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An Economic Analysis of Landfill Costs to Demonstrate the Economies of Size and Determine the Feasibility of a Community Owned Landfill in Rural Oklahoma

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ABSTRACT

New regulations have impacted landfill costs and changed solid waste management solutions. Communities must now decide between continued landfill operations and long-term uncertainties associated with contracted services. Preliminary cost analysis addresses these changes and demonstrates economies of size that make regional facilities more feasible than the once popular city-owned landfills.

An Economic Analysis of Landfill Costs to Demonstrate the Economies of Size and Determine the Feasibility of a Community Owned Landfill in Rural Oklahoma

Where people reside, there will be waste. Recycling, composting, and in some cases incineration, have the potential to reduce the solid waste stream, but they do not eliminate the need for landfills. Presently, there are no safe and cost effective alternatives to divert all the "trash" that we currently generate thereby requiring the deposit and covering of waste in landfills. Furthermore, the alternative waste management systems mentioned all produce residues that require landfill disposal. The critical question is whether it is more feasible for a community to construct and operate its own landfill or to explore alternative solutions.

Regulations in Resource Conservation and Recovery Act (RCRA) Subtitle "D" changed the design along with daily and long term procedures associated with municipal solid waste (MSW) landfill disposal. Compliance costs associated with the latest landfill management requirements have resulted in a significant change in the way landfills now operate. There are now fewer landfills that are larger in size and most are operated privately. A present day landfill encapsulates the waste by a liner system at the bottom and daily cover materials on the top. Appropriate systems are required to control contaminated water and gas emissions and reduce the adverse environmental effects. Landfill operators must also maintain all environmental protection and monitoring systems in addition to general upkeep of the site for a 30-year post closure period.

Landfill costs are very site specific. The final design and subsequent costs of a particular landfill will depend on terrain, soil type, climatic factors, site restrictions and regulatory factors. The type of waste disposed, preprocessing and potential for groundwater contamination will also impact the design process. Landfill costs are also greatly affected by the daily volume of material received, that is, there are significant economies of size associated with landfills.

Total landfill costs or life cycle costs are defined as all costs incurred from the time the landfill is conceived, through the 30-year post-closure period. These costs include: preconstruction/planning, engineering, legal, licensing, and land acquisition; construction; operating; closure; and post-closure. Life-cycle costs are the basis for tipping fees. Profit must also be included for privately operated landfills.

Three factors included in life-cycle costs must be noted. First, a large amount of capital is needed to construct and operate a landfill and, therefore, the cost of capital (interest) must be included. Second, closure and post-closure costs are significant. State regulators administer by law regulations to assure future funds for facility closure and post-closure. The financial instrument filed with the state to guarantee funding for these activities is known as "financial assurance." Finally, inflation over the life of the landfill, including the post-closure period, must be factored into the life-cycle costs. Responsible landfill management will include all the above when establishing charges for solid waste services and/or tipping fees.

To illustrate costs, data are presented for an example landfill in rural Oklahoma. It is a small rural community that is currently operating their own landfill that will be out of space in a few years. National and local average costs were used to estimate the costs for construction, operation, monitoring, closure and post-closure of a landfill large enough to serve a population of 30,000 (estimated 87.7 tons per day). Additional estimates are provided for a larger landfill (200 tons per day) to demonstrate existing economies of size. Data used for this analysis are believed to be the best estimates available. However, due to the many site-specific variances between landfill locations, these costs required numerous assumptions and are only intended as a guide to aid decision-makers as they seek to provide future solid waste disposal services for their community. A specific site evaluation will be necessary to obtain a more accurate estimate.

Facility Sizing

The size of a MSW facility or site is affected by the size of population served waste shed), the desired life span of the facility and the height or "lift" of the buried waste. **Table 1** presents the estimated size of a landfill with enough capacity to serve the area. Based on current trends, it was estimated that the landfill accepted 23,996 tons of waste per year. It was assumed that the landfill would have a 20-year life. Given the estimates for waste received at the landfill and an appropriate population growth rate for rural populations (0.31), the volume can be estimated for the 20-year span.

