EPA's cost analysis is based on costing functions and/or unit costs for on- and off-site treatment and disposal costs and for on-site storage of recyclable materials. To develop the cost functions, EPA identified all of the treatment and disposal permutations that are available in the various baseline-Option scenarios. Similarly, EPA identified all of the possible storage practices available under any of the assumed baseline practices and regulatory options considered. The costing functions were developed by estimating costs for facilities of different sizes and curve-fitting these individual facility costs. For some equipment associated with disposal and storage practices, the Agency has used rental costs rather than purchase costs, irrespective of the quantities of material involved. EPA recognizes the likelihood that mineral processing facilities actually own this equipment, such as front end loaders and dump trucks. To be conservative, however, the Agency included rental costs as a simple way to account for the use of this equipment.

The cost functions and associated assumptions are presented in the following seven sections:

a. Annualization of Before-Tax Compliance Costs
b. On-site Treatment and Disposal Costs
c. Off-site Treatment and Disposal Costs
d. Storage of Solid Materials
e. Storage Of Liquid Materials
f. Curve-fit Cost functions
g. Costs of Groundwater Monitoring

D.1 Annualization of Before-Tax Compliance Costs

Under Executive Order 12866, EPA must determine whether a regulation constitutes a "significant regulatory action." One criterion for defining a significant regulatory action, as defined under the Executive Order, is if the rule has an annual effect on the economy of $100 million or more. To determine whether a rule is a significant regulatory action under this criterion, all costs are annualized on a before-tax basis assuming a seven percent real rate of return and a 20-year operating life. The savings attributable to corporate tax deductions or depreciation on capital expenditures for pollution control equipment are not considered in calculating before-tax costs.

Annual before-tax compliance costs were determined for on-site treatment, disposal, and storage. Before-tax compliance costs were used because they represent a resource cost of the rule, measured before any business expense tax deductions available to affected companies. Also, as described in section 3.2.2 of this RIA, screening level economic impacts are computed based upon other pre-tax indications or financial wherewithal, such as value of shipments and value added. Accordingly, computing management and compliance costs on a pre-tax basis provides a consistent measure of impacts on all affected facilities, and is the method used throughout this RIA. In reformulating the costs of compliance, EPA used a public sector discount rate of seven percent and assumed a 20-year operating life for annualizing capital costs.

The following formula was used to determine the before-tax annualized costs:

Before-Tax Costs = (Capital Costs)(CRF) + (Annual Capital + O&M Costs) + (Closure Costs)*(CRF)/(1.07^{21})

Where: CRF = Capital recovery factor based on a 7 percent real rate of return (i) as follows:

$$\frac{(1+i)^n(i)}{(1+i)^n-1} = 0.09439 \quad \text{where } n = 20$$

D.2 On-site Treatment and Disposal

Neutralization and Precipitation of Acidic and Caustic Liquid Wastes

Neutralization is the process of adjusting either acidic or caustic liquid waste streams to a pH of approximately seven. Many manufacturing and processing operations produce effluents that are acidic or alkaline (caustic) in nature. Neutralization of acidic or caustic waste streams is necessary in a variety of situations: (1) to prevent metal corrosion and/or damage to other construction materials; (2) as a preliminary treatment for optimum operation of subsequent waste treatment processes; and (3) to provide neutral water for recycling, either as process water or as boiler feed. Treatment to adjust pH also may be desirable to break emulsions, to precipitate certain chemical species, or to control chemical reaction rates (e.g., chlorination). Precipitation, which may occur as a result of the addition of neutralization reagents, or which may require additional reagents, is necessary to remove dissolved solids, such as toxicity characteristic metals from solutions. Corrosive waste streams are neutralized by the addition of an alkaline material, such as lime. Caustic waste streams are neutralized by the addition of an acidic material, such as sulfuric acid. Additional reagent will cause precipitation of dissolved metals. The assumptions described in the following subsections were used in preparing cost estimates, with one exception: batch runs were assumed for 3,510 metric tons per year (mt/yr) and 350 mt/yr, adjusting the operating hours per year to 876 and 88, respectively, while 1,752 hours per year was assumed for waste flow rates of 35,130 mt/yr to 350,000 mt/yr.

Capital Costs - Neutralization

The following assumptions were used in developing the direct capital cost equations for neutralization in Exhibit D-1:

- Stainless steel neutralization reactor (1) - ½-hour retention time, 5% over design (based on waste and calcium hydroxide or sulfuric acid solution flows);
- Stainless steel mix tank (1) - two-hour retention time, 5% over design (based on 10% calcium hydroxide or 20% sulfuric acid solution flows);
- Piping, electrical, and instrumentation; and

- Neutralization is performed in <90 day accumulation treatment tanks (40 CFR 262.34); therefore, a RCRA permit is not required.

Acidic Waste Only

- Carbon steel holding tank (1) - two-hour retention time, 5% over design (based on 10% calcium hydroxide solution flow);
- Carbon steel centrifugal pumps (3) - for the calcium hydroxide solution out of the mix tank and out of the holding tank, and for the waste flow into the reactor;
- Stainless steel centrifugal pump (1) - for the waste flow into the reactor;
- Cast iron agitators (2) - for the mix tank and the holding tank; and
- Stainless steel agitator (1) - for the reactor.

Caustic Waste Only

- Stainless steel pump (1) - for sulfuric acid flow out of the mix tank;
- Carbon steel pumps (2) - for the waste flow into and out of the neutralization reactor; and
- Stainless steel agitators (2) - for the sulfuric acid mix tank and the neutralization reactor.

Capital costs are similar for either type of waste due to the use of a high cost stainless steel reactor in both designs.

Operation and Maintenance Costs - Neutralization

The following assumptions were used in development of the O&M cost equations for neutralization in Exhibit D-1:

- Operating hours - 90 percent operating factor (i.e., 330 days/year);
- Labor - one operator at 20 percent time for continuous systems, or ½ hour of labor per batch;
- Power - electricity for pumps and agitators; and
- Materials - waste pH was assumed to be 1.0 (acidic wastes) and 13.0 (caustic wastes) and waste specific gravity was assumed to be 1.03. Material quantities calculated from the stoichiometric addition of 0.033 gallon of 10% calcium hydroxide or 0.022 gallon of 20% sulfuric acid solution needed per gallon of waste.

O&M costs are similar for either acidic or alkaline waste due to roughly equal neutralizing material costs.

EXHIBIT D-1

COST EQUATIONS FOR ON-SITE NEUTRALIZATION AND PRECIPITATION OF PHASE IV WASTES (1995 $)

Neutralization	
Capital Costs ($350 \leq Q \leq 370{,}000$ mt/yr)[1]	$Cost(\$) = 36{,}131 + 151.95\ Q^{.5}$
O&M Costs / Yr ($350 \leq Q \leq 370{,}000$ mt/yr)	$Cost(\$) = -206{,}719 + 36{,}594 \ln Q$
Precipitation	
Capital Costs ($350 \leq Q \leq 370{,}000$ mt/yr)[2]	$Cost(\$) = 3{,}613 + 15.195\ Q^{.5}$
O&M Costs / Yr ($350 \leq Q \leq 370{,}000$ mt/yr)	$Cost(\$) = 0.3465\ Q + 826.48$
Closure	
Closure Costs ($Q < 37{,}910$ mt/yr)	$Cost(\$) = 6{,}493$
Closure Costs ($37{,}910 \leq Q \leq 370{,}000$ mt/yr)	$Cost(\$) = 6{,}361 + 3.0 \times 10^{-3}\ Q$

Note:
For quantities above the upper limit of the cost equations, a second system is required.

[1] Q = Annual quantity of acidic or caustic waste managed (mt/yr). Capital and O&M equations apply to either type of waste (similar costs due to use of high cost stainless steel reactor in both designs and roughly equal neutralizing material costs). Fifteen percent of the waste stream neutralized and precipitated will need to be treated by stabilization due to sludge formation (see cost equations for Case A in Exhibit D-2 and use 0.15 * Q).

Performance Assumptions

The following performance goals were assumed for neutralization:

- Neutralized waste exits with a pH of approximately seven;
- Solid residuals are generated, with half of inlet total suspended solids (TSS) level of 3.0% assumed to settle and form a sludge with 10% solids content. Therefore, 15% of the original waste stream will leave the neutralization step as hazardous sludge, due to

precipitation of a portion of the 500 ppm TC-metals assumed to be in the inlet waste stream--this sludge will require dewatering, stabilization, and disposal; and

- The quantity of calcium hydroxide or sulfuric acid solutions added to the waste streams results in minimal flow changes.

Closure Costs

Cost equations for closure of the neutralization tanks and associated equipment are listed in Exhibit D-1 and include the following components:

- Decontamination of tank interiors, pumps, and liners;
- Management and off-site disposal of decontamination residuals as hazardous waste;
- Testing rinsate to demonstrate tanks and equipment are successfully decontaminated; and
- Certification of closure by a professional engineer.

Precipitation

EPA has assumed that in some cases, precipitation will require more reagent than used for neutralization, though these reagents will be added to the same reactor vessel. To account for this possibility, the Agency has determined that the capital cost for precipitation will consist of the cost of a small reagent holding tank, assumed to be 10 percent of the capital cost equation. O & M costs will consist of doubling the original reagent cost.

Surge Capacity

EPA also has assumed that a seven day surge tank is needed. The cost of this tank was developed along with that of other storage tanks, and is presented below in section 5.

On-Site Dewatering and Stabilization

Chemical stabilization/fixation, which consists of cement solidification and pozzolonic (lime-fly ash) solidification, is used to solidify organic and inorganic sludges. It also may be used to reduce the leachability of solid residues by first dissolving the materials and subsequently precipitating and fixing the dissolved solids. This technology adds cement and water to hazardous sludges to form a rock-like material that binds waste constituents in a solidified matrix. The process improves the physical characteristics of the waste by increasing its strength and reducing the leachability of contaminants after the solidified waste is land disposed. Cement solidification is particularly successful with sludges generated by the precipitation of heavy metals because the high pH of the cement mixture tends to keep the metals in the form of insoluble hydrated oxides, hydroxides, or carbonates. There is probably no lower limit on the solids content of sludges handled by cement solidification, although dewatering is advantageous as a volume reduction measure.

The stabilization process requires storage tanks and weighing equipment for both cement and the hazardous waste, a concrete mixer, and a loading hopper. Waste streams and cement are pumped from storage tanks to their respective weigh batchers, where the proper ratio for cement fixation is obtained. The two materials are then discharged from the weigh batchers to a concrete mixer. The proper amount of water is added to the two materials in the mixer, which then produces a homogeneous mixture. The mixture is discharged into a loading hopper, which may be transported by truck to a landfill site for disposal.

The assumptions described in the following subsections were used in generating cost equations for on-site dewatering and stabilization.

Capital Costs

The following assumptions were used in development of the direct capital cost equations for dewatering and stabilization presented in Exhibit D-2:

- Stabilization direct capital costs include the purchase costs for storage bins, weigh batchers, a concrete mixer, a loading hopper, instruments, controls, and pumps;

- The dewatering direct capital cost includes a scroll centrifuge;

- Installation charges were estimated at 15% of the equipment purchase costs;

- Storage tanks have a maximum capacity to store waste and cement for five days. The system is run as a batch processing operation. Waste rates considered range from 350 mt/yr to 370,000 mt/yr; and

- Stabilization is performed in a <90 day accumulation treatment tank (40 CFR 262.34); therefore, a RCRA permit is not required.

Operation and Maintenance Costs

The following assumptions were used in the development of the O&M cost equations for stabilization in Exhibit D-2:

- Direct operation and maintenance costs consist of operating labor, electricity, and cement and water consumption;

- The cement mixer has a minimum retention time of 15 minutes;

- Operating hours--90% operating factor (i.e., 330 days/year);

EXHIBIT D-2
COST EQUATIONS FOR ON-SITE DEWATERING AND STABILIZATION OF PHASE IV WASTES (1995 $)

Case A - Dewatering of 1-10% Solids-Containing Wastes	
Capital Costs ($350 \le Q \le 370{,}000$ mt/yr)[1]	Cost($) = $95{,}354 + 664.48\ Q^{.5}$
O&M Costs / Yr ($350 \le Q \le 370{,}000$ mt/yr)	Cost($) = $12{,}219 + 286.86\ Q^{.5}$
Case B - Stabilization Only of >10% (35% average) Solids-Containing Wastes	
Capital Costs ($425 \le Q \le 200{,}000$ mt/yr)	Cost($) = $207.93\ Q^{.78}$
O&M Costs / Yr ($425 \le Q \le 200{,}000$ mt/yr)	Cost($) = $87{,}839 + 52.16\ Q$
Closure Costs	
Closure Costs ($350 \le Q \le 200{,}000$ mt/yr)	Cost($) = $9{,}806 + 0.19\ Q$

[1] Q = Annual quantity of waste managed (mt/yr)

- The dewatered sludge (Case A) has a specific gravity of 1.03, while wastes with greater than 10 percent solids (Case B) have a specific gravity of 1.25;

- The Case A mixing ratio for fixation is 0.05 : 0.50 : 1.00 (water : cement : waste) by weight. The mixing ratio assumes that the stabilized waste quantity is approximately equal to 9% of the initial sludge amount prior to being dewatered to a sludge consisting of 60% solids and specific gravity of 1.56; and

- The Case B mixing ratio for fixation is 0.05 : 0.70 : 1.00 (water : cement : waste) by weight. The mixing ratio assumes that the stabilized waste quantity is equal to 100% of the initial sludge amount with a solids content of 35% and sludge specific gravity of 1.25.

