City of St. Joseph, Missouri

Facilities Plan

Biosolids Management Evaluation

By

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Work Order No. 09-001
B&V Project 163509

September 29, 2010

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1.0 Executive Summary

The City of St. Joseph currently beneficially uses Class B biosolids generated at the Water Protection Facility (WPF) through land application. However, the City is interested in converting to a Class A program, either through generation of Class A cake or a heat dried product. The purpose of this evaluation is to review current biosolids disposal expenses incurred by the City and compare the costs and benefits of alternative biosolids management options. Four biosolids management alternatives were identified for evaluation, including both the current system and Class A systems. The four programs evaluated are as follows:

- Base Alternative. Continued hauling and land application by the City of a Class B product mirroring present operations.
- Alternative 1. Contracted hauling, permitting, off-site storage, and land application of the dewatered cake (Class B product). The City would maintain responsibility for the land applied material.
- Alternative 2. Thermal drying of digested biosolids to generate a Class A product. The heat dried product could be sold or given away.
- Alternative 3. Seek process to further reduce pathogens (PFRP) equivalency for the current thermophilic anaerobic digestion process through sampling, laboratory analyses, and certification with the Pathogen Equivalency Committee (PEC) and the United States Environmental Protection Agency (USEPA) Region 7. Final disposal of the Class A product would continue as the current hauling and land application operation by the City.

Solids quantities used for this evaluation were based on the solids quantities presented in Technical Memorandum (TM) TM-WW-6 – Biosolids Facilities. The projected solids production and resulting design dewatered cake projections are presented in Table ES-1 and Table ES-2.

Table ES-1 Projected Solids Production [1]		
Parameter	**Design Conditions (2030)**	
	Annual Average	**Maximum Month**
Primary Solids		
Dry solids, ppd	18,980	30,520
Volatile Solids, %	71	60
Waste Activated Sludge		
Dry Solids, ppd	13,560	29,040
Volatile Solids, %	78	78
Total Dry Solids, ppd	32,540	59,560
1. Projected solids production without chemical phosphorus removal.		

Table ES-2 Design Dewatered Cake Projections (2030)			
Parameter	**Units**	**Annual Average**	**Maximum Month**
Cake Production	ppd (dry)	19,300	37,000
	ppd (wet)	77,200	148,100
Cake Volume	cu yd/day	48	93
	cu yd/hr	3.0	5.4

The opinion of probable capital and life cycle costs for the four alternatives considered are presented in Table ES-3.

Table ES-3 Opinion of Probable Alternative Costs and Unit Prices				
Parameter	**Alternative**			
	Base (Present)	**1 (Contract Hauling)**	**2 (Thermal Drying)**	**3 (PFRP Equivalency)[1]**
Capital (2010 $M)	$0.66	$0	$24.51	$0.09
Annual O&M ($)	$268,000	$327,000	$625,000	$0
Present Worth of Annual O&M ($M)	$3.34	$4.08	$7.79	$0
Total Present Worth ($M)	$4.41	$4.08	$31.02	$0.09
Unit Cost ($/dry ton)	$60	$55	$419	$15
1. PFRP equivalency costs are in addition to the costs of the Base Alternative.				

As presented in Table ES-3, the unit cost of the City's current operation of biosolids hauling and land application of a Class B product (Base Alternative) is nearly equivalent to the unit cost expected for contract operations of the same services (Alternative 1). If the City continues a cake land application program, it can choose between in-house or contracted operations based on non-economic issues, such as staffing requirements and desired level of control and oversight effort for the program. Regardless of ownership of the application process, the City would retain responsibility for all land applied biosolids.

Generation of dry biosolids through a thermal drying process (Alternative 2) would be desirable due to the Class A status, low weight, public acceptance, and ability to sell to other markets such as biomass combustion or compost generation; however, the unit cost is much higher than all other alternatives considered.

Achieving PFRP-Equivalency status for the current process (Alternative 3) is likely to require significant effort and cost, without guaranteed results. However, pathogen measurement can be used to meet Class A criteria as an alternative to obtaining PFRP status.

It is recommended that the City continue the current operation of biosolids hauling and land application of a Class B product unless non-economic issues by City staff favor a contract operation of the program. Space on the WPF site should be allocated for a future thermal dryer facility should evaluation factors change in the future, including availability of land for application and public acceptance of a Class B product.

2.0 Purpose of Evaluation

The City of St. Joseph is considering various alternatives for the final use of the biosolids generated at the St. Joseph WPF. The purpose of this evaluation is to review current biosolids disposal expenses incurred by the City and compare the costs and benefits of alternative biosolids management options.

3.0 Introduction

This evaluation considers four different alternatives that the City of St. Joseph is analyzing as options for long-term biosolids hauling and disposal:

- Base Alternative. Continued hauling and land application by the City of a Class B product.

- Alternative 1. Contracted hauling and land application of a Class B product. The City would manage and maintain responsibility for the land application program.
- Alternative 2. Thermal drying of digested biosolids to generate a Class A product.
- Alternative 3. Land application of Class A biosolids, with Class A compliance based on PFRP equivalency of the current process with continued hauling and land application by the City. The cost of this alternative is in addition to the costs of the Base Alternative.

The information sources used for this evaluation include:

- Solids production estimates as presented in TM-WW-6 – Biosolids Facilities.
- Class A biosolids requirements as presented in the Class A Biosolids Certification memorandum.
- Solids hauling and disposal costs as provided by the City including: polymer consumption, gasoline purchases, hauling and spreading equipment capital costs and maintenance, landfill fees, laboratory costs (both in-house and outsourced), and operation and management labor costs.
- Domestic sludge reporting documents by the City of St. Joseph to the State of Missouri for the years 2007, 2008, and 2009.
- Preliminary cost estimates for hauling, storage, and land application by contractors.
- Vendor quotes for heat drying equipment.

4.0 Regulatory Requirements

Biosolids are regulated by USEPA 40 Code of Federal Regulations (CFR) Part 503 Rule and by state and local ordinances. Odor, pathogens (e.g. disease-causing bacteria and viruses), biological vectors (e.g. rodents and flies), and heavy metals impact biosolids management, disposal, and final use practices. Federal and state biosolids regulations are discussed in the following sections.

4.1 Federal Regulations

The Part 503 Rule sets standards for final use or disposal when biosolids are applied to agricultural and non-agricultural land (including products sold or given away), placed in or on surface disposal sites, or incinerated. The Part 503 Rule also requires compliance with 40 CFR Part 258 for landfill disposal or use as a landfill daily cover.

The Part 503 Rule primarily regulates land application practices, surface disposal (monofills), sewage sludge incineration, pathogen, and vector attraction reduction. The requirements are described in the following sections.

4.1.1 Metal Limits

The Part 503 Regulations list two different concentration limits for pollutants for applying biosolids on land: ceiling concentration limit (CCL) and pollutant concentration limit (PCL). The CCL sets the maximum allowable pollutant concentration in biosolids that are applied to land. If the biosolids contain pollutants greater than the CCL, they cannot be land applied. The PCL sets a lower pollutant concentration threshold which, when achieved, relieves the owner from certain recordkeeping and reporting requirements for metal loadings. While biosolids that meet the CCL but exceed the PCL can still be land applied, the cumulative loadings of pollutants to land must be monitored and recorded. In comparison, biosolids that meet the lower PCL can be distributed to the public or applied to land without tracking the metal loading rates. The CCL and PCL for metals, established by Part 503 Regulations, are listed in Table 1.

