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# A Norm Disposal Cost Study

## Project No. SA49

FIRST EDITION, FEBRUARY 1996

American Petroleum Institute

## FOREWARD

This publication is based on oil and gas company questionnaires representing NORM (Naturally Occurring Radioactive Materials) accumulated to the end of 1992 and annually produced during 1993. Some late replies from 1994 have also been added. The production of oil and gas in the United States has resulted in the co-production of scales and sludges contaminated NORM. This study is based on the actual costs of NORM disposal obtained through questionnaire replies from oil and gas producers. The NORM questionnaire replies were received from companies representing 46 percent of the domestic U.S. oil, gas, and gas condensate production. The survey results were prorated to represent 100 percent of the U.S. oil and gas industry. Most of the oil and gas producing states of the U.S. are represented in the survey replies.

This document details the reported quantities of NORM that have accumulated over the years and the annual rate of NORM production for 1993 from the domestic U.S. oil and gas condensate production. No data was received for NORM in the gas industry. This publication documents the 1992 costs of the available NORM disposal options at that time and calculates the cost impact of disposing of the accumulated NORM and the annual cost of compliance with existing and proposed NORM regulations.

Over a number of years, some 10 million drums (55 gallons each) of NORM have accumulated in production, process equipment, produced water ponds, and treatment pits. NORM continues to be produced at a minimum rate of 140,000 drums per year from oil and gas condensate production.

Survey monitoring programs to detect and quantify NORM are in operation in virtually all domestic U.S. oil and gas producing areas. These programs are designed to provide NORM data to satisfy regulatory reporting requirements. The questionnaire replies include two reports of very large NORM accumulations. These two reports along with a concentration of reported NORM data from the Gulf Coast of Louisiana and Texas were included in the database used to extrapolate the reported NORM quantities to represent the entire U.S. oil and gas condensate production industry. However, recent reports of NORM in the feed stocks to the downstream refining and processing industry that are not included in this report may indicate an underreporting of the annual NORM production rate of 140,000 drums per year. Other studies[3],[7] have indicated that this annual figure could be four times higher than reported in the questionnaire replies even after prorating to represent the entire industry.

There are a growing number of NORM disposal options defined by the specific activity of the NORM that they will accept, all of which are licensed or permitted by federal and state agencies. The NORM acceptance criteria are different for each disposal site, as are disposal costs. The range of available NORM disposal options at the end of 1993 include:

- Burial in 10,000 = year perpetual care sites.
- Land management and dilution with Nonhazardous Oilfield Waste (NOW) material.
- Injection into class II wells after processing either in the area of the producing field or at a private facility after dilution with NOW material.
- Sale of NORM contaminated steel to China.
- Disposal reprocessing and placement of NORM material as a cap for the Chernobyl reactor.
- Disposal in old production wells being plugged and abandoned.

Disposal costs per drum of NORM vary depending on the specific activity of the scale, the number of drums, and the disposal option selected. Costs range from approximately $74 minimum to $3,333 per drum. Actual average costs to date reported in the NORM questionnaire from the U.S. domestic oil and gas industry are $544 per drum with a maximum of $20,000 per drum reported by more than one company.

Using the average disposal cost per drum of $544, the annual cost impact of disposing of the 142,000 drums of NORM produced would be $77 million per year. The potential cleanup over 25 years of the accumulated NORM volume of 10,000,000 drums at 400,000 drums per year, adds an additional cost of $218 million per year. The total annual NORM disposal cost could be $295 million per year for the next 25 years. These figures do not include the costs to identify, sample, analyze, clean and containerize the NORM ready for disposal.

NORM disposal costs may be reduced significantly if one or more of the following options are used:

a. Volume discounts offered by the disposal companies.

b. Cheaper disposal options becoming an operational reality.

c. Disposal volume reduction due to regulatory compliance matched to real risk.

d. Exempt concentration level above 30 pCi/g.

Other disposal options may have been introduced since the date of this survey in 1992-93. They are not evaluated in this publication.

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# A NORM Disposal Cost Study

## SECTION 1—VOLUME ESTIMATES OF NORM WASTES

### 1.1 INTRODUCTION

NORM production data was received from the oil and gas producing states of the U.S. shaded in Figure 1. Most of the questionnaire replies were grouped by individual oil company regions; most regions included more than one state. Because of the different grouping of states included by each company the information was analyzed using the five regions shown. Figure 1 illustrates the states from which the data was compiled and how they are grouped into the five regions used in the data analysis.

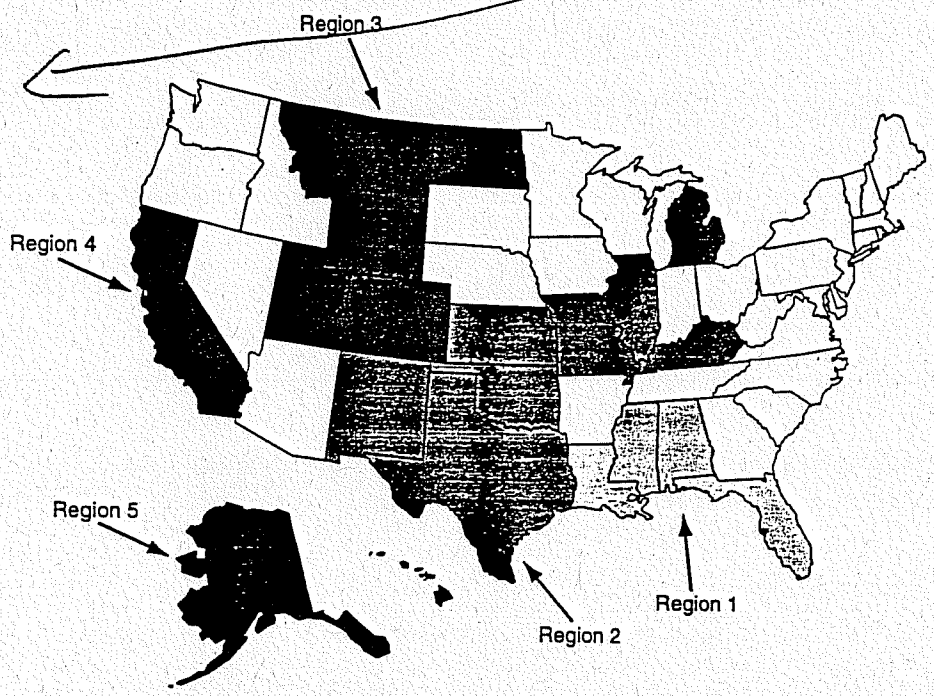


Figure 1—Responding States Grouped Into Regions

The NORM survey questionnaire was sent out to API member companies. The appendices and tables in this document were derived from the 50 questionnaire replies received representing approximately 46 percent of the domestic U.S. oil, gas, and gas condensate production capacity. The questionnaire replies are summarized in Table 1 by total oil and gas condensate production as a percentage of each region total. Annual oil and gas condensate production figures from the Oil and Gas Journal [5] are shown for comparison. No replies were received relating to NORM as natural gas.

The data for oil and condensate production in section 1.6.1 of Appendix C were cross-checked with reported oil and gas condensate figures from the Dwights Energydata, Inc.(6) information database to ensure an accurate division of production by state and region for the responding companies. This was done to prorate the figures for the total accumulated NORM to December 1992, and the 1993 annual NORM production to represent the total oil and gas condensate production in each region. The Dwights [6] information also allowed the replies to be more accurately divided by state and grouped by region.

No two questionnaire replies had the same regional grouping of states; hence, the replies were adjusted to the regional groupings shown in Figure 1. The two survey replies with NORM drum disposal costs of $20,000 per drum were omitted due to the unusual operational problems causing these high costs which are not anticipated to recur. The first high-cost NORM disposal job reported was due to the loss of the use of the well because junk steel was lost in the well bore. The second high-cost NORM disposal job was also due to an unusable well bore because a piece of equipment lodged in the well.

#### 1.1.1 COMMENTS ON THE NORM SURVEY DATA

The NORM surveys did not use a single, consistent survey procedure or dose rate decision criteria. For example,

Table 1—Oil and Gas Questionnaire Replies (000BPD) 1992

| Region | Gulf Coast | Mid-Continent | Rocky Mountains | California | Alaska | Total |
|---|---|---|---|---|---|---|
| Replies 000 BPD | 972 | 323 | 68 | 158 | 1,624 | 3,132 |
| (Percentage of Region Responding) | (44%) | (20%) | (13%) | (17%) | (100%) | (46%) |
| 000 BPD (100 Percent) Ref [5] | 2,233 | 1,583 | 512 | 936 | 1,624 | 6,888 |

the distance of the detector from the item being surveyed (when known) varied from 1 centimeter to 18 inches. The dose rate decision criteria of either 25 or 50 microR/h was universally applied to NORM in equipment in drums on the ground and in produced water pits. The reported data did not include the number of items surveyed and found to be free of NORM, thee items would be more numerous than items found contaminated.

Figure 2 prepared from the previously unpublished Lmoga NORM survey data shows that 90 percent of the NORM held in storage in 1992 using a 25 microR/h decision criteria had a specific activity less than 100 picoCuries per gram. However, Norm surveys conducted by surveying the outside surfaces of the oil, gas, and gas condensate

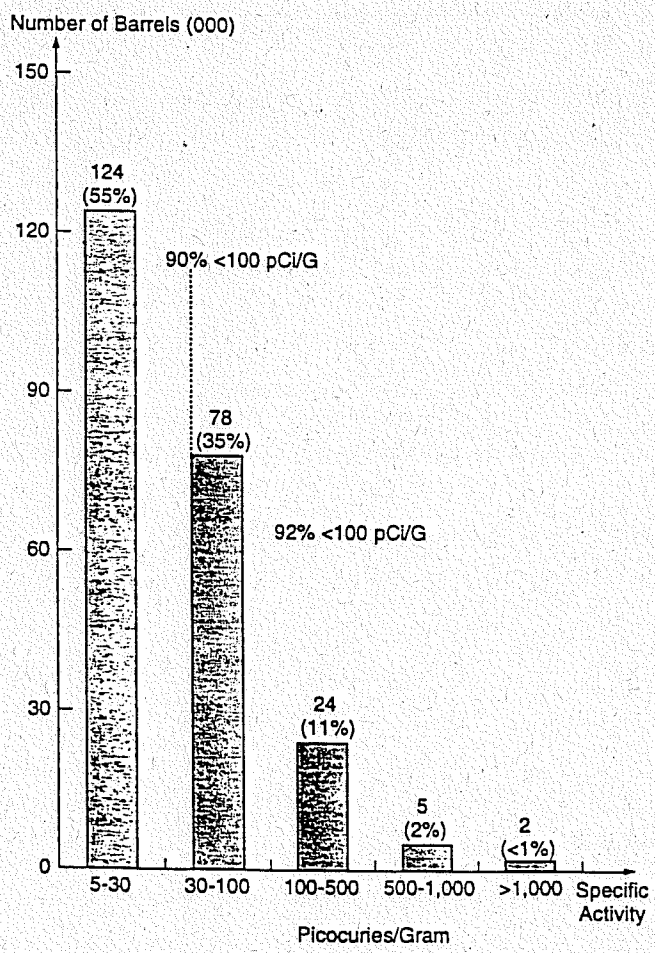


Figure 2—Drums of Stored NORM by Specific Activity and Percentage of Total Stored Per Activity Range

equipment and tubulars and using an action level of 50 microR/h may have difficulty [8], depending on the quantity of NORM material accumulated inside the equipment and the thickness of the steel, and in detecting NORM on the inside of the item being surveyed where the specific activity is less than 100 picoCuries per gram. Hence, it is possible that only NORM with a specific activity greater than 100 picoCuries per gram (that is 9 percent of all NORM) was being reliably detected with an external dose rate over 50 (R/h, and reported in the survey replies. Figure 2 also illustrates that less than 1 percent of NORM has a specific activity greater than 1000 picoCuries per gram. Other field survey factors that affect the production, detection, and reporting of NORM are:

a. Sensitivity of the survey detector

b. Action level for reporting (currently 50 micro/h)

c. Oil and gas production rates

d. Ratio of produced water to oil; that is, barrels of water per barrel of oil

e Use of scale inhibitors to prevent NORM

f. Percent of produced water re-injected versus surface treatment processing

#### 1.1.1.1 NORM Database Information

The norm information used throughout this publication was obtained via a survey questionnaire. Appendices A through G provide examples of the questionnaire, the information received, and various summaries of the information. A description of the contents of each appendix follows.

Appendix A illustrates a typical questionnaire reply received with the universal and notable absence of NORM data associated with gas production. Only one reply contained NORM specific activity information. Figure 3 summarizes the dose rate data for the accumulated NORM.

Appendix B includes a range of NORM disposal job/program costs to illustrate the data received in the questionnaire replies and incorporated into the database in Appendix C.

Appendix C - Questionnaire Survey Replies Database - The survey questionnaire replies for the oil and gas condensate production were checked with data from Dwights Energydata Inc. [6] to enable the information to be prorated to represent 100 percent of the oil, gas, and gas condensate production in each region.