Performance Assumptions

The following performance goals were assumed for stabilization:

- The subsequent leaching of hazardous constituents from land disposal of a stabilized waste is reduced by approximately two orders of magnitude; and

- The amount of solidified waste disposed of in a landfill is 1.55 (Case A) and 1.75 (Case B) times the quantity, on a weight basis, of the waste generated.

Closure Costs

Cost equations for closure of the stabilization tanks and associated equipment are listed in Exhibit D-2 and include the following components:

- Decontamination of tank interiors, pumps, and lines;
- Management and off-site disposal of decontamination residuals as hazardous waste;
- Testing rinsate to demonstrate tanks and equipment are successfully decontaminated; and
- Certification of closure by a professional engineer.

On-site Subtitle C Landfill

Initial Capital Costs and Assumptions

The landfill design assumes a 20-year operating life with one new cell opened per year (20 cells for 20-year operating life). The following assumptions were used in the development of the initial capital cost equation for landfill operations in Exhibit D-3:

- Land, which includes 5 meters between cells, 15 meters between the cells and the edge of the active area, and a 46-meter buffer around the 20 cell area;
- Site preparation, which includes clearing the 20-cell area and the 21 meters around the 20-cell area of vegetation;
- Gravel roads within the active area;
- A 50-foot x 35-foot concrete pad for unloading waste and truck cleaning;
- Warning, stop, and directional signs;
- A maintenance building for equipment repair;
- Utilities site work that includes the installation of electricity, a septic system, a domestic well, a gas line to propane tank, and a telephone at the site;
- An earthen berm around the 20-cell active area for surface water control;
- A package leachate treatment system;

EXHIBIT D-3

COST EQUATIONS FOR ON-SITE SUBTITLE C LANDFILLS
PHASE IV WASTES (1995 $)

Capital Costs ($Q \geq$ 1,000 mt/yr)	Cost($) = 83,378 + 23,422 $Q^{0.5}$
Annual Capital Costs ($Q \geq$ 1,000 mt/yr)	Cost($) = 3,137 $Q^{0.64}$
O&M Costs / Yr ($Q \geq$ 1,000 mt/yr)	Cost($) = 114,223 + 1,737 $Q^{0.5}$
Closure Costs ($Q \geq$ 1,000 mt/yr)	Cost($) = 1,829 $Q^{0.57}$
Post-Closure Costs / Yr ($Q \geq$ 1,000 mt/yr)	Cost($) = 1,523 $Q^{0.50}$
Cover Replacement Costs / Yr ($Q \geq$ 1,000 mt/yr)	Cost($) = 3,502 $Q^{0.59}$

Note: Q = Annual quantity of waste managed (mt/yr) ranging from 1,000 to 150,000 MT/yr.

- A groundwater monitoring system that includes six upgradient wells (three shallow wells to provide a horizontal profile of groundwater composition and one cluster of three wells at different depths near one another to provide a vertical profile of groundwater composition) and a minimum of nine downgradient wells (three three-well clusters with the wells in each cluster at different depths). For facilities with an active area side dimension greater than 300 ft, the unit would have the minimum three three-well cluster for the first 300 ft, plus one cluster of three wells for every additional 150 ft.;
- Portable submersible pumps for cell dewatering and leachate removal if sump pump fails;
- Heavy equipment, which includes dozers, landfill compactors, scrapers, and utility trucks;
- Construction of the first cell with the following containment system design in descending order starting with the layer closest to the waste:
  - 0.3 meter protective soil layer;

- geotextile filter fabric;
- 0.3 meter sand layer (LCS);
- 30 mil HDPE liner;
- 0.3 meter sand layer (LDS);
- 30 mil HDPE liner; and
- 0.91 meter clay layer;

- Wet wells and pumps for the leachate collection system and the leachate detection system;
- RCRA initial costs, which include the following items:
  - ID number;
  - waste analysis;
  - waste analysis plan;
  - inspection schedule;
  - personnel training;
  - alarm and spill equipment;
  - arrangement with local land authority;
  - contingency plan;
  - operating record;
  - groundwater monitoring plan;
  - background groundwater monitoring;
  - closure plan, closure cost estimate, post-closure plan, post-closure cost estimate;
  - closure/post-closure financial assurance (obtain mechanism - excludes payments to mechanism);
  - liability insurance (obtain mechanism - excludes payments to mechanism);
  - Part A permit application; and
  - Part B permit application; and
- Fees, which include construction quality assurance (CQA), engineering, construction and inspection, construction and field expenses, contractor's overhead and profit, spare parts inventory, and contingency.

Annual Capital Costs and Assumptions

Annual capital costs include the construction of one new cell and closure (i.e., final cover) of the previously used cell each year for the operating life (i.e., 19 years). The following assumptions were used in the development of the annual capital cost equation for landfill operations in Exhibit D-3:

- Cell construction consisting of the same containment design as described in the initial capital cost assumptions;
- Construction of each cell's cover with the following cover system design in ascending order starting with the layer closest to the waste:
  - 0.6 meter clay layer;
  - 30 mil PVC liner;
  - 0.3 meter sand layer;
  - geotextile filter fabric;
  - 0.6 meter topsoil layer; and
  - vegetation; and
- Fees which include CQA, engineering, construction and inspection, contractor's overhead and profit, and contingency.

Operation and Maintenance Costs and Assumptions

The following assumptions were used in the development of the O&M cost equation for landfill operations in Exhibit D-3:

- Labor for personnel to operate the landfill, which includes equipment operators, laborers, clerical, a technician, a manager, and an engineer;
- RCRA administrative costs, which include the following items:
  - review waste analysis and plan;
  - conduct and record inspections;
  - training program review for facility personnel;
  - review contingency plan;
  - maintain operating record;
  - review closure/post-closure plan;
  - update closure/post-closure cost estimate;
  - review closure/post-closure financial assurance mechanism;
  - review third party liability mechanism;
  - review corrective action schedule; and
  - permit renewal (Assumed the Part B permit is renewed every five years. Averaged the periodic costs out on an annual basis.);

- Maintenance labor and supplies;
- Leachate treatment;
- Groundwater monitoring semi-annually for the following parameters: pH; specific conductance; total organic carbon; total organic halogens; metals; and VOC's; and
- Utilities, which include fuel for heavy equipment, electricity for maintenance building and pumps, and heat for maintenance building.

Closure Costs and Assumptions

The following assumptions were used in the development of the closure cost equation for landfill operations in Exhibit D-3:

- Construction of the final cell's (cell 20) cover consisting of the same cover design described in the annual capital cost assumptions;
- Decontamination by steam cleaning of heavy equipment (dozers, scrapers, compactors, and trucks). Assumed residuals generated at 100 gal/hr and managed off-site as a hazardous waste (transportation 100 miles one-way and commercial hazardous waste treatment);
- Pumps and lines decontaminated with an alkaline solution. Assumed residuals generated at 500 gal/pump and managed off-site as a hazardous waste (transportation 100 miles one-way and commercial hazardous waste treatment);
- Certification of closure by an independent registered professional engineer; and
- Fees, which include CQA, engineering, construction and inspection, contractor's overhead and profit, and contingency.

Post-Closure Costs and Assumptions

The following assumptions were used in the development of the post-closure and cover replacement cost equations for landfill operations in Exhibit D-3:

- Survey plat indicating location and dimension of cells to permanently surveyed benchmarks;
- Waste record submitted to local land authority;
- Note added to property deed stating previous land use;
- Final cover inspected semi-annually;
- Maintenance of final cover (i.e., mow semi-annually and fertilize annually);

- Reseed, fertilize, mulch, and water 1/6 of entire 20-cell area every five years;
- Conduct routine erosion damage repair of cover and ditch every five years;
- Exterminate for burrowing rodents every two years;
- Replace the cover on the first five cells during the last five years of post-closure;
- Leachate managed off-site as a hazardous waste (transportation 100 miles one-way and commercial hazardous waste treatment) for all landfill sizes;
- Pumps replaced annually;
- Groundwater monitoring semi-annually for the following parameters: pH; specific conductance; total organic carbon; total organic halogens; metals; and VOC's;
- Certification of post-closure by an independent registered professional engineer; and
- Fees, which include administration, CQA, engineering, construction inspection testing, construction and field expenses, contractor's overhead and profit on the cover replacement cost, and contingency.

Disposal of Solid Materials in On-site Subtitle D Piles

The waste pile disposal cost function includes land, a compacted soil base, and the costs of a dump truck to move the material to the pile.

EPA made the following assumptions in assembling these cost functions:

- The purchase cost of land is $2500/acre (from CKD Monofill Model Cost Documentation, 1995);
- The unit does not require a formal liner, though it is assumed that it will need at least a foot of compacted soil as a base;
- The cost of compacted soil is $0.2325/ft3 (from CKD Monofill Model Cost Documentation, 1995);
- The unit must be sized for 20 years' accumulation of waste;
- The necessary land area is determined by assuming the material is stored in a conical pile with a maximum height of 100 ft, where the height of the pile is 1/2 the radius and the volume of the pile is calculated using the following formula: V = 1/3πr2h;
- The length of a side of the square plot for a single pile is the twice the radius plus a ten foot buffer zone around the edge of the pile to move equipment; therefore, the area of the pile is $[2*(r+10)]^2$;
- The area of the square plot for multiple piles is calculated by assuming that the volume to be stored is equally divided by the number of piles, then adding the area of each individual pile with its buffer zone (to allow equipment to move between the piles);

- The density of solid materials is the same as crushed furnace slag (85 lb/ft3);
- The cost of purchasing a 25 short ton capacity dump truck is $275,000 (vendor quote, 1996);
- The cost of renting a 25 short ton capacity dump truck is $775/day (from Means, 1995);
- The fuel and maintenance cost of the truck is $18.85/hr (from Means, 1995);
- The cost of labor to operate the truck is $22.80/hr (Engineering News Record,10/31/94, p. 49);
- It would take 1/2 hour to drive the dump truck to the waste pile, empty it, and return to the point of generation;
- There is no cost associated with a conveying system at the waste pile; and
- Below 50 mt/yr, facilities would not use a pile for disposal as it would be more economically attractive to send the material off-site for disposal, even for Subtitle C treatment and disposal.

The costs of disposing solid materials in on-site subtitle D piles are shown in Exhibit D-4.

Disposal of Liquid Materials in Surface Impoundments (on-site Subtitle D)

On-site disposal of liquids (for the no prior treatment baseline) poses some interesting problems, in that release of wastewater is regulated under the NPDES programs, which places limits on what "pollutants" can be released into the environment, including heat, turbidity, and percent solids, to name a few. Because EPA has assumed simple release of materials (for this baseline) under the RCRA program, but some treatment or settling is required under the NPDES programs, EPA has assumed that a facility operator will "treat" liquid waste in surface impoundments, by adding reagent in a tank basin before the waste enters the surface impoundment. Further EPA has assumed that the facility will then hold the material in the surface impoundment for 15 days before release. Because, however, facility operators will have to treat these waste liquids to UTS levels in a tank system before release, EPA believes the cost of constructing the surface impoundment is a sunk cost, and should not be counted towards calculating the baseline cost.[1]

Equations were developed for the capital and O & M costs for on-site neutralization of acidic and caustic wastewaters subject to federal NPDES standards. The cost functions were developed by estimating the costs for different size facilities and curve fitting the results. These equations are presented in Exhibit D-5. Because the capital costs for acidic and caustic wastes are very close, EPA used the costs for acidic wastes for all waste streams in the cost model. The Agency based this decision on the assumption that the majority of corrosive mineral processing wastestreams were acidic rather than caustic.

---

[1]EPA believes it is inappropriate to include sunk capital costs in the baseline, because the incremental costs of this rule are calculated as the diffrence between the post rule costs and the baseline costs. If EPA included these non-recoverable costs in the baseline, the incremental cost of the rule would be understated.