If the landfill accepts waste 310 days per year, the average MSW deliveries for this example would total 87.7 tons per day or 494,440 tons during the site life. The MSW must be covered each day and therefore additional capacity must be included to account for daily cover (10 percent of delivered weight). With an assumed 30-foot lift and estimated compaction rate of 1000 pounds per cubic yard, a footprint of 22.5 acres would be required to provide the necessary capacity. The total permitted acres must also include land for buildings, stockpiling, and buffer zones (40 percent). This analysis assumed a permitted site of 31.5 acres. Purchasing additional acres might be considered to allow for extended life.

Facility Development and Construction Costs

The capital investment portion of the total costs is divided between site development, equipment purchases and construction costs. The facility development costs are preliminary costs associated with the entire site (e.g., characterization studies, land acquisition, engineering and design studies, and permit package fees) thereby occurring only in the first year of operation. The construction phase typically occurs in stages as required. Only a portion of the site or "cell" is developed with each subsequent cell being developed as the previous cell nears capacity. It

was assumed that the facility would be developed in three phases, with each cell containing approximately 7.5 acres. Each cell would be constructed in 6 to 7 year increments. (A new cell should be ready to accept waste before the old cell reaches capacity.)

Site Development and Equipment Purchases

The estimated site development costs are given in **Table 2**. There is an extensive list of possible development tasks to perform depending on the location, typography, etc. of the chosen site. It is difficult to estimate the costs of each individual task and therefore the costs in **Table 2** are not intended as all-inclusive, but rather detail the major cost items.

Prior to acquiring the land, the solid waste quantities and potential site should be analyzed to characterize acceptability and feasibility. Critical studies include topographic surveys, hydrological studies and collection of climatological data. All federal state and local regulations must be identified. With a 15 percent contingency, to cover site-specific incidentals, costs for land acquisition, site development and equipment are estimated at $1,490,669.

Construction Costs

As previously mentioned, the construction costs will be incurred in three phases. **Table 3** provides the estimated construction costs for Phase 1. Phase 1 costs include development of the first cell plus the addition of all permanent structures, utility establishment and other improvements that will be needed during operations and, in some cases, during the post-closure period.

The first step is to get all necessary equipment and personnel onsite to start construction. These initial costs are referred to as mobilization costs. Mobilization will be required each time a cell is opened and closed and then again at site closure. Mobilization estimates for Phase 1 are $18,897. Each cell must be cleared of trees and debris. The cell must be excavated with the

topsoil and subsoil material stockpiled in separate locations. Several structures will be necessary to operate the landfill. These structures include a truck scale, scale house, and leachate storage tanks as well as a building to accommodate an office and provide space for maintenance. The entire facility will have to be fenced and quality roadways will have to be built.

RCRA Subtitle "D" regulations require several water monitoring and control systems that are significantly costly to install. These water systems include leachate management, surface water control, and groundwater monitoring and gas management. Each new cell must have a composite liner and leachate collection system installed. Surface water control costs including sedimentation pond and drainage construction will occur primarily in the Phase 1. Phase 1 installation and management costs for the leachate liner system are estimated at $723,899. The remaining Phase 1 estimates for environmental management are $22,112 for surface water control and $20,762 for groundwater and gas monitoring systems.

The remaining costs include engineering services, overhead, profit and closeout. Total construction costs for Phase 1 including 10 percent contingency costs are estimated to be $1,904,873. Upon completion of this initial construction phase, the facility would be ready to start operations. Additional cells would then be developed as the first and subsequent cells are filled.

The construction costs associated with the remaining phases are represented in **Table 4**. While Phase 2 and 3 will not include costs for initial structures, **Table 4** presents estimates that reflect 2 cells and therefore will be higher. Total construction costs for subsequent phases are $3,548,344 making construction costs for all phases total $5,453,219.