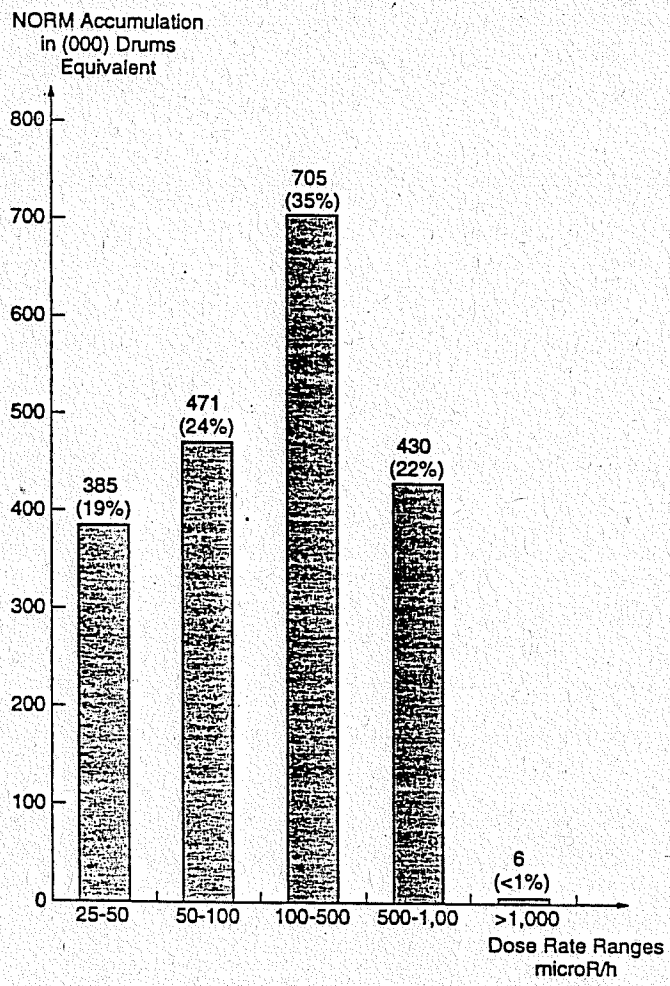


Figure 3—Drums of Stored Norm by Dose Rate
Corrected to 100% Production
From API Survey 1993

Appendix D - Transportation Cost Matrix by Region to Permitted Disposal Sites (1993) - Estimates were derived from transport company rate sheets and modified through discussions with oil and gas producing companies. Rates are for exclusive use full-load vehicles.

Appendix E - Actual Disposal Costs per Drum for Plug and Abandonment Summarized from Appendix C - Maximum, average and minimum costs per drum for NORM disposal injection or encapsulation placement was obtained; virtually all the data came from Region 1—the Gulf coast.

Appendix F - NORM Disposal Costs by Region for Real Disposal Options— This matrix summarizes the maximum, average, and minimum disposal cost per drum from each region to each disposal site and adds in the transport costs to give the total disposal costs per drum for the annual NORM production and the accumulated NORM material for each region to each disposal site. The accumulated NORM drums per region is multiplied by these costs to give the range of accumulated NORM disposal costs per region. See Section 3.2 (Table 7).

The annual NORM production rates from Table 3 for all five regions are also multiplied by the minimum average and maximum average transport and disposal costs per drum (from Appendix F) to give the annual NORM transport and disposal cost range summarized in Table 9.

Each of the five regions is summarized separately, and all five are totaled to give the range of transport plus disposal costs for all accumulated NORM and the annual cost of disposal for the annual volume of NORM produced; see Section 4.3.

Appendix G - NORM Production by Type of Source — Summarized data from the replies are grouped for comparison by the source generating the NORM. The two enormous accumulation reports (# 137 and # 146) were checked with the responding companies and their accuracy confirmed; these reports are representative of the historical NORM accumulations.

Appendix G shows that stored solids (A) were not identified in the survey concerning their original source of production. NORM-contaminated stored tubulars (B) and equipment (C) along with stored solids (A) each represent less than 1 percent of the total NORM known to have been produced and accumulated by December 1993. The single largest source of accumulated oilfield NORM reported in the questionnaire replies is contained in produced water pits or ponds.

## 1.2 VOLUMES OF NORM WASTE—PAST, PRESENT, AND FORECAST

The actual survey replies represent 46 percent of the domestic oil, gas, and gas condensate production. The ratio of the total oil and gas condensate production from the *Oil and Gas Journal* [5] to the reported production data was used to multiply the reported number of drums (of NORM for each region) to represent 100 percent of the domestic oil and gas condensate production as shown in Table 2.

The U.S. oil and gas producing states from which replies were received and shown in Figure 1 have been grouped into five regions to facilitate the calculation of the NORM disposal costs. Most responding companies had operating areas with different state groupings, some of which were not identified by individual states. In those cases, the survey data was prorated for the total production between the individual states and regions.

Region 1, the Gulf Coast survey, reported oil, gas, and gas condensate production was 971.62 mbpd (43.5 percent of the actual 2,333 mbpd [5] (100 percent) produced in Region 1. Hence the prorating factor is (100/43.5) = 2.3 The prorating factor for Regions 2, 3, 4, and 5 were calculated in the same manner.

Table 2—NORM Generated Per Region From 100 Percent Of Producers

| | Regions 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Derivation of Production Multiplier to 100 Percent mbpd | | | | | |
| Production replies | 971.62 | 322.67 | 67.85 | 145.3 | 1,624.0 |
| Oil and gas journal ave | 2,230.0 | 1,559.0 | 517.0 | 936.0 | 1,624.0 |
| Percent of regional total | 43.5 | 20.7 | 13.1 | 15.5 | 100.0% |
| Multiplier | $^{100}/_{43.5} = 2.3$ | $^{100}/_{20.7} = 4.8$ | $^{100}/_{13.1} = 7.6$ | $^{100}/_{15.5} = 6.45$ | 1.0 |

Table 3— Annual NORM Generation Rate is calculated from the reported annual NORM generation rates contained in the survey replies.

The annual reported quantities of NORM generated for Regions 1, 2, 3, and 5 are based on a fraction of each regions oil and gas production which is first multiplied by a factor derived in Table 2 which then equates the annual NORM generation rate to 100 percent of the production for each region.

The NORM survey dose rate decision criteria of 50 microR/h is measured on the outside of the steel components surveyed. No one measurement protocol was used to take the readings. Some of the survey issues affecting the accuracy of these readings are the various thicknesses of the equipment steel, the distance of the detector from the component and its orientation to the equipment being surveyed, the quantity of NORM present within a component, and the possibility of non-radioactive shielding barium scales. Because of these sources of error and external decision criteria it is difficult to detect NORM with a specific activity less than 100 picoCi/gram.

The production of NORM in oil and gas equipment (see Figure 2) has a relationship between the quantity produced and the specific activity such that based on the Lmoga data 90 percent of the NORM produced is less than 100 picoCi/gram. This material is not easily detected by external surveys unless they are carefully conducted by trained and experienced NORM technicians [8]. From a review of the difficulties and the factors that affect the accuracy of these readings even in a laboratory controlled situation [8], the reported quantities of NORM based on these readings may be underestimated by a factor of 2 to 10. Hence, both the annual and the accumulated quantities of NORM are multiplied by a factor of between 2 and 10 to represent the full range of NORM specific activities. This document uses the factor 10 to calculate the total annual NORM production and the quantities of NORM accumulated over many years of production.

Table 3 shows the annual NORM generation rates reported by Regions 1, 2, 3, and 5. The reported figures are multiplied by the factor from Table 2 to represent 100 percent of the production and then by 10 to take into account the difficulties in detecting the lower specific activities of NORM.

The data in Figure 3 comes directly from the questionnaire replies and shows the reported quantities (in 000's of drums) of stored NORM grouped by the dose rate ranges 25-50; 50-100; 100-500; 500-1,000; and greater than 1,000 microR/h. From the previous discussion, the readings over 50 microR/h represent NORM over 100 picoCi/gram; and from Figure 2A, shows this is 10 percent of the total NORM produced. The total quantity of NORM based on these data, if fully identified, can be illustrated in this equation

Total NORM accumulated

= 10 x (471,000 + 705,000 + 430,000 + 6,000) drums

= 16,120,000 drums.

Table 3—Annual NORM Production Rate 1993

| Region | NORM Reported > 100 pCi/g | Prorated to 100 Percent Production | Total Per Annum Prorated Drums | Multiplier for All NORM | Total NORM Production Per Annum Drums |
|---|---|---|---|---|---|
| Gulf Coast | 4,106 | 2.3 | 9,444 | 10 | 94,440 |
| Mid-Continent | 367 | 4.8 | 1,762 | 10 | 17,620 |
| Rocky Mountain | 106 | 7.6 | 1,216 | 10 | 12,160 |
| California | 0 | 0.0 | 1064[a] | 10 | 10,640[a] |
| Alaska | 753 | 1.0 | 753 | 10 | 7,530 |
| | | | 14,239[b] | | 142,390 |

Note: Using the multiplier 10 as previously discussed gives a total annual NORM production of 142,000 drums.

[a]Calculated value.

[b]Reported number represents NORM greater than 100 pCi/g; from Figure 2 that is 10 percent of the total Annual production.

### 1.2.1 Calculation of the NORM Production in Region 4—California

From the survey results, no NORM was reported for Region 4. However, a 1995 NORM survey of oil and gas production equipment in California by the California Department of Health Services Radiological Health Branch (RHB) found that NORM was present in some of the oil and gas equipment that had been removed from service. Their survey locations were selected to maximize the chance of finding the existence of NORM; hence, their preliminary detection frequency (23 percent) is not thought to be representative of the real occurrence rate previously reported as 3.42 percent [1]. From recent NORM survey work in California by a number of oil and gas companies, it has been learned that the occurrence of NORM appears to be lower in California than the Gulf Coast states. Because of the data in these reports and in discussion with the RHB, an estimate has been made of NORM occurrence for the California region by comparing it to the next closest region 2—(Mid-Continent) in both oil and gas production and NORM incidence reported [1] and calculated for the states grouped in each region.

Region 2—Mid Continent
- Reported oil and gas condensate production
- From questionnaire = 323,000 bpd
- Reported annual NORM production = 367 drums per annum
- Total annual oil and gas production [5] = 1,583,000 bpd
- Total annual NORM generated = 323,000 ——— x 367
- Total = 1,799 Drums

Region 4—California
- Reported oil and gas condensate production
- From questionnaire = 145,000 bpd
- Reported annual NORM production = 0 drums per annum
- Total annual oil and gas production [5] = 936,000 bpd
- Total annual NORM generated ——— x 1,799
- Total = 1,064 Drums

Table 4 - Accumulated NORM in Drums, Tubulars, Vessels, Process Equipment, ponds, and on Sites is summarized in Table 4. The questionnaire replies and the multipliers developed in Table 2 were used to prorate the reply data to represent 100 percent of each region except Region 4, which was calculated as above. Table 4 summarizes the total accumulated NORM from all sources calculated from the replies and representing the total industry.

Region 4 is a calculated value for a 15-year accumulation based on the annual value calculated in Table 3

The minimum annual NORM generation rate of 142,390 drums was derived from the reported data. The reported NORM accumulations prorated to represent all the domestic oil and gas condensate production totals 10,056,597 drums from the domestic U.S. oil and gas production.

Table 5 - NORM Quantities by Specific Activity for Each Region uses the graph in Figure 2 together with the total accumulated NORM in Table 4 to calculate the actual number of drums in each specific activity range.

Figure 2 shows that 92 percent of all NORM is less than 200 picoCuries/gram, and 7 percent is greater than 200 but less than 2000 picoCuries/gram Applying these percentages to the accumulated NORM per region from Table 4 gives the number of drums in each band of specific activity. These numbers will be used to calculate the minimum average and maximum average cost of disposal per drum, including transportation.

The bands of specific activity were chosen because of the limits set on some of the disposal facilities. Disposal options 2 and 4 could (at the date of the survey–1993) accept NORM with a radium concentration up to 2,000 picoCi/gram. Disposal option 3 could accept NORM with a radium content up to 200 picoCi/gram.

The bands chosen for costing are:

0 to < 200 picoCi/gram

over 200 < 2,000 picoCi/gram

>2,000 picoCi/gram

Table 4—Accumulated NORM in Drums, Tubulars, Vessels, Process Equipment, Ponds, and on Sites.*

| Region | 1 | 2 | 3 | 4 | 5 | Total |
|---|---|---|---|---|---|---|
| Replies, drums (Appendix C) | 128,846.0 | 1,902,199.0 | 61,693.0 | 10,640.0 | 1,229.0 | 159,388.0 |
| Multiplier to represent 100 percent production (Table 2) | 2.3 | 4.8 | 7.6 | | 1.0 | |
| 100 percent of region | 296,346.0 | 9,130,055.0 | 468,867.0 | 159,600.0 | 1,229.0 | 10,056,597.0 |

*Prorated to 100 percent of each region.
Note: Calculated value based on the average NORM drums produced per million bpd per region

Table 5—NORM Specific Activity Distribution by Region

| Region | < 200 pCi/g (92%) | > 200 < 2,000 pCi/g (7%) | > 2,000 pCi/g (< 1%) | Total |
|---|---|---|---|---|
| | Number of Drums | | | |
| 1. Gulf Coast | 128,846 | 26,671 | 2,964 | 296,346 |
| 2. Mid-Continent | 8,217,499 | 821,750 | 91,306 | 9,130,555 |
| 3. Rocky Mountain | 421.980 | 42,198 | 4,689 | 468,867 |
| 4. California | 372,978 | 37,298 | 4,144 | 414,420 |
| 5. Alaska | 1,106 | 111 | 12 | 1,229 |

## SECTION 2—REFERENCES

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2. Unpublished Report, Louisiana Mid-Continent Oil and Gas Producers Association.