Exhibit D-4

Annual Disposal Cost of Solids in Waste Piles

Waste Pile - Disposal	**Unit Cost**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Waste Quantities (mt/yr)		50	500	5,000	50,000	75,000	100,000	250,000	500,000
Waste Quantity (ft3/yr)		1,297	12,968	129,682	1,296,824	1,945,235	2,593,647	6,484,118	12,968,235
Total Unit Waste Quantity (ft3)		25,936	259,365	2,593,647	25,936,471	38,904,706	51,872,941	129,682,353	259,364,706
Unit Construction									
Number of Piles		1	1	1	7	10	13	31	62
Radius of Pile (ft)		47	89	180	202	205	207	210	210
Height of Pile (ft)		18	40	85	96	98	98	100	100
Unit size (ft2)		8,733	31,772	130,272	1,142,363	1,683,210	2,223,596	5,463,850	10,927,699
Unit size (acres)		0.20	1	3	26	39	51	125	251
Annualized Land ($/yr)	$2500/acre	47	172	706	6,188	9,118	12,046	29,599	59,198
Unit base (compacted soil)	$0.2325/ft3	192	697	2,859	25,070	36,939	48,798	119,908	239,816
Dump Truck									
Number of trips - Annual		3	23	221	2,205	3,307	4,410	11,023	22,046
Number of hours - annual		1.5	12	111	1,103	1,654	2,205	5,512	11,023
Annual Rental Cost	$775/day	2,325	17,825	-	-	-	-	-	-
Number of Original Trucks Needed		1	1	1	1	1	1	3	5
Lifetime of Truck(s)		20	20	20	20	16	12	14	12
Total Number of Trucks Needed		1	1	1	1	2	2	6	10
Annualized Purchase cost	$275,000	-	-	25,957	25,957	34,915	37,646	107,762	188,224
Annualized Labor Cost	$22.80/hr	34	262	2,519	25,137	37,700	50,274	125,662	251,324
Ann. Fuel and Maintenance Cost	$18.85/hr	28	217	2,083	20,782	31,168	41,564	103,892	207,784
Total Annual Cost ($/yr)		2,626	19,173	34,124	103,135	149,841	190,329	486,823	946,345
Unit Cost ($/mt)		52.53	38.35	6.82	2.06	2.00	1.90	1.95	1.89

Exhibit D-5
COST EQUATIONS FOR ON-SITE DISPOSAL OF WASTEWATERS
(TO MEET NPDES STANDARDS ONLY - 1995 $)

Capital Costs ($350 \leq Q \leq 350{,}000$ mt/yr)[1] $Cost(\$) = 16{,}777 + 75.08\ Q^{.5}$

O&M Costs / Yr ($350 \leq Q \leq 350{,}000$ mt/yr) $Cost(\$) = -113{,}989 + 19{,}114 \ln Q$

[1] Q = Annual quantity of waste managed (mt/yr)

D.3 Off-site Treatment and Disposal

The cost of sending liquids off-site for treatment and disposal of residues is $175/mt, which includes a cost of $25/mt for transportation and a cost of $150/mt for treatment. The cost of sending solid waste off-site for treatment is $175/mt, which includes $25/mt for transportation, $88/mt for stabilization, and $35/mt for disposal (which is adjusted to $61/mt because stabilization increases the mass of waste to be disposed to 175 percent of the original mass). The price of off-site treatment ofliquids was taken from the September 1994 document Estimating Costs for the Economic Benefit of RCRA Noncompliance. The cost of off-site Subtitle D disposal is taken from the Technical Background Document: Data and Analyses Addressing the Costs of CKD Management Alternatives. The commercial price for stabilization is estimated at $88/mt, based on an $80/short ton difference between off-site landfill and stabilization ($170/short ton) and off-site landfill alone ($90/short ton) reported in *EI Digest*, November 1994.

D.4 Storage of Solid Materials

Storage of Solid Materials in Drums

The drum storage cost function for solids includes the capital cost of the drums, labor to open and close drums, and labor to move the drums either manually (using a handtruck) or using a pallet truck. The drum(s) would be filled by placing them under a hopper or chute, and would then be closed by a laborer. The drum would be moved to a storage area within the same area of the facility either on a handtruck (using manual labor) or on a pallet truck. Later, the drum would be moved to the point of reentry and opened. The normal feed handling equipment would be used to reinsert the material back into the process.

The Agency made the following assumptions in assembling these cost functions:

- The capital cost of a carbon steel drum is $52 (from Non-RCRA Tanks, Containers, and Buildings, December 1996, p. 17. This price includes $2 per drum for freight);
- 55 gallon drums have 50 gallons of usable capacity;
- The density of solid materials is the same as crushed furnace slag (85 lb/ft3);
- A laborer could close (or open) drums at the rate of 12 drums per hour;
- A laborer could move a drum from the point of generation to the storage area (or back from the storage area to the point of reentry) using a handtruck at a rate of 8 drums per hour;
- A laborer could move drums from point of generation to the storage area (or back from the storage area to the point of reentry) using a pallet truck at a rate of 32 drums per hour;
- The material to be stored is generated continuously, therefore, unless more than 90 drums are generated, the efficiencies of using a pallet truck would be lost and facilities would use manual labor to move drums rather than use the pallet truck;
- The cost of unskilled labor is $19/hr (from CKD Monofill Model Cost Documentation, 1995);
- The cost of a small equipment operator is $24.60/hr (Engineering News Record, 10/31/94, p. 49);
- The cost of a handtruck is $209, and the cost of a pallet truck is $3,020 (from Peters and Timmerhaus, 1990, updated to 1995 dollars);
- The cost of fuel and maintenance for the pallet truck is $1.50/hr, which is estimated to be the same as the fuel and maintenance cost of a gasoline powered cart (from Means Building Construction Cost Data, 1995, p. 18);
- Once a drum had been returned to the point of reentry it would be handled by the normal processing equipment, and would not incur any further "storage" costs; and
- The upper limit of material being stored in drums is 200 mt/yr, because having more than 200 drums would both be impractical and impose opportunity costs that have not been fully accounted for (there is likely to be both a practical limit on the floor space available to store the drums, and a cost associated with using additional floor space).

The costs of storing solid materials in drums are shown in Exhibit D-6.

Exhibit D-6

Annual Storage Cost Assuming Quarterly Storage of Solids in Drums

Drum Storage Cost (Solids)	Unit Cost	A	B	C	D	E	F	G	H
Waste Quantities (mt/yr)		0.5	4	10	50	75	100	150	200
Waste Quantities (mt/qtr)		0.125	1	2.5	12.5	18.75	25	37.5	50
Waste Quantity (gal/qtr)		24.25	194.02	485.04	2425.22	3637.83	4850.44	7275.67	9700.89
Purchase of Drums									
Number of Drums per quarter		1	4	10	49	73	98	146	195
Annualized Cost of Drums	$52/drum	4.91	19.63	49.08	240.51	358.30	481.01	716.61	957.11
Labor to Open/Close Drums									
Number of Hours per year		0.67	2.67	6.67	32.67	48.67	65.33	97.33	130.00
Annual Labor Cost	$19/hr	12.67	50.67	126.67	620.67	924.67	1241.33	1849.33	2470.00
Move Drums									
Ann. Handtruck Capital. Cost	$209	19.73	19.73	19.73	0.00	0.00	0.00	0.00	0.00
Ann. pallet truck Cap. Cost	$3020	0.00	0.00	0.00	285.06	285.06	285.06	285.06	285.06
Number of Hours - Annual		1	4	10	12.25	18.25	24.5	36.5	48.75
Annual Labor Cost	see notes	19	76	190	301.35	448.95	602.7	897.9	1199.25
Annual Fuel and O & M Cost	$1.50/hr	0	0	0	18.38	27.38	36.75	54.75	73.13
Total Annual Cost ($/yr)		56.30	166.03	385.48	1465.96	2044.35	2646.85	3803.65	4984.55
Unit Cost ($/mt)		112.60	41.51	38.55	29.32	27.26	26.47	25.36	24.92

Storage of Solid Materials in Roll-off Containers

The roll-off container storage cost function includes the capital cost of the containers, and the rental of a truck to move full roll-offs first to the storage area and then to the point of re-entry. It also includes labor, fuel, and maintenance to operate the truck.

A roll-off container would be filled by parking it beneath a hopper or chute. It would then be driven across the site to a storage area by a truck designed to move roll-off containers. The container would be "rolled off" the truck and set on the ground. Later the container would be picked up by the truck and driven back across the site to the point of re-entry and the contents dumped into a pile beside the normal feed materials, where the material would be picked up by the normal feed handling equipment.

The Agency made the following assumptions in assembling these cost functions:

- The purchase price of a 20 yd^3 roll-off container is $2670, a 30 yd^3 container is $3,045 and a 40 yd^3 container is $3,510 (from Non-RCRA Tanks, Containers, and Buildings, December, 1996, p.27);
- The cost of shipping is $320 per container, based on a shipping cost of $1.60 per mile and an assumed distance of 200 miles (from Non-RCRA Tanks, Containers, and Buildings, December, 1996, p.27);
- The cost of a tarp is $425 (from Non-RCRA Tanks, Containers, and Buildings, December, 1996, p.25);
- The density of solid materials is the same as crushed furnace slag (85 lb/ft3);
- It would take 2 hours to move a roll-off container from the point of generation to the storage area (or back from the storage area to the point of reentry);
- The roll-off truck must be rented in full day increments each time it is necessary to move a roll-off container;
- The cost of renting the roll-off truck is $500/day or $4,500/month (based on a vendor quote of $4,500/month, and standard construction estimating practices that daily rental is a third of weekly rental, which is a third of monthly rental);
- The cost of labor to operate the roll-off truck is $22.80/hr (Engineering News Record, 10/31/94, p. 49);
- The fuel and maintenance cost of the roll-off truck is $18.85/hr (which is the fuel and maintenance cost of a 25 ton off-road dump truck from Means, 1995); and
- Once the contents of a roll-off container had been emptied into a pile at the point of reentry they would be handled by the normal processing equipment, and would not incur any further "storage" costs.

The costs of storing solid materials in roll-off containers are shown in Exhibit D-7.

Storage of Solid Materials in Buildings

The building storage cost function includes the capital cost of constructing a dome style building, such as those used by regional highway departments to store road chemicals. This cost function also includes rental of a dump truck to move material from the point of generation to the storage area and later to the point of re-entry, labor to operate the truck, truck fuel, and maintenance as well as the capital, operating, and maintenance costs of a front end loader to fill the truck at the storage building. The following is a brief description of how materials would be stored in buildings.

The dump truck would be filled by parking it under a hopper or chute, and would then be driven across the site to a storage building where it would dump the material onto the pad outside the entrance to the building. The front end loader would then push the material into a pile in the dome. Later the material would be picked up by a front end loader and put back into the dump truck, be driven across the site to the point of re-entry and dumped into a pile beside the normal feed materials, where it would be picked up by the normal feed handling equipment.

The Agency made the following assumptions in assembling these cost functions:

- The capital cost of a building is based on the average price for dome buildings (see Tables 14, 15, and 16 of Non-RCRA Tanks, Containers, and Buildings, December, 1996, pp. 32-33);
- The capacity utilization of these buildings is assumed to be 80 percent, since a conveying system is not used;
- The dome will be built on an asphalt base pad that is a square with sides equal in length to the diameter of the building plus 20 feet.
- The cost of the asphalt pad is $6.50/yd^2 (from Means Site Work 1994, p. 59
- The density of solid materials is the same as crushed furnace slag (85 lb/ft3);
- The cost of purchasing a 25 short ton capacity dump truck is $275,000. The expected lifetime of this equipment is 26,000 operating hours (vendor quote, 1996);
- The fuel and maintenance cost of the truck is $18.85/hr (from Means, 1995);
- The cost of labor to operate the truck is $22.80/hr (Engineering News Record, 10/31/94, p. 49);
- It would take 1/2 hour to drive the dump truck to the building, empty it, and return to the point of generation;
- It would take 1/2 hour to drive the truck back from the storage area to the point of reentry, and dump the contents on the ground;

Exhibit D-7

Annual Storage Cost Assuming Quarterly Storage of Solids in Roll-Off Containers

Rolloff Storage Cost	Unit Cost	A	B	C	D	E	F	G	H
Waste Quantities (mt/yr)		50	75	100	500	1,000	2,500	5,000	7,500
Waste Quantities (mt/qtr)		12.5	19	25	125	250	625	1,250	1,875
Waste Quantity (yd3/qtr)		12.0	18	24	120	240	600	1,201	1,801
Purchase of Roll-offs									
Number of 20 yd3 Roll-offs		1	1	-	-	-	-	-	-
Cost of Roll-offs	$2670/R-off	2,670	2,670	-	-	-	-	-	-
Number of 30 yd3 Roll-offs		-	-	1	-	-	-	-	-
Cost of Roll-offs	$3045/r-off	-	-	3,045	-	-	-	-	-
Number of 30 yd3 Roll-offs		-	-	-	4	7	16	31	46
Cost of Roll-offs	$3510/r-off	-	-	-	14,040	24,570	56,160	108,810	161,460
Tarp	$425 each	425	425	425	1,700	2,975	6,800	13,175	19,550
Shipping	$320 Each	320	320	320	1,280	2,240	5,120	9,920	14,720
Annualized Cost of Roll-offs		322	322	358	1,607	2,811	6,426	12,451	18,475
Roll-off Truck									
Number of Trips - Annual		8	8	8	32	56	128	248	368
Number of Rental days		8	8	8	32	56	128	248	365
Annual Rental of Roll-off Truck	$500/day	4,000	4,000	4,000	16,000	28,000	-	-	-
Annual Rental of Roll-off Truck	$4500/mo	0	0	0	0	0	54000	54000	54000
Number of Hours - Annual		16	16	16	64	112	256	496	736
Annual Labor Cost	$22.80/hr	365	365	365	1,459	2,554	5,837	11,309	16,781
Ann.Fuel and Maintenance Cost	$18.85/hr	302	302	302	1,206	2,111	4,826	9,350	13,874
Total Annual Cost ($/yr)		4,989	4,989	5,024	20,272	35,476	71,088	87,109	103,129
Unit Cost ($/mt)		99.77	66.52	50.24	40.54	35.48	28.44	17.42	13.75

- The cost of renting a 7.5 yd3 capacity 375 hp front end loader is $1,400/day (from Means, 1995);
- The fuel and maintenance cost of the front end loader is $56.15/hr (from Means, 1995);
- The cost of labor to operate the front end loader is $26.90/hr (Engineering News Record, 10/31/94, p. 49);
- The front end loader can move 20 shovelfuls per hour;
- The front end loader must be rented for full days; and
- Once the contents of the dump truck had been emptied into a pile at the point of reentry they would be handled by the normal processing equipment, and would not incur any further "storage" costs.