Based on the assumptions for this analysis, a 31.5 acre site (22.5 disposal acres) developed as described above, would require a capital investment of $6,943,886 (including a 10

percent contingency) or slightly greater than $220,000 per acre. It would cost an estimated $12.77 per ton of MSW landfilled at the facility to cover the capital investment.

Facility Operating Costs

As with capital costs, there are assumptions that must be made to estimate operating costs particularly regarding staffing, equipment, and leachate volume generation. **Table 5** presents operating costs estimates for an average site of the type described in this analysis.

It was assumed that six full time equivalent employees would be required to operate the facility. Personnel costs total (including benefits, taxes, and overhead) $154,180. Equipment operating costs are based on fuel, repairs and maintenance. They also include annualized purchase price estimates (depreciation) to insure available replacement costs as needed. Total operating costs of equipment are estimated at $275,706 per year.

Monitoring costs are also a significant portion of the annual operating costs. Many of these costs will be cumulative for short periods as each new cell is opened. However, for this analysis, environmental costs are estimated for each phase. Operation and disposal costs for leachate system total $3,649. Environmental monitoring costs, which include sampling and analysis of air, groundwater, gas, leachate and surface water, total $10,456 per year. With additional estimates for site repairs, engineering services, utilities and overhead, and disposal fees, operations and monitoring costs total $631,138 per year or $12,622,754 over the life of the facility.

Closure and Post-Closure Costs

The final steps in this analysis are to cost out the facility closure and to determine the expenditures needed for 30 years of post-closure monitoring and maintenance.

Closure costs

At the end of the operating period, the final cell would be closed since the other cells would have been closed on a phased basis during the operating period. The costs associated with the final cap, plus all the other costs needed to restore the entire site and to ready it for the post-closure period are given in **Table 6**. All temporary buildings must be removed and the site must be covered and capped (topsoil put back in place), graded and vegetation established. Equipment must then be removed and all environmental monitoring structures and equipment must be checked and/or repaired to prepare for the 30-year post closure period. Estimated total closure costs including a 10 percent contingency are $797,778.

Post-Closure

The site must be monitored and maintained for 30 years after it has been closed. **Table 7** presents the estimates for this period. In addition to vegetation and soil maintenance, all environmental monitoring must be included. All monitoring equipment must be maintained to allow for periodic sampling and analysis. Leachate collected must be treated and disposed of. Final post closure costs including administrative fees, technical services and contingency total $2,978,694.

Although landfill owners have a number of options in securing and paying their financial assurance obligations, this study assumed an annual annuity with an average investment return of 5.0 percent and a nominal inflation rate of 2.0 percent. It was also assumed that a portion of revenues received during the operation period would be placed in escrow and funded as a level annuity. To the extent investment earnings exceed inflation, the net result is substantial reduction in the funding needed for the 4 million dollar investment to closure and post-closure. Given these assumptions, approximately $2.4 million in cash outlays would be required to fund the future inflated costs of closure and post-closure care, which would total in excess of $5.6

million through the end of post-closure period. Investment earnings would pay the difference.

Cost Comparisons for a Larger Landfill

To demonstrate the economies of size, the same assumptions were applied to a landfill large enough to serve a larger population. **Table 8** presents the cost comparisons for the previously described landfill (87.7 TPD) and a landfill serving an area with approximately 60,000 residents and receiving an average 220 TPD. Both the total costs and costs per ton are presented. The economies of size become clear as average cost per ton decreases from $46.56 for the smaller landfill to $27.80 for the larger landfill. This is due to the significant quantity of fixed costs that do not increase proportionately with increased capacity. Although the capacity is increased two and one-half times, total site development and construction costs only increase 1.7 times from $7,096,892 to $11,925,591. Costs per ton drop from $13.04 to $8.74. As shown, this is largely due to the site development portion of the costs. The studies involved with preliminary site selection and permitting requirements are expensive but most costs do not increase, as the size of the permitted site grows larger.