Table 1 Metal Limits for Land Application		
Metal	**PCL, mg/kg**	**CCL, mg/kg**
Cadmium	39	85
Copper	1,500	4,300
Lead	300	840
Nickel	420	420
Zinc	2,800	7,500
Arsenic	41	75
Chromium	1,200	3,000
Mercury	17	57
Molybdenum	--	75
Selenium	36	100

4.1.2 Pathogen Reduction Requirements

The pathogen reduction requirements for biosolids are divided into Class A and Class B criteria. The goal of the Class A requirements is to reduce the pathogens in biosolids (including enteric viruses, pathogenic bacteria, and viable helminth ova) to below detectable levels. Class A biosolids have no use restrictions based on pathogen content and are considered to pose no threat to public health. Thermophilic treatment can meet Class A criteria either through pathogen measurement, adherence to the "time and temperature" definition, or by obtaining PEC certification. A more detailed discussion of the criteria is presented in the Class A Biosolids Certification memorandum. Heat drying meets Class A pathogen criteria as a PFRP if the biosolids are dried to 90 percent total solids (TS) and meet minimum temperature requirements. Unlike Class A biosolids, which are virtually pathogen free, Class B biosolids may contain some pathogens. Class B application site restrictions include limiting application to agricultural use on row crops or pasture or land reclamation, limiting public access, and establishing waiting periods between biosolids application and crop harvest or grazing.

4.1.3 Vector Attraction Reduction Requirements

Both Class A and Class B biosolids must meet vector attraction reduction (VAR) requirements for beneficial use. VAR requirements are intended to reduce the putrescibility of the solids. There are 12 VAR options for biosolids. Digestion meets VAR requirements by reducing the volatile solids content, either by a minimum of 38 percent or by demonstrating little additional reduction through bench scale testing. Heat drying meets VAR requirements by achieving a dryness of at least 90 percent TS. "Exceptional quality" (EQ) biosolids are biosolids which have met the Part 503 PCL requirements as well as Class A pathogen reduction requirements and one of the first eight vector attraction reduction options. EQ biosolids may be land applied without site restrictions, sold, or given away.

4.2 State Regulations

The State of Missouri does not have delegation over biosolids permitting; however, the state has the authority to promulgate regulations and guidelines in addition to those presented in Part 503. The Missouri Department of Natural Resources (MDNR) has incorporated the Part 503 Rules in the state requirements under the Missouri Clean Water Law and regulations. The state rules include additional requirements that are not covered under USEPA. Complying with the state rules automatically meets the USEPA requirements as well.

MDNR has its biosolids rules codified under the Code of State Regulations (CSR) Title 10. Separate divisions within Title 10 that affect the City are shown in Table 2.

Table 2
Key State Regulations Affecting Management of Biosolids

Division	Chapter	Applicability
20	6, 7, 8	Sludge disposal in surface lagoons, sludge transport for beneficial use
80	All	Solid waste management: landfilling, landfill design and operation

Biosolids treatment and management requirements are also provided through a series of water quality guides published by the University of Missouri. Five of these have been incorporated by reference into the MDNR Standard Conditions for National Pollutant Discharge Elimination System (NPDES) Permits, Part III, Sludge & Biosolids from Domestic Wastewater Treatment Facilities. The incorporated guides are as follows:

- WQ 422: Land Application of Septage
- WQ 423: Monitoring Requirements for Biosolids Land Application

- WQ 424: Biosolids Standards for Pathogens and Vectors
- WQ 425: Biosolids Standards for Metals and Other Trace Substances
- WQ 426: Best Management practices for Biosolids Land Applications

All biosolids-related guides from the University of Missouri are available in electronic format at: http://extension.missouri.edu/main/DisplayCategory.aspx?C=74. The guides follow the USEPA Part 503 regulations on most issues. However, they provide additional requirements for the following:

- Monitoring Frequency. WQ 423 provides greater delineation for monitoring frequency than Part 503. Based on the WQ 423 requirements and projected solids quantities presented in Section 5.0 of this memorandum, the City monitoring requirements are listed in Table 3.

Table 3
Recommended Monitoring Frequency per MDNR WQ 423

Design Sludge Production, dry ton/yr	Monitoring Frequency			
	Metals, Pathogens, and Vectors	Nitrogen TKN [1]	Nitrogen PAN [2]	Priority Pollutants and TCLP [3]
1,001 to 10,000	1 per month	1 per month	1 per week	See Note 4

1. Test Total Kjeldahl Nitrogen (TKN) if biosolids application is 2 dry tons per acre per year or less.
2. Calculate Plant Available Nitrogen (PAN) if biosolids application is more than 2 dry tons per acre per year.
3. Priority pollutants (40 CFR 122.21, Appendix D, Tables II and III) and toxicity characteristic leaching procedure (TCLP) (40 CFR 261.24) is required only for permit holders that must have a pre-treatment program.
4. One sample for each 1,000 dry tons of sludge.

- Application Rates. WQ 425 includes application rate limits based on the total cumulative loading limit and the soil cation exchange capacity (CEC).
- Best Management Practices. Some of the Best Management Practices (BMPs) listed in WQ 426 are more stringent than Part 503 requirements. These include increased buffer zones to protect surface waters (300 feet), dwellings (150 feet), wetlands (100 feet), and property lines (50 feet);

slope limitations for application areas; soil pH limits at the application sites (6.0 to 7.5); and biosolids storage requirements.

MDNR biosolids storage requirements vary depending on the site location, and Highway 36 is a boundary. Storage requirements are 120 days north of Highway 36 and 90 days south of Highway 36. Due to the close proximity between Highway 36 and the WPF, a storage requirement of 90 days was expected.

4.3 Regulatory Outlook and Trends

Recent discussions with MDNR and USEPA Region 7 staff identified several regulatory changes that may occur within the next 10 to 20 years. These include the addition of phosphorus limitations for land application rates and monitoring of pharmaceutical and endocrine disruption compounds. Neither of these issues has been addressed at the federal level at this time and no regulation modifications are currently pending.

5.0 Biosolids Quantities

This evaluation was based on the City's historical and projected future biosolids quantities. The historical solids production was determined based on information in the Domestic Sludge Reports (2007 to 2009) shown in Table 4.

Table 4
Historical Annual Solids Quantities [1]

Year	Annual Biosolids Production, dry tons	Landfilled Biosolids, dry tons	Land Applied Biosolids, dry tons	Solids Concentration, % TS	Volume, cu yd
2007	3,614	306	3,308	27%	15,676
2008	4,637	882	3,755	27%	19,726
2009	3,357	225	3,132	29%	13,275
Average	**3,869**	**471**	**3,399**	**28%**	**16,226**

1. From yearly Domestic Sludge Reports.

5.1 Future Solids Estimates

Future solids quantities were developed for TM-WW-6 – Biosolids Facilities_and are listed in Table 5.

