requires KDHE discharge permit
- May require odor control

Four different types of conventional package treatment systems were reviewed and investigated and the Model R Treatment System, Model 52RE100 provided by Smith & Loveless was selected for further evaluation. This type of system has been widely used for small flow applications with good results. In addition, Smith & Loveless is a local company located in Lenexa, Kansas, which make it easy for technical assistance as needed. This system will follow the primary screening and will be followed by UV disinfection. The influent flow will enter into a 3/4 inch manually cleaned bar screen, found along the annular section of the tankage and then fall by gravity into an equalization tank designed to receive large slug flows. The aeration zone will have coarse bubble diffusion, and is also found along the annular section of the Model R. The clarifier will have rotating sludge scrapper arms that drive the settled sludge towards the center, for automatic removal. Sludge and scum are stored in a solids holding basin. The current design and footprint has 12 day sludge storage zone at a 2% decant. Appendix C includes information provided by Smith & Loveless. Figure 1 presents a preliminary location for the conventional treatment system.

Alternative 5 – Tree Farm

This alternative consists of a tree farm to be irrigated with pretreated wastewater. The development of this alternative would require the involvement of a tree farm specialist to select the appropriate tree species to use. The main advantage of this alternative is very low energy input and that once the system is established it would be very close to maintenance free. However, some of the main disadvantages include:

- It may take several years to develop
- It may be a source of odors
- It requires specialized personnel for implementation
- It may require a large footprint
- It is not commonly used for similar applications. Most of the applications of this type of system are for remediation of contaminated soils and/or groundwater.

It appears that this alternative would not be feasible for the City of Lawrence airport expansion and no further consideration was given in this report.

Permitting

Burns & McDonnell consulted with Rod Geisler from KDHE (via phone call) regarding the potential for approving a National Pollutant Discharge Elimination System (NPDES) permit to discharge to Mud Creek if an on-site treatment system is installed at the airport to treat current and future expansion wastewater flow. A summary of the conversation is presented below:

- The final effluent permit limits would be the same for both wetland and conventional package treatment systems
- The total nitrogen effluent limit would be 8 mg/L or lower. An evaluation of potential lower limits would be required before establishing the final value
- The total phosphorus effluent limit would be 1.5 mg/L or lower. An evaluation of potential lower limits would be required before establishing the final value
- Nitrogen and phosphorus values would be ascertained via a Financial Capability Analysis, which determines the community's ability to pay for advanced treatment. Based on the small size of this treatment system, it is highly likely that lower limits would be established, which could add to the capital and O&M costs for onsite treatment.
- The BOD_5 effluent limit would be lower than 30 mg/L
- The cell for the wetland system would need to be lined or an application for variance would be required if we can prove no need for seepage control

- A conventional package treatment system would require redundancy of certain treatment processes and backup power. A holding basin to hold wastewater during repairs or downtime could be considered redundancy
- Typical KDHE approach has been that if there is a point of connection to the City's collection and treatment system at a reasonable distance and at a reasonable installation cost, a new NPDES permit would not be approved.

A qualitative comparison of the alternatives previously discussed is presented in Table 5. A grading scale of 1 – 5 was used to compare each of the parameters included in the comparison, with 5 being "best" and 1 being "worst". The best alternative according to this qualitative analysis is Alternative 1 – Septage Holding Well and Hauling to an Existing Wastewater Treatment Plant and the second best is Alternative 2 – Lift Station and Forcemain. The worst alternative was Alternative 5 – Farm Tree.

Table 5 – Qualitative Comparison of Alternatives

	Ability to Handle Projected WW Quality	Ability to Operate w/o Complication at a Municipal Airport	Ease of Expansion	Installed Units in Operation	Operational Complexity of the System	Ease of Permitting	Applicability for Short-Term and Long-Term Use	Total
Alternative 1: Septage Holding Well	4	5	5	5	5	Not Required	3	27
Alternative 2: Lift Station & Force Main	5	5	4	4	4	Not Required	4	26
Alternative 3: Constructed Wetland	3	3	3	4	4	2	3	22
Alternative 4: Package WWTP	4	4	4	4	3	3	3	25
Alternative 5: Tree Farm	3	2	2	3	4	3	2	19

Alternatives Selection

Based on the information previously presented and conversations with the City's personnel, it is recommended to use a phased approach to develop wastewater treatment for continued airport development. Because of the uncertainty regarding the quantity and the quality of the wastewater during the future airport development, a two-phase approach would be the best fit since it would allows for easy expansion as the site develops, starting with initial sizing of facilities to handle current flows and up to 100,000 gpd, with expansion in phases as needed. This helps to avoid over- or under-development of airport infrastructure in case development occurs at an unplanned rate.

