GENERATION AND MANAGEMENT OF RESIDUAL MATERIALS

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Petroleum Refining Performance

Generation and Management of Residual Materials

Petroleum Refining Performance 1990 Survey

Health and Environmental Affairs Department

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PREPARED UNDER CONTRACT BY:

GAIL LEVINE
SUMMATIONS
WASHINGTON, D.C.

WENDALL CLARK
WC CONSULTANTS
HOPEWELL JUNCTION, N.Y.

RALPH MITTL
CONSULTANT

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American
Petroleum
Institute

FOREWORD

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API STAFF:

Barbara Bush, Health and Environmental Affairs Department
Genevieve Laffly Murphy, Manufacturing, Distribution & Marketing
WendySams, Information Services
John Wagner, Office of General Counsel
Paul Wakim, Statistics

MEMBERS OF THE REFINING SURVEY WORKGROUP:

Mark Hopkins (Chairman), Chevron Corporation
J.M. Joyce, Phillips Petroleum Company
John Lemen, Texaco, Inc.
Richard Lindstrom, Ashland Petroleum Company
Mary Spearman, Amoco Corporation

PREFACE

To improve the quality of the data collected, and its relevance to current developments, each year the Americal Petroleum Institute (API) reviews all data collected in this survey, and evaluates and revises, as necessary, the data collection forms and instructional materials. Consistent with this ongoing effort to promote the integrity of the survey findings and its utility to the industry, API is implementing a deliverate change in the terminology used in this survey. Henceforth, in this report and all future documents developed in conjunction with this survey, API will use "residual materials or residuals" to refer to what has previously ben called "wastes and secondary materials." This change in terminology reflects industry practices--the use of many of these materials as feedstocks or for recycling, reuse, and reclamation. This change helps to reconcile the utilization of these materials in our industry with the regulatory usage of the term "waste."

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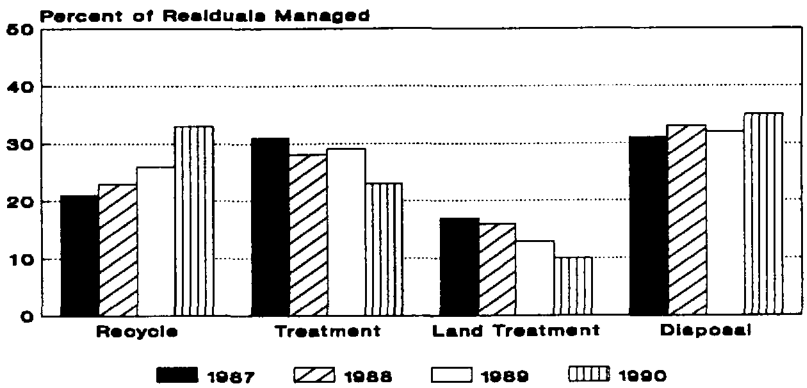
1990 Survey

In 1990, the petroleum refining industry reported that source reduction activities doubled over the last year, and that when combined with resource recovery initiatives, accounted for a reduction of close to a half a million wet tons of residual materials. Controlling for the statistical outliers, recycling rose to 33 percent, treatment and land treatment dropped to 23 and 10 percent respectively, while disposal accounted for 35 percent of the total quantity of residual material.



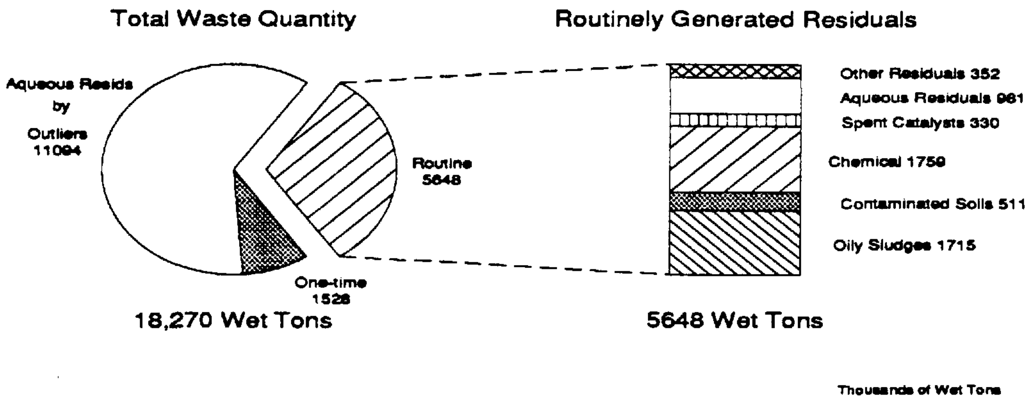
These findings were recorded by the American Petroleum Institute (API) in its fourth annual survey of refining practices. Responses from 103 refineries, representing 70 percent of the U.S. refining capacity, were used to develop industry-wide estimates. The procedures and data collection forms used in the survey were similar to those used previously. In an effort to emphasize that most materials resulting from petroleum refining processes have potential value as feedstocks and for recycling, reuse, reclamation or regeneration, API will discontinue using the term "waste", which had been used in previous surveys. Henceforth, API will use the term "residual materials" to refer to the materials that result from petroleum refining, both those derived from crude oil and those spent chemicals used in the process.

The changes in the management profile of residuals summarized above reflects several changes in the industry's generation and reporting of these materials. Waste minimization and source reduction activities improved recovery of oils and prevented creation of sludges by controlling solids entering the wastewater systems. This supported reduction in the generation of some streams, in particular, API separator sludge which decreased 40 percent from the 1989 level.

Overall, however, the quantity of residuals generated in 1990 increased to 18.2 million wet tons. Total residuals managed divided by crude oil throughput to refineries yields a ratio of 0.0277, compared with 0.0248 for 1989. When the statistical outliers are removed from the calculations, the ratio remains a low 0.008.

Much of the increased quantity of residuals was due to refiners closing surface impoundments, remediating sites, and building new process units—activities that lead to abnormal spikes in the generation of pond sediments and contaminated soils. Indeed, with the exception of the chemical category where increases in reporting of spent caustics and spent acids occurred, routinely generated wastes were approximately the same as previous years.

Residual Generation: 1990



The data for 1990 suggest that some practices in the industry are changing, while others may be more static. Two long term trends are noteworthy:

- o the amount of total residuals being **recycled** continues to rise--a 76 percent increase in total quantity compared with 1987; and
- o the amount of listed hazardous waste to **land treatment** and **disposal** continued to fall--a 57 percent decrease in quantity compared with 1987.

Thus, the 1990 results show indications of continued progress by the petroleum refining industry.

When API adds the fifth survey cycle to the database, additional analyses will be performed, which may enable further delineation of trends in the industry, perhaps even the identification of streams that are influenced largely by throughput, and others that fluctuate due to other factors.

INTRODUCTION

This report for calendar year 1990 marks the completion of four annual surveys of generation and management of residual materials within the refining segment of the petroleum industry. This fourth year is also the last year of the baseline period that API declared as it started this data collection effort. In light of the expected fluctuations in the generation of many residual materials—that some process units are serviced every three years and that maintenance turnarounds may occur at even longer intervals—this baseline period was imposed to ensure that information would be gathered on the natural fluctuation in generation rates. With this baseline data, subsequent between-year reductions (or increases) could be accurately attributed to either natural variation or to true changes in practices.

During this baseline period analytic efforts have been held primarily to descriptive statistics. This has allowed API to simply monitor and document how the industry handles residual materials, to learn more about how materials are managed, and to trace how regulatory events influence practices. During the baseline period several questionnaire items have been revised to improve the quality and consistency of the data collected, particularly with regard to the point of generation and its periodicity, and how the industry's recycling practices should be portrayed within the rubric of waste minimization, source reduction, and pollution prevention.

This baseline period has also allowed API to contemplate the nature of progress. When this survey was initiated, the underlying presumption was that *reductions* in the quantity of residual materials **generated** would serve as indicators of progress. In many situations this is true. The collection of four years of data has documented variations in the generation patterns for different streams, and led to an understanding that even the *detection* of significant change may be no small feat. Indeed, only ten of the 28 streams reported in the survey are generated routinely by the industry as indicated by the consistently high number of refineries reporting these streams in each survey year. These, then, are the streams for which it will be easiest to detect a systematic change over time. There can be substantial flux, however, in the quantities of these routinely generated streams. Thus, it may be difficult to detect reductions even in these streams. Consequently, other indicators of progress need to be identified.

In some circumstances, improvements in the way residual materials are handled constitute progress. Movement up the waste management hierarchy (source reduction, recycling, treatment, and finally disposal) should be recognized. Moreover, these changes address the entire continuum of the hierarchy: from disposal to treatment to recycling, in addition to source reduction.

Ironically, in some situations, progress may also be indicated by *increases* in generation quantities. For example, when refineries build new process units, or when they dismantle older units, they excavate soils. This increases the amount of contaminated soils and other waste generated. Similarly, while the installation of a segregated sewer system for process wastewaters and stormwaters will eventually decrease the amount of oily wastewaters and residues, construction of the sewer system, as measured by this survey, results in an increase in certain residual materials. Compliance with regulatory initiatives designed to improve the protection of the environment, can also result in peak generation quantities. For example, many refineries have decided to limit their use of impoundments and ponds in an effort to minimize air emissions and reduce the generation of oily sludges. Closure of these ponds, many of which are quite large, has resulted in the removal of millions of tons of sediments—an abnormal spike in generated residuals.

Fortunately, the ongoing nature of this survey will provide an appropriate context for viewing the findings from an individual year. Beginning with the data for 1991, API will perform a more extensive analysis, testing to identify patterns in generation and to determine the strength of any trends observed. In addition to publishing this information in an annual project report, findings from the trend analysis will be incorporated in API's Environmental Performance Documentation Program (EPDP). As part of the Strategies for Today's Environmental Partnership, the EPDP program is designed to provide a public record of the industry's environmental performance. This longitudinal analysis of the data will enable the industry, and the public, to recognize residual generation patterns and to view these reductions, changes in practices, and peaks in generation quantities from an informed perspective that benefits from the serial analysis.

The chapters of this report which follow, are structured similarly to those of the previous reports from the baseline period. Following a brief description of the survey methodology, the results on generation quantities, source reduction practices, and handling procedures are presented and discussed. The appendices to the report contain copies of the data collection forms, summaries of qualitative data on source reduction practices, printouts from the estimation procedures, and graphics on the management practices for individual streams over time.

METHODOLOGY

The same design, administrative, and analytic procedures used to collect 1987 - 1989 data were used for 1990[1]. Using a census listing of the 183 operating refineries (developed by updating the 1989 list from the Department of Energy's *1990 Petroleum Supply Annual*), survey materials were sent in September, 1991, to the respective corporate offices for the refineries. The six week interval originally allowed for form completion was extended to increase the response rate; the last survey form returned was accepted some six months later. Contact was maintained with all refineries during the field administration, with three follow-up calls placed to refineries to encourage response and through a "HELP-line" staffed by a refining expert.

The sections that follow briefly describe the data collection form and the analytic procedures used to create the population estimates. A copy of the data collection form is presented in Appendix A.

Data Collection Forms

API's survey questionnaire is comprised of a series of short-answer questions about the age, size, and complexity of the refinery, questions on resource recovery and source reduction activities, and a series of "data sheets"— one-page forms that collect empirical information on the quantities of residual materials[2] generated and how they are managed.

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[1] For more detailed discussion of the survey procedures, consult API Publications 300 and 303, the final reports for the previous surveys.

[2] As noted in the Foreword, use of the "residual material" terminology was initiated with this report. When the 1990 data were collected, the "waste" terminology was used in all data collection materials and instructions. API did not explicitly define "waste and secondary materials" when it initiated the survey, hoping that this discretionary power would encourage broad reporting of actual practices. The Instruction Manual contained the following statement:

> *Although denominated as a "solid waste" survey, it should be understood that neither this title nor the references herein (e.g., "wastes" and "residuals") are used in a statutory or regulatory sense. Whereas EPA regulations implementing RCRA have given these terms special meaning, our usage here is in a broader, more generic sense. API wants survey participants to report the management of all residual type materials (e.g., materials that are byproducts or residuals of petroleum refining operations). This includes residuals that are beneficially recycled or reclaimed, as well as material that is discarded. This will allow reporting of industry data, wherever appropriate, according to the waste management hierarchy of source reduction, recycling, treatment, and disposal. (Instruction Manual)*

The intent of this strategy was to encourage broad reporting of residual handling as it actually occurs, without introducing the potential bias of experimental or survey effects, such as arbitrary definitions of the point of generation.

The questionnaire was provided in both hard copy form and on an automated disk, written using Clipper, a commercially available compiler for dBase.

Few changes in the forms were implemented for 1990. In the *short-answer* series of questions, changes focused on improving the quality of information collected on **Source Reduction**. As noted in the reports on previous surveys, the refiners have had difficulty in applying the definition of Source Reduction to industry practices and distinguishing these from other improvements in residual management practices. Consequently, to assist refiners in classifying the types of management improvements they have instituted, a new question was developed to obtain information on **Resource Recovery** activities initiated in 1990. **Resource Recovery** was defined to include activities where residual materials are beneficially recycled in *out-of-process on-site or by other users off-site*. This question was placed immediately *before* the Source Reduction question, in an effort to force respondents to make a distinction between various beneficial activities, some of which are considered to be waste minimization, and others that are regarded as source reduction. To further emphasize the distinction used in the survey, the 1990 questionnaire used tabs (pre-labeled divider sheets), that provided visual cues to distinguish the two types of activities.

The **Source Reduction** question was in the same format as in 1989. Two changes were made requiring: 1) quantities reduced be reported by stream, as well as by source reduction method; and 2) the year the source reduction activity was initiated be specified.

Because the new Toxicity Characteristic (TC) under RCRA did not become effective until the last quarter of 1990, information was not collected on TC residuals in this survey. API plans to begin collecting information on TC residuals in the 1991 survey cycle.

The *data sheets* contained in the second part of the questionnaire were virtually the same as used before. There are 28 data sheets, one for each of the residual streams identified in Table 1. This listing of streams, and classification into six categories of residual materials that represent the typical grouping of materials in a refinery, has been used in each survey.

On the data sheets, "inputs" of residual materials are balanced against "outputs." Inputs include the quantities Generated plus Treatment Additives and the Net Removed from Storage (i.e., the total amount of material removed from storage minus the amount placed into storage) and constitute the "Total Quantity Managed." As illustrated below, this is balanced according to the waste management hierarchy by the quantities of waste *recycled, treated, or disposed.*

Quantity Generated + Treatment Additives + Net From Storage = **Total Quantity Managed**

Total Quantity Managed = Quantity Recycled + Quantity Treated + Quantity Disposed

As the footnote to Table 1 suggests, the intent of the survey was to capture information on only residual materials—not wastewater that is directly treated and discharged under a NPDES permit or discharged to a POTW.

Table 1
Refining Residual Streams

Category	Constituents
Aqueous residuals	Biomass High pH/low pH waters Oil contaminated waters (not wastewaters)* Spent Stretford solution Spent sulfide solution Other aqueous residues NOS**
Chemicals/inorganic residuals	Spent acids Spent caustics Residual amines Other inorganic residuals NOS**
Contaminated soils/solids	Contaminated soils/solids Heat exchanger bundle cleaning sludge*** Residual coke/carbon/charcoal Residual/waste sulfur Other contaminated solids NOS**
Oily sludges/other organic residuals	API separator sludge*** DAF float*** Leaded tank bottoms*** Nonleaded tank bottoms Other separator sludges Pond sediments Slop oil emulsion solids*** Waste oils/spent solvents Other oily sludges/organic residuals NOS**
Spent catalysts	Fluid cracking catalyst Hydroprocessing catalyst Other spent catalysts NOS**
Other residuals	Other wastes NOS**

* Does not include NPDES or POTW wastewaters.
** Not otherwise specified.
*** RCRA-listed hazardous wastes for petroleum refining.

Data Analysis

The data verification and estimation procedures used in 1990 were the same as those used in previous survey cycles. Data verification included 28 automated consistency checks for the variables on each data sheet, as well as final range checks across respondents and comparisons with the data previously submitted by the respective refinery.

During the range checking activity, statistical outliers were identified for separate handling during the model development[3]. The following 13 outliers were identified in the sample of 103 refineries that responded in 1990:

- o 4 refineries that generated no residuals;
- o 1 refinery which generated only 6 tons of residual material;
- o 4 refineries that deep well inject large quantities of dilute aqueous material;
- o 4 that were identified as aberrant during the data plotting phase of model development.

In all cases, the data were verified by direct contact with the facilities to ensure its accuracy.

For each survey year, API develops an estimate of residuals generated by the entire industry based upon information submitted by survey respondents[4]. To evaluate the relative impact of factors that may influence residual generation, correlation coefficients are calculated for a number of known refinery characteristics (e.g., capacity, age, sewer system) with total waste generation. In addition, scatterplots are developed to help explore any relationships which could lead to development of models to estimate total residual quantity generated. Individual factors are evaluated as well as combinations of factors. As with data from previous years, the strongest correlation observed in the 1990 data was a positive correlation between operable crude capacity (Question 3) and residual generation. Combining other factors with operable crude capacity did not significantly improve the predictable power of the model.

Thus, after examining all the model results for levels of significance, mean squared error, R-squared, and model complexity, a regression model with capacity as the explanatory variable was selected as most suitable. Additional regression diagnostics suggested that model assumptions were more closely followed with a square root transformation of the volume of generated residuals (the response or y-variable), and that such a model was statistically appropriate for 1990.

Therefore, the regression model used for 1990 was of the form:

$$\sqrt{TotalGeneratedQuantity} = a + b(Capacity)$$

or

$$TotalGeneratedQuantity = [a + b(Capacity)]^2$$

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[3] So that they do not unduly distort the statistical relationship between capacity and generated residual quantity, residual quantities from outlier facilities are temporarily separated from the sample during model development and then added back into the population estimates along with the non-respondent values.

[4] Implicit in this approach are the assumptions that: 1) the factor(s) influencing waste generation for respondents do not differ from those for non-respondents; and, 2) no additional outliers exist in the non-respondent population.

where a and b were estimated based on the data from the 90 responding refineries that were not statistical outliers[5]. The regression model was then used to estimate the total residual generated by each non-respondent by (1) inputting its capacity into the model; (2) squaring the result; and, (3) using a standard statistical procedure to adjust that number so that the final estimate is unbiased.

To estimate the total amount of residual materials generated in 1990 for all (183) of the U.S. refineries, estimates for the 80 non-respondent refineries were combined with the data obtained from the 103 survey participants including outlier facilities. All residual generation and management data shown in this report are estimates for all 183 refineries.

Based on the model approach and assumptions, the margin of error for the total estimated residual quantity is approximately 2 percent. Thus the total residual generation is estimated between 18.6 million tons and 17.9 million tons at the 95 percent confidence level.

After deriving the total quantity of generated residual, calculations were performed to estimate the generation quantities for each of the 28 residual streams. A summary of the procedure used follows:

1) The total reported quantity of residuals was determined by summing the generated quantities from all non-outlier respondents.

2) Each individual residual stream generation quantity calculated in (1) was divided by the total quantity of residuals for the 28 streams to determine the relative contribution of each stream to the total reported quantity.

3) Each proportion calculated in 2) was multiplied by the total estimated residual quantity.

[5]This model form is different from the one used in 1987-1989 because, for 1990, it was found to satisfy model assumptions more closely. Nevertheless, a comparison between the 1990 estimates derived from the old and new approaches showed close agreement, i.e., within the margin of error.

RESULTS

Response Rate

For 1990, 103 refineries participated in the survey. Eleven refineries that had previously participated in the survey did not complete the questionnaire for 1990; reciprocally, four refineries submitted data for the first time in 1990.

The 103 refineries that participated in 1990 represented 56 percent of the population of 183 refineries, but accounted for 70 percent of the domestic crude refining capacity. This response rate was less than previously observed (74 percent of capacity was represented in 1989), but still outstanding for a survey conducted during 1991-1992, when economic considerations were dictating down-sizing of the industry and careful scrutiny of labor intensive, voluntary efforts.

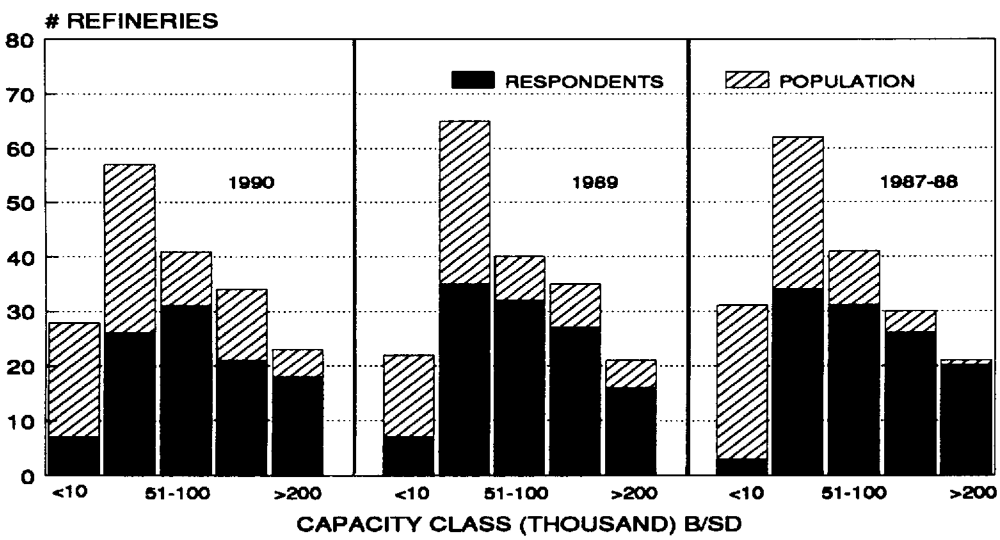
Of the 103 respondents, 84 have participated in all four years of the survey. These refineries represent 60 percent of the total refining capacity.

Respondent Characteristics

The 103 respondents reported an *operating capacity* of 11,793,750 barrels per stream day (b/sd). The total amount of crude charged was 3,748 million barrels. The modal number of days on which crude was charged was 365, which was reported by 57 refineries. With only three refineries reporting running less than 300 days, the total number of days on which crude was charged was 37,057 for the 103 respondents.

The profile of respondents by *capacity class* was generally similar to that observed previously. As depicted in Figure A, there have been some slight changes in the distribution of refineries at both ends of the spectrum.

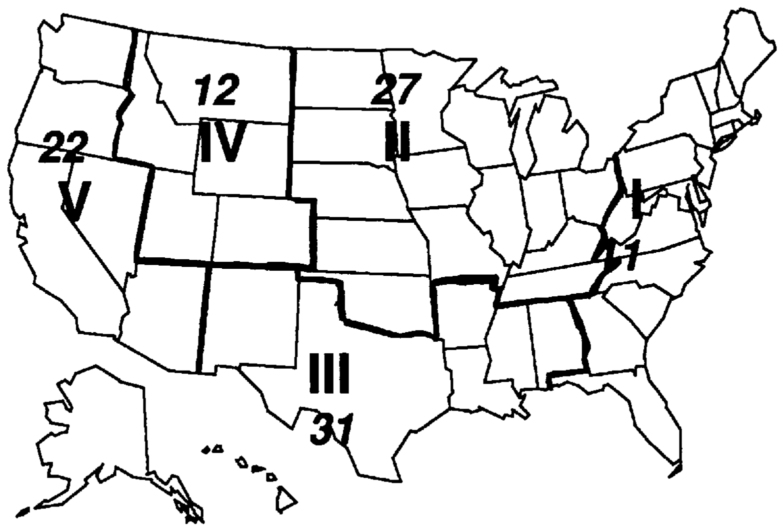
Figure A
Number of Respondents by Capacity Group



The population of small refineries, less than 10,000 b/sd, has fluctuated, increasing since 1989, but still less than the number operating in 1987-1988. The total number of refineries in the 11,000 - 50,000 b/sd class dropped from 1989, as did the number of participants in this size class. The number of refineries and participants in the 51,000 to 100,000 b/sd class remained constant since 1987, while a slight attenuation was observed in the next size class. Reciprocally, the group of refineries over 200,000 b/sd has increased over time. Only two refineries closed in 1990 and two others were reactivated, which kept the population a constant 183 for both 1989 and 1990.

The distribution of refineries by *location* was similar to that previously reported, with the highest number in U.S. Department of Energy's Petroleum Administration for Defense (PAD) III, the Texas/Louisiana region.

Figure B
Distribution of Respondents by Location



The API survey has used the NPDES permit classifications to categorize the *complexity* of the refineries. The overall distribution of respondents for 1990 was similar to previous observations, with the number of "cracking" facilities predominating. Comparing the 1990 response to the 1989's as illustrated in Figure C, a decrease in the number of the cracking refineries occurred in 1990, while there were minor changes in the number of "topping", "petrochemical", and "lube" facilities.

The data collected on the *age* of the refineries attest to the maturity of the industry, with 85 percent of the refineries being built more than 30 years ago. As shown in Figure D, there are subtle differences among survey years that reflect different refineries participating and changes due to facility closures and reactivations.

Figure C
Distribution of Respondents by NPDES Complexity Classification

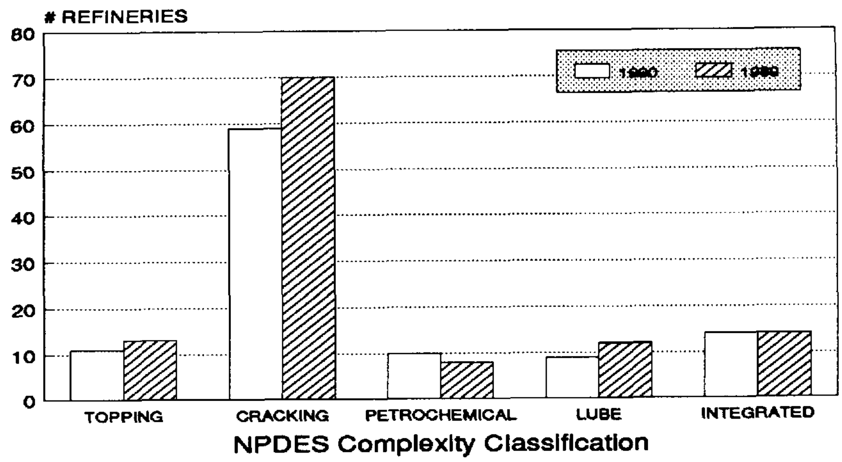
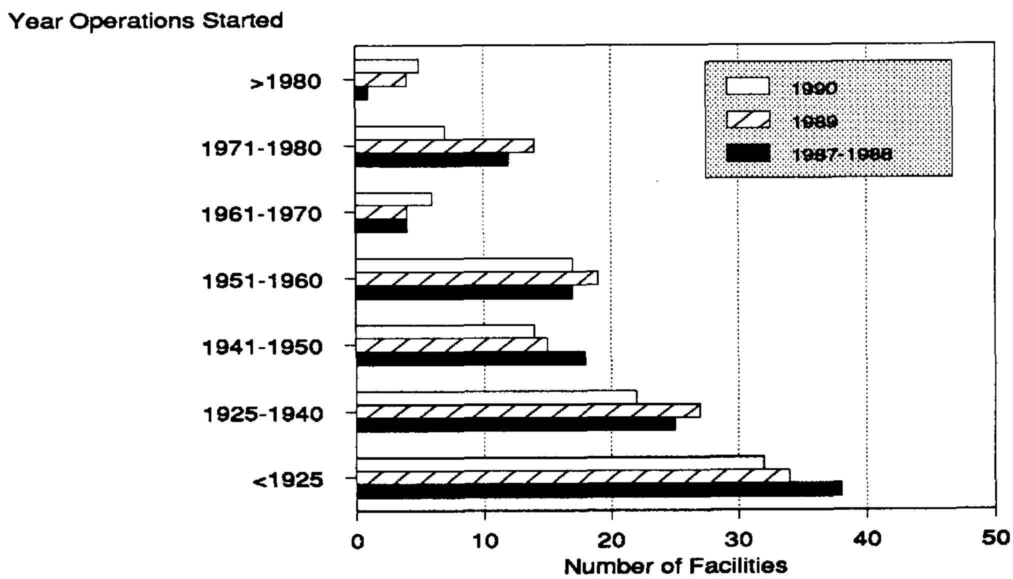
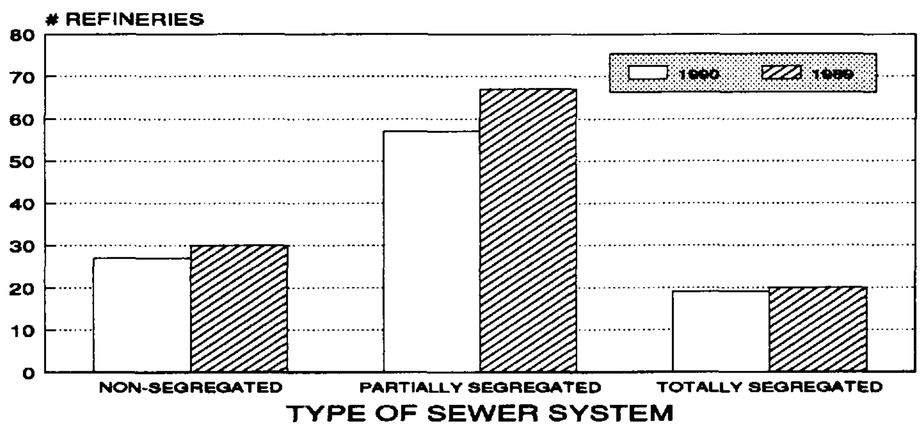


Figure D
Distribution of Respondents by Refinery Age



As illustrated in Figure E, the data collected on the type of *sewer system* seems constant from year to year. For 1990, 57 refineries, or 55 percent of the respondents, reported having sewer systems that partially segregate storm and process waters, which was comparable to the 57 percent reporting last year.

Figure E
Distribution of Respondents by Sewer Type



The survey also collected information on *RCRA Permit Status*, requiring participants to indicate their status before the September 25, 1990 effective date for the Toxicity Characteristic (TC), and thereafter. As presented in the Table 2 below, the number of refineries that filed permits and thus acquired "Interim Status" increased, drawing in refineries that had been considered generators only and not previously subject to RCRA permitting for on-site hazardous waste management.

Table 2
RCRA Permit Status

RCRA Permit Status	Before 9/25/90	After 9/25/90
Generator only; no RCRA permit required	40 (38%)	31 (30%)
Part A filed (interim status)	25 (24%)	34 (33%)
RCRA Permit issued	38 (37%)	38 (37%)

Total Management Quantity

The term "total management quantity" has been coined by API for this survey to refer to the amount of residual materials generated in a given year, plus the amount of material added to facilitate handling of the residuals, plus the amount of residuals removed from storage and handled in the target year. The following equation shows the various components.

Total Quantity Managed = Quantity Generated + Treatment Additives + Net From Storage

The following sections of the report will describe each of these factors.

Residual Generation
Using the estimation procedure described previously, the total amount of residual materials generated in 1990 by the 183 U.S. petroleum refineries was estimated to be 18.2 million wet tons. This is an increase of 1.9 million wet tons over that generated in 1989. When divided by the amount of crude run in 1990, 658 million wet tons (as reported in the DOE Petroleum Supply Annual), the ratio is 0.0277, compared with the 0.0248 reported for 1989.

As in previous years, over two thirds of the total quantity of residual generated can be traced to those refineries that have been identified as statistical outliers. For 1990, the residuals generated by the 9 refineries identified as outliers (that generated any residual material) was 12.6 million wet tons. Of this quantity, 11.1 million wet tons were primarily other aqueous wastes NOS generated on a routine basis. The remaining quantity of residuals generated by the facilities considered statistical outliers reflected either abnormal, one-time events (approximately 0.7 million wet tons), or routine generation of substantially more residual material by a refinery when compared with similar size refineries (approximately 0.8 million wet tons). The influence of these outliers is noticed in Table 3 which presents the total quantity generated by stream.

A substantial increase in the quantity of **pond sediments** generated is noted. This increase, as well as that for **contaminated soil/solids,** reflect abnormal situations, or generation peaks caused by closure of ponds, remediation of sites, or refinery construction that necessitates removal of soil. For **pond sediments,** the one-time quantity was 699,631 wet tons or 88 percent of the total amount generated. For **contaminated soils/ solids**, the quantity was 475,681 or 66 percent.

Spent acids and **waste oils/spent solvents** were two other streams with substantial increases in 1990. The generation pattern was very similar for these two streams, with four facilities contributing more than 70 percent of the amount generated in 1990.

It is harder to declare meaningful reductions in the generation quantities, due to fluctuations between survey years. The quantities of **API separator sludge** was the lowest ever reported, and begins to approximate a statistically significant reduction.

The number of refineries reporting each residual stream is presented in Table 4. The relative order of the streams has remained constant. The drop in the number of refineries reporting **FCC catalyst or equivalent** probably is due to the drop in survey participants this year, which as noted in Figure C, reduced the number of cracking facilities in the sample.

Table 3
Estimate of Residual Materials Generated by the U.S. Refining Industry: 1990
(thousands of wet tons)

Residual stream	1990	1989	1988	1987
Aqueous residuals NOS	11,107	11,100	11,076	11,296
Pond sediments	1,017	313	266	337
Contaminated soils/solids	920	512	240	165
Spent Caustics	889	716	656	675
Biomass	782	642	786	757
DAF float	553	496	655	652
Other inorganic residuals NOS	451	440	213	325
Other residuals NOS	352	325	412	203
Spent acids	336	8	149	126
Slop oil emulsion solids	291	272	224	208
API separator sludge	251	419	355	400
FCC catalyst or equivalent	198	182	193	173
Nonleaded tank bottoms	194	161	129	216
Waste oils/spent solvents	115	31	7	4
High pH/low pH waters	105	91	138	144
Other separator sludges	97	114	104	79
Residual coke/carbon/charcoal	92	129	67	43
Residual amines	75	51	14	13
Other contaminated soils NOS	69	53	68	82
Other oily sludges/organic residuals NOS	53	47	61	38
Other spent catalysts NOS	39	33	37	33
Residual sulfur	35	52	22	17
Hydroprocessing catalysts	31	36	36	40
Spent Stretford solution	29	42	49	35
Heat exchanger bundle cleaning sludge	13	2	5	3
Oil contaminated waters (not wastewaters)	8	29	36	28
Leaded tank bottoms	3	4	8	9
Spent sulfite solution	1	8	40	42
Total	18,106	16,311	16,044	16,144

Table 4
Number of Refineries Reporting Each Stream

Residual stream Total number of refineries participating	1990 103	1989 117	1988 115	1987 115
Contaminated soils/solids	87	88	77	77
API separator sludge	85	93	94	91
Other residuals NOS	85	89	85	92
FCC catalyst or equivalent	79	84	86	85
Nonleaded tank bottoms	72	72	75	72
Spent caustics	66	70	77	79
Other inorganic residuals NOS	65	73	73	77
Other spent catalysts NOS	57	60	60	62
Other contaminated soils NOS	56	61	71	70
Waste oils/spent solvents	56	56	61	52
Hydroprocessing catalysts	52	65	60	57
Heat exchanger bundle cleaning sludge	51	49	48	49
DAF float	50	47	50	53
Residual coke/carbon/charcoal	50	51	47	48
Biomass	44	44	45	47
Other oily sludges/organic residuals NOS	42	49	47	49
Residual sulfur	37	42	47	41
Slop oil emulsion solids	35	38	43	47
Pond sediments	34	31	29	26
Residual amines	27	38	36	32
Leaded tank bottoms	27	31	37	38
Spent acids	24	18	23	20
Other separator sludges	19	22	20	15
High pH/low pH waters	11	11	12	14
Other aqueous residues NOS	11	14	12	13
Oil contaminated waters (not wastewaters)	10	14	10	14
Spent Stretford solution	7	11	13	12
Spent sulfite solution	1	2	1	1

Treatment Additives

Treatment additives are chemicals that facilitate subsequent management of residuals. For example, flocculants are used to expedite filtration that reduces the volume requiring subsequent handling. Other materials may be added to residuals like pond sediments to enable the residual to pass the paint filter test, the TC criteria. The use of treatment additives increased in 1990. Specifically, after dropping to 35 thousand wet tons in 1989, 88 thousand wet tons were estimated for 1990. (In 1987, 55 thousand tons were used, while 72 thousand tons were used in 1988.) Treatment additives were reported for handling 19 residual streams, but 36 percent of the total amount used was with **pond sediments**—the stream with the highest one time quantity generated. Twelve thousand wet tons were used with **biomass** and **DAF float**; 8 thousand tons were used to pretreat **API separator sludge**; and **spent caustics** and **other separator sludges** required 7 thousand tons of additives.