3. W. Russo, "Diffuse NORM Wastes— Waste Characterization and Preliminary Risk Assessment", W. Russo of AL. EPA, May 93.

4. SPE # 23383; "Evaluating the Real Risks of Radioactive Scale in Oil and Gas Production", A. McArthur, G. Reed, and B. Holland, ICI Tracerco

5. Oil and Gas Journal, 1993.

6. Oil and Gas Journal, 1993.

7. Dwights Energydata Services, Inc.

8. API Publication # 815-13714, Potential Impact of Environmental Regulations on Oil and Gas Exploration and Production Industries, March 1995, API.

9. API Report, Methods for Measuring Naturally Occurring Radioactive Materials in Petroleum Production Equipment, December 1989.

## SECTION 3—NORM DISPOSAL OPTIONS AVAILABLE

To be included as an available option, each alternative had to be reported in the questionnaire replies, together with actual cost data, or had to have a market price schedule and existing organization that could accept NORM in drums for legal permanent disposal in a manner approved by regulation. Where appropriate, had to have a permit for each facility.

Additional options for NORM drum disposal have been reported, but without firm cost data and shipping directions they could not be included in this disposal cost study. Table 6 summarizes the real available disposal options for NORM. All NORM disposal options require permitting to meet regulatory approval.

### 3.1 BURIAL SITES

All placement and burial sites will have 10,000-year perpetual care funds along with a detailed record of all parties supplying NORM materials for burial. Should future regulatory changes dictate reopening of the site and remediation of the NORM with costs in excess of the perpetual care fund, then site users could face a share of the cost should the government of the day be unprepared or incapable of meeting the cost. Hence, use of a placement and burial site may have some future unquantifiable financial risk. Individual sites have detailed acceptance criteria. Only specific activity limitations were considered in this study.

### 3.2 SURFACE TREATMENT

A dilution and mixing of low level NORM less than 200 pCi/g with land spreading is available to reduce the NORM concentration below the levels of regulatory concerns of 5 pCi/g. This service would require large areas of land, quantities of material free from NORM, and other organic material to treat the quantities of accumulated NORM. That is to reduce 1,000,000 drums of NORM with an average specific activity of 50 pCi/g to less than 5 pCi/g would require more than 10,000,000 barrels of material with No NORM component.

### 3.3 COMMERCIAL DEEP WELL INJECTION

The processing dilution and deep well injection of NORM offers a reusable well and facility that could provide a cost-effective NORM disposal option. At this time, an acceptance limit of 2,000 pCi/g maximum is in effect. The injected NORM would be permanently placed and, provided geological factors were taken into account and the facilities operated in accordance with the regulations, this

Table 6—Disposal Costs Per Drum of Real Available Disposal Options For NORM

| Options | Type | Radium Acceptance | Disposal Cost Range Per Drum (55 Gallons) | | |
|---|---|---|---|---|---|
| | | | Low | Average | High |
| 1 | Burial | No limit on specific activity. No limit on total activity. | 395 | 515 | 730 |
| | | | Includes: • Disposal • Transportation • User fees • Perpetual care fees | | |
| 2 | Burial | 2,000 pCi/g or less. No limit on total activity. | 300 | 500 | 700 |
| | | | Additional costs: • Radiochemical analysis • Physical properties check • Transportation • Waste profile • Transport vehicle decon. | | |
| 3 | Treatment Dilution NOW (Nonhazardous Oilfield Waste) | 200 pCi/g or less. No limit on total activity. | 100 | 210 | 325 |
| | | | Additional costs: • Transport • Physical properties check • Chemical analysis • EPA/DOT NOW analysis • Packing • Radiochemical analysis | | |
| 4 | Injection Class II well after dilution | 2,000 pCi/g or less No limit on total activity. | 49 | 206 | 1,000 |
| | | | Additional costs: • Transport • Physical check • Chemical analysis • Radiochemical analysis • Packing | | |
| 5 | Recycle to China | No limits. | No cost. Steel purchase value pays for transport to port F.O.B. | | |
| 7 | Encapsulation in tubulars in plug and abandoned wells | No limits. | 792 | 1,081 | 3,333 |
| | | | All inclusive costs from actual reports for oil and gas costs. | | |
| 8,9 | Injection Class II wells, well bores, and geological formations | No limits. | 151 | 916 | 2,300 |
| | | | All inclusive costs from actual reports for oil and gas costs. | | |

Note: Minimum figure forecast to reduce with more competitive services and reusable injection well.

option could provide a local disposal service throughout the oil and gas producing states at a reasonable cost. One commercial injection facility is already in operation, with others likely to be permitted based on geographical density of demand.

## 3.4 RECYCLING OF STEEL

The purchase of NORM contaminated steel for processing and recycling in China represents the most cost effective method to dispose of scrap NORM contaminated steel. However, the environmental controls and the NORM safe work practices at the steel furnaces in China are unknown. While the recycling of high grade NORM contaminated scrap steel is an excellent objective, it represents a potentially significant future liability to users of the service unless strict procedures are used and enforced to protect personnel and the environment from contamination by NORM.

The U.S. steel recycling industry uses highly detailed procedures and sensitive inspection equipment to prevent the accidental smelting of NORM-contaminated steel. Current research work into smelting NORM-contaminated steel will help with the development of procedures to enable the safe recycling of NORM-contaminated steel in the U.S.

## 3.5 NORM RECYCLING INTO SHIELDING BRICKS

A recent industry-wide solicitation was received for the shipment of NORM waste to Russia. The proposed service would provide for the reprocessing of NORM into a brick-like form. The bricks would then be placed into the entombed reactor at Chernobyl where they would become

part of the proposed managed perpetual care fund for 200,000 years. While this technically feasible disposal option awaits detailed costs and claims regulatory approval, it is suggested that an independent risk assessment should be undertaken to determine if other financial, political, and operational factors would attach to the use of this service.

### 3.6 PLUG AND ABANDONMENT OF WELLS, INJECTION, AND ENCAPSULATION

Oilfield operations have developed a number of new techniques based on the disposal of NORM into well bores and geological formations (now being abandoned and plugged with cement). The NORM disposal may be encapsulated in steel tubulars that are placed into the well bore or mixed as a NORM fluid slurry which is then injected into the well bore or into the geological formation. The injection pressure may be sufficiently high to fracture the formation rock and allow very large quantities of NORM to be injected. All plug and abandonment operations with or without NORM disposal are covered by detailed regulatory approval procedures. All states require reporting of the NORM disposal operations.

There are no geographical limitations to oilfield operations disposal, provided the appropriate geological formations are available and the regulations are in effect to permit plug and abandonment disposal. All states with oil and gas condensate production already have these regulations in place.

One commercial project was reported covering the process and injection disposal of NORM into a Class II well which continues in use for other non-NORM Class II materials.

## SECTION 4—COST ESTIMATES FOR EACH DISPOSAL OPTION

The basic costs for each of the nine disposal options were obtained from the questionnaire replies, or from the published price schedules of the commercial facilities, or from telephone inquiries where no published price list was available for a permitted service. All cost data are indicative only, since volume discounts are an acknowledged feature of the waste disposal industry where competing services are available.

Since the questionnaire data is compiled into five regions and the disposal options are also geographically distributed throughout the lower 48 states, a transport cost matrix was developed to estimate the cost of transporting a full load of 80 drums of NORM from each region to each fixed disposal site. Transport estimates (Appendix D) are based on full load, exclusive use, or single load estimates and do not reflect bulk discounts or alternative transport options such as bulk rail shipment.

### 4.1 DISPOSAL OPTIONS REVIEW

#### 4.1.1 Commercial Burial

Permitted low-level radioactive burial sites may be private or publicly owned and operated. For oilfield NORM, the site must have a permanent care fund to provide for inspection, care, and maintenance of the site for 10,000 years. This is approximately seven times the 1,620 year half-life of radium 226, which is the longest half-life isotope found in NORM produced with oil and gas.

The NORM sent to burial sites is carefully characterized for isotope content, chemical composition free of moisture content, and physical characteristics. All companies using the site will receive a certificate of disposal acknowledging the placement of their waste into the facility.

Site acceptance criteria may include limits on the following:

a. Isotope type and concentration (for example, one site up to 2,000 pCi/g radium 226; one site with no limit on concentration of radium 228)
b. Chemical composition
c. Physical form
d. Free liquid content
e. Annual quantities from a single generator
f. Total quantities per year
g. Classes of hazardous materials
h. State NORM site use permit
i. Package in approved container or bulk shipment

Federally permitted facilities allow for the transfer of title (ownership) of NORM material when it meets the acceptance criteria and is accepted for burial. Title ownership transfers to the federal government and all future site management costs are expected to be met from the perpetual care fund established during the site operation.

**4.1.2 Treatment dilution** for NORM materials is permitted by the state of Louisiana. Input materials are limited to 200 pCi/g of total radium. Nonhazardous Oilfield Waste (NOW) mixed with NORM waste is treated by mixing both with clean material until the specific activity is less than 5 pCi/g total radium. The diluted material is then released as an unregulated material that may be reused or disposed of in a permitted landfill, depending on other non-NORM criteria.

Since 90 percent of the NORM is less than 100 pCi/g, this disposal option could accept the bulk of all NORM produced. Treated NORM that is less than 5 pCi/g radium is below regulatory concern; it is no longer considered to be a radioactive material. The volume of clean materials to dilute

the 10 million drums of NORM to less than 100 pCi/g would be very large.

The treatment site has drainage for leachate collection and deep well disposal into permitted Class II wells. The permitting of the disposal wells provides for a performance bond to cover the cost of injection well closure and abandonment. This process has been completed in many other Class II wells over the years and is well proven. Similar acceptance criteria as those for burial may be required and should be obtained from the facility operator.

**4.1.3 Injection disposal** is a recent addition to the range of disposal options for NORM. This service combines the dilution treatment of a non-hazardous oilfield waste (NOW) material and NORM and provides disposal into a Class II injection well.

NORM up to 2,000 pCi/g will be accepted for dilution to 30 pCi/g. The processed fluid will be hydrated and have viscosifiers added to suspend the NORM for injection into the Class II well. The NORM fluids will be injected into deep geological formations below the underground sources of drinking water. Through the dilution step, the NORM is reduced to and is manifested as a NOW material.

Acceptance criteria similar to that for burial may be required. The actual criteria should be obtained from the facility operator.

**4.1.4 Recycling** of NORM-contaminated steel production equipment represents a maximum of 10 percent of the total NORM volume produced. Since this option provides for the purchase of NORM-contaminated steel by the recycler, the small income may cover the transport costs to the extent that shipping provides a zero cost disposal for NORM-contaminated production equipment.

There is no information available on the protection of the workers or the environment at the recyclerís' facility. While the recycling of materials is promoted by international agreements, possible future liabilities should be considered. Title transfer occurs on receipt for shipment. Even where no compliance requirements exist, there may still be a significant liability to protect workers and the environment.

Acceptance criteria are believed to include the supply of components as sealed units to contain all NORM. Minimal or no fluid content is acceptable. There are no limits to dose rates, total activity, or quantity of materials.

**4.1.5 Encapsulation Recycling and Long-Term Storage in Russia.** NORM/NOW waste materials will be recycled into building bricks to be placed on or near the Chernobyl permanent care site as shielding material. The first shipment has been initiated to Russia and no problems have been encountered to date.

Transfer of title to the waste occurs on its acceptance for shipment and in compliance with the shipping manifest.

The acceptance criteria does not limit the specific activity or total activity provided the material meets the EPA/DOT definition of NOW waste. The limit is 10 percent on free liquids. Packaging of NORM in 55 gallon drums to DOT 17E or 17H or other acceptable container is required. Contaminated steel is also accepted.

**3.1.6 Well Bore Encapsulation** in all wells being plugged and abandoned is another disposal option. The NORM is sealed inside tubular goods that are then inserted into the well bore; a cement plug is poured on top of them. The well is then cut off below ground level and abandoned.

There are no limits to total specific activity or quantity. This technique has been proven over many years of use.

The limited volume in each well bore along with the double handling of the tubular goods used for encapsulation makes this option an expensive alternative.

**4.1.7 Injection Into Well Bore Geological Formation** may be undertaken either in association with the plug and abandonment of any well or into a Class II well with suitable geology permitted for this activity.

Injection pressures may be less than the pressure needed to fracture the geological formation or over pressure where hydraulic fracture will break open and maintain injection fractures through the geological formations.

Acceptance criteria need to consider the NORM particle size and fluid rheology for compatibility with the geological formation. There are no limits to the total specific activity or quantity of NORM that can be injected when over pressure injection is used.

## 4.2 COST ESTIMATES

Table 6 discusses the disposal costs (per/drum) of real available disposal options for NORM. The disposal cost data was obtained from the available published rate sheets for services currently available.

The reported actual costs (per/drum) of real available disposal options for NORM in Table 6 lists the NORM disposal options for which disposal cost information was available in 1993. The commercial options 1 through 6 are summarized by locations; radium acceptance criteria, where required; and a range of disposal costs per drum with minimum, average, and maximum costs.

All disposal options have additional acceptance criteria which in some cases may require the following:

a. Radiochemical analysis ($100 to $500 per sample)
b. Chemical metals analysis ($250 to $500 per sample)
c. Pretreatment washing volume reduction ($10 to $25 per drum)
d. Permitting manifesting
e. Generator administration costs
f. Non-NORM waste disposal costs

The extra cost of these analyses and this processing could increase the total disposal cost per drum to equal or considerably exceed the average cost per drum.

Disposal options 7, 8, and 9 for the plug and abandonment of wells reflect the actual experience of the oil industry while disposing of NORM through the placement of NORM into wells either encapsulated in tubular pipes or injected as a slurry into the well bore (and sometimes the geological formations). These options are more fully discussed in Sections 2 and 6. Inclusion of a real cost disposal option does not imply its acceptability or actual recommendation for use for disposal.