Total operations, closure and post-closure increase only 1.4 times from $14,991,285 to $20,592,957 decreasing costs per ton from $27.56 to $15.10. Even though the total permitted acres increased, the landfill is still developed in "cells". A basic compliment of personnel and equipment must be available during operating hours of the landfill. The smaller landfills do not fully employ equipment and labor.

A comprehensive study of Subtitle "D" type landfill life cycle costs was completed in Tennessee for landfills receiving 25 to 500 tons of solid waste per day (TPD). To further illustrate cost comparisons, **Figure 1** presents the 1991 Tennessee data (solid line) along with the two cost estimates presented in **Table 8**. Results from both studies show the economies of size

that occur with landfill disposal. The data suggests the need for regional landfills in sparsely populated rural areas where small daily generation rates would require cost prohibitive tipping fees at small community landfills.

Conclusions and Implications

This study provides estimates for a 31.5 acre permitted site receiving 87.7 tons of solid waste per day and compares it with a larger facility that would receive 220 tons per day. Results indicate that volume significantly impacts feasibility. If tipping fees have to be unreasonably high to cover costs, residents might choose alternative sites which will further increase total costs per ton. Landfill operators must attempt to control sufficient volume or be subject to the same long-term uncertainities associated with private contracts.

The authors recognize that there are many site-specific variances between landfill locations. These variances are beyond the scope of this study. Additional information is required to localize the estimate to a specific site. However, this study provides useful information to assist community and county decision-makers as they attempt to evaluate their alternatives.

References

Bureau of Labor Statistics. "Table1. National Employment and Wage Data." *Occupational Employment Statistics Survey by Occupation*,(1999).

Census Bureau. "Construction Contracts, 1998." *Statistical Abstract of the United States-1999*: 722.

Craftsman Book Company. *2000 National Construction Estimator-48th Edition*:268.

Craftsman Book Company. *2000 Oklahoma CD Estimator-Heavy*,: 151-52.

Delaware Solid Waste Authority (DSWA). *Cherry Island, Jones Crossroads, and Sandtown Landfills*.

Dahlberg, D.J. *Controlling Tipping fees Through Closure and Post-Closure.*

Eilrich, F.C., et al. *"*The Economic Feasibility of a Curbside Recycling System to Serve the Residents of Ada Oklahoma*."* Oklahoma State University, AE-9952,(Aug. 1999).

Eilrich, F.C., et al. "An Economic Analysis of a Transfer Station for the City of Ada Oklahoma." Oklahoma State University, AE-9959(Oct. 1999).

Glebs, R.T. "Estimating Landfill Costs-Environmental Planning to Post-closure Care," GRCDA Proceedings(Aug. 11-13, 1987): 84-100.

Investment Choices." SWANA Proceedings(Aug. 3-6, 1992): 225-47.

Interagency Cost Estimating Group, HTRW. "HCAS Remedial Action Work Breakdown Structure, Third Level Burdened Cost Ranges."(Dec. 30, 1999): 1-11.

Missouri Department of Natural Resources. Division of Environmental Quality, "Solid Waste Management Program Task 4-Remediation Possibilities and Costs."(Nov. 07, 2000.

R.S. Means. "Environmental Remediation Cost Data-Unit Price, 5th Annual Edition-1999." *"Means Cost Works, Heavy Construction(1999)* and *Means Cost Works, Heavy Construction,(2001).*

U.S. Army Corps of Engineers. "Construction Equipment Ownership and Operating Expense Schedule." Volume 6/Region VI), EP-1110-1-8,(Jun. 30, 1999):2-78 - 2-163.

U.S. Environmental Protection Agency. "Decision-Maker's Guide to Solid Waste Management." Second Edition. EPA530-R-95-023(Aug. 1995).

