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To: Dale Ruhter

From: Rick Nevin and Darius Brawn

Subject: Updated Closure and Post-Closure Cost Estimates for Subtitle C

The purpose of this memorandum is to propose updated closure and post-closure cost estimates for Subtitle C treatment, storage and disposal facilities (TSDFs). In generating these estimates ICF compared cost estimates used in prior financial test analyses with closure and post-closure cost estimates for hazardous waste facilities operating in Texas. Exhibit One presents the major findings of the analysis. Closure costs are estimated for: landfills, incinerators, and treater/storers. Post-closure costs are estimated for landfills.[1]

Exhibit One
Updated Closure and Post-Closure Cost Estimates

Waste Disposal Unit	ICF Estimate	
	Closure Cost	**Post-Closure Cost**
Landfill	$4,000,000	$1,000,000
Incinerator	$1,000,000	NA
Treater/Storer	$360,000	NA

The remainder of this memorandum is organized into six sections:

1. Limitations of 1988 Closure Cost Estimates;
2. Closure Cost Regression Analysis;
3. Landfill Closure Cost Estimate;
4. Landfill Post-Closure Cost Estimate;
5. Incinerator Closure Cost Estimate;
6. Treater/Storer Closure Cost Estimate.

[1] Post-closure requirements are applicable only to landfills.

1. Limitations of 1988 Closure Cost Estimates.

The 1988 analysis of the Subtitle C financial test utilized the same closure cost estimates that were used in the original 1981 financial test analysis (these estimates, developed by Pope-Reid Associates, were adjusted for inflation for the 1988 analysis). Exhibit Two presents these cost estimates adjusted to 1994 dollars.

Exhibit Two
1988 Closure Cost Estimates by Hazardous Waste Management Unit

Hazardous Waste Management Unit	Closure Cost (1994 dollars)
2,300 Gallon Treatment Tank	67,761
5,900 Gallon Storage Tank	77,184
1,250 Tons/year Incinerator	94,367
12,500 Tons/year Incinerator	235,987
2,000 Tons/year Landfill	624,264

The 1988 analysis assigned these cost estimates to facilities based on their classification in an EPA database of permitted TSDFs.[2] Facilities were classified into three categories: landfills, incinerators, and/or treater/storers. For example, if Facility A was identified as being both a treater/storer and an incinerator, the 1988 analysis assigned a closure estimate of $313,171 ($77,184 for treater/storers + $235,987 for incinerators)[3] to that facility.

The present analysis uses an identical methodology in assigning costs to hazardous waste handlers, but refines the 1988 closure cost estimates to address the following issues;

1. The 1988 analysis assigned a cost estimate for treater/storers based on the assumption they operate only *one* storage tank; and
2. The 1988 analysis assigned cost estimates for incinerators and landfills based on the specific facility sizes in Exhibit Two, which may not be representative of modern disposal facilities.

While the closure *costs* provided in Exhibit Two are reasonable for the TSDFs outlined above, the *sizes* are likely to underestimate the scale of operations at typical TSDFs. That is, landfills, incinerators, and treater/storers are likely to be larger than previously estimated. The present analysis (outlined in the following section) addresses this issue by examining the data from Texas to infer cost estimates for the "typical" TSDF.

2. Closure Cost Regression Analysis.

[2] EPA's RCRIS database identifies facilities with permits for one or more of three types of hazardous waste management units: landfill, incinerator, and treater/storer. RCRIS does not provide a further breakdown, for example a "storer" cannot be distinguished from a "treater."
[3] The 1988 analysis assumed that the larger of the cost estimates applied to treater/storers and incinerators.

In general, the data used in this analysis can be grouped into two categories: 1) closure estimates available for this analysis for facilities in Texas, and 2) the type of hazardous waste permit at all facilities from EPA's RCRIS data base described in the previous section. In order for the closure cost estimates from Texas to be useful in estimating the closure costs for all other facilities, a commonality linking the two groups is required.

ICF used these data to estimate closure costs for all RCRIS facilities by running three slightly different regressions on all RCRIS facilities with closure cost data from Texas. The equation for each of the three regressions was as follows:

$$Closure\ Costs = B_0 + B_1(Landfill) + B_2(Incinerator) + B_3(Treater/Storer)$$

where landfill, incinerator, and treater/storer are independent dummy variables indicating the type of hazardous waste handling unit, and B_0 is the constant term.

Exhibit Three presents the numbers of facilities for each combination of hazardous waste handlers from the Texas data. The original data provided 210 facilities, however RCRIS was available for only 163 facilities (i.e., RCRIS was able to identify the type of permit(s) for 163 of these facilities).