Table 7 - Average Accumulated NORM Disposal Cost Range by Specific Activity by Region and U.S. Total. Table 7 shows the minimum and the maximum average cost for transport plus disposal cost/drum for each region. The disposal cost including transportation in cost per drum from Appendix F is followed by the (disposal option number from Table 6) for example, $212. (4) means that the minimum average cost of transport plus disposal is $212/drum for disposal Option 4 from Region 1.

The number of drums are multiplied by the minimum average cost and the maximum average cost per drum to get the minimum average and the maximum average transport plus disposal costs per region after taking specific activity into account.

Based on the actual reported costs and the accumulated

Table 7—Accumulated NORM Disposal Costs Derived Using the Minimum and Maximum Average Costs per Drum

| Specific Activity Region | (0-200) Avg Min | (0-200) Avg Max | (> 200 < 2,000) Avg Min | (> 200 < 2,000) Avg Max | (> 2.000) Avg Min | (> 2.000) Avg Max | Total Drums Min | Total Drums Max |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| (Cost per Drum) (Disposal Option) | 212 (4) | 1,081 (7) | 212 (4) | 1,081 (7) | 306 (6) | 1,081 (7) | | |
| Number of Drums | 272,638 | | 20,744 | | 2,964 | | 286,346 | |
| Cost in Millions | 58 | 295 | 4 | 22 | 1 | 3 | 63 | 320 |
| 2 | | | | | | | | |
| (Cost per Drum) (Disposal Option) | 231 (4) | 1,081 (7) | 231 (4) | 1,081 (7) | 320 (6) | 1,081 (7) | | |
| Number of Drums | 8,400,111 | | 639,139 | | 91,305 | | 9,130,555 | |
| Cost in Millions | 1,940 | 9,080 | 148 | 691 | 29 | 99 | 2,117 | 9,870 |
| 3 | | | | | | | | |
| (Cost per Drum) (Disposal Option) | 231 (4) | 1,081 (7) | 231 (4) | 1,081 (7) | 320 (6) | 1,081 (7) | | |
| Number of Drums | 431,358 | | 32,820 | | 4,689 | | 468,867 | |
| Cost in Millions | 100 | 466 | 8 | 35 | 2 | 5 | 110 | 506 |
| 4 | | | | | | | | |
| (Cost per Drum) (Disposal Option) | 231 (4) | 1,081 (7) | 231 (4) | 1,081 (7) | 306 (6)+ | 1,081 (7) | | |
| Number of Drums | 146,832 | | 11,172 | | 1,596 | | 159,600 | |
| Cost in Millions | 34 | 159 | 3 | 12 | 1 | 2 | 38 | 173 |
| 5 | | | | | | | | |
| (Cost per Drum) (Disposal Option) | 346 (4) | 1,081 (7) | 246 (4) | 1,081 (7) | 320 (6) | 1,081 (7) | | |
| Number of Drums | 1,131 | | 86 | | 12 | | 1,229 | |
| Cost in Millions | 0.391 | 1,222 | 0.211 | 0.093 | 0.004 | 0.013 | 1 | 2 |
| | Average Range of NORM Transport and Disposal for Region 1-5 | | | | | Cost in Millions | $2,329 – $10,871 | |

Minimum $ 2,329 Million
Maximum $10,871 Million

NORM prorated to represent the entire U.S. oil and gas industry and using the assumptions and calculations above, the national cost impact of the implementation and enforcement of NORM regulations as currently in force and proposed on the oil and gas industry for transport and disposal of accumulated NORM is approximately $2.3 billion to $10.9 billion. This cost would be spread over a number of years (for example, 25 years at $92 to $436 million per year).

Table 8 discusses the Actual NORM Disposal Average Cost by Region. The actual norm disposal costs reported on the survey as previously discussed are for the higher specific activity NORM that represents 10 percent of total NORM over 100 pCi/g; the 1992 annual total is $7.12 million for all five regions. This total is for transport and disposal only, and it represents an average cost of $540 per drum. This total is the reported minimum annual cost of NORM disposal for 1992.

Table 9 discusses the Annual NORM Production Disposal Costs Range Using the prorated total annual NORM production figures from Table 3 and the minimum average and maximum average cost figures for transport and disposal

Table 8—Annual 1992 NORM Disposal Costs for NORM Over 100 pCi/g
(10 Percent of Total—Average Cost by Region

| Region | Actual Reported Annual Production Drums (10% of Total) | Actual Reported Average Cost per Drum | Total Cost in Millions |
|---|---|---|---|
| 1. Gulf Coast | 9,444 | 539 | 5.1 |
| 2. Mid-Continent | 1,762 | 545 | 0.96 |
| 3. Rocky Mountain | 1,216 | 543 | 0.66 |
| 4. California | – | – | – |
| 5. Alaska | 753 | 552 | 0.4 |
| Totals | 13,064 Drums | – | $7.12 Million |

Note: No reported NORM disposal in California.

from Appendix F the annual NORM production disposal cost range estimates in Table 9 were calculated. The minimum average cost impact is $40 million, and the maximum average cost impact is $227 million for the transport and disposal of the annual production of NORM.

Table 9—Annual NORM Disposal Cost Range Using Minimum and Maximum Average Costs per Drum

| Specific Activity Region | (0-200) 92% Min | (0-200) 92% Max | (> 200 < 2,000) 7% Min | (> 200 < 2,000) 7% Max | (> 2.000) 1% Min | (> 2.000) 1% Max | Total Drums Min | Total Drums Max |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| (Cost per Drum) (Disposal Option) | 212 (4) | 1,081 (7) | 212 (2) | 1,081 (7) | 306 (6) | 1,081 (7) | | |
| Number of Drums | 86,885 | | 6,611 | | 944 | | 94,440 | |
| Cost in Millions | 18.42 | 93.92 | 14.03 | 7.15 | 0.29 | 1.02 | 33 | 102 |
| 2 | | | | | | | | |
| (Cost per Drum) (Disposal Option) | 231 (4) | 1,081 (7) | 74 (4) | 3,333 (7) | 151 (6) | 3,333 (7) | | |
| Number of Drums | 16,210 | | 1,233 | | 176 | | 17,620 | |
| Cost in Millions | 3.74 | 17.52 | 0.09 | 4.11 | 0.06 | 0.20 | 4 | 22 |
| 3 | | | | | | | | |
| (Cost per Drum) (Disposal Option) | 74 (4) | 3,333 (7) | 74 (4) | 3,333 (7) | 151 (8) | 3,333 (7) | | |
| Number of Drums | 11,187 | | 851 | | 122 | | 12,160 | |
| Cost in Millions | .83 | 37.29 | 0.06 | 2.84 | 0.02 | 0.41 | 1 | 37 |
| 4 | | | | | | | | |
| (Cost per Drum) (Disposal Option) | 74 (4) | 3,333 (7) | 74 (4) | 3,333 (7) | 151 (8) | 3,333 (7) | | |
| Number of Drums | 10,108 | | 745 | | 106 | | 10,640 | |
| Cost in Millions | 0.75 | 33.69 | 0.06 | 2.48 | 0.02 | 0.35 | 1 | 37 |
| 5 | | | | | | | | |
| (Cost per Drum) (Disposal Option) | 74 (4) | 3,333 (7) | 89 (4) | 3,333 (7) | 151 (8) | 3,333 (7) | | |
| Number of Drums | 6,928 | | 527 | | 75 | | 7530 | |
| Cost in Millions | 1.51 | 23.09 | 0.05 | 1.76 | 0.01 | 0.25 | 1 | 25 |
| | Range of NORM Transport and Disposal for Regions 1-5 | | | | | Cost in Millions | $40 | $227 |

Minimum $ 40 Million
Maximum $227 Million$

# SECTION 5—INDUSTRY WIDE DISPOSAL COST IMPACT

## 5.1 ACCUMULATED NORM

The volume of NORM accumulated and produced on an annual basis together with its transport and disposal costs were derived from questionnaire responses representing 46 percent of the domestic U.S. oil, gas, and gas condensate production.

Some 10 million drums of accumulated NORM were produced by December 1993 in the oil and gas producing states. The Region 1 Gulf Coast states figure of 296,000 drums would cost an average of $63 million to $320 million to transport and dispose of to one or more of the nine real disposal options available in 1993. These significant costs do not include the costs to survey, sample, remediate, and place the NORM into drums or containers ready for disposal. The cost impact to develop, implement, and manage programs for compliance with NORM regulations will represent an additional significant cost that could double the real NORM transport and disposal costs documented in this publication.

Table 7 summarizes the cost impact for transport and disposal of accumulated NORM for the 5 specific regions. With the addition of the other costs mentioned above, it is probable that the total costs to the oil and gas industry in current dollars to implement NORM programs to meet proposed and actual NORM regulations to remediate tubulars, equipment, and sites, then to transport and dispose of the accumulated NORM produced to the end of 1993, would be approximately $2.3 to $10.9 billion dollars. The lower figure is probably more realistic due to the potential for volume discounts on transport and disposal along with the economics of scale represented by the large volume of 10 million drums for which remediation may be required. This cost would be distributed over many years as producing fields were shut down and abandoned.

The large discrepancy among regions in the reported volumes of accumulated NORM versus their production volume can be partially accounted for by one or more of the following factors:

a. The actual amount of NORM produced in each region.
b. The age of the oil fields in each region.
c. The duration and volume of the productive operations.
d. The production technology for dealing with produced water and accompanying solids, for example, surface treatment or re-injection.
e. The extent of NORM surveying completed.
f. The need for regulatory compliance and accurate reporting.

NOTE: The Gulf Coast, Region 1, has the most widespread NORM regulations.

## 5.2 ANNUAL NORM PRODUCTION

The survey replies provided the 1993 estimates of the annual NORM production rate. The most commonly used NORM survey criteria was the external dose rate of 50 microR/h measured on the outside surface of the component containing the NORM. As previously discussed, this external dose rate indicates NORM specific activity greater than 100 pCi/g. Figure 2 illustrated that 90 percent of the NORM was less than 100 pCi/g; hence, the reported annual production rate, after correction for 100 percent production volumes, is multiplied by 10 to compute the total annual NORM production figure for all specific activities of 142,000 drums per year. Other studies argue [3] that this annually produced volume estimate of NORM is low by an order of magnitude.

By taking the minimum average cost disposal options available to each region, the minimum total annual transportation and disposal cost from Table 9 is. $40 million. A worst-case scenario using the maximum average NORM transport and disposal costs results in a maximum total NORM disposal cost of $227 million per year.

When tallying the additional costs of survey, sampling, analysis, remediation, and containerization of the annual NORM production, the minimum average NORM transport and disposal cost of $40 million could double to $80 million..

## 5.3 SUMMARY OF NORM TRANSPORT DISPOSAL COST IMPACT BY REGION

| Region | Accumulated | | Annual | |
|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum |
| | Cost in Millions | | Cost in Millions | |
| 1 | 63 | 320 | 33 | 102 |
| 2 | 2,117 | 9,870 | 4 | 22 |
| 3 | 110 | 506 | 1 | 41 |
| 4 | 38 | 173 | 1 | 37 |
| 5 | 1 | 2 | 1 | 25 |
| **Total Cost In Millions** | **$2,329** | **$10,871** | **$40** | **$227** |

**5.3.1 Region 1—The Gulf Coast** data at the time of the survey in 1992-93 is more reliable since it was derived from replies from companies representing 44 percent of the annual production of oil and gas condensate in that region. In addition, NORM management and survey programs to meet regulatory requirements in Louisiana, Mississippi, and Texas were being introduced at that time.

**5.3.2 Region 2—The Mid Continent** data figures depict responses from companies representing 20 percent of

the total annual oil and gas condensate production in that region. This data includes two reports of very large NORM accumulations. One report covers accumulations of NORM within produced water pits and ponds in a major production system; the other reports NORM sludge and site contamination. These two reports have been confirmed as representative of the historical NORM accumulations over many years in this region. Appendix G shows the source of the majority of NORM accumulated as coming from sludge located on sites or in produced water ponds or pits.

**5.3.3 Region 3—The Rocky Mountain** data represents only 13 percent of the total production of this region and is also heavily biased by one report of NORM accumulations in surface pits. This reply was checked with the responding company and confirmed to be accurate of their NORM accumulation experience.

**5.3.4 Region 4—The California** data did not report the detection of any NORM 1993. Surverys in 1995 by the California Department of Health Radiological Health Section have detected NORM. The NORM estimates for both accumulated NORM and the annual production were calculated from the results reported for Region 2 and corrected for the differences in total production of oil and gas condensate between Regions 2 and 4. This assumption is thought to be reasonably consistent with early verbal reports of the state NORM survey results.

**5.3.5 Region 5—The Alaska** data represents 100 percent of the production and is highly reliable. Because the Alaskan oil and gas production has re-injected the produced water since the start of operations, the majority of NORM has returned. Scale inhibitor management programs continue to ensure that the volume of NORM produced is minimized. This means that other production factors such as increased water production, well corrosion, pressure loss, and so on, control the need to repair production wells rather than deal with NORM scale formation.

## 5.4 CONCLUSION

- The actual cost to dispose of NORM from the U.S. oil and gas industry in 1992 was $7.12 million. This data was primarily from the Gulf Coast information (Region 1) in the study.
- The cost to the entire U.S. oil and gas industry to transport and dispose of the 142,000 drums of NORM produced annually based on current and proposed regulations is approximately $40 to $227 million per year.
- The cost to remediate the 10,000,000 drums of NORM accumulated over many years of production is approximately $2.3 to $10.9 billion.