Western Mine Engineering, Inc., Data Cost Center. "Mining Equipment Costs."(Jan. 2001).

Table 1
Facility Sizing Requirements for a Municipal Solid Waste Landfill
Serving 30,000 Population in Rural Oklahoma

Requirement (units)	Amount
Annual Discards (tons)	23,996
Annual Growth Rate (%)	0.31
Average Annual MSW Deliveries (tons) (based on 310 days / year)	27,194
Average Daily MSW Deliveries (tons) (based on 310 days / year)	87.7
MSW Deliveries During Site Life (tons)	494,440
Daily Cover (% of daily deliveries)	10
Total Capacity Required (tons)	543,884
Average Depth (lift) of Waste (SEE BELOW)	30.0
Total Disposal Area Required (acres)	22.5
Additional Area for Buffers, Roads, Ponds, Storage, Etc. (40% acres)	9.0
Total Permitted Area Required (acres)	31.5
Compaction Rate (lbs. / cu. yd.)	1,000
Total Capacity Required (cu. yds.)	**1,087,769**

MSW Disposal Area Required

Depth of Fill	Acres
10 Foot Lift	67.4
15 Foot Lift	44.9
20 Foot Lift	33.7
25 Foot Lift	27.0
30 Foot Lift	22.5
35 Foot Lift	19.3
40 Foot Lift	16.9
45 Foot Lift	15.0
50 Foot Lift	13.5

Table 2
Estimated Site Development Costs for a Municipal Sold Waste Landfill Serving 30,000 Population in Rural Oklahoma

Item		Cost
Land Acquisition ($1,500 Per Acre)		$47,197
Waste Characterization Study	$92,805	
Site Selection Study	$108,733	
Perform boundary and topographic surveys		
Prepare base maps of existing conditions on and near sites		
Compile hydro geological information and prepare location map		
Compile climatological data		
Identify regulations (Federal, State, Local) and design standards		
Preliminary Studies Total Cost		$201,538
Site Engineering and Design		$43,102
Permit Package		$36,603
Equipment Acquisitions		
Fuel storage tank with pump		$2,448
Earthmoving equipment		
Compactor		$245,084
Dozer		$363,164
Front Loader		$153,997
Grader		$203,100
SUB-TOTAL SITE DEVELOPMENT COSTS		$1,296,234
Contingency (15.0%)		$194,435
TOTAL SITE DEVELOPMENT COSTS		**$1,490,669**

Table 3
Estimated Phase 1 Construction Costs for a Municipal Solid Waste Landfill
Serving 30,000 Population in Rural Oklahoma

Item	Costs
Mobilization	$18,897
Structures, Improvements, and Equipment	
Access Roads	$38,306
Office, Including Furniture, Fixtures, and Equipment	$58,488
Maintenance/Storage Buildings	$38,400
Truck Scale and Weight System	$23,206
Scale House	$4,320
Fencing (8 Foot, Chain Link)	$50,903
Leachate Storage Tank (10,000 Gallon, In Ground)	$16,492
Landscaping (Berms 12' x 3')	$33,918
Total Structures, Improvements, and Equipment	**$264,033**
Site Preparation	$320,262
Site Utilities	$14,788
Cell and Leachate System Liner System	$625,301
Leachate Management System	$98,598
Surface Water Controls	$22,112
Monitoring Systems	$20,762
SubTotal	**$1,101,823**
Construction Management	
Engineering Services	$74,132
Contractor's Markup, Overhead, and Profit	$256,368
Total Construction Management	**$330,500**
Construction Close-Out	
Site Clean-Up & Debris Removal	$3,631
Demobilization of Construction Equipment	$7,542
Demobilization of Personnel	$5,277
Total Construction Close-Out	**$16,450**
SUB-TOTAL CONSTRUCTION COST - THROUGH PHASE 1	**$1,731,703**
Contingency (10%)	$173,170
TOTAL CONSTRUCTION COST - THROUGH PHASE 1	**$1,904,873**

