United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/3-86-009
October 1986

Air

EPA

RCRA TSDF Air Emissions — Background Technical Memoranda for Proposed Standards

ESED

EPA-450/3-86-009

RCRA TSDF Air Emissions — Background Technical Memoranda for Proposed Standards

Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

October 1986

This report has been reviewed by the Emission Standards and Engineering Division of the Office of Air Quality Planning and Standards, EPA, and approved for publication. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use. Copies of this report are available through the Library Services Office (MD-35), U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711; or, for a fee, from the National Technical Information Services, 5285 Port Royal Road, Springfield, Virginia 22161.

CONTENTS

CONTENTS (continued)

FIGURE

TABLES

1. INTRODUCTION AND OVERVIEW

The Emission Standards and Engineering Division (ESED) of the U.S. Environmental Protection Agency's (EPA's) Office of Air Quality Planning and Standards (OAQPS) is responsible for developing regulations under the 1976 Resource Conservation and Recovery ACT (RCRA) and its 1984 amendments to control air emissions from hazardous waste treatment, storage, and disposal facilities (TSDF). As part of the Office of Solid Waste (OSW) effort to ban solvents from land disposal and as part of the OAQPS effort to control air emissions from TSDF, ESED is studying what air pollution regulations are appropriate for waste solvent treatment facilities (WSTF) and TSDF. The purpose of this Technical Note is to present information developed by Pacific Environmental Services (PES) and the Research Triangle Institute (RTI) under assignments for ESED to support an accelerated effort to regulate WSTF and TSDF.

Under these assignments, PES reviewed available information on treatment technologies for waste solvents and developed order-of-magnitude emission, cost, and health input estimates associated with air pollution from WSTF. The scope of these impact analyses was limited to vapor-phase mass transfer treatment technologies (e.g., distillation, steam stripping) because sufficient information was available for only these techniques. The sources of process and fugitive emissions from these technologies are generally similar. Under these assignments, RTI extended the WSTF-based analysis to TSDF in general. Consequently, the approach used to evaluate emissions and controls was a general one, and not particular to a specific treatment technology.

A summary of the impact estimates and the approach to development of the estimates are summarized in Section 2 of this Technical Note. The general approach to development of the impact estimates included (1) approximating nationwide impacts by using an average of typical basis, and (2) approximating the risk of cancer incidence to the most exposed individuals by using a reasonable worst-case basis. In reviewing and then selecting the basic facts to fill in as the basis of the impact estimates, this general approach was followed. Section 3 presents a key to where specific information developed under these assignments is located. The detailed basis of the analyses is presented in Attachments 1-9 as a series of memoranda from PES and RTI staff to the ESED Task Manager.

2. SUMMARY OF STUDY APPROACH AND ESTIMATES

2.1 APPROACH

Vapor-phase mass transfer operations separate solvent waste constituents through volatilization and condensation of the more volatile components in the waste stream. The approach taken in the estimation of order-of-magnitude emission, cost, and health impacts for WSTF is shown in Figure 2-1 and is based on the general similarity of equipment and operations, i.e., the operation of distillation, steam stripping, and thin-film evaporation all have a common process emission source and common fugitive emission sources. The common process source is the column condenser vent. The fugitive emission sources common to these operations are pumps, valves, flanges, sampling connections, open-ended lines or valves, and pressure relief devices. These sources also are common to TSDF in general.

2.2 EMISSIONS

Order-of-magnitude emission estimates were developed for these treatment operations by developing generic parameters for process and fugitive emissions from a model WSTF facility based on information in reports provided by ESED, as well as using judgment to develop best estimates of parameters. The background information in these reports is summarized in the attachments, and the reports are referenced. The estimates then were extrapolated to TSDF in general. Because insufficient information was available to characterize the specific compositions of the waste solvents and other hazardous wastes beyond total volatile organic (VO) content, the uncontrolled process and fugitive emission rate could not be precisely quantified on a chemical-by-chemical basis. Thus, to provide a broad overview of potential emissions (and costs and health impacts), estimates were developed of the maximum process emission rate expected for

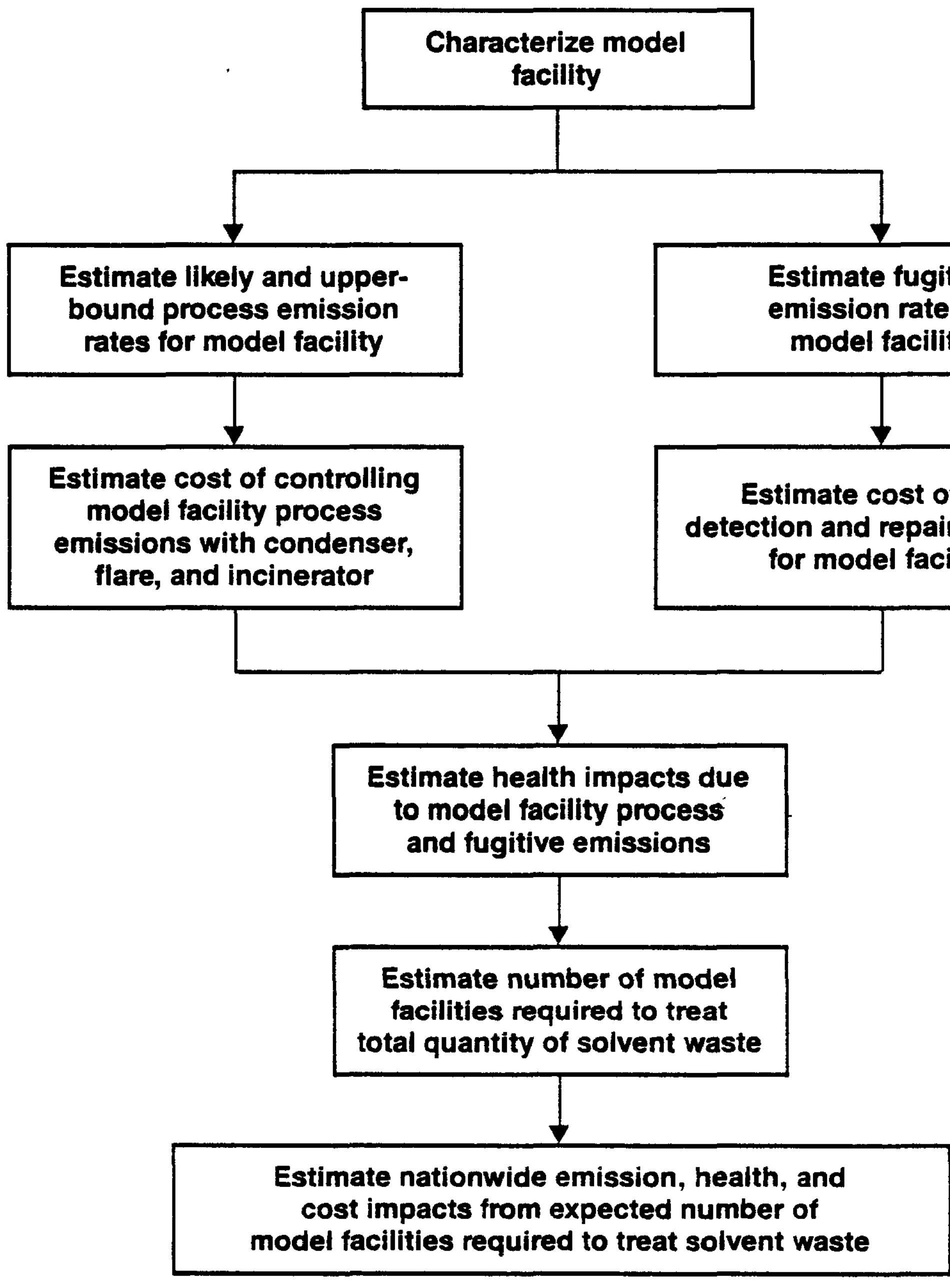


Figure 2-1. Flow diagram for WSTF analysis.

highly volatile solvents and of a likely, or typical, process emission rate from a WSTF. These emission rates were developed from a broad collection of information and should reflect a cross section of the process emission rates. Fugitive emissions from the model WSTF were estimated using synthetic organic chemical manufacturing industry (SOCMI) emission factors, and the equipment count was specified in the benzene fugitive emission standard model Case A. This basis was judged to be representative of the size and emission factors for WSTF and TSDF in general.*

2.3 COSTS

Estimates were developed of the range of costs to control process emissions and the cost to control fugitive emissions from a WSTF model facility. These estimates were used to estimate the upper-bound and likely lower-bound costs to control air emissions from WSTF. Specifically, order-of-magnitude cost estimates for process emission control were estimated assuming application of a 95-percent efficient secondary condenser, flare, or incinerator to the generic model facility condenser vent. The cost for secondary condenser control was used to estimate the likely or expected control costs, and the average of the cost to incinerate or flare emissions was used to estimate the upper bound for per plant process emission control costs. The cost to operate an inspection and maintenance program to reduce fugitive emissions was estimated using the fugitive emission cost algorithm developed by EPA for estimating the cost of controlling benzene fugitive emissions. These costs were extrapolated to TSDF in general.

In estimating likely lower-bound and upper-bound per plant costs of control for process emissions, it was necessary to specify model emission streams to be treated by a secondary condenser, flare, or incinerator. Methyl ethyl ketone (MEK) and toluene were selected as representative of typical nonhalogenated emission streams, and 1,1,1-trichloroethane was chosen to represent a typical halogenated emission stream.

---

*The emission factors were not adjusted for the waste stream composition as was done in the WET model because part of the equipment contacts the purified solvent or full-strength organics and the estimates are intended to be order-of-magnitude.

The per plant ranges of emission and cost estimates were projected to a nationwide basis using an estimate of the number of model facilities required to treat an estimated 436 x 10^6 gallons (gal) of waste solvent per year.* The number of model facilities was derived from the estimated average solvent recovery rate (i.e., the volume of solvent recovered to the volume of waste solvent treated at the facility) and the expected total volume of waste solvent.

In estimating lower-bound, or typical, nationwide control costs, it was assumed that all plants would use secondary condensers to control process emissions. In estimating upper-bound nationwide costs, it was assumed that approximately 50 percent of the total number of plants would treat halogenated compounds (and use incinerators for process emission control), and approximately 50 percent would treat nonhalogenated compounds (and use flares for process emission control).

2.4 HEALTH

Order-of-magnitude health impacts were estimated for cancer risks from exposure to air emissions from WSTF. These impacts were extrapolated to TSDF in general. Although cancer risks are not the only health impacts associated with air emissions from WSTF, they are the most available measure of direct health effects associated with chronic low-level exposures to organic solvents. The Human Exposure Model (HEM) was used to calculate the magnitude of risks posed by WSTF at both typical and maximum emission rates. Based on EPA's efforts to locate WSTF and then perform surveys of these facilities, EPA selected an urban/rural distribution and specific locations (where actual WSTF are located) to approximate this distribution in performing the risk assessment. In doing this, EPA also selected the population and meteorologic conditions needed for using the HEM. In addition, health impacts were evaluated for a range of unit risk factors (i.e., 2 x 10^{-7} and 2 x 10^{-5} cases/μg/m^3-person). The range of unit risk factors was based on an analysis of the organic chemicals associated with TSDF operations. This analysis found that carbon tetrachloride is the organic

*The estimate of the quantity of solvent waste to be treated per year was provided by OSW. Note that 1 gal = 3.785 liters (L).

chemical with the most individual impact vis-a-vis emissions and risks. Thus, it was used as the upper bound on the range of unit risk factors. The nationwide annual cancer incidence was calculated as the average annual incidence considering the projected number of WSTF and the range in emission rates, geographic location, and urban/rural sites expected for WSTF. The risk of cancer for the most exposed individuals was calculated as the largest expected risk resulting from the largest emission rate, highest exposure location, and highest unit risk factor.

2.5 SUMMARY OF RESULTS

Table 2-1 presents a summary of the model WSTF parameters and emission rates, and Table 2-2 presents the range and average of the per plant emission control cost. Nationwide emissions and costs for WSTF are summarized in Table 2-3. Nationwide emissions and costs for TSDF in general are summarized in Table 2-4.

The order-of-magnitude health impact analysis showed the emission controls would reduce the individual maximum lifetime risk (MLR) of cancer from WSTF operating at the upper-bound emission rate from about 3.7×10^{-3} to 2.6×10^{-4}. The nationwide annual incidence of cancer in the population living within 50 kilometers (km) (1 km = 0.62137 mile [mi]) of uncontrolled WSTF is estimated to be about 3.4 cases/year (yr) assuming the higher risk factor. With the process and fugitive emission controls evaluated in this study, this nationwide evidence rate would be reduced to about 0.3 case/yr.

2.6 UNCERTAINTIES IN THE ANALYSIS

It should be recognized that these order-of-magnitude emission, cost, and risk estimates possess considerable uncertainty. Even though these estimates were developed using the best available information, they are imprecise because of a paucity of specific information on WSTF and TSDF operations and inconsistencies in the available information. Considering the lack of available information, ranges of impact estimates were developed to bound what the true impacts might be. Judgment then was used to identify the most likely or "typical" impact estimates within each range. The value selected as the likely impact estimate within each range was chosen such that potential error should be on the conservative side, unless other factors indicated that another value within the range would represent a better estimate.

TABLE 2-1. SUMMARY OF MODEL PLANT PARAMETERS AND EMISSION RATES

Item	Value
General plant operation	
Waste solvent reclaimed per year	8 gigagrams/year (Gg/yr)
Emitting hours for condenser	4,160 hours/year (h/yr)
Emitting hours for fugitive emission sources	8,760 h/yr
Condenser vent stream emission characteristics	
Temperature, °F	75 °F
Flow rate	26 scfm[a]
VO emission rate	
Likely	7 pounds/hour (lb/h)
Upper-bound	75 lb/h
Fugitive emission sources	13.5 megagrams/year (Mg/yr)

[a]scfm = cubic feet per minute at specified standard conditions of temperature and pressure.

TABLE 2-2. SUMMARY OF MODEL FACILITY CONTROL COST ESTIMATES

Control device	Emission rate, lb/h	Capital cost, 1985 $		Annualized cost, 1985 $/yr	
		Range	Average	Range	Average
Condenser vent					
Case 1	7				
Secondary condenser		2,630 to 3,850	3,270	1,425 to 1,885	1,660
Flare		81,000 to 91,000	86,000	--	52,000
Incinerator		NA[a]	209,000	NA[a]	164,100
Case 2	32 to 75				
Secondary condenser		21,000 to 29,000	25,000	4,700 to 6,400	5,500
Flare		81,000 to 91,000	86,000	--	43,000
Incinerator		NA[a]	209,000	NA[a]	150,900
Fugitive sources					
LDR program	3.47	NA[a]	26,960	NA[a]	11,900

LDR = Land disposal restrictions.
NA = Not applicable.

[a]Only average value calculated.

TABLE 2-3. SUMMARY OF TYPICAL AND UPPER-BOUND ESTIMATES OF NATIONWIDE EMISSION AND CONTROL COSTS FOR 95 PLANTS

	Typical		Upper-bound	
	Uncontrolled	Controlled	Uncontrolled	Controlled
VO emissions, Mg/yr (tons/yr)	2,550 (2,810)	400 (440)	14,740 (16,250)	1,010 (1,110)
Control costs[a]				
Capital cost, $	NA	2,872,000	NA	16,635,000
Annual cost, $/yr	NA	1,288,000	NA	10,970,000
Recovery credit, $/yr[b]	NA	(1,176,000)[c]	NA	(429,000)[c]
Net annual cost (with recovery credit), $/yr	NA	112,000	NA	10,541,000

NA = Not applicable.

[a]All costs are in June 1985 $.

[b]Recovery credits were estimated assuming a recovered solvent value of $450/Mg.

[c]( ) indicates a cost credit.

TABLE 2-4. SUMMARY OF NATIONWIDE EMISSIONS AND COSTS FOR TSDF IN GENERAL[a]

	Uncontrolled	Controlled
VO emissions, Mg/yr	17,800	4,500
Control costs		
Capital cost, $	NA	35,000,000
Annual cost, $/yr	NA	9,600,000

NA = Not applicable.

[a]Estimates shown include only fugitive emissions.

The major deficiencies in the available information were:

- Characterization of WSTF. The number of facilities, the distribution of production capacities (and typical capacity), and geographical distribution were not well defined in the available reports, or only a single estimate was available. For example, the number of facilities treating waste solvents was estimated to range from about 60 to 400 based on information in various reports, and production capacity estimates were available from essentially only two surveys.

- Waste Stream Characterization. Information on specific composition of waste streams appeared to be highly uncertain because the original survey data did not include composition by constituent and subsequent estimates were derived from these data using several assumptions.

- Emission Rate and Stream Characterization. Very little information was availalbe on emission stream composition (temperature, flow rate, and concentrations) and on uncontrolled emission rates. The available information on emission rates was based on a small number of tests conducted at unknown operating conditions and waste streams of unknown composition.

Consequently, the emission, cost, and risk estimates that were developed reflect judgments on the best estimate of many of the parameters. Such judgments were made on characterization of WSTF operation, waste stream composition, the range of possible emission rates, emission stream parameters, and possible range of unit risk factors. The estimates, therefore, are believed to be useful for presenting a broad overview of the potential impacts of the control of air emissions, but not for precisely quantifying the impacts.

3. KEY TO LOCATION OF SPECIFIC INFORMATION DEVELOPED UNDER THESE ASSIGNMENTS

The memoranda prepared under these assignments and included as attachments to this Technical Note are listed below:

Attachment No. 1. Memorandum from Meyer, J., and Fitzsimons, G., Pacific Environmental Services, to Dimmick, F., U.S. EPA:ESED:SDB. October 21, 1985. Model facility parameters and draft control cost estimates.

Attachment No. 2. Memorandum from Meyer, J., Pacific Environmental Services, to Dimmick, F., U.S. EPA:ESED:SDB. October 23, 1985. Revisions to draft model facility parameters and draft condenser cost estimates.

Attachment No. 3. Memorandum from Fitzsimons, G., Pacific Environmental Services, to Dimmick, F., U.S. EPA:ESED:SDB. October 30, 1985. Revised HEM modeling inputs for WSTF model plants.

Attachment No. 4. Memorandum from Meyer, J., Pacific Environmental Services, to Dimmick, F., U.S. EPA:ESED:SDB. October 31, 1985. Chemicals covered in land banning action.

Attachment No. 5. Memorandum from Meyer, J., Pacific Environmental Services, to Dimmick, F., U.S. EPA:ESED:SDB. October 31, 1985. Revised incinerator cost estimates and additional cost estimates for secondary condenser control.

Attachment No. 6. Fitzsimons, G. (Pacific Environmental Services). Preliminary Estimate Using Model Plant Approach of Nationwide Maximum Risk and Incidence Associated with Air Emissions from WSTFs. November 11, 1985. 5 p.

Attachment No. 7. Memorandum from Fitzsimons, G., Pacific Environmental Services, to Dimmick, F., U.S. EPA:ESED:SDB. January 24, 1986. Revised costs for fugitive emission control at a model WSTF.

Attachment No. 8. Memorandum from Fitzsimons, G., Pacific Environmental Services, to Dimmick, F., U.S. EPA:ESED:SDB. January 24, 1986. Estimates of nationwide emissions and cost of control for waste solvent treatment facilities (WSTFs).

Attachment No. 9. Memorandum from York, S., Research Triangle Institute, to Dimmick, F., U.S. EPA:ESED:SDB. June 5, 1986. Draft calculation of impacts for proposed WSTF standards.

Table 3-1 presents a key to where major work outputs and assumptions are located in the attachments.

TABLE 3-1. KEY TO LOCATION OF MAJOR WORK OUTPUTS AND ASSUMPTIONS

Item	Attachment no. 1	2	3	4	5	6	7	8	9
General model facility characterization									
Waste solvent reclamation rate......	D	F							
Operating hours....................	D	F							
Chemicals of concern................				F					
Model chemicals selected............	D	D	F						
Equipment count (for fugitive emission estimate)................	F								
Process emission stream temperature......................	D	F	F						
Per plant VO emission estimates									
Uncontrolled and controlled process emission rate range.......	D	F	F						
Uncontrolled and controlled fugitive emission rate............	D	F	F						
Range of per plant total emissions........................								F	
Per plant control cost estimates									
Incinerator control of process emissions........................	D				F				
Flare control of process emissions........................	F								
Condenser control of process emissions........................	D	D			D			F	
Fugitive emission control...........	D						F		
Range of total per plant costs for process and fugitive controls........................								F	F
Estimate of nationwide emission and cost impacts (WSTF/TSDF)............								F	
Preliminary risk assessment									
Model case inputs to Human Exposure Model (HEM)..............			F						
Estimate of maximum lifetime risk and nationwide annual incidence........................						F			

D = Draft (subject to revision in a latter attachment).
F = Final estimate used.

Standards for the control of volatile organic (VO) air emissions from hazardous waste treatment, storage, and disposal facilities (TSDF) and waste solvent treatment facilities (WSTF) are being proposed under the authority of Section 3004(n) of the 1976 Resource Conservation and Recovery Act (RCRA). These standards would apply to certain process vents associated with distillation and stripping equipment at WSTF (and at TSDF, if applicable) and to fugitive emissions from equipment leaks at TSDF where the waste stream (or its derivatives) contain 10 percent or more total organics. This document contains a technical note and background memoranda considered in developing the proposed standards.