The costs of storing solid materials in buildings are shown in Exhibit D-8.

Storage of Solid Materials in RCRA Containment Buildings

The RCRA containment building storage cost function is similar to the regular building cost functions, with two exceptions: 1) the RCRA building is assumed to be rectangular rather than round, and 2) the building itself must meet the standards outlined in 40 CFR 264 Subpart DD. EPA used containment building costs from the Cost and Economic Impact Analysis of Land Disposal Restrictions for Newly Listed Wastes and Contaminated Debris (Phase 1 LDRs) Final Rule, EPA Office of Solid Waste, June 10, 1992. The annualized capital cost listed on Page 3-17 of that document includes the capital cost of the building (annualized using a 3 percent social discount rate over 20 years) as well as an O & M cost (equivalent to 10 percent of the initial capital). Because EPA has used a 7 percent discount rate in other parts of this analysis, the Agency backed out the original capital costs and re-annualized them using a seven percent discount rate. The Agency then used these annualized costs in the building cost calculations to compute the cost of storage in RCRA containment buildings.

The Agency made the following assumptions in assembling these cost functions:

- The necessary building area is determined by assuming the material is stored in a conical pile with a maximum height of 18 ft, (or for smaller piles the height of the pile is equal to the radius) where the volume of the pile is calculated using the following formula: V = 1/3πr2h;
- The length of a side of the building is the twice the pile radius plus a ten foot buffer zone around the edge of the pile to move equipment; therefore, the area of the building is $[2*(r+10)]^2$;

Exhibit D-8

Annual Storage Cost Assuming Quarterly Storage of Solids in Dome Buildings

Building Storage Cost	**Unit Cost**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Waste Quantities (mt/yr)		1,380	2,048	2,660	15,800	17,952	28,448	42,072	50,764
Waste Quantities (mt/qtr)		345	512	665	3,950	4,488	7,112	10,518	12,691
Waste Quantity (ft3/qtr)		8,948	13,279	17,248	102,449	116,403	184,460	272,800	329,160
Waste Quantity (yd3/qtr)		331	492	639	3,794	4,311	6,832	10,104	12,191
Capital Cost									
Number of Buildings		1	1	1	1	1	1	1	1
Diameter of Building (ft)		40	40	50	100	100	124	150	150
size of base pad (yd2)		400	400	544	1,600	1,600	2,304	3,211	3,211
Asphalt Pad	6.50/yd2	2,600	2,600	3,539	10,400	10,400	14,976	20,872	20,872
Total Cost of Building		50,500	62,500	72,000	121,000	134,000	190,000	343,000	381,500
Annualized Cost of Building		5,012	6,145	7,130	12,403	13,630	19,348	34,346	37,980
Dump Truck									
Number of trips - quarter		32	46	60	350	396	628	928	1,120
Number of trips - annual		128	184	240	1,400	1,584	2,512	3,712	4,480
Number of hours - annual		64	92	120	700	792	1,256	1,856	2,240
Lifetime of Truck		20	20	20	20	20	20	14	12
Annualized Purchase cost	$275,000	25,957	25,957	25,957	25,957	25,957	25,957	36,018	37,793
Annual Labor Cost	$22.80/hr	1,459	2,098	2,736	15,960	18,058	28,637	42,317	51,072
Ann. Fuel and Maintenance Cost	$18.85/hr	1,206	1,734	2,262	13,195	14,929	23,676	34,986	42,224
Front End Loader									
Number of Hours (annual)		9	13	17	101	115	182	269	325
Number of Days (annual)		4	4	4	12	12	20	28	36
Annual Rental	$1,400/day	5,600	5,600	5,600	16,800	16,800	28,000	39,200	50,400
Annual Labor Cost	$26.90/hr	238	353	458	2,722	3,093	4,901	7,248	8,745
Ann. Fuel and Maintenance Cost	$ 56.15/hr	496	736	957	5,681	6,455	10,230	15,129	18,254
Total Annual Cost ($/yr)		39,969	42,623	45,100	92,718	98,922	140,748	209,243	246,468
Unit Cost ($/mt)		28.96	20.81	16.95	5.87	5.51	4.95	4.97	4.86

- If the volume to be stored exceeds 290,600 ft3, more than one building must be constructed;
- The costs of the dump truck and front end loader are based on the same assumptions used in calculating the dome building cost function.

The costs of storing solid material in RCRA containment buildings are shown in Exhibit D-9.

Storage of Solid Materials in Lined Waste Piles (Assuming No Free Liquids)

The waste pile storage cost function includes land, a liner base, a liner, liner protections, the costs of a dump truck to move the material to the storage site and back, and a front end loader to move the material at the pile. The following is a brief description of how solid materials would be stored in waste piles.

A dump truck would be filled by parking it under a hopper or chute, and would then be driven across the site to a waste pile where it would dump the material (either on the lined site directly, or onto a conveyer system). The waste pile is lined with a foot of compacted soil under 3 feet of compacted clay. Later, the material is picked up by a front end loader, put back into the dump truck, driven across the site to the point of re-entry, and dumped into a pile beside the normal feed materials, where it would be picked up by the normal feed handling equipment.

EPA made the following assumptions in assembling these cost functions:

- The purchase cost of land is \$2500/acre (from CKD Monofill Model Cost Documentation, 1995);
- The cost of compacted soil is \$0.2325/ft3 (from CKD Monofill Model Cost Documentation, 1995);
- The cost of compacted clay is \$0.3667/ft3 (from CKD Monofill Model Cost Documentation, 1995);The necessary land area is determined by assuming the material is stored in a conical pile with a maximum height of 100 ft, where the height of the pile is 1/2 the radius and the volume of the pile is calculated using the following formula: V = 1/3πr2h;
- The length of a side of the square plot for a single pile is the twice the radius plus a ten foot buffer zone around the edge of the pile to move equipment; therefore, the area of the pile is $[2*(r+10)]^2$;
- The area of the square plot for multiple piles is calculated by assuming that the volume to be stored is equally divided by the number of piles, then adding the area of each individual pile with its buffer zone (to allow equipment to move between the piles);

Exhibit D-9
Annual Storage Cost Assuming Quarterly Storage of Solids in RCRA Containment Buildings

Building Storage Cost	Unit Cost	A	B	C	D	E
Waste Quantities (mt/yr)		135	600	2,400	8,245	42,130
Waste Quantities (mt/qtr)		34	150	600	2,061	10,533
Waste Quantity (ft3/qtr)		875	3,890	15,562	53,462	273,176
Waste Quantity (yd3/qtr)		32	144	576	1,980	10,118
Capital Cost						
Fixed height pile		0	0	1	1	1
Number of Buildings		1	1	1	1	1
Average sq ft of building		1,509	2,599	6,001	16,005	68,000
Capital Cost of building		400,679	514,305	777,438	1,375,466	4,784,231
Maintenance cost of building		40,068	51,430	77,744	137,547	478,423
Annualized Cost of Building		77,888	99,976	151,126	267,377	930,007
Dump Truck						
Number of trips - quarter		4	14	54	182	930
Number of trips - annual		16	56	216	728	3,720
Number of hours - annual		8	28	108	364	1,860
Lifetime of Truck		20	20	20	20	14
Annualized Purchase cost	$275,000	25,957	25,957	25,957	25,957	36,039
Annual Labor Cost	$22.80/hr	182	638	2,462	8,299	42,408
Ann. Fuel and Maintenance Cost	$18.85/hr	151	528	2,036	6,861	35,061
Front End Loader						
Number of Hours (annual)		1	4	15	53	270
Number of Days (annual)		4	4	4	8	28
Annual Rental	$1,400/day	5,600	5,600	5,600	11,200	39,200
Annual Labor Cost	$26.90/hr	23	103	413	1,420	7,258
Ann. Fuel and Maintenance Cost	$ 56.15/hr	49	216	863	2,965	15,149
Total Annual Cost ($/yr)		109,850	133,018	188,458	324,080	1,105,121
Unit Cost ($/mt)		813.71	221.70	78.52	39.31	26.23

- The density of solid materials is the same as crushed furnace slag (85 lb/ft3);
- The cost of purchasing a 25 short ton capacity dump truck is $275,000. The expected lifetime of this equipment is 26,000 operating hours (vendor quote, 1996);
- The fuel and maintenance cost of the truck is $18.85/hr (from Means, 1995);
- The cost of labor to operate the truck is $22.80/hr (Engineering News Record, 10/31/94, p. 49);
- It would take 1/2 hour to drive the dump truck to the waste pile, empty it, and return to the point of generation;
- There is no cost associated with a conveying system at the waste pile;
- It would take 1/2 hour to drive the truck back from the storage area to the point of reentry, and dump the contents on the ground;
- The cost of renting a 7.5 yd3 capacity 375 hp front end loader is $1,400/day (from Means, 1995);
- The fuel and maintenance cost of the front end loader is $56.15/hr (from Means, 1995);
- The cost of labor to operate the front end loader is $26.90/hr (Engineering News Record, 10/31/94, p. 49);
- The front end loader can move 20 shovelfuls per hour;
- The front end loader must be rented for full days; and
- Once the contents of the dump truck had been emptied into a pile at the point of reentry they would be handled by the normal processing equipment, and would not incur any further "storage" costs.

The costs of storing solid materials with no free liquids in waste piles are shown in Exhibit D-10.

Storage of Solid Materials in Unlined Waste Piles (with Groundwater Monitoring)

The costs of storing materials in unlined waste piles are very similar to the costs of storing materials in lined waste piles, with two notable exceptions: The costs of the liner and liner protection are not used, and costs of groundwater monitoring have been added. (The development of groundwater monitoring costs is described later in this Appendix.) One of the stipulations of using these units is that if monitoring reveals contamination, the facility is responsible for the costs of corrective action. However, even without adding the potential costs of corrective action, these costs of regular monitoring are higher than the costs of liners. Therefore, EPA considered this option to be economically inferior to storage in waste piles with liners, and did not attempt to add corrective action costs to the costs shown in Exhibit D-11.

Exhibit D-10
Annual Storage Cost Assuming Quarterly Storage of Solids with No Free Liquids in Lined Waste Piles

Waste Pile - No Free Liquids	Unit Cost	A	B	C	D	E	F	G	H
Waste Quantities (mt/yr)		500	5,000	15,000	25,000	40,000	70,000	90,000	120,000
Waste Quantities (mt/qtr)		125	1,250	3,750	6,250	10,000	17,500	22,500	30,000
Waste Quantity (ft3/qtr)		3,242	32,421	97,262	162,103	259,365	453,888	583,571	778,094
Waste Quantity (yd3/qtr)		120	1,201	3,602	6,004	9,606	16,811	21,614	28,818
Unit Construction									
Unit size (ft2)		3,218	9,825	17,987	24,118	31,772	44,394	51,693	61,619
Annualized Land ($/yr)	$2500/acre	17	53	97	131	172	240	280	334
Ann. Liner base (compacted soil)	$0.2325/ft3	71	216	395	529	697	974	1,134	1,352
Annualized Liner (3 ft of clay)	$0.3667/ft3	334	1,020	1,868	2,504	3,299	4,610	5,368	6,398
Ann. Liner Protection (cmpct. soil)	$0.2325/ft3	71	216	395	529	697	974	1,134	1,352
Dump Truck									
Number of trips - quarter		12	112	332	552	882	1,544	1,986	2,646
Number of trips - annual		48	448	1,328	2,208	3,528	6,176	7,944	10,584
Number of hours - annual		24	224	664	1,104	1,764	3,088	3,972	5,292
Number of Original Trucks Needed		1	1	1	1	1	2	2	2
Lifetime of Truck(s)		20	20	20	20	15	17	13	10
Total Number of Trucks Needed		1	1	1	1	2	4	4	4
Annualized Purchase cost	$275,000	25,957	25,957	25,957	25,957	35,533	68,529	73,324	78,617
Annualized Labor Cost	$22.80/hr	547	5,107	15,139	25,171	40,219	70,406	90,562	120,658
Ann. Fuel and Maintenance Cost	$18.85/hr	452	4,222	12,516	20,810	33,251	58,209	74,872	99,754
Front End Loader									
Number of Hours (annual)		3.20	32.02	96.06	160.10	256.16	448.28	576.37	768.49
Number of Days (annual)		4	8	16	24	36	60	76	100
Annual Rental	$1,400/day	5,600	11,200	22,400	33,600	50,400	84,000	106,400	140,000
Annual Labor Cost	$26.90/hr	86	861	2,584	4,307	6,891	12,059	15,504	20,672
Ann. Fuel and Maintenance Cost	$56.15/hr	180	1,798	5,394	8,990	14,384	25,171	32,363	43,151
Total Annual Cost ($/yr)		33,316	50,651	86,745	122,529	185,543	325,173	400,942	512,289
Unit Cost ($/mt)		66.63	10.13	5.78	4.90	4.64	4.65	4.45	4.27