Storage

API's data sheets provide spaces for refiners to designate the amount of material removed from storage and the quantity placed into storage. When added together, a "Net from Storage" quantity is derived, which then becomes a factor in the waste management equation.

Table 5 presents a listing of the five streams with the largest quantities removed from storage in 1990. Only one stream, **FCC catalyst or equivalent** had a significant quantity of material removed from storage: 61 thousand wet tons, which represented 15 percent of the total quantity generated for that stream. Two thirds of this amount was reported by one refinery that conducted a periodic clean-out of the pond in which FCC catalyst slurry was managed to allow gravity separation. For the remaining streams, the amount of material removed from storage was less than 1 percent of the total amount of managed.

Table 5
Top-five Residual Streams Removed from Storage
(thousands of wet tons)

Residual Stream	Total Managed	From Storage	% of Total
FCC catalyst or equivalent	259	39	15
DAF float	643	5	1
API separator sludge	260	4	<1
Biomass	794	4	<1
Other inorganic residuals NOS	453	4	<1

None of the streams placed into storage were large volumes. It is interesting to note that three of the five streams with the greatest tonnage removed from storage were also streams with the largest quantity placed into storage: **DAF float, biomass**, and **API separator sludge** (See Table 6.)

Table 6
Top-five Residual Streams Placed Into Storage
(thousands of wet tons)

Residual Stream	Total Managed	Into Storage	% of Total
Pond sediments	1091	6	<1
DAF float	643	6	<1
Biomass	794	4	<1
API separator sludge	260	4	1
Contaminated soils/solids	914	4	<1

Total Quantity Managed
Table 7 presents the estimates of generation quantities for each residual stream, the amount of treatment additives used, the net amount from storage, and the summation of these factors—the total amount of managed in 1990.

Table 7
Estimated Quantities of Residual Materials: 1990 (wet tons)

Residual stream	Amount Generated	Treatment Additives	From Storage	Total Amount Managed
Aqueous residuals NOS	11,106,421	0	0	11,106,421
Pond sediments	1,016,597	31,987	(8,939)	1,039,645
Contaminated soils/solids	920,444	11	(5,529)	914,926
Spent caustics	888,511	5,951	(204)	894,258
Biomass	782,000	12,347	(302)	794,045
DAF float	552,938	11,709	(344)	564,303
Inorganic residuals NOS	451,464	542	1,157	453,163
Other residuals NOS	352,114	459	(23)	352,550
Spent acids	336,259	398	(66)	336,591
Slop oil emulsion solids	290,862	4,428	(254)	295,036
API separator sludge	251,183	7,801	617	259,601
FCC catalyst/equivalent	198,295	0	61,016	259,311
Nonleaded tank bottoms	193,694	3,203	(412)	196,485
Waste oils/spent solvents	114,611	0	(2)	114,609
High pH/low pH waters	105,238	0	0	105,238
Other separator sludges	96,511	7,350	0	103,861
Residual coke/carbon/charcoal	91,798	0	0	91,789
Residual amines	74,861	0	0	74,861
Contaminated soils NOS	69,310	86	(16)	69,380
Oily sludges/organic residuals NOS	53,199	373	(72)	53,500
Other spent catalysts	39,165	1,231	194	40,590
Residual sulfur	34,614	0	(70)	34,544
Hydroprocessing catalysts	30,658	0	(282)	30,376
Spent Stretford solution	29,334	180	0	29,514
Heat exch. bundle cleaning sludge	12,775	245	(45)	12,975
Oil contaminated waters (not wastewaters)	8,281	16	2	8,299
Leaded tank bottoms	3,066	34	398	3,066
Spent sulfite solution	1,173	0	0	1,173
Total	**18,105,376**	**88,351**	**46,824**	**18,240,110**

Table 8 presents the total amount of residuals managed in 1990 along with that reported for the preceding survey years.

Table 8
Total Amount of Residual Material Managed (Estimated Quantities) (wet tons)

Residual streams	1990	1989	1988	1987
Aqueous residuals NOS	11,106,421	11,100,221	11,076,251	11,296,230
Pond sediments	1,039,6457	273,217	311,268	359,996
Contaminated soils/solids	914,926	495,511	242,074	185,819
Spent caustics	894,258	715,540	655,528	674,522
Biomass	794,045	654,977	748,589	720,355
DAF float	564,303	520,798	660,514	653,899
Inorganic residuals NOS	453,163	440,809	220,503	322,702
Other residuals NOS	352,550	325,212	412,380	202,645
Spent acids	336,591	8,424	160,399	130,436
Slop oil emulsion solids	295,036	262,349	213,551	211,854
API separator sludge	259,601	424,501	430,042	563,733
FCC catalyst/equivalent	259,311	185,380	189,191	170,853
Nonleaded tank bottoms	196,485	163,700	130,851	217,869
Waste oils/spent solvents	114,609	30,896	7,346	4,453
High pH/low pH waters	105,238	91,513	138,269	144,015
Other separator sludges	103,861	116,945	110,251	82,797
Residual coke/carbon/charcoal	91,798	137,103	66,549	42,712
Residual amines	74,861	51,053	13,798	13,107
Contaminated soils NOS	69,380	53,266	76,698	88,002
Oily sludges/organic residuals NOS	53,500	47,219	61,336	40,024
Other spent catalysts	40,590	33,396	37,904	38,238
Residual sulfur	34,544	51,705	22,714	17,299
Hydroprocessing catalysts	30,376	35,787	36,630	39,415
Spent Stretford solution	29,514	42,449	49,264	34,881
Heat exchanger bundle cleaning sludge	12,975	2,455	4,643	2,977
Oil contaminated waters (not wastewaters)	8,299	28,907	35,867	28,156
Leaded tank bottoms	3,066	4,471	9,615	9,264
Spent sulfite solution	1,173	7,937	40,274	42,262
Total	**18,240,114**	**16,305,741**	**16,162,299**	**16,338,555**

As previously noted, a substantial contribution to the overall quantity of residual material managed in 1990 was due to the closure of surface impoundments (which resulted in the creation of **pond sediments**) and remediation and construction at the refineries that spiked the generation of **contaminated soils/solids.**

Figure F illustrates the relative contributions to the total quantity of waste managed in 1989 and 1990 by contrasting the overwhelming quantity of other aqueous residuals reported as generated routinely by the statistical outliers, with the quantities of pond sediments and contaminated soils that were reported as abnormal, one-time events, and with all other residuals. This graph highlights that the 1990 spike in pond sediments and contaminated soils was four times the amount reported as one-time quantities for these same streams in 1989.

Figure F
Comparison of Managed Quantities: 1989 - 1990

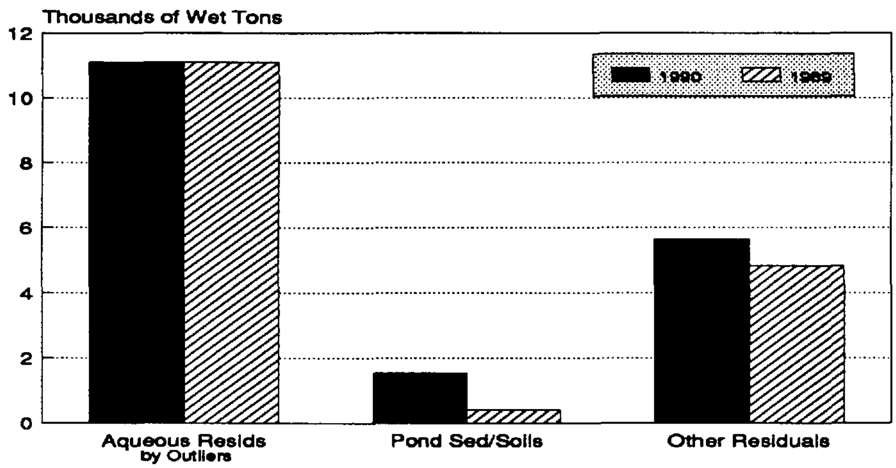
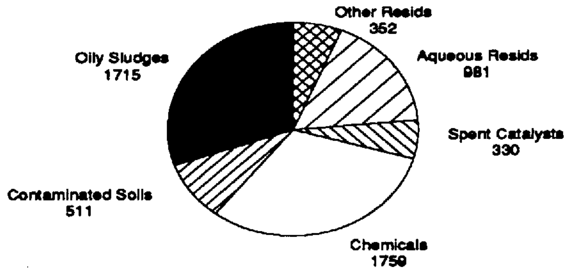


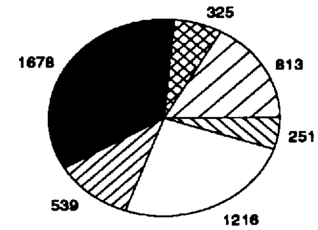
Figure F also shows that there was a slight increase in the other residuals streams, most of which are generated on a routine basis.

Figure G summarizes the differences in management quantities for these residuals, grouped according to the six residuals classes discussed previously. The largest increase was in the Chemicals category, which includes the **Spent acid** and **spent caustic** streams. As the pieces of the pie charts indicate, the remaining categories remained quite constant, ranging from a drop of 37 tons for Contaminated Soils to an increase of 168 tons for the category that includes **biomass**, among the other Aqueous Residuals.

Figure G
Distribution of Routinely Generated Residuals: 1989 - 1990 (excluding outliers)
(thousands of wet tons)



1990



1989

Source Reduction and Resource Recovery

API uses the waste management hierarchy to structure its collection of information on refining practices. Placed at the top of the hierarchy, source reduction is the most desirable approach to managing residuals: preventing their creation in the first place. Both EPA and API have learned through their respective survey efforts, however, that it is difficult to capture information on such practices because of the variety of potential activities involved, many of which result in residual reductions as a secondary benefit. Another, and perhaps the central problem with collecting reliable data is that source reduction involves counting a negative: the residual material which was *not* produced as a result of the source reduction activity. As the API survey has demonstrated, the quantities of residuals generated vary from year to year, creating a "noisy" background against which to calculate source reduction benefits.

To help clarify what is meant by source reduction, and to promote the development of more reliable estimates of residual prevented, API revised its form for 1990 to distinguish between

1) **Resource Recovery** activities that minimize residuals, and

2) **Source Reduction** activities.

In particular, resource recovery activities were defined as those which involve *out-of-process* recycling, while source reduction encompassed a variety of procedure and equipment modifications, as well as *in-process* recycling activities. In addition to classifying the activities as either source reduction or resource recovery, refiners were asked to categorize quantities reduced by stream and by activity. The descriptive information obtained from these questions, and the quantitative information obtained is summarized below.

Source Reduction

In 1990, 62 refineries reported source reduction activities. This increase from 55 refineries in 1989 seems nominal, but actually represents a 10 percent increase in the reporting rate. The amount of material reported—315,524 wet tons—is nearly twice that reported previously.

Table 9 summarizes the source reduction information according to the six activity categories that have been recognized by EPA in guidance materials. Procedure modifications were reported most frequently and resulted in 177,387 wet tons of residual prevented or 33 percent of all source reduction activity. A greater variety of activities were considered procedure modifications: improvements in separation techniques, changes in how and when clean-outs and changeouts are performed, and modification of cokers to accept different residuals.

Within process recycling accounted for 31 percent of the source reduction activity (98,200 wet tons), reflecting the recycling of recovered oils to crude units and cokers.

Table 9
Summary of Source Reduction Methods

Source Reduction Method	# Citations	Wet Tons Reported
Procedure modifications	73	177,387
Within process recycling activities	64	98,200
Improved housekeeping, training, or inventory control activities	41	25,330
Equipment and technology modifications	18	13,864
Activities to substitute materials	6	698
Activities to reformulate or design products	5	45
TOTAL	207	315,524

Improved housekeeping, training and inventory controls were reported by 41 refiners and resulted in a reduction of 25,330 wet tons of residual. The industry continued to improve its procedures for minimizing solids entering the sewer systems, installing concrete drains, ditches and sump pads, reducing reliance on sand bags for hot work, as well as improving grounds keeping, particularly by increases in sweeping and paving.

The number of refineries reporting **equipment and technology modifications** was slightly less in 1990, but likely reflects more accurate and consistent use of this source reduction category. The types of modifications reported included upgrading separators, changing piping systems and replacing units (kerosene Merox heaters, Stretford units, cyclones, isomerization units).

Given the nature of the industry and the performance specifications for fuel products, few refineries reported **activities to reformulate or design products** or to **substitute materials.** Phase out of leaded gasolines accounts for most of the changes in products, while the substitution of materials involves use of less hazardous substances, such as non-solvent cleaners.

The source reduction methods were categorized by stream. As shown in Table 10. At least one type of source reduction activity was reported for 25 of the 28 residual streams.

Activities to prevent the creation of listed hazardous wastes—**API separator sludge, DAF float, slop oil emulsion solids, leaded tank bottoms, and heat exchanger bundle cleaning sludge**—summed to 139,126 wet tons or 30 percent of the total. Other streams with substantial quantities eliminated include **spent caustics, biomass**, and **nonleaded tank bottoms**.

Table 10
Summary of Source Reduction Activities - 1990

Residual stream	Wet Tons	SOURCE REDUCTION METHOD 1	2	3	4	5	6
API Separator Sludge	17,920	✓	✓			✓	✓
DAF Float	87,871		✓			✓	✓
Slop Oil Emulsion Solids	33,040		✓			✓	✓
Leaded Tank Bottoms	74		✓	✓			
Other Separator Sludges	6,452		✓			✓	✓
Pond Sediments	9,345		✓				✓
Nonleaded Tank Bottoms	30,020	✓	✓			✓	✓
Waste Oils/Spent Solvents	8,013	✓			✓	✓	✓
Other Oily Sludges/Organic Wastes	855	✓	✓			✓	✓
Heat Exch Bundle Cleaning Sludge	221	✓				✓	✓
Contaminated Soil/Solids	4,251	✓		✓	✓		✓
Residual coke/Carbon/Charcoal	14					✓	
Other Contaminated Soils NOS	599	✓	✓			✓	✓
FCC Catalyst or Equivalent	3,202	✓	✓		✓		
Hydroprocessing catalysts	60		✓				
Other Spent Catalysts	10	✓	✓				
Biomass	34,351		✓			✓	✓
Oil Contaminated Waters/not WW	315					✓	
High pH/Lo pH Waters	9,102		✓				
Spent Stretford Solution	160	✓					
Other Aqueous Waste NOS	4,882	✓	✓				✓
Spent Caustics	43,672	✓	✓			✓	
Residual amines	19,328		✓				✓
Other inorganic residuals NOS	2,109		✓		✓	✓	
Other Residuals NOS	295		✓		✓	✓	✓
TOTAL	315,524						

SOURCE REDUCTION METHOD CODES
1 = Equipment or Technology Modifications
2 = Procedure Modifications
3 = Reformulation or Design of Products
4 = Substitution of Raw Materials
5 = Recycling Within a Process
6 = Improved Housekeeping, Training, or Inventory Control

There were a number of changes in the types of source reduction methods reported by stream. In 1990, procedure modifications were reported most frequently (for 19 streams), followed by recycling and housekeeping improvements (both 15 streams). In 1989, equipment modification and recycling led reporting by streams with 15 each, followed by housekeeping improvements (12 streams) and procedure modifications (11 streams).

These changes in the activities undertaken affected all but two streams, **other separator sludges** and **waste oils/spent solvents**, where procedures remained constant. In all, there were 38 changes between the two years, including: (1) four new streams with equipment/technology modifications; (2) nine different streams with procedural changes; (3) five streams with new housekeeping improvements. Reciprocally, seven streams for which equipment modifications had been reported in 1989, did not report modifications in 1990. There were also five fewer reports in 1990 of substitution of materials.

Appendix B contains a summary of the raw data collected on source reduction which supports the foregoing discussion. Refer to these tables for a slightly more detailed presentation of the actual methods performed on each stream to prevent the generation of residual material.

The survey also included questions on the *incentives* for implementing source reduction, and the *barriers* that impeded these activities. As shown in Table 11, the most frequently cited reason for implementing source reduction activities was economic: to reduce treatment and disposal costs. It is not surprising with land disposal restrictions for listed hazardous wastes becoming effective in 1990, the percentage of refineries citing this reason rose. Refineries citing other process cost reductions also rose in 1990 to 43% of respondents. The percentage of refineries reporting the remaining reasons remained fairly constant, with less than a third reporting occupational safety or concerns with public opinions as motivating factors.

Table 11
Incentives for Source Reduction Activities (% of refineries reporting)

Reasons	1990	1989
Reduction of treatment/disposal cost	93%	84%
Self-initiated review	69%	67%
Regulatory requirement for waste	43%	44%
Other process cost reduction	43%	26%
Occupational safety	31%	33%
Concern over public reactions	25%	31%
Pressure from public or environmental groups	5%	9%

Cost was also the most frequently cited *barrier* to implementing source reduction. Sixteen refineries or 34 percent of the 47 refineries that did not implement source reduction activities reported that source reduction was not economically feasible.

Resource Recovery

Significant editing was required to make the resource recovery reports conform to the intent of the question: to capture information on the reuse of residual materials, either on-site or for other uses off-site that were *initiated in 1990*. For example, many refiners initially reported in-process recycling of oily materials under this question, rather than as a source reduction activity. These responses were recategorized as source reduction during the data cleaning process. In this editing process, care was exerted to assure that activities were not reported under both resource recovery and source reduction.

Twenty eight (28) refiners reported some type of resource recovery activity. Because many refiners reported multiple conservation activities this resulted in a total frequency of 60 reports, involving 19 streams.

As shown in Table 12, the number of refineries reporting initiating resource recovery activity for any individual stream was low. The stream with the highest frequency of resource recovery reports was **other residuals NOS** with eight reports. This was followed by **FCC catalyst or equivalent** and **hydroprocessing catalysts** with seven each, and **other inorganic residuals** with 6 refineries.

A total of 143,841 wet tons of residual materials were reported as reused. This is less than 1 percent of the total quantity of waste managed in 1990. This suggests that most of the off-site or out-of-process recycling reported on the data sheets, but not captured here, reflected industry practices that predated the 1990 initiation criteria of this question.

Table 12 also presents a brief narrative description of the resource recovery activities reported. Reuse on-site of **spent acids** and **caustics** to adjust the pH of the wastewater system was reported by four refiners, but constituted close to 70 percent of all residuals reused. Reuse in cement kilns, an off-site activity, was cited for six streams: **contaminated soils/solids, other inorganic residuals NOS, API separator sludge, residual coke/carbon/charcoal, FCC catalyst or equivalent**, and **waste oils/spent solvents**. This accounted for approximately 25 percent of the material reused. The resource recovery question was not designed to capture information regarding the purpose of materials reused in cement kilns. However, those residues with a high hydrocarbon content would be used for fuels to a kiln, while inorganic residuals would be used as an ingredient in the cement production process.

The stream that had the greatest variety of activities reported—**other residuals NOS**—represents a large variety of materials: batteries, lab wastes, paper products etc. The variety of recovery methods for **other residuals NOS** reflects the inherent diversity of the category and underscores the need tailor reuse activity to the residual under consideration.

Table 12
Summary of Resource Recovery Data

Residual stream	# Citations	Wet Tons	DESCRIPTION OF ACTIVITIES
Spent Acids	1	67,000	Reuse to adjust pH of wastewater system
Contaminated Soils/Solids	3	30,499	Reused in asphalt & cement kilns
Spent Caustics	3	29,768	Reuse to adjust pH of wastewater system
Nonleaded Tank Bottoms	4	6,804	Centrifuge tank bottoms; recycle recovered oil
Other inorganic residuals NOS	6	3,893	Lime solids/slurry sold as raw material for cement kilns Pretreatment recycle or stabilize
FCC Catalyst or Equivalent	7	1,329	Reuse in cement kilns Reuse as road base filler Sold for recycle
Residual coke/Carbon/Charcoal	4	1,087	Fines sold for reuse Regenerated Reused in cement kilns
Other Spent Catalysts NOS	4	925	Off-site recovery Reuse as fertilizer feed
Hydroprocessing Catalysts	7	871	Off-site reclamation Metals recovery
Slop Oil Emulsion Solids	1	818	Oil recovered used as fuel off-site
API Separator Sludge	5	335	Use as fuel for cement kiln Coke fine recovery system used Thicken in storage tanks
Oil Contaminated Waters	1	300	Recycle toluene unit cooling water
Other Contaminated Soils NOS	1	125	Centrifuge filter clay to recover kerosene
Other Residuals NOS	8	68	Send batteries to reclaimer Send white & computer paper to pulp mill Send aluminum cans to recycler Metal reclamation off-site Waste paint used in fuel blend
Waste Oils/Spent Solvents	2	9	Reuse as fuel for cement kiln Off-site reclamation
Other Oily Sludges/Organic Residuals NOS	1	5	Anti-freeze to recycler
Residual sulfur	1	4	Recover sulfur spill
Heat Exch. Bndl Clean Sludge	1	1	Treated water reused
Pond Sediments	1	1	Pond not used; water recycled
TOTAL	60	143,841	

Management of Residual Materials

The remaining steps of the waste management hierarchy—recycling, treatment, and disposal—were used on API's data sheets to categorize the practices used to handle wastes and residual materials. In the data collection phase of this survey, Land Treatment is classified under the broader category of Treatment; however, as in previous reports, Land Treatment practices are described in a separate section. The SAS printouts that support the following discussion of the handling practices are presented in Appendix C.

Recycling

In 1990, 1.9 million wet tons of waste and residual materials were recycled by petroleum refiners. This is about 10 percent of the total amount of waste managed—an increase of 2 percent over the total recycled in 1989. After adjustment to correct for the outliers—the percentage of materials recycled is 33 percent of the total residuals managed. Tracing this statistic over time, the industry is steadily increasing its reliance on recycling: from 21 percent in 1987, to 23 percent in 1988, to 26 percent in 1989 to 33 percent in 1990. Indeed, over the four survey years, over 76 percent more material is managed by recycling.

Table 13 summarizes how materials are recycled. As in previous years, more waste and residual materials were reported as being reclaimed or regenerated, followed by the "Other" recycling category. A drop in the amount of materials sent to the coker was observed in 1990. A small, but steady increase in utilization of crude units has been reported over time.

Table 13
Summary of Recycling Practices
(thousands of wet tons)

Method of Recycling	1990 Tons	%	1989 Tons	%	1988 Tons	%	1987 Tons	%
Coker	192	10	231	17	186	16	148	14
Crude unit	174	9	125	9	85	7	68	6
Reclamation/regeneration	872	46	611	44	434	38	447	42
Other	655	35	408	30	474	41	410	38
Total	1,893	100	1,376	100	1,179	100	1,073	100

Table 14 provides a more detailed presentation of these data, showing the recycling methods used with each stream. **Chemicals/inorganic residuals** and **spent catalysts** contribute the biggest quantities of materials for reclamation and regeneration. As in previous years, **spent caustics** accounted for more than half of the material recycled in this category.

Table 14
Estimated Quantities of Recycled Materials
(thousands of wet tons)

Recycling Method/Residual stream	1990	1989	1988	1987
Coker				
DAF float	75	79	45	82
Biomass	56	59	27	25
Slop oil emulsion solids	42	9	23	19
API separator sludge	8	55	73	14
Nonleaded tank bottoms	7	23	7	0
All others	4	6	11	8
Total	192	231	186	148
Crude unit				
Waste Oils/Spent Solvents	64	0	0	0
Nonleaded tank bottoms	34	18	13	11
Slop oil emulsion solids	29	17	27	12
DAF float	22	34	19	16
Other separator sludges	13	26	13	8
API separator sludge	10	24	13	18
All others	2	6	0	3
Total	174	125	85	68
Reclamation/regeneration				
Spent caustics	535	459	243	262
Spent acids	200	0	56	57
Hydroprocessing catalysts	28	32	21	26
FCC catalyst or equivalent	7	27	7	11
Residual coke/carbon/charcoal	48	40	43	27
All others	54	35	120	212
Total	872	611	378	390
Other*				
Spent acids	128	1	0	0
Other inorganic residuals NOS	102	6	14	18
Spent caustics	123	138	254	232
Slop oil emulsion solids	54	63	0	0
Residual coke/carbon/charcoal	25	67	9	0
All others	218	141	220	178
Total	655	409	474	410
Grand total	1,893	1,369	1,156	1,055

* Includes materials sent to industrial furnaces and unspecified practices.

This year, **spent acids**, which had not previously been included in the high quantity streams, became the second highest volume material for reclamation/regeneration activity. In fact, with the exception of **hydroprocessing catalysts**, there was a fair degree of change in the amounts of materials reclaimed/regenerated. With 7 thousand wet tons—a figure comparable to the 1988 and 1987 reports—**FCC catalyst or equivalent** was less than half of that reported in 1989. This may reflect the reduced number of cracking facilities in the sample, but also suggests that there is a pattern of variability even in continuously generated high volume streams.

Recycling via cokers accounted for 10 percent of the recycling within the industry. **DAF float** and **biomass** remained the two highest quantity streams, with steady increases over time. The amount of **slop oil emulsion solids** sent to cokers jumped in 1990, while the amount of **API separator sludge** dropped. Use of the crude unit to manage oily residuals accounted for 9 percent of recycling. **Waste oils/spent solvents**, a stream that did not previously have high quantities, accounted for 37 percent of the material returned to the crude unit. In 1990, the quantities of both **nonleaded tank bottoms** and **slop oil emulsion solids** sent to the crude unit nearly doubled from 1989.

In the "Other" recycling category, two streams which had not previously been high quantity streams were identified: **spent acids** and **other inorganic residuals**.

Table 15 presents information on the location of the recycle activities, distinguishing between on-site and off-site activities. Oily materials—**DAF float, waste oils/spent solvents, nonleaded tank bottoms, slop oil emulsion solids**, and **API separator sludge**—were handled on-site. In addition, **biomass**, which was recycled to the coker, generally did not leave the refinery. In contrast, **spent catalysts** and **residual coke/carbon/charcoal** almost always were sent off-site for reclamation and regeneration. **Spent caustics** and **spent acids**, which can be used either on-site to adjust the pH of wastewater treatment systems or off-site for regeneration or other reuse, exhibited a more equally divided pattern of location for recycling.

Table 15
Location of Recycling Activities
(thousands of wet tons)

Residual Stream	Quantity	% On-Site	% Off-site
Spent caustics	658	53	47
Spent Acids	328	32	68
DAF float	138	98	2
Waste oils/spent solvents	109	100	0
Other inorganic residuals	104	86	14
Slop oil emulsion solids	137	97	3
Biomass	58	100	0
FCC catalyst or equivalent	62	7	93
Contaminated soils/solids	49	7	93
Nonleaded tank bottoms	44	99	1
API separator sludge	29	73	27
Hydroprocessing catalysts	28	0	100
Residual coke/carbon/charcoal	74	0	100

evidence a straightforward relationship—a correlation between the amount reclaimed and the number of refineries reporting the method.

This is not the case for recycling via cokers and crude units. Cokers accounted for 10 percent of the material recycled and were cited 63 times. Crude units accounted for 9 percent and were cited 73 times. Thus more material is sent to cokers by a fewer number of refineries. The pattern for the **biomass** stream is especially noteworthy: although this stream is second highest volume recycle stream for cokers, it only represents four refineries. Thus, while the quantities of residuals provide a good profile of how materials are handled, the capabilities of individual refineries exert a significant influence on the site-specific protocols for handling residual materials. In particular, not all refiners have cokers, and those that do have their own priorities for handling materials in the unit.

Treatment

The refining industry relies heavily on treatment to manage residual materials that might otherwise be disposed. Treatment is considered to be less desirable than recycling in the waste management hierarchy, but is more preferable than disposal. Thus, it is a necessary component in any waste management plan.

In 1990, the refining industry managed 1,874 thousand wet tons of residuals by treatment. This included a significant amount of water resulting from dewatering certain residuals. Streams that rely most heavily on treatment include some of the low volume streams such as **residual amines** (96 percent eliminated by treatment), **high pH/low pH waters** (85 percent) **spent Stretford solution** (78 percent), and **residual sulfur** (50 percent). The higher volume streams that undergo substantial treatment tend to be more dilute residuals: **DAF float** (61 percent), **other aqueous residues** and **biomass** (both 51 percent).

As shown in Table 16, the total of 1,874 thousand wet tons was more than previously reported, and involves an increase in the use of stabilization and fixation, which was used to handle the large, abnormal peak quantities of pond sediments and contaminated soils. While material managed by incineration remained a constant 9 percent, an increase in the absolute quantity of material incinerated was observed. The increase in the quantity of material sent to incinerators is mostly accounted for by **other inorganic residuals NOS**, and a slight increase in the amount of **DAF float**.

Table 16
Summary of Treatment Methods
(thousands of wet tons)

Method of Treatment	1990 Tons	1990 %	1989 Tons	1989 %	1988 Tons	1988 %	1987 Tons	1987 %
Wastewater	1,265	68	1,176	78	1,045	72	1,167	74
Incineration	165	9	143	9	131	9	107	7
Chemical/physical	131	7	143	9	148	10	117	7
Stabilize/Fixation	276	15	4	<1	5	<1	<1	<1
Other	37	2	45	3	117	8	186	12
Total	1,874	100	1,511	100	1,446	100	1,577	100

In Table 17, wastewater treatment consists of two subcategories:

- o *wastewater from, dewatering/deoiling of oily residuals* (approximately 45 percent of the total) that is subsequently treated in the wastewater treatment system; and

- o *dilute aqueous residuals* treated directly in the wastewater system.[6]

For aqueous chemical residuals and inorganics that received wastewater treatment, increases were reported for **biomass, spent caustics, high pH/low pH waters, residual amines**, and **other inorganic residuals.**

The 7 percent of residual materials managed by chemical or physical treatment was consistent with those previously observed, but this summary statistic hides the fact that there was a dramatic increase in the use of this treatment method for **spent caustics**, and for the first time, noteworthy quantities of **biomass** were handled this way.

Weathering and other treatment methods accounted for only 2 percent of the total quantity of material treated in 1990, with **pond sediments** accounting for the largest amount.

As presented in Table 18, almost all treatment is performed on-site. The stream with the highest proportion of off-site treatment, 30 percent, was **spent caustics.**

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[6] The survey only reports certain residual streams managed in the wastewater treatment system. It does not gather data on the much larger volume of dilute aqueous streams (e.g., tank water draws, cooling water blowdown, etc.) treated and discharged under NPDES permits or discharged directly to POTWs.

Table 17 Estimated Quantities of Residuals Treated
(Does not include land treatment) *(thousands of wet tons)*

Treatment Method/Residual stream	1990	1989	1988	1987
Wastewater treatment				
From dewatered oily materials				
DAF Float	306	248	236	263
API separator sludge	56	149	136	146
Slop oil emulsion solids	108	98	57	98
Other separator sludges	51	53	48	32
Nonleaded tank bottoms	37	37	30	87
Pond sediments	1	48	22	74
Subtotal	559	633	529	700
Aqueous chemical wastes/inorganics				
Biomass	288	249	222	234
Spent caustics	132	93	74	87
High pH/low pH waters	90	53	40	33
Residual amines	71	46	2	2
Other inorganic residuals NOS	50	23	39	33
Spent Stretford solution	16	29	39	17
Oil contaminated waters (not wastewaters)	1	19	35	26
All others	58	31	594	735
Total	1,265	1,176	1,045	1,167
Incineration				
Biomass	98	103	73	64
DAF float	32	26	47	35
Other inorganic residuals NOS	25	0	<1	<1
All others	9	14	11	8
Total	164	143	131	107
Chemical/physical				
Spent caustics	70	8	18	17
Biomass	20	0	17	0
API separator sludge	13	35	10	2
DAF float	5	9	0	0
All others	23	17	120	98
Total	131	143	131	117
Stabilize/Fixation				
Pond Sediments	211	0	0	0
Contaminated soils/solids	55	4	0	<1
Others	10	0	0	<1
Total	276	4	0	<1
Weathering/Other				
Other inorganic residuals NOS	4	23	23	22
Pond Sediments	27	16	21	88
Others	5	10	78	76
Total	36	49	122	186
Grand total	1,877	1,511	1,446	1,577

Table 18
Location of Treatment Activities
(thousands of wet tons)

Residuals Stream	Quantity	% On-Site	% Off-site
DAF float	344	100	0
Biomass	408	89	11
Pond sediments	239	100	0
Spent caustics	203	70	30
High pH/low pH water	90	99	1
Other inorganic residuals	83	100	0
API separator sludge	80	97	3
Residual amines	72	100	0
Slop oil emulsion solids	114	99	1
Other separator sludges	51	100	0
Nonleaded tank bottoms	40	100	0
Spent Stretford solution	23	87	13
Other spent catalysts NOS	12	100	0

Review of the frequency counts for reports of each method again show how the large quantities generated by a few refineries affect the management profile. Not surprisingly, wastewater treatment was reported most frequently—cited 188 times. The second most frequently reported method was incineration, with 117 reports. Thus, many refineries send small quantities of waste to incinerators. The count for stabilization and fixation was most interesting: only 17 refiners reported this method, but because this included the statistical outliers that generated one-time peaks of pond sediments and contaminated soils, it accounted for 15 percent of the total amount of waste treated.