Note: This cost would be spread over many years and would be related to the life of each producing field and the time for preparation for abandonment.

- No questionnaire replies included NORM from gas production, although it is known to exist and represents a potentially significant cost.
- NORM is not produced in every oil and gas producing well in the U.S. The large variations in the occurrence and production of NORM both in any one field and from field to field make it an issue that requires regulation by the individual States.

# APPENDICES

## INTRODUCTION—ASSUMPTIONS FOR DISPOSAL ANALYSIS

1. Each responding company surveyed all business units within their organization.

2. The oil and gas condensate production figures from the questionnaires sections 1.6.1 were cross-checked with the Dwight Energydata Services, Inc.[7] computer database for each region and the Dwight's figures were used in cases of conflict. This method enabled more accurate production figures to be derived for each reply. The Oil and Gas Journal [5,6] daily oil and gas condensate production in 000 bpd from June 30, 1993, and December 31, 1993, were averaged to give the 1993 daily production figure used in this document.

3. Grouping replies into 5 regions of interest required some revision of the oil and gas condensate production totals to reflect the reported percentages by region for each reply.

4. Replies 102, 120, and 148 (referenced in Appendix C) were not used to calculate disposal cost per drum in Appendix F because of extraordinary uncontrollable costs associated with the disposal well problems.

5. Drums referenced are 55 gallons of 7.35 ft3.

6. NORM volumes per tubular goods were calculated using a scale thickness of 0.25 inches over the inner surface of each tubular good to give equivalent drums.

7. Total accumulations of stored NORM were obtained by adding sections 1.1.1 + 1.2.1 + 1.3.1 + 1.4.1 + 1.5 + 1.7.1 + 1.8.1.

8. "P" and "A" means "plug and abandon"—this is an oilfield term that means injecting concrete and taking other precautions required by regulations to make a well safe for abandonment.

9. Cost analysis sections 3.1 in Appendices A and B indicate:

a. Plug and abandonment of well with NORM injected as a fluid suspension.
b. Plug and abandonment of well with NORM encapsulated in sealed tubular goods and placed into the well.
c. Plug and abandonment of well with NORM injected as a fluid suspension and the well is held available for additional NORM disposal operations.
d. Transport estimates based on 80 drums of NORM per load for full load exclusive use vehicle.

10.Annual reported NORM generation rate is based on 50 microR/h on the external surfaces of steel components. This external dose rate represents a specific activity over 100 picoCuries/g. Since only 10% of NORM reported in the survey replies is over 100 pCi/g the annual figure must be multiplied by 10 to get the true annual NORM production rate.

# APPENDIX A—SAMPLE OF NORM DISPOSAL COST SURVEY QUESTIONNAIRE

Company _____ 2. Contact Name _____

Operating Area _____ Job Title _____

_____ Phone _____

Section 1.0 NORM from Oil and Gas Production

Note: All dose rate readings in microRem/hr (mR/hr), including background)

1.1 Solid NORM Wastes in Storage (Scale and Sludge from Oil and Gas Production

1.1.1 Solid Wastes (scale, sludges, etc.) 600 drums

Other Solid Wastes (please describe) _____ drums

| Radium concentrations (pCi/gram) (if known) | | | Surface Dose Rates (mR/hr) | |
|---|---|---|---|---|
| % < 5 | _____ | % | 15 | % (25-50) |
| 5 < % < 30 | _____ | % | 8 | % (50-100) |
| 30 < % < 200 | _____ | % | 60 | % (100-500) |
| 200 < % < 1000 | _____ | % | 8 | % (500-1000) |
| % > 1000 | _____ | % | 9 | % (> 1000) |

1.1.2 Approximate Geographic Distribution

| State | Region (North N. South S. OCS/Offshore O) | Percent |
|---|---|---|
| LA | LA–G | 10 |
| | LA–OCS/Offshore | 90 |

Comments: _____

1.2 NORM Contaminated Tubular Goods in storage (Tubulars, Sucker Rods, Flow Lines)

1.2.1 Total Length in Feet 15,000' 34' x 0.0315 drums/jt = 14 drums

Approximate Percentage Distribution by Size

| | | |
|---|---|---|
| Less than 2" | _____ | % |
| 2-3" | 100 | % |
| Larger than 3" | _____ | % |

| Radium concentrations (pCi/gram) (if known) | | | Surface Dose Rates (mR/hr) | |
|---|---|---|---|---|
| % < 5 | _____ | % | _____ | % (25-50) |
| 5 < % < 30 | _____ | % | 50 | % (50-100) |
| 30 < % < 200 | _____ | % | 50 | % (100-500) |
| 200 < % < 1000 | _____ | % | _____ | % (500-1000) |
| % > 1000 | _____ | % | _____ | % (> 1000) |

1.2.2 Approximate Geographic Distribution

| State | Region (See section 1.1.2 | Percent |
|---|---|---|
| LA | LA–G | 100 |

Comments: _____

# APPENDIX A—CONTINUED

1.3 NORM Contaminated Stored Vessels, Tanks, Treaters, Etc. (Out-of-Service, In storage)

| 1.3.1 Approximate Number of Items | Separators | Treaters | Tanks | Other | Estimated Total NORM Volume* (After decontamination) |
|---|---|---|---|---|---|
| 0 # | 0 # | 0 # | 0 # | 0 # | 0 drums |

| Radium Concentrations (pCi/gram) (if known) | | | Surface Dose Rates | (mR/hr) |
|---|---|---|---|---|
| % < 5 | | % | | % (25-50) |
| 5 < % < 30 | | % | | % (50-100) |
| 30 < % < 200 | | % | | % (100-500) |
| 200 < % < 1000 | | % | | % (500-1000) |
| % > 1000 | | % | | % (> 1000) |

1.3.2 Approximate Geographic Distribution of the Contaminated Equipment

| State | Region (See section 1.1.2) | Percent |
|---|---|---|

Comments: None

1.4 NORM Contaminated Processing Facilities, Tank Batteries, Well Pads Estimated Volume of Contaminated Soil (In Service and Out of Service on Location)

| 1.4.1 Estimated Number of Facilities | Estimated Total NORM Volume* |
|---|---|
| 30 | 3200 drums |

| Radium Concentrations Estimate (pCi/gram) | | | Surface Dose Rates | (mR/hr) |
|---|---|---|---|---|
| % < 5 | | % | 60 | % (25-50) |
| 5 < % < 30 | 80 | % | 20 | % (50-100) |
| 30 < % < 200 | 20 | % | 20 | % (100-500) |
| 200 < % < 1000 | | % | | % (500-1000) |
| % > 1000 | | % | | % (> 1000) |

1.4.2 Approximate Geographic Distribution of Facilities

| State | Region (See section 1.1.2) | Percent |
|---|---|---|
| LA | LA–G | 80 |
| | LA–OCS/Offshore | 20 |

Comments:

1.5 Estimated total Number of NORM Contaminated Items Generated in 1992

| | Solid Wastes | Tubing | Equipment | Other Accumulations |
|---|---|---|---|---|
| Estimated Total | 740 drums | 9,000 feet | 4 number | — drums |

= 749 drums

Comments:

*Further described in the instruction letter.

# APPENDIX A—CONTINUED

| 1.6 Well Production Data | 1992 Oilwells | 1992 Gaswells | 1993 (estimate) Oilwells | 1993 (estimate) Gaswells |
|---|---|---|---|---|
| 1.6.1 Total Number of Wells | | | | |
| Number of wells in production | | | | |
| Total Annual production for: (state units used) | | | | |
| Oil ( ) | | | | |
| Water ( ) | | | | |
| Gas ( ) | | | | |
| Condensate ( ) | | | | |

1.6.2 Approximate Geographic Distribution

| State | Region (See section 1.1.2) | Percent |
|---|---|---|
| LA | LA–G | 25 |
| LA | LA–OSC/Offshore | 75 |

Comments:

1.7 Produced Water Ponds, Pits, Etc., (in Service)

| | 1992 | |
|---|---|---|
| 1.7.1 Number | 3 | |
| Average Area ($ft^2$) | 25,000 | |
| Estimated Sludge Depth (ft) | 6 | |
| Average Years in Service | 35 | |
| Average Inflow Bpd | 25,000 | |
| Percent Checked for NORM | 100 | |
| Percent of Pits Checked Found with NORM | 67% | > 5 pCi/gm but < 30 pCi/gm |
| Estimated NORM Contents | 0 | |
| Estimated Total Drums of NORM Contaminated Soil & Sludge | 0 | |

1.7.2 Approximate Geographic Distribution

| State | Region (See section 1.1.2 | Percent |
|---|---|---|
| LA | LA–G | 100 |

Comments: Above numbers do not include out-of-service pits

1.7 P & A (Plug and Abandonment) Program

| | 1992 | 1993 (estimate) |
|---|---|---|
| 1.7.1 Number of Wells P & A's | 4 | 21 |
| Number of Wells P & A'd with NORM Tubulars in Place | | 6 |
| Number of Wells P & A'd Used for Disposal of NORM Solids | | 17 |
| Number of Drums NORM Disposed by P & A | | 1,400 |

1.7.2 Approximate Geographic Distribution

| State | Region (See section 1.1.2) | Percent |
|---|---|---|
| LA | LA–G | 40 |
| LA | LA–OCS/Offshore | 60 |

Comments:

# APPENDIX A—CONTINUED

Section 2.0 NORM From Gas Plant Operations

2.1 Solid NPRM Wastes in Storage (Gas Processing)

2.1.1 Lead–210 Scales and Sludge from Gas Processing _____ drums

Other Solid Wastes (please describe) _____ drums

Lead–210 Concentration (pCi/Gram) (if known)

% < 150 _____ %

% > 150 _____ %

2.1.2 Approximate Geographic Distribution

| State | Region (North N. South S. OCS/Offshore O) | Percent |
|---|---|---|
| LA | LA–G & LA–OCS/Offshore | |

Comments: N/A for this region.

2.2 NORM Contaminated Stored Vessels, Tanks, Equipment, Etc. (Out-of-Service, In Storage)

2.2.1 Approximate Number of Items

| # | Pumps | Filters | Other | Tanks | Approximate Volume of NORM |
|---|---|---|---|---|---|
| _____ | _____ | _____ | _____ | _____ | _____ |

Lead–210 Concentration (pCi/gram) (if known)

% < 5 _____ %

5 < % < 30 _____ %

Average Interior Surface Dose Rates (mR/hr)

_____ % (25-50)

_____ % (50-100)

_____ % (100-500)

2.1.2 Approximate Geographic Distribution

| State | Region (North N. South S. OCS/Offshore O) | Percent |
|---|---|---|

Comments: _____

# APPENDIX A—CONTINUED

2.3 NORM Contaminated Gas Processing Plants (In Service and Out-of-Service on Location)

2.3.1 Approximate Number of Facilities _____

% Checked for NORM _____ %

Average Exterior Surface Dose Rates (mR/hr)

_____ % (25-50)
_____ % (50-100)
_____ % (100-500)
_____ % (> 500)

2.3.2 Approximate Geograhic Distribution

State Region (North N. South S. OCS/Offshore) Percent

2.4 Estimated NORM (Lead–210) Contaminated Items Generated in 1992

| | Solid Wastes | Piping | | Equipment | | Other Accumulations |
|---|---|---|---|---|---|---|
| Estimated Total Drums | _____ | _____ | Feet | _____ | Number | _____ Drums |

Comments: _____

# APPENDIX A—CONTINUED

Section 3.0 NORM Disposal Job Program Costs

3.1 Typical NORM Disposal Job

Job Description: Dispose of NORM Slurry in P & A wells typical job

Duration: 20 Days

NORM Disposal: 550 Drums State: _____ Region: OCS

| Breakdown of Services Included | (Y) | (N) | ($0000) | and/or | Cost as Percent of Total |
|---|---|---|---|---|---|
| Decon Tubulars | ( ) | (ū) | | | |
| Decon Equipment | (ū) | ( ) | | | |
| Decon Site | ( ) | (ū) | | | |
| NORM Transportation | (ū) | ( ) | | | |
| NORM Storage Company | ( ) | (ū) | | | |
| Disposal Downhole (P & A) | (ū) | ( ) | | | |
| Disposal On Site | ( ) | (ū) | | | |
| Disposal Commercial | ( ) | (ū) | | | |
| Sample Analysis | (ū) | ( ) | | | |
| Other Add Description: | | | | | |
| Rig Up Equipment | (ū) | ( ) | | | |
| | ( ) | ( ) | | | |
| Total | | | $ | | 100% |

3.2 NORM Program Regulatory Training Activities

Per Annum 1991 ? 1992 ? 1993 35

Comments: 1991 and 1992 NORM training was conducted "in-house;" Not able to trace costs. 1993 training was conducted by consultants.

Note Please photocopy this sheet and complete one of each typical job.