Exhibit D-11
Annual Storage Cost Assuming Quarterly Storage of Solids in Unlined Waste Piles with Groundwater Monitoring

Waste Pile - Free Liquids	Unit Cost	A	B	C	D	E	F	G	H
Waste Quantities (mt/yr)		500	5,000	15,000	25,000	40,000	70,000	90,000	120,000
Waste Quantities (mt/qtr)		125	1,250	3,750	6,250	10,000	17,500	22,500	30,000
Waste Quantity (ft3/qtr)		3,242	32,421	97,262	162,103	259,365	453,888	583,571	778,094
Waste Quantity (yd3/qtr)		120	1,201	3,602	6,004	9,606	16,811	21,614	28,818
Unit Construction									
Unit size (ft2)		3,218	9,825	17,987	24,118	31,772	44,394	51,693	61,619
Annualized Land ($/yr)	$2500/acre	17	53	97	131	172	240	280	334
Unit base (compacted soil)	$0.2325/ft3	71	216	395	529	697	974	1,134	1,352
Groundwater Monitoring									
Number of Downgradient Wells		3	3	3	3	3	3	3	3
Annualized Capital Cost		6,722	6,722	6,722	6,722	6,722	6,722	6,722	6,722
Annual O & M Cost		7,290	7,290	7,290	7,290	7,290	7,290	7,290	7,290
Dump Truck									
Number of trips - quarter		12	112	332	552	882	1,544	1,986	2,646
Number of trips - annual		48	448	1,328	2,208	3,528	6,176	7,944	10,584
Number of hours - annual		24	224	664	1,104	1,764	3,088	3,972	5,292
Number of Original Trucks Needed		1	1	1	1	1	2	2	2
Lifetime of Truck(s)		20	20	20	20	15	17	13	10
Total Number of Trucks Needed		1	1	1	1	2	4	4	4
Annualized Purchase cost	$275,000	25,957	25,957	25,957	25,957	35,533	68,529	73,324	78,617
Annualized Labor Cost	$22.80/hr	547	5,107	15,139	25,171	40,219	70,406	90,562	120,658
Ann. Fuel and Maintenance Cost	$18.85/hr	452	4,222	12,516	20,810	33,251	58,209	74,872	99,754
Front End Loader									
Number of Hours (annual)		3.20	32.02	96.06	160.10	256.16	448.28	576.37	768.49
Number of Days (annual)		4	8	16	24	36	60	76	100
Annual Rental	$1,400/day	5,600	11,200	22,400	33,600	50,400	84,000	106,400	140,000
Annual Labor Cost	$26.90/hr	86	861	2,584	4,307	6,891	12,059	15,504	20,672
Ann. Fuel and Maintenance Cost	$56.15/hr	180	1,798	5,394	8,990	14,384	25,171	32,363	43,151
Total Annual Cost ($/yr)		46,923	63,427	98,495	133,508	195,560	333,601	408,452	518,551
Unit Cost ($/mt)		93.85	12.69	6.57	5.34	4.89	4.77	4.54	4.32

Storage of Solid Materials in Unlined, Unmonitored Waste Piles

The costs of storing materials in unlined, unmonitored waste piles are similar to the costs of storing wastes in lined piles. The notable exception is the cost of the liner and liner protection. These costs are listed in Exhibit D-12. In addition, EPA developed the costs of just the operation and maintenance costs of storing materials in unlined, unmonitored units for baseline-option combinations that induce a change of storage units from land based to non-land based units (i.e., storing sludges in the prior treatment baseline and in RCRA containment buildings in Option 1). The O & M costs of storing materials in unlined, unmonitored piles are shown in Exhibit D-13.

D.5 Storage of Liquid Materials

Storage of Liquid Materials in Drums or Mobile Mini-Bulk Tanks

Low volumes of liquid materials can be stored in either drums or mobile mini-bulk containers, which are small tanks that are designed to be moved by a pallet truck. The costs associated with storing liquid materials in drums are calculated in same manner as storing solid materials in drums, with the following exceptions:

- Liquid materials are stored for 30 days, while solid materials are stored for 90 days. Therefore, fewer drums are required;
- Because liquid materials are often corrosive, polyethylene drums and mini-bulk containers are used;
- The density of liquid materials is the same as water (62.4 lb/ft3);
- The capital cost of a 55-gallon polyethylene drum is $127 (from Non-RCRA Tanks, Containers, and Building, December 1996, p. 17. This price includes $2 per drum for freight);
- The capital cost of a 220-gallon polyethylene mini-bulk tank is $285 (from Non-RCRA Tanks, Containers, and Building, December 1996, Appendix D); and
- A laborer could move mini-bulks from point of generation to the storage area (or back from the storage area to the point of reentry) using a pallet truck at a rate of 4 tanks per hour;

The costs of storing liquid materials in drums and mobile mini-bulk tanks are shown in Exhibit D-14.

Exhibit D-12

Annual Storage Cost Assuming Quarterly Storage of Solids in Unlined, Unmonitored Waste Piles

Waste Pile - Free Liquids	Unit Cost	A	B	C	D	E	F	G	H
Waste Quantities (mt/yr)		500	5,000	15,000	25,000	40,000	70,000	90,000	120,000
Waste Quantities (mt/qtr)		125	1,250	3,750	6,250	10,000	17,500	22,500	30,000
Waste Quantity (ft3/qtr)		3,242	32,421	97,262	162,103	259,365	453,888	583,571	778,094
Waste Quantity (yd3/qtr)		120	1,201	3,602	6,004	9,606	16,811	21,614	28,818
Unit Construction									
Unit size (ft2)		3,218	9,825	17,987	24,118	31,772	44,394	51,693	61,619
Annualized Land ($/yr)	$2500/acre	17	53	97	131	172	240	280	334
Unit base (compacted soil)	$0.2325/ft3	71	216	395	529	697	974	1,134	1,352
Dump Truck									
Number of trips - quarter		12	112	332	552	882	1,544	1,986	2,646
Number of trips - annual		48	448	1,328	2,208	3,528	6,176	7,944	10,584
Number of hours - annual		24	224	664	1,104	1,764	3,088	3,972	5,292
Number of Original Trucks Needed		1	1	1	1	1	2	2	2
Lifetime of Truck(s)		20	20	20	20	15	17	13	10
Total Number of Trucks Needed		1	1	1	1	2	4	4	4
Annualized Purchase cost	$275,000	25,957	25,957	25,957	25,957	35,533	68,529	73,324	78,617
Annualized Labor Cost	$22.80/hr	547	5,107	15,139	25,171	40,219	70,406	90,562	120,658
Ann. Fuel and Maintenance Cost	$18.85/hr	452	4,222	12,516	20,810	33,251	58,209	74,872	99,754
Front End Loader									
Number of Hours (annual)		3.20	32.02	96.06	160.10	256.16	448.28	576.37	768.49
Number of Days (annual)		4	8	16	24	36	60	76	100
Annual Rental	$1,400/day	5,600	11,200	22,400	33,600	50,400	84,000	106,400	140,000
Annual Labor Cost	$26.90/hr	86	861	2,584	4,307	6,891	12,059	15,504	20,672
Ann. Fuel and Maintenance Cost	$56.15/hr	180	1,798	5,394	8,990	14,384	25,171	32,363	43,151
Total Annual Cost ($/yr)		32,911	49,415	84,483	119,495	181,547	319,589	394,439	504,538
Unit Cost ($/mt)		65.82	9.88	5.63	4.78	4.54	4.57	4.38	4.20

Exhibit D-13
Annual Storage Cost (O & M only) Assuming Quarterly Storage of Solids in Unlined, Unmonitored Waste Piles

Waste Pile - Free Liquids	Unit Cost	A	B	C	D	E	F	G	H
Waste Quantities (mt/yr)		500	5,000	15,000	25,000	40,000	70,000	90,000	120,000
Waste Quantities (mt/qtr)		125	1,250	3,750	6,250	10,000	17,500	22,500	30,000
Waste Quantity (ft3/qtr)		3,242	32,421	97,262	162,103	259,365	453,888	583,571	778,094
Waste Quantity (yd3/qtr)		120	1,201	3,602	6,004	9,606	16,811	21,614	28,818
Unit Construction									
Unit size (ft2)		3,218	9,825	17,987	24,118	31,772	44,394	51,693	61,619
Annualized Land ($/yr)	$2500/acre								
Unit base (compacted soil)	$0.2325/ft3								
Dump Truck									
Number of trips - quarter		12	112	332	552	882	1,544	1,986	2,646
Number of trips - annual		48	448	1,328	2,208	3,528	6,176	7,944	10,584
Number of hours - annual		24	224	664	1,104	1,764	3,088	3,972	5,292
Number of Original Trucks Needed		1	1	1	1	1	2	2	2
Lifetime of Truck(s)		20	20	20	20	15	17	13	10
Total Number of Trucks Needed		1	1	1	1	2	4	4	4
Annualized Purchase cost	$275,000	25,957	25,957	25,957	25,957	35,533	68,529	73,324	78,617
Annualized Labor Cost	$22.80/hr	547	5,107	15,139	25,171	40,219	70,406	90,562	120,658
Ann. Fuel and Maintenance Cost	$18.85/hr	452	4,222	12,516	20,810	33,251	58,209	74,872	99,754
Front End Loader									
Number of Hours (annual)		3.20	32.02	96.06	160.10	256.16	448.28	576.37	768.49
Number of Days (annual)		4	8	16	24	36	60	76	100
Annual Rental	$1,400/day	5,600	11,200	22,400	33,600	50,400	84,000	106,400	140,000
Annual Labor Cost	$26.90/hr	86	861	2,584	4,307	6,891	12,059	15,504	20,672
Ann. Fuel and Maintenance Cost	$56.15/hr	180	1,798	5,394	8,990	14,384	25,171	32,363	43,151
Total Annual Cost ($/yr)		32,823	49,146	83,991	118,835	180,678	318,374	393,025	502,852
Unit Cost ($/mt)		65.65	9.83	5.60	4.75	4.52	4.55	4.37	4.19

Exhibit D-14
Annual Storage Cost Assuming 30 Day Storage of Liquids in Drum and Mini-Bulks

Drum Storage Cost (liquids)	Unit Cost	A	B	C	D	E	F	G	H
Waste Quantities (mt/yr)		0.5	10	50	75	100	150	200	250
Waste Quantities (mt/mo)		0.042	0.833	4.167	6.250	8.333	12.500	16.667	20.833
Waste Quantity (gal/mo)		11.01	220.24	1101.20	1651.79	2202.39	3303.59	4404.78	5505.98
Purchase of Drums									
Number of Drums		1	5	0	0	0	0	0	0
Annualized Cost of Drums	$127/drum	127.00	635.00	0.00	0.00	0.00	0.00	0.00	0.00
Number of 220-gallon Mini-bulks		0	0	6	8	11	16	21	26
Cost of Mini-bulk	$285/tank	0.00	0.00	1881.00	2508.00	3448.50	5016.00	6583.50	8151.00
Annualized Capital Cost		11.99	59.94	177.55	236.73	325.50	473.46	621.42	769.37
Labor to Open/Close Drums									
Number of Hours per year		2	10	-	-	-	-	-	-
Annual Labor Cost	$19/hr	38	190	-	-	-	-	-	-
Move Drums									
Ann. Handtruck Capital. Cost	$209	19.73	19.73	0.00	0.00	0.00	0.00	0.00	0.00
Ann. Pallet Truck Cap. Cost	$3020	0	0	285	285	285	285	285	285
Number of Hours - Annual		1	5	12	16	22	32	42	52
Annual Labor Cost	$19/hr	19	95	228	304	418	608	798	988
Ann. Fuel and Maintenance Cost	$1.5/hr	0	0	18	24	33	48	63	78
Total Annual Cost ($/yr)		88.72	364.67	708.61	849.79	1061.56	1414.52	1767.47	2120.43
Unit Cost ($/mt)		177.43	36.47	14.17	11.33	10.62	9.43	8.84	8.48

Storage of Liquid Materials in Tanks

The tank storage cost function includes the capital cost of the tanks, as well as piping to move the liquids from the point of generation to the storage area and then back to the point of re-entry. Liquid materials would be piped from the point of generation to storage tanks. When these materials are going to be reused they would be piped back through the same pipes to the point of re-entry, where they would be handled by the normal feed dispersing equipment.

The Agency made the following assumptions in assembling the tank storage cost function:

- Liquids are stored for a maximum of 30 days;
- The density of liquid materials is the same as water (62.4 lb/ft3);
- Tank capital and O & M costs were developed following the method used by DPRA for the "Organic Dyes and Pigments Waste Listings," 1995, and include the minimal plumbing associated with the tank only;
- For tanks with a capacity of or less than 25,000 gallons, the base capital cost was updated using the price of a single walled vertical tank (from Non-RCRA Tanks, Containers, and Building, December 1996, p. 22.)
- For tanks greater than 25,000 gallons EPA used the cost from the "Organic Dyes and Pigments Waste Listings document" (these costs were adjusted to use the correct discount rate and retention time);
- The distance from the point of generation to the storage tank, and from the storage tank back to the point of reentry are a function of the amount of material to be stored. Small volumes of liquid material to be stored do not require additional piping, while large volumes of material to be stored will need to be piped to storage areas further away;
- There is no cost associated with pumping the material to and from the tank; and
- Once the liquid has been returned to the point of reentry it will be handled by the normal processing equipment, and would not incur any further "storage" costs.