Land Treatment

The petroleum refining industry has long relied on land-based "bio-remediation" to manage many of its residual materials. In land treatment or land farming, organisms that naturally exist in soil are used to biodegrade organic materials. Organic wastes and residual materials are tilled with fertilizers into soil, and watered. Tilling oxygenates the mixture, while the nutrients and moisture encourage the growth of biological organisms that feed on organics.

Because land treatment involves placing residual materials on the land, it is subject to land disposal restrictions under RCRA. These prohibitions became effective in late 1990. Unless refiners obtained "no migration" petitions, they are not able to continue the placement of listed hazardous wastes in land treatment units. Because land treatment is most effective with the oily materials that are subject to these requirements, 1990 witnessed the last year in which refiners could use land treatment to handle such residuals without approval of a "no migration" petition.

From this perspective, one would have anticipated an increase in the amount of materials land treated in 1990. Although an increase was observed, as shown in Table 18, it resulted from the peak, abnormal quantities of **pond sediments** and **contaminated soils and solids**, which were mixed, and nourished, by increased quantities of **biomass.** Indeed, these three streams account for 80 percent of the waste which was land treated in 1990.

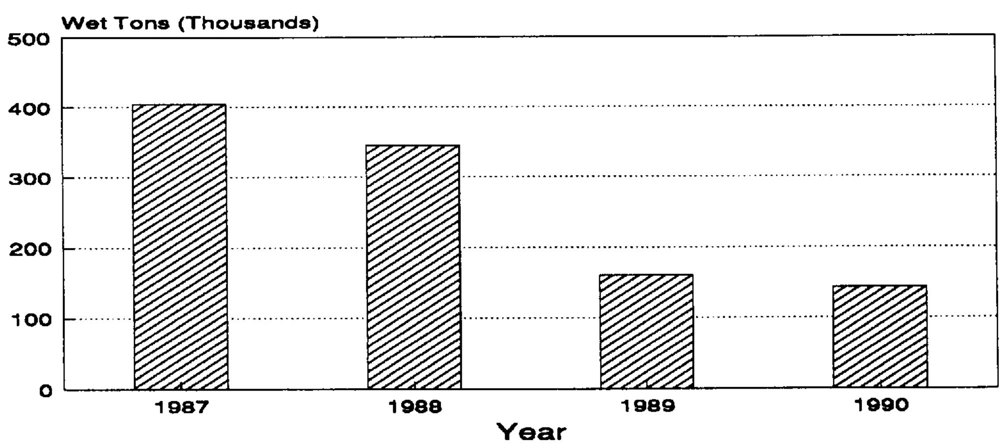
Table 19 portrays some systematic changes in how land treatment has been used. The quantities for both **pond sediments** and **contaminated soils and solids** increased in 1989 and remained high in 1990, after being initially low. With the exception of **other separator sludges** (which becomes primary sludge in 1991, and will subsequently be prohibited from land treatment), the quantities land treated for all other residual streams have decreased over time, with the greatest reductions in **API separator sludge** and **DAF Float.**

Table 19
Estimated Quantities of Land Treated Residuals (thousands of wet tons)

Residual stream	1990	1989	1988	1987
Pond sediments	349	127	64	67
Contaminated soils/solids	299	132	28	22
Biomass	267	187	259	236
API separator sludge*	65	61	85	211
DAF float*	60	72	203	159
Other separator sludges	31	30	22	12
Nonleaded tank bottoms	23	36	34	58
Slop oil emulsion solids	18	27	57	35
Other inorganic residuals NOS	10	16	30	25
Other contaminated soils	7	10	28	22
Other oily sludges/organic wastes	5	6	6	11
All others	14	5	11	14
Total	1,148	709	832	850

In fact, as shown in Figure H, 1990 continued the trend of decreased reliance on land treatment for wastes listed as hazardous under RCRA: down 65 percent when the quantity is compared with 1987.

Figure H
Land Treatment of Listed Hazardous Waste: 1987 - 1990



Disposal

Disposal is considered the least preferred option of the waste management hierarchy. It is virtually inevitable that some material will remain, even after assiduous efforts to recycle valuable material and to reduce volumes by treatment. As has been observed in previous API reports, disposal capacity is essential for the miscellany of wastes that do not contain valuable constituents or that are generated aperiodically, and consequently do not exert a constant demand on limited disposal capacity.

In 1990, a total of 13.3 million wet tons of material was disposed. As shown in Table 20 this is higher than previously reported, with increases primarily due to the amount of material that is placed in landfills.

Table 20
Summary of Disposal Practices
(thousands of wet tons)

Method of Disposal	1990 Tons	%	1989 Tons	%	1988 Tons	%	1987 Tons	%
Disposal impoundments	129	1	113	1	245	2	280	2
Landfills	1,889	13	1,375	11	1,200	9	1,070	8
Landspread	174	1	95	1	160	1	109	1
Injection	11,125	84	11,106	87	11,097	87	11,329	88
Other	8	<1	21	<1	1	<1	41	<1
Total	13,325	100	12,710	100	12,703	100	12,829	100

As review of the data in Table 21 indicates, most of the increase in the use of landfills reflects the generation of peak quantities of **contaminated soils/solids** and **pond sediments** in 1990. Increases were also noted for **nonleaded tank bottoms**, although of a lessor magnitude. The quantities of the other streams that required landfill capacity fluctuated, but within the range anticipated from previous observations.

Disposal impoundments accounted for less than 1 percent of the total amount of waste disposed; **other inorganic waste NOS** was the largest contributor with 86 thousand wet tons. Similarly, landspreading accounted for less than 1 percent.

Regarding the location of the disposal activities, all but the deep well injection of other aqueous residues, require a mix of on-site and off-site capacity. As shown in Table 22, only four streams—**high pH/low pH waters, biomass, spent caustics**, and **residual coke/carbon/ charcoal**—used on-site capacity to dispose of the majority of residuals. Seven streams required almost equal amounts of on-site and off-site capacity: **other residuals NOS, other inorganic residuals NOS, FCC catalyst, spent caustics, residual coke/carbon/ charcoal** and **other oily sludges/organic residuals NOS**. The remaining residual streams relied on off-site capacity for disposal.

Table 21
Estimated Quantities of Wastes Eliminated by Disposal
(thousands of wet tons)

Disposal Method/Residual stream	1990	1989	1988	1987
Disposal impoundment				
Other inorganic residuals NOS	86	65	25	56
High ph/low Ph waters	13	24	16	25
FCC catalyst or equivalent	20	14	13	11
All others	10	10	191	188
Total	129	113	245	280
Landfill				
Contaminated soils/solids	497	317	189	141
Pond sediments	405	60	50	7
Other residuals NOS	336	315	384	195
Other inorganic residuals NOS	162	227	77	155
API separator sludge	79	77	51	54
FCC catalyst or equivalent	117	104	115	123
Nonleaded tank bottoms	82	45	42	53
Other contaminated soils NOS	46	38	69	82
Biomass	32	37	48	41
Slop oil emulsion solids	22	19	22	25
DAF float	21	29	51	31
Residual sulfur	17	20	19	16
Residual coke/carbon/charcoal	15	28	13	13
Other oily sludges/organic residuals NOS	13	22	14	8
All others	30	37	56	56
Total	1,889	1,375	1,200	1,070
Landspread				
Biomass	26	15	48	51
Contaminated soils/solids	15	16	11	4
Pond Sediments	46	1	15	18
Other inorganic residuals NOS	8	14	10	11
FCC catalyst or equivalent	57	13	1	5
Slop oil emulsion solids	1	20	2	4
All others	21	16	73	15
Total	174	95	160	109
Injection				
Aqueous residuals NOS	11,089	11,091	11,067	11,289
Spent caustics	32	14	24	33
All others	4	1	6	7
Total	11,125	11,106	11,097	11,329
Other methods	8	21	2	41
Grand total	13,325	12,710	12,703	12,829

Table 22
Location of Disposal Activities
(thousands of wet tons)

Residual Stream	Quantity	% On-Site	% Off-site
Aqueous residuals NOS	6	100	0
Contaminated soils/solids	512	4	96
Pond sediments	451	11	89
Other residuals NOS	336	48	52
Other inorganic residuals NOS	256	43	57
API separator sludge	84	5	95
FCC catalyst or equivalent	194	48	52
Biomass	61	67	33
Nonleaded tank bottoms	89	13	87
Other contaminated soils NOS	58	19	81
Spent caustics	34	55	45
Slop oil emulsion solids	24	1	99
DAF float	22	3	97
Residual coke/carbon/charcoal	18	28	72
Other oily sludges/organic residuals NOS	15	55	45
Residual sulfur	17	10	90
High pH/low pH waters	14	92	8
Other spent catalysts NOS	15	35	65

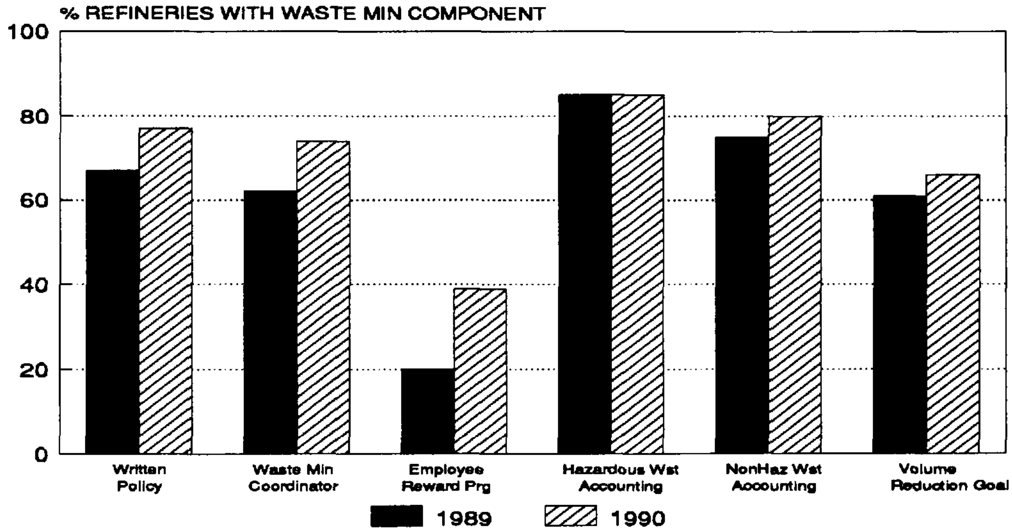
Waste Minimization Programming

Section 3002(b)(1) of RCRA requires that generators of hazardous waste have "a program in place to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable." In its technical assistance and guidance documents, EPA has identified management commitment, characterization of wastes and delineation of volume reduction goals as important components of a waste minimization program.

For the survey, indicators of management commitment to waste minimization were the availability of a written policy directive, the dedication of personnel to the project, and the presence of employee awards to promote waste minimization. The presence of hazardous and non-hazardous waste accounting mechanisms were used to measure waste characterization activities. Refineries were also asked whether goals had been set for waste reductions.

As depicted in Figure I, the percentage of refineries reporting the presence of each waste minimization program component increased in 1990. The largest increase was for the Employee Award Program which almost doubled. Despite this gain, this remained the only program component that had not been adopted by a majority of refineries. Indeed, the five other components have been adopted over 60 percent of the reporting refineries.

Figure I
Waste Minimization Program Components



DISCUSSION

Residual Generation

In 1990, the petroleum refining industry generated approximately 18.2 million wet tons of residual materials. This is approximately 1.9 million wet tons more than was generated in 1989, or a 12 percent increase. When divided by the amount of crude oil refined in 1990 (658 million wet tons) the ratio of residual to crude oil is 0.0277, compared with 0.0248 in 1989. Removing the effect of the statistical outliers reduces this ratio to 0.008 or less than 1 percent.

Nonetheless, an increase of 1.9 million wet tons of residual materials is a substantial quantity in its own right, and deserves further evaluation. To this end, API has performed some preliminary analysis to better understand the increase.

Table 23 presents the estimates for each residual waste stream for 1990 and 1989, along with the difference between years and the percent change. As indicated by the negative values, 9 streams had overall *decreases.* Of the remaining 19 streams, 6 remained constant with changes less than 10 percent, 8 had moderate increases, while 5 had substantial changes (greater than 80 percent).

Table 23 suggests the overall increase in 1990 can be traced back the four streams with substantial changes: **pond sediments, contaminated soils, spent acids,** and **spent caustics**. The largest increase was for **pond sediments**, where 894 wet tons of the total of 1,017 wet tons were reported as a result of "abnormal events", herein, the closure of ponds.

The 80 percent increase in **contaminated soils** reflects the influence of abnormal or one-time events, with 604 thousand or 66 percent of the total quantity generated because of remediation or construction activities that necessitate one-time removal of soil. Thus, the driving force for this increase is similar in nature to the one-time activities associated with pond closures.

These one-time events probably reflect some of the regulatory developments that occurred in 1990. In particular, policy guidance contained in several rules enabled the industry to begin some long term planning efforts. Promulgation of the final land disposal restrictions under the Resource Conservation and Recovery Act (RCRA) set forth the treatment standards for listed hazardous wastes. Until these waste treatment standards were codified, industry could not reliably predict which technologies would satisfy the treatment criteria. Similarly, passage of the Clean Air Act Amendments in 1990 charted a course which will result in the development of new fuels, requiring new equipment and processes.

In addition, promulgation on March 7, 1990, of the Benzene Waste New Emission Standard for Hazardous Air Pollutants (NESHAP) under the Clean Air Act and the final RCRA rule on November 2, 1990, listing sludges from primary oil/water/solid separation as hazardous set forth a new regulatory framework for handling additional materials associated with wastewater treatment. While neither of these rules exerted an immediate impact in 1990, both affected similar residual materials, and influenced activities undertaken by refiners to handle these materials in the future. Indeed, finalization of these regulations, even though their effective

Table 23
Comparison of Residual Materials Generated in 1990 and 1989
(thousands of wet tons)

Residual stream	1990	1989	Change	% Change
Aqueous residuals NOS	11,106	11,100	6	<1%
Pond sediments	1,017	313	704	225%
Contaminated soils/solids	920	512	408	80%
Spent Caustics	889	716	173	24%
Biomass	782	642	140	22%
DAF float	553	496	57	11%
Other inorganic residuals NOS	451	440	11	3%
Other residuals NOS	352	325	27	8%
Spent acids	336	8	328	410%
Slop oil emulsion solids	291	272	19	7%
API separator sludge	251	419	-168	-40%
FCC catalyst or equivalent	198	182	16	9%
Nonleaded tank bottoms	194	161	33	20%
Waste oils/spent solvents	115	31	84	271%
High pH/low pH waters	105	91	14	15%
Other separator sludges	97	114	-17	-15%
Residual coke/carbon/charcoal	92	129	-37	-29%
Residual amines	75	51	24	47%
Other contaminated soils NOS	69	53	4	6%
Other oily sludges/organic residuals NOS	53	47	6	13%
Other spent catalysts NOS	39	33	6	18%
Residual sulfur	35	52	-17	-33%
Hydroprocessing catalysts	31	36	-5	-14%
Spent Stretford solution	29	42	-13	-31%
Heat exchanger bundle cleaning sludge	13	2	11	550%
Oil contaminated waters (not wastewaters)	8	29	-21	-72%
Leaded tank bottoms	3	4	-1	-25%
Spent sulfite solution	1	8	-7	-88%
Total	18,106	16,311	1,775	10.8%

dates were more than two years after the 1990 survey cycle, combined with the policy guidance on waste treatment standards, provided substantial incentives for the industry to voluntarily initiate remediation activities before regulatory mandates required these actions and before the costs associated with handling materials considered regulated wastes, increased.

Turning back to Table 23, for **spent acids**, the increase appears to reflect several factors: four refineries that reported this stream in 1990, but not in 1989 (contributing 106 thousand wet tons), and four refineries that did not participate in 1989, but did in 1990 (also reporting 106 thousand wet tons). While this does not account for all of the increase observed, it does raise a question regarding the potential influence of respondent bias or error on this question. Specifically, API had previously hypothesized that many refineries do not report all of the spent acid they generate because they sell this as a by-product or reuse it on-site. Consequently they do not consider **spent acid** to be a waste. This reporting practice may have changed in 1990 as evidenced by not only the increase in generated quantity, but the increases noted in the quantities of **spent acid** recycled in 1990: 200 thousand wet tons reported as reclaimed/regenerated and 128 thousand wet tons that was recycled via "other methods" (including being sold for off-site reuse).

A change in reporting criteria may also be responsible for the increase in the quantity of **spent caustics** generated in 1990. In reviewing the raw data, the quantities reported by two thirds of the refineries that participated in both years are fairly constant. Substantial increases are noted, however, for several refineries. In addition, one refinery that did not report any **spent caustics** in 1989 reported a large amount in 1990. Turning again to the recycling practices (Table 13), a 16 percent increase in the reclamation/regeneration rate is noted. While this is not as dramatic an increase as that noted for **spent acids**, it may indicate a similar change in the pattern of reporting.

Indeed, API considers the point of generation of a residual an important issue. If a refinery wants to report in this survey its beneficial handling practices that reduce the quantity of residual ultimately requiring disposal, it must designate the point of generation of the residual earlier in the process. Consequently, the refinery reports a larger quantity of residual generated, and subsequently, on the management side of the equation, a greater proportion eliminated by recycling and treatment. Conversely, if a refinery prefers to report a small quantity of residual, and not report on-site practices that minimize waste, the point of generation is defined closer to the point of disposal. Although there may be little latitude in this decision for many streams, for several streams like **spent acids** and **spent caustics**, more discretion is involved. Indeed, given the ongoing cultural change that embraces waste minimization and pollution prevention, more refineries may choose to report larger quantities of these streams as residuals so that they can report reclamation/regeneration and reuse, even though they previously viewed these materials as by-products, and not residuals.

The last stream that had a substantial increase was **biomass**, with 173 thousand more wet tons more generated in 1990 than in 1989. Although there is no ready explanation for this increase, it is interesting to note that four of the statistical outliers also reported large quantities of this stream.

There was a fairly dramatic decrease in the amount of **API separator sludge** generated. The industry has reduced the quantity of this stream by 40 percent, largely through the source reduction activities reported in 1989 and 1990. Specifically, the refiners have exerted a concerted effort to reduce the generation of this hazardous waste by modifying procedures and housekeeping practices that minimize the amount of solids entering the wastewater system, and thus preventing the creation of oily sludges.

Some of the small decreases in streams such as in **spent Stretford solution** or **spent sulfite solution** may not be statistically significant, but remain noteworthy. Although very few refineries generate either of these residuals, API's survey is documenting ongoing changes in practices at these facilities. For **spent Stretford solution**, only 7 refineries still generate this residual (4 less than in 1989), while only one facility still creates **spent sulfite solution**. These changes therefore symbolize some of the procedural changes going on at refineries. The reductions noted for the other streams are much smaller and, in most cases, it is difficult to determine their significance.

The observations on generation quantities for 1990 defy a simple assessment of industry progress. Overall numbers have increased by 11 percent, but most of this can be traced to activities performed at a small number of refineries and generally reflect one-time events. These one time events—the closing of surface impoundments and ponds, remediation of sites, and construction of new units—should be viewed as indicators of change and improved handling practices.

It is likely that some of the peak quantities noted for **pond sediments** and **contaminated soils** in 1990 will persist for more than one year, since many of the projects undertaken to close ponds and to install new sewers and tank systems are multi-year construction projects. Thus, overall generation quantities may continue to be inflated by what are considered abnormal events. However, the more detailed, longitudinal analysis that will be undertaken next year will help to identify the sources of variability in the generation quantities. Indeed, the availability of a cohort of over 80 refineries that have participated in all five survey cycles will enable a more sensitive analysis of generation patterns.

Clearly, the generation of residual materials by the refining industry is a complex phenomena . At the *refinery level*, it reflects longstanding practices, maintenance, and turnaround schedules. These patterns are affected, or can be modified by, regulatory initiatives and corporate management decisions to change procedures or to enhance physical plants. Lastly, there are of course the unplanned events—spills, fires, floods and unit failures—that cause unanticipated spikes in the generation profile.

At the *industry level*, as captured by this survey, these procedures are classified according to a framework intended to impose consistency on reporting various activities. This framework itself introduces potential reporting bias for refiners who are forced to categorize activities by an externally imposed metric. Moreover, because participation in the survey is voluntary, there is some turnover in the respondent pool for each survey cycle. Even within refineries that participate in successive years, changes in the people who fill out the survey forms can affect the quality of the data received. Consequently, there are many potential reasons why changes in generation quantities occur.

Resource Recovery and Source Reduction

The data collected on resource recovery and source reduction show that the industry has reduced, by close to half a million tons (459 thousand), the amount of waste material requiring disposal. Precisely, resource recovery accounted for 143 thousand wet tons of material that was recycled out-of-process or off-site, while 316 thousand wet tons of waste was prevented due to source reduction practices. When these reductions are compared with the quantities of residuals generated by typical refineries (i.e., facilities that are not statistical outliers) they constitute 8 percent of the total quantity of waste generated—a substantial increase over the quantity reported as source reduced in 1989.

Classifying these practices according to the definitions used in the survey remained problematic, with some refiners reporting in-process recycling as resource recovery, and others reporting off-site reclamation or reuse as source reduction. Although the editing process catches these reports, corrects them, and controls for double counting, it is clear that these questions require yet another revision to improve the quality of the data and to ensure that API is helping the refiners to understand the subtle nuances in this terminology which was coined outside of the refinery.

Indeed, it appears that just as the instructions included in the 1987-1988 survey lead to misinterpretations, the quality control checks tested by API in 1990 also served to further confuse the respondents. Specifically, this year the two questions on resource recovery and source reduction were placed in the beginning of the questionnaire, along with other short answer items. In an effort to encourage responding, and consistent reporting, space was provided on the data sheet for each stream for refiners to indicate whether they had performed source reduction activities and the quantities reduced. Comparison of the data sheet responses with those obtained on question 10 revealed significant disparities. Follow up conversations with refiners to clarify these differences indicated that many refiners intentionally provided two different numbers, assuming that there was no reason to duplicate responses. Consequently, the more detailed information on the source reduction practices contained in question 10 were considered more reliable, and used in the analysis.

Based in this experience, API revised these questionnaire items for 1991. The resource recovery and source reduction questions were combined into one item. This was structured much like the previous source reduction question, requiring respondents to first indicate the quantity of residual reduced, then to code the type of activity performed, and finally to provide a brief narrative of what was done. The six element code system used for source reduction was expanded to ten categories, enabling refiners to distinguish between various on-site recycling activities and off-site reuse and reclamation practices. To reduce respondent burden, this item was placed on each data sheet. This avoided requiring the respondent to additionally code information on the residual stream. Placing it on the data sheet, also consolidated the effort required to provide quantitative information on specific streams. Now all of this information is contained on the respective data sheet.

A final, and significant modification of the item was to label it *pollution prevention*, the only terminology which adequately addresses the broad range of beneficial activities performed by the refining industry. Indeed, the semantics of classifying these activities has been a source of confusion. Although API understands the subtle distinctions between waste minimization, resource recovery, source reduction, and pollution prevention, and has tried to promote an appreciation of these terms within the industry, these distinctions do not promote consistency in this survey application. Use of the pollution prevention rubric, with its broader conceptual base, translated into several more classifications for the various types of beneficial activities, should improve the quality of the data collected. Moreover, using this broader pollution prevention framework will not impede efforts to use the data to demonstrate waste minimization or source reduction progress should the need to do so arise, *since the codes* that comport with these activities can be summed individually.

Despite these data issues, and API's desire to continually improve the quality and ease of the data collection effort, the responses to the resource recovery and source reduction questions indicated that these practices are widespread across the industry. Taken together, the responses to the two questions demonstrate the industry's reliance on recycling activity: 242 thousand wet tons were recycled, reused, or reclaimed. Of this total, 143 thousand wet tons were in out-of-process activities initiated in 1990 and 98 thousand wet tons were within oil refining processes. The former includes reuse of spent chemicals to adjust the pH of refinery wastewater systems, reclamation and recovery of catalysts off-site and the use of soils and inorganics in cement kilns. The in-process recycling reported as source reduction refers largely to the recovery and reuse of oily materials as feed for crude units and cokers.

The responses to the source reduction question indicated that the industry has undertaken a variety of activities to reduce their generation of residual materials. A substantial reduction of 177 thousand wet tons of residuals was achieved by *procedure modifications*, many of which include enhanced filtration and centrifugation to maximize recovery of useable oil. Another 25 thousand wet tons of waste was prevented by *improved housekeeping, training, and inventory control measures*. Many of these activities focused on minimizing the amount of particulate matter entering the wastewater system, which attenuated creation of sludges. Specific activities included paving sumps and collection drains at the refineries, reducing the use of sand for hot work, segregating materials, and increased inventory controls.

Close to 14 thousand tons of residuals were prevented through *equipment and technology modifications*. Such changes usually require greater capital expenditures as older units are retired or replaced (e.g., a sulten unit replacing a Stretford unit) or for the research to identify alternative approaches (e.g., reductions in generation of waste oils/spent solvents by replacing chlorinated solvent vapor degreasers with high pressure power washers).

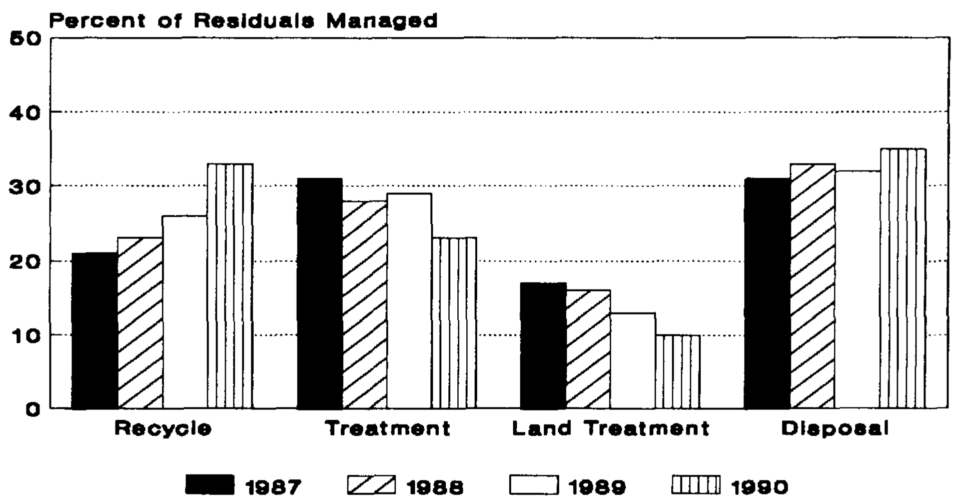
When the source reduction data is looked at by stream, it is clear that refiners exerted effort to reduce the generation of materials that are regulated as hazardous. **API separator sludge, DAF float** and **slop oil emulsion solids** all had sizeable reduction quantities reported. Other streams with large reductions tended to also be routinely generated materials, such as **non-leaded tank bottoms, biomass** and **spent caustics**.

Because refiners have already focused attention on these common streams, and have reported implementing a variety of equipment modifications and procedural and housekeeping measures in 1989 and 1990 to improve efficiencies, it is difficult to predict whether this trend will continue. API believes that source reduction is under reported in the survey and therefore, quantities should increase in successive years as refiners recognize that many ongoing improvements qualify as source reduction. API also recognizes, however, that source reduction achievements are additive, and can quickly reach a plateau after which it is difficult to progress. Indeed, the evolutionary nature of source reduction, and for that matter, pollution prevention, is to achieve fairly dramatic results early on, when common sense and simple procedural changes maximize the efficiency of standard practices. Thereafter, improvements may be incremental, but demand time and resources to develop new technologies, products and processes. Given the refining industry's recognition of the benefits of (or incentives for) source reduction and the continued enhancement of waste minimization programs documented by the 1990 data collection effort, it is reasonable to assume that 1990 represented an early phase of this continuum. It is premature to predict trends in source reduction for subsequent years. It is realistic, however, to caution that any continued incremental reductions may be overshadowed by unanticipated events, like this year's closure of surface impoundments and remediation activities. Use of the revised pollution prevention question for 1991 should help to address the concerns about underreporting of these activities and, at the same time, enable a more precise assessment of the industry's performance.

Residual Management Practices

The survey recorded a series of changes in the way the petroleum industry handles its residual materials, which are graphically depicted in Figure J. When the overwhelming influence of the statistical outliers is controlled (by removing them from calculations), recycling accounted for 33 percent of the residual materials. This 76 percent increase in the quantity of material recycled (compared with 1987), represents the industry's ongoing, progressive effort to maximize recovery, and to increase the reuse and reclamation of oily materials and spent chemicals.

Figure J
Summary of Residual Management Practices: 1987 - 1990
Outliers Removed



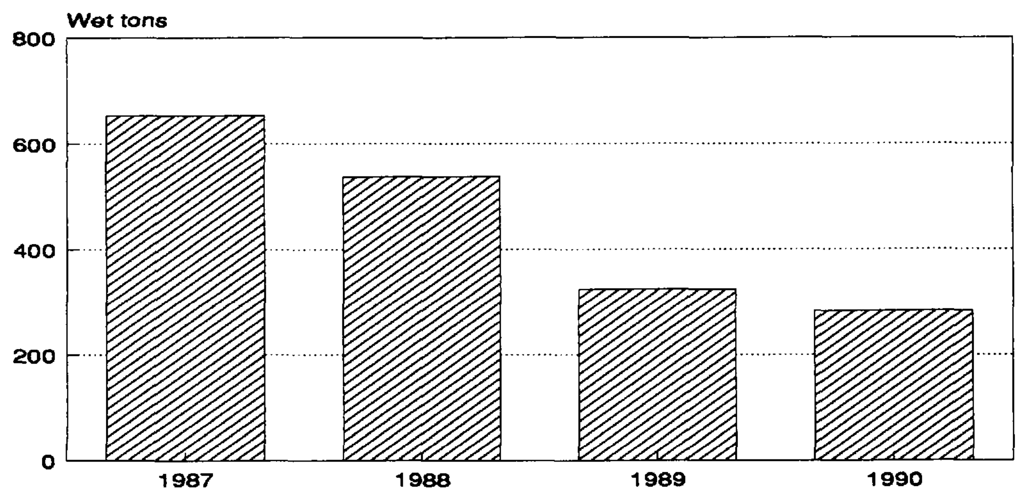
The use of treatment dropped from 29 percent in 1989 to 23 percent in 1990. Although 1990 witnessed an increase in the use of stabilization and fixation for the one-time quantities of contaminated soils and pond sediments (approximately half of which was generated by two of the statistical outliers), there was also a 10 percent reduction in the use of wastewater treatment.

Reliance on land treatment dropped to 10 percent for the non-outlier facilities in 1990. (When the outliers are considered, there is an overall increase in land treatment since this technology is ideally suited to handle some of the peak quantities of pond sediments and contaminated soils generated by outliers.)

When disposal is considered for the facilities that do not deep well inject aqueous wastes and the outliers with large quantities of pond sediments, a slight increase is noted for 1990.

These changes serve to underscore the complexity of residual management decisions and the numerous factors that must be considered. Some of these decisions, particularly those framed by regulatory constraints, are more predictable. For example, prohibitions on land disposal of listed hazardous wastes have forced the industry to place successively smaller quantities of these materials in land farms and disposal units. Figure K shows the clear and consistent decrease in reliance on these methods for listed hazardous wastes.

Figure K
Land Treatment and Disposal of Listed Hazardous Wastes



Another example of how fluctuations in generation quantities influence handling practices involves API separator sludge. As previously noted, the quantity of API separator sludge decreased substantially in 1990. This reduced the amount of oily material to recycle back to cokers. Consequently, the availability of additional coker capacity provided the incentive for refiners to further modify coker functioning so that other streams could be thus handled. Similarly, the availability of additional cement kiln capacity in 1990 influenced how refiners chose to handle those streams that could be used as feedstock or fuel for these units.

While these fluctuations in generation quantities were anticipated, others, like the spikes in the generation of pond sediments and contaminated soils, were less predictable. These one-time quantities pose the biggest challenge to improvements in residual management. Because these materials are only generated periodically, there are fewer opportunities to look for ways to improve handling practices. Moreover, these residuals do not contain valuable materials (e.g., oily portions) that lend themselves to recycling or reuse). Thus, while refiners have succeeded in finding external capacity to handle, often beneficially reusing, routinely generated materials, this is not a viable strategy for handling residuals that are created only periodically. Consequently, larger quantities of these one-time residuals are ultimately disposed.

How the industry accounts for these materials poses another problem. If they are simply added in with all the other information gathered in this survey, they can overshadow the progress achieved with individual streams. This year API removed these one-time quantities from the summary statistics. Next year, consideration will be given to handling these streams differently throughout the estimation procedures, potentially developing separate models for routinely generated materials, other aqueous residuals and other materials generated on a one time basis.

Regarding the management of individual streams, Appendix D contains a series of bar charts summarizing the management practices for each stream for the last four survey cycles. In previous final reports, API created and presented summary charts that aggregated the data for streams with each of the six main categories. Because this tends to overshadow the changes that go on within a particular stream, this has not been done for the 1990 data. Interested readers should review these charts to glean information on the changes in handling practices that have occurred for specific residual streams.

Again, API looks to the trend analysis to be performed with the 1991 survey cycle to more clearly explicate the changes in handling practices. Having the substantial cohort of 80 refiners that have participated in all five survey years will facilitate this analysis.

APPENDIX A - Questionnaire

1990 API Solid Waste Survey-Refining

API ID ____ Leave Blank

1) What was the approximate year this facility began operations?

Check the appropriate box.

☐ Before 1925	☐ 1961 - 1970
☐ 1925 - 1940	☐ 1971 - 1980
☐ 1941 - 1950	☐ After 1980
☐ 1951 - 1960	

2) Which of the following USEPA National Pollutant Discharge Elimination System (NPDES) - Permit Fact Sheet Classifications best describes this refinery?

Check the appropriate box

☐ **Topping**
Refinery uses topping and catalytic reforming, but **not** thermal processes or cracking.

☐ **Cracking**
Refinery uses topping and cracking, but none of the operations designated in the categories below.

☐ **Petrochemical**
Refinery uses topping and cracking, and 1) at least 15% of refinery production is first-generation petrochemicals and isomerization products (e.g., BTX, olefins), or 2) the refinery produces second-generation petrochemicals (e.g., alcohols, cumene), and 3) there is no lube oil manufacturing.

☐ **Lube**
Refinery uses topping, cracking, and lube oil manufacturing processes, but **not** petrochemical operations.

☐ **Integrated**
Refinery uses topping, cracking, lube oil, and petrochemical manufacturing processes.

(NOTE: If your facility does not fit one of these categories, please call Wendall Clark at (914) 227-5769 to clarify the types of operations performed at your facility.)

A - 1

3) What type of sewer system does this facility have?

Check the appropriate box.