ATTACHMENT 1

OCT 2 1 1985

DRAFT

M E M O R A N D U M

SUBJECT: Model Facility Parameters and Draft Control Cost Estimates

TO: Fred Dimmick, SDB

FROM: Jan Meyer, PES
Graham Fitzsimons, PES

- -

I. Purpose

The model facility parameters recommended for waste solvent treatment facilities (WSTF's) and the basis for recommendation of these parameters are presented in this memorandum. In addition, draft estimates of control costs are presented for 95 percent control of condenser vent emissions by an incinerator, a flare, or a condenser and for control of fugitive emissions using an inspection and maintenance program.

II. Discussion

A. Model Facility Parameters

Model facility parameters were developed to characterize emissions and costs for control of air emissions from WSTF's using distillation treatment technologies. The analysis is being limited to distillation technologies because of (1) their greater potential for significant air emissions and (2) the paucity of information on treatment of highly aqueous-organic streams and the applicability of previously developed control requirements to these technologies.

Model facility parameters were developed to characterize both process and fugitive emissions from distillation treatment technologies at WSTF's. Process emissions from distillation technologies (these operations include distillation, steam stripping, thin film evaporation, and air stripping) consist mainly of emissions from the condenser vent. Consequently, for the purpose of the cost and emission rate* analyses, model operating conditions and condenser vent characteristics were developed. The recommended parameters for process emissions and the basis for the recommendations are summarized in Table 1. These parameters are considered to represent best judgments of reasonable values for the parameters based on our review of the information provided on WSTF's and distillation operations in Synthetic Organic Chemical Manufacturing

---

*This emission rate is the rate per quantity of reclaimed solvent. Emission rates used to estimate nationwide emissions will be developed from these rates using best estimates of recovery rates for concentrated organic liquids and for aqueous-organic liquids.

Industry (SOCMI). Since WSTF operations are expected to be predominantly batch operations, the use of SOCMI distillation column parameters, which are continuous operations, is expected to introduce errors of unknown direction and magnitude. Furthermore, because of considerable uncertainty on emission rates from condenser vents from batch operations, two estimates of emission rates are presented in Table 1 to allow development of upper and lower bound emission estimates.

Because of the similarity of equipment and operations, fugitive emissions from WSTF's were characterized using information developed in VOC Fugitive Emissions in SOCMI and in Benzene Fugitive Emissions Standard. Table 2 summarizes the recommended equipment inventory and emission factors for WSTF's.

B. Cost Estimates

Cost estimates were developed for application of a control device to the condenser vent and for implementation of a fugitive emission inspection and maintenance program. Cost estimates were developed for control of the condenser vent stream using a condenser, an incinerator, or a flare to present the range of control options available to WSTF's. These cost estimates were developed using cost algorithms developed in Distillation Operations in SOCMI and Polymers and Resins.

Table 3 summarizes the preliminary cost estimates developed for incinerator or flare control of condenser vent emissions, and Table 4 presents preliminary cost estimates for secondary condenser control of these emissions. Table 5 presents the estimated emission reduction, annualized cost, and cost effectiveness for a fugitive emission control program at a WSTF. Appendix A presents the basis for the control cost estimates for control devices applied to the condenser vent.

TABLE 1. MODEL FACILITY: PROCESS EMISSIONS

Item	Recommendation	Basis	Comments
GENERAL PLANT OPERATION:			
Waste Solvent Reclamation Rate	8000 Metric Tons per year	Subjective judgement after reviewing 1978 EPA Source Assessment,[1] 1/30/81 Engineering Science Memorandum,[2] SOCMI Distillation NSPS BID, and RTI/Radian site visit reports.	Most solvent reclamation plants appear to be in the range of 2-8000 metric tons/yr. A size at the large end of this range was chosen because some model plant parameters (e.g., airflow) are being based on SOCMI Distillation, and a large solvent reclamation facility is closer to a small SOCMI Distillation facility.
Operating Hours	4160 per year	Intermittent operation: 2 shifts/day x 5 day/wk x 52 wk/yr.	
Condenser Stream Cases	(1) 99% Hexane (2) 99% Toluene (3) 99% 1,1,1 trichloroethane	Subjective judgment after review of references 1-5.	
CONDENSER VENT STREAM EMISSION CHARACTERISTICS:			
Temperature	75°F	RTI/Engineering Science site visit reports.	Range was about 50-80°F. Highest used was 90°F in ICF report.[4]
Flowrate	26 scfm	SOCMI Distillation NSPS BID, "Case 5" (page 8-15).	Range of flowrates reported for all SOCMI Distillation facilities was 0.005-637 scfm. No correlation of plant size and flowrate possible. No information found on flowrates at waste solvent recovery facilities.
VOC Emission Rate	7-82 lb/hr	Lower limit based on avg. AP-42 emission factor (1.7g VOC/kg reclaimed solvent) applied to 8000 metric tons/yr plant. Upper limit is emission rate shown for Case 5 (cited above) in SOCMI Distillation BID.	AP-42 factor used in GCA Technote.[5] (Range of AP-42 factor is 0.26-4.17 g/kg reclaimed solvent). Range of SOCMI Distillation emission rates reported was 0-3668 lb/hr, with 78 lb/hr the average. Example material balance in EPA Source Assessment (page 22) indicate much lower emission factor.

[1]"Source Assessment: Reclaiming of Waste Solvents, State of the Art," EPA-600/2-78-004f, April 1978.

[2]Memorandum, "Development of a Control Technology Guideline (CTG) Document for the Waste Solvent Recovery Industry," from L.L. Lloyd of Engineering Science to F.L. Porter of EPA/ESED.

[3]"Preliminary Assessment of Hazardous Waste Pretreatment as an Air Pollution Control Technique," prepared by RTI for EPA/IERL, October 15, 1984.

[4]"The RCRA Risk-Cost Analysis Model - Phase III Report," prepared by ICF, Inc. for EPA/OSW, March 1, 1984.

[5]Draft Technical Note, "Emission Algorithm Development for Pretreatment Operations," prepared by GCA Corp. for EPA/ESED/CPB, July 1985.

TABLE 2. MODEL FACILITY: FUGITIVE EMISSIONS ESTIMATE

Item	Recommendation	Basis	Comments
Operating Hours	8760 h/yr	Assumes system is not purged between batches.	SOCMI uses 8760 h/yr field reports hrs highly variable (4000 h/yr to 8760 h/yr).
Source Inventory	Model Unit A in Benzene Fugitive Emissions Standard (See Attachment 1)	Smallest reviewed inventory available.	Available information on equipment counts is poor. GCA TechNote inventory is for a very small pot still and is very loosely derived from SOCMI Case A model unit.
Emission Factors for Leaks from Equipment	SOCMI Factors (See Attachment 2)	SOCMI factors are for fairly comparable composition streams.	Factors will overestimate emissions from aqueous-organic streams. The factors could be weighted by average organic content of streams but that would require apportioning the equipment between 2 types of streams.

TABLE 3. SUMMARY OF CONTROL COST ESTIMATES FOR WSTF DISTILLATION VENTS - INCINERATOR AND FLARE CONTROL[a]

(June 1985 dollars)

Item / Stream[b]	Case 1 VOC = 7 lb/h Toluene	Case 2 VOC = 82 lb./h Toluene	Case 3 VOC = 7 lb/h Hexane	Case 4 VOC = 82 lb/h Hexane	Case 5 VOC = 7 lb/h Trichloroethane	Case 6 VOC = 82 lb/L Trichloroethane
Control System[c,e]	Flare	Flare	Flare	Flare	Incinerator	Incinerator
Control costs:						
Capital, $	81,000	81,000	91,000	91,000	758,000	758,000
Operating[f], $	39,800	30,000	39,800	30,000	159,000	140,000
Total annualized,[d,f], $	52,000	43,000	52,000	43,000	312,000	293,000
Annual emissions, t/yr	14.56	170.56	14.56	170.56	14.56	170.56

[a] Cost estimates are developed using Radian's "Documentation for the Synthetic Organic Chemicals Manufacturing Industry (SOCMI) Incinerator/Flare Costing Algorithm."

[b] Stream characteristics = 26 scfm at 75° (assumed to consist of VOC and nitrogen).

[c] Flare system costs include flare stack, flare tip, knock out drum, seal, 400 ft length duct work, and 350 ft pipe rack. It is not known if the total costs include a compressor. Incinerator System costs include combustion chamber, 150 ft duct work, fan, stack, and quench/scrub system. It is unknown if the system includes a heat exchanger.

[d] Based on 4,160 annual operating hours, 15 years life for flares, 10 years life for incinerators, and 10 percent interest rates.

[e] For cases 1 through 4, lowest size flares (i.e., 2 in. dia and 30 ft high) are required, and for cases 5 and 6, lowest size incinerators (i.e., 1 m^3 combustion chamber) are required.

[f] Calculations for case 5 resulted in negative fuel costs.

TABLE 4. SUMMARY OF CONTROL COST ESTIMATES FOR WSTF DISTILLATION VENTS - CONDENSER CONTROL

Item / Stream	Case 1[a] VOC = 7 lb/h Toluene	Case 2 VOC = 82 lb/h Toluene	Case 3[a] VOC = 7 lb/h Hexane	Case 4 VOC = 82 lb/h Hexane	Case 5[a] VOC = 7 lb/h Trichloroethane	Case 6 VOC = 82 lb/h Trichloroethane
Control System[c,e]	Condenser	Condenser	Condenser	Condenser	Condenser	Condenser
Control costs:						
Capital, $	3,336	b	2,843	b	2,280	b
Total annualized, $	1,631		1,398		1,219	
Recovery Credit, $	(4,230)		(4,479)		(921)	
Net Annualized, $	(2,599)		(3,081)		298	
Annual Emission Reduction, ton/yr	13.83	162	13.83	162	13.83	162
Cost Effectiveness, $/ton	(178.50)	b	(211.61)	b	20.46	b

( ) indicates a credit.

[a] Cost estimates were developed using PES' condenser cost algorithm in "Polymers Manufacturing NSPS"; all costs are in June 1980 dollars.

[b] Cost estimates will be developed using standard cost estimation procedures and vendor data for condenser costs.

TABLE 5. DRAFT FUGITIVE EMISSION REDUCTIONS AND CONTROL COST ESTIMATES

EMISSION SOURCE		NUMBER OF SOURCES	ANNUAL EMISS. (Mg/YR)	CONTROL EFFIC. (%)	EMISSION REDUCTION (Mg/YR)	CAPITAL COST ($)	ANNUALIZ. COST ($/YR)	RECOVERY CREDIT ($/YR) (a	COST EFFECT. ($/Mg)
PUMP SEALS									
LIGHT LIQUID		5	2.2	61	1.3	292	1787	591	911
HEAVY LIQUID		0	0.0	0	0.0	0	0		
COMPRESSORS		0	0.0	100	0.0	0	0	0	NA
FLANGES		0	0.0	0	0.0	NA	NA	NA	NA
VALVES	GAS	34	1.6	73	1.2	336	8413	526	1437
	LIQUID	87	5.3	59	3.2			1422	
SAFETY/RELIEF VALVES	GAS	3	2.7	100	2.7	11541	3280	1222	759
	LIQUID	0	0.0						
SAMPLING CONNECTIONS		9	1.2	100	1.2	5146	1530	528	955
OPEN-ENDED LINES		35	0.5	100	0.5	2338	550	228	656
MONITOR. INSTRUMENT (a,b,c		NA	NA	NA	NA	6309	2366	NA	NA
TOTAL		173	13.5		10.0	25961	17926	4518	1339

(a ASSUME 1 INSTRUMENT PER PLANT

(b CAPITAL RECOVERY FACTOR IS BASED ON 10% INTEREST AND 6-YR EQUIPMENT LIFE (CRF=0.2296)

(c MAINTENANCE, TAXES, INSURANCE =25% OF CAPITAL COST

Attachment 1

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/3-80-032b
June 1982

Air

EPA

Benzene Fugitive Emissions—

Background Information for Promulgated Standards

EIS

NESHAP

Attachment 1

Table 2-5. ANNUALIZED MODEL UNIT CONTROL COSTS AND SAVINGS[a] OF THE BENZENE FUGITIVE EMISSIONS STANDARD[b]
(Thousand May 1979 Dollars)

Item	Model Unit[c] A New	A Existing	B New	B Existing	C New	C Existing
Installed Capital Cost	16	17	31	32	48	49
Total Annualized Cost	10.1	10.2	20.1	20.2	30.1	30.4
Recovery Credit	6.9	6.9	20.5	20.5	33.8	33.8
Net Annualized Cost or Savings[d]	3.2	3.3	(0.40)[d]	(0.30)[d]	(3.7)[d]	(3.4)[d]
VOC/Yr Emission Reduction	19 Mg	19 Mg	56 Mg	56 Mg	93 Mg	93 Mg
Benzene/Yr Emission Reduction	12 Mg	12 Mg	31 Mg	31 Mg	71 Mg	71 Mg
Cost (Savings) per Mg Total Emissions Reduced[e]	0.17	0.17	(0.007)[d]	(0.005)[d]	(0.040)[d]	(0.036)[d]
Cost (Savings) per Mg Benzene Reduced	0.27	0.28	(0.013)[d]	(0.010)[d]	(0.052)[d]	(0.048)[d]

[a]Costs are for new and existing units and include monitoring instruments but do not include cost for compressors because compressors in benzene service are not known to exist. Recovery credits are based on total emission reductions (benzene and other VOC) and $370/Mg.

[b]The standard requires monthly leak detection and repair programs for valves and pumps, and equipment specifications for pressure relief devices, open-ended lines, sampling connections, and product accumulator vessels.

[c]Model units have the following numbers of components:

	Model Unit A	B	C
Pumps	5	15	25
Valves			
Gas	34	100	167
Light Liquid	87	254	439
Pressure Relief Devices (gas)	3	9	16
Open-ended Lines	35	105	175
Sampling Connections	9	26	44
Accumulator Vessels	1	2	2

Several assumptions are made to compute model unit costs. For pressure relief devices 75 percent are assumed already controlled in the absence of the standard. For the 25 percent of pressure relief devices that are uncontrolled, it is assumed that 75 percent will be controlled with a closed vent system to flare and 25 percent will be controlled with a rupture disk system. For relief valves using rupture disks, one-half will be controlled with block valves and one-half will be controlled with 3-way valves. For accumulator vessels, 95 percent are assumed already controlled in the absence of the standard.

[d]Numbers in parenthesis denote savings.

[e]Total emissions include benzene and other VOC.

Attachment 2

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/3-80-033b
June 1982

Air

EPA

VOC Fugitive Emissions in Synthetic Organic Chemicals Manufacturing Industry—

Background Information for Promulgated Standards

EIS

NSPS

TABLE 3-2. COMPARISON OF EMISSION FACTORS, kg/hr/source

Source	AID	BID
Pumps - light liquid	0.0494	0.114
- heavy liquid	0.0214	0.021
Valves - gas	0.0056	0.0268
- light liquid	0.0071	0.0109
- heavy liquid	0.00023	0.00023
Compressors	0.228	0.636
Pressure relief devices - gas	0.104	0.16
Flanges	0.00083	0.00025
Oper-ended lines	0.0017	0.0023
Sampling connections	0.0150	0.0150

Appendix A. Summary of Details of Control Cost Estimates

Table 2. DETAILS OF EMISSION CONTROL COST ESTIMATES FOR TSDF DISTILLATION VENTS

Item \ Stream	Case 1 VOC 7 lb/h Toluene	Case 2 VOC = 82 lb/h Toluene	Case 3 VOC = 7 lb/h Hexane	Case 4 VOC 82 lb/h Hexane	Case 5 VOC 7 lb/h Halogenated comp'd	Case 6 VOC 82 lb/h Halogenated comp'd
CONTROL SYSTEM DESIGN CONDITION						
Design flow, cfm	35.5	26	35.2	26	525	525
Size	2 in. dia & 30 ft high	2 in. dia & 30 ft high	2 in. dia & 30 ft high	2 in. dia & 30 ft high	36 ft³	36 ft³
Life	15	15	15	15	10	10
CAPITAL COSTS, JUNE 1985 #						
Flare & flare services	53,000	53,000	53,000	53,000		
Incinerator					736,000	736,000
Ducting	15,000	15,000	15,000	15,000	7,000	7,000
Pipe rack	13,000	13,000	13,000	13,000	13,000	13,000
Total capital	81,000	81,000	81,000	81,000	758,000	758,000
ANNUALIZED OPERATING COSTS, #						
Direct:						
Operating labor	7,600	7,600	↑	↑	29,000	29,000
Supervision	1,100	1,100			4,000	4,000
Maintenance	2,400	2,400			23,000	23,000
Maintenance parts	2,400	2,400			23,000	23,000
Utilities:						
Electricity	4,000	4,000			1,000	1,000
Fuel (Natural gas)	12,000	2,000	Same as	Same as	11,000	− 8,000
Quench water			for Case 1	for Case 2	1,000	1,000
Scrub water					2,000	2,000
Chemicals					20,000	20,000
Steam	1,300	1,500				
Overhead	9,000	9,000			45,000	45,000
Total direct	39,800	30,000			159,000	140,000
Indirect:						
Capital recovery	10,600	10,600			123,400	123,400
Taxes, insurance & administrat.	2,400	2,400	↓	↓	30,000	30,000
Total annualized	52,000	43,000	88,000	79,000	312,400	293,400

Table 3. ANNUALIZED COST BASES

Item	Value
Annual operating hours, hrs	4,160
Operating labor rate $/h	12.05
Supervision	15 % of op. labor
Maintenance labor	3 % of capital cost
Overhead	80 % of op. labor, supervis and maintenance
Electricity, $/$10^3$ kWh	51.20
Natural gas, $/$10^6$ Btu	5.20
Quench & scrubbing water, $/$10^3$ gal	0.292
Steam, $/$10^3$ lb	5.18
Caustic, $/$10^3$ lb	57.89

CONDENSATION SYSTEM DESIGN SUMMARY

Production capacity, Gg/yr	8
Operating hours per year	4160
Inlet emission factor, kg VOC/Mg product	1.65
Emission reduction	95.0%
Outlet emission factor, kg VOC/Mg product	0.0825
Inlet temperature, deg.F	75
Inlet pressure, atmospheres	1
Inlet TOLUENE mass flow rate, lb/hr	7.00
Inlet gas stream volumetric flow rate, acfm	14.69
Gas outlet temperature required for reduction, deg.F	-11.37
Coolant temperature selected, deg.F	-20
Design heat load, Btu/hr	2557
Code for coolant selected (1 = Freon-502; 2 = Freon-12; 3 = 1/2 ethylene glycol & 1/2 water; 4 = water)	3
Required condenser area, sq.ft	15.31
Selected condenser area, sq.ft	20.93
Heat exchanger actual inner shell diameter, in.	4.026
Length of heat exchanger, ft	3.000
Number of tubes in heat exchanger	108
Tube outer diameter, in.	0.25
Tube inside cross-sectional area, sq.ft per tube	0.000205
Coolant specific gravity (relative to water at 60 deg.F)	1.486
Coolant flow in heat exchanger, gpm	29.79
Coolant temperature change, deg.F	0.539
Required refrigeration capacity, tons of refrigeration	0.2131
Selected refrigeration capacity, tons of refrigeration	NA
Selected refrigeration capacity, compressor horsepower	0.75
Horsepower per ton of refrigeration for coolant temperature	3.215

CAPITAL AND ANNUAL OPERATING COST ESTIMATION

Capital Costs	
Heat exchanger	
Installed cost per Enviroscience, December 1979	NA
Installed cost per vendors, July 1984 (est.)	$862
Installed cost, June 1980	$750
Refrigeration	
Installed cost per Enviroscience, December 1979	NA
Installed cost per vendors, June 1980 (est.)	$2,585
Installed cost, June 1980	$2,585
Total Installed Capital Cost, June 1980	$3,336
Annualized Costs	
Operating labor	$497
Maintenance materials & labor	$167
Utilities	
Electricity, pumping	$131
Electricity, refrigeration	$144
Coolant, make-up	$16
Capital recovery	$543
Taxes, administration, & insurance	$133
Total annualized cost without recovery credit	$1,631
TOLUENE recovery credit	($4,230)
Net Annualized Cost (after recovery credit)	($2,599)
TOLUENE Emission Reduction, Mg/yr	12.5407
Average Cost Effectiveness, $/Mg	($207)

CONDENSATION SYSTEM DESIGN SUMMARY

Production capacity, Gg/yr	6
Operating hours per year	4.60
Inlet emission factor, kg VOC/Mg product	1.65
Emission reduction	95.0%
Outlet emission factor, kg VOC/Mg product	0.0825
Inlet temperature, deg.F	75
Inlet pressure, atmospheres	1
Inlet HEXANE mass flow rate, lb/hr	7.00
Inlet gas stream volumetric flow rate, acfm	2.86
Gas outlet temperature required for reduction, deg.F	-16.25
Coolant temperature selected, deg.F	-30
Design heat load, Btu/hr	1440
Code for coolant selected (1 = Freon-502; 2 = Freon-12; 3 = 1/2 ethylene glycol & 1/2 water; 4 = water)	2
Required condenser area, sq.ft	1.97
Selected condenser area, sq.ft	2.29
Heat exchanger actual inner shell diameter, in.	3.068
Length of heat exchanger, ft	0.667
Number of tubes in heat exchanger	56
Tube outer diameter, in.	0.25
Tube inside cross-sectional area, sq.ft per tube	0.000205
Coolant specific gravity (relative to water at 60 deg.F)	1.502
Coolant flow in heat exchanger, gpm	15.45
Coolant temperature change, deg.F	0.582
Required refrigeration capacity, tons of refrigeration	0.1200
Selected refrigeration capacity, tons of refrigeration	NA
Selected refrigeration capacity, compressor horsepower	0.75
Horsepower per ton of refrigeration for coolant temperature	4.436