The costs of storing liquid materials in tanks are shown in Exhibit D-15.

Storage of Liquid Materials in RCRA Tanks

The RCRA storage tank cost function is similar to the regular storage tank cost functions, with the exception that the tank must have secondary containment, and be inspected daily. (See 40 CFR 264 Subpart J.) EPA assumed double walled tanks to meet the secondary containment requirement. EPA used the prices from Non-RCRA Tanks, Containers, and Building, December 1996, p. 22 for tanks with a capacity of 25,000 gallons or less, and vendor quotes for large field erected double walled tanks.

Exhibit D-15

Annual Storage Cost Assuming 30 Day Storage of Liquids in Tanks

Tank Storage Cost (Liquids)	Unit Cost	A	B	C	D	E	F
Waste Quantities (mt/yr)		45.4	227.0	1,135.1	22,702.6	90,810.4	181,620.7
Waste Quantity (gal/yr)		12,000	60,000	300,000	6,000,000	24,000,000	48,000,000
Waste Quantity (gal/mo)		1,000	5,000	25,000	500,000	2,000,000	4,000,000
Waste Flow rate (gal/day)		33	167	833	16,667	66,667	133,333
Purchase of Tanks							
Number of Tanks		1	1	1	1	1	1
Cap. Cost of Double Walled Tanks		1,246	3,466	9,405			
Freight and Installation		374	1,040	2,822			
Indirect Capital		518	1,442	3,912			
Annualized Cost of Tanks		202	561	1,523	9,318	23,897	40,604
Annual O & M		141	393	1,065	6,515	16,710	28,392
Piping							
Length of additional pipe (ft)		-	-	-	500	1,000	1,000
Piping - Annualized Capital		-	-	-	425	821	821
Piping - Annual O & M		-	-	-	1,000	1,000	1,000
Total Annual Cost ($/yr)		343	954	2,589	17,258	42,428	70,817
Unit Cost ($/mt)		7.55	4.20	2.28	0.76	0.47	0.39

EPA also assumed that it would take a skilled laborer ($39.50/hr, from CKD Monofill Model Cost Documentation, 1995) a half hour per day to inspect a tank and file any necessary paperwork. The cost of storage in RCRA storage tanks are shown in Exhibit D-16.

Storage of Liquid Materials in Lined Surface Impoundments

The surface impoundment storage cost function includes the capital cost of land, site preparation, a liner, and piping of liquids to the surface impoundment. Liquid materials would be piped from the point of generation to the surface impoundment. When these materials are going to be reused they would be piped back through the same pipes to the point of reentry, where they would be handled by the normal feed equipment.

The Agency made the following assumptions in assembling the surface impoundment storage cost function:

- Liquid materials are stored for a maximum of 30 days;
- The density of liquid materials is the same as water (62.4 lb/ft3);
- The purchase cost of land is $2500/acre (from CKD Monofill Model Cost Documentation, 1995);
- The cost of excavation is $0.1077/ft3 (from CKD Monofill Model Cost Documentation, 1995); The cost of a 40 mil HDPE geomembrane liner is 0.5602/ft2 (from CKD Monofill Model Cost Documentation, 1995);
- The area of the surface impoundment is calculated using the formulas described in section D.7;
- The distance from the point of generation to the surface impoundment, and from the surface impoundment back to the point of reentry, are a function of the amount of material to be stored, but the minimum distance is 500 feet. Larger quantities of material to be stored will need to be piped 1000 feet away;
- There is no cost associated with pumping the material to and from the surface impoundment; and
- Once the liquid has been returned to the point of reentry it will be handled by the normal processing equipment, and would not incur any further "storage" costs.

Exhibit D-16
Annual Storage Cost Assuming 30 Day Storage of Liquids in RCRA Tanks

Tank Storage Cost (Liquids)	Unit Cost	A	B	C	D	E	F	G
Waste Quantities (mt/yr)		45.4	227.0	1,135.1	5,221.6	21,340.4	52,261.4	184,390.4
Waste Quantity (gal/yr)		12,000	60,000	300,000	1,380,000	5,640,000	13,812,000	48,732,000
Waste Quantity (gal/mo)		1,000	5,000	25,000	115,000	470,000	1,151,000	4,061,000
Waste Flow rate (gal/day)		33	167	833	3,833	15,667	38,367	135,367
Purchase of Tanks								
Number of Tanks		1	1	1	1	1	1	1
Cap. Cost of Double Walled Tanks		1,619	6,164	17,417	110,000	200,000	350,000	900,000
Freight and Installation		486	1,849	5,225	33,000	60,000	105,000	270,000
Indirect Capital	32% of cap	674	2,564	7,245	45,760	83,200	145,600	374,400
Annualized Cost of Tanks		262	998	2,821	17,817	32,395	56,691	145,776
Annual O & M		183	698	1,973	12,458	22,651	39,640	101,930
Annual Inspection Cost (Labor)	$39.5/hr	7,209	7,209	7,209	7,209	7,209	7,209	7,209
Piping								
Length of additional pipe (ft)		-	-	-	1,000	1,000	1,000	1,000
Piping - Annualized Capital		-	-	-	821	821	821	821
Piping - Annual O & M		-	-	-	1,000	1,000	1,000	1,000
Total Annual Cost ($/yr)		446	1,697	4,794	32,096	56,867	98,151	249,528
Unit Cost ($/mt)		9.81	7.47	4.22	6.15	2.66	1.88	1.35

The costs of storing liquid materials in lined surface impoundments are shown in Exhibit D-17.

Storage of Liquid Materials in Unlined Surface Impoundments with Groundwater Monitoring

The costs of storing materials in unlined surface impoundments are very similar to the costs of storing materials in lined surface impoundments, with two notable exceptions: The cost of the liner is not used, and costs of groundwater monitoring have been added. (The development of groundwater monitoring costs are described later in this Appendix.) One of the stipulations of using these units is that if monitoring reveals contamination, the facility is responsible for the costs of corrective action. However, even without adding the potential costs of corrective action, these costs of regular monitoring are higher than the costs of liners. Therefore, EPA considered this option to be economically inferior to storage in surface impoundments with liners, and did not attempt to add corrective action costs to the costs shown in Exhibit D-18.

Storage of Liquid Materials in Unlined, Unmonitored Surface Impoundments

The costs of storing materials in unlined, unmonitored surface impoundments are similar to the costs of storing wastes in lined surface impoundments. The notable exception is the cost of the liner. The costs of storing liquid materials in unlined surface impoundments without groundwater monitoring are shown in Exhibit D-19. In addition, EPA developed the costs of just the operation and maintenance costs of storing materials in unlined, unmonitored units for baseline-option combinations that induce a change of storage units from land based to non-land based units (i.e., storing by-products in the prior treatment baseline and in RCRA tanks in Option 1). The O & M costs of storing materials in unlined, unmonitored surface impoundments are shown in Exhibit D-20.

D.6 Curve Fit Cost Functions

The Agency plotted and curve fit each set of cost results (from Exhibits D-4, and D-6 through D-20) to transform the costs into cost functions. Exhibit D-21 presents these curve fit storage and disposal cost functions, along with the range for which these cost equations are valid. EPA determined the break-even points between the relevant storage methods for each Baseline or Option. Exhibit D-21 also presents the optimum management ranges allowed under each baseline and option. Cells in this exhibit which have been blacked out under a particular option or baseline are unallowable management methods. Finally, Exhibits D-22 through D-38 present graphs of the individual cost for our sample waste generation rates along with the resulting curve fit cost functions.

Exhibit D-17
Annual Storage Cost Assuming Quarterly Storage of Solids in Unlined, Unmonitored Waste Piles

Waste Quantities (mt/yr)		500	5,000	25,000	50,000	100,000	200,000	1,000,000	2,000,000
Waste Quantities (mt/mo)		42	417	2,083	4,167	8,333	16,667	83,333	166,667
Waste Quantity (ft3/mo)		1,472	14,721	73,604	147,209	294,418	588,835	2,944,177	5,888,355
Waste Quantity (gal/mo)		11,012	110,120	550,598	1,101,196	2,202,392	4,404,784	22,023,919	44,047,837
Waste Quantity (gal/day)		367	3,671	18,353	36,707	73,413	146,826	734,131	1,468,261
Unit Construction									
Unit size (ft2)		4,061	6,410	15,688	26,478	47,192	87,314	395,890	774,557
Unit size (acres)		0.09	0.15	0.36	0.61	1.08	2.00	9.09	17.78
Annualized Land ($/yr)	$2500/acre	22	35	85	143	256	473	2,145	4,196
Annualized Excavation	$0.17077/ft3	24	237	1,186	2,373	4,746	9,491	47,457	94,914
Ann. Liner (40 mil geomembrane)	$0.5602/ft2	215	339	830	1,400	2,495	4,617	20,934	40,956
Material Handling									
Distance to Unit (ft)		500	500	500	500	1,000	1,000	1,000	1,000
Piping - annualized capital		425	425	425	425	821	904	1,120	1,390
Piping - annual O & M		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total Annual Cost ($/yr)		1,685	2,036	3,526	5,341	9,318	16,485	72,655	142,457
Unit Cost ($/mt)		3.37	0.41	0.14	0.11	0.09	0.08	0.07	0.07

Exhibit D-18
Annual Storage Cost Assuming 30 Day Storage of Liquids in Unlined Surface Impoundments with Groundwater Monitoring

Surface Impoundment	Unit Cost	A	B	C	D	E	F	G	H
Waste Quantities (mt/yr)		500	5,000	25,000	50,000	100,000	500,000	1,000,000	2,000,000
Waste Quantities (mt/mo)		42	417	2,083	4,167	8,333	41,667	83,333	166,667
Waste Quantity (ft3/mo)		1,472	14,721	73,604	147,209	294,418	1,472,089	2,944,177	5,888,355
Waste Quantity (gal/mo)		11,012	110,120	550,598	1,101,196	2,202,392	11,011,959	22,023,919	44,047,837
Waste Quantity (gal/day)		367	3,671	18,353	36,707	73,413	367,065	734,131	1,468,261
Unit Construction									
Unit size (ft2)		4,061	6,410	15,688	26,478	47,192	204,364	395,890	774,557
Unit size (acres)		0.09	0.15	0.36	0.61	1.08	4.69	9.09	17.78
Annualized Land ($/yr)	$2500/acre	22	35	85	143	256	1,107	2,145	4,196
Annualized Excavation	$0.17077/ft3	24	237	1,186	2,373	4,746	23,729	47,457	94,914
Groundwater Monitoring									
Number of Downgradient Wells		3	3	3	3	4	7	10	13
Annualized Capital Cost		6,722	6,722	6,722	6,722	7,840	11,193	14,545	17,898
Annual O & M Cost		7,290	7,290	7,290	7,290	8,760	13,170	17,580	21,990
Material Handling									
Distance to Unit (ft)		500	500	500	500	1,000	1,000	1,000	1,000
Piping - annualized capital		425	425	425	425	821	985	1,120	1,390
Piping - annual O & M		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total Annual Cost ($/yr)		15,483	15,709	16,709	17,954	23,423	51,183	83,847	141,388
Unit Cost ($/mt)		30.97	3.14	0.67	0.36	0.23	0.10	0.08	0.07

Exhibit D-19
Annual Storage Cost Assuming 30 Day Storage of Liquids in Unlined, Unmonitored Surface Impoundments

Surface Impoundment	Unit Cost	A	B	C	D	E	F	G	H
Waste Quantities (mt/yr)		500	5,000	25,000	50,000	100,000	500,000	1,000,000	2,000,000
Waste Quantities (mt/mo)		42	417	2,083	4,167	8,333	41,667	83,333	166,667
Waste Quantity (ft3/mo)		1,472	14,721	73,604	147,209	294,418	1,472,089	2,944,177	5,888,355
Waste Quantity (gal/mo)		11,012	110,120	550,598	1,101,196	2,202,392	11,011,959	22,023,919	44,047,837
Waste Quantity (gal/day)		367	3,671	18,353	36,707	73,413	367,065	734,131	1,468,261
Unit Construction									
Unit size (ft2)		4,061	6,410	15,688	26,478	47,192	204,364	395,890	774,557
Unit size (acres)		0.09	0.15	0.36	0.61	1.08	4.69	9.09	17.78
Annualized Land ($/yr)	$2500/acre	22	35	85	143	256	1,107	2,145	4,196
Annualized Excavation	$0.17077/ft3	24	237	1,186	2,373	4,746	23,729	47,457	94,914
Material Handling									
Distance to Unit (ft)		500	500	500	500	1,000	1,000	1,000	1,000
Piping - annualized capital		425	425	425	425	821	985	1,120	1,390
Piping - annual O & M		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total Annual Cost ($/yr)		1,470	1,697	2,696	3,941	6,823	26,820	51,722	101,500
Unit Cost ($/mt)		2.94	0.34	0.11	0.08	0.07	0.05	0.05	0.05

Exhibit D-20

Annual Storage Cost (O & M only) Assuming 30 Day Storage of Liquids in Unlined, Unmonitored Waste Piles