☐ Non-segregated between process water & storm water

☐ Partially segregated between process water & storm water

☐ Totally segregated between process water & storm water

4) Indicate your facility's RCRA permitting status and the regulatory authority for the permit.

In each column, check the **ONE** category that best describes this facility.

Before 9/25/90	After 9/25/90	
☐	☐	Generator only; no RCRA permit required. (Hazardous waste is NOT treated, stored or disposed of on-site.)
☐	☐	Part A filed (interim status).
☐	☐	RCRA permit issued.

5) For 1990, what was this facility's operable crude oil capacity in BARRELS PER STREAM DAY as reported in the Oil & Gas Journal?

__________ Barrels per Stream Day

6) What was the **TOTAL AMOUNT** of crude processed (throughput) in 1990?

__________ Million Barrels

7) In 1990, on how many days was crude charged? __________ Days

1990 API Solid Waste Survey-Refining

WASTE MINIMIZATION refers to a variety of activities that reduce the amount of waste that will ultimately require disposal. Frequently, the waste management hierarchy of source reduction, recycle, treatment and disposal is used to illustrate how different activities--at different points in the waste generation and management continuum--work in concert to minimize the amount of waste that will finally require disposal.

Increasing emphasis is being placed on SOURCE REDUCTION activities--those changes in practices that **prevent** waste from being generated in the first place. QUESTIONS ON SOURCE REDUCTION ACTIVITIES ARE IN A LATER SECTION OF THIS QUESTIONNAIRE.

RESOURCE RECOVERY activities reflect the second element of the hierarchy wherein waste materials are beneficially recycled in out-of-process or secondary processes onsite or by other users offsite. Examples of onsite resource recovery operations include the reuse of spent acids and caustics to adjust the pH of the wastewater system. Reuse and reclamation of materials offsite, such as the sale of spent caustics to the paper industry and the reclamation of metals from catalysts should also be reported in the following question.

NOTE THAT SOURCE REDUCTION INFORMATION SHOULD BE RECORDED ON PAGES 6 AND 7.

IF YOU HAVE QUESTIONS AS TO WHETHER AN ACTIVITY SHOULD BE REPORTED AS

RESOURCE RECOVERY OR SOURCE REDUCTION, CALL WENDALL CLARK AT (914) 227-5769.

9) In 1990, did you initiate any new RESOURCE RECOVERY activities that minimize the amount of waste that will ultimately require disposal?

☐ NO ☐ YES

If Yes, indicate the waste streams affected (using the API codes), the amount of waste minimized and then briefly describe the new RESOURCE RECOVERY practice you implemented.

WASTE STREAM	QUANTITY REDUCED	NEW WASTE HANDLING PRACTICE
____	____	____________
____	____	____________
____	____	____________
____	____	____________

8) Have any of the following activities been instituted on a company wide basis and/or at your refinery?

Check the appropriate boxes to indicate the organizational level where these activities have been initiated.

- Prepared a written policy directive on waste minimization.

  ☐ Company wide ☐ Refinery Specific ☐ Both ☐ Neither

- Designated a waste minimization coordinator at each facility.

  ☐ Company wide ☐ Refinery Specific ☐ Both ☐ Neither

- Initiated a program to reward employees that identify/implement waste minimization activities.

  ☐ Company wide ☐ Refinery Specific ☐ Both ☐ Neither

- Set specific goals for reducing the volume or toxicity of wastes.

  ☐ Company wide ☐ Refinery Specific ☐ Both ☐ Neither

- Developed quantitative data on the generation of hazardous waste to measure progress on waste minimization.

  ☐ Company wide ☐ Refinery Specific ☐ Both ☐ Neither

- Developed quantitative data on the generation of non-hazardous waste to measure progress on waste minimization.

  ☐ Company wide ☐ Refinery Specific ☐ Both ☐ Neither

API ID ________ Leave Blank

SOURCE REDUCTION refers to a variety of activities that <u>**prevent or decrease**</u> the amount of waste created or the toxicity of waste generated. Source reduction activities include:

- **equipment and technology modifications** such as the development of new catalysts; the use of belt filter presses and centrifuges to recover oil; modification of the coking process to accept API Separator Sludges and DAF Float in the quench water cycle; use of seal-less pumps or double mechanical seals to reduce losses from leaks.

- **procedure modifications** include many of the improvements made in maintenance activities such as sealing off sewers during maintenance; segregating non-hazardous and hazardous materials, including oily and non-oily dirts; repairs of leaky seals to prevent hydrocarbons from entering the wastewater system; use of mechanical stripping and cleaning devices in lieu of solvents.

- **reformulation or design of products** is difficult to accomplish in the petroleum refining industry given the performance requirements for most fuels, but in some cases product specifications can be adjusted to reduce chemical use.

- **substitution of raw materials** is another difficult activity for the petroleum refining industry, but is accomplished when refineries change their types of crude feedstock.

- **recycling within a process** includes the recycle of oily materials to crude units and cokers; and

- **improved housekeeping, training or inventory control** activities include dust and dirt suppression methods such as street sweeping, planting trees, covering sewers, installation of secondary containment to control spills and increase reuse potential; use of bulk chemicals; training employees to control solvent releases by conserving solvent use during equipment cleaning.

QUESTIONS 10 - 13 REQUEST INFORMATION ON SOURCE REDUCTION ACTIVITIES

IF YOU DID NOT IMPLEMENT ANY SOURCE REDUCTION ACTIVITIES, SKIP ON TO QUESTION 14

10) In the spaces below, summarize each **SOURCE REDUCTION** activity performed by <u>circling</u> the appropriate method code. Then indicate the waste streams affected (use the API code numbers to designate streams) and the tons of each stream that were eliminated. Finally, provide a brief narrative description of the actual activities performed and indicate the year the source reduction activity was initiated.

SOURCE REDUCTION METHODS

1) equipment and technology modifications;
2) procedure modifications;
3) reformulation or design of products;
4) substitution of raw materials;
5) recycling within a process; and
6) improved housekeeping, training or inventory control.

OUT OF PROCESS RECYCLE OR REUSE OFFSITE SHOULD BE REPORTED AS RESOURCE RECOVERY ON QUESTION 8

ACTIVITY 1

METHOD
1 2 3 4 5 6

WASTE STREAM AFFECTED ____ ____ ____ ____ ____
TONS REDUCED PER STREAM ____ ____ ____ ____ ____

Description of Source Reduction Activity 1: ____________________

____

____________________ Year Activity Begun ________

ACTIVITY 2

METHOD
1 2 3 4 5 6

WASTE STREAM AFFECTED ____ ____ ____ ____ ____
TONS REDUCED PER STREAM ____ ____ ____ ____ ____

Description of Source Reduction Activity 2: ____________________

____

____________________ Year Activity Begun ________

ACTIVITY 3

METHOD
1 2 3 4 5 6

WASTE STREAM AFFECTED ____ ____ ____ ____ ____
TONS REDUCED PER STREAM ____ ____ ____ ____ ____

Description of Source Reduction Activity 3: ____________________

____

____________________ Year Activity Begun ________

1990 API Solid Waste Survey-Refining

API ID ______
Leave Blank

ACTIVITY 4

METHOD 1 2 3 4 5 6

WASTE STREAM AFFECTED ____ ____ ____ ____ ____
TONS REDUCED PER STREAM ____ ____ ____ ____ ____

Description of Source Reduction Activity 4: ______________________________

____

______________________________ Year Activity Begun ________

ACTIVITY 5

METHOD 1 2 3 4 5 6

WASTE STREAM AFFECTED ____ ____ ____ ____ ____
TONS REDUCED PER STREAM ____ ____ ____ ____ ____

Description of Source Reduction Activity 5: ______________________________

____

______________________________ Year Activity Begun ________

11) What method did you use to calculate the quantity of waste that was prevented by your source reduction activities?

____

____

12) Did you implement any activities that reduced the toxicity (i.e., reduced the concentration of hazardous constituents) of your wastes? Examples include the substitution of non-chromium-based cooling water; use of non-chlorinated or aqueous solvents etc.

☐ NO ☐ YES

If Yes, indicate the waste streams affected and describe the toxicity reduction method.

WASTE STREAM	TOXICITY REDUCTION ACTIVITY
____	______________________________
____	______________________________
____	______________________________

13) Listed below are several reasons why source reduction activities might be undertaken. Check all that apply.

- ☐ Regulatory requirement for waste.
- ☐ Reduction of treatment or disposal cost.
- ☐ Other process cost reduction.
- ☐ Self-initiated review.
- ☐ Occupational safety.
- ☐ Concern over public reaction to release amounts.
- ☐ Actual pressure from public or environmental groups.
- ☐ Other. Describe: ______________________________

BECAUSE YOUR FACILITY HAS ALREADY IMPLEMENTED SOURCE REDUCTION ACTIVITIES, PLEASE GO ON TO THE DATA SHEETS. (SKIP QUESTION 14)

14) If you did not initiate any source reduction activities, identify those factors listed below that limited your ability to implement source reduction activities.

Check all that apply.

- ☐ Insufficient capital to install new source reduction equipment or source reduction practices.
- ☐ Lack of technical information on source reduction techniques applicable to specific production processes.
- ☐ Source reduction not economically feasible; cost savings in waste management or production will not recover the capital investment.
- ☐ Concern that product quality will decline as a result of source reduction.
- ☐ Technical limitations of the production processes.
- ☐ Permitting burdens.
- ☐ Other. Describe: ______________________________

____

WASTE CODES FOR 1987-1988 API SOLID WASTE SURVEY

OILY SLUDGES AND OTHER ORGANIC WASTES

101 API SEPARATOR SLUDGE (K051)

102 DISSOLVED AIR FLOTATION FLOAT (K048)

103 SLOP OIL EMULSION SOLIDS (K049)

104 LEADED TANK BOTTOMS (K052)

105 OTHER SEPARATOR SLUDGES
- Induced Air Flotation (IAF) Float
- Separator Sludge, Other

106 POND SEDIMENTS
- Stormwater pond sludge
- Evaporation pond sludge
- Equalization pond sludge
- Secondary Wastewater Treatment Sludge
- Polishing pond sludge

107 NONLEADED TANK BOTTOMS
- Tank asphalt sludge
- Tank basic sediment sludge (muck/scale)
- Tank cat tar sludge
- Tank clarified oil sludge
- Tank crude sludge (muck/scale)
- Tank product sludge (muck/scale)
- Tank other sludge

108 WASTE OILS/SPENT SOLVENTS
- Benzene
- Naphtha
- Specialty oil, waste
- Toluene
- Waste oil (not used)
- Waste oil, used

109 OTHER OILY SLUDGES & ORGANIC WASTES NOS
- Desalter Sludge
- HF acid tars
- Pretreatment sludge
- Scraper trap waste (PL pigging sludge)
- Other organic sludges, NOS above
- Tetraethyl lead*
- Spent additive (gasoline)
- Other organic liquids, NOS

CONTAMINATED SOIL/SOLIDS

201 HEAT EXCHANGER BUNDLE CLEANING SLUDGE (K050)

202 CONTAMINATED SOIL/SOLIDS
- Soil (crude) contaminated
- Soil (product) contaminated
- Debris, contaminated
- Used Sand Blasting Grit

203 WASTE COKE/CARBON/CHARCOAL
- Activated carbon
- Carbon Black
- Charcoal
- Coke Chunks
- Filter media, activated carbon
- VRU charcoal

204 WASTE SULFUR
- Claus unit waste
- Contaminated sulfur
- Sulfur with Stretford contamination

205 OTHER CONTAMINATED SOILS NOS
- Activated alky alumina
- Activated alumina
- Asphalt spill
- Catacarb filter media
- Stretford solution
- Filter sand
- Filter clay
- Grit trap waste
- Oil (crude) spill, non-soil
- Oil (product) spill debris, non-soil
- Tank bottoms, absorbent materials
- Waste oil absorbents
- Wax, contaminated
- Other contaminated solids, NOS above

SPENT CATALYSTS

301 FLUID CRACKING CATALYST OR EQUIVALENT
- FCCU cat dust
- Spent FCCU cat
- Contaminated FCCU cat

302 HYDROPROCESSING CATALYSTS
- Metallic Catalysts

303 OTHER SPENT CATALYSTS NOS
- Reformer catalysts
- Shift converter catalysts
- Other Metallic catalysts NOS
- Other Spent Catalysts, NOS

AQUEOUS WASTES

401 BIOMASS
- Biox Sludge

402 OIL CONTAMINATED WATERS OTHER THAN WASTEWATER
- Miscellaneous aqueous liquids
- Water, contaminated - oil, gasoline, etc
- Bilge water

403 HIGH PH/LOW PH WATERS
- Ammonia & Water

404 SPENT SULFITE SOLUTION

405 SPENT STRETFORD SOLUTION
- Stretford slurry froth

406 OTHER AQUEOUS WASTE NOS
- (Do not include refinery process and/or storm wastewater)

CHEMICALS/INORGANIC WASTES

501 SPENT CAUSTICS
- Caustic, cresylic
- Caustic, sulfidic

502 SPENT ACIDS
- Acids, spent
- Sulfuric acid (excluding that exempted under C F R 261 4(a)(7))

503 WASTE AMINES
- Amine Sludges
- Amine Reclaimer Sludges
- Spent Amines
- Other Amine Wastes NOS

504 OTHER INORGANIC WASTES NOS
- Boiler feed treatment sludge
- Caustic Tank Sludge
- Cleaners, acid
- Cleaners, caustic
- Cooling tower sludge
- Ion exchange resin
- Iron sulfide rust sludge
- Lime sludge, water treatment
- Lime sludge, alky
- Inorganic liquids, not specified above
- Inorganic sludges, not specified above

OTHER WASTES

601 OTHER WASTES NOS
- Asbestos insulation
- Drums, empty
- Lab sample container, empty
- Laboratory wastes
- Batteries
- Butyl mercaptan
- Cement
- Desiccant, air drier
- Fiberglass
- Filter cartridges
- Filter, turbo fuel
- Oily rags
- Paint waste
- PCB capacitors
- PCB transformers
- PCB liquid
- Other listed wastes, not specified abo
- Other organic gases not specified ab

SEPARATION TECHNIQUES, RECYCLE. TREATMENT, DISPOSAL CODES

SEPARATION TECHNIQUES	On-Site	Off-Site
Decanting	S100	S101
Thickening	S120	S121
Centrifugal	S150	S151
Filtration	S160	S161

RECYCLE METHOD	On-Site	Off-Site	Sold
Coker	R200	R201	R203
Crude Unit	R210	R211	R213
Desalter	R220	R221	R223
Sour Water Stripper	R230	R231	R233
Industrial Furnace	R240	R241	R243
Reclamation	R250	R251	R253
Regeneration	R260	R261	R263
Other *	R920	R921	R923

TREATMENT METHOD	On-Site	Off-Site
Weathering	T310	T311
Chemical	T330	T331
Heat	T340	T341
Impoundment	T370	T371
Physical	T380	T381
Wastewater Treatment	T390	T391
Incineration	T400	T401
Land Treatment	T410	T411
Stabilization/Fixation	T420	T421
Other *	T940	T941

DISPOSAL METHODS	On-Site	Off-Site
Disposal Impoundment	D500	D501
Landfill	D510	D511
Landspread	D520	D521
Injection	D530	D531
Other *	D950	D951

* Describe method in Comment section of data sheet

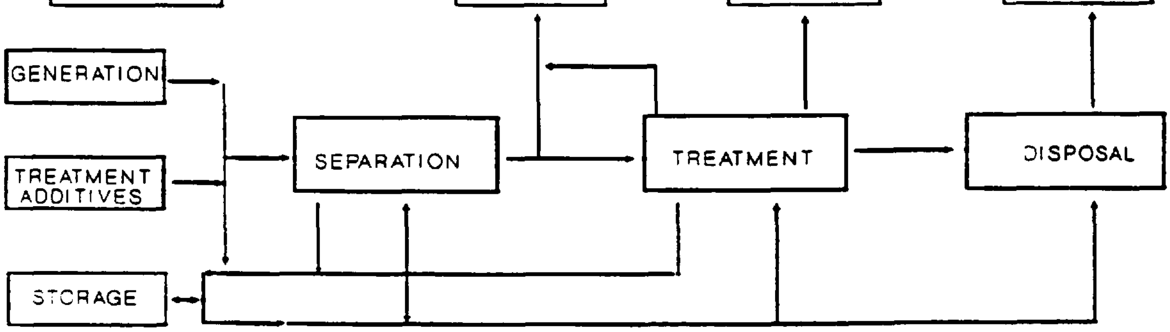
1990

API ID#__________
(LEAVE BLANK)

DID YOUR FACILITY GENERATE AND/OR MANAGE:
CODE 101 API SEPARATOR SLUDGE (K051) IN 1990? ________ (YES/NO)

WASTE MANAGEMENT

INPUTS		OUTPUTS						
GENERATION	WET TONS	**SEPARATION TECHNIQUES**	**ELIMINATED BY RECYCLE**		**ELIMINATED BY TREATMENT**		**DISPOSAL**	
		CODE	WET TONS	CODE	WET TONS	CODE	WET TONS	CODE
ROUTINE	____							
ONE-TIME *	____	S ____	____	R ____	____	T ____	____	D ____
HAVE THESE GENERATION QUANTITIES HAD PRIOR DEWATERING? ☐ YES ☐ NO		S ____	____	R ____	____	T ____	____	D ____
TREATMENT ADDITIVES	____	S ____	____	R ____	____	T ____	____	D ____
STORAGE		S ____	____	R ____	____	T ____	____	D ____
REMOVED FROM	____		____	R ____	____	T ____	____	D ____
PLACED INTO — (____)								
TOTALS	☐	=	☐		+ ☐		+ ☐	



HAZARDOUS WASTE

______ RCRA HAZARDOUS WASTE + NA OTHER WASTE DESIGNATED HAZARDOUS BY STATE = ______ TOTAL HAZARDOUS WASTE

SOURCE REDUCTION PRACTICES

DID YOUR REFINERY INITIATE ANY ACTIVITIES, CHANGE ANY PRACTICES OR FEEDSTOCKS, OR MODIFY ANY EQUIPMENT THAT DECREASED THE AMOUNT OF THIS WASTE GENERATE IN 1990? ☐ NO ☐ YES IF YES, ENTER AMOUNT REDUCED ________ WET TONS
PLEASE CHECK TO MAKE SURE YOU HAVE ENTERED THIS INFORMATION ON QUESTION 10.

COMMENTS/CALCULATIONS:

★ DESCRIBE ONE-TIME EVENT:

APPENDIX B - Summary of Source Reduction Practices

SOURCE REDUCTION 1990 - EQUIPMENT AND TECHNOLOGY MODIFICATONS

WASTE STREAM	# Refineries Reporting	Wet Tons Reported	DESCRIPTION OF EQUIPMENT AND TECHNOLOGY MODIFICAITONS
API Separator Sludge	2	132	Upgrade separators Retire API separator
Nonleaded Tank Bottoms	1	5	Install mixers in tanks
Waste Oils/ Spent Solvents	2	3068	Installed high pressure power washer (to replace chlorinated solvent vapor degreaser) Replace packed seals w/ mechanical ones
Other Oily Sludges & Organic Wastes NOS	1	1	Install non-mercury switches in process units
Heat Exchanger Bundle Cleaning Sludge	1	1	Systematic improvement of selected exchangers to improve efficiency
Contaminated Soils/Solids	3	1674	Retrofit tanks w/ new bottoms Refurbish/eliminate underground piping build new load facility to replace 3 older ones
Other Contaminated Soils NOS	3	56	Kersene Merox heater replaced Dikes constructed around storm water surge tanks
FCC Catalyst or Equivalent	1	1	Improve cyclones, ski jumps & air grid
Other Spent Catalysts NOS	1	6	Upgraded isom unit: new feed dryers & 2nd reactor
Spent Stretford Solution	1	160	Replaced Stretford unit w/ a sulften unit
Other Aqueous Waste NOS	1	1	Benzene removal from wastewater system
Spent Caustics	1	8759	Piping modifications allow additional treatment
TOTAL	18	13,864	

SOURCE REDUCTION 1990 - PROCEDURE MODIFICATIONS

WASTE STREAM	# Refineries Reporting	Wet Tons Reported	DESCRIPTION OF PROCEDURE MODIFICATIONS
API Separator Sludge	19	15,397	Improve filtration/separation/centrifugation techniques Modify coker for reinjection More frequent clean-out of calcium flouride pond to reduce carry over Non-hazardous lime solids diverted from discharge
DAF Float	12	67,455	Improve filtration/separation/centrifugation techniques Modify coker for reinjection Additional thermal treatment More frequent clean-out of calcium flouride pond to reduce carry over Continue use of washed limestone instead of caleche
Slop Oil Emulsion Solids	5	7,464	Improve filtration Modify coker for reinjection Additional thermal treatment
Leaded Tank Bottoms	1	29	Improve separation techniques
Other Separator Sludges	4	3500	Improve filtration/centrifugation techniques More frequent clean-out of calcium flouride pond to reduce carry over Continue use of washed limestone instead of caleche
Pond Sediments	3	9335	Improve filtration/separation/centrifugation techniques Coker for reinjection
Nonleaded Tank Bottoms	5	5347	Improve filtration/separation/centrifugation techniques Coker for reinjection FCCU modified to reduce cat slurry Less asbestos removal; reduce frequency of tank cleanings
Other Oily Sludges & Organic Wastes NOS	4	189	Improve filtration/separation/centrifugation techniques Coker for reinjection
Other Contaminated Soils NOS	4	187	Centrifuge material to recover useful products Recover/sell spilled asphalt Reuse of activated alumina in downstream units Improve steam out procedures to reduce volatile organics

WASTE STREAM	# Refineries Reporting	Wet Tons Reported	DESCRIPTION OF PROCEDURE MODIFICATIONS (CONTINUED)
FCC Catalyst or Equivalent	2	3185	Segregate sandblast sand Less frequent changeouts
Hydroprocessing Catalysts	2	60	Less frequent changeouts Improve steam out procedures to reduce volatile organics
Other Spent Catalysts NOS	1	4	Less frequent changeouts
Biomass	2	34,351	Improve separation of oil and water Procedures reduce contaminants in process sewers & maintenance activities
High pH/Low pH Waters	1	9102	Material now sent to wastewater treatment system
Other Aqueous Waste NOS	1	4881	Improve filtration/oil recovery Process changes
Spent Caustics	2	14,973	Process changes Reduce volume of diluting water
Waste Amines	1	88	Treated via WWTP NPDES system
Other Inorganic Wastes NOS	2	1598	Improve filtration Additional thermal treatment
Other Wastes NOS	2	242	Less asbestos removal Bulk chemical port a feeds reduced drum disposal
TOTAL	73	177,387	

SOURCE REDUCTION 1990 - ACTIVITIES TO REFORMULATE OR DESIGN PRODUCTS

WASTE STREAM	# Refineries Reporting	Wet Tons Reported	DESCRIPTION OF ACTIVITIES TO REFORMULATE OR DESIGN PRODUCTS
Leaded Tank Bottoms	5	45	Eliminate/reduce leaded gasoline production

SOURCE REDUCTION 1990 - ACTIVITIES TO SUBSTITUTE MATERIALS

WASTE STREAM	# Refineries Reporting	Wet Tons Reported	DESCRIPTION OF ACTIVITIES TO SUBSTITUTE MATERIALS
Waste Oils/ Spent Solvents	1	1	Non-hazardous cleaner used instead of solvents in mechanical shop
Contaminated Soils/Solids	1	150	Reuse non-hazardous soil in refinery construction projects
FCC Catalyst or Equivalent	1	16	Asphalt inclusion
Other Inorganic Wastes NOS	1	500	Convert cooling towers to chromates
Other Wastes NOS	2	31	Convert cooling towers to chromates Replaced PCB oils in transformers
TOTAL	6	698	

SOURCE REDUCTION 1990 - WITHIN PROCESS RECYCLING ACTIVITIES

WASTE STREAM	# Refineries Reporting	Wet Tons Reported	DESCRIPTION OF WITHIN PROCESS RECYCLING ACTIVITIES
API Separator Sludge	11	1,306	Recovered oil to crude or coker unit
DAF Float	9	19,516	Recovered oil to crude, cracker or coker unit
Slop Oil Emulsion Solids	6	25,465	Recovered oil to crude or coker unit
Other Separator Sludges	7	1,954	Recovered oil to crude or coker unit
Nonleaded Tank Bottoms	8	24,179	Recovered oil to crude or coker unit
Waste Oils/ Spent Solvents	3	4939	Zero sample draws Spent solvents to reclaimer Slop oil recover via API separator
Other Oily Sludges & Organic Wastes NOS	4	664	Recovered oil to crude or coker unit
Heat Exchanger Bundle Cleaning Sludge	4	212	Recovered oil to crude or coker unit
Waste Coke/Carbon/Charcoal	3	14	Recycled to coker Reclaimed
Other Contaminated Soils NOS	3	327	Asphalt waste melted & returned to process Recycle to crude unit
Oil Contaminated Waters Other than Wastewater	2	315	Recycle of toluene cooling water Recycle to crude unit
Spent Caustics	1	19,940	Recycling WWTP crude
Other Inorganic Wastes NOS	1	3	Recyle oil to crude unit
Other Wastes NOS	2	3	Spent paint solvents recovered by distillation Paper recycling program
TOTAL	65	98,834	

SOURCE REDUCTION 1990 - IMPROVED HOUSEKEEPING, TRAINING OR INVENTORY CONTROL ACTIVITIES

WASTE STREAM	# Refineries Reporting	Wet Tons Reported	DESCRIPTION OF IMPROVED HOUSEKEEPING, TRAINING OR INVENTORY CONTROL ACTIVITIES
API Separator Sludge	11	1085	improved management of filter operations Phase out of sand bags for hot work Install concrete drains ditches/rebuild drains Waste minimization training program Reduce solids to sewers by modifying sweeping
DAF Float	4	900	Improved management of filter operations Phase out of sand bags for hot work Install concrete drains ditches/rebuild drains Reduce solids to sewers by modifying sweeping
Slop Oil Emulsion Solids	1	111	Improved management of filter operations
Other Separator Sludges	4	998	Tighter inventory controls Install concrete drain ditches/rebuild drains Reduce solids to sewers by modifying sweeping
Pond Sediments	1	10	Rebuilt sewers; installed paving in process unit; rebuilt burner
Nonleaded Tank Bottoms	1	489	Cleaned out decanted oil tank
Waste Oils/Spent Solvents	1	5	Storage in bulk tanks
Other Oily Sludges/Organic Wastes NOS	1	1	Use of bulk chemicals
Heat Exchanger Bundle Cleaning Sludge	1	8	Segregate bundle sludge from other sludges
Contaminated Soils/Solids	9	2427	Segregate sand blast sand Install concrete sump pads Waste minimization training program Reduce solids to sewers paving Tighter inventory controls
Other Contaminated Soils NOS	1	29	Install concrete drain ditches/rebuild drains
Waste Amines	1	19,240	Reduction & recovery by improved operations
Other Inorganic Wastes NOS	2	8	Use of bulk chemicals to prevent residuals in drums Cement lining of unit areas
Other Wastes NOS	3	19	Storage of chemicals in bulk tanks Cement lining of unit areas
TOTAL	41	25,330	

APPENDIX C - Computer Printouts Summarizing Management Practices

API SOLID WASTE SURVEY
1990

Estimated Waste Quantities

(Wet Tons)	Managed	Generated	Treatment Additives	NetStore
Other Aqueous Wastes NOS	11,106,421	11,106,421	0	0
Pond Sediments	1,039,645	1,016,597	31,987	-8,939
Contaminated Soil/Solids	914,926	920,444	11	-5,529
Spent Caustics	894,258	888,511	5,951	-204
Biomass	794,045	782,000	12,347	-302
Dissolved Air Flotation Float	564,303	552,938	11,709	-344
Other Inorganic Wastes NOS	453,163	451,464	542	1,157
Other Wastes NOS	352,550	352,114	459	-23
Spent Acids	336,591	336,259	398	-66
Slop Oil Emulsion Solids	295,036	290,862	4,428	-254
API Separator Sludge	259,601	251,183	7,801	617
Fluid Cracking Catalyst or Equivalent	259,311	198,295	0	61,016
Nonleaded Tank Bottoms	196,485	193,694	3,203	-412
Waste Oils/Spent Solvents	114,609	114,611	0	-2
High pH/Low pH Waters	105,238	105,238	0	0
Other Separator Sludges	103,861	96,511	7,350	0
Waste Coke/Carbon/Charcoal	91,798	91,798	0	0
Waste Amines	74,861	74,861	0	0
Other Contaminated Soils NOS	69,380	69,310	86	-16
Other Oily Sludges & Organic Wastes	53,500	53,199	373	-72
Other Spent Catalysts NOS	40,590	39,165	1,231	194
Waste Sulfur	34,544	34,614	0	-70
Hydroprocessing Catalysts	30,376	30,658	0	-282
Spent Stretford Solution	29,514	29,334	180	0
Heat Exchanger Cleaning Bundle Sludge	12,975	12,775	245	-45
Oil Contaminated Water NOT Wastewater	8,299	8,281	16	2
Leaded Tank Bottoms	3,066	2,634	34	398
Spent Sulfite Solution	1,173	1,173	0	0

Estimated Tonnage Eliminated by Techniques for Each Waste Stream

Waste Stream	Managed (Tons)	Recycled (Tons)	Treated (Tons)	Land Treated (Tons)	Disposed (Tons)
API Separator Sludge	259,600	29,302	80,358	65,496	84,444
Dissolved Air Flotation Float	564,300	138,048	344,087	60,464	21,701
Slop Oil Emulsion Solids	295,036	138,641	114,260	17,811	24,324
Leaded Tank Bottoms	3,066	45	517	47	2,457
Other Separator Sludges	103,861	14,893	51,386	30,682	6,900
Pond Sediments	1,039,645	360	239,714	348,855	450,716
Nonleaded Tank Bottoms	196,485	44,249	39,914	22,854	89,468
Waste Oils/Spent Solvents	114,611	109,442	571	1,491	3,107
Other Oily Sludges & Organic Wastes	53,498	21,658	11,747	4,827	15,266
Heat Exchanger Cleaning Bundle Sludge	12,975	2,001	3,680	3,816	3,478
Contaminated Soil/Solids	914,926	48,851	55,202	298,736	512,137
Waste Coke/Carbon/Charcoal	91,798	73,831	53	81	17,833
Waste Sulfur	34,543	46	17,151	6	17,340
Other Contaminated Soils NOS	69,381	2,503	1,879	7,352	57,647
Fluid Cracking Catalyst or Equivalent	259,310	62,338	52	3,261	193,659
Hydroprocessing Catalysts	30,376	27,803	0	80	2,493
Other Spent Catalysts NOS	40,589	11,044	11,746	2,892	14,907
Biomass	794,046	57,595	408,471	266,982	60,998
Oil Contaminated Water NOT Wastewater	8,299	1,400	1,497	3	5,399
High pH/Low pH Waters	105,238	0	89,740	1,268	14,230
Spent Sulfite Solution	1,173	1,173	0	0	0
Spent Stretford Solution	29,514	2,259	22,902	0	4,353
Other Aqueous Wastes NOS	11,106,421	0	12,033	360	11,094,028
Spent Caustics	894,259	657,821	202,633	0	33,805
Spent Acids	336,592	328,054	7,959	0	579
Waste Amines	74,860	1,476	71,855	118	1,411
Other Inorganic Wastes NOS	453,163	103,815	83,298	10,373	255,677
Other Wastes NOS	352,549	14,633	1,439	28	336,449
	==========	==========	==========	==========	==========
	18,240,114	1,893,281	1,874,144	1,147,883	13,324,806

Estimated Quantities of Waste Recycled and Percentage of Total Amount Managed
By Waste Stream

Waste Stream	Quantity Recycled (Tons)	% of Total Managed (Tons)
API Separator Sludge	29,302	11.29
Dissolved Air Flotation Float	138,048	24.46
Slop Oil Emulsion Solids	138,641	46.99
Leaded Tank Bottoms	45	1.47
Other Separator Sludges	14,893	14.34
Pond Sediments	360	0.03
Nonleaded Tank Bottoms	44,249	22.52
Waste Oils/Spent Solvents	109,442	95.49
Other Oily Sludges & Organic Wastes	21,658	40.48
Heat Exchanger Cleaning Bundle Sludge	2,001	15.42
Contaminated Soil/Solids	48,851	5.34
Waste Coke/Carbon/Charcoal	73,831	80.43
Waste Sulfur	46	0.13
Other Contaminated Soils NOS	2,503	3.61
Fluid Cracking Catalyst or Equivalent	62,338	24.04
Hydroprocessing Catalysts	27,803	91.53
Other Spent Catalysts NOS	11,044	27.21
Biomass	57,595	7.25
Oil Contaminated Water NOT Wastewater	1,400	16.87
High pH/Low pH Waters	0	0
Spent Sulfite Solution	1,173	100.00
Spent Stretford Solution	2,259	7.65
Other Aqueous Wastes NOS	0	0
Spent Caustics	657,821	73.56
Spent Acids	328,054	97.46
Waste Amines	1,476	1.97
Other Inorganic Wastes NOS	103,815	22.91
Other Wastes NOS	14,633	4.15
	==========	
	1,893,281	

API SOLID WASTE SURVEY
1990

15:46 Tuesday, July 27, 1993

Estimated Tonnage Eliminated by Recycle Techniques for Each Waste Stream

Waste Stream	Coker	Crude Unit	Desalter	Sour Water Stripper	Industrial Furnace	Reclamation	Regeneration	Other	Other Sold
API Separator Sludge	8,373	10,015	0	0	864	3,942	0	4,682	1,426
Dissolved Air Flotation Float	74,597	21,625	0	0	492	1,505	0	38,551	1,278
Slop Oil Emulsion Solids	41,799	28,895	0	0	3,698	4,999	0	59,250	0
Leaded Tank Bottoms	0	45	0	0	0	0	0	0	0
Other Separator Sludges	772	12,581	0	0	0	0	0	1,540	0
Pond Sediments	0	360	0	0	0	0	0	0	0
Nonleaded Tank Bottoms	6,562	34,288	0	0	0	3,043	0	356	0
Waste Oils/Spent Solvents	2,197	64,393	0	0	3	191	34	42,624	0
Other Oily Sludges & Organic Wastes	578	980	532	0	13,070	6,497	0	1	0
Heat Exchanger Cleaning Bundle Sludge	563	132	0	0	432	745	0	129	0
Contaminated Soil/Solids	2	6	0	0	0	6,961	0	41,882	0
Waste Coke/Carbon/Charcoal	3	0	0	0	25,064	48,282	451	31	0
Waste Sulfur	0	0	0	0	19	27	0	0	0
Other Contaminated Soils NOS	385	52	0	0	0	1,987	0	16	63
Fluid Cracking Catalyst or Equivalent	0	0	0	0	4,942	5,515	1,337	40,303	10,241
Hydroprocessing Catalysts	0	0	0	0	0	25,689	2,113	1	0
Other Spent Catalysts NOS	0	0	0	0	0	9,873	771	98	302
Biomass	55,907	0	0	0	3	1,685	0	0	0
Oil Contaminated Water NOT Wastewater	460	55	0	0	0	860	0	25	0
High pH/Low pH Waters	0	0	0	0	0	0	0	0	0
Spent Sulfite Solution	0	0	0	0	0	1,173	0	0	0
Spent Stretford Solution	0	0	0	0	0	2,223	36	0	0
Other Aqueous Wastes NOS	0	0	0	0	0	0	0	0	0
Spent Caustics	0	43	0	0	1,786	235,667	299,164	92,840	28,321
Spent Acids	0	0	0	0	0	151,387	48,539	104,906	23,222
Waste Amines	193	0	0	0	0	2	1,281	0	0
Other Inorganic Wastes NOS	74	172	0	0	3	1,109	0	102,457	0
Other Wastes NOS	0	94	0	0	141	4,444	0	9,954	0
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	192,465	173,736	532	0	50,517	517,806	353,726	539,646	64,853