CAPITAL AND ANNUAL OPERATING COST ESTIMATION

Capital Costs	
Heat exchanger	
Installed cost per Enviroscience, December 1979	NA
Installed cost per vendors, July 1984 (est.)	$296
Installed cost, June 1980	$258
Refrigeration	
Installed cost per Enviroscience, December 1979	NA
Installed cost per vendors, June 1980 (est.)	$2,585
Installed cost, June 1980	$2,585
Total Installed Capital Cost, June 1980	$2,843
Annualized Costs	
Operating labor	$497
Maintenance materials & labor	$142
Utilities	
Electricity, pumping	$69
Electricity, refrigeration	$112
Coolant, make-up	$2
Capital recovery	$463
Taxes, administration, & insurance	$114
Total annualized cost without recovery credit	$1,398
HEXANE recovery credit	($4,479)
Net Annualized Cost (after recovery credit)	($3,081)
HEXANE Emission Reduction, Mg/yr	12.5407
Average Cost Effectiveness, $/Mg	($246)

CONDENSATION SYSTEM DESIGN SUMMARY

Production capacity, Gg/yr	5
Operating hours per year	4160
Inlet emission factor, kg VOC/Mg product	1.65
Emission reduction	95.0%
Outlet emission factor, kg VOC/Mg product	0.0825
Inlet temperature, deg.F	75
Inlet pressure, atmospheres	1
Inlet TRICHLORO mass flow rate, lb/hr	7.00
Inlet gas stream volumetric flow rate, acfm	2.25
Gas outlet temperature required for reduction, deg.F	-17.51
Coolant temperature selected, deg.F	-30
Design heat load, Btu/hr	967
Code for coolant selected (1 = Freon-502; 2 = Freon-12; 3 = 1/2 ethylene glycol & 1/2 water; 4 = water)	2
Required condenser area, sq.ft	1.11
Selected condenser area, sq.ft	2.19
Heat exchanger actual inner shell diameter, in.	3.068
Length of heat exchanger, ft	0.667
Number of tubes in heat exchanger	56
Tube outer diameter, in.	0.25
Tube inside cross-sectional area, sq.ft per tube	0.000205
Coolant specific gravity (relative to water at 60 deg.F)	1.502
Coolant flow in heat exchanger, gpm	15.45
Coolant temperature change, deg.F	0.391
Required refrigeration capacity, tons of refrigeration	0.0806
Selected refrigeration capacity, tons of refrigeration	NA
Selected refrigeration capacity, compressor horsepower	0.5
Horsepower per ton of refrigeration for coolant temperature	4.436

CAPITAL AND ANNUAL OPERATING COST ESTIMATION

Capital Costs	
Heat exchanger	
Installed cost per Enviroscience, December 1979	NA
Installed cost per vendors, July 1984 (est.)	$296
Installed cost, June 1980	$258
Refrigeration	
Installed cost per Enviroscience, December 1979	NA
Installed cost per vendors, June 1980 (est.)	$2,022
Installed cost, June 1980	$2,022
Total Installed Capital Cost, June 1980	$2,280
Annualized Costs	
Operating labor	$497
Maintenance materials & labor	$114
Utilities	
Electricity, pumping	$69
Electricity, refrigeration	$75
Coolant, make-up	$2
Capital recovery	$371
Taxes, administration, & insurance	$91
Total annualized cost without recovery credit	$1,219
TRICHLORO recovery credit	($921)
Net Annualized Cost (after recovery credit)	$298
TRICHLORO Emission Reduction, Mg/yr	12.5407
Average Cost Effectiveness, $/Mg	$24

ATTACHMENT 2

OCT 2 3 1985

SUBJECT: Revisions to Draft Model Facility Parameters and Draft Condenser Cost Estimates

TO: Fred Dimmick, SDB

FROM: Jan Meyer, PES

Attached are revised Tables 1 and 4 presenting model facility parameters and control condenser cost estimates.

TABLE 1. MODEL FACILITY: PROCESS EMISSIONS

Item	Recommendation	Basis	Comments
GENERAL PLANT OPERATION:			
Waste Solvent Reclamation Rate	8000 Metric Tons per year	Subjective judgement after reviewing 1978 EPA Source Assessment,[1] 1/30/81 Engineering Science Memorandum,[2] SOCMI Distillation NSPS BID, and RTI/Radian site visit reports.	Most solvent reclamation plants appear to be in the range of 2-8000 metric tons/yr. A size at the large end of this range was chosen because some model plant parameters (e.g., airflow) are being based on SOCMI Distillation, and a large solvent reclamation facility is closer to a small SOCMI Distillation facility.
Operating Hours	4160 per year	Intermittent operation: 2 shifts/day x 5 day/wk x 52 wk/yr.	
Condenser Stream Cases	(1) Hexane (2) Toluene (3) 1,1,1 trichloroethane	Subjective judgment after review of references 1-5.	
CONDENSER VENT STREAM EMISSION CHARACTERISTICS:			
Temperature	75°F	RTI/Engineering Science site visit reports.	Range was about 50-80°F. Highest used was 90°F in ICF report.[4]
Flowrate	26 scfm	SOCMI Distillation NSPS BID, "Case 5" (page 8-15).	Range of flowrates reported for all SOCMI Distillation facilities was 0.005-637 scfm. No correlation of plant size and flowrate possible. No information found on flowrates at waste solvent recovery facilities.
VOC Emission Rate	(1) 12 lb/hr toluene (2) 7-59 lb/hr hexane (3) 7-75 lb/hr trichloroethane	Lower limit based on avg. AP-42 emission factor (1.7g VOC/kg reclaimed solvent) applied to 8000 metric tons/yr plant. Upper limit is emission rate associated with gas stream at the dew point of the compound.	AP-42 factor used in GCA Technote.[5] (Range of AP-42 factor is 0.26-4.17 g/kg reclaimed solvent). Range of SOCMI Distillation emission rates reported was 0-3668 lb/hr, with 78 lb/hr the average. Example material balance in EPA Source Assessment (page 22) indicate much lower emission factor.

[1]"Source Assessment: Reclaiming of Waste Solvents, State of the Art," EPA-600/2-78-004f, April 1978.

[2]Memorandum, "Development of a Control Technology Guideline (CTG) Document for the Waste Solvent Recovery Industry," from L.L. Lloyd of Engineering Science to F.L. Porter of EPA/ESED.

[3]"Preliminary Assessment of Hazardous Waste Pretreatment as an Air Pollution Control Technique," prepared by RTI for EPA/IERL, October 15, 1984.

[4]"The RCRA Risk-Cost Analysis Model - Phase III Report," prepared by ICF, Inc. for EPA/OSW, March 1, 1984.

[5]Draft Technical Note, "Emission Algorithm Development for Pretreatment Operations," prepared by GCA Corp. for EPA/ESED/CPB, July 1985.

TABLE 4. SUMMARY OF CONTROL COST ESTIMATES FOR WSTF DISTILLATION VENTS - CONDENSER CONTROL

Item / Stream	Case 1[a] VOC = 7 lb/h Toluene	Case 2[b] VOC = 12 lb./h Toluene	Case 3[a] VOC = 7 lb/h Hexane	Case 4[b] VOC = 58.9 lb/h Hexane	Case 5[a] VOC = 7 lb/h Trichloroethane	Case 6[b] VOC = 75 lb/h Trichloroethane
Control System[c,e]	Condenser	Condenser	Condenser	Condenser	Condenser	Condenser
Control costs:						
Capital, $	3,336	21,000	2,843	38,000	2,280	29,000
Total annualized, $	1,631	4,700	1,398	8,100	1,219	5,500
Recovery Credit, $	(4,230)	(8,126)	(4,479)	(41,900)	(921)	(11,025)
Net Annualized, $	(2,599)	(3,426)	(3,081)	(33,800)	298	(5,525)
Annual Emission Reduction, ton/yr	13.83	23.9	13.83	116.39	13.83	148.99
Cost Effectiveness, $/ton	(187.92)	(143.35)	(222.78)	290.40	21.55	(37.08)

( ) indicates a credit.

[a] Cost estimates were developed using PES' condenser cost algorithm in "Polymers Manufacturing NSPS"; all costs are in June 1980 dollars.

[b] Cost estimates developed using standard cost estimation procedures and vendor data for condenser costs; all costs are in 1985 dollars.

ATTACHMENT 3

M E M O R A N D U M

October 30, 1985

TO: Fred Dimmick, SDB

FROM: Graham Fitzsimons, PES

SUBJECT: Revised HEM Modeling Inputs for WSTF Model Plants

Attached for your review are revised HEM modeling inputs for each of the uncontrolled and controlled model cases that PES has developed for the WSTF project. Attachment 1 presents a key to the various model case inputs prepared. The inputs for each case are presented in Attachment 2.

The revised inputs were prepared based on our discussions with you and K.C. Hustvedt concerning the model inputs PES submitted on October 23. The specific changes from the October 23 inputs are: 1) the controlled and uncontrolled cases for toluene at an uncontrolled emission rate of 7 lb/h from the condenser vent have been dropped, and 2) methyl ethyl ketone (at uncontrolled emission rates of 7 and 32 lb/h) has been substituted for hexane.

Our recommendations for candidate rural and urban locations for modeling remain the same. These locations correspond to existing solvent reclamation facility sites. The recommended candidate locations and the EPA ID numbers of the facilities at those locations are shown below.

EPA ID #	Plant Location	Latitude	Longitude	Rural/Urban
CAT000646117	Kettleman City, CA	36° 06' 20"	120° 05' 20"	R
OKD065438376	Waynoka, OK	36° 32' 30"	98° 48' 00"	R
OHD052324548	Twinsburg, OH	41° 27' 30"	81° 29' 40"	U
NJD002182897	Linden, NJ	40° 44' 30"	74° 16' 10"	U
NCD071572036	Greensboro, NC	36° 07' 50"	79° 56' 10"	U
ORD009020231	Beaverton, OR	45° 30' 00"	122° 49' 30"	U

Please call me if you have any questions on the modeling inputs or recommended candidate modeling locations.

Attachment 1. KEY TO MODEL CASES

Pollutant	Emission Rate[1] lb/h	Uncontrolled Case Nos.	Controlled Case Nos.		
			Condenser	Incinerator	Flare
MEK	7	1	2	NA	3
	32	5	6	NA	10
Toluene	7	1	2	NA	3
1,1,1-Trichloroethane	7	1	2	4	NA
	75	7	8	9	NA

[1]Uncontrolled emission rate from the condenser vent. In addition, fugitive emissions of 3.44 lb/h and 0.88 lb/h were included in the uncontrolled and controlled cases, respectively. Condenser vent emissions were assumed to occur 4160 hrs/yr and fugitive emissions were assumed to occur 8760 hrs/yr.

ATTACHMENT 2

HEM INPUTS FOR MODEL CASES

HEM INPUTS FOR MODEL CASE NO. 1

Model Case No. 1
Condenser Vent Controls: None
Fugitive Emission Controls: None
Pollutant: MEK, Toluene, or 1,1,1-Trichloroethane
Uncontrolled Condenser Vent Emission Rate: 7 lb/h
Condenser Vent Flowrate: 26 scfm

Emission Point	Emission Rate kg/yr (tons/yr)	Operating Hours Per Year	Emission Point Elevation m (ft)	Emission Point Diameter[1] m (in)	Emission Point Cross Sectional Area m^2 (in^2)	Emission Point Gas Exit Velocity m/s (ft/s)	Emission Point Gas Temperature °K (°F)
Condenser Vent	13,209 (14.6)	4,160	6.5 (21.3)	0.0381 (1.5)	0.00114 (1.77)	10.8 (35.4)	297 (75)
Fugitive Emissions from Pumps, Valves, etc.	13,666 (15.1)	8,760	0	--	--	--	293 (68)

1 Assumed value to result in an exit velocity of approximately 10 meters per second.

HEM INPUTS FOR MODEL CASE NO. 2

Model Case No. 2
Condenser Vent Controls: Secondary Condenser (95% eff.)
Fugitive Emission Controls: Leak Detection and Repair
Pollutant: MEK, Toluene, or 1,1,1 - Trichloroethane
Uncontrolled Condenser Vent Emission Rate: 7 lb/h
Condenser Vent Flowrate: 26 scfm

Emission Point	Emission Rate kg/yr (tons/yr)	Operating Hours Per Year	Emission Point Elevation m (ft)	Emission Point Diameter m (in)	Emission Point Cross Sectional Area m^2 (in^2)	Emission Point Gas Exit Velocity m/s (ft/s)	Emission Point Gas Temperature °K (°F)
Secondary Condenser Vent	660 (0.7)	4,160	6.5 (21.3)	0.0381 (1.5)	0.00114 (1.77)	10.8 (35.4)	293 (68)
Fugitive Emissions from Pumps, Valves, etc.	3,513 (3.9)	8,760	0	--	--	--	293 (68)

HEM INPUTS FOR MODEL CASE NO. 3

Model Case No. 3
Condenser Vent Controls: Flare (98% eff.)
Fugitive Emission Controls: Leak Detection and Repair
Pollutant: Toluene or MEK
Uncontrolled Condenser Vent Emission Rate: 7 lb/h
Condenser Vent Flowrate: 26 scfm

Emission Point	Emission Rate kg/yr (tons/yr)	Operating Hours Per Year	Emission Point Elevation[2] m (ft)	Emission Point Diameter[2] m (in)	Emission Point Cross Sectional Area m^2 (in^2)	Emission Point Gas Exit Velocity[1] m/s (ft/s)	Emission Point Gas Temperature[2] °K (°F)
Flare	264 (0.3)	4,160	10 (33)	0.0508 (2)	0.002 (3.14)	18 (60)	811 (1,000)
Fugitive Emissions from Pumps, Valves, etc.	3,513 (3.9)	8,760	0	--	--	--	293 (68)

1 Computed based on requirements for maximum flare exit velocity contained in 50 FR 14941, April 16, 1985, and assuming a gas heat content of 300 Btu/scf.

2 Assumed value based on engineering judgement.

HEM INPUTS FOR MODEL CASE NO. 4

Model Case No. 4
Condenser Vent Controls: Incinerator (98% eff.)
Fugitive Emission Controls: Leak Detection and Repair
Pollutant: 1,1,1-Trichloroethane
Uncontrolled Condenser Vent Emission Rate: 7 lb/h
Condenser Vent Flowrate: 26 scfm

Emission Point	Emission Rate kg/yr (tons/yr)	Operating Hours Per Year	Emission Point Elevation[1] m (ft)	Emission Point Diameter[1] m (in)	Emission Point Cross Sectional Area m^2 (in^2)	Emission Point Gas Exit Velocity m/s (ft/s)	Emission Point Gas Temperature[1] °K (°F)
Incinerator	264 (0.3)	4,160	7 (23)	0.3048 (12)	0.073 (113)	7.6 (25)	811 (1,000)
Fugitive Emissions from Pumps, Valves, etc.	3,513 (3.9)	8,760	0	--	--	--	293 (68)

[1] Assumed value based on engineering judgement.

HEM INPUTS FOR MODEL CASE NO. 5

Model Case No. 5
Condenser Vent Controls: None
Fugitive Emission Controls: None
Pollutant: MEK
Uncontrolled Condenser Vent Emission Rate: 32 lb/h
Condenser Vent Flowrate: 26 scfm

Emission Point	Emission Rate kg/yr (tons/yr)	Operating Hours Per Year	Emission Point Elevation m (ft)	Emission Point Diameter m (in)	Emission Point Cross Sectional Area m^2 (in^2)	Emission Point Gas Exit Velocity m/s (ft/s)	Emission Point Gas Temperature °K (°F)
Condenser Vent	60,383 (66.6)	4,160	6.5 (21.3)	0.0381 (1.5)	0.00114 (1.77)	10.8 (35.4)	297 (75)
Fugitive Emissions from Pumps, Valves, etc.	13,666 (15.1)	8,760	0	--	--	--	293 (68)

HEM INPUTS FOR MODEL CASE NO. 6

Model Case No. 6
Condenser Vent Controls: Secondary Condenser (95% eff.)
Fugitive Emission Controls: Leak Detection and Repair
Pollutant: MEK
Uncontrolled Condenser Vent Emission Rate: 32 lb/h
Condenser Vent Flowrate: 26 scfm

Emission Point	Emission Rate kg/yr (tons/yr)	Operating Hours Per Year	Emission Point Elevation m (ft)	Emission Point Diameter m (in)	Emission Point Cross Sectional Area m^2 (in^2)	Emission Point Gas Exit Velocity m/s (ft/s)	Emission Point Gas Temperature °K (°F)
Secondary Condenser Vent	3,019 (3.3)	4,160	6.5 (21.3)	0.0381 (1.5)	0.00114 (1.77)	10.8 (35.4)	293 (68)
Fugitive Emissions from Pumps, Valves, etc.	3,513 (3.9)	8,760	0	--	--	--	293 (68)

HEM INPUTS FOR MODEL CASE NO. 7

Model Case No. 7
Condenser Vent Controls: None
Fugitive Emission Controls: None
Pollutant: 1,1,1-Trichloroethane
Uncontrolled Condenser Vent Emission Rate: 75 lb/h
Condenser Vent Flowrate: 26 scfm

Emission Point	Emission Rate kg/yr (tons/yr)	Operating Hours Per Year	Emission Point Elevation m (ft)	Emission Point Diameter m (in)	Emission Point Cross Sectional Area m^2 (in^2)	Emission Point Gas Exit Velocity m/s (ft/s)	Emission Point Gas Temperature °K (°F)
Condenser Vent	141,521 (156)	4,160	6.5 (21.3)	0.0381 (1.5)	0.00114 (1.77)	10.8 (35.4)	297 (75)
Fugitive Emissions from Pumps, Valves, etc.	13,666 (15.1)	8,760	0	--	--	--	293 (68)

HEM INPUTS FOR MODEL CASE NO. 8

Model Case No. 8
Condenser Vent Controls: Secondary Condenser (95% eff.)
Fugitive Emission Controls: Leak Detection and Repair
Pollutant: 1,1,1-Trichloroethane
Uncontrolled Condenser Vent Emission Rate: 75 lb/h
Condenser Vent Flowrate: 26 scfm

Emission Point	Emission Rate kg/yr (tons/yr)	Operating Hours Per Year	Emission Point Elevation m (ft)	Emission Point Diameter m (in)	Emission Point Cross Sectional Area m^2 (in^2)	Emission Point Gas Exit Velocity m/s (ft/s)	Emission Point Gas Temperature °K (°F)
Secondary Condenser Vent	7,076 (7.8)	4,160	6.5 (21.3)	0.0381 (1.5)	0.00114 (1.77)	10.8 (35.4)	293 (68)
Fugitive Emissions from Pumps, Valves, etc.	3,513 (3.9)	8,760	0	--	--	--	293 (68)

HEM INPUTS FOR MODEL CASE NO. 9

Model Case No. 9
Condenser Vent Controls: Incinerator (98% eff.)
Fugitive Emission Controls: Leak Detection and Repair
Pollutant: 1,1,1-Trichloroethane
Uncontrolled Condenser Vent Emission Rate: 75 lb/h
Condenser Vent Flowrate: 26 scfm

Emission Point	Emission Rate kg/yr (tons/yr)	Operating Hours Per Year	Emission Point Elevation m (ft)	Emission Point Diameter m (in)	Emission Point Cross Sectional Area m^2 (in^2)	Emission Point Gas Exit Velocity m/s (ft/s)	Emission Point Gas Temperature °K (°F)
Incinerator	2,830 (3.1)	4,160	7 (23)	0.3048 (12)	0.073 (113)	7.6 (25)	811 (1,000)
Fugitive Emissions from Pumps, Valves, etc.	3,513 (3.9)	8,760	0	--	--	--	293 (68)

HEM INPUTS FOR MODEL CASE NO. 10

Model Case No. 10
Condenser Vent Controls: Flare (98% eff.)
Fugitive Emission Controls: Leak Detection and Repair
Pollutant: MEK
Uncontrolled Condenser Vent Emission Rate: 32 lb/h
Condenser Vent Flowrate: 26 scfm

Emission Point	Emission Rate kg/yr (tons/yr)	Operating Hours Per Year	Emission Point Elevation m (ft)	Emission Point Diameter m (in)	Emission Point Cross Sectional Area m^2 (in^2)	Emission Point Gas Exit Velocity m/s (ft/s)	Emission Point Gas Temperature °K (°F)
Flare	1,208 (1.33)	4,160	10 (33)	0.0508 (2)	0.002 (3.14)	59 (195)	811 (1,000)
Fugitive Emissions from Pumps, Valves, etc.	3,513 (3.9)	8,760	0	--	--	--	293 (68)

ATTACHMENT 4

M E M O R A N D U M

October 31, 1985

TO: Fred Dimmick, SDB

FROM: Jan Meyer, PES

SUBJECT: Chemicals Covered in Land Banning Action

- -

The list of chemicals effected by OSW's land-banning regulation was inadvertently omitted from the HEM modeling input parameters submitted on October 30, 1985. Attached is a list of chemicals likely to be present in wastes effected by the land-banning/pretreatment requirements.

cc: Mike Dusetzina, PAB

CHEMICALS LIKELY TO BE COVERED
BY ACTION

P022 - carbon disulfide
U002 - acetone
U031 - n butyl alcohol
U037 - chlorobenzene
U052 - cresols & cresylic acid
U057 - cyclohexanone
U070 - o-dichlorobenzene
U060 - methylene chloride
U112 - ethyl acetate
U117 - ethyl ether
U140 - isobutanol
U154 - methanol
U159 - methyl ethyl ketone
U161 - methyl isobutyl ketone
U169 - nitrobenzene
U196 - pyridine
U210 - tetrachloroethane
U211 - carbon tetrachloride
U220 - toluene
U226 - 1,1,1-trichloroethane
U228 - trichloroethylene
U229 - trichlorofluoromethane
U239 - xylene
- ethyl benzene
- tetrachloroethylene
- 1,1,2-trichloro - 1,2,2-trifluoroethane

ATTACHMENT 5

October 31, 1985

TO: Fred Dimmick, SDB

FROM: Jan Meyer, PES

SUBJECT: Revised Incinerator Cost Estimates and Additional Cost Estimates for Secondary Condenser Control

---

As agreed in recent discussions, we have (1) developed revised cost estimates for incinerator control of a halogenated compound and (2) have substituted a methyl ethyl ketone (MEK) model case for the hexane model case and have developed condenser control cost estimates for the new case. Because of concerns regarding the applicability of the cost estimates developed using the incinerator cost program in the SOCMI[a] distillation Background Document to small gas streams, cost estimates were developed using vendor cost information. These revised cost estimates are presented in Table 1 along with the initial cost estimates. Table 2 presents the secondary condenser control cost estimates for the MEK case, and presents corrected cost effectiveness values for Cases 1 and 5.