Surface Impoundment	Unit Cost	A	B	C	D	E	F	G	H
Waste Quantities (mt/yr)		500	5,000	25,000	50,000	100,000	500,000	1,000,000	2,000,000
Waste Quantities (mt/mo)		42	417	2,083	4,167	8,333	41,667	83,333	166,667
Waste Quantity (ft3/mo)		1,472	14,721	73,604	147,209	294,418	1,472,089	2,944,177	5,888,355
Waste Quantity (gal/mo)		11,012	110,120	550,598	1,101,196	2,202,392	11,011,959	22,023,919	44,047,837
Waste Quantity (gal/day)		367	3,671	18,353	36,707	73,413	367,065	734,131	1,468,261
Unit Construction									
Unit size (ft2)		4,061	6,410	15,688	26,478	47,192	204,364	395,890	774,557
Unit size (acres)		0.09	0.15	0.36	0.61	1.08	4.69	9.09	17.78
Annualized Land ($/yr)	$2500/acre								
Annualized Excavation	$0.17077/ft3								
Material Handling									
Distance to Unit (ft)		500	500	500	500	1,000	1,000	1,000	1,000
Piping - annualized capital									
Piping - annual O & M		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Total Annual Cost ($/yr)		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Unit Cost ($/mt)		2.00	0.20	0.04	0.02	0.01	0.00	0.00	0.00

Exhibit D-21
Relevant Ranges of Use for Curve Fit Cost Functions

Solids	**Equation**	**Range**	**NPT, MPT**	**PT SL/BP**	**PT SM**	**Opt. 1**	**Opt. 2**	**Opt. 3**	**Opt. 4**
Drums - solid	y = 24.589x + 132.23	0.5 -200	0 - 200	0 - 200	0 - 200	0 - 200	0 - 200	0 - 200	0 - 200
Roll-off	y = - 0.0022x^2 + 29.272x +4840.9	50-7500	200 - 935	200 - 935	200 - 1343.1	200-7500	200 - 1343.1	200 - 1343.1	200 - 935
Building	y = 0.00002x^2 + 3.2395x + 35800	1300 - 51000			1343.1 ++		1343.1 ++	1343.1 ++	
RCRA BUilding	y = 23.399x + 121689	120 - 45000				7500-45000			
LIne Pile	y = 4.0924x + 27676	500 - 120,000				45000++	45000++	45000++	
Unlined Pile	y = 4.0335x + 26522	500 - 120,000	935 ++	935 ++					935 ++
Unlined Pile - O $ M	y = 4.0207x + 26271	500 - 120,000	935 ++	935 ++					
Disposal Pile	y = 1.8703x + 12308	50 -500000							
Liquids									
Drum	y = -0.0074x^2+9.4798x+189.34	0.5 - 250	0-220	0-220	0-220	0-250	0-220	0-220	0-220
Tanks	y = -9e-7x^2 + 0.55x + 1795.7	45 - 200000	220-500	220-500	220++,		220-1 million	220 - 1 million	220-500
RCRA Tanks	y = -4e-6x^2 + 2.0665x + 6953.8	45 - 200000				250 - 1 million			
Lined SI	y = 0.0704x + 1955.1	500 - 2000000				1 million ++	1 million ++	1 million ++	
Unlined SI	y = 0.05x + 1565.9	500 - 2000000	500++	500++					500++
Unlined SI (O & M)	y = 1000	500 - 2000000	500++	500++					500++
DIsposal SI	y = 0.025x + 1491.4	500 - 2000000							