Table 4
Estimated Subsequent Phase Construction Costs for a Municipal Solid Waste Landfill Serving 30,000 Population in Rural Oklahoma

Item	Costs
Mobilization	$18,897
Structures, Improvements, and Equipment	$19,694
Site Preparation	$597,357
Cell and Leachate System Liner System	$1,250,603
Surface Water Controls	$1,517
Monitoring Systems	$0
Leachate Management System	$185,488
Construction Final Cap for Closed Cells	$584,194
Construction Management	
Engineering Services	$67,393
Contractor's Markup, Overhead, and Profit	$492,497
Total Construction Management	**$559,890**
Construction Close-Out	
Site Clean-Up & Debris Removal	$3,301
Demobilization of Construction Equipment	$7,542
Demobilization of Personnel	$5,277
Total Construction Close-Out	**$16,120**
SUB-TOTAL CONSTRUCTION COST - REMAINING PHASES	**$3,225,767**
Contingency (10%)	$322,577
TOTAL CONSTRUCTION COST - REMAINING PHASES	**$3,548,344**
SUB-TOTAL CONSTRUCTION COST - ALL PHASES	**$4,957,471**
Contingency (10%)	$495,747
TOTAL CONSTRUCTION COST - ALL PHASES	**$5,453,217**

Table 5
Annual Facility Operating and Monitoring Costs for a Municipal Solid Waste Landfill Serving 30,000 Population in Rural Oklahoma

Item	Units	Unit Cost	Total Costs
Personnel (Includes Benefits, Taxes & Overhead)			
Facility Manager	1	$32,500.00	$32,500
Equipment Operators	2	$32,448.00	$64,896
Scale House Attendant	1	$18,928.00	$18,928
General Laborers	2	$18,928.00	$37,856
Total Personnel			**$154,180**
Equipment Operating Costs (Fuel, Repairs & Maintenance)			
Bulldozer (hours)	1,590	$50.58	$80,422
Compactor (hours)	1,590	$48.16	$76,574
Front-End Loader (hours)	1,590	$46.37	$73,728
Grader (hours)	1,590	$28.29	$44,981
Total Equipment			**$275,706**
Site Repairs and Maintenance (Materials, Parts, and Services)			$80,693
Leachate System Operation and Disposal			
Average Annual Operating Cost			$410
Equipment Maintenance and Repairs			$964
Remove, Haul and Treat Off-Site			$2,276
Total Leachate System Operation and Disposal			**$3,649**
Environmental Monitoring			
Ground Water Sampling & Analysis			$8,816
Gas Sampling & Analysis			$700
Leachate Sampling & Analysis			$420
Surface Water Sampling & Analysis			$520
Total Environmental			**$10,456**
Engineering Services			$13,194
Utilities, Supplies, Overhead, Indirects, and Contingency (10%)			$52,468
Solid Waste Disposal Fees to OK Dept. of Environmental Quality (tons)	27,194	$1.50	$40,791
ANNUAL FACILITY OPERATIONS AND MONITORING COSTS			$631,138
Estimated Operating Life of Facility (Years)			20
TOTAL OPERATIONS AND MONITORING COSTS FOR LIFE OF SITE			**$12,622,754**

Table 6
Facility Closure Costs for a Municipal Solid Waste Landfill
Serving 30,000 Population in Rural Oklahoma