# APPENDIX B—SAMPLES OF NORM DISPOSAL JOB/PROGRAM COSTS

Section 3.0 NORM Disposal Job/Program Costs

3.1 Typical NORM Disposal Job

Job Description: _____

_____

Duration: _____ Days

NORM Disposal: _____ Drums State: _____ Region: _____

| Breakdown of Services Included | (Y) | (N) | ($0000) | and/or | Cost as Percent of Total |
|---|---|---|---|---|---|
| Decon Tubulars | ( ) | ( ) | _____ | | _____ |
| Decon Equipment | ( ) | ( ) | _____ | | _____ |
| Decon Site | ( ) | ( ) | _____ | | _____ |
| NORM Transportation | ( ) | ( ) | _____ | | _____ |
| NORM Storage Company | ( ) | ( ) | _____ | | _____ |
| Disposal Downhole (P & A) | ( ) | ( ) | _____ | | _____ |
| Disposal On Site | ( ) | ( ) | _____ | | _____ |
| Disposal Commercial | ( ) | ( ) | _____ | | _____ |
| Sample Analysis | ( ) | ( ) | _____ | | _____ |
| Other Add Description | | | _____ | | _____ |
| _____ | ( ) | ( ) | _____ | | _____ |
| _____ | ( ) | ( ) | _____ | | _____ |
| | | Total | $ _____ | | _____ 100% |

3.2 NORM Program Regulatory Training Activities

Per Annum 1991 _____ 1992 _____ 1993 _____

Comments: _____

_____

_____

Note: Please photocopy this sheet and complete one of each typical job.

# APPENDIX B—CONTINUED

Section 3.0 NORM Disposal Job/Program Costs

3.1 Typical NORM Disposal Job

Job Description: Sand sludge generated offshore processed for reuse as landfill cover.

Duration: 1 Days

NORM Disposal: 4 Drums State: LA Region 1

| Breakdown of Services Included | (Y) | (N) | ($0000) | and/or | Cost as Percent of Total |
|---|---|---|---|---|---|
| Decon Tubulars | ( ) | (ū) | | | |
| Decon Equipment | ( ) | (ū) | | | |
| Decon Site | ( ) | (ū) | | | |
| NORM Transportation | (ū) | ( ) | 0.1675 | | 50 |
| NORM Storage Company | ( ) | (ū) | | | |
| Disposal Downhole (P & A) | ( ) | (ū) | | | |
| Disposal On Site | ( ) | (ū) | | | |
| Disposal Commercial | ( ) | (ū) | | | |
| Sample Analysis | ( ) | ( ) | | | |
| Other Add Description: | | | | | |
| Now Land Spreading | (ū) | ( ) | 0.1675 | | 50 |
| | ( ) | ( ) | | | |
| | | Total | $0.335 | | 100 100% |

3.2 NORM Program Regulatory Training Activities

Per Annum 1991 - 1992 - 1993 -

Comments:

Note: Please photocopy this sheet and complete one of each typical job.

# APPENDIX B—CONTINUED

Section 3.0 NORM Disposal Job/Program Costs

3.1 Typical NORM Disposal Job

Job Description: Shell production pad (I.e., Soil)

Duration: 41 Days

NORM Disposal: 215 Drums State: LA Region 5

| Breakdown of Services Included | (Y) | (N) | ($0000) | and/or | Cost as Percent of Total |
|---|---|---|---|---|---|
| Decon Tubulars | ( ) | (ũ) | | | |
| Decon Equipment | (ũ) | ( ) | 162,500 | | 25 |
| Decon Site | (ũ) | ( ) | 325,000 | | 50 |
| NORM Transportation | ( ) | (ũ) | | | |
| NORM Storage Company | ( ) | (ũ) | | | |
| Disposal Downhole (P & A) | (ũ) | ( ) | 10,000 | | 1.5 |
| Disposal On Site | (ũ) | ( ) | | | |
| Disposal Commercial | ( ) | (ũ) | | | |
| Sample Analysis | (ũ) | ( ) | 52,500 | | 8 |
| Other Add Description: | | | | | |
| Work Done in Remote Location | ( ) | ( ) | | | |
| Housing, Per Diem | ( ) | ( ) | | | |
| | | Total | $650,000 | | 100% |

3.2 NORM Program Regulatory Training Activities

Per Annum 1991 1992 1993

Comments:

Note: Please photocopy this sheet and complete one of each typical job.

# APPENDIX B—CONTINUED

Section 3.0 NORM Disposal Job/Program Costs

3.1 Typical NORM Disposal Job

Job Description: Dispose of NORM slurry in P & A wells.
Typical job.

Duration: 20 Days

NORM Disposal: 550 Drums State: _____ Region OCS

| Breakdown of Services Included | (Y) | (N) | ($0000) | and/or | Cost as Percent of Total |
|---|---|---|---|---|---|
| Decon Tubulars | ( ) | (ū) | | | |
| Decon Equipment | (ū) | ( ) | 60 | | 21.5 |
| Decon Site | ( ) | (ū) | | | |
| NORM Transportation | (ū) | ( ) | 40 | | 14.3 |
| NORM Storage Company | ( ) | (ū) | | | |
| Disposal Downhole (P & A) | (ū) | ( ) | 145 | | 51.8 |
| Disposal On Site | ( ) | (ū) | | | |
| Disposal Commercial | ( ) | (ū) | | | |
| Sample Analysis | (ū) | ( ) | 10 | | 3.6 |
| Other Add Description: | | | | | |
| Rig Up Equipment | (ū) | ( ) | 25 | | 8.9 |
| | ( ) | ( ) | | | |
| Total | | | $280 | | 100.0 100% |

3.2 NORM Program Regulatory Training Activities

Per Annum 1991 ? 1992 ? 1993 35

Comments: 1991 and 1992 NORM training was conducted 'in-house." Not able to trace costs. 1993 training was conducted by consultants

Note: Please photocopy this sheet and complete one of each typical job.

# APPENDIX B—CONTINUED

Section 3.0 NORM Disposal Job/Program Costs

3.1 Typical NORM Disposal Job

Job Description: NORM scale/sludge disposal in P & A well.

Duration: 20 Days

NORM Disposal: 400 Drums State: LA Region S

| Breakdown of Services Included | (Y) | (N) | ($0000) | and/or | Cost as Percent of Total |
|---|---|---|---|---|---|
| Decon Tubulars | ( ) | (ũ) | | | |
| Decon Equipment | (ũ) | ( ) | 20 | | 13 |
| Decon Site | ( ) | ( ) | | | |
| NORM Transportation | (ũ) | ( ) | 10 | | 7 |
| NORM Storage Company | ( ) | (ũ) | | | |
| Disposal Downhole (P & A) | (ũ) | ( ) | 120 | | 80 |
| Disposal On Site | ( ) | (ũ) | | | |
| Disposal Commercial | ( ) | (ũ) | | | |
| Sample Analysis | ( ) | (ũ) | | | |
| Other Add Description: | | | | | |
| | (ũ) | ( ) | | | |
| | ( ) | ( ) | | | |
| Total | | | $150 | | 100 100% |

3.2 NORM Program Regulatory Training Activities

Per Annum 1991 - 1992 10,000 1993 40.000

Comments:

Note: Please photocopy this sheet and complete one of each typical job.

# APPENDIX B—CONTINUED

Section 3.0 NORM Disposal Job/Program Costs

3.1 Typical NORM Disposal Job–1993

Job Description: Decontamination of production equipment, encapsulate in 7 5/8" casing, run into P & A well.

Duration: 6 Days

NORM Disposal: 32.5 Drums State: OCS Region S

| Breakdown of Services Included | (Y) | (N) | ($0000) | and/or | Cost as Percent of Total |
|---|---|---|---|---|---|
| Decon Tubulars | ( ) | (ü) | | | |
| Decon Equipment | (ü) | ( ) | 2,800 | | |
| Decon Site | ( ) | (ü) | | | |
| NORM Transportation | ( ) | (ü) | | | |
| NORM Storage Company | ( ) | (ü) | | | |
| Disposal Downhole (P & A) | (ü) | ( ) | 15,500 | | |
| Disposal On Site | ( ) | (ü) | | | |
| Disposal Commercial | ( ) | (ü) | | | |
| Sample Analysis | ( ) | (ü) | | | |
| Other Add Description: | | | | | |
| Encapsulate | (ü) | ( ) | 7,500 | | |
| | ( ) | ( ) | | | |
| Total | | | $25,800 | | 100% |

3.2 NORM Program Regulatory Training Activities

Per Annum 1991 - 1992 - 1993 $5,000

Comments: These are actual cost for disposal job in 1993

Note: Please photocopy this sheet and complete one of each typical job.

# APPENDIX B—CONTINUED

Section 3.0 NORM Disposal Job/Program Costs

3.1 Typical NORM Disposal Job–1992

Job Description: Decontamination of production equipment, slurry and pump down of NORM into P & A well.

Duration: 15 Days

NORM Disposal: 36 Drums State: OCS Region 1

| Breakdown of Services Included | (Y) | (N) | ($0000) | and/or | Cost as Percent of Total |
|---|---|---|---|---|---|
| Decon Tubulars | (ü) | ( ) | 4,200 | | 3.9 |
| Decon Equipment | (ü) | ( ) | 19,300 | | 18.0 |
| Decon Site | ( ) | (ü) | | | |
| NORM Transportation | (ü) | ( ) | 4,200 | | 3.9 |
| NORM Storage Company | ( ) | (ü) | | | |
| Disposal Downhole (P & A) | (ü) | ( ) | 79,300 | | 74.2 |
| Disposal On Site | ( ) | (ü) | | | |
| Disposal Commercial | ( ) | (ü) | | | |
| Sample Analysis | ( ) | (ü) | | | |
| Other Add Description: | | | | | |
| | ( ) | ( ) | | | |
| | ( ) | ( ) | | | |
| Total | | | $107,000 | | 100% |

3.2 NORM Program Regulatory Training Activities

Per Annum 1991 - 1992 $5,000 1993 -

Comments: This is the actual job done in 1992. The slurry and pump was performed on the offshore platform.

Note: Please photocopy this sheet and complete one of each typical job.

# APPENDIX C—NORM DISPOSAL COST STUDY QUESTIONNAIRE REPLIES REGION 1

| Section/Sub | 1/1.1.1 | 1/1.1.1 | 1/1.2.1 | 1/1.2.1 | 1/1.3.1 | 1/1.3.1 | 1/1.4.1 | 1/1.4.1 | 1/1.5 | 1/1.6.1 | 1/1.6.1 | 1/1.7.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reply Reference | Drums | Avg uR/h Dose Rates | Tubular Drums Equiv | Avg uR/h Dose Rates | Estimate Drums | Avg uR/h Dose Rates | Facilities/ Drums | Avg uR/h Dose Rates | 1992 Forecast Drums | Oil Prod 000 BPD | Condensate 000 BPD | Pits/Drums |
| 101 | 10 | 1,000 | 24 | 500 | 30 | 300 | 0 | 0 | 19 | 13 | 4 | 0/0 |
| 102 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 1 | 0/0 |
| 102 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 103 | 315 | 100 | 0 | 0 | 100 | 100 | 4/1,000 | 100 | 270 | 5 | 8 | 0/0 |
| 105 | 600 | 500 | 0 | 0 | 0 | 0 | 1/1,000 | 200 | 300 | 8 | 3 | 0/0 |
| 107 | No | Data | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 110 | No | Data | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 112 | 800 | 500 | 14 | 250 | 0 | 0 | 32/3,200 | 50 | 750 | 202 | 15 | 3/0 |
| 113 | 38 | 100 | 0 | 0 | 0 | 0 | 2/10 | 100 | 50 | 1 | 1 | 0/0 |
| 114 | No | Data | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 115 | 153 | 100 | 119 | 50 | 10 | 50 | 7/100 | 50 | 196 | 44 | 0 | 0/0 |
| 116 | No | Data | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 117 | 13 | 250 | 1 | 100 | 2 | 50 | 14/88 | 100 | 15 | 2 | 1 | 3/0 |
| 118 | 3,200 | 500 | 51 | 0 | 30 | 0 | 7/4,000 | 500 | 404 | 113 | 0 | 0/0 |
| 119 | 7,000 | 500 | 0 | 0 | 0 | 0 | 44/5,000 | 500 | 1,000 | 71 | 11 | 0/0 |
| 120 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0/0 |
| 120 | Cost | Data | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 120 | Cost | Data | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 120 | Cost | Data | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 121 | 90 | 100 | 10 | 50 | 90 | 0 | 30/0 | 25 | 0 | 3 | 1 | - |
| 124 | 32 | 1,000 | 5 | 100 | 41 | 250 | 18/0 | 250 | 31 | 35 | 2 | 0/0 |
| 124 | Cost | Data | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 124 | Cost | Data | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 129 | 4 | 750 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0/0 |
| 130 | No | Data | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 136 | 580 | 250 | 188 | 500 | 150 | 250 | 150/150 | 250 | 283 | 73 | 6 | 0/0 |
| 140 | 40 | 250 | 0 | 0 | 0 | 0 | 17/50 | 100 | 100 | 19 | 6 | 0/0 |
| 140 | Cost | Data | 0 | 0 | 0 | 0 | 0/0 | 0 | - | 0 | 0 | 0/0 |
| 141 | 25 | 500 | 0 | 0 | 0 | 0 | 3/10 | 250 | 3 | 34 | 12 | 0/0 |
| 142 | 4 | 500 | 0 | 0 | 2 | 100 | 2/4 | 100 | 4 | 7 | 2 | 0/0 |
| 146 | 530 | 250 | 234 | 100 | 400 | 100 | 8,000/8,000 | 100 | 143 | 43 | 16 | 700/12,000 |
| 147 | 3 | 250 | 7 | 100 | 4 | 250 | 6/40 | 250 | 36 | 6 | 7 | 0/0 |
| 147 | Cost | Data | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 |
| 148 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 1 | 0/0 |
| 149 | 43 | 500 | 441 | 500 | 0 | 0 | 0 | 0 | 500 | 147 | 9 | 0/0 |
| Totals | 13,280 | | 1,151 | | 859 | | 8,300/94,630 | | 4,106 | 655 | 116 | 706/12,000 |