Exhbit D-22
Storage of Solids in Drums

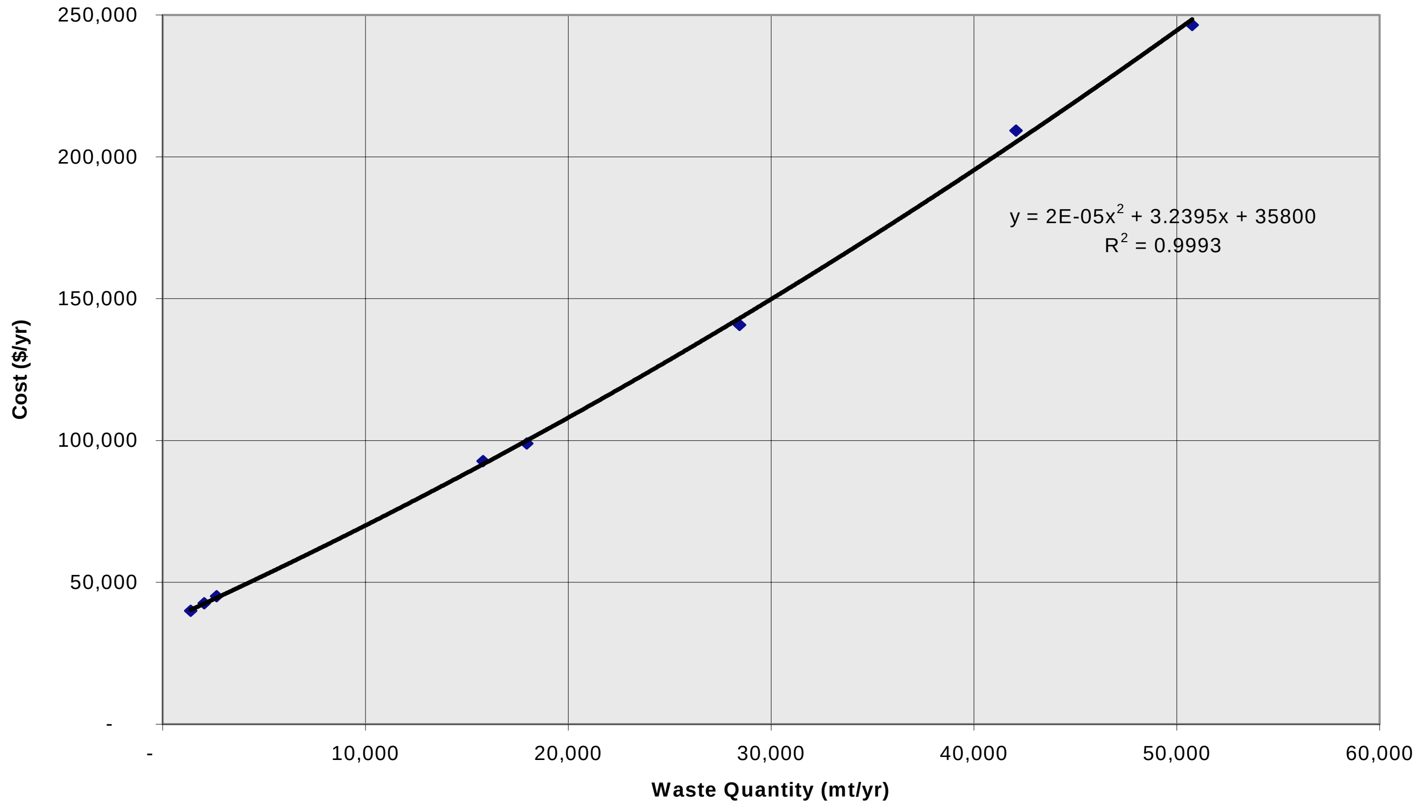


Exhibit D-23
Storage of Solids in Roll-off

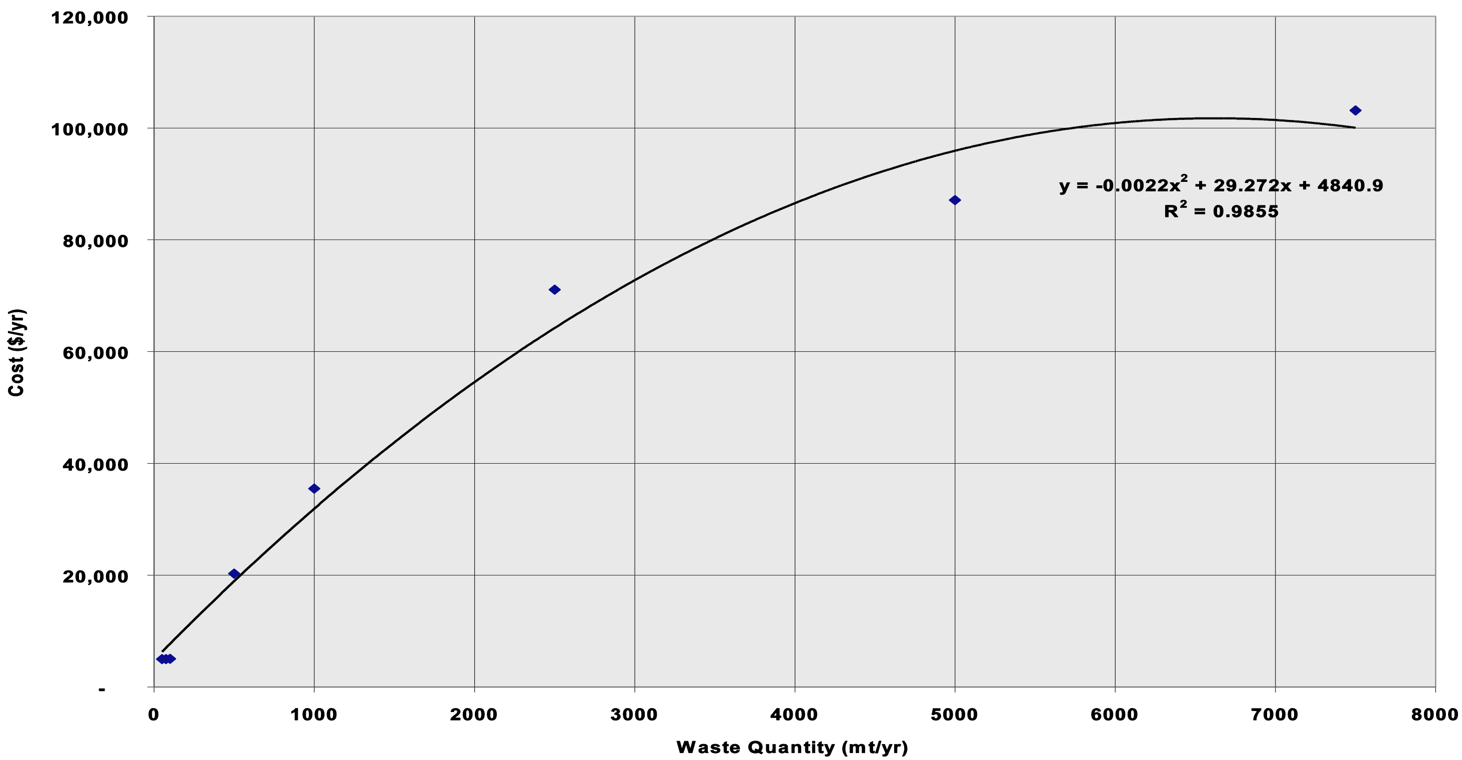


Exhibit D-24
Storage of Solids in Dome Buildings

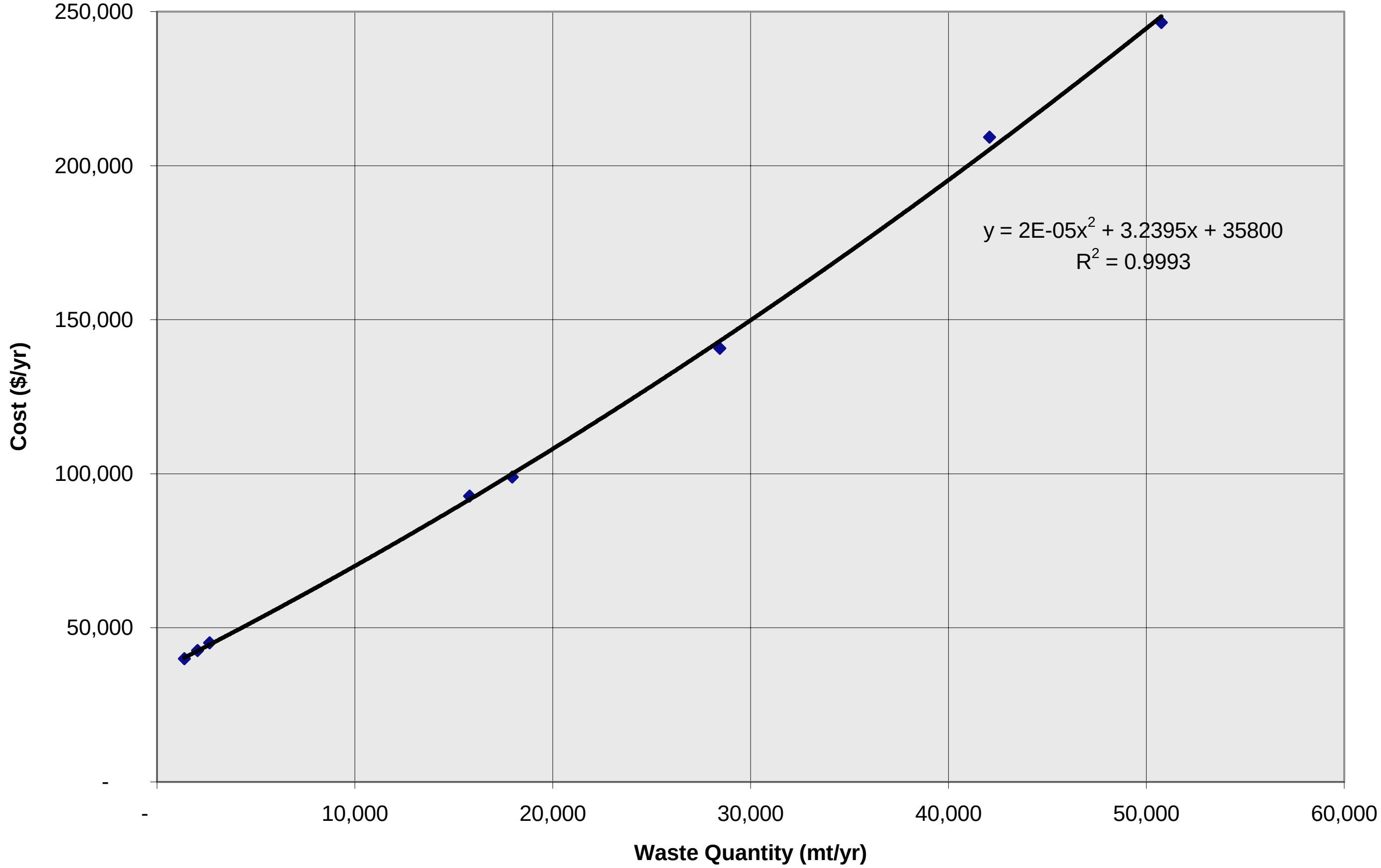


Exhibit D-25

Storage of Solids in RCRA Containment Building

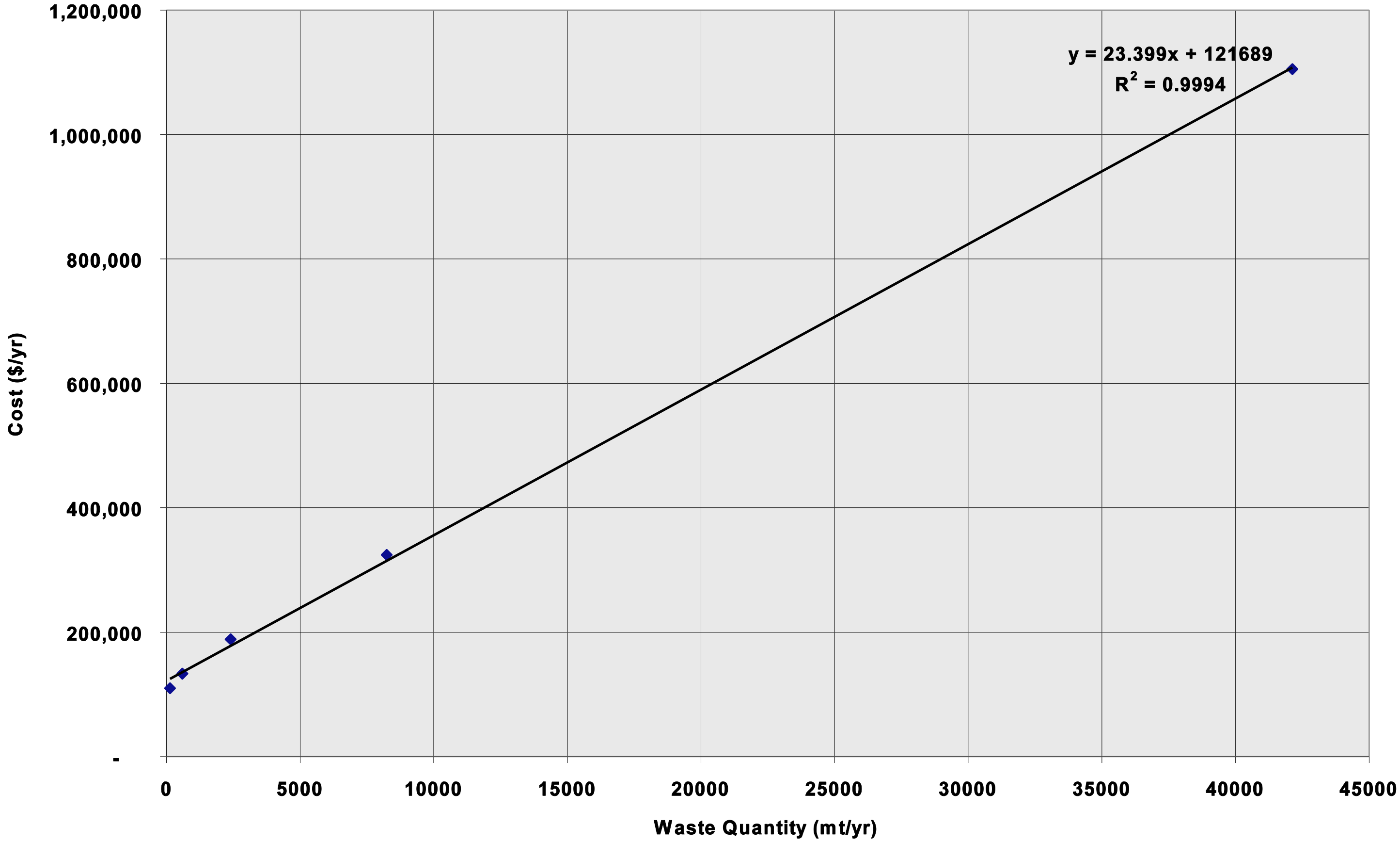


Exhibit D-26

Storage Cost of Solids in Lined Piles

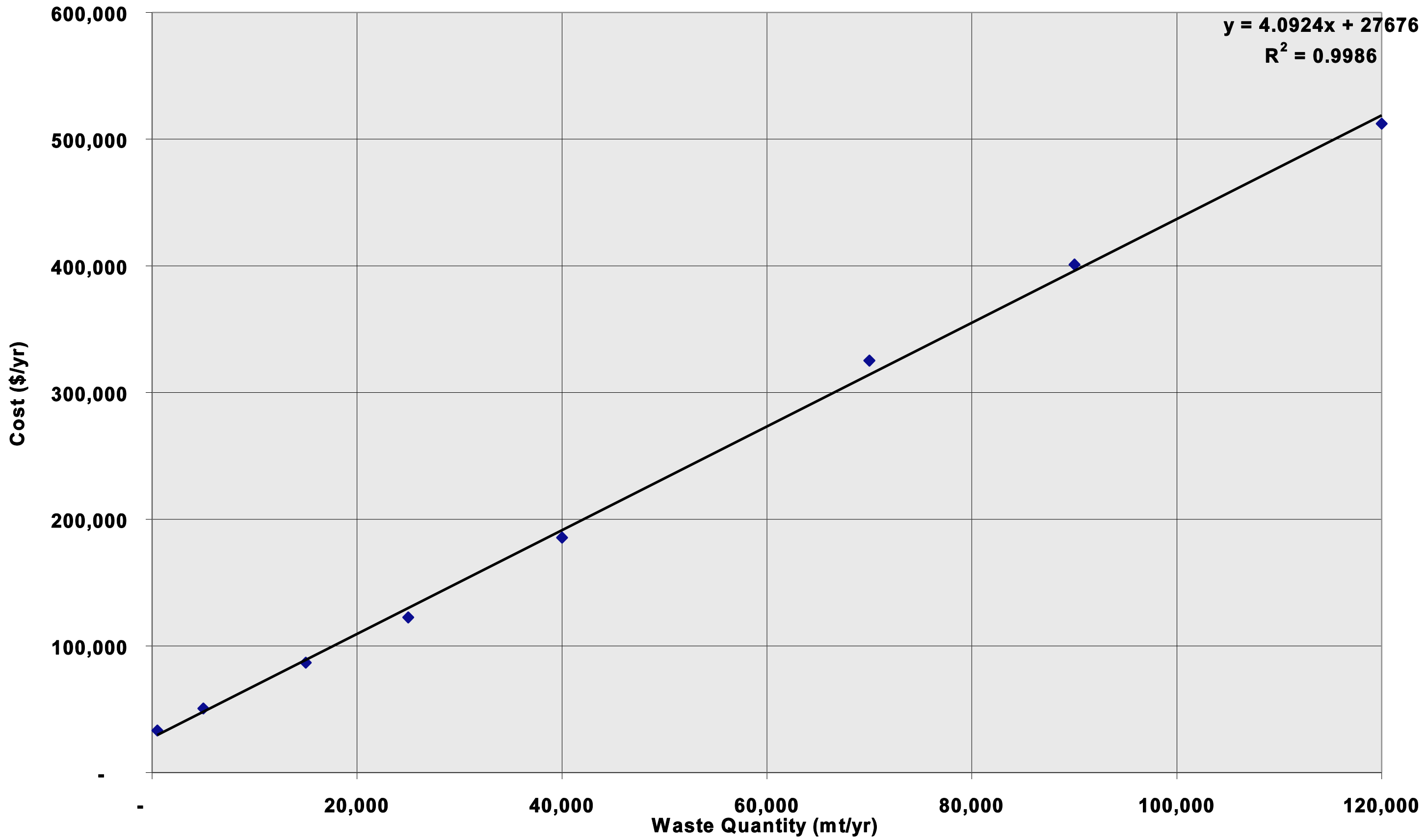
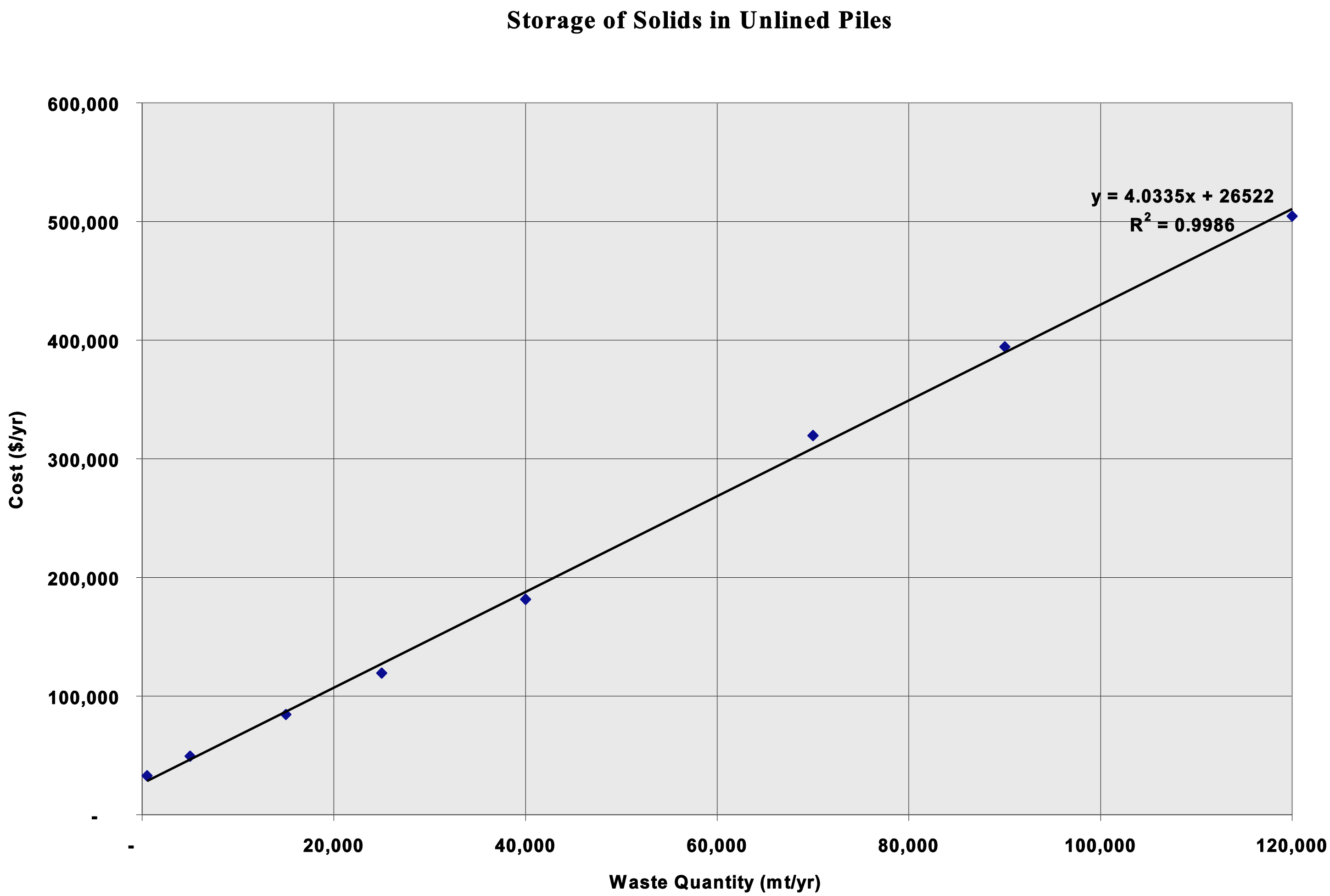


Exhibit D-27



Storage of Solids in Unlined Piles
600,000
500,000
400,000
300,000
200,000
100,000
-
Cost ($/yr)
-
20,000
40,000
60,000
80,000
100,000
120,000
Waste Quantity (mt/yr)
y = 4.0335x + 26522
R2 = 0.9986