The SAS System

(Thousands of Wet Tons)

Waste Stream	Recycled Tons	% Recycled On-Site	% Recycled Off-Site
API Separator Sludge	29	73	27
Dissolved Air Flotation Float	138	98	2
Slop Oil Emulsion Solids	139	97	3
Leaded Tank Bottoms	0	100	0
Other Separator Sludges	15	99	1
Pond Sediments	0	100	0
Nonleaded Tank Bottoms	44	99	1
Waste Oils/Spent Solvents	109	100	0
Other Oily Sludges & Organic Wastes	22	96	4
Heat Exchanger Cleaning Bundle Sludge	2	72	28
Contaminated Soil/Solids	49	7	93
Waste Coke/Carbon/Charcoal	74	0	100
Waste Sulfur	0	100	0
Other Contaminated Soils NOS	3	26	74
Fluid Cracking Catalyst or Equivalent	62	7	93
Hydroprocessing Catalysts	28	0	100
Other Spent Catalysts NOS	11	0	100
Biomass	58	100	0
Oil Contaminated Water NOT Wastewater	1	95	5
High pH/Low pH Waters	0	0	0
Spent Sulfite Solution	1	0	100
Spent Stretford Solution	2	82	18
Other Aqueous Wastes NOS	0	0	0
Spent Caustics	658	53	47
Spent Acids	328	32	68
Waste Amines	1	21	79
Other Inorganic Wastes NOS	104	86	14
Other Wastes NOS	15	47	53

Respondent Frequencies for Recycle Techniques for Each Waste Stream

Waste Stream	Coker	Crude Unit	Desalter	Sour Water Stripper	Industrial Furnace	Reclamation	Regeneration	Other	Other Sold
API Separator Sludge	10	16	0	0	5	8	0	5	1
Dissolved Air Flotation Float	15	10	0	0	3	4	0	5	1
Slop Oil Emulsion Solids	3	6	0	0	4	5	0	3	0
Leaded Tank Bottoms	0	1	0	0	0	0	0	0	0
Other Separator Sludges	3	3	0	0	0	0	0	4	0
Pond Sediments	0	2	0	0	0	0	0	0	0
Nonleaded Tank Bottoms	8	7	0	0	0	4	0	1	0
Waste Oils/Spent Solvents	4	8	0	0	2	26	6	7	0
Other Oily Sludges & Organic Wastes	3	7	1	0	9	5	0	1	0
Heat Exchanger Cleaning Bundle Sludge	5	3	0	0	1	2	0	1	0
Contaminated Soil/Solids	1	1	0	0	0	1	0	4	0
Waste Coke/Carbon/Charcoal	1	0	0	0	1	2	3	1	0
Waste Sulfur	0	0	0	0	1	1	0	0	0
Other Contaminated Soils NOS	1	3	0	0	0	3	0	2	1
Fluid Cracking Catalyst or Equivalent	0	0	0	0	3	8	3	24	7
Hydroprocessing Catalysts	0	0	0	0	0	42	9	1	0
Other Spent Catalysts NOS	0	0	0	0	0	36	5	3	3
Biomass	4	0	0	0	1	2	0	0	0
Oil Contaminated Water NOT Wastewater	1	3	0	0	0	2	0	1	0
High pH/Low pH Waters	0	0	0	0	0	0	0	0	0
Spent Sulfite Solution	0	0	0	0	0	1	0	0	0
Spent Stretford Solution	0	0	0	0	0	2	1	0	0
Other Aqueous Wastes NOS	0	0	0	0	0	0	0	0	0
Spent Caustics	0	1	0	0	1	27	4	9	5
Spent Acids	0	0	0	0	0	4	1	1	2
Waste Amines	1	0	0	0	0	1	3	0	0
Other Inorganic Wastes NOS	3	1	0	0	1	4	0	5	0
Other Wastes NOS	0	1	0	0	2	21	0	9	0
	=====	=====	========	==========	==========	===========	============	=====	=====
	63	73	1	0	34	211	35	87	20

API SOLID WASTE SURVEY
1990

Estimated Quantities of Waste Treated and Percentage of Total Amount Managed
By Waste Stream

Waste Stream	Quantity Treated (Tons)	% of Total Managed (Tons)
API Separator Sludge	80,358	30.95
Dissolved Air Flotation Float	344,087	60.98
Slop Oil Emulsion Solids	114,260	38.73
Leaded Tank Bottoms	517	16.86
Other Separator Sludges	51,386	49.48
Pond Sediments	239,714	23.06
Nonleaded Tank Bottoms	39,914	20.31
Waste Oils/Spent Solvents	571	0.50
Other Oily Sludges & Organic Wastes	11,747	21.96
Heat Exchanger Cleaning Bundle Sludge	3,680	28.36
Contaminated Soil/Solids	55,202	6.03
Waste Coke/Carbon/Charcoal	53	0.06
Waste Sulfur	17,151	49.65
Other Contaminated Soils NOS	1,879	2.71
Fluid Cracking Catalyst or Equivalent	52	0.02
Hydroprocessing Catalysts	0	0
Other Spent Catalysts NOS	11,746	28.94
Biomass	408,471	51.44
Oil Contaminated Water NOT Wastewater	1,497	18.04
High pH/Low pH Waters	89,740	85.27
Spent Sulfite Solution	0	0
Spent Stretford Solution	22,902	77.60
Other Aqueous Wastes NOS	12,033	0.11
Spent Caustics	202,633	22.66
Spent Acids	7,959	2.36
Waste Amines	71,855	95.99
Other Inorganic Wastes NOS	83,298	18.38
Other Wastes NOS	1,439	0.41
	==========	
	1,874,144	

Estimated Tonnage Eliminated by Treatment Techniques for Each Waste Stream

Waste Code	Weathering	Chemical	Heat	Impoundment	Physical	Waste H2O Treatment	Incineration	Stabilization and/or Fixation	Other
API Separator Sludge	0	0	2,336	0	12,618	55,690	4,639	5,075	0
Dissolved Air Flotation Float	0	3,241	0	0	2,433	305,645	32,199	569	0
Slop Oil Emulsion Solids	0	5,221	0	0	0	107,851	734	454	0
Leaded Tank Bottoms	316	0	0	0	0	102	66	33	0
Other Separator Sludges	0	0	0	0	0	51,383	3	0	0
Pond Sediments	0	0	0	0	1	1,201	0	211,100	27,412
Nonleaded Tank Bottoms	0	0	0	0	1,182	37,418	184	1,130	0
Waste Oils/Spent Solvents	413	0	2	0	0	74	82	0	0
Other Oily Sludges & Organic Wastes	0	0	0	0	0	11,661	84	2	0
Heat Exchanger Cleaning Bundle Sludge	0	0	0	0	0	3,576	102	2	0
Contaminated Soil/Solids	11	0	0	0	0	21	92	55,070	8
Waste Coke/Carbon/Charcoal	0	0	0	0	0	0	53	0	0
Waste Sulfur	0	0	0	0	0	17,145	0	0	6
Other Contaminated Soils NOS	0	0	0	0	0	1,693	186	0	0
Fluid Cracking Catalyst or Equivalent	0	0	0	0	0	52	0	0	0
Hydroprocessing Catalysts	0	0	0	0	0	0	0	0	0
Other Spent Catalysts NOS	0	0	0	0	0	11,746	0	0	0
Biomass	0	0	0	0	20,290	288,341	98,158	0	1,682
Oil Contaminated Water NOT Wastewater	0	800	0	0	0	697	0	0	0
High pH/Low pH Waters	0	124	0	0	0	89,616	0	0	0
Spent Sulfite Solution	0	0	0	0	0	0	0	0	0
Spent Stretford Solution	0	0	0	0	4,935	15,687	0	2,280	0
Other Aqueous Wastes NOS	0	0	0	0	0	10,735	1,298	0	0
Spent Caustics	0	69,953	0	0	0	132,680	0	0	0
Spent Acids	0	6,355	0	0	8	1,075	106	0	415
Waste Amines	0	0	0	0	169	70,649	1,037	0	0
Other Inorganic Wastes NOS	4,003	138	0	0	4,008	50,430	24,703	16	0
Other Wastes NOS	0	0	0	0	0	263	1,176	0	0
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	4,743	85,832	2,338	0	45,644	1265431	164,902	275,731	29,523

(Thousands of Wet Tons)

Waste Stream	Treated Tons	% Treated On-Site	% Treated Off-Site
API Separator Sludge	80	97	3
Dissolved Air Flotation Float	344	100	0
Slop Oil Emulsion Solids	114	99	1
Leaded Tank Bottoms	1	81	19
Other Separator Sludges	51	100	0
Pond Sediments	240	100	0
Nonleaded Tank Bottoms	40	100	0
Waste Oils/Spent Solvents	1	86	14
Other Oily Sludges & Organic Wastes	12	99	1
Heat Exchanger Cleaning Bundle Sludge	4	97	3
Contaminated Soil/Solids	55	100	0
Waste Coke/Carbon/Charcoal	0	59	41
Waste Sulfur	17	100	0
Other Contaminated Soils NOS	2	90	10
Fluid Cracking Catalyst or Equivalent	0	100	0
Hydroprocessing Catalysts	0	0	0
Other Spent Catalysts NOS	12	100	0
Biomass	408	89	11
Oil Contaminated Water NOT Wastewater	1	47	53
High pH/Low pH Waters	90	99	1
Spent Sulfite Solution	0	0	0
Spent Stretford Solution	23	87	13
Other Aqueous Wastes NOS	12	91	9
Spent Caustics	203	70	30
Spent Acids	8	99	1
Waste Amines	72	100	0
Other Inorganic Wastes NOS	83	100	0
Other Wastes NOS	1	19	81

Respondent Frequencies for Treatment Techniques for Each Waste Stream

Waste Code	Weathering	Chemical	Heat	Impoundment	Physical	Waste H2O Treatment	Incineration	Stabilization and/or Fixation	Other
API Separator Sludge	0	0	1	0	2	28	18	3	0
Dissolved Air Flotation Float	0	1	0	0	1	21	17	2	0
Slop Oil Emulsion Solids	0	1	0	0	0	12	8	2	0
Leaded Tank Bottoms	1	0	0	0	0	1	5	1	0
Other Separator Sludges	0	0	0	0	0	4	0	0	0
Pond Sediments	0	0	0	0	1	3	0	1	1
Nonleaded Tank Bottoms	0	0	0	0	1	8	2	2	0
Waste Oils/Spent Solvents	1	0	1	0	0	3	10	0	0
Other Oily Sludges & Organic Wastes	0	0	0	0	0	6	5	1	0
Heat Exchanger Cleaning Bundle Sludge	0	0	0	0	0	12	7	1	0
Contaminated Soil/Solids	1	0	0	0	0	1	2	2	1
Waste Coke/Carbon/Charcoal	0	0	0	0	0	0	3	0	0
Waste Sulfur	0	0	0	0	0	1	0	0	1
Other Contaminated Soils NOS	0	0	0	0	0	1	2	0	0
Fluid Cracking Catalyst or Equivalent	0	0	0	0	0	1	0	0	0
Hydroprocessing Catalysts	0	0	0	0	0	0	0	0	0
Other Spent Catalysts NOS	0	0	0	0	0	1	0	0	0
Biomass	0	0	0	0	1	10	5	0	1
Oil Contaminated Water NOT Wastewater	0	1	0	0	0	4	0	0	0
High pH/Low pH Waters	0	1	0	0	0	7	0	0	0
Spent Sulfite Solution	0	0	0	0	0	0	0	0	0
Spent Stretford Solution	0	0	0	0	1	3	0	1	0
Other Aqueous Wastes NOS	0	0	0	0	0	2	1	0	0
Spent Caustics	0	6	0	0	0	21	0	0	0
Spent Acids	0	8	0	0	1	4	1	0	1
Waste Amines	0	0	0	0	1	15	2	0	0
Other Inorganic Wastes NOS	1	3	0	0	1	14	3	1	0
Other Wastes NOS	0	0	0	0	0	5	26	0	0
	==========	========	====	===========	========	=========	============	=============	=====
	4	21	2	0	10	188	117	17	5

Estimated Quantities of Waste Land Treated and Percentage of Total Amount Managed
By Waste Stream

Waste Stream	Quantity Land Treated (Tons)	% of Total Managed (Tons)
API Separator Sludge	65,496	25.23
Dissolved Air Flotation Float	60,464	10.71
Slop Oil Emulsion Solids	17,811	6.04
Leaded Tank Bottoms	47	1.53
Other Separator Sludges	30,682	29.54
Pond Sediments	348,855	33.56
Nonleaded Tank Bottoms	22,854	11.63
Waste Oils/Spent Solvents	1,491	1.30
Other Oily Sludges & Organic Wastes	4,827	9.02
Heat Exchanger Cleaning Bundle Sludge	3,816	29.41
Contaminated Soil/Solids	298,736	32.65
Waste Coke/Carbon/Charcoal	81	0.09
Waste Sulfur	6	0.02
Other Contaminated Soils NOS	7,352	10.60
Fluid Cracking Catalyst or Equivalent	3,261	1.26
Hydroprocessing Catalysts	80	0.26
Other Spent Catalysts NOS	2,892	7.13
Biomass	266,982	33.62
Oil Contaminated Water NOT Wastewater	3	0.04
High pH/Low pH Waters	1,268	1.20
Spent Sulfite Solution	0	0.00
Spent Stretford Solution	0	0.00
Other Aqueous Wastes NOS	360	0.00
Spent Caustics	0	0.00
Spent Acids	0	0.00
Waste Amines	118	0.16
Other Inorganic Wastes NOS	10,373	2.29
Other Wastes NOS	28	0.01
	==========	
	1,147,883	

(Thousands of Wet Tons)

Waste Stream	Land Treated Tons	% Land Treated On-Site	% Land Treated Off-Site
API Separator Sludge	65	97	3
Dissolved Air Flotation Float	60	59	41
Slop Oil Emulsion Solids	18	90	10
Leaded Tank Bottoms	0	100	0
Other Separator Sludges	31	100	0
Pond Sediments	349	100	0
Nonleaded Tank Bottoms	23	96	4
Waste Oils/Spent Solvents	1	100	0
Other Oily Sludges & Organic Wastes	5	96	4
Heat Exchanger Cleaning Bundle Sludge	4	55	45
Contaminated Soil/Solids	299	99	1
Waste Coke/Carbon/Charcoal	0	100	0
Waste Sulfur	0	100	0
Other Contaminated Soils NOS	7	90	10
Fluid Cracking Catalyst or Equivalent	3	60	40
Hydroprocessing Catalysts	0	0	100
Other Spent Catalysts NOS	3	100	0
Biomass	267	98	2
Oil Contaminated Water NOT Wastewater	0	100	0
High pH/Low pH Waters	1	100	0
Spent Sulfite Solution	0	0	0
Spent Stretford Solution	0	0	0
Other Aqueous Wastes NOS	0	100	0
Spent Caustics	0	0	0
Spent Acids	0	0	0
Waste Amines	0	100	0
Other Inorganic Wastes NOS	10	92	8
Other Wastes NOS	0	72	28

Off-Site includes Sold

API SOLID WASTE SURVEY
1990

Respondent Frequencies for Land Treatment for Each Waste Stream

Waste Stream	Land Treatment
	24
API Separator Sludge	24
Dissolved Air Flotation Float	16
Slop Oil Emulsion Solids	11
Leaded Tank Bottoms	2
Other Separator Sludges	7
Pond Sediments	16
Nonleaded Tank Bottoms	20
Waste Oils/Spent Solvents	1
Other Oily Sludges & Organic Wastes	12
Heat Exchanger Cleaning Bundle Sludge	10
Contaminated Soil/Solids	22
Waste Coke/Carbon/Charcoal	6
Waste Sulfur	1
Other Contaminated Soils NOS	15
Fluid Cracking Catalyst or Equivalent	4
Hydroprocessing Catalysts	1
Other Spent Catalysts NOS	6
Biomass	16
Oil Contaminated Water NOT Wastewater	1
High pH/Low pH Waters	2
Other Aqueous Wastes NOS	1
Waste Amines	3
Other Inorganic Wastes NOS	13
Other Wastes NOS	4
	=========
	238

Estimated Quantities of Waste Disposed and Percentage of Total Amount Managed
By Waste Stream

Waste Stream	Quantity Disposed (Tons)	% of Total Managed (Tons)
API Separator Sludge	84,444	32.53
Dissolved Air Flotation Float	21,701	3.85
Slop Oil Emulsion Solids	24,324	8.24
Leaded Tank Bottoms	2,457	80.14
Other Separator Sludges	6,900	6.64
Pond Sediments	450,716	43.35
Nonleaded Tank Bottoms	89,468	45.53
Waste Oils/Spent Solvents	3,107	2.71
Other Oily Sludges & Organic Wastes	15,266	28.54
Heat Exchanger Cleaning Bundle Sludge	3,478	26.81
Contaminated Soil/Solids	512,137	55.98
Waste Coke/Carbon/Charcoal	17,833	19.43
Waste Sulfur	17,340	50.20
Other Contaminated Soils NOS	57,647	83.09
Fluid Cracking Catalyst or Equivalent	193,659	74.68
Hydroprocessing Catalysts	2,493	8.21
Other Spent Catalysts NOS	14,907	36.73
Biomass	60,998	7.68
Oil Contaminated Water NOT Wastewater	5,399	65.06
High pH/Low pH Waters	14,230	13.52
Spent Sulfite Solution	0	0
Spent Stretford Solution	4,353	14.75
Other Aqueous Wastes NOS	11,094,028	99.89
Spent Caustics	33,805	3.78
Spent Acids	579	0.17
Waste Amines	1,411	1.88
Other Inorganic Wastes NOS	255,677	56.42
Other Wastes NOS	336,449	95.43
	==========	
	13,324,806	

API SOLID WASTE SURVEY
1990

Estimated Tonnage Eliminated by Disposal Techniques for Each Waste Stream

Waste Stream	Disposal Impoundment	Landfill	Landspread	Injection	Other
API Separator Sludge	249	79,342	3,952	0	901
Dissolved Air Flotation Float	0	20,910	575	0	216
Slop Oil Emulsion Solids	0	21,933	143	1,456	792
Leaded Tank Bottoms	0	2,434	0	0	23
Other Separator Sludges	0	6,042	858	0	0
Pond Sediments	0	404,887	45,829	0	0
Nonleaded Tank Bottoms	2,017	82,087	4,989	0	375
Waste Oils/Spent Solvents	2	3,034	0	69	2
Other Oily Sludges & Organic Wastes	0	12,896	2,370	0	0
Heat Exchanger Cleaning Bundle Sludge	0	3,446	12	0	20
Contaminated Soil/Solids	0	497,140	14,770	0	227
Waste Coke/Carbon/Charcoal	2	15,115	2,713	0	3
Waste Sulfur	53	17,286	0	0	1
Other Contaminated Soils NOS	0	45,895	6,256	0	5,496
Fluid Cracking Catalyst or Equivalent	20,168	116,619	56,844	0	28
Hydroprocessing Catalysts	0	2,440	0	0	53
Other Spent Catalysts NOS	0	14,830	77	0	0
Biomass	2,249	32,337	26,412	0	0
Oil Contaminated Water NOT Wastewater	5,225	172	0	0	2
High pH/Low pH Waters	12,849	81	0	1,291	9
Spent Sulfite Solution	0	0	0	0	0
Spent Stretford Solution	439	3,914	0	0	0
Other Aqueous Wastes NOS	0	5,367	0	11,088,661	0
Spent Caustics	90	925	0	32,213	577
Spent Acids	0	76	0	503	0
Waste Amines	0	945	0	451	15
Other Inorganic Wastes NOS	85,664	162,255	7,758	0	0
Other Wastes NOS	0	336,427	0	0	22
	===========	==========	==========	==========	==========
	129,007	1,888,835	173,558	11,124,644	8,762

(Thousands of Wet Tons)

Waste Stream	Disposed Tons	% Disposed On-Site	% Disposed Off-Site
API Separator Sludge	84	5	95
Dissolved Air Flotation Float	22	3	97
Slop Oil Emulsion Solids	24	1	99
Leaded Tank Bottoms	2	0	100
Other Separator Sludges	7	84	16
Pond Sediments	451	11	89
Nonleaded Tank Bottoms	89	13	87
Waste Oils/Spent Solvents	3	2	98
Other Oily Sludges & Organic Wastes	15	55	45
Heat Exchanger Cleaning Bundle Sludge	3	0	100
Contaminated Soil/Solids	512	4	96
Waste Coke/Carbon/Charcoal	18	28	72
Waste Sulfur	17	10	90
Other Contaminated Soils NOS	58	19	81
Fluid Cracking Catalyst or Equivalent	194	48	52
Hydroprocessing Catalysts	2	8	92
Other Spent Catalysts NOS	15	35	65
Biomass	61	67	33
Oil Contaminated Water NOT Wastewater	5	97	3
High pH/Low pH Waters	14	92	8
Spent Sulfite Solution	0	0	0
Spent Stretford Solution	4	10	90
Other Aqueous Wastes NOS	11094	100	0
Spent Caustics	34	55	45
Spent Acids	1	0	100
Waste Amines	1	32	68
Other Inorganic Wastes NOS	256	43	57
Other Wastes NOS	336	48	52

Off-Site includes Sold

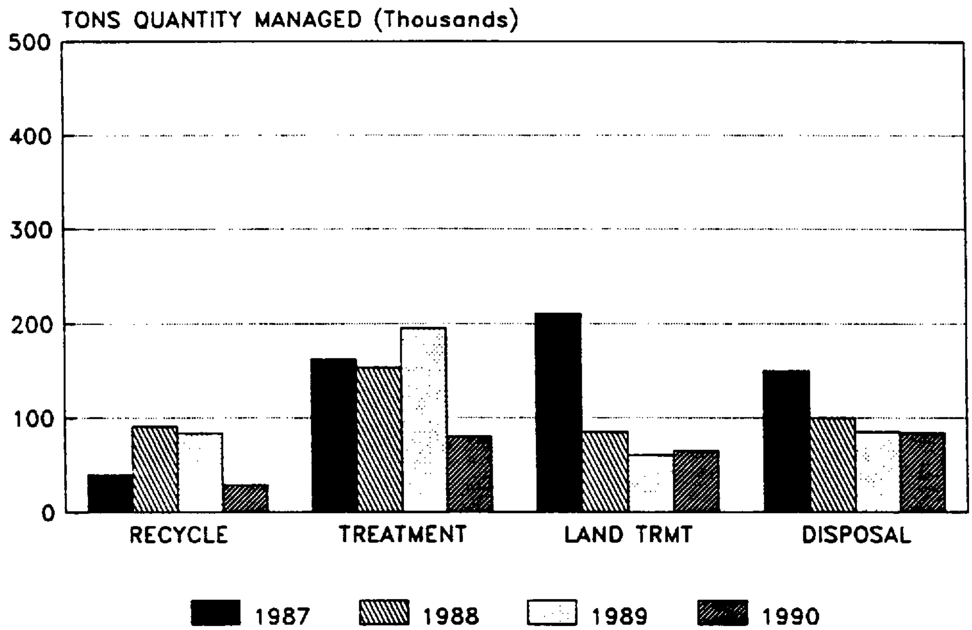
API SOLID WASTE SURVEY 15:46 Tuesday, July 27, 1993 7
1990

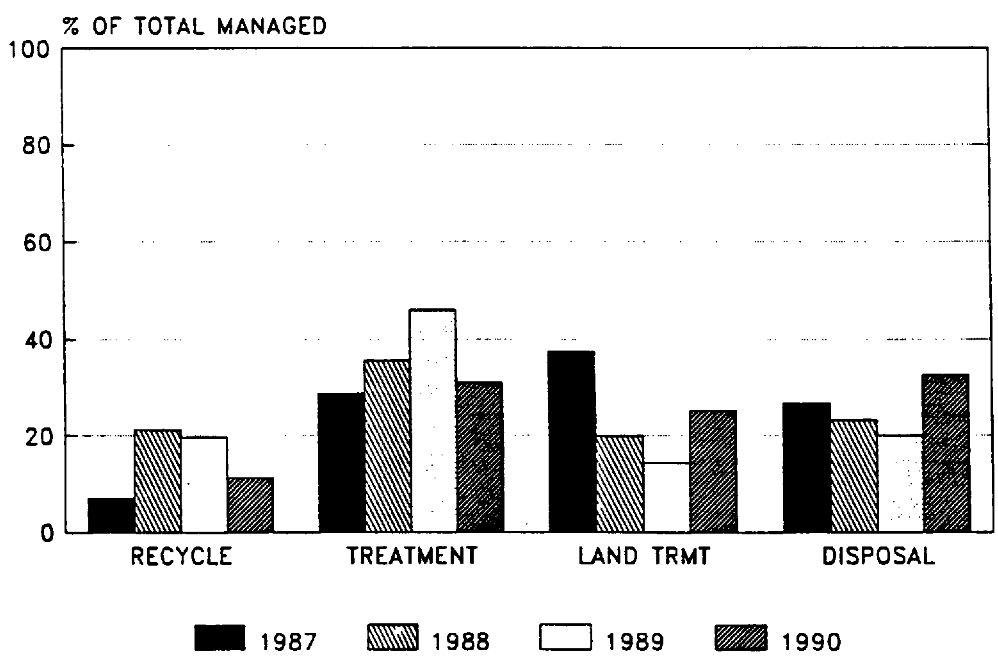
Respondent Frequencies for Disposal Techniques for Each Waste Stream

Waste Stream	Disposal Impoundment	Landfill	Landspread	Injection	Other
API Separator Sludge	1	58	5	0	4
Dissolved Air Flotation Float	0	27	2	0	3
Slop Oil Emulsion Solids	0	20	1	1	3
Leaded Tank Bottoms	0	19	0	0	1
Other Separator Sludges	0	9	1	0	0
Pond Sediments	0	15	6	0	0
Nonleaded Tank Bottoms	1	48	7	0	2
Waste Oils/Spent Solvents	1	8	0	1	1
Other Oily Sludges & Organic Wastes	0	21	3	0	0
Heat Exchanger Cleaning Bundle Sludge	0	29	1	0	2
Contaminated Soil/Solids	0	76	7	0	1
Waste Coke/Carbon/Charcoal	1	38	2	0	1
Waste Sulfur	1	34	0	0	1
Other Contaminated Soils NOS	0	61	1	0	1
Fluid Cracking Catalyst or Equivalent	2	53	3	0	1
Hydroprocessing Catalysts	0	11	0	0	1
Other Spent Catalysts NOS	0	44	1	0	0
Biomass	1	17	4	0	0
Oil Contaminated Water NOT Wastewater	1	2	0	0	1
High pH/Low pH Waters	1	1	0	2	1
Spent Sulfite Solution	0	0	0	0	0
Spent Stretford Solution	2	2	0	0	0
Other Aqueous Wastes NOS	0	1	0	1	0
Spent Caustics	2	2	0	10	1
Spent Acids	0	2	0	1	0
Waste Amines	0	9	0	1	1
Other Inorganic Wastes NOS	7	47	5	0	0
Other Wastes NOS	0	99	0	0	5
	===========	========	==========	=========	=====
	21	753	49	17	31

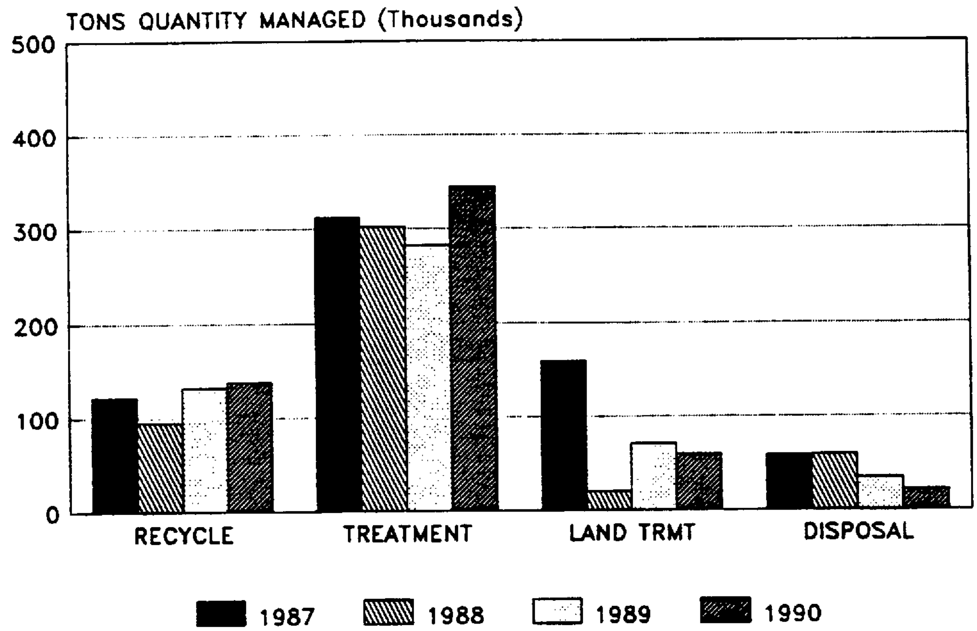
APPENDIX D - Bar Charts of Management Practices for Each Residual Stream