Phase I should consist of the implementation of Alternative 1 – Septage Holding Well and Hauling to an Existing WWTP.

Implementation of Phase II would be required once the flow rate reaches a value at which Alternative 1 and hauling wastewater in not practical for the City. Phase II would then consist of implementing any of the alternatives listed below. The selection of the alternative to be implemented will depend, besides technical considerations, on a financial analysis discussed in the following sections of this report.

- Conversion of the septage storage well into a lift station and construction of a force main to discharge to the City's collection system
- Constructed wetland with or without septic tanks
- Conventional package treatment system with or without septic tanks

In an attempt to maximize utilization of existing infrastructure, Burns & McDonnell considered the continued use of the existing on-site septic tanks followed by on-site constructed wetlands or conventional package treatment plant. The continued use of existing septic tanks would reduce the size of the constructed wetland regarding organic loading; however, hydraulically it should be nearly the same size as the system without a septic tanks. The size of the conventional package treatment plant would not be reduced since the hydraulic loading would be the same as the size without septic tanks; however, the aeration requirements and sludge generation would be reduced.

The present scope of services does not include an evaluation of the existing septic tanks at the airport site; however, it appears that additional septic tanks would be required for the future airport expansion ahead of any on-site treatment system. Additional septic tanks plus potential repairs/replacements of existing tanks will increase operational and maintenance effort which may not be practical or economically justifiable. For the purpose of this evaluation, it was assumed that no septic tanks will be used ahead of any on-site treatment system and that the existing septic tanks will be abandoned once the selected new system starts operation. A cost for demolition of the existing septic tanks was not included in the report since it will be the same for comparison purposes of the two alternatives where applicable.

Opinion of Probable Costs

This section includes an opinion of probable construction cost for Phase I and the three selected alternatives in Phase II and an opinion of annual operational and maintenance (O&M) cost for each of them.

These opinions of probable costs are based primarily on our experience on similar projects combined with information from the City, equipment suppliers, and published sources. The opinions of probable costs are budgetary and preliminary in detail and are intended for fiscal planning purposes only. Since Burns & McDonnell has no control over weather, cost and availability of labor, material and equipment, labor productivity, construction contractor's procedures and methods, unavoidable delays, construction contractor's methods of determining prices, economic conditions, government regulations and laws (including the interpretation thereof), competitive bidding or market conditions, and other factors affecting such opinions or projections; consequently, the final project costs may vary from the opinions of costs presented in this study and funding needs must be carefully reviewed prior to making specific financial decisions or establishing final budgets.

The opinions of probable costs include the following: equipment, installation, piping, electrical, instrumentation, design engineering, and contractor markups. Contractor markups include field overhead, home office G&A, subcontractor profit, prime contractor, and overhead/profit. However, they do not include wastewater characterizations, treatability testing, pilot testing, removal and disposal of hazardous materials and waste, sales tax, escalation, financing expenses, interest during construction, legal expenses or other non-construction costs, permitting expenses, surveying, geotechnical investigations, utilities including electrical services, emergency generator, fencing and security, chemical addition, and special construction methods.

A thirty percent (30%) contingency allowance is included to cover all types of unaccounted-for project costs resulting from conditions, details or components, which are not normally known or determined until final detailed design.

The following assumptions were made to develop the opinions of probable construction and annual O&M costs:

- Land application of biosolids
- Biosolids disposal cost of $0.10 per gal
- Screenings disposal cost of $60 per cubic yard
- Septage disposal cost of $0.10 per gal
- Power cost of $0.05 per kW-hr
- Concrete cost of $500 per cubic yard (cast-in-place)
- Excavation cost of $12 per cubic yard
- Pipe cost of $40 per linear foot (6-inch, SCH 80 PVC)
- Labor cost of $40 per hour
- Interest rate of 8%
- Evaluation period of 20 years
- Easement cost of $0.35 per square foot (assumed 10 feet wide easement)
- Electrical and instrumentation at 15% of equipment cost

Tables 6, 7, 8, and 9 present the main cost items included in the opinions of probable construction and O&M cost for each of the alternatives. A more detailed breakdown cost for each alternative is included in Appendix D.