# APPENDIX C—CONTINUED

| Section/Sub | 1/1.8.1 | 2/2.3.1 | 2/2.4 | 3/3.1 | 3/3.1 | 3/3.1 | 3/3.2 Training (0008) | | | A | | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reply Reference | P & A Wells Well Drums | Checked # Facilities | Estimate Drums | Summary Description | Drums | Cost (000$) | 91 | 92 | 93 | Calculated Cost per Drum | | Total Accumulated Drums Drums |
| 101 | 65/40 | 1 | 0 | 0 | 0 | 0 | 5 | 5 | 5 | 0 | | 123 |
| 102 | 0/0 | 0 | 0 | P & A Injection | 2 | 30 | - | - | - | 15,000 | • Blending Problems | 0 |
| 102 | 0/0 | 0 | 0 | Land | 2 | 0 | 0 | 0 | 0 | 167 | | 0 |
| 103 | 1/2 | 0 | 0 | P & A (1) | 215 | 102 | 0 | 0 | 0 | 474 | | 1,687 |
| 105 | 3/600 | 0 | 0 | P & A (1) Injection | 900 | 1,600 | 0 | 3 | 3 | 1,700 | | 1,901 |
| 107 | 0/0 | 0 | 0 | No Data | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 110 | 0/0 | 0 | 0 | No Data | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 112 | 17/1,400 | 0 | 0 | P & A (1) Injection | 550 | 280 | 0 | 0 | 35 | 509 | | 5,964 |
| 113 | 0/0 | 0 | 0 | No Data | 0 | 0 | 0 | 0 | 2 | 0 | | 98 |
| 114 | 0/0 | 0 | 0 | No Data | 0 | 0 | 1 | 2 | 2 | 0 | | 580 |
| 115 | 0/0 | 0 | 0 | No Data | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 116 | 0/0 | 0 | 0 | No Data | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 117 | 0/0 | 0 | 0 | P & A Pipe (2) Encapsulate | 13 | 10 | 0 | 0 | 1 | 792 | | 97 |
| 118 | 0/0 | 0 | 0 | No data | 0 | 0 | 0 | 0 | 0 | 0 | | 7,685 |
| 119 | 2/300 | 0 | 0 | No Data | 0 | 0 | 0 | 10 | 10 | 0 | | 13,800 |
| 120 | 0/0 | 0 | 0 | P & A Encapsulate | 8 | 160 | 0 | 0 | 0 | 20,000 | • Junk in Hole No Cleaning | 8 |
| 120 | 0/0 | 0 | 0 | P & A Encapsulated | 8 | 10 | 0 | 0 | 0 | 1,250 | No Tubular Cleaning | 8 |
| 120 | 0/0 | 0 | 0 | P & A (2) Encapsulate | 37 | 31 | 0 | 0 | 0 | 838 | No Tubular Cleaning | 37 |
| 120 | 0/0 | 0 | 0 | P & A (2) Encapsulate | 6 | 20 | 0 | 0 | 0 | 3,333 | No Tubular Cleaning | 6 |
| 121 | 2/2 | 0 | 0 | P & A (1) | 90 | 14 | 0 | 2 | 2 | 151 | | 192 |
| 124 | 0/0 | 0 | 0 | Cutting Box | 5 | 2 | 0 | 0 | 0 | 0 | | 127 |
| 124 | 0/0 | 0 | 0 | NORM Transfer | 23 | 1 | 0 | 0 | 0 | 0 | | 0 |
| 124 | 0/0 | 0 | 0 | SITE Cleanup | 0 | 2 | 0 | 0 | 0 | 0 | | 0 |
| 129 | 0/0 | 0 | 0 | Decon Tubulars | 5 | 16 | 0 | 0 | 1 | 0 | | 4 |
| 130 | 0/0 | 0 | 0 | No Data | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 136 | 11/1,000 | 0 | 0 | P & A (1) Injection | 400 | 150 | 0 | 10 | 40 | 375 | | 1,350 |
| 140 | 00 | 0 | 0 | P & A (1) Injection | 100 | 200 | 1 | 2 | 6 | 2,000 | | 190 |
| 140 | 0/0 | 0 | 0 | P & A (1) Injection | 158 | 199 | 0 | 0 | 0 | 1,260 | | 0 |
| 141 | 0/0 | 0 | 0 | No Data | 0 | 0 | .5 | .1 | 2 | 0 | | 38 |
| 142 | 0/0 | 1 | 0 | Survey | 0 | 1 | 0 | 0 | 0 | 0 | | 14 |
| 146 | 5/400 | 27 | 3 | P & A (1) Wellbore | 80 | 32 | 15 | 10 | 5 | 400 | | 93,710 |
| 147 | 3/62 | 0 | 0 | P & A (1) Injection | 38 | 84 | 0 | 5 | 0 | 2,300 | | 152 |
| 147 | 0/0 | 0 | 0 | P & A (2) Encapsulate | 26 | 26 | 0 | 0 | 5 | 1,000 | | 0 |
| 148 | 0/0 | 0 | 0 | P & A Encapsulate | 1 | 20 | 0 | 0 | 0 | 20,000 | • No Cleaning Downhole Item | 0 |
| 149 | 0/0 | 0 | 0 | P & A (1) Injectors | 615 | 220 | 0 | 2 | 0 | 357 | | 1,078 |
| **Totals** | **109/3,808** | **29** | **3** | | **3,280** | **3,210** | **22** | **52** | **119** | **71,906 16,908** | • **Average 1056.6 $/Drum** | **128,849** |

# APPENDIX C—CONTINUED

| Section/Sub Reply Reference | 1/1.1.1 Drums | 1/1.1.1 Avg uR/h Dose Rates | 1/1.2.1 Tubular Drums Equiv | 1/1.2.1 Avg uR/h Dose Rates | 1/1.3.1 Estimate Drums | 1/1.3.1 Avg uR/h Dose Rates | 1/1.4.1 Facilities/ Drums | 1/1.4.1 Avg uR/h Dose Rates | 1/1.5 1992 Forecast Drums | 1/1.6.1 Oil Prod 000 BPD | 1/1.6.1 Condensate 000 BPD | 1/1.7.1 Pits/Drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 106 | 15 | 0 | 85 | 0 | 890 | 500 | 71/96,178 | 100 | 0 | 0.00 | 0.0 | 0/0 |
| 109 | 0 | 0 | 11 | 100 | 1 | 100 | 43,404 | 50 | 0 | 1.70 | 2.0 | 36,526 |
| 111 | 1,712 | 500 | 50 | 500 | 125 | 500 | 0/0 | 0 | 258 | 82.60 | 1.2 | 0/0 |
| 122 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 | 0 | 0 | 30.60 | 1.3 | 0/0 |
| 123 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 | 0 | 0 | 30.50 | 1.3 | 0/0 |
| 125 | 5 | 250 | 13 | 50 | 0 | 0 | 6/714 | 250 | 13 | 5.50 | 0.0 | 28/0 |
| 128 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 | 0 | 0 | 0.72 | 0.7 | 0/0 |
| 133 | 20 | 2 | 1 | 100 | 10 | 100 | 0/0 | 0 | 33 | 16.60 | 3.2 | 0/0 |
| 137 | 0 | 2 | 0 | 0 | 0 | 0 | 60/1,800,000 | 500 | 0 | 24.70 | 1.4 | 0/0 |
| 137 | Cost | Data | 0 | 0 | 0 | 0 | 0/0 | 0 | 0 | 0.00 | 0.0 | 0/0 |
| 139 | 242 | 100 | 25 | 250 | 71 | 250 | 19/221 | 250 | 63 | 75.00 | 2.3 | 11/823 |
| 143 | 0 | 0 | 0 | 0 | 0 | 0 | 1/10 | 0 | 0 | 15.70 | 0.3 | 0/0 |
| 144 | 0 | 0 | 0 | 0 | 0 | 0 | 1/10 | 0 | 0 | 15.70 | 0.3 | 0/0 |
| 145 | 100 | 0 | 0 | 0 | 0 | 0 | 0/0 | 0 | 0 | 9.60 | 0.0 | 0/0 |
| **Totals** | **2,094** | | **185** | | **1,097** | | **162/1,897,133** | | **367** | **308.82** | **13.85** | |

| Section/Sub Reply Reference | 1/1.8.1 P & A Wells Well/Drums | 2/2.3.1 Checked # Facilities | 2/2.4 Estimate Drums | 3/3.1 Summary Description | 3/3.1 Drums | 3/3.1 Cost (000$) | 3/3.2 Training (000$) 91 | 92 | 93 | A Calculated Cost $/Drum | | B Total Accumulated Drums Drums |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 106 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Abandoned Field | 97,108 |
| 109 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 22 |
| 111 | 3/40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 2,545 |
| 122 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 123 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 125 | 0/0 | 0 | 0 | Build Storage | 0 | 10 | 0 | 0 | 0 | 0 | | 745 |
| 128 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 133 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 64 |
| 137 | 0/0 | 0 | 0 | Clean Tank | 550 | 2.5 | 0 | 0 | 0 | 0 | Many Similar Projects | 1,800,000 |
| 137 | 00 | 0 | 0 | Clean Tubing | 24 | 10.0 | 0 | 0 | 0 | 0 | | 0 |
| 139 | 0/0 | 0 | 0 | Clean Tanks | 10 | 3.6 | 10 | 10 | 10 | 0 | | 1,445 |
| 143 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 5 |
| 144 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 5 |
| 145 | 1/100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 200 |
| **Totals** | **40/823** | | **0** | | **584** | **26.1** | **10** | **10** | **10** | **0** | | **1,902,199** |

# APPENDIX C—CONTINUED

| Section/Sub | 1/1.1.1 | 1/1.1.1 | 1/1.2.1 | 1/1.2.1 | 1/1.3.1 | 1/1.3.1 | 1/1.4.1 | 1/1.4.1 | 1/1.5 | 1/1.6.1 | 1/1.6.1 | 1/1.7.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reply Reference | Drums | Avg uR/h Dose Rates | Tubular Drums Equiv | Avg uR/h Dose Rates | Estimate Drums | Avg uR/h Dose Rates | Facilities/ Drums | Avg uR/h Dose Rates | 1992 Forecast Drums | Oil Prod 000 BPD | Condensate 000 BPD | Pits/Drums |
| **REGION 3** | | | | | | | | | | | | |
| 127 | 1 | 250 | 375 | 100 | 1 | 250 | 3/1 | 250 | 26 | 36 | 0.2 | 120/60,000 |
| 131 | 0 | 25 | 0 | 0 | 0 | 0 | 0/0 | 0 | 0 | 10.7 | 0.1 | 0/0 |
| 137 | 130 | 500 | 25 | 400 | 1,000 | 500 | 0/0 | 0 | 134 | 16.5 | 4.4 | 0/0 |
| **Totals** | **131** | | **400** | | **1,001** | | **3/1** | | **160** | **63.1** | **4.7** | |
| **REGION 4** | | | | | | | | | | | | |
| 104 | 0 | 0 | 0 | 0 | 0 | 0 | 7/0 | 100 | 0 | 47.0 | 03 | 0/0 |
| 138 | 0 | 0 | 0 | 0 | 0 | 0 | 0/0 | 0 | 0 | 108.0 | 0.0 | 3/0 |
| **Totals** | **0** | | **0** | | **0** | | **7/0** | | **0** | **155.0** | **0.3** | |
| **REGION 5** | | | | | | | | | | | | |
| 108 | 0 | 300 | 45 | 100 | 0 | 0 | 0/0 | 0 | 3.5 | 813.0 | 0.0 | 0/0 |
| 108 | Cost | Data | | 0 | 0 | 0 | 0/0 | 0 | 0.0 | 0 | 0.0 | 0/0 |
| 126 | 367 | 50 | 40 | 250 | 1 | 500 | 8/0 | 0 | 737.0 | 9.1 | 0.0 | 2/0 |
| 134 | 1 | 120 | 21 | 500 | 1 | 150 | 0/0 | 0 | 13.0 | 802.0 | 0.0 | 0/0 |
| Total | 368 | | 106 | | 2 | | 3/1 | | 753.5 | 1,624.1 | 0.0 | |

| Section/Sub | 1/1.8.1 | 2/2.3.1 | 2/2.4 | 3/3.1 | 3/3.1 | 3/3.1 | 3/3.2 Training (000$) | | | A | | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Reply Reference | P & A Wells Well/Drums | Checked # Facilities | Estimate Drums | Summary Description | Drums | Cost (000$) | 91 | 92 | 93 | Calculated Cost $/Drum | | Total Accumulated Drums Drums |
| **REGION 3** | | | | | | | | | | | | |
| 127 | 0/0 | All | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Abandoned Field | 60,404 |
| 131 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 137 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 1,289 |
| **Totals** | **0/0** | | **0** | | **0** | **0** | **0** | **0** | **0** | **0** | | **61,693** |
| **REGION 4** | | | | | | | | | | | | |
| 104 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 138 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| Total | **0/0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | | **0** |
| **REGION 5** | | | | | | | | | | | | |
| 108 | 0/0 | 2 | 0 | Process Injection | 350 | 181 | 0 | 0 | 0 | 517 | | 48.5 |
| 108 | 0/0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 |
| 126 | 00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 1,145.0 |
| 134 | 0/0 | 2 | 0 | 0 | 0 | 0 | 5 | 15 | 15 | 0 | | 36.0 |
| Totals | | **0** | | | **350** | **181** | **5** | **15** | **15** | **0** | | **1,229.5** |