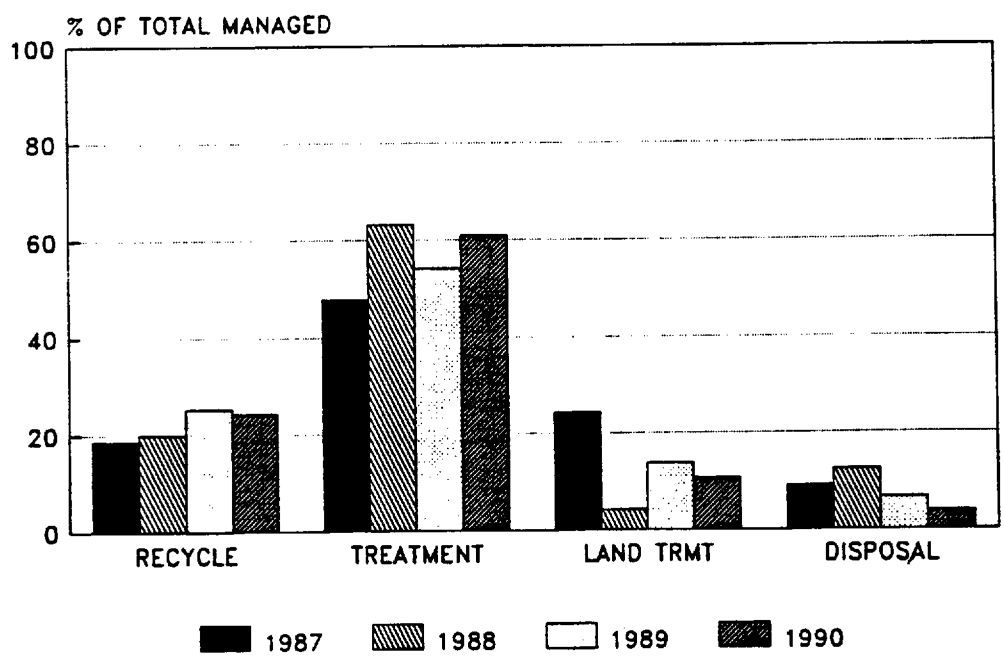
API SEPARATOR SLUDGE
1987 - 1990



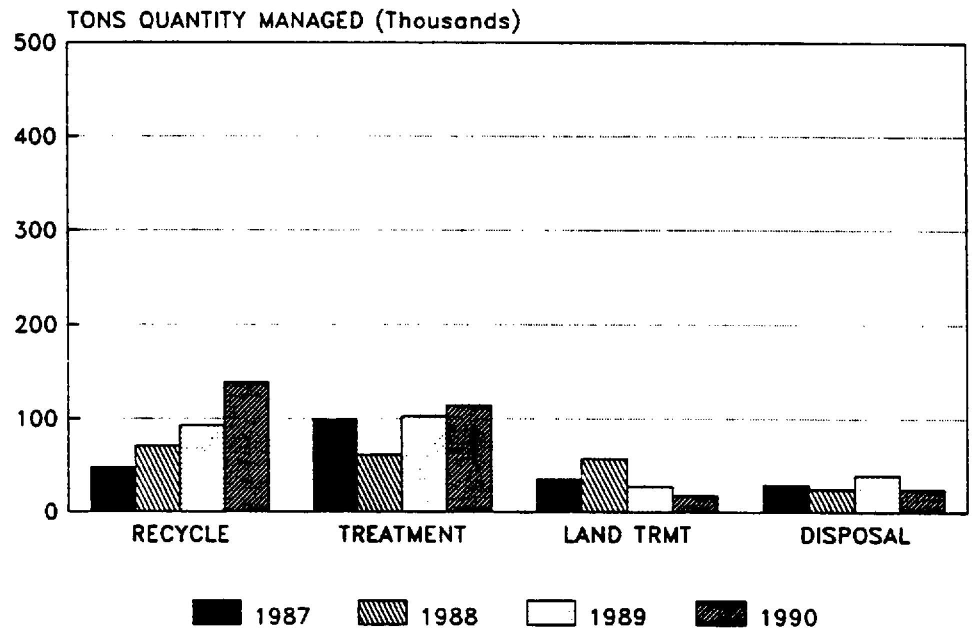


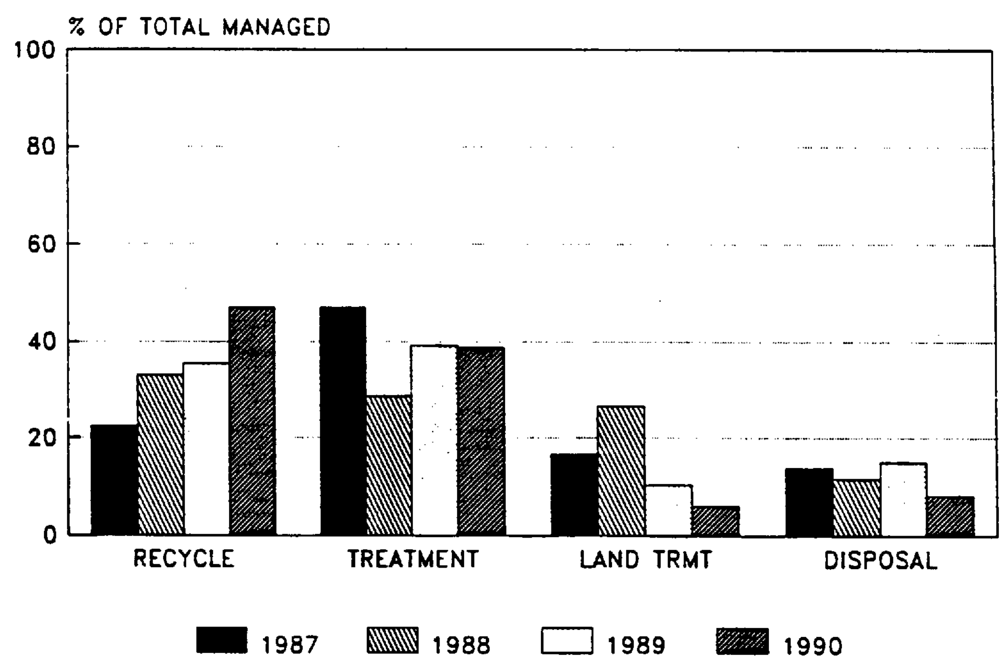
DAF FLOAT
1987 - 1990



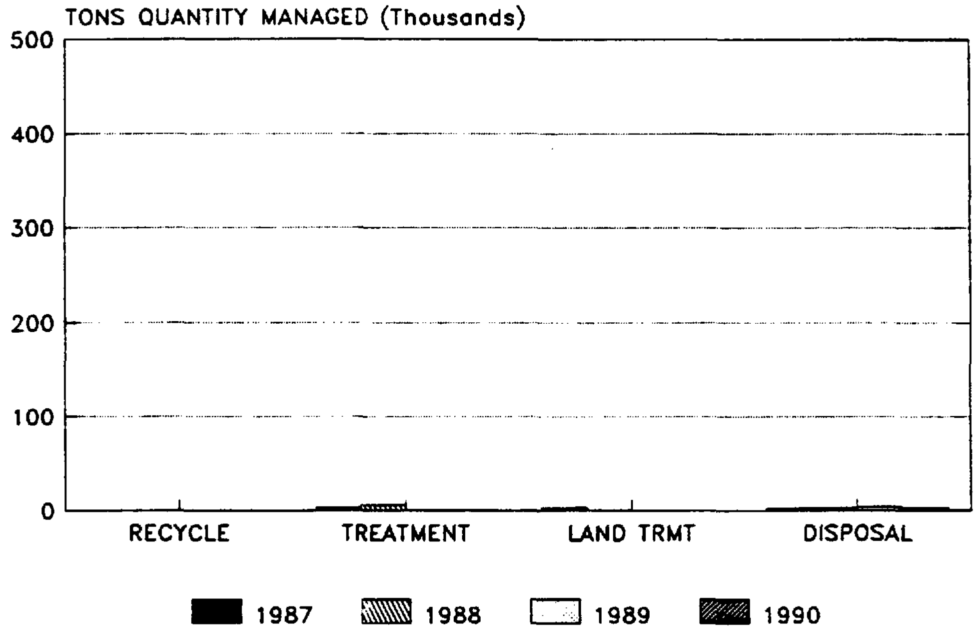


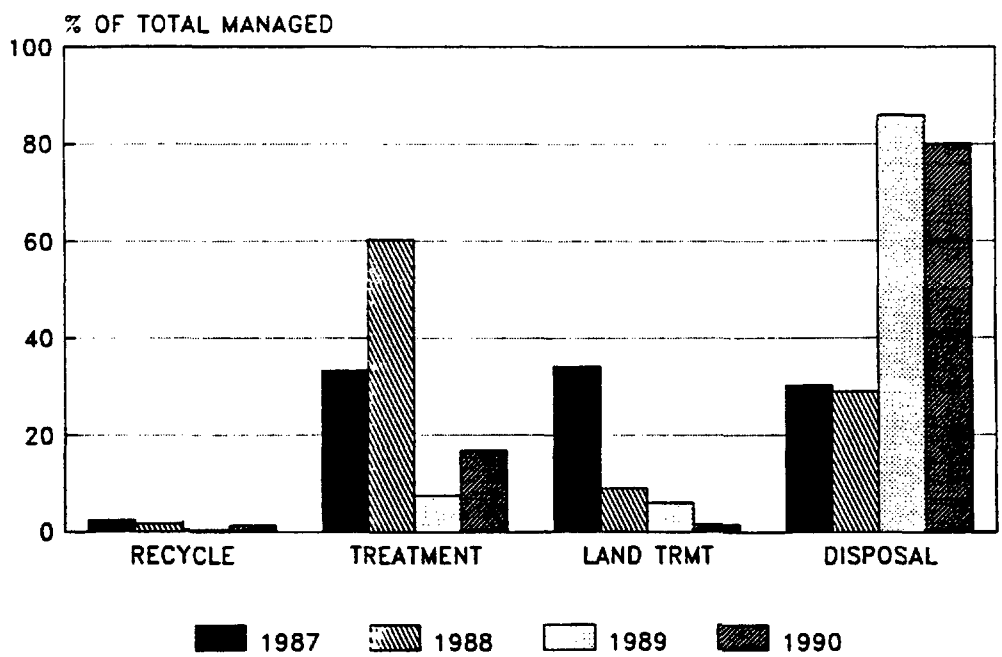
SLOP OIL EMULSION SOLID
1987 - 1990



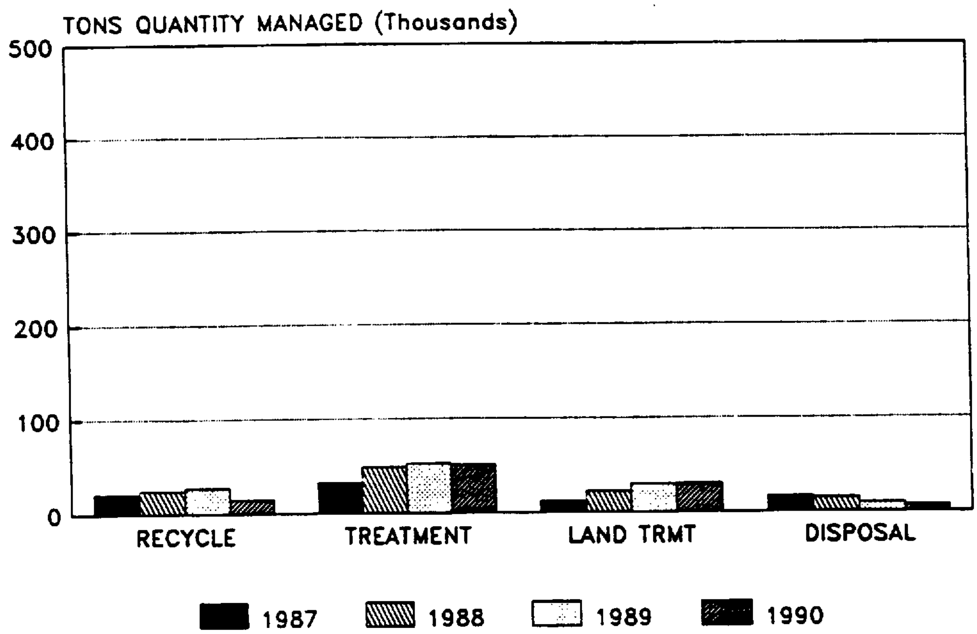


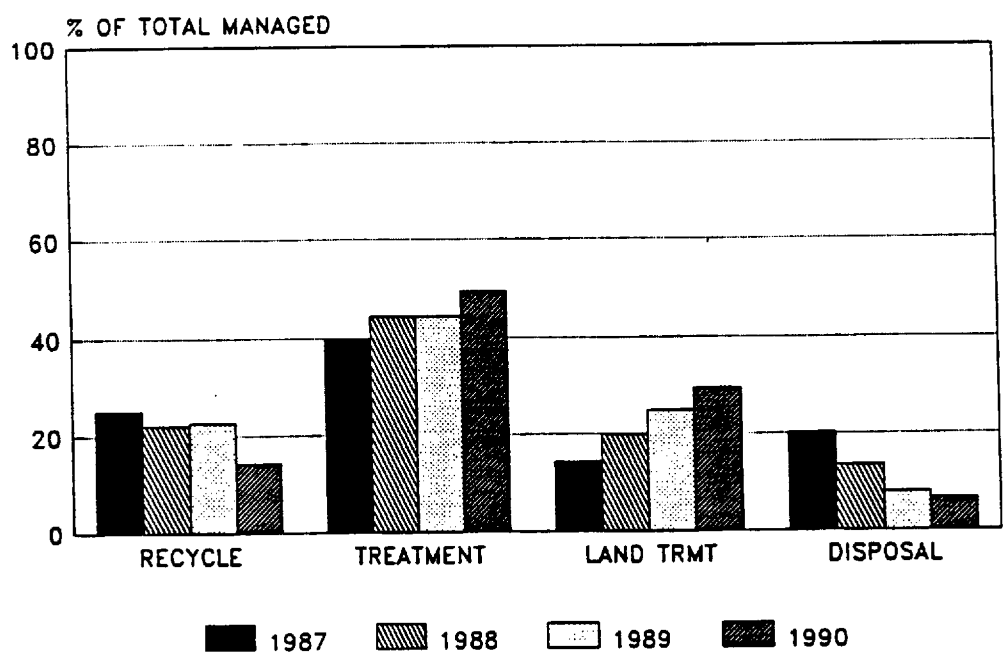
LEADED TANK BOTTOMS
1987 - 1990



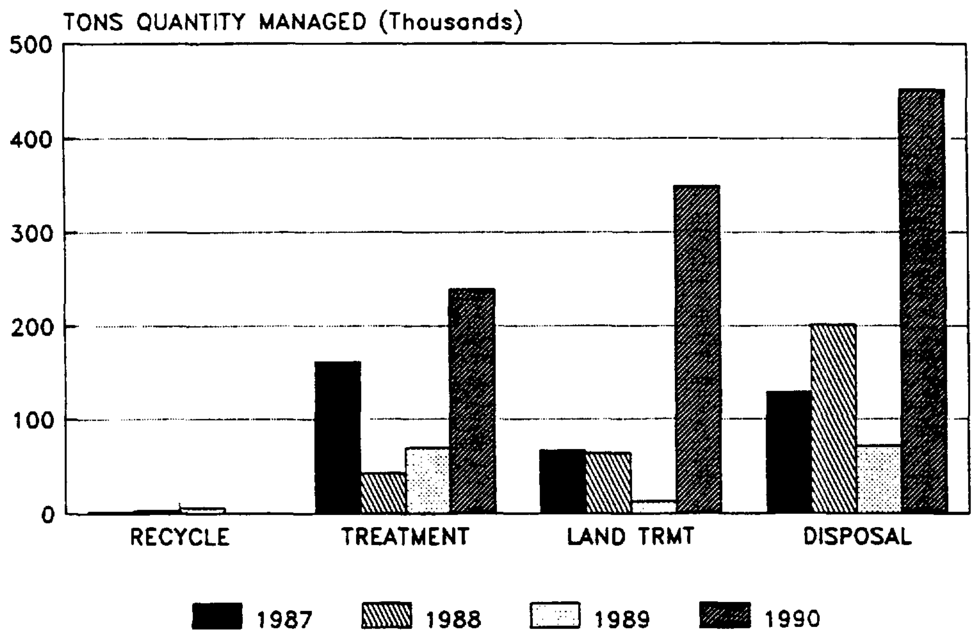


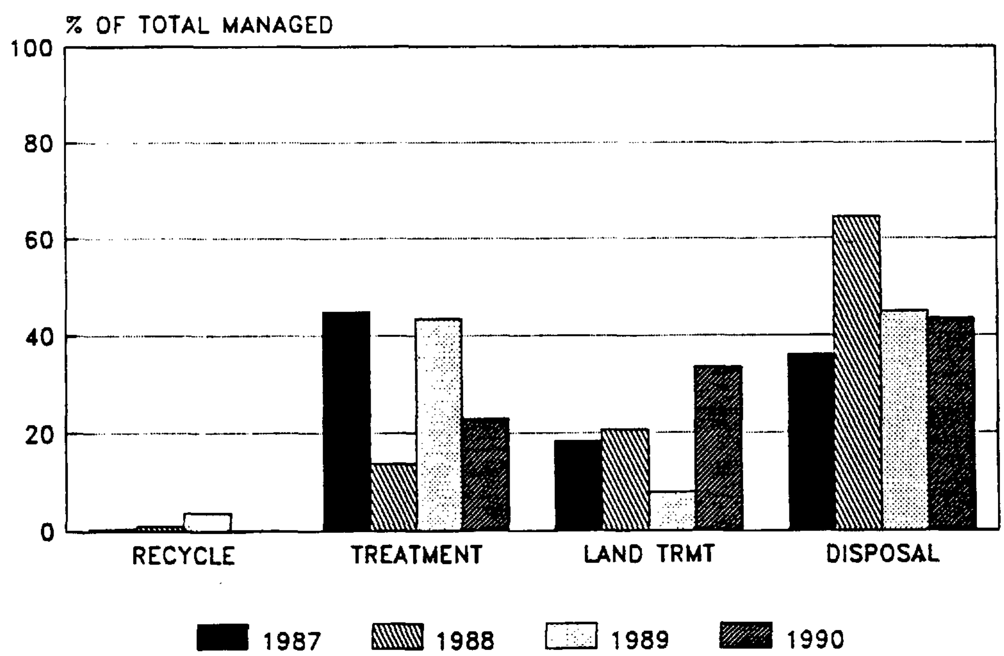
OTHER SEPARATOR SLUDGE
1987 - 1990



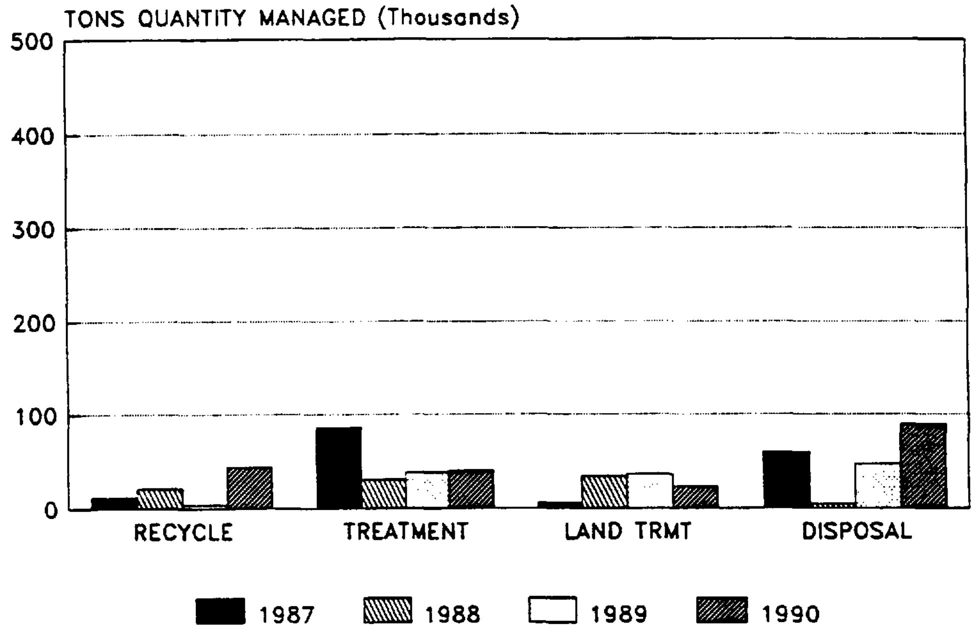


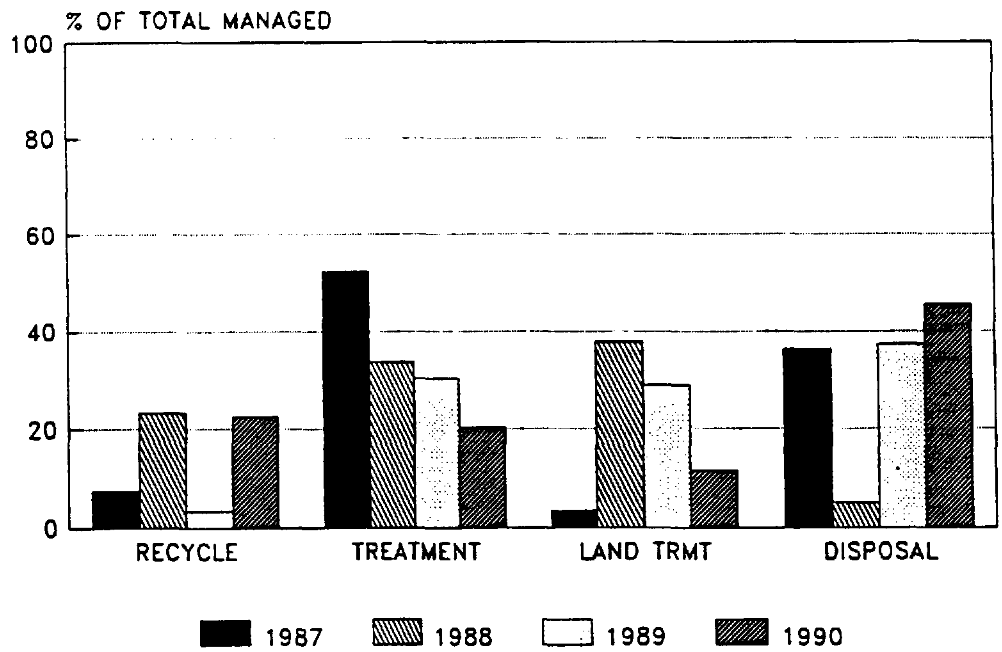
POND SEDIMENTS
1987 - 1990



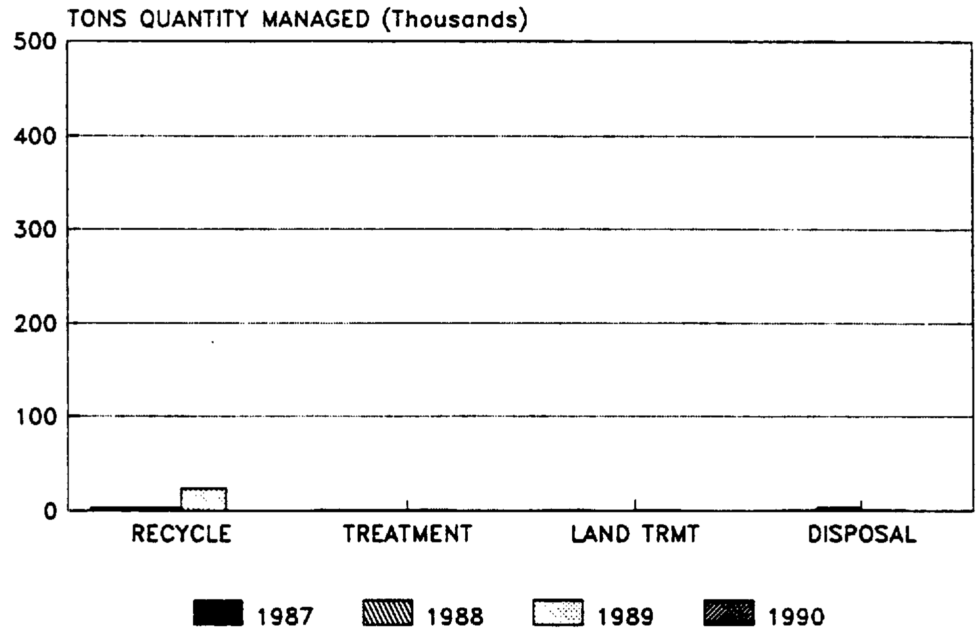


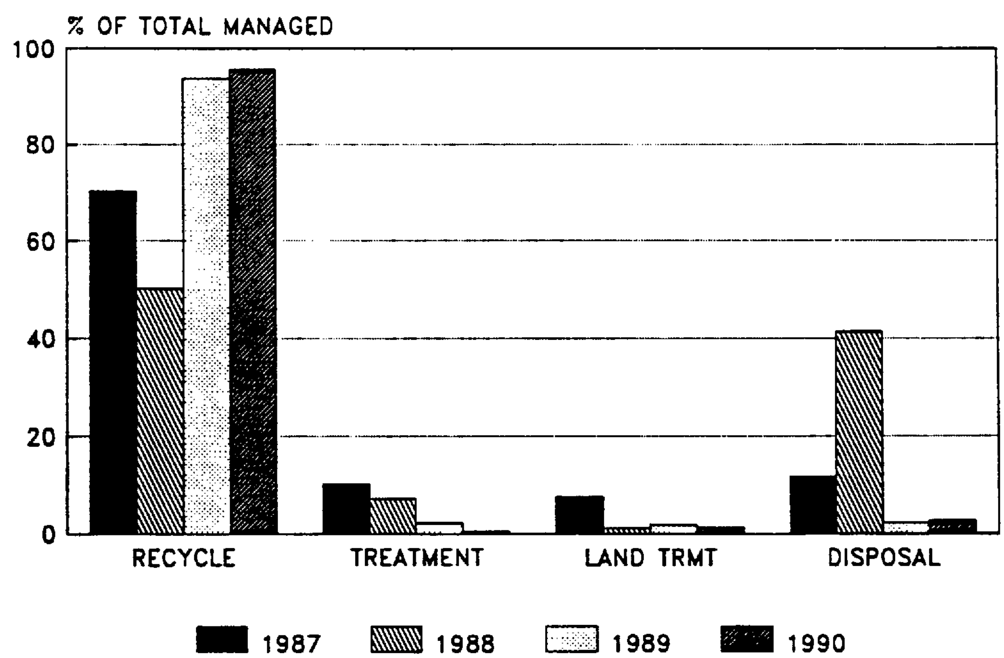
NONLEADED TANK BOTTOM
1987 - 1990



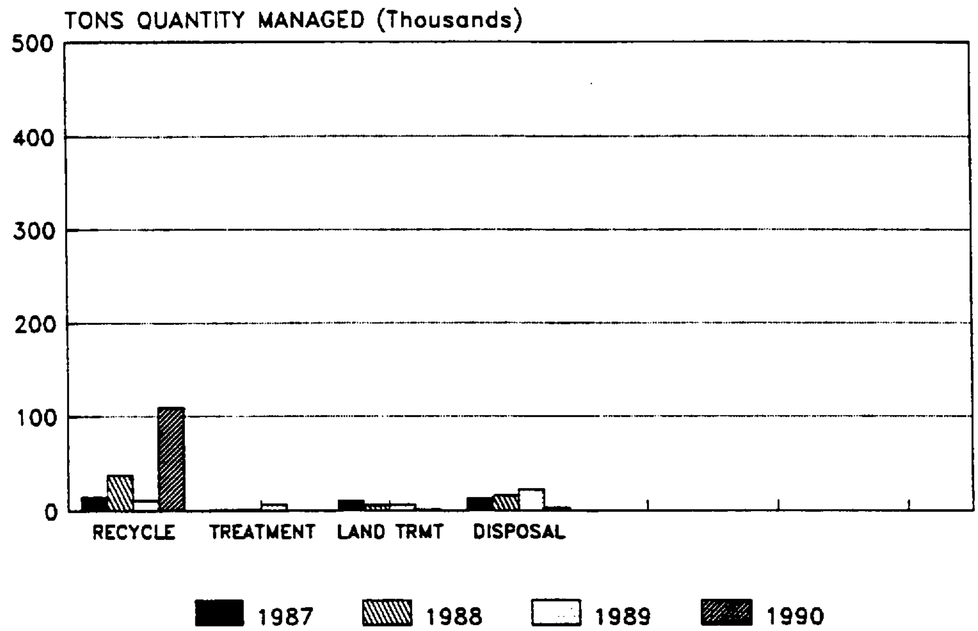


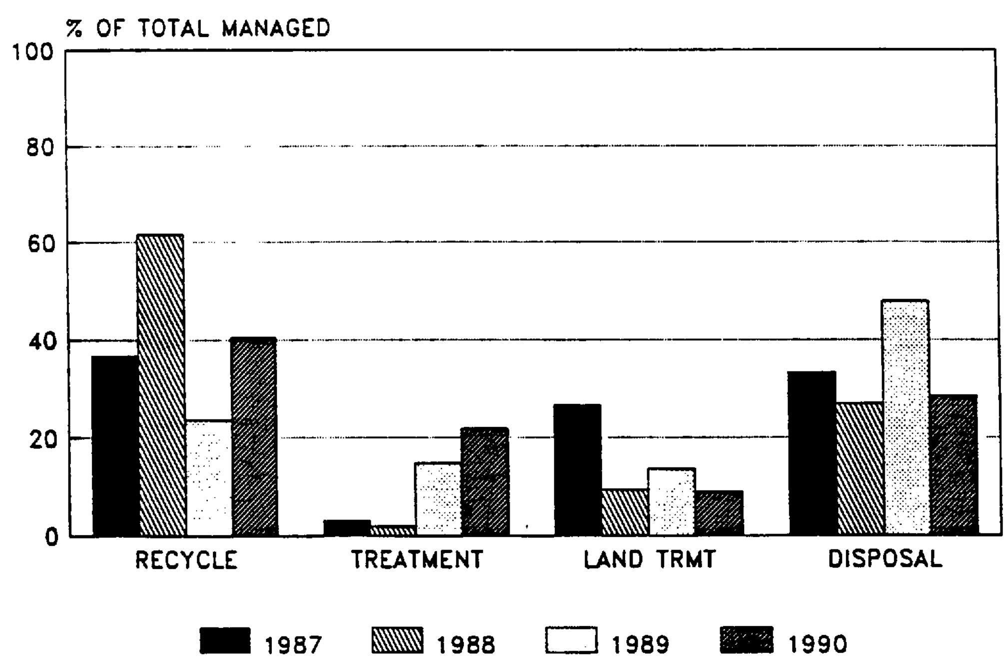
RESIDUAL OILS/SPENT SOLVENT
1987 - 1990



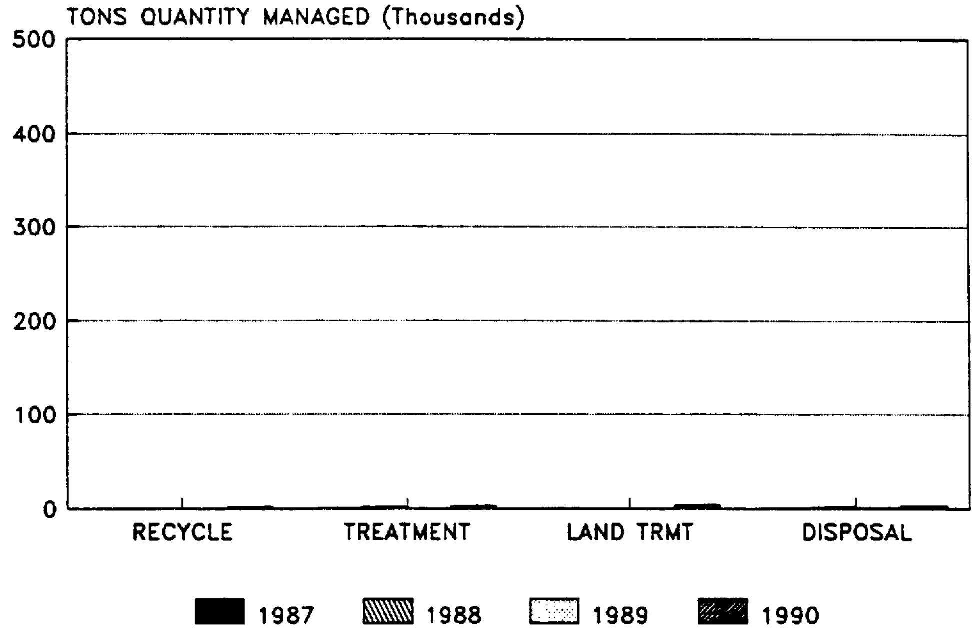


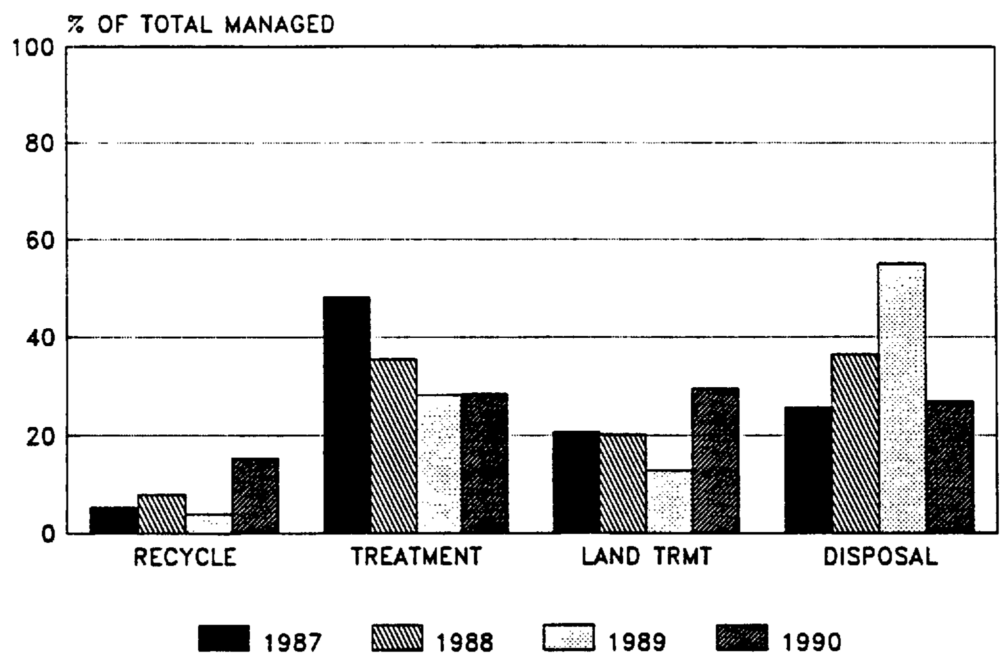
OTHER OILY SLUDGES & INORG RESIDUAL
1987 - 1990