Table 5 Projected Solids Production [1]		
	Design Conditions (2030)	
Parameter	**Annual Average**	**Maximum Month**
Primary Solids		
Dry solids, ppd	18,980	30,520
Volatile Solids, %	71	60
Waste Activated Sludge		
Dry Solids, ppd	13,560	29,040
Volatile Solids, %	78	78
Total Dry Solids, ppd	32,540	59,560
1. Projected solids production without chemical phosphorus removal.		

Dewatered cake quantities were developed based on a digester design volatile solids reduction (VSr) of 55 percent. While the plant data indicate a historical cake solids concentration of 28 percent TS, planned improvements to the collection system are expected to reduce the influent load of silt. Consequently, a cake solids concentration of 25 percent was used for this evaluation. Projected cake quantities are presented in Table 6. The quantities listed in Table 6 were used for developing biosolids management alternative costs. The 2030 maximum month conditions were used to size equipment and are therefore the basis for capital costs. The 2030 annual average conditions were used to develop annual operating costs. Typically, midpoint (in this case 2020) annual average conditions are used to develop operating costs; however, little growth is expected over the 20 year study period. Consequently, 2020 and 2030 annual average conditions are similar.

Table 6 Design Dewatered Cake Projections (2030)			
Parameter	**Units**	**Annual Average**	**Maximum Month**
Cake Production	ppd (dry)	19,300	37,000
	ppd (wet)	77,200	148,100

Table 6
Design Dewatered Cake Projections (2030)

Parameter	Units	Annual Average	Maximum Month
Cake Volume	cu yd /day	48	93
	cu yd/hr	3.0	5.4

6.0 Biosolids Management Alternatives

The evaluated biosolids management alternatives are presented in the following sections. Appendix A provides detail of the historical solids hauling and land application costs, and Appendix B provides detail of the development of the opinion of probable costs for the solids management alternatives.

6.1 Base Alternative: Continue Current Hauling and Disposal

The current biosolids management program consists of anaerobic digestion, dewatering, and hauling to land application or landfill disposal of a Class B product. The City uses three full-time operators for solids hauling and application. On occasion, the city has stockpiled biosolids on abandoned taxiways for up to 14 days on the airport site. Historically, the City has applied approximately 88 percent of its biosolids. The remaining 12 percent of the biosolids production has been landfilled. The City owns the following land application equipment:

- Two tractors (New Holland and Ford TW-35)
- Three spreaders (one Roto-mix and two John Deere)
- One set of disks (John Deere 630 disk)
- Two push trailers
- Three dump trucks (Volvo)

Advantages and disadvantages of the current biosolids hauling and land application program are listed in Table 7.

Table 7 Advantages and Disadvantages: Current Biosolids Program	
Advantages	**Disadvantages**
• City has control over program. • No dependency on third party contract. • Long relationship with land owners and neighbors at land application sites. • Low cost as compared to heat drying.	• Application program is impacted by inclement weather. • Permitting of land application sites is time consuming. • Increased urbanization will reduce available application sites. • Costs are affected by increases in diesel fuel prices. • No available storage facility, requiring significant solids to be hauled to landfill.

A summary of the annual expenses for the current land application program was provided by the City and is listed in Table 8. The costs include:

- Labor for hauling, land application, and program management
- Cake sampling and analysis
- Equipment maintenance
- Diesel fuel costs
- Disposal fees for biosolids that are landfilled

Table 8
Historical Annual Costs for Biosolids Management

Category	Year		
	2007	**2008**	**2009**
Solids Production, dtpy	3,614	4,637	3,357
Total Solids, %	27%	27%	29%
Diesel Fuel	$66,421	$78,250	$47,118
Labor: Equipment Operations	$113,550	$113,550	$113,550
Labor: Management and Reporting	$10,800	$10,800	$10,800
Landfill Disposal	$39,616	$108,374	$30,828
Equipment Maintenance	$10,800	$8,600	$49,000
Total[1]	**$234,534**	**$311,749**	**$246,584**
Unit Costs[2]			
Per Dry Ton	$65	$67	$73

Table 8 Historical Annual Costs for Biosolids Management			
Category	Year		
	2007	2008	2009
Per Wet Ton	$18	$18	$22
Average Unit Cost[2]			
Per Dry Ton	$69		
Per Wet Ton	$19		

1. Costs do not include dewatering polymer or laboratory analysis.
2. Based on tonnage of dewatered, digested biosolids

The City's total biosolids management costs include polymer and laboratory costs for on-site and contracted analysis, in addition to those presented in Table 8. Since the costs for dewatering polymer and laboratory analysis are expected to be the same for all options, these costs were not included in this comparison.

The biosolids hauling and application equipment purchase dates and costs are listed in Table 9. Replacement costs have been estimated based on Engineering News Record (ENR) Building Cost Index (BCI) price escalation values. Pusher trailers, which are currently in the City's vehicle inventory, are no longer used for the biosolids program and have therefore not been included in Table 9.

Table 9
Equipment Purchase Dates and Costs

Equipment	Purchase Date	Purchase Cost	Replacement Cost [1]
Tractor: New Holland	September 2007	$113,000	$120,100
Tractor: Ford TW-35	October 1988	$47,929	$88,400
Spreader: Roto-mix	March 2007	$27,400	$29,900
Spreader: John Deere	November 1988	$9,822	$18,100
Spreader: John Deere	December 1997	$11,050	$15,800
Disks: John Deere (630 disks)	November 1993	$11,977	$19,000
Dump Truck (3 ea): Volvo	February 2002	$90,818	$122,200

1. Replacement costs presented in April 2010 dollars (ENR BCI = 4816.51).

Current unit costs for the City's biosolids management program were developed based on information presented in Tables 8 and 9 and were calculated using the following parameters. The current unit costs are presented in Table 10.

- 90 percent of the diesel purchased by the Department of Water Protection was used for the biosolids program. The diesel expenses presented in Table 8 are for the biosolids program only.
- Historical laboratory costs of approximately $37,000 per year were expected to remain unchanged regardless of management program and were therefore not included in the cost calculations.
- The useful life of the hauling and spreading equipment was considered to be 10 years. This report focuses on a 20 year operation, resulting in two complete rounds of equipment replacement.
- No salvage value was assigned for equipment at the end of its 10-year useful lifetime.
- No additional costs were considered for storage requirements (90 days per MDNR requirements).

Table 10
Costs for Base Case Alternative

Category	Cost
Total Equipment Replacement Cost [1,2]	$660,000
Annual Equipment Replacement Cost	$65,800
Total Unit Costs[3]	
Per Dry Ton	$60
Per Wet Ton	$15

1. Cost in 2010 dollars.
2. Based on two replacement cycles during 20-year project life.
3. Based on tonnage of raw primary and WAS solids at 25% TS cake.

The opinion of probable capital, operations and maintenance (O&M), and present worth costs for the base case alternative are presented in Table 11.

Table 11 Capital, O&M, and Present Worth Costs: Base Case Alternative				
Capital Cost, $M	**Annual O&M, $**	**Present Worth of Annual O&M, $M**	**Total Present Worth, $M**	**Unit Cost, $/dt**
$0.66 [1]	$268,000	$3.34	$4.41	$60[2]
1. Includes hauling and land application equipment replacement costs. 2. Based on tonnage of raw primary and WAS solids				

6.2 Alternative 1: Contract Biosolids Management

Alternative 1 is based on continuing land application of a Class B cake, but uses contracted labor for the site identification, permitting, hauling, and application. Several firms provide these services in the St. Joseph area. In many cases, off-site cake storage and documentation for the biosolids annual reports can be provided within the scope of the application contract. Using a contractor for the permitting and application process does not relieve the City of responsibility for the quality of the biosolids, suitability of the application sites, or the application rates used. Consequently, it is important to select a contractor with experience and a good track record. Advantages and disadvantages of contract hauling and application are listed in Table 12.