After you review these cost estimates, please let us know which incinerator cost estimates should be used in estimation of nationwide control cost.

---

[a] SOCMI - Synthetic Organic Chemical Manufacturing Industry

TABLE 1. SUMMARY OF CONTROL COST ESTIMATES FOR WSTF DISTILLATION VENTS - INCINERATOR CONTROL

(June 1985 dollars)

Item / Stream[b]	October 21, 1985, Estimate[a] Case 5 VOC = 7 lb/h Trichloroethane	Case 6 VOC = 82 lb/h Trichloroethane	Revised Cost Estimate[b] Case 5 VOC = 7 lb/h Trichloroethane	Case 6 VOC = 75 lb/h Trichloroethane
Control System[c,e]	Incinerator	Incinerator	Incinerator	Incinerator
Control costs:				
Capital, $	758,000	758,000	209,000	209,000
Operating[f],$	159,000	140,000	121,700	108,500
Total annualized,[d]$	312,000	293,000[f]	164,100	150,900
Emission Reduction, t/yr	13.8	148.2	13.8	148.2

[a]Cost estimates are developed using Radian's "Documentation for the Synthetic Organic Chemicals Manufacturing Industry (SOCMI) Incinerator/Flare Costing Algorithm."

[b]Capital cost estimates were developed using "Report of Fuel Requirements, Capital Cost and Operating Expense for Catalytic Afterburners," EPA-450/3-76-031 (1976) and CE Price Indexes. Natural gas and electricity costs are estimated using standard procedures and gas cost of $\$5.08/10^6$ Btu and electricity cost of \$0.0512/kWh.

[c]Incinerator system costs include combustion chamber, 150 ft duct work, fan, stack, and quench/scrub system. It is unknown if the system includes a heat exchanger.

[d]Based on 4,160 annual operating hours, 15 years life for flares, 10 years of life for incinerators, and 10 percent interest rates.

[e]For Cases 5 and 6, lowest size incinerators (i.e., 1 m^3 combustion chamber) are required.

[f]Calculations for case 5 resulted in negative fuel costs.

TABLE 2. SUMMARY OF CONTROL COST ESTIMATES FOR WSTF DISTILLATION VENTS - CONDENSER CONTROL

Item / Stream	Case 1[a] VOC = 7 lb/h Toluene	Case 2[b] VOC = 12 lb/h Toluene	Case 3[a] VOC = 7 lb/h Methyl Ethyl Ketone	Case 4[b] VOC = 32 lb/h Methyl Ethyl Ketone	Case 5[a] VOC = 7 lb/h Trichloroethane	Case 6[b] VOC = 75 lb/h Trichloroethane	Case 7[d,a] VOC = 0.7 lb/h Methyl Ethyl Ketone
Control System	Condenser	Condenser	Condenser	Condenser	Condenser	Condenser	Condenser
Control costs:							
Capital, $	3,336	21,000	2,891	28,500	2,280	29,000	1,520
Total annualized, $	1,631	4,700	1,445	6,400	1,219	5,500	924
Recovery Credit, $	(4,230)	(8,126)	(8,957)	(45,525)	(921)	(11,025)	(518)
Net Annualized, $	(2,599)	(3,426)	(7,513)	(39,125)	298	(5,525)	407
Annual Emission Reduction, ton/yr	13.83	23.9	13.83	63.23	13.83	148.99	0.8
Cost Effectiveness, $/ton	(187.92)	(143.35)	(543.24)	(618.77)	21.54	(37.08)	509

( ) Indicates a credit.

[a] Cost estimates were developed using PES' condenser cost algorithm in "Polymers Manufacturing NSPS"; all costs are in June 1980 dollars.

[b] Cost estimates developed using standard cost estimation procedures and vendor data for condenser costs; all costs are in 1985 dollars.

[c] To be provided later

[d] Supplemental case to evaluate impact of approximately one order-of-magnitude change in the primary condenser flow rate.

ATTACHMENT 6

PRELIMINARY ESTIMATE USING MODEL PLANT APPROACH
OF NATIONWIDE MAXIMUM RISK AND INCIDENCE ASSOCIATED
WITH AIR EMISSIONS FROM WSTFs

GIVEN:

- o WSTF Model Plant Size = 8 Gg per year of Reclaimed Solvent Produced.
- o Amount of spent solvent waste to be handled = 436.3 million gallons/yr (428 + 8.3 million gallons).
- o Uncontrolled model plant emissions range from 7 lb/h to 75 lb/h from the condenser vent plus uncontrolled fugitive emissions (one rate).
- o Proposed action would require 95% control of condenser vent emissions plus fugitive controls.
- o Six candidate facility locations (4 urban and 2 rural).
- o Range for Unit Risk Factor in earlier preliminary risk assessment for TSDFs was 2×10^{-7} to 2×10^{-5}.

SUMMARY OF APPROACH: HEM was used to calculate max. risk and incidence for a plant with 7 lb/h condenser vent emissions and 75 lb/h condenser vent emissions at each of the six candidate locations (fugitive emissions were also included). Max. nationwide uncontrolled risk was assumed to be the highest risk in any of these model cases. To determine nationwide uncontrolled incidence, the total number of 8 Gg/yr production plants required to handle 436.3 million gallons of waste solvent was estimated. These plants were then assumed to be distributed as follows: 1/2 were assumed to have condenser vent emissions of 7 lb/h and be equally spread among the six locations, and 1/2 were assumed to have condenser vent emissions of 75 lb/h and also spread equally among the six locations. Nationwide incidence for controlled emissions was similarly calculated assuming 95% control of condenser vent emissions plus fugitive controls (see next page for details).

SUMMARY OF RESULTS USING THIS APPROACH:

	Uncontrolled[1]	Controlled[1]
Max. Individual Risk	3.7×10^{-5} to 3.7×10^{-3}	2.6×10^{-6} to 2.6×10^{-4}
Nationwide Incidences Per Year	.034 - 3.4	.0028 - .28

[1]Range based on range of unit risk factor.

DETAILS ON APPROACH USED FOR ESTIMATING INCIDENCE AND MAX RISK:

I. Incidence

A. Uncontrolled Emissions

1) HEM was run for uncontrolled condenser vent emissions of 7 lb/h and 75 lb/h at the six candidate locations (plus uncontrolled fugitives in each case). Twelve dispersion modeling runs were required for this. The HEM inputs for these cases were Model Case 1 and Model Case 7 in the Oct. 31, 1985 memo from G. Fitzsimons to F. Dimmick. The six candidate locations (where WSTFs are actually located) are:

Rural	Urban
Kettleman City, CA	Twinsburg, OH
Waynoka, OK	Linden, NJ
	Greensboro, NC
	Beaverton, OR

2) In calculating risk and incidence for the cases in A1 above, a range of unit risk factors from 2.0E-07 to 2.0E-05 was used. This is the same as used by GCA in previous risk assessments of TSDFs.

3) Using an assumed average solvent recovery rate of 55 %, it was estimated that 95 - 8 Gg/yr model plants would be necessary to handle 436.3 million gallons of solvent waste (see Attachment 1).

4) The result of A1 and A2 above was that a range of incidences/yr was calculated for each of 12 model cases (2 condenser vent emission rates X six locations). To estimate nationwide incidence, it was assumed that 1/12 of the number of plants calculated in A3 correspond to each case, and then the number of plants of each case type multiplied by the incidence associated with each case type was summed as follows:

$$\text{Nationwide Incidence} = \frac{1}{12} \times \text{95 Total Plants Reqd.} \times \sum_{i=1}^{12} \left(\begin{array}{c}\text{incidence}\\ \text{for each}\\ \text{model case}\end{array}\right)$$

B. Controlled Emissions

1) HEM was run at the 6 candidate locations for the control cases where uncontrolled condenser vent emissions of 7 lb/h and 75 lb/h are controlled with a 95% efficient secondary condenser, and fugitive controls are applied. The model plant HEM inputs for these cases were Model Case 2 and Model Case 8 in the Oct. 31 memo.

2) To estimate nationwide incidence, the same procedure as in A2 - A4 above was used.

II. Maximum Risk

The maximum individual risks calculated for any single plant in IA and IB above were assumed to be the nationwide maximums.

Note: The approach described above to estimate the range in nationwide risks differs from that used to estimate nationwide emissions and costs. The range in health risk estimates calculated using the above approach represents the range of risks at the midpoint nationwide emission estimate and not the range of risks at the upper or lower bound nationwide emission estimate. This approach was used to minimize the number of estimates presented.

ATTACHMENT 1 - DETERMINATION OF NUMBER OF MODEL PLANTS REQUIRED TO HANDLE 436.3 MILLION GALLONS OF SOLVENT WASTE PER YEAR

Assumptions:

Model Plant Size = 8 Gg Solvent Produced/yr
= 8E+06 kg/yr

Density of Reclaimed Solvent = 7 lb/gal = 3.175 kg/gal

Estimate of Number of Model Plants Required:

1) Mass of Recovered Solvent = Vol. of Waste Treated (gal) X Recovery Rate X Density of Recovered Solvent (kg/gal)

= 436,300,000 gal X Recovery Rate X 3.175 kg/gal

= 1.3853E+09 kg/yr X Recovery Rate

where: Recovery Rate = $\dfrac{\text{Vol. Solvent Recovered}}{\text{Vol. Waste Treated}}$

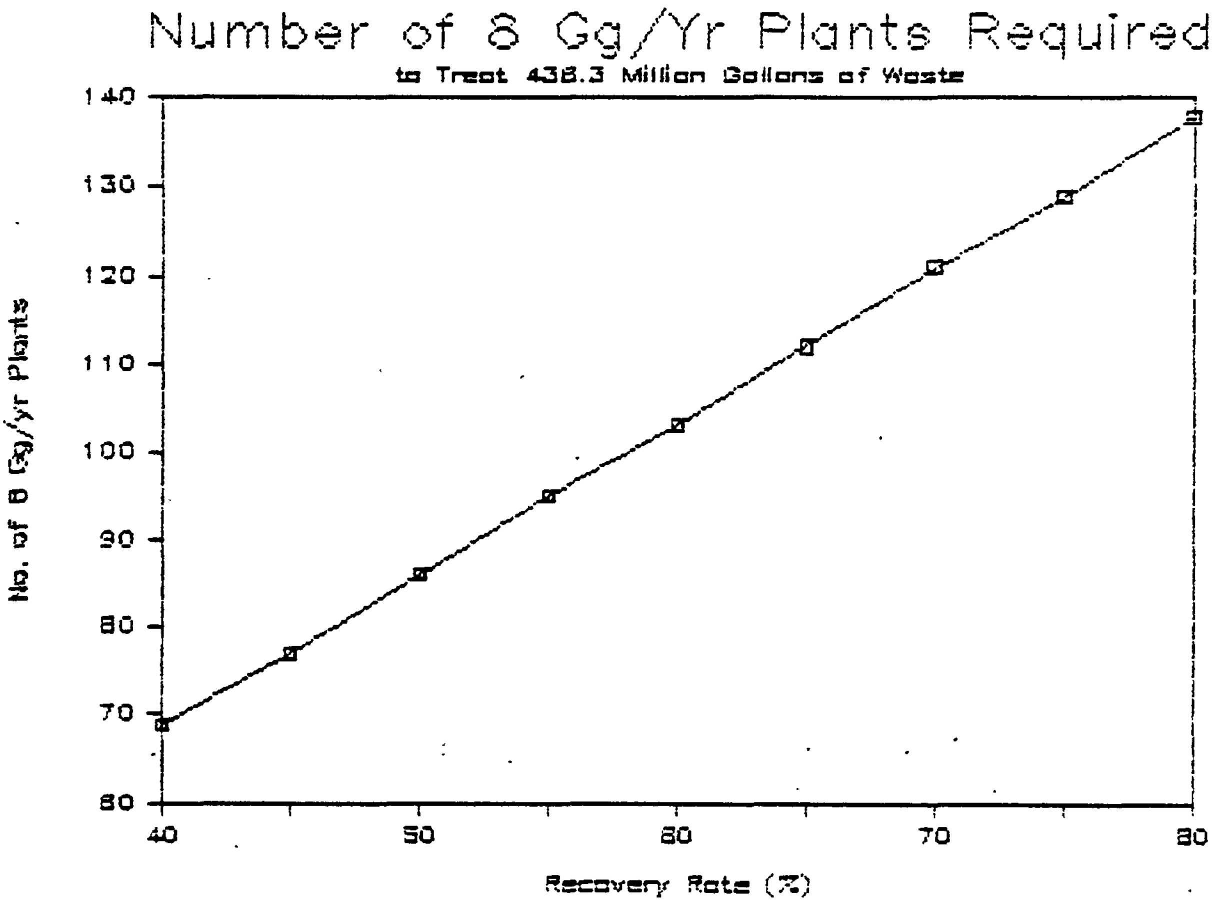
2) Number of 8 Gg/yr Plants Reqd. = $\dfrac{\text{Mass of Recovered Solvent}}{\text{8E+06 kg/yr/model plant}}$

= $\dfrac{\text{1.3853E+09 kg/yr X Recovery Rate}}{\text{8E+06 kg/yr/model plant}}$

= 173.17 X Recovery Rate

3) Recovery Rate vs. Number of Plants is shown in Figure 1. Based on a review of the literature, an overall average recovery rate of .55 (55%) appears reasonable. Using this recovery rate, the total number of plants required to treat 436.3 million gallons of solvent waste is 95.

Figure 1.



Number of 8 Gg/Yr Plants Required
to Treat 438.3 Million Gallons of Waste
No. of 8 Gg/yr Plants
Recovery Rate (%)
140
130
120
110
100
90
80
70
60
40
50
60
70
80

ATTACHMENT 7

M E M O R A N D U M

DATE: January 24, 1986

SUBJECT: Revised Costs for Fugitive Emission Control at a Model WSTF

FROM: Graham Fitzsimons, PES

TO: Fred Dimmick, EPA/SDB

PES' draft estimates of the costs associated with controlling fugitive emissions from a WSTF model facility were presented in Table 5 of the memorandum to you, "Model Facility Parameters and Draft Control Cost Estimates," dated October 21, 1985. The draft estimates were prepared using EPA/CPB's LOTUS 1-2-3 costing program for a leak detection and repair program (LDRP) for pumps, valves, and other potentially leaking sources.

PES' review of the LOTUS program since those draft estimates were prepared revealed that the program assumed 10 minutes would be required for each valve check. Following discussions with you, PES reran the LOTUS program assuming 2 minutes per valve check, which is consistent with EPA's approach to costing LDRP's for other standards.

The results of the program assuming 2 minutes per valve are shown in Table 1. The only difference from the results presented in the October 21, 1985, memo is that the annual cost to implement the LDRP for valves is decreased to $2,378/yr (from $8,413/yr). This decreased the total annualized cost of control for all fugitive sources evaluated at the model plant to $11,901 (from $17,936).

Table 1. Cost, Emission Reduction, and Cost Effectiveness of Model Plant Fugitive Emission Controls

EMISSION SOURCE		NUMBER OF SOURCES	ANNUAL EMISS. (Mg/YR)	CONTROL EFFIC. (%)	EMISSION REDUCTION (Mg/YR)	CAPITAL COST ($)	ANNUALIZ. COST ($/YR)	RECOVERY CREDIT[d] ($/YR) (a	COST EFFECT. ($/Mg)
PUMP SEALS									
LIGHT LIQUID		5	2.2	61	1.3	292	1797	530	912
HEAVY LIQUID		0	0.0	0	0.0	0	0		
COMPRESSORS		0	0.0	100	0.0	0	0	0	NA
FLANGES		0	0.0	0	0.0	NA	NA	NA	NA
VALVES	GAS	34	1.6	73	1.2	336	2378	525	100
	LIQUID	87	5.3	59	3.2			1419	
SAFETY/RELIEF VALVES	GAS	3	2.7	100	2.7	11541	3280	1220	760
	LIQUID	0	0.0						
SAMPLING CONNECTIONS		9	1.2	100	1.2	6146	1530	527	857
OPEN-ENDED LINES		35	0.5	100	0.5	2338	560	228	657
MONITOR. INSTRUMENT (a,b,c		NA	NA	NA	NA	6309	2366	NA	NA
	TOTAL	173	13.5		10.0	26961	11901	4500	708

(a ASSUME 1 INSTRUMENT PER PLANT

(b CAPITAL RECOVERY FACTOR IS BASED ON 10% INTEREST AND 6-YR EQUIPMENT LIFE (CRF=0.2296)

(c MAINTENANCE, TAXES, INSURANCE =25% OF CAPITAL COST

d Assumes approximately $450/Mg credit for recovery

ATTACHMENT 8

MEMORANDUM

DATE: January 24, 1986

SUBJECT: Estimates of Nationwide Emissions and Cost of Control for Waste Solvent Treatment Facilities (WSTFs)

FROM: Graham Fitzsimons, PES

TO: Fred Dimmick, EPA/SDB

The purpose of this memorandum is to present PES' estimates of the following nationwide impacts for WSTFs: (1) nationwide uncontrolled VOC process and fugitive emissions; (2) nationwide VOC emissions with 95 percent process emission control and a leak detection and repair program for fugitive emission control; and (3) nationwide capital and annual costs to apply these controls. PES prepared the nationwide estimates by extrapolating from the most recent emission and cost data developed for a variety of "model cases." These model cases correspond to a plant of 8 Gg per year solvent production capacity with a range of uncontrolled process emission rates and various controls applied to achieve at least 95 percent control. One uncontrolled or controlled rate for fugitive emissions was included in each case based on an assumed equipment count and SOCMI emission factors.

Due to the wide range of emission and cost estimates for the model cases, lower and upper bound estimates were made for the nationwide impacts. PES used the following general approach to estimate the lower and upper bound estimates: First, the number of 8 Gg per year capacity plants required to treat 436 million gallons per year of solvent waste was estimated.[1] Secondly, from the model case analysis, representative lower and upper bound estimates of emissions and costs on a per plant basis were selected. Finally, the total number of 8 Gg per year plants was multiplied by the representative per plant estimates to derive the nationwide impacts.

The estimated nationwide impacts are presented below. It should be emphasized that, although we feel the approach used to estimate the nationwide impacts is reasonable given the limited data available, the impacts presented are highly uncertain, and at best represent order-of-magnitude estimates.

---

[1]Based on information provided by EPA, PES understands that the impacts are to be estimated for treating 428 million gallons of solvent waste currently treated by distillation plus an additional 8.3 million gallons that may be treated by distillation as a result of EPA/OSW's proposed land banning action.

Estimate of the Total Number of 8 Gg per Year (Solvent Production Capacity Plants Required

The assumptions and calculations used to estimate the number of 8 Gg per year (production capacity) model plants necessary to treat 436 million gallons of solvent waste are presented in Attachment 1. The key assumption affecting the result is the average recovery factor assumed.[2] Based on a review of available information, an average recovery factor of 55 percent appears reasonable.[3] Using this as an assumed average recovery rate, the number of 8 Gg per year plants required to treat 436 million gallons of solvent waste is 95.

Estimates of Lower and Upper Bound Nationwide Emissions

The upper and lower bound estimates of per plant uncontrolled and controlled condenser vent (process), fugitive, and total emissions are presented in Table 1. The nationwide estimates of total uncontrolled and controlled emissions assuming 95 plants are shown in Table 2.

Estimate of Lower Bound Nationwide Control Cost

Of the control techniques costed for application to the model cases (secondary condensers, flares, and incinerators), secondary condenser control is the least costly method of controlling process condenser vent emissions. Therefore, this control technique applied to process condenser vent emissions, plus fugitive emission controls, is assumed as the basis of lower bound control cost estimates.

Table 3 presents a summary of cost estimates to apply secondary condenser control to process condenser vent emissions for the various cases analyzed.[4] As can be seen, there is a large difference in the estimates prepared using the condenser costing program and those prepared by hand calculation. Considering that the costs for the 7 lb/h emission rate cases were consistently computed using the cost program, and that these are the lower cost estimates, it was decided to use these in developing a lower bound nationwide cost estimate.

Table 4 shows the range and average of per plant estimates of capital cost, annual cost (before recovery credit), recovery credit, and net annual cost for the 7 lb/h condenser vent emission cases.