Table 6 – Opinions of Probable Cost for Septage Holding Well

Description	**Total Cost**
Concrete Septage Holding Well – 10,000-gal (includes civil works)	$84,000
Aeration System	$15,000
Odor Control (Activated Carbon System)	$40,000
Subtotal	**$139,000**
Electrical and Instrumentation	$8,000
Subtotal	**$147,000**
Markups	$50,000
Subtotal	**$197,000**
Contingency	$59,000
Subtotal	**$256,000**
Engineering	$75,000
Opinion of Probable Construction Cost	**$331,000**
Description	**Total Cost**
Electricity	$3,200
Septage Hauling/Disposal	$36,400
Activated Carbon Replacement	$8,000
Labor	$10,400
Subtotal	**$58,000**
Contingency	$12,000
Opinion of Probable Annual O&M Cost	**$70,000**

Table 7 – Opinions of Probable Cost for Lift Station and Forcemain

Description	Total Cost
Pump Station	$224,000
Force Main (6-inch, PVC Pipe)	$340,000
Easement Cost (10 ft wide by 8,000 ft long)	$28,000
	$592,000
Electrical and Instrumentation	$32,000
Subtotal	**$624,000**
Markups	$214,000
Subtotal	**$838,000**
Contingency	$251,000
Subtotal	**$1,089,000**
Engineering	$131,000
Opinion of Probable Construction Cost	**$1,220,000**
Description	**Total Cost**
Electricity	$32,000
Activated Carbon Replacement	$8,000
Labor	$21,000
Subtotal	**$61,000**
Contingency	$12,000
Opinion of Probable Annual O&M Cost	**$73,000**

Table 8 – Opinions of Probable Cost for Constructed Wetlands

Description	Total Cost
Pump Station	$214,000
Screen and Screen Channel	$110,000
UV Disinfection	$25,000
Pipe from PS to Constructed Wetland	$348,000
Easement Cost (10 ft wide by 4,400 ft long)	$15,000
Subtotal	**$712,000**
Electrical and Instrumentation	$51,000
Subtotal	**$763,000**
Markups	$261,000
Subtotal	**$1,024,000**
Installed Constructed Wetland	$1,530,000
Subtotal	**$2,554,000**
Contingency	$766,000
Subtotal	**$3,320,000**
Engineering	$120,000
Opinion of Probable Construction Cost	**$3,440,000**
Description	**Total Cost**
Electricity	$35,000
Activated Carbon Replacement	$8,000
Screenings Hauling/Disposal	$1,000
Labor	$50,000
Parts and Vegetation Maintenance	$9,000
Subtotal	**$103,000**
Contingency (20%)	$20,000
Opinion of Probable Annual O&M Cost	**$123,000**

Table 9 – Opinions of Probable Cost for Package Treatment Plant

Description	Total Cost
Pump Station	$214,000
Package Treatment WWTP	$710,000
Screen and Screen Channel	$110,000
UV Disinfection	$25,000
Pipe from PS to Package WWTP	$348,000
Easement Cost (10 ft wide by 4,400 ft long)	$15,000
Subtotal	**$1,422,000**
Electrical and Instrumentation	$140,000
Subtotal	**$1,562,000**
Markups	$534,000
Subtotal	**$2,096,000**
Contingency	$629,000
Subtotal	**$2,725,000**
Engineering	$325,000
Opinion of Probable Construction Cost	**$3,050,000**
Description	**Total Cost**
Electricity	$46,000
Activated Carbon Replacement	$8,000
Screenings Hauling/Disposal	$1,000
Sludge Disposal	$38,000
Labor	$50,000
Subtotal	**$143,000**
Contingency	$29,000
Opinion of Probable Annual O&M Cost	**$172,000**

Table 10 presents a summary of the opinions of capital and O&M cost and present worth values for each of the alternatives presented in previous sections.

Table 10 – Summary of Opinions of Probable Cost and PWV

Alternative	Opinion of Construction Cost	Opinion of O&M Cost	Present Worth Value (PWV)
Phase I			
Septage Holding Well	$331,000	$70,000	$800,000
Phase II			
Lift Station and Force Main	$1,220,000	$73,000	$2,600,000
Constructed Wetland	$3,440,000	$123,000	$5,000,000
Conventional Package Treatment Plant	$3,050,000	$172,000	$4,900,000

The capital cost for Phase II implementation does not include the Phase I cost. The total project capital cost would be the cost for Phase I plus the cost for Phase II. However, the PWV includes both phases assuming the Phase II would be implemented 5 years after the implementation of Phase I. The evaluation period for the PWV was 20 years.