Table 12 Advantages and Disadvantages: Contracted Hauling and Disposal Program	
Advantages	**Disadvantages**
• Reduced City staffing requirements. • Contractor has responsibility for identifying and permitting application sites. • Contractor provides off-site storage for dewatered cake. • Preparation of annual biosolids reports can be included in contract. • Contract land application has been used extensively in Midwest with good results. • Low costs as compared to heat drying.	• City does not shed responsibility for issues associated with application process (application rates, noise, neighbor complaints, etc.). • Less control over contract cost increases than City-operated program. • Contract typically requires re-bid every 3 to 5 years.

Two companies, Nutra-Ject and Synagro, were contacted for budget-level cost opinions for land applying the City's dewatered cake. Both firms have extensive land application experience, Nutra-Ject in the Midwest and Synagro nationally. The reported costs, listed in Table 13 include contractor provided off-site storage for up to 90 days, to comply with the MDNR requirement.

Table 13
Contracted Land Application Costs

Entity	Units	Range	Characteristics
Nutri-Ject	$/wet ton	$17-$19	Costs include all analysis, hauling, land application and reporting.
Nutri-Ject	$/wet ton	$20-$23	Total unit cost including $200,000 to $250,000 additional capital for 90 day off-site storage (cost provided by Nutri-Ject).
Synagro	$/wet ton	$24-$26	Costs include hauling, land application, data tracking, and reporting. Costs also include 90 day off-site storage.

The average cost for the two proposals was $23 per wet ton. The opinion of probable capital, O&M, and present worth costs for Alternative 1 are presented in Table 14.

Table 14
Capital, O&M, and Present Worth Costs:
Alternative 1 – Contracted Hauling and Application

Capital Cost, $M	Annual O&M, $	Present Worth of Annual O&M, $M	Total Present Worth, $M	Unit Cost, $/dt
$0	$327,000	$4.08	$4.08	$55

6.3 Alternative 2: Class A Solids Through Thermal Drying

Alternative 2 consists of the addition of thermal drying to the existing biosolids treatment process. The dryer would be installed downstream of dewatering. Dried material meets Class A pathogen requirements and therefore could be sold, given away, or applied to agricultural land. Several types of thermal dryers are available, with varying cost and levels of complexity. This evaluation was based on a modular dryer, available from Komline-Sanderson or Gouda. Costs were based on quotes from

Komline-Sanderson. A schematic of the drying process is shown on Figure 1. Process considerations include:

- Digester biogas will be used for thermal drying. Additional energy requirements will be provided using purchased natural gas.
- Waste heat from the drying process can be recovered from the dryers and used to help heat the digesters; however, no evaluation was performed on the quantity of waste heat available or the digester heating requirements.

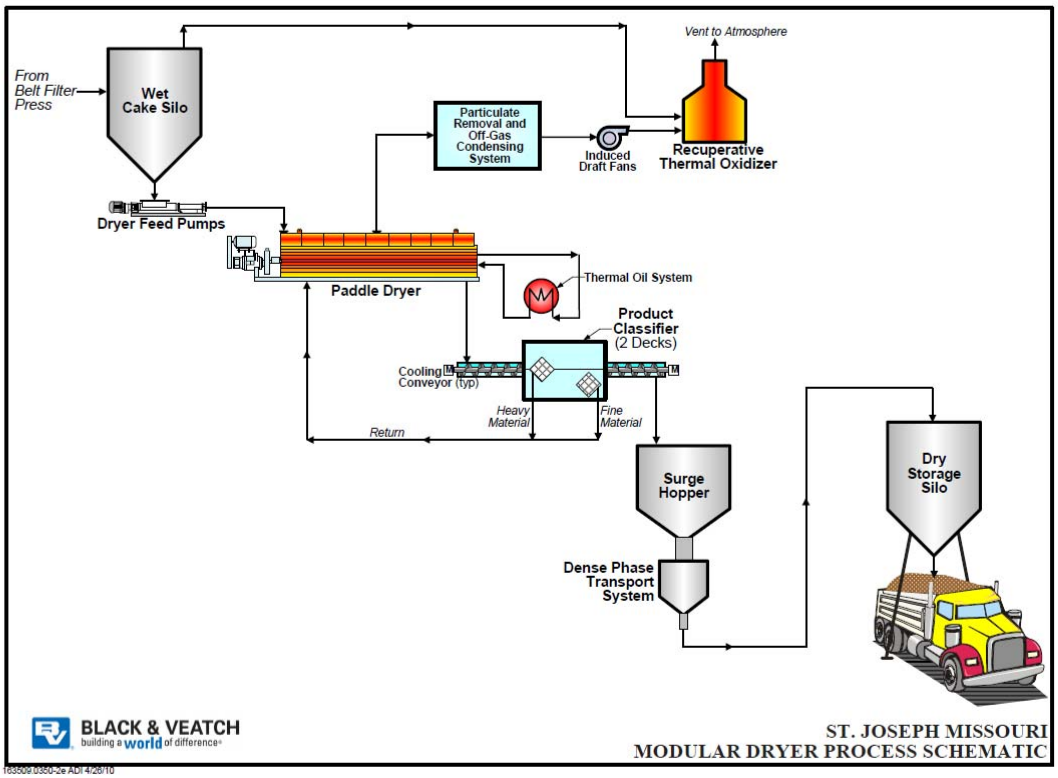

Figure 1 – Process Schematic for Modular Dryer

Advantages and disadvantages of a Class A thermal drying program are listed in Table 15.

Table 15 Advantages and Disadvantages: Class A Thermal Drying Program	
Advantages	**Disadvantages**
• Drying reduces biosolids volume. • Very flexible outlets for dried product (land application or sale/give away). • Reduced weather impacts. • Reduced land application staff requirements.	• High capital cost. • Purchased energy cost can be significant. • Increased electrical requirements. • Increased process staff. • More complex treatment process. • Increased greenhouse gas emissions.

Dewatered cake must be conveyed to the dryer using screw or belt conveyors, positive displacement pumps, or by hauling. Conveyors can be constructed to move cake for extended lengths, but the conveyors must be covered (if outdoors) and may have increased maintenance in inclement or freezing weather. Consequently, conveyor runs are usually limited to a few hundred feet or less. Pumping using progressing cavity pumps (Moyno, Seepex, or Netsch) typically have maximum pumping distances of 150 feet. Based on these issues and the available space on the plant site for construction of a new drying facility, the following options were considered:

1. Install the new thermal dryer on a new, upper floor of the existing digester control/dewatering facility. The structural characteristics of this building have not been evaluated; therefore, this alternative would require a detailed analysis of the structure and possible reinforcement and modifications.
2. Install the thermal dryer in a new building southeast of the existing digester control/dewatering building. However, two force mains (36 inch and 42 inch) from the Whitehead Pump Station run through this area. Relocating these pipelines would be expensive and could impact plant service. Consequently, this location was not considered further.
3. Install new dewatering and drying in a new two-story building in the northwestern corner of the WPF site as shown on Figure 2. Drying equipment would be located on the first floor, with dewatering equipment on the second floor. The existing dewatering equipment has approximately 10 years of remaining life and could be relocated to the

new facility. However, since the cost of re-locating existing dewatering equipment or purchasing new dewatering equipment would be significant, the option may be more attractive if it can be phased to match the scheduled replacement of the existing dewatering equipment. The costs presented in this memorandum do not include dewatering relocation or replacement.