Using the average costs of condenser vent process emission controls from Table 4, and the cost of fugitive emission controls

---

[2] $\text{Recovery Factor} = \frac{\text{Volume of Solvent Recovered}}{\text{Volume of Waste Treated}}$

[3] A separate memorandum will be submitted on selection of the average recovery factor.

[4] This is Table 3 from the October 21 memo with all costs updated to June 1985 $.

Table 1. LOWER AND UPPER BOUND ESTIMATES OF ANNUAL VOC EMISSIONS FROM A WSTF MODEL PLANT (8 Gg/y Solvent Production)

Description	Uncontrolled Emissions, Mg/yr (tons/yr)[a]			Controlled Emissions, Mg/yr (tons/yr)[b]		
	Condenser Vent[c]	Fugitives[d]	Total	Condenser Vent	Fugitives	Total
Lower Bound Estimate (Uncontrolled Condenser Vent Emissions = 3.2 kg/h [7 lb/h])	13.2 (14.6)	13.7 (15.1)	26.9 (29.6)	0.7 (0.7)	3.5 (3.9)	4.2 (4.6)
Upper Bound Estimate (Uncontrolled Condenser Vent Emissions = 34 kg/h [75 lb/h])	141.5 (156.0)	13.7 (15.1)	155.2 (171.1)	7.1 (7.8)	3.5 (3.9)	10.6 (11.7)

[a]All figures are rounded to the nearest one-tenth.

[a]Assumed control level is 95% control of condenser vent emissions plus a leak detection and repair program for fugitive emission control. All figures are rounded to the nearest one-tenth.

[c]To compute condenser vent emissions, 4,160 hours per year of operation was assumed.

[d]To compute fugitive emissions, 8,760 hours per year of operation was assumed.

Table 2. LOWER AND UPPER BOUND ESTIMATES OF NATIONWIDE ANNUAL VOC EMISSIONS FROM 95 WSTF MODEL PLANTS

Description	Nationwide Uncontrolled Emissions, Mg/yr (tons/yr)[a]	Nationwide Controlled Emissions, Mg/yr (tons/yr)[a]
Lower Bound Estimate	2,550 (2,810)	400 (440)
Upper Bound Estimate	14,740 (16,250)	1,010 (1,110)

[a]Includes condenser vent and fugitive emissions. All figures are rounded to the nearest 10.

Table 3. SUMMARY OF CONTROL COST ESTIMATES FOR WSTF DISTILLATION VENTS - CONDENSER CONTROL (June 1985 $)

Item / Stream	Case 1[a] VOC = 7 lb/h Toluene	Case 2[b] VOC = 12 lb/h Toluene	Case 3[a] VOC = 7 lb/h Methyl Ethyl Ketone	Case 4[b] VOC = 32 lb/h Methyl Ethyl Ketone	Case 5[a] VOC = 7 lb/h Trichloroethane	Case 6[b] VOC = 75 lb/h Trichloroethane
Control System	Condenser	Condenser	Condenser	Condenser	Condenser	Condenser
Control costs:						
Capital, $	3,850	21,000	3,337	28,500	2,631	29,000
Total annualized, $	1,885	4,700	1,678	6,400	1,425	5,500
Recovery Credit, $	(4,550)	(8,126)	(8,957)	(45,525)	(10,077)	(11,025)
Net Annualized, $	(2,665)	(3,426)	(7,279)	(39,125)	(8,652)	(5,525)
Annual Emission Reduction, ton/yr	13.83	23.9	13.83	63.23	13.83	148.99
Cost Effectiveness, $/ton	(192.70)	(143.35)	(526.32)	(618.77)	(625.60)	(37.08)

( ) indicates a credit.

[a]Cost estimates were developed using PES' condenser cost algorithm in "Polymers Manufacturing NSPS"; all costs have been adjusted to June 1985 dollars.

[b]Cost estimates developed using standard cost estimation procedures and vendor data for condenser costs.

Table 4. RANGE AND AVERAGE OF PER PLANT COSTS TO APPLY SECONDARY CONDENSER CONTROL TO 7 lb/h MODEL CASES

	Range of Cost or Credit	Average Cost or Credit[a]
Capital Cost Range, $	2,631 - 3,850	3,270
Annual Cost Range, $/yr	1,425 - 1,885	1,660
Recovery Credit Range, $/yr	(4,550 - 10,077)	(7,860)
Net Average Annualized Cost with Recovery Credit, $/yr		(6,200)

( ) Indicates a cost credit.

[a]Rounded to the nearest 10.

computed using ESED/CPB's LOTUS 1-2-3 costing program for fugitive emission controls for pumps, valves, and leaks, total lower bound per plant and nationwide control costs are presented in Table 5.

Estimate of Upper Bound Nationwide Control Cost

Upper bound control costs were estimated assuming: (1) incinerator control of condenser vent process emissions for halogenated compounds (plus fugitive controls); (2) flare control of condenser vent process emissions for non-halogenated compounds (plus fugitive controls); and (3) that 20 percent of plants process halogenated compounds and 80 percent process non-halogenated compounds.[5]

Table 6 presents the range and average of per plant costs computed by PES to apply incinerator control to process condenser vent emissions for the model cases involving halogenated compounds. Table 7 presents this information for flare controlled cases involving non-halogenated compounds.

Using the average costs presented in Table 6, Table 8 shows the estimated cost to apply incinerator control to process condenser vent emissions plus fugitives emission control at 19 model plants (20% of 95 total plants). Similarly, Table 9 shows the costs to apply flare control to process condenser vent emissions plus fugitive controls at 76 plants (80% of 95 total plants).

The upper bound nationwide costs are then computed as the sum of the total control cost for 19 plants (Table 8) and the total control cost for 76 plants (Table 9). The total upper bound nationwide cost of control is shown in Table 10.

Summary of Nationwide Estimates

A summary of lower and upper bound nationwide estimates of emissions and control costs is presented in Table 11.

---

[5]PES judgment based on a review of material supplied by K.C. Hustvedt of ESED/CPB.

Table 5. ESTIMATE OF LOWER BOUND NATIONWIDE
COST TO APPLY CONTROLS
(June, 1985 $)

	Per Plant Cost			
	Process Control[a]	Fugitive Control[b]	Total	Nationwide Total[c]
Capital Cost, $	3,270	26,960	30,230	2,872,000
Annual Cost, $/yr	1,660	11,900	13,560	1,288,000
Recovery Credit, $/yr	(7,860)	(4,520)	(12,380)	(1,176,000)
Net Annual Cost (with Recovery Credit), $/yr	(6,200)	7,380	1,180	112,000

(   ) Indicates a cost credit.

[a]Source: See Table 4.

[b]Source: Memorandum. Fitzsimons, G., Pacific Environmental Services, Inc., to Dimmick F., U.S. EPA:ESED:SDB. January 24, 1986. Revised Costs for Fugitive Emission Control at a Model WSTF.

[c]Assuming 95 model plants. All figures are rounded to the nearest 1,000.

Table 6. RANGE AND AVERAGE OF PER PLANT COSTS TO APPLY INCINERATOR CONTROL TO MODEL CASES[a]

	Range of Cost	Average Cost
Capital Cost Range, $	209,000[b]	209,000
Annual Cost Range, $/yr	151,000-164,000	158,000

[a]Source: Memorandum. Meyer, J., Pacific Environmental Services, Inc., to Dimmick, F., U.S. EPA:ESED:SDB. October 31, 1985. Revised Incinerator Cost Estimates and Additional Cost Estimates for Secondary Condenser Control.

[b]Capital cost identical in both cases analyzed.

Table 7. RANGE AND AVERAGE OF PER PLANT COSTS TO APPLY FLARE CONTROL TO MODEL CASES[a]

	Range of Cost	Average Cost
Capital Cost Range, $	81,000-91,000	86,000
Annual Cost Range, $/yr	43,000-52,000	48,000

[a]Source: Memorandum. Meyer, J., Pacific Environmental Services, Inc., to Dimmick, F., U.S. EPA:ESED:SDB. October 21, 1985. Model Facility Parameters and Draft Control Cost Estimates.

Table 8. ESTIMATE OF COST TO APPLY INCINERATOR PROCESS EMISSION CONTROL PLUS FUGITIVE EMISSION CONTROL AT 50% OF THE PLANTS[a]
(June 1985 $)

	Per Plant Costs			
	Process Control[b]	Fugitive Control[c]	Total	Cost to Control 48 Plants
Capital Cost, $	209,000	26,960	235,960	11,326,000
Annual Cost, $/yr	158,000	11,900	169,900	8,155,000
Recovery Credit, $/yr	--	(4,520)	(4,520)	(217,000)
Net Annual Cost, $/yr	158,000	7,380	165,380	7,938,000

( ) Indicates a cost credit.

[a]20% of 95 total plants (19 plants) are estimated to treat halogenated compounds.

[b]See Table 6.

[c]Source: Memorandum. Fitzsimons, G., Pacific Environmental Services, Inc., to Dimmick F., U.S. EPA:ESED:SDB. January 24, 1986. Revised Costs for Fugitive Emission Control at a Model WSTF.

Table 9. ESTIMATE OF COST TO APPLY FLARE PROCESS EMISSION CONTROL PLUS FUGITIVE EMISSION CONTROL AT 50% OF THE PLANTS[a]
(June 1985 $)

	Per Plant Costs			
	Process Control[b]	Fugitive Control[c]	Total	Cost to Control 47 Plants
Capital Cost, $	86,000	26,960	112,960	5,309,000
Annual Cost, $/yr	48,000	11,900	59,900	2,815,000
Recovery Credit, $/yr	--	(4,520)	(4,520)	(212,000)
Net Annual Cost, $/yr	48,000	7,380	55,380	2,603,000

( ) Indicates a cost credit.

[a]80% of 95 total plants (76 plants) are estimated to treat non-halogenated compounds.

[b]See Table 7.

[c]Source: Memorandum. Fitzsimons, G., Pacific Environmental Services, Inc., to Dimmick F., U.S. EPA:ESED:SDB. January 24, 1986. Revised Costs for Fugitive Emission Control at a Model WSTF.

Table 10. ESTIMATE OF UPPER BOUND NATIONWIDE COST TO APPLY PROCESS AND FUGITIVE CONTROLS AT 95 PLANTS[a] (June 1985 $)

	Cost to Control 95 Plants
Capital Cost, $	16,635,000
Annual Cost, $/yr	10,970,000
Recovery Credit, $/yr	(429,000)
Net Annual Cost, $/yr	10,541,000

( ) Indicates a cost credit.

[a]Computed from Tables 8 and 9.

Table 11. SUMMARY OF LOWER AND UPPER BOUND ESTIMATES OF NATIONWIDE EMISSIONS AND CONTROL COSTS FOR 95 PLANTS

	Lower Bound		Upper Bound	
	Uncontrolled	Controlled	Uncontrolled	Controlled
VOC Emissions,[a] Mg/yr (tons/yr)	2,550 (2,810)	400 (440)	14,740 (16,250)	1,010 (1,110)
Control Costs[b]				
Capital Cost, $	n.a.	2,872,000	n.a.	16,635,000
Annual Cost, $/yr	n.a.	1,289,000	n.a.	10,970,000
Recovery Credit, $/yr	n.a.	(1,176,000)[c]	n.a.	(429,000)[c]
Net Annual Cost (with recovery credit), $/yr	n.a.	113,000	n.a.	10,541,000

[a]From Table 2.

[b]From Tables 5 and 10. All costs are in June, 1985 $.

[c]( ) Indicates a cost credit.

ATTACHMENT 1 - DETERMINATION OF NUMBER OF MODEL PLANTS REQUIRED TO HANDLE 436.3 MILLION GALLONS OF SOLVENT WASTE PER YEAR

Assumptions:

Model Plant Size = 8 Gg Solvent Produced/yr
= 8E+06 kg/yr

Density of Reclaimed Solvent = 7 lb/gal = 3.175 kg/gal

Estimate of Number of Model Plants Required:

1) Mass of Recovered Solvent = Vol. of Waste Treated (gal) X Recovery Rate X Density of Recovered Solvent (kg/gal)

= 436,300,000 gal X Recovery Rate X 3.175 kg/gal

= 1.3853E+09 kg/yr X Recovery Rate

where: Recovery Rate = $\dfrac{\text{Vol. Solvent Recovered}}{\text{Vol. Waste Treated}}$

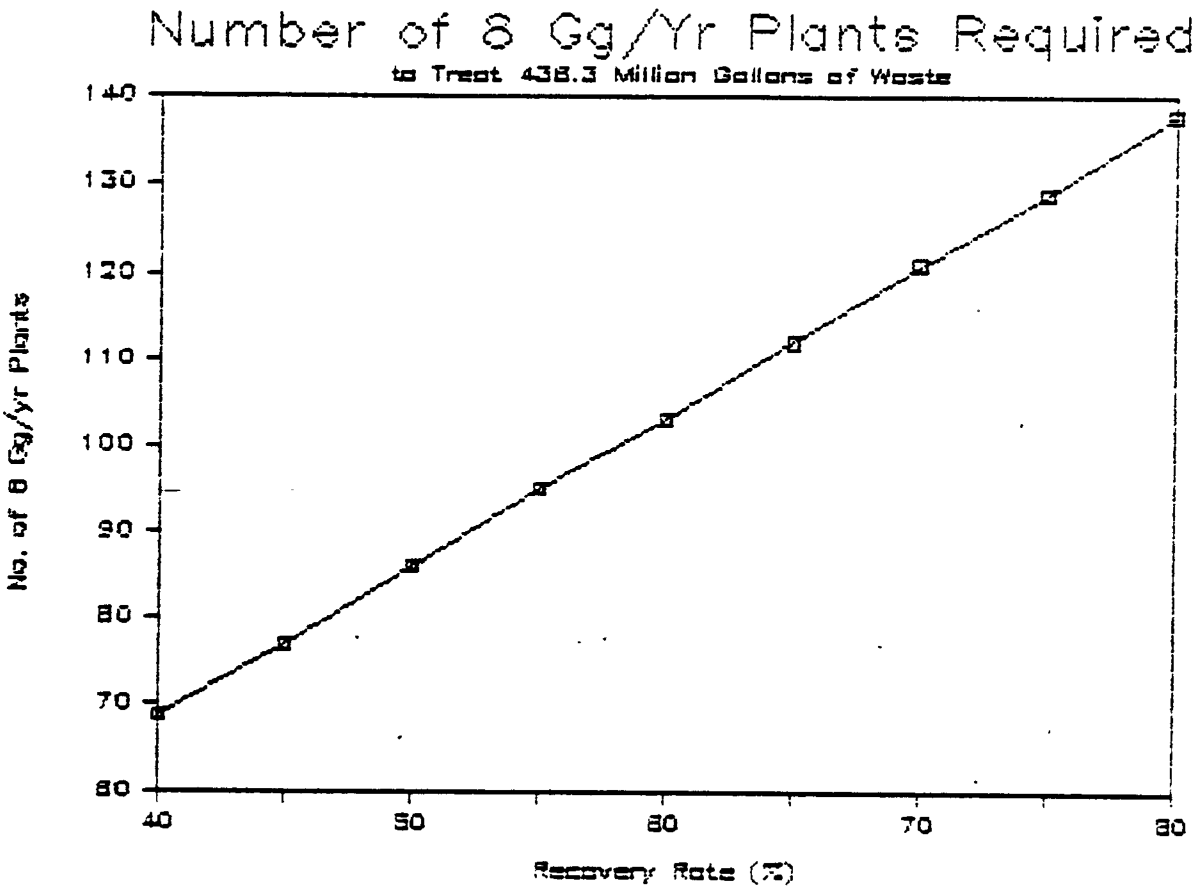
2) Number of 8 Gg/yr Plants Reqd. = $\dfrac{\text{Mass of Recovered Solvent}}{\text{8E+06 kg/yr/model plant}}$

= $\dfrac{\text{1.3853E+09 kg/yr X Recovery Rate}}{\text{8E+06 kg/yr/model plant}}$

= 173.17 X Recovery Rate

3) Recovery Rate vs. Number of Plants is shown in Figure 1. Based on a review of the literature, an overall average recovery rate of .55 (55%) appears reasonable. Using this recovery rate, the total number of plants required to treat 436.3 million gallons of solvent waste is 95.

Figure 1.


Number of 8 Gg/Yr Plants Required
to Treat 438.3 Million Gallons of Waste
No. of 8 Gg/yr Plants
140
130
120
110
100
90
80
70
60
40
50
60
70
80
Recovery Rate (%)

ATTACHMENT 9

June 5, 1986

MEMORANDUM

TO: Fred Dimmick, SDB

FROM: Steve York, RTI

SUBJECT: Draft Calculation of Impacts for Proposed WSTF Standards

Per your request of 5/20/86, we have developed rough estimates of the environmental, health, and cost impacts of controlling all TSDF operations handling waste streams with greater than 10% organics. The impacts only account for fugitive emissions; insufficient data are available to estimate the number of TSDF's handling waste streams with greater than 10% organics that have process vents, the number of process vents per TSDF if there are process vents, and the number of process vents with emission controls already in place.

The first step in estimating impacts was to estimate the number of TSDF's handling waste streams with greater than 10 percent organics. Because of the present lack of detailed waste characterization data, the industry profile was used to generate a range of the number of TSDF's that potentially manage greater than 10 percent organic content wastes. The industry profile contains information about the types of management methods employed and the waste types (RCRA codes) managed by facilities that have submitted RCRA Part A applications. As a lower bound estimate, the number of facilities with incinerators was calculated, based on the assumption that incinerators would be used as treatment for high organic content streams. The number is overstated to some extent because solids incineration could not be separated from liquid incineration. As an upper bound estimate, the number of facilities managing organic liquids, pesticides, and D001 and D002 wastes was computed. Table 1 lists the RCRA codes classified as organic liquid and

TABLE 1. RCRA CODES SERVING AS BASIS FOR UPPER BOUND ESTIMATE

Waste type	RCRA Waste Code				
Organic liquids	K011	K012	K013	K014	K022
	K023	K026	K027	K047	K073
	P002	P003	P005	P009	P014
	P018	P019	P022	P025	P042
	P046	P053	P054	P069	P077
	P081	P082	P083	P086	P093
	P100	P101	P102	U001	U003
	U004	U005	U007	U008	U009
	U012	U015	U021	U022	U028
	U031	U037	U051	U052	U053
	U055	U056	U083	U085	U086
	U088	U089	U090	U091	U092
	U096	U098	U099	U100	U101
	U102	U103	U104	U105	U106
	U107	U108	U109	U110	U111
	U112	U113	U115	U116	U118
	U119	U122	U124	U125	U133
	U140	U149	U150	U152	U153
	U155	U162	U165	U167	U169
	U170	U171	U172	U173	U174
	U175	U176	U177	U178	U179
	U180	U186	U188	U191	U197
	U200	U201	U213	U221	U223
	U237				
Pesticides	D012	D013	D014	D015	D016
Herbicides	D017	F027	K031	K032	K033
	K034	K036	K037	K038	K039
	K040	K041	K042	K043	P001
	P004	P007	P008	P020	P021
	P034	P035	P037	P038	P039
	P040	P041	P043	P044	P045
	P047	P048	P049	P050	P051
	P057	P058	P059	P060	P066
	P067	P070	P071	P072	P075
	P085	P088	P089	P090	P091
	P092	P094	P097	P108	P109
	P111	P113	P114	P115	P116
	P117	P118	P122	U010	U011
	U014	U017	U036	U058	U060
	U061	U062	U066	U082	U087
	U097	U114	U136	U142	U158
	U224	U230	U231	U232	
Characteristic of ignitability	D001				
Characteristic of corrosivity	D002				

pesticide wastes. The upper bound estimate double counts some facilities with incinerators and WSTF's (e.g., P022, U031, U037, U052, U060, U112, U140, U169). The lower and upper bound estimates of TSDF's handling greater than 10 percent organic waste streams are 269 and 2,332 facilities. To estimate impacts, the midpoint of this range, 1300 facilities, was used.

As you suggested, "per facility" estimates from the WSTF assessment were used to calculate the national impacts of regulating fugitive VOC emissions from TSDF's handling greater than 10 percent organic waste streams. Table 2 presents the nationwide emission and health risk impacts and associated control costs.

Several uncertainties are apparent in the estimation of impacts of controlling all TSDF operatons handling waste streams with greater than 10% organics. There is little basis for estimating the number of these facilities, as is evidenced by the range between the upper and lower bound estimates. The nationwide impacts are based on "per facility" estimates for WSTF's, which in turn are based on SOCMI emission factors and the equipment count specified in the benzene fugitive emission standard model case A. Fugitive emissions are proportional to the number of pumps, valves, flanges, sampling connections, etc. Therefore, the "per facility" estimates of fugitive emissons and the associated incidence and control costs are only as good as the benzene fugitive emission standard model case A is representative of a TSDF handling greater than 10% organic content wastes.

Also at your request, we have calculated incremental environmental, health, and cost impacts of using flares/incinerators versus condensers to control WSTF process emissions. Table 3 presents these estimates, based on a prorating analysis as you suggested.

TABLE 2. NATIONWIDE IMPACTS

	Factor/facility Uncontrolled	Factor/facility Controlled	Number of facilities	Nationwide estimates Uncontrolled	Nationwide estimates Controlled
Fugitive emissions (Mg/yr)[a]	13.7	3.5	1300	17,810	4,550
Incidences (cases/yr)[b]	0.0005	0.0001	1300	0.65	0.13
Control cost[c]: capital ($)	N/A	26,960	1300	N/A	35,000,000
annual ($/yr)	N/A	7,380	1300	N/A	9,600,000

[a] Attachment 8, Table 1, Lower Bound Estimate.