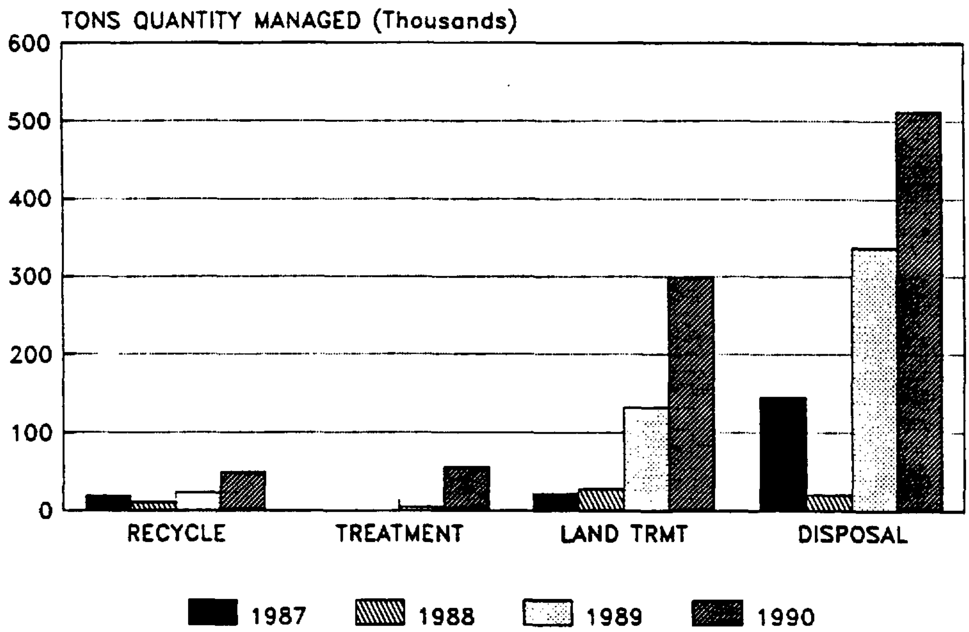


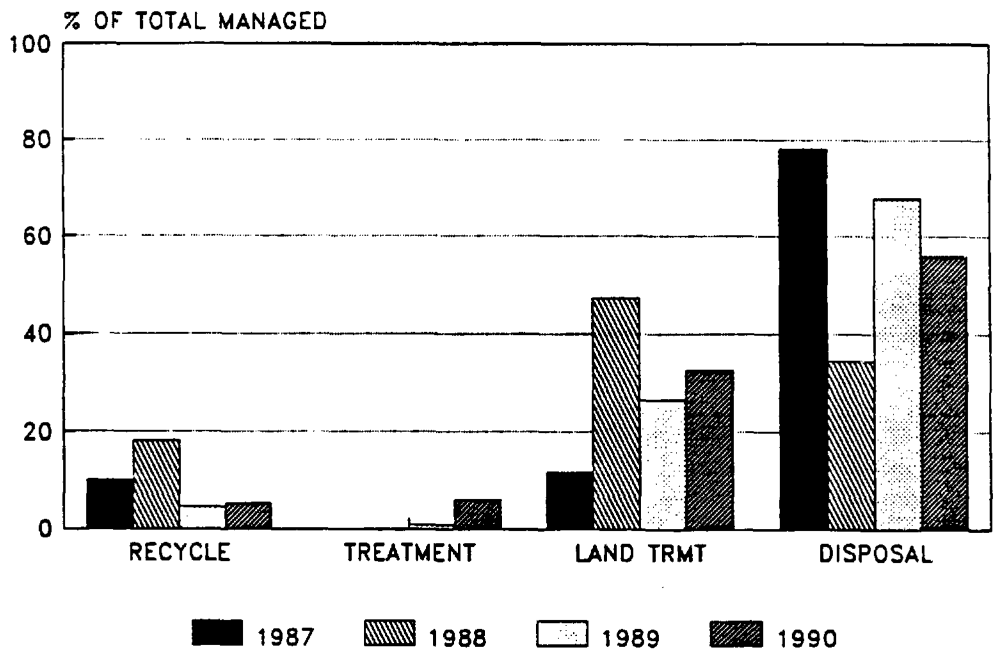
HEAT EXCHANGER CLEANING BUNDLE SLUDGE
1987 - 1990



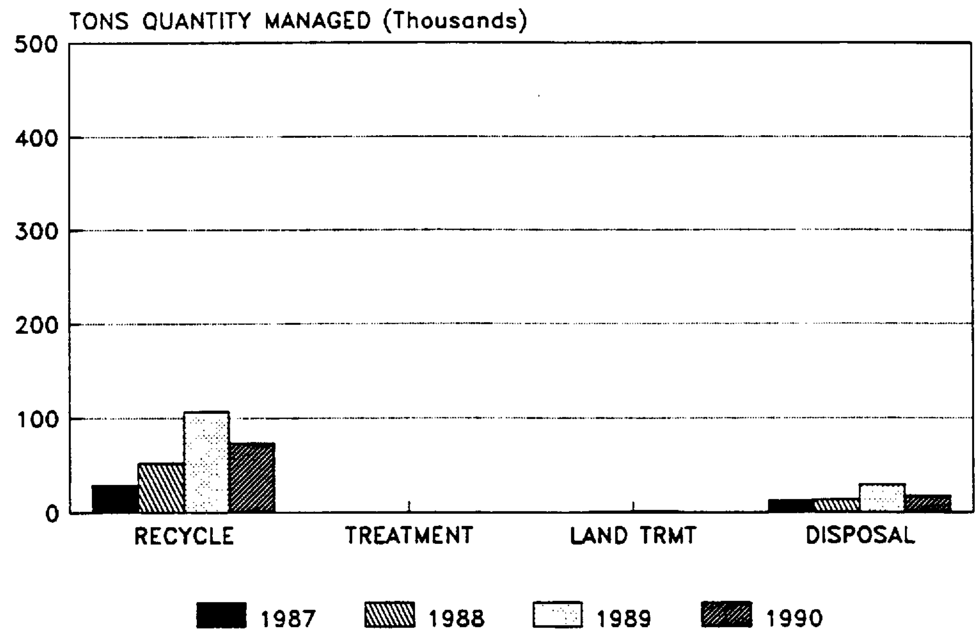


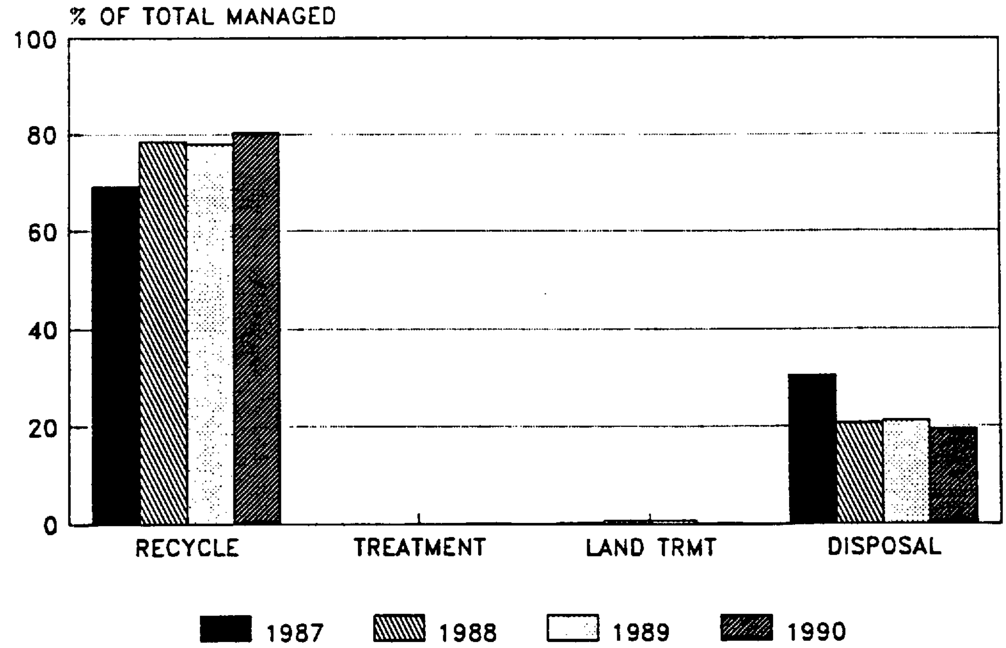
CONTAMINATED SOIL/SOLID
1987 - 1990



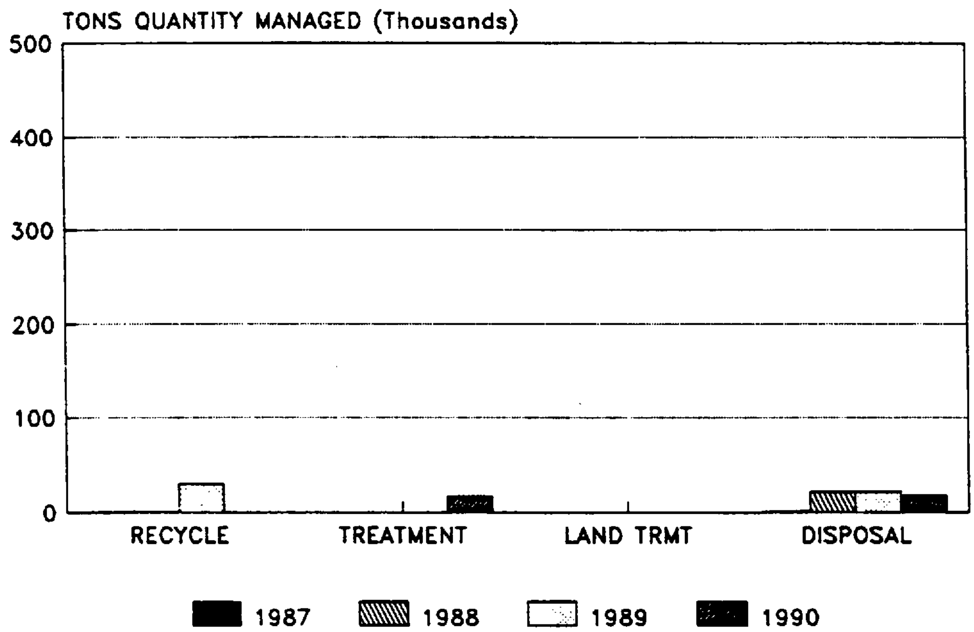


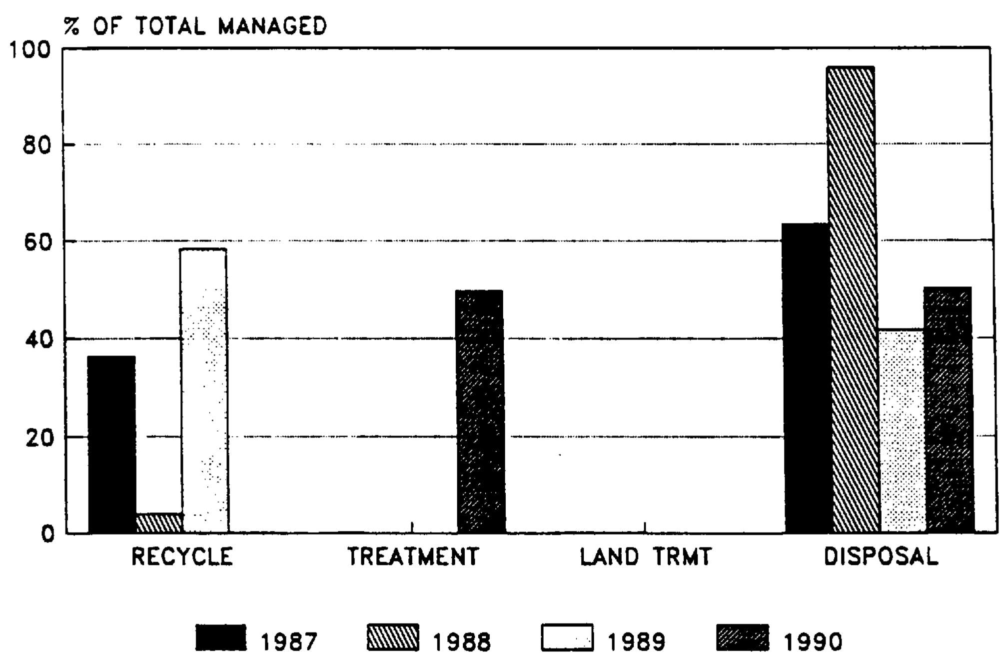
RESIDUAL COKE/CARBON/CHARCOAL
1987 - 1990



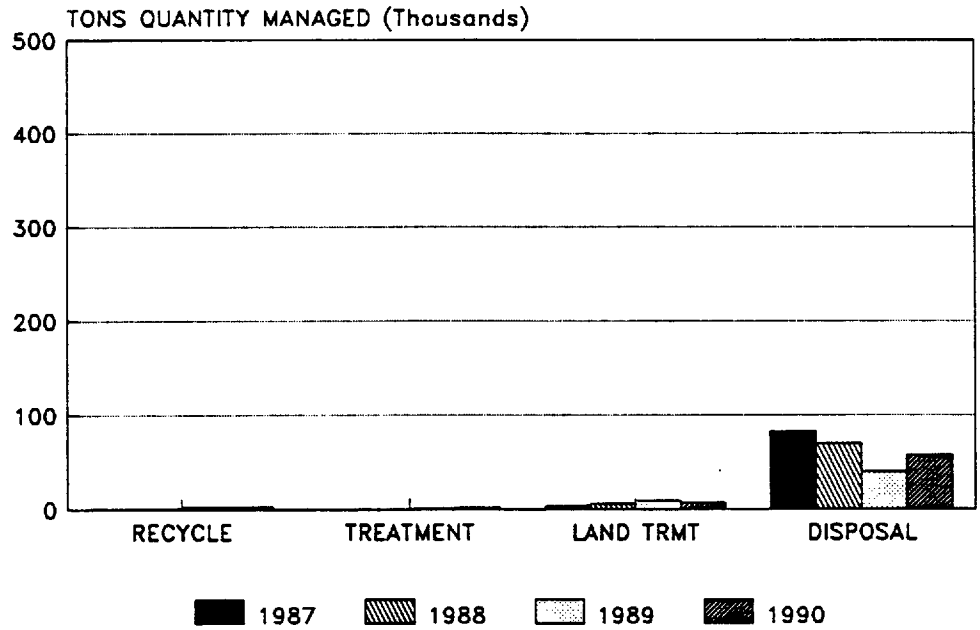


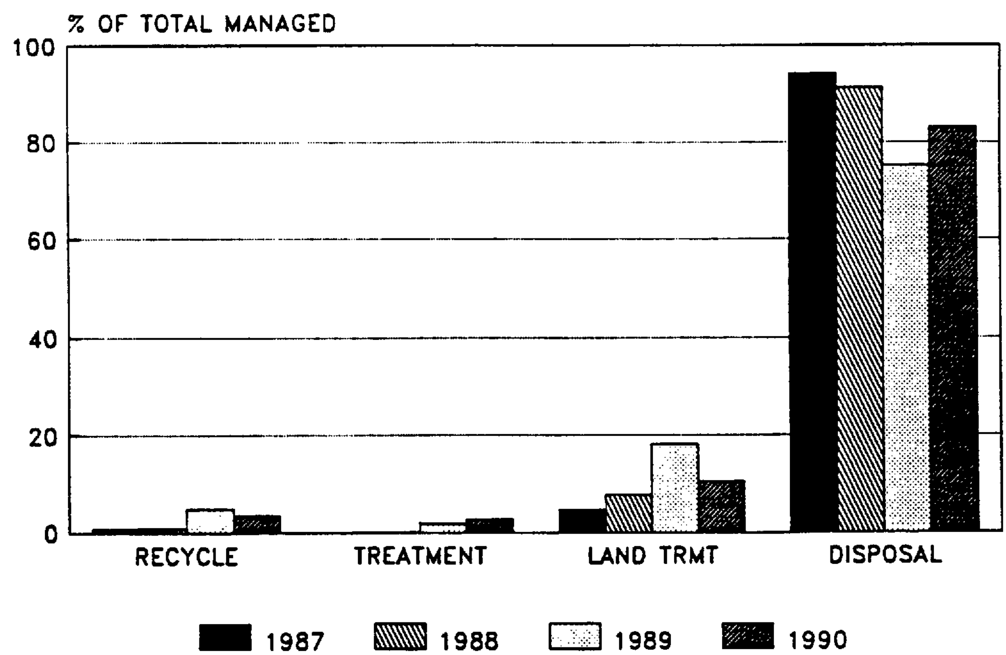
RESIDUAL SULFUR
1987 - 1990



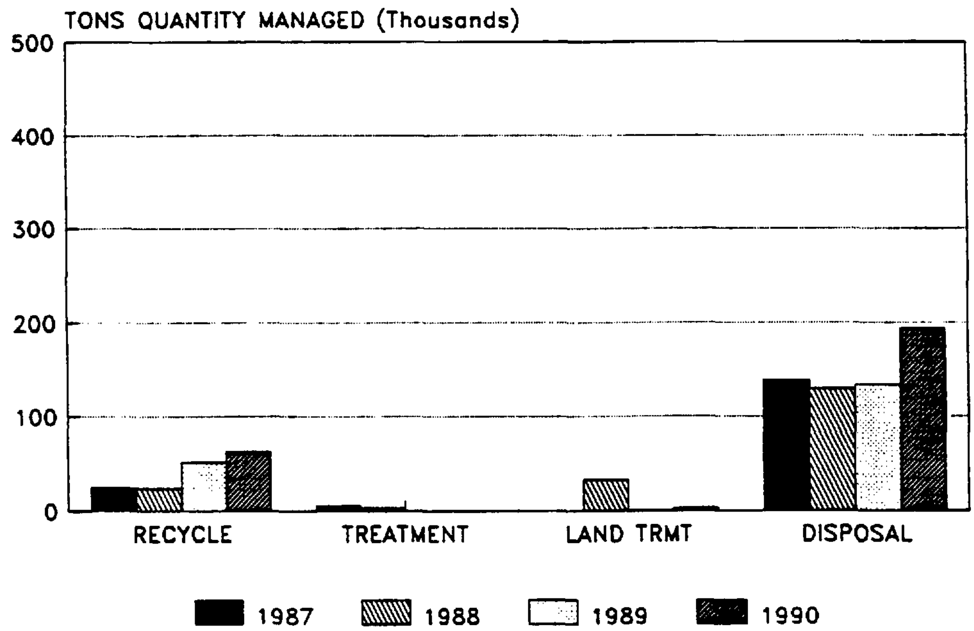


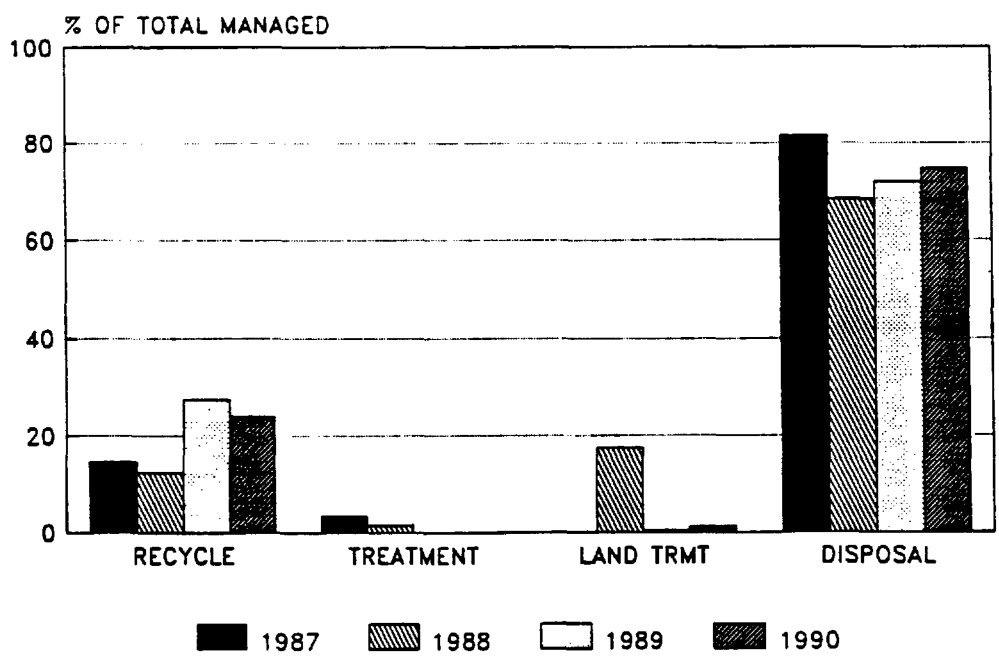
OTHER CONTAMINATED SOILS NOS
1987 - 1990