Based on the complications associated with Options 1 and 2, costs were only developed for Option 3. Thermal drying operating parameters used for this evaluation are listed in Table 16. Equipment requirements are listed in Table 17.

Table 16
Thermal Drying Operating Parameters

Parameter	Units	Value	
		Average Annual	Maximum Month
Operating Schedule	day/wk hr/day	5 24	6 24
Dry Solids Characteristics			
Dried solids	% TS	92	
Dry solids density	lb/cu yd	1,250	
Dry solids production	ppd	19,300	37,000
Product volume	cu yd/d	17	32

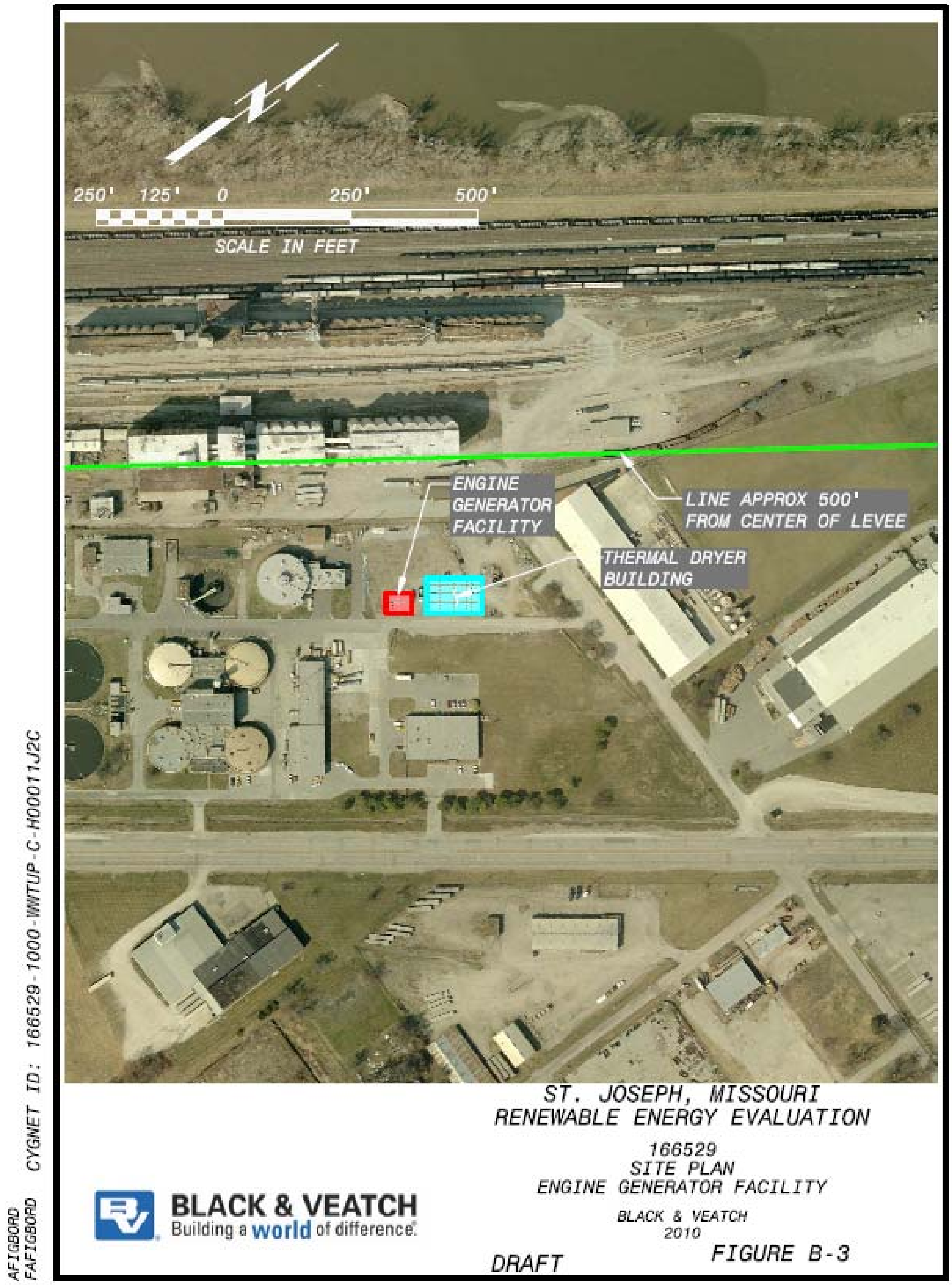

Figure 2 – Proposed Thermal Dryer Facility Site Location

Table 17 Thermal Drying Equipment	
Parameter	**Value**
Modular Dryer (Komline-Sanderson)	
Number	1
Type	Paddle Dryer
Heat Source	Thermal Oil
Wet Cake Silo with Hydraulic Sliding Frame	
Number	1
Volume, cu yd	130
Dryer Feed Pumps (VFD)	
Number	1 duty + 1 standby
Dryer Discharge Conveyor (Horizontal Screw)	
Number	1
Dry Product Cooling Conveyors	
Number	2
Return Conveyor	
Number	1
Dense Phase Transport System	
Type	Compressed Air
Number	1
Product Storage Silo	
Number	1
Volume, cu ft	6,000
Odor Control	
Type	RTO
Number	1
Air Flow, scfm	800

Total system installed horsepower is 412 hp, with the majority of the power required for the dryer agitator/screw assembly. A preliminary equipment layout is shown on Figure 3.