[b] Attachment 6, Summary of Results Using this Approach. Nationwide incidences per year for 2×10^{-6} Unit Risk Factor (the midpoint of the range of Unit Risk Factors) were factored by percentage of nationwide emissions estimated to be fugitive from Attachment 8, Table 1 and by 95 3.2 kg/h WSTF plants to derive per facility factor. (Note that incidence presented in Attachment 6 was estimated using 50 percent 3.2 kg/h and 50 percent 34 kg/h plants).

[c] Attachment 8, Table 5.

TABLE 3. INCREMENTAL IMPACTS OF CONTROLLING WSTF PROCESS VENT EMISSIONS[a] WITH FLARES/INCINERATORS VERSUS CONDENSERS

Process Vent Emissions Control Technique	Nationwide Emissions (Mg/yr)[b]		Nationwide Control Cost ($/yr)[c]	Nationwide Incidences per year[d]		Maximum Individual Risk[e]	
	Uncontrolled	Controlled		Uncontrolled	Controlled	Uncontrolled	Controlled
Condensers	8,660	700	112,000	0.34	0.028	3.7×10^{-3}	2.6×10^{-4}
Flares/incinerators	8,660	470	7,351,000	0.34	0.018	3.7×10^{-3}	2.0×10^{-4}
Incremental Impact		230	7,239,000		0.010		6.0×10^{-5}

[a] Fugitive emissions and control costs are included, but control efficiency and cost of controlling fugitive emissions are the same for the upper and lower bound cases, therefore the incremental impacts represent differences in process vent emissions and control costs.

[b] Attachment 8, Table 1, average of Lower Bound Estimate and Upper Bound Estimate of uncontrolled condenser vent and fugitive emissions x 95 WSTF's. Condenser achieves 95% control; flares and incinerators achieve 98% control; leak detection and repair program achieves 75% control of fugitive emissions.

[c] Lower bound nationwide control cost is cost of condenser control of process emissions plus fugitive emission control from Attachment 8, Table 5. Upper bound nationwide control cost is cost of incinerator process emission control plus fugitive emission control at 20% of the plants and flare process emission control plus fugitive emission control at 80% of the plants from Attachment 8, Tables 8 and 9, respectively.

[d] From Attachment 6, Summary of Results Using this Approach. Based on Unit Risk Factor of 2×10^{-6}, the midpoint of the range of Unit Risk Factors. Nationwide incidences per year for flares/incinerators control of process vent emissions factored from nationwide incidences per year for uncontrolled emissions using ratio of nationwide controlled and uncontrolled emissions.

[e] From Attachment 6, Summary of Results Using this Approach. Based on maximum Unit Risk Factor of 2×10^{-5}. Maximum individual risk for flares/incinerators control of process vent emissions factored from maximum individual risk for uncontrolled emissions using ratio of nationwide controlled and uncontrolled emissions.

APPENDICES

APPENDIX A

REFERENCES

APPENDIX A - LIST OF REFERENCES

AUTHOR: Allen, C., Brant, G., Husband, S., and Simpson, S.
DOC.TYPE: Site Visit Report
TITLE1: Hazardous Waste Pretreatment for Emissions Control: Field
TITLE2: Evaluations - Oil & Solvent Process Co., Azusa, CA
DATE: May 22, 1985

AUTHOR: Allen, C., Brant, G., and Simpson, S.
DOC.TYPE: Site Visit Report
TITLE1: Hazardous Waste Pretreatment for Emissions Control: Field
TITLE2: Evaluations - Environmental Recycling, Durham, N.C.
DATE: May 22, 1985

AUTHOR: Allen, C., Brant, G., and Simpson, S.
DOC.TYPE: Site Visit Report
TITLE1: Hazardous Waste Pretreatment for Emissions Control: Field
TITLE2: Evaluations - Plant A
DATE: May 22, 1985

AUTHOR: Allen, C., Brant, G., and Simpson, S.
DOC.TYPE: Site Visit Report
TITLE1: Hazardous Waste Pretreatment for Emissions Control: Field
TITLE2: Evaluations - Romic Chemical Corporation, E. Palo Alto, CA
DATE: May 22, 1985

AUTHOR: Allen, C., Brant, G., and Simpson, S.
DOC.TYPE: Site Visit Report
TITLE1: Hazardous Waste Pretreatment for Emissions Control: Field
TITLE2: Evaluations - IT Corporation, Martinez, CA
DATE: May 22, 1985

AUTHOR: Allen, C., Brant, G., and Simpson, S.
DOC.TYPE: Site Visit Report
TITLE1: Hazardous Waste Pretreatment for Emissions Control: Field
TITLE2: Evaluations - Alternate Energy Resources, Inc., Augusta, GA
DATE: May 22, 1985

AUTHOR: Allen, C.C., et. al., Research Triangle Institute
DOC.TYPE: Final Report for EPA/ORD
TITLE1: Field Evaluations of Hazardous Waste Pretreatment As An Air
TITLE2: Pollution Control Technique
DATE: September 1985

AUTHOR: Allen, C.C., et. al., Research Triangle Institute
DOC.TYPE: Final Report for EPA/ORD
TITLE1: Field Evaluations of Hazardous Waste Pretreatment as an Air
TITLE2: Pollution Control Technique
DATE: April 1985

AUTHOR: Arienti, M., et. al., GCA Corporation
DOC.TYPE: Final Report for EPA/OSW
TITLE1: Technical Assessment of Treatment Alternatives for Wastes
TITLE2: Containing Halogenated Organics
DATE: October 1984

AUTHOR: Balfour, W.D., et. al., Radian Corporation
DOC.TYPE: Report for EPA/ORD
TITLE1: Evaluation of Air Emissions From Hazardous Waste Treatment,
TITLE2: Storage, and Disposal Facilities
DATE: June 1984

AUTHOR: Battye, W., et. al., GCA Corporation
DOC.TYPE: Final Report for EPA/OAQPS
TITLE1: Preliminary Source Assessment for Hazardous Waste Air Emissions
TITLE2: From Treatment, Storage, and Disposal Facilities (TSDFs)
DATE: February 1985

AUTHOR: Breton, M., et. al., GCA Corporation
DOC.TYPE: Draft Final Report for EPA/OSW
TITLE1: Assessment of Air Emissions From Hazardous Waste Treatmt, Storage
TITLE2: and Disposal Facilities-Preliminary National Emissions Estimates
DATE: August 1983

AUTHOR: Engineering Science
DOC.TYPE: Draft Final Report
TITLE1: Supplemental Report on the Technical Assessment of Treatment
TITLE2: Alternatives for Waste Solvents
DATE: September 1984

AUTHOR: Fitzsimons, G., Pacific Environmental Services, Inc.
DOC.TYPE: Memorandum to Project File
TITLE1: Miscellaneous Information Received From EPA/ESED on the
TITLE2: Composition of Wastes Processed at TSDF's
DATE: November 20, 1985

AUTHOR: GCA Corp.
DOC.TYPE: Monthly Progress Report No. 5
TITLE1: Performance Evaluations of Existing Treatment Systems
TITLE2:
DATE: September 1985

AUTHOR: Hargate, A., Liberty Solvents and Chemicals Company
DOC.TYPE: Letter to K.C. Hustvedt/EPA
TITLE1: Corrections to Case Study Prepared by Engineering Science on
TITLE2: Liberty Solvents
DATE: August 30, 1984

AUTHOR: ICF Inc. .
DOC.TYPE: Report for EPA/OSW
TITLE1: The RCRA Risk-Cost Analysis Model Waste Stream Data Base
TITLE2:
DATE: July 9, 1984

AUTHOR: ICF, Inc.
DOC.TYPE: Report for EPA/OSW
TITLE1: The RCRA Risk-Cost Analysis Model - Phase III Report
TITLE2:
DATE: March 1, 1984

AUTHOR: Lloyd, L.L., Engineering Science
DOC.TYPE: Memorandum to Porter, F.L.
TITLE1: Development of a Control Technology Guideline (CTG) Document
TITLE2: for the Waste Solvent Recovery Industry
DATE: January 30, 1981

AUTHOR: Radian Corporation
DOC.TYPE: Data Vol. for Site 6
TITLE1: Evaluation of Air Emissions From Hazardous Waste Treatmt, Storage
TITLE2: and Disposal Facilities in Support of the RCRA Air Emission RIA
DATE: February 21, 1984

AUTHOR: Research Triangle Institute
DOC.TYPE: Report for EPA/IERL
TITLE1: Preliminary Assessment of Hazardous Waste Pretreatment as an
TITLE2: Air Pollution Control Technique
DATE: October 15, 1984

AUTHOR: Rimpo, T., Radian Corporation
DOC.TYPE: Letter to D. Beck, EPA/CPB
TITLE1: Documentation for the Synthetic Organic Chemicals Manufacturing
TITLE2: Industry (SOCMI) Incinerator/Flare Costing Algorithm
DATE: September 9, 1985

AUTHOR: Roeck, D., et. al., GCA Corporation
DOC.TYPE: Draft Final Report for EPA/OSW
TITLE1: Assessment of Wastes Containing Halogenated Organic Compounds
TITLE2: and Current Disposal Practices
DATE: August 1984

AUTHOR: Spivey, J.J., et. al., Research Triangle Institute
DOC.TYPE: Final Report for EPA/IERL/ORD
TITLE1: Preliminary Assessment of Hazardous Waste Pretreatment as an
TITLE2: Air Pollution Control Technique
DATE: October 15, 1984

AUTHOR: Surprenant, N., et. al., GCA Corporation
DOC.TYPE: Draft Final Report for EPA/OSW
TITLE1: Land Disposal Alternatives for Certain Solvents
TITLE2:
DATE: January 1984

AUTHOR: Turner, M., GCA Corp.
DOC.TYPE: Draft Technical Note
TITLE1: Emission Algorithm Development for Pretreatment Operations
TITLE2:
DATE: July, 1985

AUTHOR: Turner, M., GCA Corporation
DOC.TYPE: Memorandum
TITLE1: Review of OSW WET-Model Emission Estimation Methodology for
TITLE2: Pretreatment
DATE: June 24, 1985

AUTHOR: U.S. EPA
DOC.TYPE: Source Assessment
TITLE1: Reclaiming of Waste Solvents, State of the Art
TITLE2: (EPA-600/2-78-004f)
DATE: April 1978

AUTHOR: U.S. EPA
DOC.TYPE: BID
TITLE1: Benzene Fugitive Emissions - Background Information for
TITLE2: Promulgated Standards (EPA-450/3-80-032b)
DATE: June 1984

AUTHOR: U.S. EPA
DOC.TYPE: BID
TITLE1: VOC Fugitive Emissions in Synthetic Organic Chemicals Mfg. Indus.
TITLE2: Background Information for Proposed Standards (EPA-450/3-80-033a)
DATE: November 1980

AUTHOR: U.S. EPA
DOC.TYPE: BID
TITLE1: VOC Fugitive Emissions in Synthetic Organic Chemicals Mfg. Indus.
TITLE2: Background Information for Promulgated Stds. (EPA-450/3-80-033b)
DATE: June 1982

AUTHOR: U.S. EPA
DOC.TYPE: BID
TITLE1: Distillation Operations in Synthetic Organic Chemical Mfg.
TITLE2: Background Information for Proposed Standards (EPA-450/3-83-005a
DATE: December 1983

AUTHOR: U.S. EPA
DOC.TYPE: Federal Register Notice
TITLE1: Equipment Leaks of VOC From SOCMI...; Distillation Unit Operatior
TITLE2: Operations;... and General Provisions (50 FR 14941)
DATE: April 16, 1985

AUTHOR: Wyrick, E.T., Morflex Chemical Company
DOC.TYPE: Letter to K.C. Hustvedt,EPA
TITLE1: Corrections to Case Study Visit Report for Morflex Chemical,
TITLE2: Greensboro, N.C. by Versar Inc.
DATE: June 15, 1984

APPENDIX B

HUMAN EXPOSURE MODEL (HEM) RESULTS FOR WSTF MODEL CASES

MEMORANDUM

SUBJECT: Human Exposure Model Results for Model WSTF Cases

FROM: Graham Fitzsimons, PES

TO: Project File

DATE: November 19, 1985

Attached is the computer printout containing the results of a preliminary risk assessment using the Human Exposure Model (HEM) for each of the model cases developed for waste solvent treatment facilities. A key to the model cases is also attached.

Each model case was run at six locations. On the printout, the corresponding case number for each location can be found at the right end of each line.

The area assumed for fugitive emissions (modeled as an area source) was 5 square meters. The unit risk factor used to calculate maximum risk and incidence was 2.0E-05. To obtain results for a risk factor of 2.0E-07, divide the results on the attached printout by 100.

Attachments

Attachment 1. KEY TO MODEL CASES

Pollutant	Emission Rate[1] lb/h	Uncontrolled Case Nos.	Controlled Case Nos.		
			Condenser	Incinerator	Flare
MEK	7	1	2	NA	3
	32	5	6	NA	10
Toluene	7	1	2	NA	3
1,1,1-Trichloroethane	7	1	2	4	NA
	75	7	8	9	NA

[1]Uncontrolled emission rate from the condenser vent.

WSTF MODEL PLANT RUNS

(5 m²) — *area assumed for fugitives*

10PT

* * * * * * UNIVAC 1100 II EXSHARING EXEC --- MULTI-PROCESSOR SYSTEM --- LEV. $RRS7-60-S4A SITE * F.P.A. * * * * * *

RUNID * 10PT USER ID * OGM PART NUMBER * 12 INPUT DEVICE * F005CR OUTPUT DEVICE * F005PR

FILE NAME * PR*00210PT CREATED AT: 07:41:15 NOV 06,1985 PRINTED AT: 07:44:49 NOV 06,1985

1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890***SEQ.NO.02

SUMMARY FOR [illegible]
MAXIMUM RADIUS = [illegible]

LEVEL	CONCENTRATION	POPULATION	EXPOSURE
1	1.65E+02	1	1.35E+02
2	1.00E+02	209	2.97E+04
3	5.00E+01	684	6.53E+04
4	2.50E+01	1,920	1.07E+05
5	1.00E+01	5,960	1.60E+05
6	5.00E+00	15,600	2.37E+05
7	2.50E+00	47,500	3.42E+05
8	1.00E+00	178,000	5.34E+05
9	5.00E-01	470,000	7.37E+05
10	2.50E-01	1,160,000	9.74E+05
11	1.00E-01	3,490,000	1.31E+06
12	5.00E-02	7,280,000	1.58E+06
13	2.50E-02	15,400,000	1.80E+06
14	1.00E-02	35,300,000	2.18E+06
15	5.00E-03	51,300,000	2.30E+06
16	2.50E-03	70,700,000	2.37E+06
17	1.00E-03	107,000,000	2.42E+06
18	5.00E-04	149,000,000	2.45E+06
19	2.50E-04	171,000,000	2.46E+06
20	1.00E-04	175,000,000	2.46E+06
21	4.95E-05	176,000,000	2.46E+06

Conc × Exposure × risk factor

USING A RISK FACTOR OF 2.00E-05

LEVEL	RISK LEVEL	POPULATION	EXPOSURE
1	3.71E-03	1	2.71E-03
2	2.50E-03	172	5.10E-01
3	1.00E-03	684	1.31E+00
4	5.00E-04	1,920	2.13E+00
5	2.50E-04	4,880	3.08E+00
6	1.00E-04	15,000	4.74E+00
7	5.00E-05	47,500	6.85E+00
8	2.50E-05	127,000	9.53E+00
9	1.00E-05	470,000	1.47E+01
10	5.00E-06	1,160,000	1.95E+01
11	2.50E-06	2,600,000	2.45E+01
12	1.00E-06	7,280,000	3.17E+01
13	5.00E-07	15,400,000	3.73E+01
14	2.50E-07	30,100,000	4.25E+01
15	1.00E-07	51,300,000	4.60E+01
16	5.00E-08	70,700,000	4.74E+01
17	2.50E-08	96,000,000	4.82E+01
18	1.00E-08	149,000,000	4.91E+01
19	5.00E-09	171,000,000	4.93E+01
20	2.50E-09	175,000,000	4.93E+01
21	9.91E-10	176,000,000	4.93E+01

SUMMARY FOR USIF
WITH A UNIT RISK OF 2.[illegible]E-05

[illegible]

59,700 - ULA #

CONC	PEOPLE	EXPOSURE	LIFETIME INCIDENCE	MAX RISK	CONC	PEOPLE	EXPOSURE	ANNUAL INCIDENCE	REPEAT INTERVAL	S O U R C E	
4.14E+01	<1	5.57E-01	1.71E-05	8.29E-04	1.71E-03	91,400	9.25E+02	0.0003	3,800.	CAT000646117	KETTLEMAN CITY,C 1
2.46E+01	<1	2.47E+00	4.94E-05	4.91E-04	9.78E-04	26,000	2.02E+02	0.0001	17,000.	OKD065438376	WAYNOKA,OK 1
2.99E+01	5	1.62E+02	3.24E-03	5.99E-04	5.30E-04	2,500,000	2.59E+04	0.0074	130.	OHD052324548	TWINSBURG,OH 1
3.20E+01	35	1.11E+03	2.22E-02	6.40E-04	4.78E-04	12,700,000	1.54E+05	0.044	23.	NJD002182897	LINDEN,NJ 1
3.31E+01	1	2.41E+01	4.83E-04	6.61E-04	6.89E-04	915,000 902000	[illegible].60E+05	0.0022	460.	NCD071572036	GREENSBORO,NC 1
3.25E+01	<1	1.77E+00	3.54E-05	6.49E-04	4.52E-04	1,330,000	3.52E+04	0.010	99.	ORD009020231	BEAVERTON,OR 1
6.96E+01	<1	1.44E+00	2.88E-05	1.39E-03	4.71E-03	91,400	2.54E+03	0.0007	1,400.	CAT000646117	KETTLEMAN CITY,C 5
6.25E+01	<1	6.29E+00	1.26E-04	1.25E-03	2.69E-03	26,000	5.52E+02	0.0002	6,300.	OKD065438376	WAYNOKA,OK 5
8.05E+01	5	4.36E+02	8.71E-03	1.61E-03	1.40E-03	2,500,000	7.15E+04	0.02	49.	OHD052324548	TWINSBURG,OH 5
8.62E+01	35	2.99E+03	5.98E-02	1.72E-03	1.32E-03	12,700,000	4.23E+05	0.12	8.3	NJD002182897	LINDEN,NJ 5
8.90E+01	1	6.50E+01	1.30E-03	1.78E-03	1.90E-03	915,000	2.11E+04	0.0060	170.	NCD071572036	GREENSBORO,NC 5
8.72E+01	<1	4.75E+00	9.50E-05	1.74E-03	1.24E-03	1,330,000	9.70E+04	0.028	36.	ORD009020231	BEAVERTON,OR 5
1.25E+02	<1	2.58E+00	5.16E-05	2.50E-03	9.86E-03	91,400	5.31E+03	0.0015	660.	CAT000646117	KETTLEMAN CITY,C 7
1.28E+02	<1	1.28E+01	2.57E-04	2.56E-03	5.65E-03	26,000	1.15E+03	0.0003	3,000.	OKD065438376	WAYNOKA,OK 7
1.67E+02	5	9.06E+02	1.81E-02	3.35E-03	3.00E-03	2,500,000	1.50E+05	0.043	23.	OHD052324548	TWINSBURG,OH 7
1.79E+02	35	6.22E+03	1.24E-01	3.59E-03	2.70E-03	12,700,000	8.68E+05	0.25	3.9	NJD002182897	LINDEN,NJ 7
1.85E+02	1	1.35E+02	2.71E-03	3.71E-03	3.98E-03	915,000	4.42E+04	0.013	79.	NCD071572036	GREENSBORO,NC 7
1.81E+02	<1	9.87E+00	1.97E-04	3.63E-03	2.51E-03	1,330,000	2.03E+05	0.058	17.	ORD009020231	BEAVERTON,OR 7
9.01E+00	<1	1.88E-01	3.75E-06	1.80E-04	2.08E-04	91,400	1.44E+02	<0.0001	20,000.	CAT000646117	KETTLEMAN CITY,C 2
4.12E+00	<1	4.14E-01	8.27E-06	8.25E-05	1.52E-04	26,000	3.16E+01	<0.0001	110,000.	OKD065438376	WAYNOKA,OK 2
4.76E+00	5	2.59E+01	5.18E-04	9.53E-05	8.22E-05	2,500,000	4.03E+03	0.0012	870.	OHD052324548	TWINSBURG,OH 2
5.09E+00	35	1.77E+02	3.53E-03	1.02E-04	7.42E-05	12,700,000	2.39E+04	0.0068	150.	NJD002182897	LINDEN,NJ 2
5.25E+00	1	3.84E+00	7.67E-05	1.05E-04	1.07E-04	915,000	1.19E+03	0.0003	2,900.	NCD071572036	GREENSBORO,NC 2
5.17E+00	<1	2.82E-01	5.63E-06	1.03E-04	7.01E-05	1,330,000	5.47E+03	0.0016	640.	ORD009020231	BEAVERTON,OR 2
8.87E+00	<1	1.83E-01	3.67E-06	1.77E-04	2.08E-04	91,400	1.44E+02	<0.0001	24,000.	CAT000646117.	KETTLEMAN CITY,C 3
4.08E+00	<1	4.09E-01	8.17E-06	8.13E-05	1.52E-04	26,000	3.15E+01	<0.0001	110,000.	OKD065438376	WAYNOKA,OK 3
4.75E+00	5	2.57E+01	5.14E-04	9.49E-05	8.22E-05	2,500,000	4.03E+03	0.0012	870.	OHD052324548	TWINSBURG,OH 3
5.06E+00	35	1.76E+02	3.51E-03	1.01E-04	7.42E-05	12,700,000	2.39E+04	0.0068	150.	NJD002182897	LINDEN,NJ 3
5.23E+00	1	3.82E+00	7.64E-05	1.05E-04	1.07E-04	915,000	1.19E+03	0.0003	2,900.	NCD071572036	GREENSBORO,NC 3
5.15E+00	<1	2.80E-01	5.61E-06	1.03E-04	7.01E-05	1,330,000	5.47E+03	0.0016	640.	ORD009020231	BEAVERTON,OR 3
8.64E+00	<1	1.79E-01	3.57E-06	1.73E-04	2.39E-04	91,400	1.29E+02	<0.0001	27,000.	CAT000646117	KETTLEMAN CITY,C 4
3.70E+00	<1	3.71E-01	7.43E-06	7.39E-05	1.37E-04	26,000	2.85E+01	<0.0001	120,000.	OKD065438376	WAYNOKA,OK 4
4.20E+00	5	2.27E+01	4.55E-04	8.40E-05	7.44E-05	2,500,000	3.64E+03	0.0010	960.	OHD052324548	TWINSBURG,OH 4
4.44E+00	35	1.54E+02	3.08E-03	8.87E-05	6.71E-05	12,700,000	2.15E+04	0.0062	160.	NJD002182897	LINDEN,NJ 4
4.59E+00	1	3.35E+00	6.71E-05	9.17E-05	9.69E-05	915,000	1.07E+03	0.0003	3,300.	NCD071572036	GREENSBORO,NC 4
4.54E+00	<1	2.47E-01	4.94E-06	9.07E-05	6.35E-05	1,330,000	4.93E+03	0.0014	710.	ORD009020231	BEAVERTON,OR 4
1.04E+01	<1	2.16E-01	4.31E-06	2.08E-04	4.16E-04	91,400	2.25E+02	0.0001	16,000.	CAT000646117	KETTLEMAN CITY,C 6
6.01E+00	<1	6.04E-01	1.21E-05	1.20E-04	2.30E-04	26,000	4.91E+01	<0.0001	71,000.	OKD065438376	WAYNOKA,OK 6
7.29E+00	5	3.95E+01	7.89E-04	1.46E-04	1.29E-04	2,500,000	6.31E+03	0.0018	550.	OHD052324548	TWINSBURG,OH 6
7.60E+00	35	2.70E+02	5.41E-03	1.55E-04	1.16E-04	12,700,000	3.73E+04	0.011	94.	NJD002182897	LINDEN,NJ 6
8.05E+00	1	5.88E+00	1.18E-04	1.61E-04	1.68E-04	915,000	1.86E+03	0.0005	1,900.	NCD071572036	GREENSBORO,NC 6
7.91E+00	<1	4.31E-01	8.61E-06	1.58E-04	1.10E-04	1,330,000	8.56E+03	0.0024	410.	ORD009020231	BEAVERTON,OR 6
1.28E+01	<1	2.66E-01	5.31E-06	2.57E-04	6.74E-04	91,400	3.63E+02	0.0001	9,600.	CAT000646117	KETTLEMAN CITY,C 8
9.28E+00	<1	9.33E-01	1.87E-05	1.86E-04	3.65E-04	26,000	7.91E+01	<0.0001	44,000.	OKD065438376	WAYNOKA,OK 8
1.16E+01	5	6.30E+01	1.26E-03	2.33E-04	2.09E-04	2,500,000	1.02E+04	0.0029	340.	OHD052324548	TWINSBURG,OH 8