Item	Costs
Provide Facility Closure Administration Services	$55,350
Construction Management	$117,627
Terminate Operations & Remove Buildings, Structures, & Equipment	$117,029
Construct Final Cap	$293,914
Environmental Monitoring	$97,294
Drainage / Erosion Control	$13,656
Testing	
Top Soil Sampling & Analysis	$1,441
Surface Water Sampling & Analysis	$130
Ground Water Sampling & Analysis	$2,204
Gas Sampling & Analysis	$175
Leachate Sampling & Analysis	$210
Total Testing	**$4,160**
Complete Final Closure and Secure Permitted Area	
Inspect and Repair site Buffers / Landscaping (% of Cost)	$1,696
Inspect and Repair Fencing, Gates, and Posts (% of Cost)	$2,545
Inspect and Repair Remaining On-Site Roads (% of Cost)	$1,915
Disconnect / Remove All Utility Services Not Needed During Post-Closure	$3,697
Site Clean-Up & Debris Removal (Acres)	$1,651
Demobilize Equipment	$7,542
Demobilize Labor	$5,277
Total Final Closure	**$24,323**
TOTAL CLOSURE COST	$725,252
Contingency (10%)	$72,525
TOTAL FINAL CLOSURE COST	**$797,778**

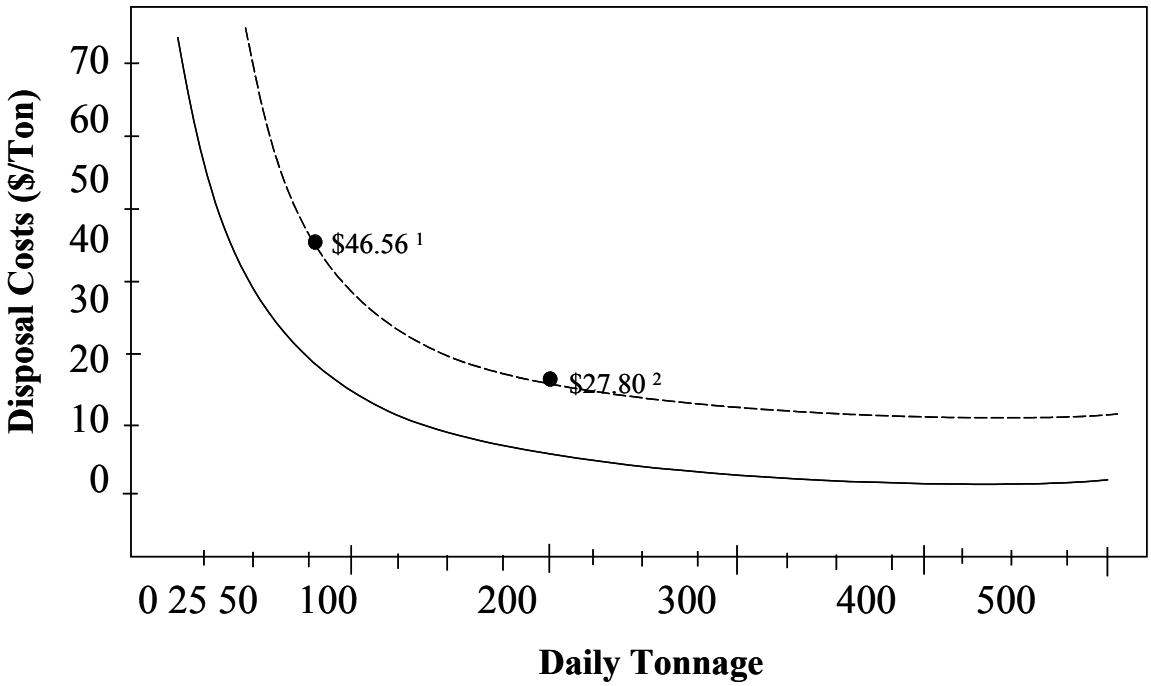
Table 7
Facility Post-Closure Costs for a Municipal Solid Waste Landfill
Serving 30,000 Population in Rural Oklahoma