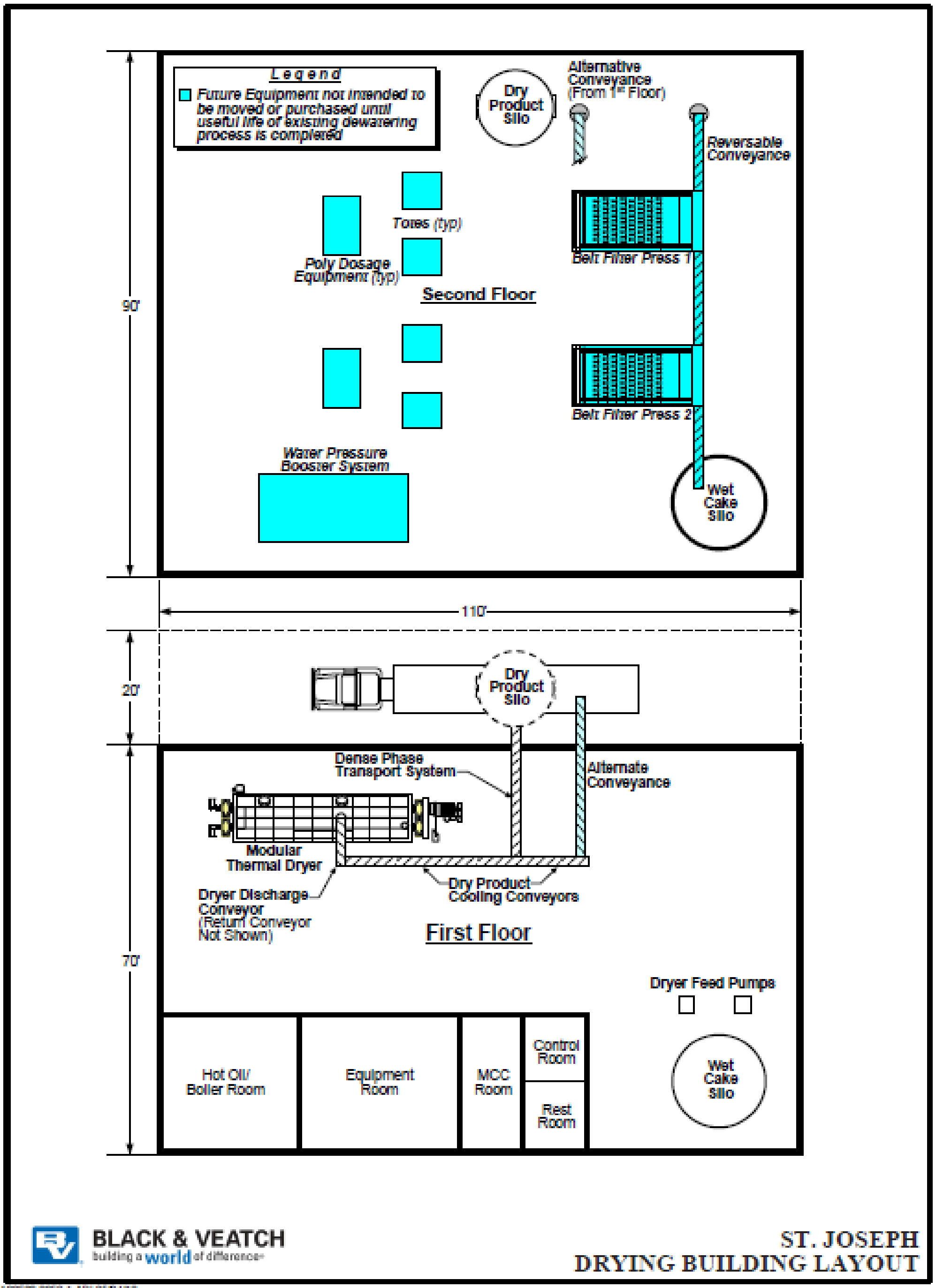

Figure 3 – Proposed Thermal Drying and Dewatering Building Layout

The following items were added to the drying equipment price to develop the project cost:

- Installation at 30 percent of the equipment cost.

- Two-story drying/dewatering building (70 feet by 110 feet), constructed on piles.
- Yard piping including the following pipelines: 2 inch hot water, 4 inch digested solids, 4 inch biogas.

Operating costs are based on the following:

- Five day per week operation, 24 hours per day.
- 50 week per year dryer operation. Landfill disposal of dewatered cake during 2 week dryer downtime.
- 80 percent power usage.
- Dust control chemical at a dose of 7.7 lbs/dry ton.

A list of the construction cost factors, unit costs, and financial factors used in developing lifecycle costs are listed in Table 18. Unit costs are based on information provided by the City. Costs for line items not currently used by the City were based on vendor-provided information or typical national costs.

Table 18
Cost Factors

Parameter	Value
Construction Cost Factors	
Electrical, Instrumentation and Controls [1], %	25
Sitework, %	10
General Requirements, %	12
Contingency, %	25
Engineering, Legal, and Administration. %	20
Unit Costs	
Power, $/kWh	0.10
Labor, $/hr	32.80
Natural Gas, $/mmBtu	6.00
Dust Control Chemicals for Heat Dried Product, $/gal	3.50
Contract Hauling and Land Application. $/wet ton	23
Equipment Maintenance (of equipment cost), %	2

Table 18 Cost Factors	
Parameter	**Value**
Financial Factors	
Project Life, years	20
Interest Rate, %	5
Equipment Life, years	20
Building, Piping Life, years	50
1. Electrical, instrumentation and controls cost factors were not applied to pile costs.	

The opinion of probable capital, O&M, and present worth costs for Alternative 2 – Thermal Drying are presented in Table 19.

Table 19 Capital, O&M, and Present Worth Costs: Alternative 2 – Thermal Drying				
Capital Cost, $M	**Annual O&M, $**	**Present Worth of Annual O&M, $M**	**Total Present Worth, $M**	**Unit Cost, $/dt**
$24.51 [1]	$625,000	$7.79	$31.02	$419
1. Does not include salvage value.				

Costs for thermal heat drying are relatively high compared to typical unit costs; however, the capital costs include construction of a dewatering area within the new drying facility.

6.4 Alternative 3: Seek Class A Equivalency

This alternative is based on continuation of the current City-operated land application system (Base Alternative), but includes application for PFRP equivalency for the existing thermophilic digestion process to meet Class A pathogen criteria. The application process is described in the Class A Biosolids Certification memorandum. Advantages and disadvantages of bulk land application of Class A cake are listed in Table 20.

Table 20 Advantages and Disadvantages: Class A Cake Program	
Advantages	**Disadvantages**
• Reduced site restrictions for a Class A cake as compared to Class B. • May require no changes to the current equipment and operations.	• PFRP equivalency is not guaranteed. • Obtaining PFRP equivalency requires significant testing and analysis. • Public typically unaware of differences between Class A and Class B cake.

Since the equivalency application process is site specific, actual costs are not known. However, estimated costs for the process were developed based on average pathogen analysis expenses presented in the Class A Biosolids Certification memorandum and potential testing requirements listed in Table 21.

Table 21 Estimated Testing Requirements for Class A PFRP-Equivalency Filing	
Parameter	**Characteristics**
Parameters measured per sampling period	
Pathogens (units)	Fecal Coliforms (MPN/g TS) *Salmonella* spp. (MPN/4g TS) Enteric Virus (PFU/4g TS) Helminth Ova (viable ova/4g TS)
Other (units)	Total Solids (% TS)
Sampling points	Digester Feed Digester Discharge Dewatered Cake
Sampling schedule	2 Sampling Events/Month 9 Months of Sampling

Other costs and sampling characteristics considered included:

- An additional 10 percent cost for shipping.
- Two hours of labor per sample for collecting, documenting, and shipping.
- Five hours per week for program management during the testing period (nine months).
- Three months of 25 percent time for one person to draft reports, requests, procedures, and file all documents.

The estimated costs, which are a one-time expense, total approximately $90,000. Actual costs will vary depending on the application requirements developed by USEPA Region 7 staff.

7.0 Cost Summary

The opinion of probable costs for the four evaluated alternatives are summarized in Table 22.