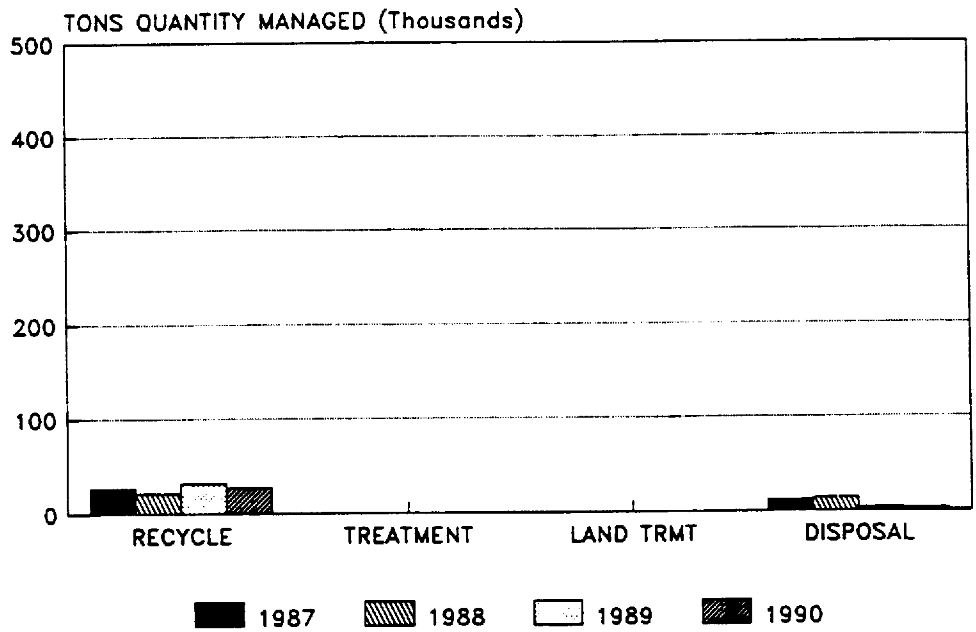


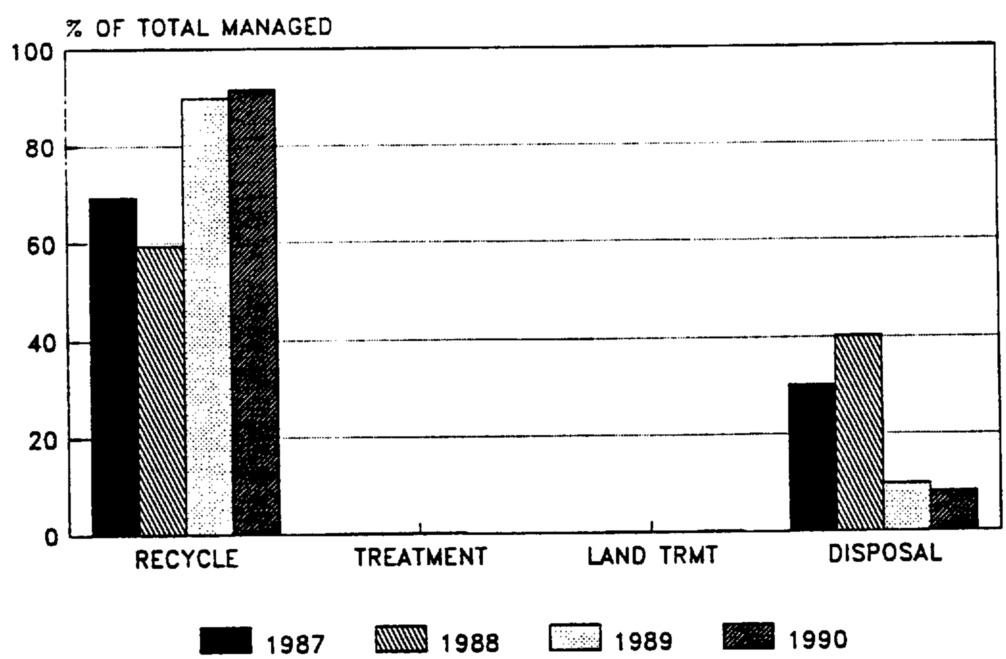
FLUID CRACKING CATALYST OR EQUIVALENT
1987 - 1990



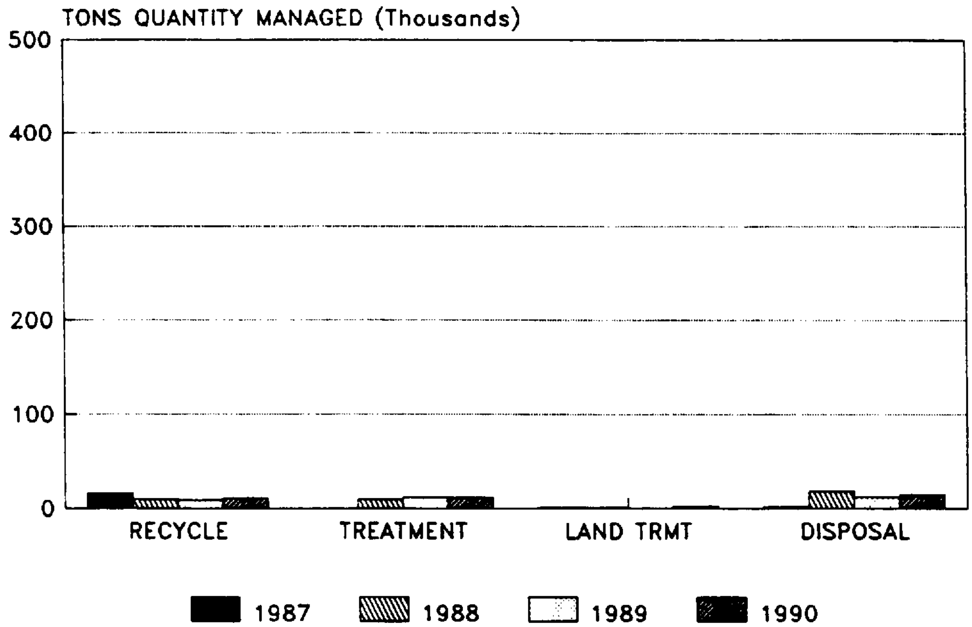


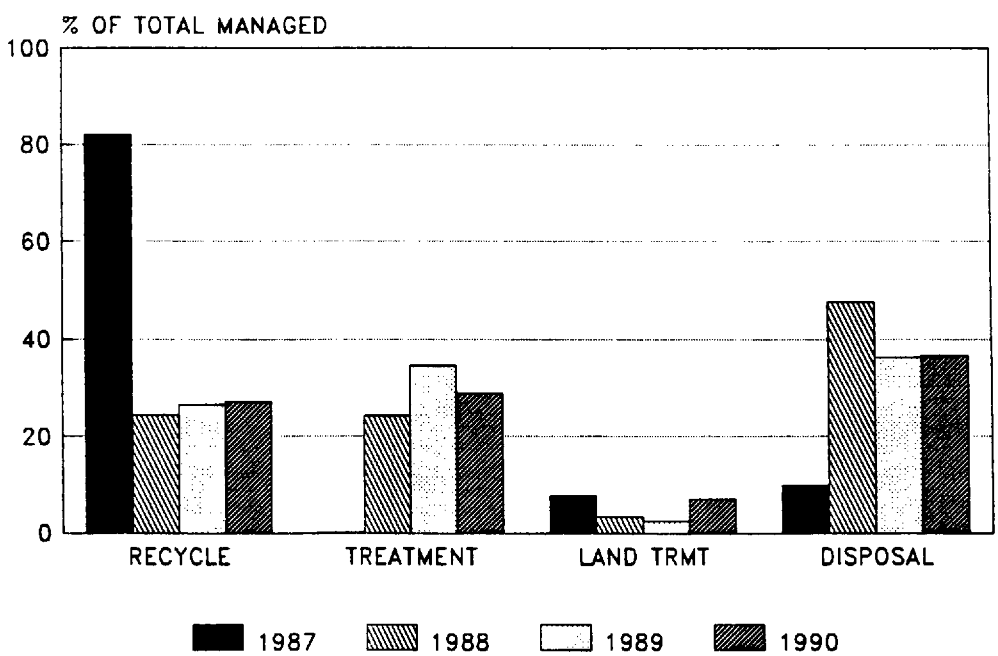
HYDROPROCESSING CATALYST
1987 - 1990



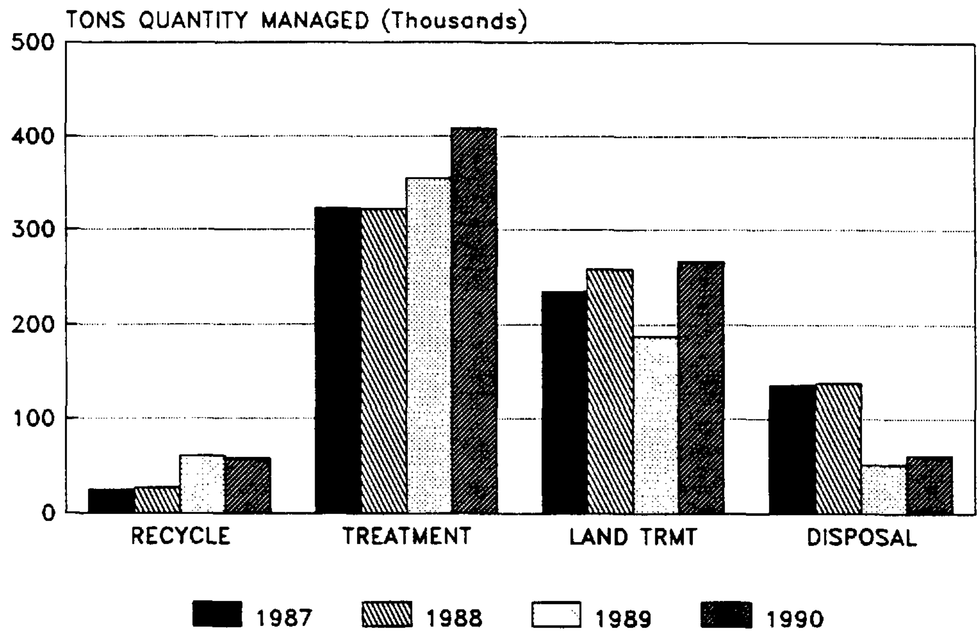


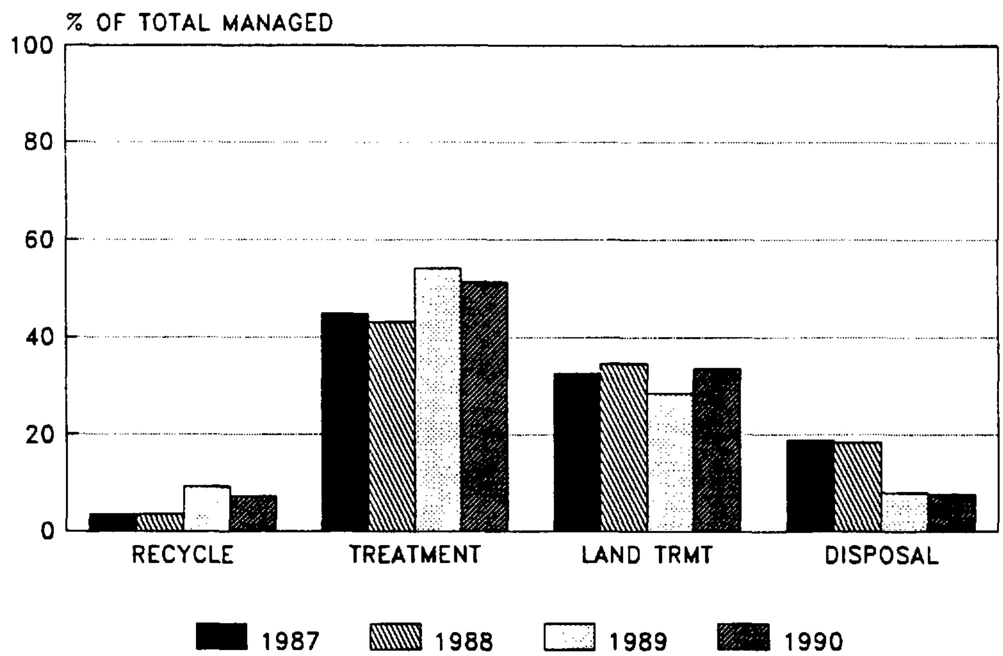
OTHER SPENT CATALYSTS NOS
1987 - 1990



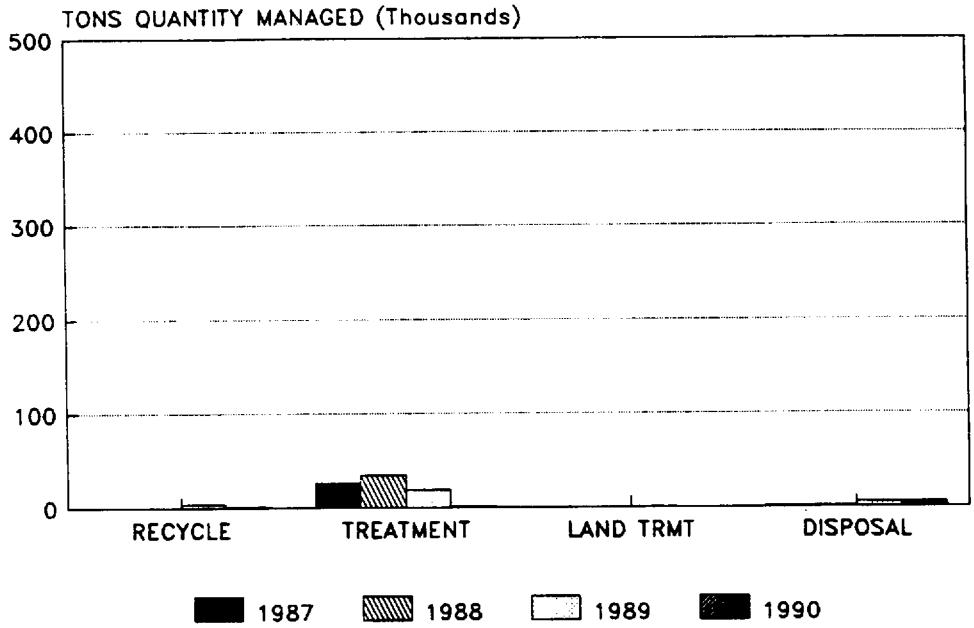


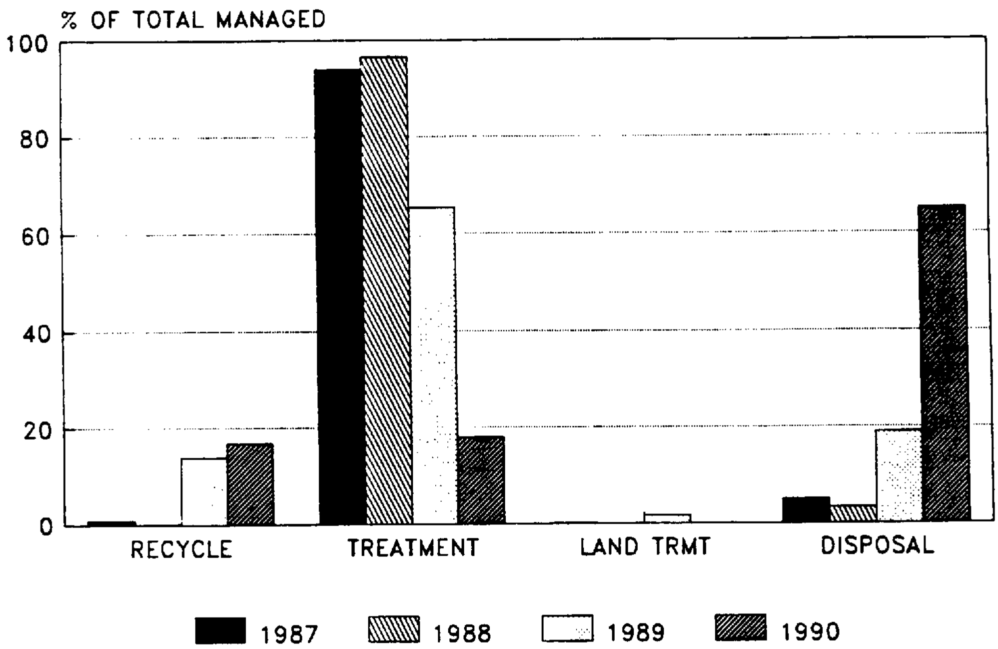
BIOMASS
1987 - 1990



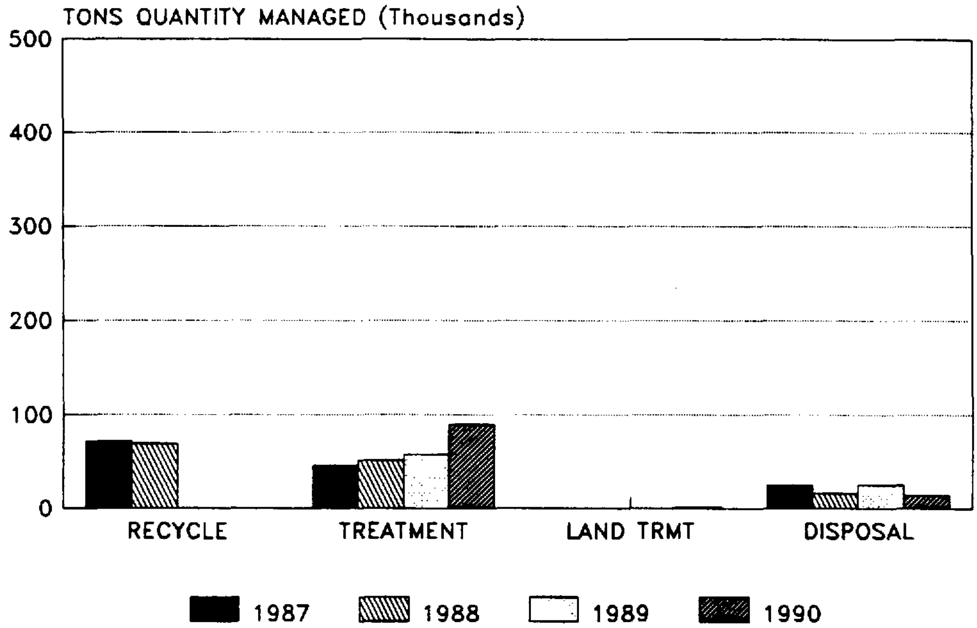


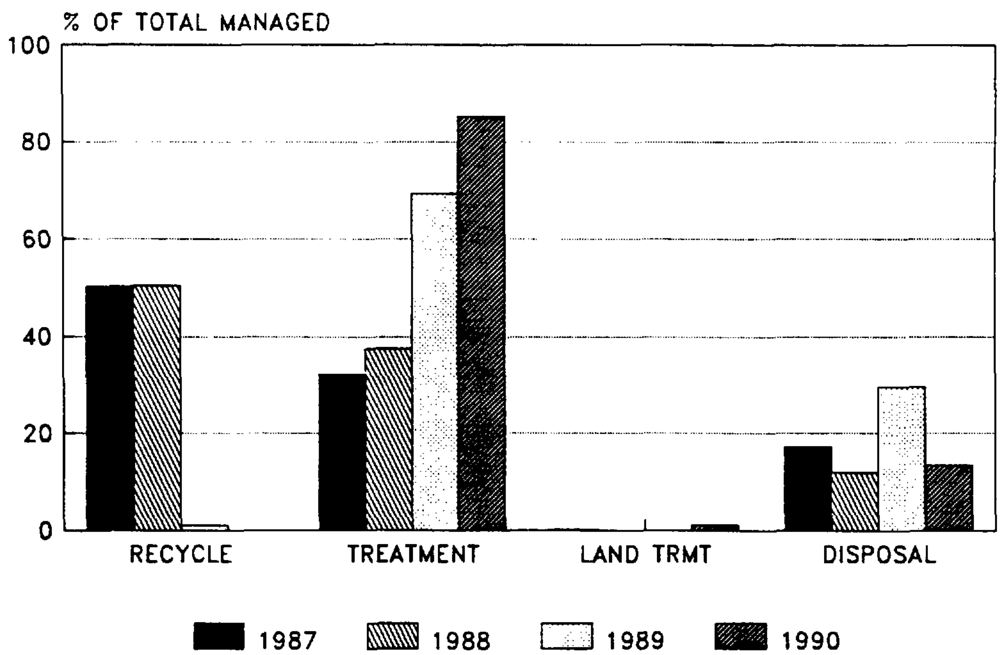
OIL CONTAMINATED WATER NOT WASTEWATER
1987 - 1990



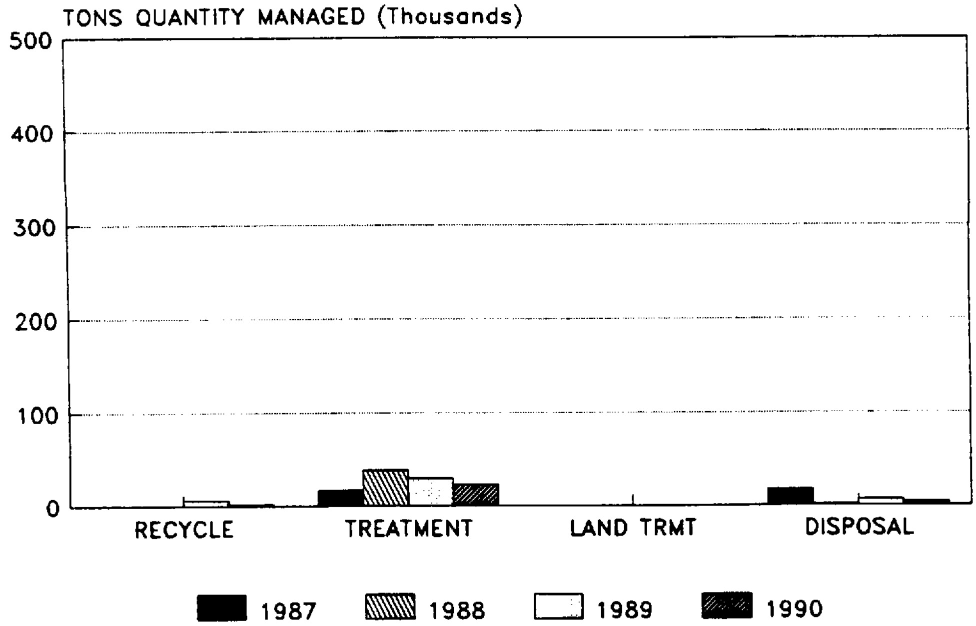


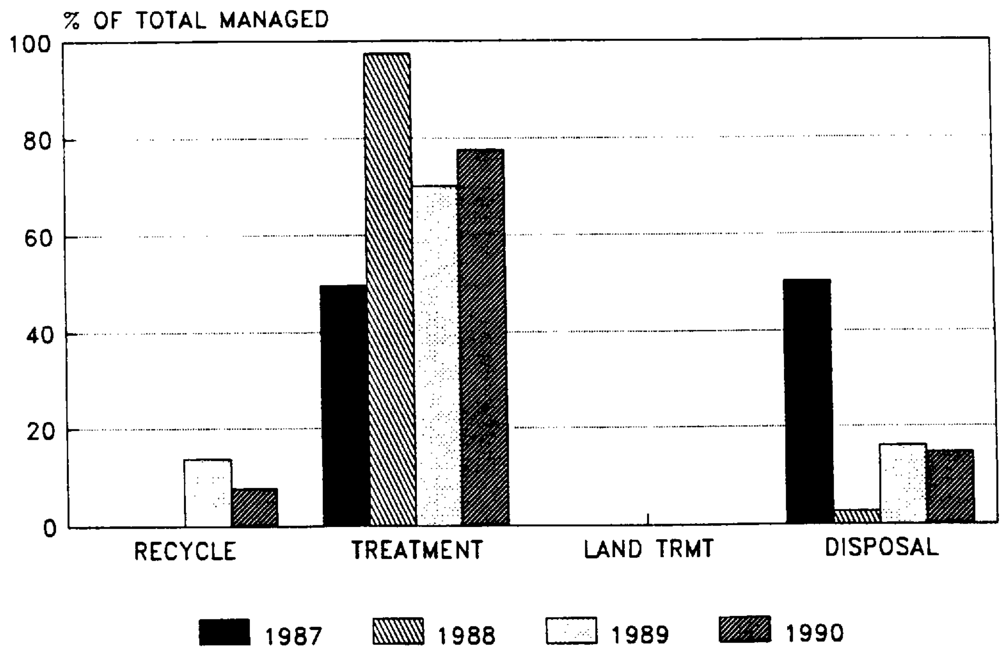
HIGH pH/LOW pH WATERS
1987 - 1990



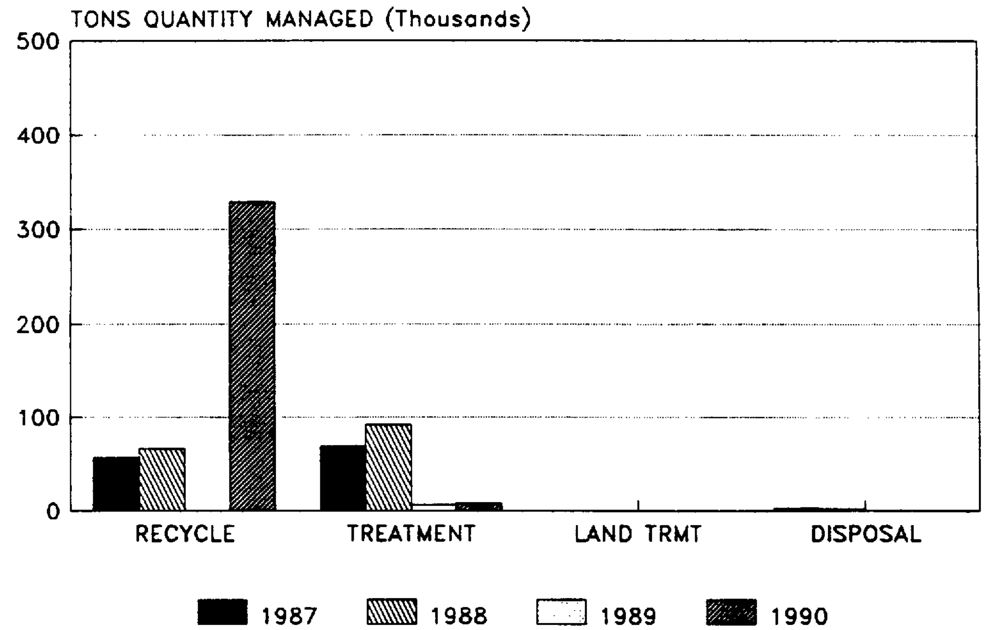


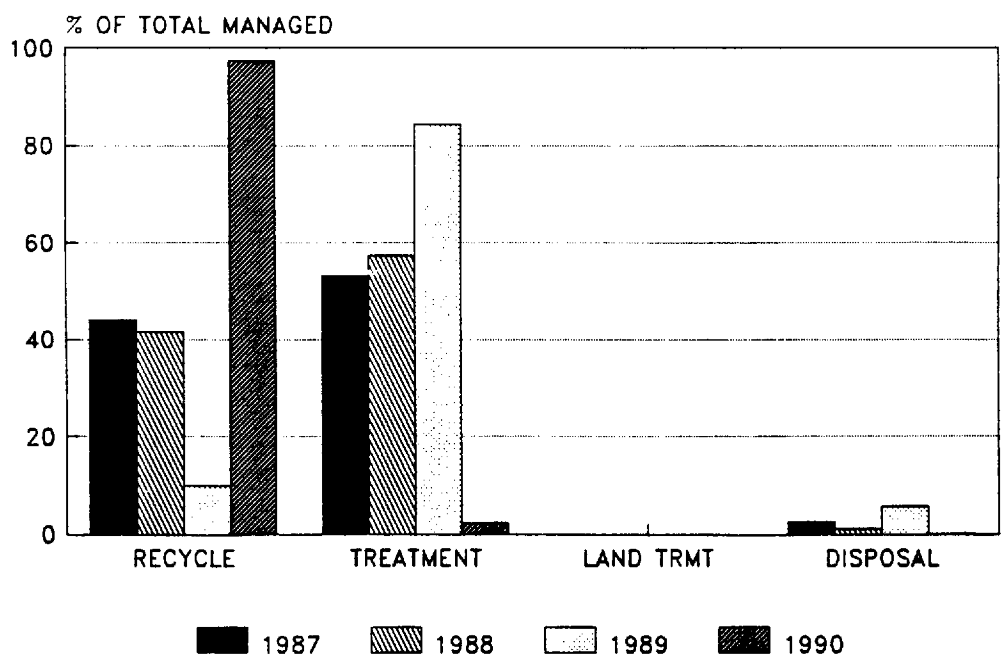
SPENT STRETFORD SOLUTION
1987 - 1990



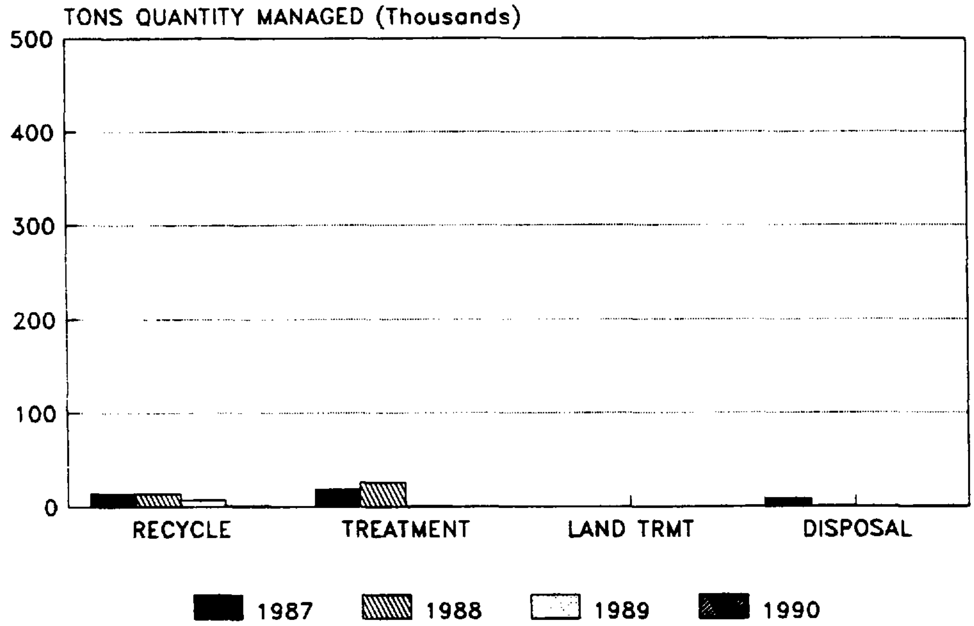


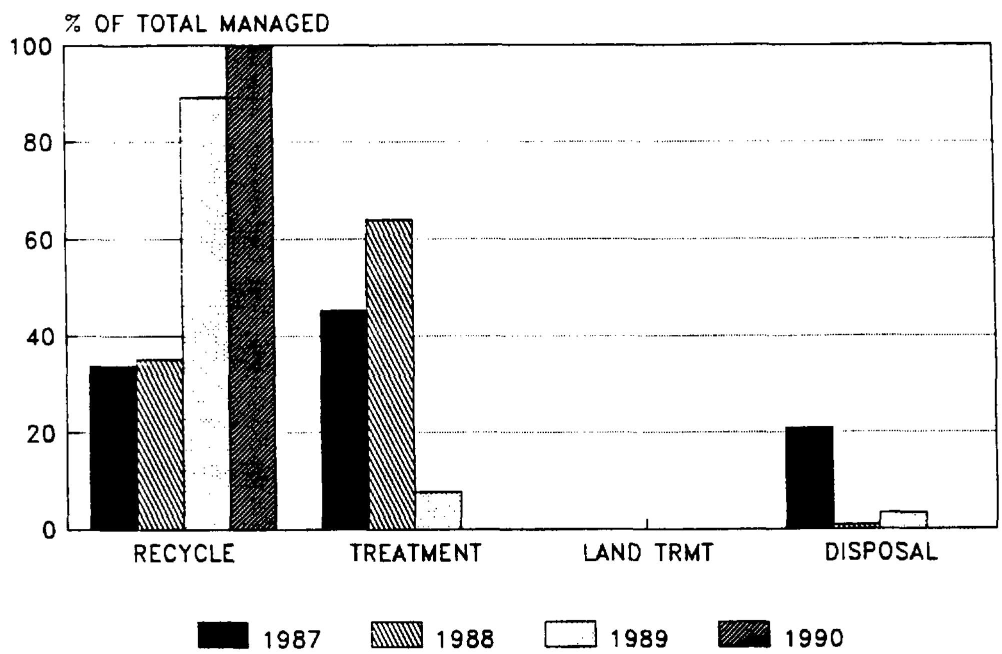
SPENT ACIDS
1987 - 1990



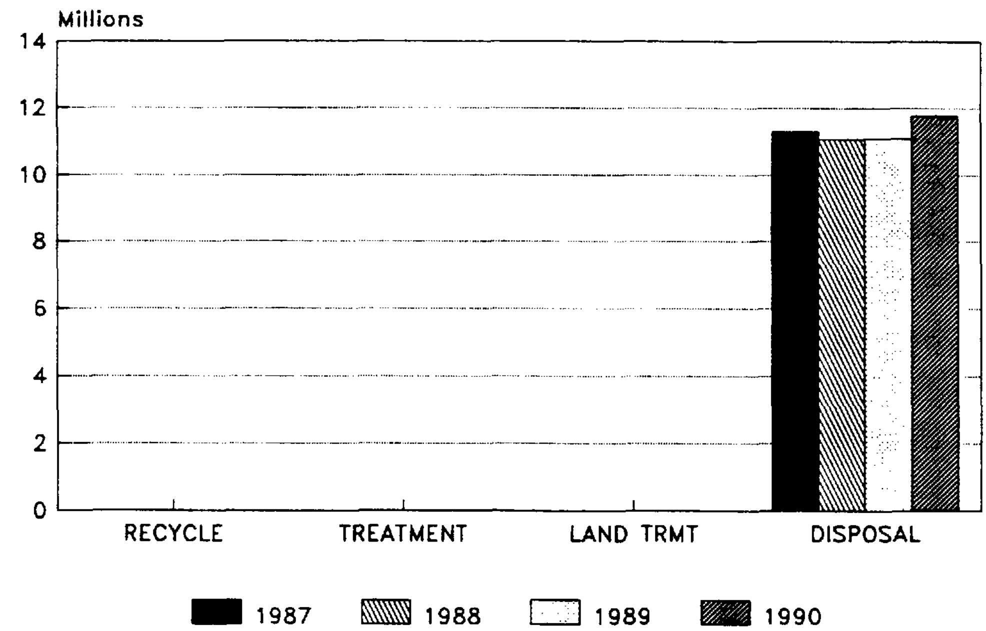


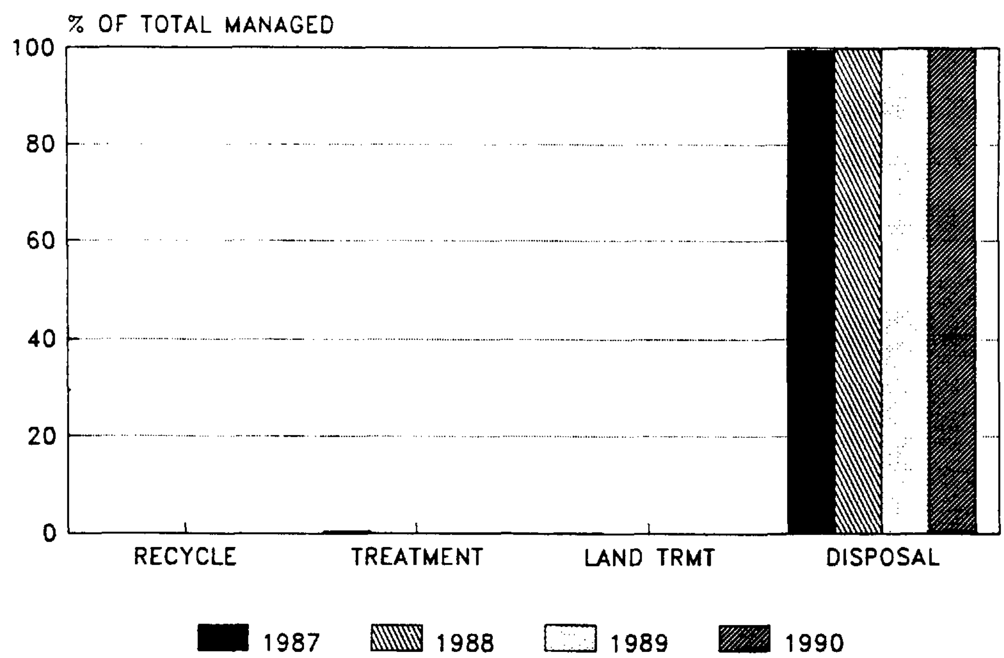
SPENT SULFITE SOLUTION
1987 - 1990



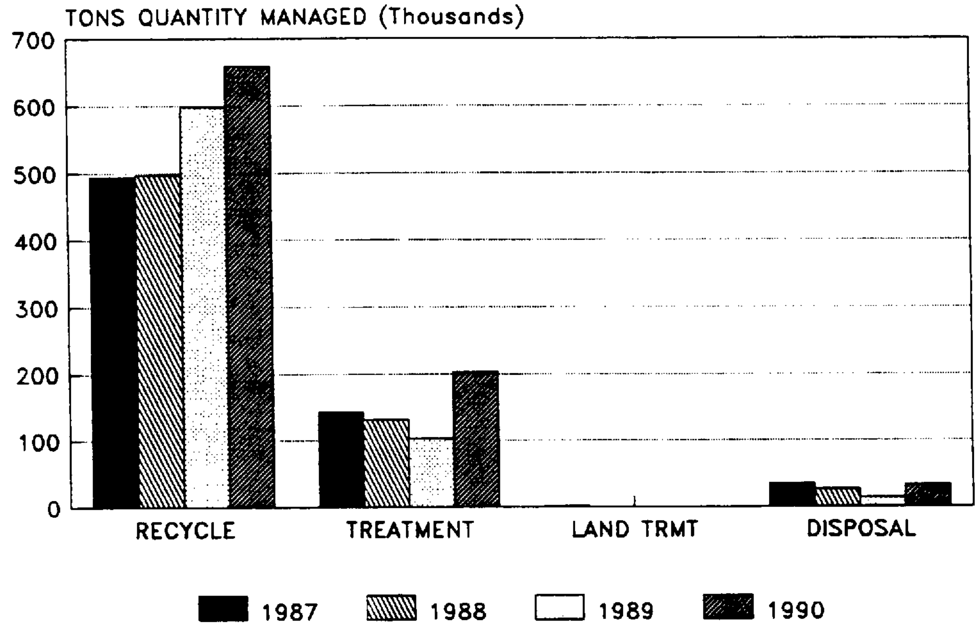


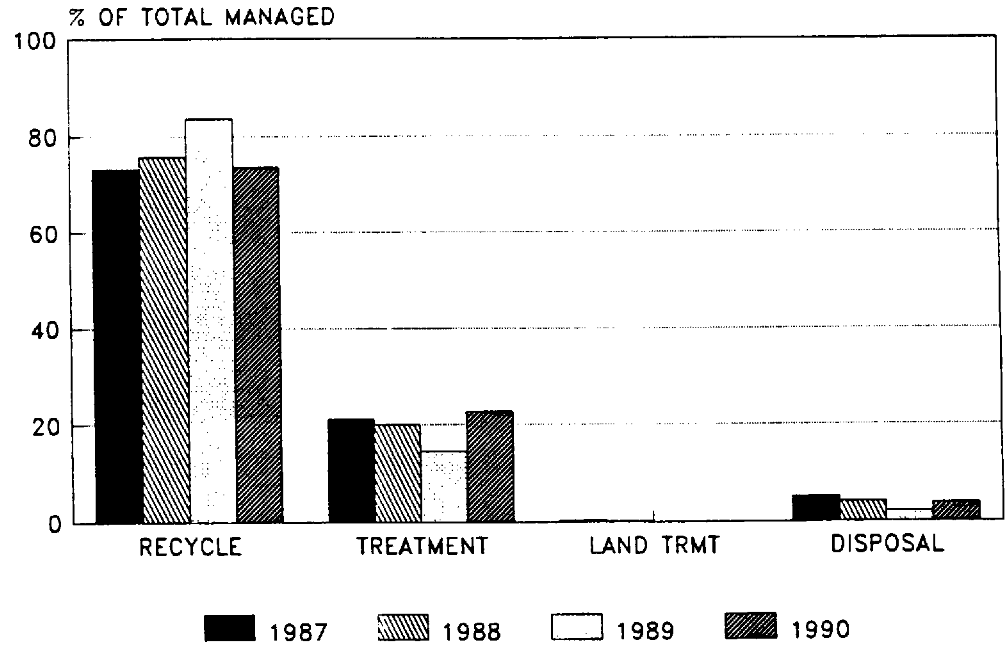
OTHER AQUEOUS RESIDUALS NOS
1987 - 1990



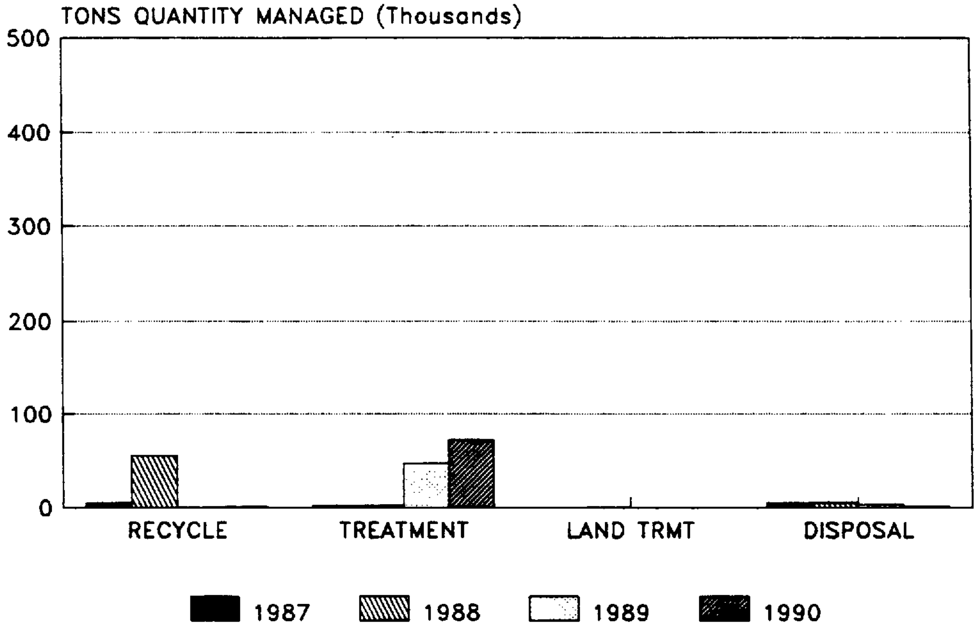


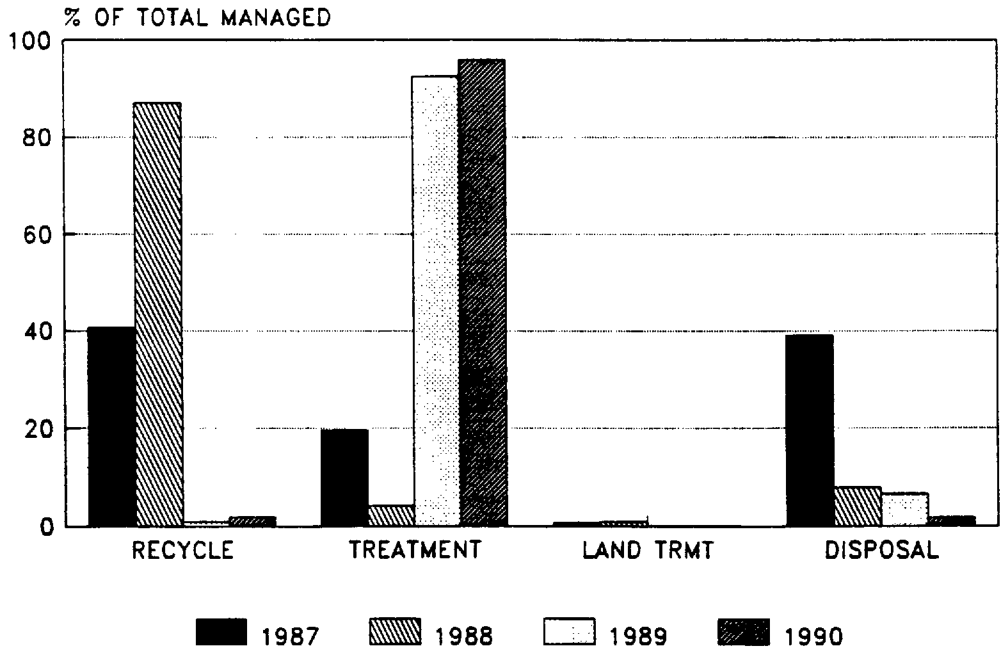
SPENT CAUSTICS
1987 - 1990



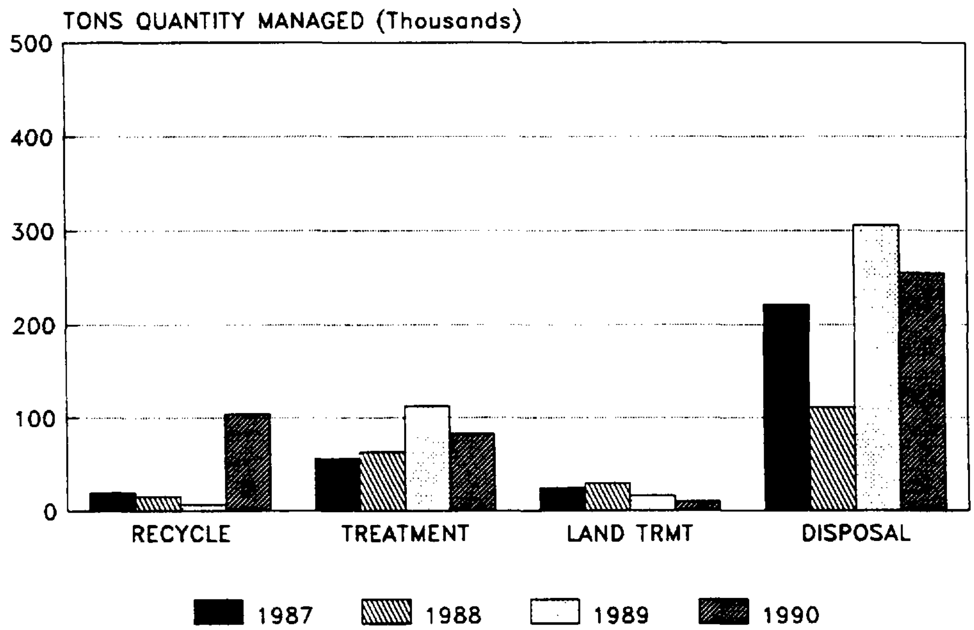


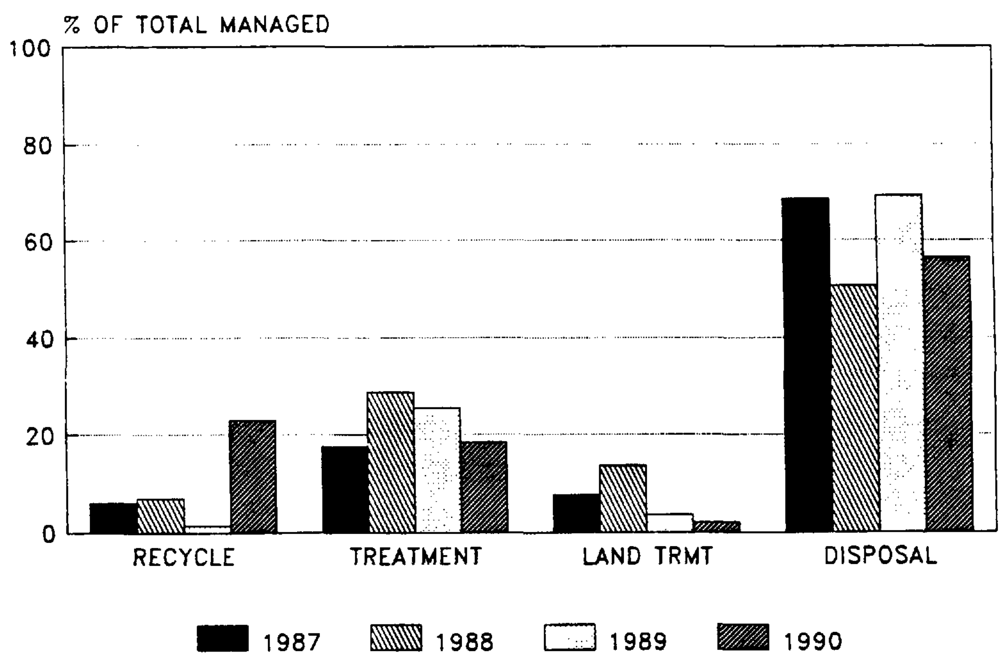
RESIDUAL AMINES
1987 - 1990



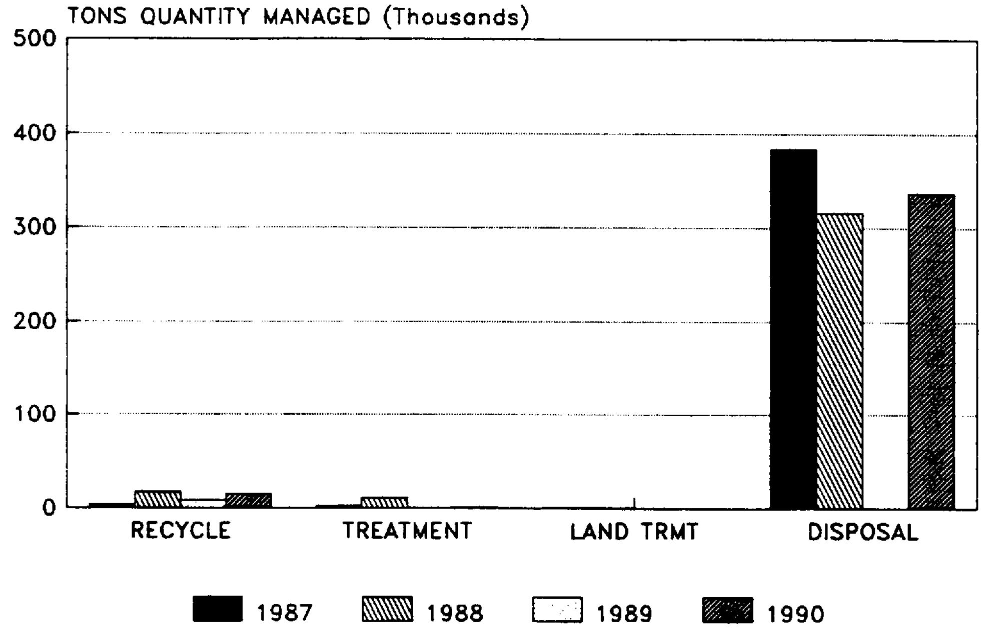


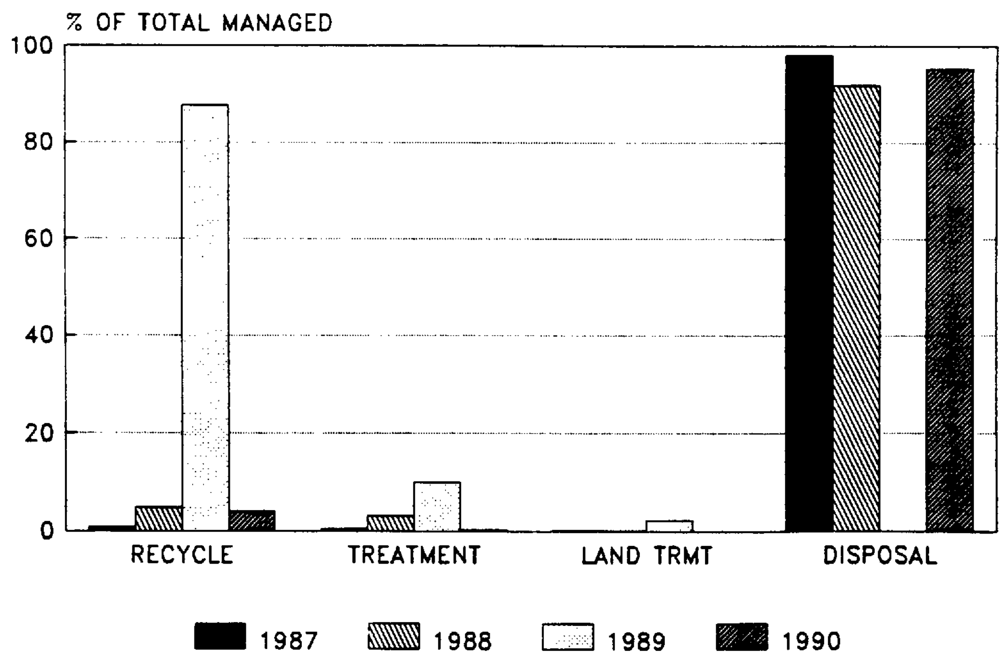
OTHER INORGANIC RESIDUALS NOS
1987 - 1990





OTHER RESIDUALS NOS
1987 - 1990





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