Item	Cost
Provide Post-Closure Administration Services	
Conduct Periodic Site Inspections / Surveys	269,260
Engineering / Legal Services	206,909
Oversight and Record keeping / Reporting	34,479
Total Administration Services	**510,648**
Construction Management (% of cost)	261,348
Maintain Final Cap	
Replace Top Soil and Mow / Fertilize as Needed	338,386
Replace Material for Drainage Layer as Needed	15,142
Repair/Replace Compact Clay / Geosynthetic Liner as Needed	340,652
Replace Material for Gas Venting Layer as Needed	3,842
Total Final Cap	**698,022**
Maintain Drainage / Erosion Control System	132,935
Maintain Gas Control System	
Repair / Replace Gas Vents as Needed	45,668
Repair / Replace / Plug Gas Probes as Needed	25,725
Total Gas Control	**71,393**
Operate and Maintain Leachate Management System	
Clean and Repair Leachate System	78,704
Operate Leachate Management System	73,734
Remove, Haul, and Treat Off-Site	409,636
Total Operation and Maintenance of Leachate System	**562,074**
Maintain Ground Water Monitoring Wells	46,276
Testing	
Top Soil Sampling & Analysis	10,806
Surface Water Sampling & Analysis	7,800
Ground Water Sampling & Analysis	132,240
Gas Sampling & Analysis	10,500
Leachate Sampling & Analysis	12,600
Total Testing	**173,946**
Provide Miscellaneous Site Maintenance	237,266
Perform Required Activities at End of Post-Closure Care Period	
Cap / Plug / Disconnect Environmental Monitoring Equipment	5,650
Disconnect Utilities	1,000
Remove All Machinery, Buildings, and Equipment	7,346
Total End Activities	13,996
SUBTOTAL POST-CLOSURE COSTS	**2,707,904**
Contingency (10%)	270,790
TOTAL FINAL POST-CLOSURE COSTS	**2,978,694**

Table 8
Comparison of Total Facility Costs for Tow Municipal Solid Waste Landfills
Serving 30,000 and 60,000 Populations in Rural Oklahoma

	88 Tons per Day		220 Tons per Day	
Item	**Cost per Ton**	**Total Cost**	**Cost per Ton**	**Total Cost**
Site Development Costs	$2.38	$1,296,233	$1.00	$1,367,400
Contingency (15%)	$0.36	$194,435	$0.15	$205,110
Construction Costs - Through Phase 1	$3.18	$1,731,704	$1.03	$1,408,461
Construction Costs - Remaining Phases	$5.93	$3,225,767	$5.70	$7,769,866
Contingency (10%)	$0.91	$495,747	$0.67	$917,833
Site Development & Construction Financing Cost	$0.28	$153,006	$0.19	$2556,922
Total Site Development and Construction Costs	**$13.04**	**$7,096,892**	**$8.74**	**$11,925,591**
Net Interest on Revenue Bonds	$5.94	$3,233,157	$3.96	$5,402,863
Total Site Development, Construction, and Financing		**$10,330,049**		**$17,328,454**
Operations and Monitoring Costs	$23.21	$12,622,754	$12.21	$16,647,632
Closure Costs (Annuity Payments)	$0.71	$385,127	$0.30	$415,341
Post-Closure Care Costs (annuity payments)	$3.65	$1,983,405	$2.59	$3,529,983
Total Operations, Closure, and Post-Closure Costs	**$27.56**	**$14,991,285**	**$15.10**	**$20,592,957**
Total Estimated Costs	**$46.56**	**$25,321,334**	**$27.80**	**$37,921,412**
Number of Acres Developed		31.5		78.9
Development, Construction, and Financing Per Acre		**$327,938**		**$219,626**
Average Total Cost Per Acre		**$804,762**		**$480,571**
Site Capacity (tons)		543,884		1,364,000
Average Cost Per Ton		**$46.56**		**$27.80**

Figure 1. ESTIMATED COST OF A SUB-TITLE "D" LANDFILL.



— Dunsmore, 1991 ● Eilrich, VanFleet, 2001.

1 Landfill Serving 30,000 population

2 Landfill Serving 60,000 population