Exhibit Three
Numbers of Facilities in Texas Data by
Hazardous Waste Handler

Hazardous Waste Unit	# of Obs
Land	27
Land and Incinerator	0
Land and Treater/Storer	30
Land, Incinerator and Treater/Storer	25
Incinerator	9
Incinerator and Treater	17
Treater	55
Total	163

Approximately 55 percent of these Texas TSDFs have closure cost estimates of less than $1 million. Another 25 percent have closure costs between $1 and $5 million, but 20 percent have closure costs that range from $5 million to $64 million. The high-cost outliers in this distribution may not be representative of facilities outside of Texas. Therefore, ICF ran three different regressions, using the equation specified above, for three distinct "cuts" of the data:

- **Regression One** includes all closure cost estimates;
- **Regression Two** includes all but the highest and lowest five closure cost estimates;
- **Regression Three** includes all but the highest and lowest ten estimates.

Exhibit Four provides the results of each regression.

Exhibit Four
Statistical Description of Regression Analyses

				Intercept		Landfill		Incinerator		Treater/Storer	
Reg.	# Obs.	R^2	F-Stat	Coefficient (million $)	T-Stat	Coefficient (million $)	T-Stat	Coefficient (million $)	T-Stat	Coefficient (million $)	T-Stat
1	163	0.19	12.57	-1.73	-1.10	6.43	5.33	3.82	3.03	1.29	0.88
2	153	0.23	15.02	0.09	0.11	3.92	6.47	0.96	1.50	0.32	0.44
3	143	0.25	15.17	-0.03	-0.06	3.01	6.47	1.04	2.14	0.45	0.82

Regression three demonstrated the best overall fit with an R^2 of 0.25 and an F-statistic of 15.17. All three runs showed the landfill coefficient to be significant at a 95 percent confidence level with a t-statistic of greater than 1.96. The incinerator coefficient was significant only in regressions one and three, while the treater/storer coefficient was not significant in any of the regression runs, but its t-statistic is highest in regressions one and three. Regressions two and three have very similar coefficient values, and result in intercept values close to zero consistent with theoretical expectations (a facility with no permit should have no closure cost estimate).

The coefficients for all three regressions suggest closure cost estimates that are much higher than those used in the 1988 analysis. For example, the regressions estimate landfill closure costs to range from three to 6.4 million dollars versus the estimate of 0.6 million dollars used in the 1988 analysis. This suggests that Texas landfills may be much larger than 2,000 tons per year.

Alternative Regression

As a method of confirming the results described above, ICF ran three additional regressions: 1a, 2a, and 3a corresponding to regressions one, two and three. The equation for the new regressions is specified below:

$$Closure\ Costs = B_0 + B_1(Landfill) + B_2(Incinerator)$$

where landfill, and incinerator are independent dummy variables indicating the type of hazardous waste handling unit and B_0 , the constant term, serves as the treater/storer dummy variable. Exhibit Five presents the results.

Exhibit Five
Statistical Description of Alternative Regression Analyses

				Intercept		Landfill		Incinerator	
Reg.	# Obs	R^2	F-Stat	Coefficient ($ millions)	T-Stat	Coefficient ($ millions)	T-Stat	Coefficient ($ millions)	T-Stat
1a	163	0.18	18.5	-0.61	-0.66	1.16	5.28	1.26	3.1
2a	153	0.23	22.6	0.36	0.79	3.85	6.61	0.97	1.53
3a	143	0.24	22.5	0.36	1.00	2.91	6.48	1.05	2.17

The new regression results are very similar to those of the previous regression runs. The R^2 values are roughly the same between the two sets and the coefficients for landfills and incinerators in regressions 2a and 3a are nearly identical to their corresponding coefficients in regressions two and three (3.85 and 2.91 million dollars versus 3.92 and 3.01 million dollars, respectively). The B_0 term has values in regressions 2a and 3a that lie in between the treater/storer coefficients indicated by regressions two and three (0.36 million dollars versus 0.32 and 0.45 million dollars). In addition, the F-statistic increased for all three regressions indicating that the variables, when considered together, are significant. The following sections compare the regression results from Exhibit Four with various outside sources to determine appropriate closure cost estimates for each of the three types waste management units.

3. Landfill Closure Cost Estimates.

Exhibit Six presents estimated closure costs for Subtitle D landfills based on inflation adjustments to the cost estimates used in the proposed Subtitle D financial test analysis. These estimates should also approximate the costs for Subtitle C facilities because closure requirements for Subtitle C and D landfills are very similar.

Exhibit Six
Estimated Subtitle C and D Closure Costs
(by size category)

Size Range in tons per day	1991 Subtitle D Analysis Closure Costs (1995 dollars)	Subtitle C Size Suggested by Regression Analyses
50 – 125	$2,400,000	$3.0 million (Regression Three)
126 – 275	$4,600,000	$4.0 million (Regression Two)
276 – 563	$7,500,000	$6.4 million (Regression One)
564 – 1125	$10,700,000	NA

By combining the closure estimates from the 1989 memorandum with the regression results presented in Exhibit Four, it is possible to approximate the typical size (as measured in tons per day) of landfills associated with each regression run. For example, regression two estimates a closure cost for landfills of roughly $4,000,000 which corresponds to the 1989 estimate for landfills processing approximately 125 - 275 tons per day. The third column of Exhibit Four presents these results.