SUMMARY FOR WSTF
WITH A UNIT RISK OF 2.[illegible]E-05

- M A X I M U M -					- - N A T I O N A L - -						
CONC	PEOPLE	EXPOSURE	LIFETIME INCIDENCE	MAX RISK	CONC	PEOPLE	EXPOSURE	ANNUAL INCIDENCE	REPEAT INTERVAL	S O U R C E	
1.25E+01	35	4.32E+02	8.64E-03	2.49E-04	1.88E-04	12,700,000	6.05E+04	0.017	58.	NJD002182897	LINDEN,NJ 8
1.29E+01	1	9.40E+00	1.88E-04	2.57E-04	2.72E-04	915,000	3.02E+03	0.0009	1,200.	NCD071572036	GREENSBORO,NC 8
1.26E+01	<1	6.87E-01	1.37E-05	2.52E-04	1.78E-04	1,330,000	1.39E+04	0.0040	250.	ORD009020231	BEAVERTON,OR 8
9.08E+00	<1	1.88E-01	3.76E-06	1.82E-04	3.99E-04	91,400	2.14E+02	0.0001	16,000.	CAT000646117	KETTLEMAN CITY,C 9
5.03E+00	<1	5.05E-01	1.01E-05	1.01E-04	2.30E-04	26,000	4.62E+01	<0.0001	76,000.	OKD065438376	WAYNOKA,OK 9
6.80E+00	5	3.68E+01	7.36E-04	1.36E-04	1.25E-04	2,500,000	6.11E+03	0.0017	570.	OHD052324548	TWINSBURG,OH 9
7.23E+00	35	2.51E+02	5.02E-03	1.45E-04	1.13E-04	12,700,000	3.61E+04	0.010	97.	NJD002182897	LINDEN,NJ 9
7.49E+00	1	5.47E+00	1.09E-04	1.50E-04	1.63E-04	915,000	1.80E+03	0.0005	1,900.	NCD071572036	GREENSBORO,NC 9
7.34E+00	<1	4.00E-01	7.99E-06	1.47E-04	1.07E-04	1,330,000	8.28E+03	0.0024	420.	ORD009020231	BEAVERTON,OR 9
8.73E+00	<1	1.80E-01	3.61E-06	1.75E-04	2.96E-04	91,400	1.59E+02	<0.0001	22,000.	CAT000646117	KETTLEMAN CITY,C 10
4.03E+00	<1	4.05E-01	8.11E-06	8.07E-05	1.71E-04	26,000	3.46E+01	<0.0001	100,000.	OKD065438376	WAYNOKA,OK 10
4.81E+00	5	2.60E+01	5.21E-04	9.62E-05	9.30E-05	2,500,000	4.53E+03	0.0013	770.	OHD052324548	TWINSBURG,OH 10
5.04E+00	35	1.75E+02	3.49E-03	1.01E-04	8.39E-05	12,700,000	2.67E+04	0.0076	130.	NJD002182897	LINDEN,NJ 10
5.24E+00	1	3.82E+00	7.65E-05	1.05E-04	1.21E-04	915,000	1.34E+03	0.0004	2,600.	NCD071572036	GREENSBORO,NC 10
5.16E+00	<1	2.81E-01	5.61E-06	1.03E-04	7.93E-05	1,330,000	6.13E+03	0.0018	570.	ORD009020231	BEAVERTON,OR 10
						176,090,000	2.46E+06	0.70	1.4	O V E R A L L	

SUMMARY FOR SITE
WITH A UNIT RISK OF 2.00E-05

	M A X I M U M				C U M U L A T I V E							
CONC	PEOPLE	EXPOSURE	LIFETIME INCIDENCE	MAX RISK	CONC	PEOPLE	EXPOSURE	ANNUAL INCIDENCE	REPEAT INTERVAL	S O U R C E		
1.85E+02	1	1.35E+02	2.71E-03	3.71E-03	3.98E-03	915,000	4.42E+04	0.013	79.	NCD071572036	GREENSBORO,NC	7
1.81E+02	<1	9.87E+00	1.97E-04	3.63E-03	2.61E-03	1,330,000	2.03E+05	0.058	17.	ORD009020231	BEAVERTON,OR	7
1.79E+02	35	6.22E+03	1.24E-01	3.59E-03	2.76E-03	12,700,000	8.86E+05	0.25	3.9	NJD002182897	LINDEN,NJ	7
1.67E+02	5	9.06E+02	1.81E-02	3.35E-03	3.00E-03	2,500,000	1.50E+05	0.043	23.	OHD052324548	TWINSBURG,OH	7
1.28E+02	<1	1.28E+01	2.57E-04	2.56E-03	5.65E-03	26,000	1.15E+03	0.0003	3,000.	OKD065438376	WAYNOKA,OK	7
1.25E+02	<1	2.58E+00	5.16E-05	2.50E-03	9.86E-03	91,400	5.31E+03	0.0015	660.	CAT000646117	KETTLEMAN CITY,C	7
8.90E+01	1	6.50E+01	1.30E-03	1.78E-03	1.90E-03	915,000	2.11E+04	0.0060	170.	NCD071572036	GREENSBORO,NC	5
8.72E+01	<1	4.75E+00	9.51E-05	1.74E-03	1.24E-03	1,330,000	9.70E+04	0.028	36.	ORD009020231	BEAVERTON,OR	5
8.62E+01	35	2.99E+03	5.98E-02	1.72E-03	1.32E-03	12,700,000	4.23E+05	0.12	8.3	NJD002182897	LINDEN,NJ	5
8.05E+01	5	4.36E+02	8.71E-03	1.61E-03	1.46E-03	2,500,000	7.15E+04	0.020	49.	OHD052324548	TWINSBURG,OH	5
6.96E+01	<1	1.44E+00	2.88E-05	1.39E-03	4.71E-03	91,400	2.54E+03	0.0007	1,400.	CAT000646117	KETTLEMAN CITY,C	
6.25E+01	<1	6.29E+00	1.26E-04	1.25E-03	2.69E-03	26,000	5.52E+02	0.0002	6,300.	OKD065438376	WAYNOKA,OK	5
4.14E+01	<1	8.57E-01	1.71E-05	8.27E-04	1.71E-03	91,400	9.25E+02	0.0003	3,800.	CAT000646117	KETTLEMAN CITY,C	
3.31E+01	1	2.41E+01	4.83E-04	6.61E-04	6.89E-04	915,000	7.66E+03	0.0022	460.	NCD071572036	GREENSBORO,NC	1
3.25E+01	<1	1.77E+00	3.54E-05	6.49E-04	4.52E-04	1,330,000	3.52E+04	0.010	99.	ORD009020231	BEAVERTON,OR	1
3.20E+01	35	1.11E+03	2.22E-02	6.40E-04	4.78E-04	12,700,000	1.54E+05	0.044	23.	NJD002182897	LINDEN,NJ	1
2.99E+01	5	1.62E+02	3.24E-03	5.99E-04	5.30E-04	2,500,000	2.59E+04	0.0074	130.	OHD052324548	TWINSBURG,OH	1
2.46E+01	<1	2.47E+00	4.94E-05	4.91E-04	9.78E-04	26,000	2.02E+02	0.0001	17,000.	OKD065438376	WAYNOKA,OK	1
1.29E+01	1	9.40E+00	1.88E-04	2.57E-04	2.72E-04	915,000	3.02E+03	0.0009	1,200.	NCD071572036	GREENSBORO,NC	8
1.28E+01	<1	2.66E-01	5.31E-06	2.57E-04	6.74E-04	91,400	3.63E+02	0.0001	9,600.	CAT000646117	KETTLEMAN CITY,C	
1.26E+01	<1	6.87E-01	1.37E-05	2.52E-04	1.78E-04	1,330,000	1.39E+04	0.0040	250.	ORD009020231	BEAVERTON,OR	8
1.25E+01	35	4.32E+02	8.64E-03	2.49E-04	1.86E-04	12,700,000	6.05E+04	0.017	58.	NJD002182897	LINDEN,NJ	8
1.16E+01	5	6.30E+01	1.26E-03	2.33E-04	2.09E-04	2,500,000	1.02E+04	0.0029	340.	OHD052324548	TWINSBURG,OH	8
1.04E+01	<1	2.16E-01	4.31E-06	2.08E-04	4.16E-04	91,400	2.25E+02	0.0001	16,000.	CAT000646117	KETTLEMAN CITY,C	
9.28E+00	<1	9.33E-01	1.87E-05	1.86E-04	3.85E-04	26,000	7.91E+01	<0.0001	44,000.	OKD065438376	WAYNOKA,OK	8
9.08E+00	<1	1.88E-01	3.76E-06	1.82E-04	3.99E-04	91,400	2.14E+02	0.0001	16,000.	CAT000646117	KETTLEMAN CITY,C	
9.01E+00	<1	1.86E-01	3.73E-06	1.80E-04	2.66E-04	91,400	1.44E+02	<0.0001	24,000.	CAT000646117	KETTLEMAN CITY,C	
8.87E+00	<1	1.83E-01	3.67E-06	1.77E-04	2.66E-04	91,400	1.44E+02	<0.0001	24,000.	CAT000646117	KETTLEMAN CITY,C	
8.73E+00	<1	1.80E-01	3.61E-06	1.75E-04	2.96E-04	91,400	1.59E+02	<0.0001	22,000.	CAT000646117	KETTLEMAN CITY,C	
8.64E+00	<1	1.79E-01	3.57E-06	1.73E-04	2.39E-04	91,400	1.29E+02	<0.0001	27,000.	CAT000646117	KETTLEMAN CITY,C	
8.05E+00	1	5.88E+00	1.18E-04	1.61E-04	1.68E-04	915,000	1.86E+03	0.0005	1,900.	NCD071572036	GREENSBORO,NC	6
7.91E+00	<1	4.31E-01	8.61E-06	1.58E-04	1.10E-04	1,330,000	8.50E+03	0.0024	410.	ORD009020231	BEAVERTON,OR	6
7.80E+00	35	2.70E+02	5.41E-03	1.56E-04	1.16E-04	12,700,000	3.73E+04	0.011	94.	NJD002182897	LINDEN,NJ	6
7.49E+00	1	5.47E+00	1.09E-04	1.50E-04	1.63E-04	915,000	1.80E+03	0.0005	1,900.	NCD071572036	GREENSBORO,NC	9
7.34E+00	<1	4.00E-01	7.99E-06	1.47E-04	1.07E-04	1,330,000	8.28E+03	0.0024	420.	ORD009020231	BEAVERTON,OR	9
7.29E+00	5	3.95E+01	7.89E-04	1.46E-04	1.29E-04	2,500,000	6.31E+03	0.0018	550.	OHD052324548	TWINSBURG,OH	6
7.23E+00	35	2.51E+02	5.02E-03	1.45E-04	1.13E-04	12,700,000	3.61E+04	0.010	97.	NJD002182897	LINDEN,NJ	9
6.80E+00	5	3.68E+01	7.35E-04	1.35E-04	1.25E-04	2,500,000	6.11E+03	0.0017	570.	OHD052324548	TWINSBURG,OH	9
6.01E+00	<1	6.04E-01	1.21E-05	1.20E-04	2.38E-04	26,000	4.91E+01	<0.0001	71,000.	OKD065438376	WAYNOKA,OK	6
5.25E+00	1	3.84E+00	7.67E-05	1.05E-04	1.07E-04	915,000	1.19E+03	0.0003	2,900.	NCD071572036	GREENSBORO,NC	2
5.24E+00	1	3.82E+00	7.65E-05	1.05E-04	1.21E-04	915,000	1.34E+03	0.0004	2,600.	NCD071572036	GREENSBORO,NC	10
5.23E+00	1	3.82E+00	7.64E-05	1.05E-04	1.07E-04	915,000	1.19E+03	0.0003	2,900.	NCD071572036	GREENSBORO,NC	3
5.17E+00	<1	2.82E-01	5.63E-06	1.03E-04	7.01E-05	1,330,000	5.47E+03	0.0016	640.	ORD009020231	BEAVERTON,OR	2
5.16E+00	<1	2.81E-01	5.61E-06	1.03E-04	7.93E-05	1,330,000	6.13E+03	0.0018	570.	ORD009020231	BEAVERTON,OR	10
5.15E+00	<1	2.80E-01	5.61E-06	1.03E-04	7.01E-05	1,330,000	5.47E+03	0.0016	640.	ORD009020231	BEAVERTON,OR	3

SUMMARY FOR WSTF
WITH A UNIT RISK OF 2.00E-05

- - M A X I M U M - -					- - T O T A L U S E - -						
CONC	PEOPLE	EXPOSURE	EFFECTIVE INCIDENCE	MAX RISK	CONC	PEOPLE	EXPOSURE	ANNUAL INCIDENCE	REPEAT INTERVAL	S O U R C E	
5.09E+00	35	1.77E+02	3.55E-03	1.12E-04	7.42E-05	12,700,000	2.39E+04	0.0068	150.	NJD002182897	LINDEN,NJ 2
5.09E+00	35	1.76E+02	3.51E-03	1.01E-04	7.42E-05	12,700,000	2.39E+04	0.0068	150.	NJD002182897	LINDEN,NJ 3
5.04E+00	35	1.75E+02	3.49E-03	1.01E-04	8.39E-05	12,700,000	2.67E+04	0.0076	130.	NJD002182897	LINDEN,NJ 10
5.03E+00	<1	5.35E-01	1.01E-05	1.01E-04	2.30E-04	26,000	4.62E+01	<0.0001	70,000.	OKD065438376	WAYNOKA,OK 9
4.81E+00	5	2.60E+01	5.21E-04	9.62E-05	9.30E-05	2,500,000	4.53E+03	0.0013	770.	OHD052324548	TWINSBURG,OH 10
4.76E+00	5	2.58E+01	5.16E-04	9.55E-05	8.22E-05	2,500,000	4.03E+03	0.0012	870.	OHD052324548	TWINSBURG,OH 2
4.75E+00	5	2.57E+01	5.14E-04	9.49E-05	8.22E-05	2,500,000	4.03E+03	0.0012	870.	OHD052324548	TWINSBURG,OH 3
4.59E+00	1	3.35E+00	6.71E-05	9.17E-05	9.69E-05	915,000	1.07E+03	0.0003	3,300.	NCD071572036	GREENSBORO,NC 4
4.54E+00	<1	2.47E-01	4.94E-06	9.07E-05	6.35E-05	1,330,000	4.93E+03	0.0014	710.	ORD009020231	BEAVERTON,OR 4
4.44E+00	35	1.54E+02	3.09E-03	8.87E-05	6.71E-05	12,700,000	2.15E+04	0.0062	160.	NJD002182897	LINDEN,NJ 4
4.20E+00	5	2.27E+01	4.55E-04	8.40E-05	7.14E-05	2,500,000	3.64E+03	0.0010	960.	OHD052324548	TWINSBURG,OH 4
4.12E+00	<1	4.14E-01	8.27E-06	8.23E-05	1.52E-04	26,000	3.16E+01	<0.0001	110,000.	OKD065438376	WAYNOKA,OK 2
4.06E+00	<1	4.09E-01	8.17E-06	8.13E-05	1.52E-04	26,000	3.15E+01	<0.0001	110,000.	OKD065438376	WAYNOKA,OK 3
4.03E+00	<1	4.05E-01	8.11E-06	8.07E-05	1.71E-04	26,000	3.46E+01	<0.0001	100,000.	OKD065438376	WAYNOKA,OK 10
3.70E+00	<1	3.71E-01	7.43E-06	7.39E-05	1.37E-04	26,000	2.83E+01	<0.0001	120,000.	OKD065438376	WAYNOKA,OK 4
						170,000,000	2.46E+06	0.70	1.4	O V E R A L L	