Table 22
Opinion of Probable Alternative Costs and Unit Prices

Parameter	Alternative			
	Base (Present)	1 (Contract Hauling)	2 (Thermal Drying)	3 (PFRP Equivalency)[1]
Capital (2010 $M)	$0.66	$0	$24.51	$0.09
Annual O&M ($)	$268,000	$327,000	$625,000	$0
Present Worth of Annual O&M ($M)	$3.34	$4.08	$7.79	$0
Total Present Worth ($M)	$4.41	$4.08	$31.02	$0.09
Unit Cost ($/dry ton)	$60	$55	$419	$15

1. PFRP equivalency costs are in addition to the costs of the Base Alternative.

8.0 Conclusions and Recommendations

As presented in Table 22, the unit cost of the City's current operation of biosolids hauling and land application of a Class B product (Base Alternative) is within 10 percent of, and approximately equivalent to, the unit cost expected for contract operations of the same services (Alternative 1). If the City continues a cake land application program, it can choose between in-house or contracted operations based on non-economic issues, such as staffing requirements and desired level of control and oversight effort for the program. Regardless of ownership of the application process, the City would retain responsibility for all land applied biosolids.

Generation of dry biosolids through a thermal drying process (Alternative 2) would be desirable due to the Class A status, low weight, public acceptance, and ability to sell to other markets such as biomass combustion or compost generation; however, the unit cost is much higher than all other alternatives considered.

Achieving PFRP-Equivalency status for the current process (Alternative 3) is likely to require significant effort and cost, without guaranteed results. However, pathogen measurement can be used to meet Class A criteria as an alternative to obtaining PFRP status.

It is recommended that the City continue the current operation of biosolids hauling and land application of a Class B product unless non-economic issues by City staff favor a contract operation of the program. Space on the WPF site should be allocated for a future thermal dryer facility should evaluation factors change in the future, including availability of land for application and public acceptance of a Class B product.

9.0 References

- Domestic Sludge Reporting (2007-2009), City of St. Joseph to the Missouri Department of Natural Resources.
- Class A Biosolids Certification Memorandum (Black & Veatch, May 4, 2010).
- Technical Memorandum TM-WW-6 – Biosolids Facilities (Black & Veatch, April 30, 2010).
- Design Memorandum for Wastewater Treatment Plant Improvements (Camp Dresser & McKee, Inc., Delich Roth & Goodwillie, P.A., and Snyder & Associates, 2003).

Appendix A

Historical Solids Hauling and Land Application Costs

Owner:	St.Joseph, MO	Computed By:	CDL
Plant:	Water Pollution Facility	Date:	May 10, 2010
PN:	163509 File No.	Checked By:	PAS
Title:	**Hauling and Disposal**	Date:	May 7, 2010
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HAULING AND DISPOSAL

Historic Hauling and Disposal Costs Experienced by the City

Category	Year		
	2007	2008	2009
Solids Generated (dtpa)	3,614	4,637	3,357
Total Solids (%)	27%	27%	29%
Gasoline Purchases: total	$66,421	$78,250	$47,118
Gasoline Purchases: specific for land application (90% of total)	$59,779	$70,425	$42,406
Labor: 3 Equipment operators	$113,550	$113,550	$113,550
Labor: Management and Reporting	$10,800	$10,800	$10,800
Landfill Fees	$39,615	$108,374	$30,827
Equipment Maintenance Costs	$10,800	$8,600	$49,000
Polymer Costs*	$111,141	$132,452	$100,874
Laboratory Costs*	$22,000	$22,000	$22,000
Laboratory Outsourced Testing*	$15,000	$15,000	$15,000
* Values not considered in evaluation due to their requirement in all options			

Yearly Costs (all values):	$382,700	$481,200	$384,500
Yearly Costs (for this evaluation):	$234,500	$311,700	$246,600

Biosolids Management Cost (no equipment replacement included)

Unitary Hauling & Disposal Costs	Year		
	2007	2008	2009
Per dry ton	$65	$67	$73
Per wet ton	$18	$18	$22
Average Historical Hauling/Disposal Costs ($/dry ton)			**$69**
Average Historical Hauling/Disposal Costs ($/wet ton)			**$19**

Present Equipment Costs

Present ENR BCI (Building Cost Index): 4816.51

Equipment	Purchase Date	Purchase Price	ENR value (BCI)	Present Price
Tractor: New Holland	9/28/2007	$113,000	4533	$120,100
Tractor: Ford TW-35	10/27/1988	$47,929	2612	$88,400
Spreader: Roto-mix	3/2/2007	$27,400	4411	$29,900
Spreader: John Deere	11/9/1988	$9,822	2616	$18,100
Spreader: John Deere	12/23/1997	$11,050	3370	$15,800
Disks: John Deere (630 disks)	11/24/1993	$11,977	3029	$19,000
Dump Truck: Volvo (952-33)	2/12/2002	$90,818	3581	$122,200
Dump Truck: Volvo (952-35)	2/12/2002	$90,818	3581	$122,200
Dump Truck: Volvo (952-69)	2/12/2002	$90,818	3581	$122,200
Pusher Trailer (I)*	6/1/1995	$54,356	3095	$84,600
Pusher Trailer (II)*	6/1/1995	$54,356	3095	$84,600
* Equipment cost not considered in evaluation as it is no longer used				

Total equipment replacement cost (only equipment used):	$657,900
Estimated lifetime of equipment (years):	10
Yearly equipment ammortization cost (for this evaluation):	$65,800.00

Hauling Quotes

Operator	Range	Quote	Other costs	Contract	wtpa (AA	Cost	Cost $/wet
Nutriject	High	$17.00	$200,000	20	4,933.54	$93,870	$19.03
	Low	$19.00	$250,000	20	4,933.54	$106,237	$21.53
Synagro	High	$24.00	$0	20	4,933.54	$118,405	$24.00
	Low	$26.00	$0	20	4,933.54	$128,272	$26.00
Average							**$22.64**

Appendix B

Opinion of Probable Costs for Solids Management Alternatives

Owner	St.Joseph, MO	Computed By:	CDL
Plant:	Water Pollution Facility	Date:	May 10, 2010
PN:	163509 File No.	Checked By:	PAS
Title:	Cost Summary	Date:	May 7, 2010
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CAPITAL COST

Historic Hauling and Disposal Costs Experienced by the City

Item Description	No. of Units	Unit Cost	2010 Cost	2020 Cost	SV at 2030
Vehicle Replacement			$660,000	$660,000	
Subtotal			**$660,000**	**$660,000**	**$0**
Total Capital Costs			**$660,000**	**$660,000**	
Electrical & Instrumentation	0%		$0	$0	
Subtotal			**$660,000**	**$660,000**	
Sitework	0%		$0	$0	
Construction Subtotal			**$660,000**	**$660,000**	
General Requirements	0%		$0	$0	
Contingencies	0%		$0	$0	
Engineering, Legal & Administration	0%		$0	$0	
Total Project Cost			**$660,000**	**$660,000**	**$0**

ANNUAL OPERATING COSTS

Item Description		Units	Unit Cost	$/per year
Land application and disposal (based on historical costs)	14,096	wtpy	$19.00	$267,800
Total Operating Cost				**$268,000**