ICF has examined the "typical" size category of Subtitle C Landfills to identify which size category, and which regression run provides the most appropriate closure cost estimate. For example, if the "typical" landfill processed roughly 75 tons per day then regression three would provide the most appropriate closure cost estimate.

In determining the size of the "typical" landfill, ICF examined information available in *EI Digest*[4] outlining the quantity of RCRA hazardous waste handled by commercial landfills in the US. Based on these data ICF determined that the median size commercial landfill in the US handled approximately 310 tons per day. This would indicate that regression one provides the best

[4] Neidor, Robin, "Hazardous Waste Landfills 1995", *EI Digest*, April 1995. pp 25 - 31.

closure cost estimate. This estimate, however, is probably too high because it reflects only commercial landfills. Many facilities covered by RCRA handle their waste on-site and do not ship it to these commercial landfills. These captive facilities are likely to be somewhat smaller than their commercial counterparts. For this reason, ICF believes that a more suitable estimate for a "typical" landfill would fall within the 125 - 275 tons per day category making regression two's closure cost estimate of $4,000,000 the appropriate figure.

4. Landfill Post-Closure Cost Estimate

Post-closure cost estimates for the Texas TSDFs showed the same high cost outliers as was found in the closure cost estimates. As a result, ICF elected to use a median value, rather than an average value, to limit the effect of outliers on the sample. The median post-closure cost for landfills from the Texas data was approximately $1,000,000.

Exhibit Seven presents the post-closure cost estimates for various size categories from the 1989 memorandum described earlier.

Exhibit Seven
Estimated Subtitle C and D Post-Closure Costs in 1989
(by size category)

Size (Range) in tons per day	1989 Post-Closure Costs (1995 dollars)	Median Post-Closure Cost From Texas Data
50 - 125	$750,000	$1,000,000 ↕
126 - 275	$900,000	
276 - 563	$1,300,000	
564 - 1125	$1,600,000	

The median, when compared with the 1989 data, indicates a post closure cost associated with landfills that process approximately 125 -275 tons per day. This is consistent with the findings from the closure cost analysis which indicated that the "typical" landfill handles approximately the same quantity of waste per day. This finding suggests a post-closure estimate of $1,000,000 to be reasonable.

5. Incinerator Closure Cost Estimate.

The regressions estimate closure costs for incinerators to range from approximately one million to 3.9 million dollars. These costs are considerably higher than the estimate provided by the 1988 analysis of $235,987, suggesting that incinerators today are generally much larger than the 12,500 tons per year assumed by that analysis. This is confirmed by an analysis of the current capacities of commercial incineration facilities.[5] These facilities handle an average of 48,500 tons

[5] Hanke, Jon, "Hazardous Waste Incineration 1995", *EI Digest*, May 1995, pp 31 - 38.

per year of waste, approximately four times the amount assumed by the 1988 analysis.[6] The regression runs provide estimates much more consistent with these larger incinerators.

Regression one's estimate, however, of 3.9 million dollars seems excessively high. It is approximately sixteen times larger than the 1988 cost estimate while incinerators are, on average, only four times larger. Regressions two and three estimate a closure cost for incinerators of one million dollars. This estimate is roughly four times larger than the 1988 estimate, a finding, that is much more consistent with the reported size of incinerators. As a result, ICF proposes to use a closure estimate of one million dollars for incinerators.

6. Treater/Storer Closure Cost Estimate

The regression results estimated closure costs for treater/storers to range from $300,000 to $1.3 million dollars. Using the 1988 closure estimate of $78,000 per tank, the results suggest treater/storers operate approximately four ($300,000 divided by $78,000) to 17 ($1,300,000 divided by $78,000) tanks per facility.

As noted above, B_0 (the constant term) in regressions 2a and 3a was similar to the coefficients for treater/storer in regressions two and three (0.36 million dollars in 2a and 3a versus 0.32 and 0.45 million dollars). The similarity between these numbers suggest a reasonable closure estimate for treater/storers is somewhere within this range. To see how B_0 in the alternative regressions correspond to B_3 (the coefficient for treater/storers) in regressions one two and three, consider a facility that is identified by RCRIS as being only a treater/storer. Regressions one, two and three would assign the treater/storer coefficient as the closure estimate for this facility. Regressions 1a, 2a, and 3a do not have a treater/storer coefficient and could only assign the constant term (i.e., B_0) to this facility. Therefore, the fact that B_0 in regressions 2a and 3a is consistent with the treater/storer coefficient in regressions two and three is important.

Additionally, the mean and median values of the closure cost estimates from the Texas data for facilities that are exclusively treater/storers are $512,000 and $120,000, respectively. Regressions two, three, 2a, and 3a all provide estimates that lie in-between these numbers.

While outside data is not available that could further validate the findings of this analysis for treater/storers, the regression results, coupled with the mean and median values suggest a treater/storer cost estimate of approximately $360,000.

[6] An average value could be used here because the distribution of incinerator capacities was approximately normal. The median estimate was only slightly different at 45,000 tons per year.