# APPENDIX D—TRANSPORTATION COST MATRIX BY REGION TO PERMITTED DISPOSAL SITES

## Permitted Disposal Location

| | | | |
|---|---|---|---|
| 1. | Richland | Washington | Burial |
| 2. | Salt Lake | Utah | Burial |
| 3. | Lafayette | Louisiana | Treat Spread |
| 4. | Port Arthur | Texas | Injection |
| 5. | Nearest | Major Port or Houston) | China Recycle |
| 6. | Nearest | Major Port (or Houston) | Russia Encapsulation |
| 7,8,9. | Local Well | Nearest Suitable Well | Plug & Abandon or Injection |

### Transport Cost Estimates per Drum

| Region/Disposal Site | 1–A | 2–B | 3–B | 4–B | 5–B | 6–B | 7, 8, 9–A |
|---|---|---|---|---|---|---|---|
| 1 | 0 | 25 | 6 | 6 | 10 | 10 | 0 |
| 2 | 0 | 20 | 10 | 10 | 10 | 10 | 0 |
| 3 | 0 | 6 | 25 | 25 | 20 | 20 | 0 |
| 4 | 0 | 6 | 25 | 25 | 6 | 6 | 0 |
| 5 | 0 | 30 | 35 | 40 | 20 | 20 | 0 |

A. Transport included in rates.
B. Volume on a full load and exclusive use truck.

# APPENDIX E—ACTUAL DISPOSAL COSTS (PER/DRUM) FOR PLUG AND ABANDONMENT OF WELLS

All Cost Data From Region 1

| P & A Injection | | | |
|---|---|---|---|
| | Drums No. | Cost ($000) | Cost ($000) |
| | 215 | 102.0 | 474 |
| | 900 | 1,600.0 | 1,700 |
| | 550 | 200.0 | 509 |
| | 90 | 13.6 | 151 |
| | 400 | 150.0 | 375 |
| | 100 | 200.0 | 2,000 |
| | 158 | 199.0 | 1,260 |
| | 80 | 32.0 | 400 |
| | 36 | 83.5 | 2,300 |
| | 615 | 220.0 | 357 |
| **Total** | **3,144** | **2,880.0** | **916/Drum** |
| Maximum | | | 2,300 Cost Per Drum |
| Average | | | 916 Cost Per Drum |
| Minimum | | | 151 Cost Per Drum |

| P & A Encapsulation | | |
|---|---|---|
| Drums No. | Cost ($000) | Cost ($000) |
| 13 | 10.3 | 792 |
| 8 | 10.0 | 1,250 |
| 37 | 31.0 | 830 |
| 6 | 20.0 | 3,333 |
| 26 | 26.0 | 1,000 |
| 90 | 97.3 | 970 |
| **90** | **97.3** | **970** |
| Maximum | | 2,300 Cost Per Drum |
| Average | | 916 Cost Per Drum |
| Minimum | | 151 Cost Per Drum |

# APPENDIX F—NORM DISPOSAL COSTS BY REGION FOR REAL DISPOSAL OPTIONS

| Real Disposal Options | | Disposal Cost per Drum | Region 1 Transport Cost per Drum | Region 1 Disposal + Transport | Region 1 Accumulated NORM Drums | Region 1 Disposal Cost Accumulated Per Million | Region 1 Annual 1992 Disposal of 94,440 Drums Per Million | Region 2 Transport Cost per Drum | Region 2 Disposal + Transport | Region 2 Accumulated NORM Drums | Region 2 Disposal Cost Accumulated Per Million | Region 2 Annual 1992 Disposal of 17,622 Drums Per Million | Region 3 Transport Cost per Drum | Region 3 Disposal + per Drum | Region 3 Accumulated NORM Drums | Region 3 Disposal Cost Accumulated Per Million | Region 3 Annual 1992 Disposal of 12,160 Drums Per Million |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Min | 395 | 0 | 395 | 296,346 | 117.1 | 37 | 0 | 395 | 9,130,555 | 3,606 | 7 | 0 | 395 | 468,867 | 185.2 | 5 |
| | Avg | 515 | 0 | 515 | | 152.6 | 49 | 0 | 515 | | 4,702 | 9 | 0 | 515 | | 241.5 | 6 |
| | Max | 730 | 0 | 730 | | 216.3 | 69 | 0 | 730 | | 6,665 | 13 | 0 | 730 | | 342.3 | 9 |
| 2 | Min | 300 | 25 | 325 | | 96.3 | 31 | 20 | 320 | | 2,922 | 6 | 6 | 306 | | 144 | 4 |
| | Avg | 500 | 25 | 525 | | 155.6 | 50 | 20 | 520 | | 4,748 | 9 | 6 | 506 | | 237.2 | 6 |
| | Max | 700 | 25 | 725 | | 214.9 | 68 | 20 | 720 | | 6,574 | 13 | 6 | 706 | | 331 | 9 |
| 3 | Min | 100 | 6 | 106 | | 31.4 | 10 | 25 | 125 | | 1,141 | 2 | 25 | 125 | | 58.6 | 1 |
| | Avg | 210 | 6 | 216 | | 64 | 20 | 25 | 235 | | 2,146 | 4 | 25 | 235 | | 110.2 | 3 |
| | Max | 325 | 6 | 331 | | 98.1 | 31 | 25 | 350 | | 3,196 | 6 | 25 | 350 | | 164.1 | 4 |
| 4 | Min | 49 | 6 | 55 | | 16.3 | 5 | 25 | 74 | | 676 | 1 | 25 | 74 | | 34.7 | 1 |
| | Avg | 206 | 6 | 212 | | 62.8 | 20 | 25 | 231 | | 2,109 | 4 | 25 | 231 | | 108.3 | 0.28 |
| | Max | 1,000 | 6 | 1,006 | | 298.1 | 95 | 25 | 1,025 | | 9,359 | 18 | 25 | 1,025 | | 480.6 | 1.25 |
| 5 | Break even on contaminated steel. No drums of NORM accepted. | | | | | | | | | | | | | | | | |
| 6 | Avg | 300 | 6 | 306 | | 90.7 | 29 | 20 | 320 | | 2,922 | 6 | 20 | 320 | | 150 | 4 |
| 7 | Min | 792 | 0 | 792 | | | 75 | 0 | 792 | | 7,231 | 14 | 0 | 792 | | 371.3 | 10 |
| | Avg | 1,081 | 0 | 1,081 | | | 102 | 0 | 1,081 | | 9,870 | 19 | 0 | 1,081 | | 506.8 | 13 |
| | Max | 3,333 | 0 | 3,333 | | | 315 | 0 | 3,333 | | 30,432 | 59 | 0 | 3,333 | | 1562.7 | 40 |
| 8 & 9 | Min | 151 | 0 | 151 | | | 14 | 0 | 151 | | 1,379 | 3 | 0 | 151 | | 70.8 | 2 |
| | Avg | 919 | 0 | 919 | | | 86 | 0 | 916 | | 8,364 | 16 | 0 | 916 | | 429.5 | 11 |
| | Max | 2,300 | 0 | 2,300 | | | 217 | 0 | 2,300 | | 21,000 | 40 | 0 | 2,300 | | 1,078.4 | 28 |

Transport Estimate

# APPENDIX F—CONTINUED

| Real Disposal Options | | Disposal Cost per Drum | Region 4 Transport Cost per Drum | Region 4 Disposal + Transport | Region 4 Accumulated NORM Drums | Region 4 Disposal Cost Accumulated Per Million | Region 4 Annual 1992 Disposal of 10,640 Drums Per Million | Region 5 Transport Cost per Drum | Region 5 Disposal + Transport | Region 5 Accumulated NORM Drums | Region 5 Disposal Cost Accumulated Per Million | Region 5 Annual 1992 Disposal of 7,530 Drums Per Million | Totals Transport Cost per Drum | Totals Disposal + per Drum | Totals Accumulated NORM Drums | Totals Disposal Cost Accumulated Per Million | Totals Annual 1992 Disposal of 142,390 Drums Per Million |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Min | 395 | 0 | 395 | 159,600 | 63 | 4 | 0 | 395 | 1,299 | 0.51 | 0.2 | | | | 3,971.8 | 53.3 |
| | Avg | 515 | 0 | 515 | | 82 | 5 | 0 | 515 | | 0.67 | 34 | | | | 5,178.8 | 103 |
| | Max | 730 | 0 | 730 | | 117 | 8 | 0 | 730 | | 0.95 | 5 | | | | 7,341.6 | 104 |
| 2 | Min | 300 | 6 | 306 | | 49 | 3 | 35 | 335 | | 0.44 | 3 | | | | 3,211.2 | 47 |
| | Avg | 500 | 6 | 506 | | 81 | 5 | 35 | 535 | | 0.69 | 4 | | | | 5,222.5 | 74 |
| | Max | 700 | 6 | 706 | | 113 | 7 | 35 | 735 | | 0.95 | 6 | | | | 7,233.9 | 103 |
| 3 | Min | 100 | 25 | 125 | | 20 | 1 | 40 | 140 | | 0.18 | 1 | | | | 1,251.2 | 15 |
| | Avg | 210 | 25 | 235 | | 37 | 2 | 40 | 250 | | 0.32 | 2 | | | | 2,357.5 | 31 |
| | Max | 325 | 25 | 350 | | 56 | 4 | 40 | 365 | | 0.47 | 3 | | | | 3,514.7 | 48 |
| 4 | Min | 49 | 25 | 74 | | 12 | 1 | 40 | 89 | | 0.12 | 1 | | | | 739.1 | 9 |
| | Avg | 206 | 25 | 231 | | 37 | 2 | 40 | 246 | | 0.32 | 2 | | | | 2,317.4 | 28.28 |
| | Max | 1,000 | 25 | 1,025 | | 164 | 11 | 40 | 1,040 | | 1.35 | 8 | | | | 10,303.1 | 133.25 |
| 5 | Break even on contaminated steel. No drums of NORM accepted. | | | | | | | | | | | | | | | | |
| 6 | Avg | 300 | 6 | 306 | | 49 | 3 | 20 | 320 | | 0 | 1 | | | | 3,212.1 | 43 |
| 7 | Min | 792 | 0 | 792 | | 126 | 8 | 0 | 792 | | 1 | 6 | | | | 7,729.3 | 113 |
| | Avg | 1,081 | 0 | 1,081 | | 173 | 12 | 0 | 1,081 | | 1 | 8 | | | | 10,551.2 | 154 |
| | Max | 3,333 | 0 | 3,333 | | 532.00 | 35 | 0 | 3,333 | | 4 | 3 | | | | 32,531.0 | 452 |
| 8 & 9 | Min | 151 | 0 | 151 | | 24 | 2 | 0 | 151 | | 0 | 1 | | | | 1,474.0 | 22 |
| | Avg | 916 | 0 | 916 | | 146 | 10 | 0 | 916 | | 1 | 7 | | | | 8,940.7 | 130 |
| | Max | 2,300 | 0 | 2,300 | | 367 | 24 | 0 | 2,300 | | 3 | 17 | | | | 22,448.4 | 326 |

Transport Estimate

# APPENDIX G—NORM PRODUCTION BY TYPE OF SOURCE

| | Drums of NORM | | | | No. of Wells | |
|---|---|---|---|---|---|---|
| Reply No. | (A) Stored Solids | B Tubulars | (C) Equipment | (D) Sludge and Sites | Oil | Gas |
| 101 | 10 | 31 | 30 | 0 | 514 | 50 |
| 108 | 0 | 48 | 0 | 0 | 1,087 | |
| 109 | 0 | 11 | 1 | 10 | 400 | 300 |
| 111 | 1,712 | 50 | 125 | 0 | 6,085 | 1,066 |
| 113 | 38 | 0 | 0 | 10 | 15 | - |
| 115 | 153 | 120 | 10 | 100 | 855 | 514 |
| 117 | 13 | 1 | 2 | 66 | 290 | 296 |
| 118 | 3,200 | 451 | 30 | 4,000 | 8,800 | 2,340 |
| 119 | 7,000 | 0 | 0 | 5,000 | 823 | 334 |
| 120 | 0 | 41 | 0 | 0 | 42 | 41 |
| 121 | 90 | 10 | 90 | 0 | 38 | 45 |
| 124 | 32 | 5 | 41 | 0 | 245 | 155 |
| 125 | 5 | 13 | 0 | 714 | 1,620 | 0 |
| 126 | 367 | 40 | 1 | 0 | 32 | 13 |
| 127 | 0 | 375 | 1 | 1 | 1,095 | 143 |
| 133 | 20 | 0 | 10 | 0 | 958 | 727 |
| 137 | 130 | 25 | 1,000 | 1,800,000 | 10,800 | 1,135 |
| 139 | 242 | 25 | 71 | 221 | 6,844 | 994 |
| 140 | 40 | 0 | 0 | 50 | 361 | 461 |
| 141 | 27 | 0 | 0 | 10 | 2 | 52 |
| 142 | 4 | 0 | 2 | 4 | 75 | 23 |
| 145 | 100 | 0 | 0 | 0 | 519 | 1 |
| 146 | 530 | 234 | 400 | 80,000 | 2,100 | 900 |
| 147 | 3 | 7 | 4 | 35 | 70 | 189 |
| 149 | 43 | 441 | 0 | 0 | 1,070 | 384 |
| **Totals** | **2,383** | **1,928** | **1,818** | **1,890,221** | **44,740** | **10,163** |
| **Percentage of Total** | **<1%** | **<1%** | **<1%** | **99.7%** | | |

A + B + C + D = 1,896,350