PRESENT WORTH & ANNUALIZED UNIT COST

Period, years	20
Replacement period, years	10
Interest Rate	5%
P/A Factor, Operations	12.46
Equipment Replacement Period	10.00
P/A Factor, Equipment Replacement	0.61
P/F 2020 Eqipment Replacement	0.614
P/F Salvage in 2030	(0.377)
Year 0 Capital Costs	$660,000
Year 10 Capital Costs	$660,000
PW Year 10 Capital Costs	$405,000
PW of Salvage Value	$0
Total Present Worth Capital Costs	$1,065,000
Present Worth Cost of Annual O&M	**$3,340,000**
Total Present Worth Costs	**$4,410,000**
Annualized Present Worth Costs	$354,000
Annual Average Cake Production (dt/yr)	5,938
Annualized Unit Cost ($/dt)	**$60**
Annualized Unit Cost ($/wt)	**$15**

Owner	St.Joseph, MO		Computed By:	CDL
Plant:	Water Pollution Facility		Date:	May 10, 2010
PN:	163509	File No.	Checked By:	PAS
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CAPITAL COST

Contract - Operated Land Application

Item Description	No. of Units	Unit Cost	2010 Cost
No Capital Expenses			
Subtotal			**$0**
Total Capital Costs			**$0**
Electrical & Instrumentation	25%		$0
Subtotal			**$0**
Sitework	10%		$0
Construction Subtotal			**$0**
General Requirements	12%		$0
Contingencies	25%		$0
Engineering, Legal & Administration	20%		$0
Total Project Cost			**$0**

ANNUAL OPERATING COSTS

Item Description		Units	Unit Cost	$/per year
Labor				
Management	250	hr	$32.78	$8,200
Solids Hauling Contract	14,096	wtpa	$22.64	$319,100
Total Operating Cost				**$327,000**

PRESENT WORTH & ANNUALIZED UNIT COST

Period, years	20
Interest Rate	5%
P/A Factor, Operations	12.46
Year 0 Capital Costs	$0
Total Present Worth Capital Costs	$0
Present Worth Cost of Annual O&M	**$4,075,000**
Total Present Worth Costs	**$4,080,000**
Annualized Present Worth Costs	$327,000
Dewatered Annual Average Cake Production (dt/yr)	5,938
Annualized Unit Cost ($/dt)	**$55**

Owner	St.Joseph, MO	Computed By:	CDL
Plant:	Water Pollution Facility	Date:	May 10, 2010
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CAPITAL COST

Heat Drying

Item Description	No. of Units		Unit Cost	2010 Cost	2020 Cost	SV at 2030
Dryer and installation (KS 13W-2000)	1	LS	$4,998,500	$4,999,000		
2" return heat line	610	LF	$40	$24,000		$2,562
4" sludge line to new buidling	610	LF	$80	$49,000		$5,856
4" biogas line to new building	610	LF	$80	$49,000		$5,856
Drying building (2 floors)	17,600	SF	$230	$4,048,000		$2,428,800
HVAC	17,600	SF	$35	$616,000		$369,600
Plumbing	17,600	SF	$10	$176,000		$105,600
Fire protection	17,600	SF	$4	$62,000		$37,200
Piles	160	EA	$4,550	$728,000		$436,800
Subtotal				**$10,750,000**		**$3,390,000**
Total Capital Costs				**$10,750,000**		**$3,390,000**
Electrical & Instrumentation	25%			$2,506,000		
Subtotal				**$13,260,000**		**$3,390,000**
Sitework	10%			$1,326,000		
Construction Subtotal				**$14,590,000**		**$3,390,000**
General Requirements	12%			$1,751,000		
Contingencies	25%			$4,085,000		
Engineering, Legal & Administration	20%			$4,085,000		
Total Project Cost				**$24,510,000**		**$3,390,000**

ANNUAL OPERATING COSTS

Item Description		Units	Unit Cost	$/per year
Power	1,888,872	kWh	$0.100	$189,000
Labor				
Operations	6,240	hr	$32.78	$204,500
Maintenance	520	hr	$32.78	$17,000
Management of downtime hauling subcontract (2 wks)	520	hr	$32.78	$17,000
Dryer downtime biosolids hauling subcontract (2 wks)	757	wet ton	$22.64	$17,100
Equipment Maintenance	1	LS	$77,000	$77,000
Chemicals	18,585	lb	$3.47	$64,400
Natural Gas Consumption	6,519	MMBtu/yr	$6.00	$39,100
Total Operating Cost				**$625,000**

PRESENT WORTH & ANNUALIZED UNIT COST

Period, years	20
Interest Rate	5%
P/A Factor, Operations	12.46
P/F Salvage in 2030	(0.377)
Year 0 Capital Costs	$24,510,000
PW of Salvage Value (Buildings)	($1,278,000)
Total Present Worth Capital Costs	$23,232,000
Present Worth Cost of Annual O&M	**$7,789,000**
Total Present Worth Costs	**$31,020,000**
Annualized Present Worth Costs	$2,489,000
Dewatered Annual Average Cake Production (dt/yr)	5,938
Annualized Unit Cost ($/dt)	**$419**

Owner:	St.Joseph, MO	Computed By:	CDL
Plant:	Water Pollution Facility	Date:	May 10, 2010
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Title:	**Natural Gas and Fuel Costs**	Date:	May 7, 2010
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D O N O T W R I T E I N T H I S S P A C E

NATURAL GAS AND FUEL USE AND COSTS

Natural Gas Cost ($/mm Btu) $6.00

Diesel Consumption for Current Operation

Equipment	Use (gal/yr)	Unit Price ($/gal)	Cost ($/yr)
Diesel for hauling	23,411	$2.457	57,520
	Total		$ 58,000

Energy Demands and Diesel Consumption for Contracted Hauling and Disposal

Equipment	Use (mmBtu/hr)	Hr/Day	Day/Wk	Wk/Yr	Unit Price ($/mmBtu)	Use (mm Btu/yr)	Cost ($/yr)
Energy use	0.0	0	0	0	0.00	0	0
			Total			0	$ -

Energy Demands for Heat Drying

Water Pollution Facility							
Equipment	Use (mmBtu/hr)	Hr/Day	Day/Wk	Wk/Yr	Unit Price ($/mmBtu)	Use (mm Btu/yr)	Cost ($/yr)
Natural Gas Use	1.1	24	5	50	6.00	6,519	39,116
			Total			6,519	$ 39,000

Owner	St.Joseph, MO	Computed By:	CDL
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CHEMICAL USE AND COSTS

Dust Control $3.47

Chemical Consumption for Current Operation

Chemical	Dose (lb/dt)	Solids (dtpd)	Solids (dtpy)	Chemical (ppy)	Chemical ($/lb)	Cost	($/yr)
Historic Hauling and Disposal Costs							
Chemicals	0	0.0	0	0	$0.00	$	-
Total						**$**	**-**

Chemical Consumption for Contracted Hauling and Disposal

Chemical	Dose (lb/dt)	Solids (dtpd)	Solids (dtpy)	Chemical (ppy)	Chemical ($/lb)	Cost	($/yr)
Land Application Program							
Chemical use	0	0.0	0	0	$0.00	$	-
Total						**$**	**-**

Chemical Consumption for Heat Drying

Water Pollution Facility							
Chemical	Dose (lb/dt)	Solids (dtpd)	Solids (dtpy)	Chemical (ppy)	Chemical ($/lb)	Cost	($/yr)
Heat Drying							
Dust Control	7.70	9.7	2,414	18,585	$3.47	$	64,398
Total						**$**	**64,400**