Summary and Recommendations

The City of Lawrence, Kansas is evaluating alternatives for treatment of the wastewater generated at the City's airport to accommodate planned growth. Due the uncertainty of the potential businesses to be included in the future as a part of this growth, wastewater flow predictions are a challenging task. Because of that situation, the decision was made to provide a design approach that allows for easy expansion as the site fully develops, starting with initial sizing of facilities to handle current flows and up to 100,000 gpd and expandable in modules as needed.

A phased approach is recommended with implementation of Phase I followed by implementation of Phase II when required by wastewater flow increase. A summary of the alternatives with opinions of probable construction and O&M cost is presented in Table 10.

Based on the information previously presented and the cost in Table 10, the Lift Station and Force Main alternative appears to be the most attractive alternative to implement during Phase II, with the most advantages and the lowest total opinion of probable construction cost of approximately $1,220,000. The total opinion of probable construction cost for implementation of Phase I followed by this alternative during Phase II would be approximately $1,551,000. The PWV for this alternative for a 20-year period is approximately $2,600,000. The PWV for all the alternatives do not include the revenue to the City from the discharging facilities at the airport to any new on-site WWTP at the cost indicated in the City Code. Alternatives 1 and 2 were also the best alternatives based on the qualitative analysis presented in Table 5.

The timing for implementing Phase II will depend on the amount of wastewater generation during the expansion. Currently the wastewater flow is approximately 1,000 gpd which would require emptying the Septage Holding Well and hauling the wastewater every 10 days. At a wastewater flow generation of 10,000 gpd the frequency of emptying/hauling would be once a day which appears to become labor intensive. Consequently, wastewater generation of 10,000 gpd appears to be appropriate for implementation of Phase II. The hydraulic retention time (HRT) of the wastewater in the force main for the proposed route to an existing manhole, at a pumping rate of 10,000 gpd, is approximately 1.2 days. A potential issue of concern regarding HRT is the generation and release of hydrogen sulfide. Long HRT increases the potential for hydrogen sulfide generation and its release, which becomes an odor generation issue. Besides HRT there are other factors that need to be considered in the extent and release of hydrogen sulfide, such as:

- Sulfate concentration
- Dissolved oxygen
- pH
- Metal concentration
- Stream velocity
- Depth of flow or surface area
- Temperature
- Organic matter measured as BOD_5 and nutrients
- Presence of biological slime layer on the pipe wall or in sludge and silt deposits on the pipe invert

Because of the uncertainty about the quality of the wastewater to be generated during the airport expansion and the different variables and environmental conditions affecting hydrogen sulfide generation, it is very difficult to predict at this time hydrogen sulfide generation and potential odor issues after implementing Phase II. However, if the main wastewater contributors during the airport expansion would be commercial and/or industrial facilities, the concentration of sulfate in the wastewater could be anticipated to be lower than typical sanitary sewage (between 20 mg/L and 50 mg/L) which reduces hydrogen sulfide generation and consequently odor issues.

In case hydrogen sulfide and odor generation becomes an issue, there are available measures that can be implemented to mitigate the problem. Some of these measures include the following:

- Air injection
- Oxygen injection
- Chlorine addition
- Hydrogen peroxide addition
- Metal salts addition (iron zinc, copper)
- Nitrate addition
- Strong alkalies addition
- Potassium permanganate
- Proprietary products

Any of any of the above measures can be easily implemented as required at a relatively minor cost and does not represent significant modifications to existing infrastructure.

If treatment and discharge to Mud Creek is desired, the Conventional Package Treatment Plant has a lower opinion of probable construction cost and a lower PWV than the Constructed Wetland but a higher annual O&M cost. The decision to use any of these two options needs to be made based on short term and long term financial analyses. However, as previously stated KDHE will probably not approve a direct discharge to Mud Creek as long as discharge to the City's collection and treatment system is a financially viable option.

Please, feel free to contact me with any questions or comments at 816-822-3185 or via email at rgonzal@burnsmcd.com

Sincerely,

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