SUMMARY FOR [illegible]
WITH A UNIT RISK OF 2.00E-05

CONC	PEOPLE	EXPOSURE	LIFETIME INCIDENCE	MAX RISK	CONC	PEOPLE	EXPOSURE	ANNUAL INCIDENCE	REPEAT INTERVAL	SOURCE
1.79E+02	35	6.22E+03	1.24E-01	3.59E-03	2.76E-03	12,700,000	8.80E+05	0.25	3.9	NJD002182897 LINDEN,NJ 7
8.62E+01	35	2.99E+03	5.98E-02	1.72E-03	1.32E-03	12,700,000	4.23E+05	0.12	8.3	NJD002182897 LINDEN,NJ 5
1.81E+02	<1	9.87E+00	1.97E-04	3.65E-03	2.01E-03	1,330,000	2.03E+05	0.058	17.	ORD009020231 BEAVERTON,OR 7
3.20E+01	35	1.11E+03	2.22E-02	6.41E-04	4.78E-04	12,700,000	1.54E+05	0.044	23.	NJD002182897 LINDEN,NJ 1
1.67E+02	5	9.06E+02	1.81E-02	3.35E-03	3.06E-03	2,500,000	1.50E+05	0.043	23.	OHD052324548 TWINSBURG,OH 7
8.72E+01	<1	4.75E+00	9.50E-05	1.74E-03	1.29E-03	1,330,000	9.70E+04	0.028	36.	ORD009020231 BEAVERTON,OR 5
8.05E+01	5	4.36E+02	8.71E-03	1.61E-03	1.46E-03	2,500,000	7.15E+04	0.020	49.	OHD052324548 TWINSBURG,OH 5
1.25E+01	35	4.32E+02	8.64E-03	2.49E-04	1.88E-04	12,700,000	6.05E+04	0.017	58.	NJD002182897 LINDEN,NJ 8
1.85E+02	1	1.35E+02	2.71E-03	3.71E-03	3.98E-03	915,000	4.42E+04	0.013	79.	NCD071572036 GREENSBORO,NC 7
7.80E+00	35	2.70E+02	5.41E-03	1.56E-04	1.16E-04	12,700,000	3.73E+04	0.011	94.	NJD002182897 LINDEN,NJ 6
7.23E+00	35	2.51E+02	5.02E-03	1.45E-04	1.13E-04	12,700,000	3.61E+04	0.010	97.	NJD002182897 LINDEN,NJ 9
3.25E+01	<1	1.77E+00	3.54E-05	6.49E-04	4.52E-04	1,330,000	3.52E+04	0.010	99.	ORD009020231 BEAVERTON,OR 1
5.04E+00	35	1.75E+02	3.49E-03	1.01E-04	8.39E-05	12,700,000	2.67E+04	0.0076	130.	NJD002182897 LINDEN,NJ 10
2.99E+01	5	1.62E+02	3.24E-03	5.99E-04	5.30E-04	2,500,000	2.59E+04	0.0074	130.	OHD052324548 TWINSBURG,OH 1
5.09E+00	35	1.77E+02	3.55E-03	1.02E-04	7.12E-05	12,700,000	2.39E+04	0.0068	150.	NJD002182897 LINDEN,NJ 2
5.06E+00	35	1.76E+02	3.51E-03	1.01E-04	7.42E-05	12,700,000	2.39E+04	0.0068	150.	NJD002182897 LINDEN,NJ 3
4.44E+00	35	1.54E+02	3.08E-03	8.87E-05	6.71E-05	12,700,000	2.15E+04	0.0062	160.	NJD002182897 LINDEN,NJ 4
8.90E+01	1	6.57E+01	1.31E-03	1.78E-03	1.70E-03	915,000	2.11E+04	0.0060	170.	NCD071572036 GREENSBORO,NC 5
1.26E+01	<1	6.87E-01	1.37E-05	2.52E-04	1.78E-04	1,330,000	1.39E+04	0.0040	250.	ORD009020231 BEAVERTON,OR 8
1.16E+01	5	6.30E+01	1.26E-03	2.33E-04	2.09E-04	2,500,000	1.02E+04	0.0029	340.	OHD052324548 TWINSBURG,OH 8
7.91E+00	<1	4.31E-01	8.61E-06	1.58E-04	1.10E-04	1,330,000	8.56E+03	0.0024	410.	ORD009020231 BEAVERTON,OR 6
7.34E+00	<1	4.00E-01	7.99E-06	1.47E-04	1.07E-04	1,330,000	8.28E+03	0.0024	420.	ORD009020231 BEAVERTON,OR 9
3.31E+01	1	2.41E+01	4.83E-04	6.61E-04	6.89E-04	915,000	7.66E+03	0.0022	460.	NCD071572036 GREENSBORO,NC 1
7.29E+00	5	3.95E+01	7.89E-04	1.46E-04	1.29E-04	2,500,000	6.31E+03	0.0018	550.	OHD052324548 TWINSBURG,OH 6
5.16E+00	<1	2.81E-01	5.61E-06	1.03E-04	7.93E-05	1,330,000	6.13E+03	0.0018	570.	ORD009020231 BEAVERTON,OR 10
6.80E+00	5	3.68E+01	7.36E-04	1.36E-04	1.25E-04	2,500,000	6.11E+03	0.0017	570.	OHD052324548 TWINSBURG,OH 9
5.17E+00	<1	2.82E-01	5.63E-06	1.03E-04	7.01E-05	1,330,000	5.47E+03	0.0016	640.	ORD009020231 BEAVERTON,OR 2
5.15E+00	<1	2.80E-01	5.61E-06	1.03E-04	7.01E-05	1,330,000	5.47E+03	0.0016	640.	ORD009020231 BEAVERTON,OR 3
1.25E+02	<1	2.58E+00	5.16E-05	2.50E-03	9.86E-03	91,400	5.31E+03	0.0015	660.	CAT000646117 KETTLEMAN CITY,C
4.54E+00	<1	2.47E-01	4.94E-06	9.07E-05	6.35E-05	1,330,000	4.93E+03	0.0014	710.	ORD009020231 BEAVERTON,OR 4
4.81E+00	5	2.60E+01	5.21E-04	9.62E-05	9.30E-05	2,500,000	4.53E+03	0.0013	770.	OHD052324548 TWINSBURG,OH 10
4.76E+00	5	2.58E+01	5.16E-04	9.53E-05	8.22E-05	2,500,000	4.03E+03	0.0012	870.	OHD052324548 TWINSBURG,OH 2
4.75E+00	5	2.57E+01	5.14E-04	9.49E-05	8.22E-05	2,500,000	4.03E+03	0.0012	870.	OHD052324548 TWINSBURG,OH 3
4.20E+00	5	2.27E+01	4.55E-04	8.40E-05	7.44E-05	2,500,000	3.64E+03	0.0010	960.	OHD052324548 TWINSBURG,OH 4
1.29E+01	1	9.40E+00	1.88E-04	2.57E-04	2.72E-04	915,000	3.02E+03	0.0009	1,200.	NCD071572036 GREENSBORO,NC 8
6.96E+01	<1	1.44E+00	2.88E-05	1.39E-03	4.71E-03	91,400	2.54E+03	0.0007	1,400.	CAT000646117 KETTLEMAN CITY,C
8.05E+00	1	5.88E+00	1.18E-04	1.61E-04	1.68E-04	915,000	1.86E+03	0.0005	1,900.	NCD071572036 GREENSBORO,NC 6
7.49E+00	1	5.47E+00	1.09E-04	1.50E-04	1.63E-04	915,000	1.80E+03	0.0005	1,900.	NCD071572036 GREENSBORO,NC 9
5.24E+00	1	3.82E+00	7.65E-05	1.05E-04	1.21E-04	915,000	1.34E+03	0.0004	2,600.	NCD071572036 GREENSBORO,NC 10
5.25E+00	1	3.84E+00	7.67E-05	1.05E-04	1.07E-04	915,000	1.19E+03	0.0003	2,900.	NCD071572036 GREENSBORO,NC 2
5.23E+00	1	3.82E+00	7.64E-05	1.05E-04	1.07E-04	915,000	1.19E+03	0.0003	2,900.	NCD071572036 GREENSBORO,NC 3
1.28E+02	<1	1.28E+01	2.57E-04	2.56E-03	5.65E-03	26,000	1.15E+03	0.0003	3,000.	OKD065438376 WAYNOKA,OK 7
4.59E+00	1	3.35E+00	6.71E-05	9.18E-05	9.69E-05	915,000	1.07E+03	0.0003	3,300.	NCD071572036 GREENSBORO,NC 4
4.14E+01	<1	8.57E-01	1.71E-05	8.29E-04	1.71E-03	91,400	9.25E+02	0.0003	3,800.	CAT000646117 KETTLEMAN CITY,C
6.25E+01	<1	6.29E+00	1.26E-04	1.25E-03	2.69E-03	26,000	5.52E+02	0.0002	5,300.	OKD065438376 WAYNOKA,OK 5

SUMMARY FOR [illegible]SIF
WITH A UNIT RISK OF 2.[illegible]E-05

-- M A X I M U M --					-- I N C I D E N C E --						
CONC	PEOPLE	EXPOSURE	LIFETIME INCIDENCE	MAX RISK	CONC	PEOPLE	EXPOSURE	ANNUAL INCIDENCE	REPEAT INTERVAL	S O U R C E	
1.28E+01	<1	2.60E-01	5.31E-06	2.57E-04	5.74E-04	91,400	3.63E+02	0.0001	9,600.	CAT000646117	KETTLEMAN CITY,C
1.04E+01	<1	2.10E-01	4.31E-06	2.08E-04	4.16E-04	91,400	2.25E+02	0.0001	15,000.	CAT000646117	KETTLEMAN CITY,C
9.08E+00	<1	1.88E-01	3.76E-06	1.82E-04	3.99E-04	91,400	2.14E+02	0.0001	16,000.	CAT000646117	KETTLEMAN CITY,C
2.46E+01	<1	2.47E+00	4.94E-05	4.91E-04	9.78E-04	20,000	2.92E+02	0.0001	17,000.	OKD065438376	WAYNOKA,OK 1
8.73E+00	<1	1.80E-01	3.61E-06	1.75E-04	2.96E-04	91,400	1.59E+02	<0.0001	22,000.	CAT000646117	KETTLEMAN CITY,C
9.01E+00	<1	1.86E-01	3.73E-06	1.80E-04	2.66E-04	91,400	1.44E+02	<0.0001	24,000.	CAT000646117	KETTLEMAN CITY,C
8.87E+00	<1	1.83E-01	3.67E-06	1.77E-04	2.66E-04	91,400	1.44E+02	<0.0001	24,000.	CAT000646117	KETTLEMAN CITY,C
8.64E+00	<1	1.79E-01	3.57E-06	1.73E-04	2.39E-04	91,400	1.29E+02	<0.0001	27,000.	CAT000646117	KETTLEMAN CITY,C
9.28E+00	<1	9.33E-01	1.87E-05	1.86E-04	3.65E-04	20,000	7.91E+01	<0.0001	44,000.	OKD065438376	WAYNOKA,OK 8
6.01E+00	<1	6.04E-01	1.21E-05	1.20E-04	2.38E-04	20,000	4.91E+01	<0.0001	71,000.	OKD065438376	WAYNOKA,OK 6
5.03E+00	<1	5.05E-01	1.01E-05	1.01E-04	2.30E-04	20,000	4.62E+01	<0.0001	76,000.	OKD065438376	WAYNOKA,OK 9
4.03E+00	<1	4.05E-01	8.11E-06	8.07E-05	1.71E-04	20,000	3.40E+01	<0.0001	100,000.	OKD065438376	WAYNOKA,OK 10
4.12E+00	<1	4.14E-01	8.27E-06	8.23E-05	1.52E-04	20,000	3.16E+01	<0.0001	110,000.	OKD065438376	WAYNOKA,OK 2
4.06E+00	<1	4.09E-01	8.17E-06	8.13E-05	1.52E-04	20,000	3.15E+01	<0.0001	110,000.	OKD065438376	WAYNOKA,OK 3
3.70E+00	<1	3.71E-01	7.43E-06	7.39E-05	1.37E-04	20,000	2.83E+01	<0.0001	120,000.	OKD065438376	WAYNOKA,OK 4
						170,000,000	2.46E+06	0.70	1.4	O V E R A L L	

APPENDIX C

ADDITIONAL DOCUMENTATION

MEMORANDUM

TO: File, PES Project No. 758 Date: November 18, 1985

FROM: Jan Meyer, Pacific Environmental Services, Inc.

SUBJECT: Recovery Factor Estimate

This memorandum documents the method used to estimate the solvent recovery factor. This factor is a conversion factor that relates the volume of waste solvent entering a waste solvent treatment facility to the volume of recovered solvent exiting the facility. Estimation of a recovery factor enables determination of the number of model plants that would be needed to handle the nationwide volume of waste solvent requiring treatment. The number of model plants is then used to estimate nationwide emissions of VOC and costs to control these emissions.

A. Recovery Factor Definition

The recovery factor is defined as the volume of VOC recovered by a facility per volume of waste solvent entering the facility, and is a function of two parameters: (1) the VOC composition of the waste stream, and (2) the VOC distillation efficiency of which the facility is capable. This relationship can be represented as follows:

$$\frac{Vol_{voc\ out}}{Vol_{waste\ in}} = \left(\frac{Vol_{voc\ in}}{Vol_{waste\ in}}\right)\left(\frac{Vol_{voc\ out}}{Vol_{voc\ in}}\right)$$

where:

$$\text{recovery factor} = \frac{Vol_{voc\ out}}{Vol_{waste\ in}},$$

$$\text{waste stream VOC composition} = \frac{Vol_{voc\ in}}{Vol_{waste\ in}}, \text{ and}$$

$$\text{distillation efficiency} = \frac{Vol_{voc\ out}}{Vol_{voc\ in}}.$$

B. Recovery Factor Determination

1. Waste Stream VOC Composition

Attachment 1 is a summary of available information on the major solvent wastes composition. From Attachment 1, the volume weighted average composition of F001-F005 wastes appears to be about 60 percent VOC. Barring receipt of information that shows the basis of these numbers to be faulty, this estimate appears to be the best that can be developed given the limited information and time available.

2. Distillation Efficiency

Attachment 2 presents a summary of information on distillation efficiencies reported in the provided literature sources. Several of the case study reports suggest that efficiencies of 80 to 90 percent are typical of concentrated streams while efficiencies of 50 to 70 percent are expected of dilute or sludgy streams. The data summarized in Attachment 2, however, do not support this generalization. The available data suggest that, regardless of VOC composition, distillation efficiencies can range up to 99 or 100 percent. The average and median efficiencies attained are 85 and 90 percent, respectively. Although the data are believed to be rather uncertain, the best estimate of typical distillation efficiency is 85 to 90 percent.

C. Conclusion

To estimate volume of VOC recoverable per volume of waste solvent entering the facility, the volume weighted average VOC composition of the waste is multiplied by the distillation efficiency. At the median distillation efficiency, the recovery factor is approximately 55 percent.

$$\left(\frac{0.6\ VOC_{in}}{waste_{in}}\right) x \left(\frac{0.90\ VOC_{out}}{VOC_{in}}\right) = 0.55$$

Attachment 1

WASTE STREAM VOC COMPOSITION

Waste Code	Amt. Land Disposed 10^6 Gallons[a]	Avg. VOC Content, %[b]	Total Amount VOC Land Disposed 10^6 Gallons
F001	<4.5	31	<1.4
F002	16.1	63	10.14
F003	77.67	81	62.91
F004	<4.5	100	<4.5
F005	460.05	55	253.05
Total	562.82		331.98
Vol. Wted. Avg.		vol. wted. average = 59% round to 60% (arith. avg. = 66%)	

[a]Source: OSW Summary of March 7, 1985, Top 30 Waste Streams in Land Disposal (Excluding Injection Wells), by volume.

[b]Source: GCA-TR-83-94-G, p. 31.

Note: There are several references with different volume estimates for these categories of wastes.

Frequency Distribution of VOC Concentration

Range	Amount		Frequency
<30% VOC	<4.5	4.5	0.8%
<65% VOC	476.15	480.7	85%
<85% VOC	77.67	558.3	99.2
<100% VOC	<4.5	562.8	100

Avg. 60%

Attachment 2

Summary of Recovery Efficiency Information

Facility (References)	Feed Composition, % (A)	Distillation Efficiency, % (B)	Recovery Factor, % (A X B)
Plant A: Thin Film Evap. (RTI-Field Study)	100	85 typical	85
Romic (Thin Film Evap.) (RTI-Field Study)	100	80	80
IT Corp.: Steam Stripper (RTI-Field Study)	≤10	90	9
IT Corp.: Air Stripper (RTI-Field Study)	≤3	N.A. (to atmos.)	0
AER, Inc: Steam Stripping (RTI-Field Study)	N.A.	50 to 70	-
Environ. Recycling: (Thin Film Evap.) (RTI-Field Study)	83		
Oil & Solvent Recycling: (Thin Film Evap.) (RTI-Field Study)	N.A.	80-85	80
Morflex: Dist. Col. (Versar Report incomplete)	95	N.A.	<90
Plant D: Steam Stripping (RTI-Field Studies Report)	18	43	8
	74	100	74
	26	92.5	25
	3	100	3
Plant D: Dist. Col. (RTI-Field Studies Report)	5	99	5
	23	99	23
Radian Test-Site (Thin-Film Evap)	85 (MEK)	92	78
Average		Avg. = 85% overall	
<50% VOC			12% to 15%[b]
>50% VOC			79% to 80%[b]

[a] = midpoint of VOC range x .85

[b]Average of recoveries observed for range. >50% biased by the majority cases with 100% VOC feed streams.

MEMORANDUM

November 27, 1985

SUBJECT: Summary of Information on the Number and Treatment Capacities of Waste Solvent Treatment Facilities (WSTF's)

FROM: Jan Meyer, PES
David Cole, PES

TO: Project 758 File

- -

Information on treatment capacities and number of WSTF's presented in the references provided by EPA is summarized in Table 1. The only information on the distribution of treatment capacities was presented in Reference 1 and the distribution is presented in Table 2.

Table 1. ESTIMATES OF NUMBER AND TYPICAL CAPACITIES OF WSTF'S

Source	Number of WSTF's	Typical Capacity,[a] Gg/yr	Comments
Engineering Science, September 1984(1)	61	4	Estimate projected from survey of National Association of Solvent Recyclers
	4,000	N.A.	Monsanto Research Survey of 1978
GCA, February 1985 Contract No. 68-01-6871(2)	392	5.5	Number of facilities reported to be from 1984 Westat survey
OSW Summary of TSDF information(3)	177	N.A.	Excludes TSDF's incinerating waste solvent streams

[a]Calculated from information presented in each report assuming an average solvent density of 7 lb/gal.

N.A. - Not applicable.

Table 2. CUMULATIVE FREQUENCY DISTRIBUTION OF WASTE SOLVENT RECOVERY CAPACITIES (Source: Reference 1)

Capacity Range (1,000 gallons of solvent per year)	Proportion in Internal (n)	Proportion in Internal (%)	Capacity (1,000 gallons of solvent per year)	Cumulative Frequency (n)	Cumulative Frequency (%)
0 - 499	10	34.5	<500	10	34.5
500 - 999	3	10.3	<1000	13	44.8
1000 - 1499	3	10.3	<1500	16	55.2
1500 - 1999	4	13.8	<2000	20	69.0
2000 - 2499	0	0.0	<2500	20	69.0
2500 - 2999	2	6.9	<3000	22	75.9
3000 - 3499	1	3.4	<3500	23	79.3
3500 - 3999	5	17.2	<4000	28	96.6
4000 - 4499	0	0.0	<4500	28	96.6
4500 - 4999	0	0.0	<5000	28	96.6
5000 - 5499	0	0.0	<5500	28	96.6
5500 - 5999	1	3.4	<6000	29	100.0
Total	29	100	--	29	100.0

References

1. Engineering Science. Supplemental Report on the Technical Assessment of Treatment Alternatives for Waste Solvents. Prepared for U.S. Environmental Protection Agency, Washington, D.C. September 1984. pp. 4-74 to 4-82.

2. Battye, W., C. Vought, D. Zimmerman, M. Clowers, and E. Ryan (GCA Corporation). Preliminary Source Assessment for Hazardous Waste Air Emissions from Treatment, Storage, and Disposal Facilities (TSDF's). Prepared for U.S. Environmental Protection Agency, Research Triangle Park, N.C. February 1985.

3. Memorandum from G. Fitzsimons (PES) to Project File. November 20, 1985. Miscellaneous Information on the Composition of Wastes Processed at WSTF's.

M E M O R A N D U M

November 25, 1985

SUBJECT: Estimate of Proportion of Waste Solvent Streams Containing Halogenated Solvents

FROM: Jan Meyer, PES

TO: Project #758 File

- -

I. Purpose

This memorandum presents the basis for the assumption that 20 percent of waste solvent treatment facilities (WSTF's) process halogenated solvent wastes and that 80 percent process nonhalogenated solvent wastes.

II. Discussion

The assumption that 20 percent of the facilities treating halogenated solvent wastes was derived from the information presented in Attachment 1.* The fraction of facilities treating halogenated waste solvents was calculated:

$$fraction_{hal.} = \frac{\text{No. of facilities treating halogenated waste solvents}}{\text{Total number of facilities treating waste solvents}}$$

$$fraction_{hal.} = \frac{68}{312}$$

$$= 0.21$$

Among the treatment categories presented in the table, the fraction halogenated ranged from 0.24 to 0.13.

Several assumptions were made in use of this factor to estimate the upper bound control costs. These assumptions were: (1) the population of TSDF's surveyed included WSTF's, and (2) the distribution of treatment capacities of WSTF's treating halogenated waste solvents does not differ significantly from that of WSTF's treating nonhalogenated waste solvents. If these assumptions are invalid, it

---

*This information source was used in lieu of derivation of an estimate from estimates of volume of halogenated and nonhalogenated waste solvent due to significant differences between the estimates presented in the various studies provided (see draft Technical Note for list of references) and the estimates of organic liquid waste being used in this study (429×10^6 gallons and 11.1×10^6 gallons).

is believed that the upper bound cost estimates at worst will slightly underrepresent the actual upper limit of control costs.

Attachment 1

NOV 20 1985

MEMORANDUM

SUBJECT: Miscellaneous Information on the Composition of Wastes Processed at TSDF's

FROM: Graham Fitzsimons, PES

TO: Project File

Attached is miscellaneous information on the composition of wastes processed by hazardous waste treatment, storage, and disposal facilities (TSDF's). This information was provided to PES by the Chemical and Petroleum Branch of EPA/ESED for use in estimating nationwide emissions from waste solvent treatment facilities (WSTF's).

Attachments

Attachment 1

DRAFT

APR 19 [illegible]
LER

Number of Facilities Managing Solvent Wastes
Based on the RIA National Survey of TSD's

Response to Question:	total	halogenated sbtl	halogenated F001,2	halogenated U&P	nonhalogenated sbtl	nonhalogenated F004,5	nonhalogenated F003	nonhalogenated U&P	nonhalogenated D001
total quantity managed	1886	634	495	139	1252	208	224	283	537
total quantity disposed	79	20	13	7	59	5	7	17	30
by landfilling	45	12	8	4	33	4	4	8	17
by deep well injection	17	5	2	3	12	0	2	6	4
by land treatment	6	0	0	0	6	0	0	1	5
in a surface impoundment	8	2	2	0	6	0	1	2	3
by "other" means	3	1	1	0	2	1	0	0	1
total quantity treated	380	68	44	24	312	39	47	91	135
in tanks	69	13	10	3	56	8	8	10	30
in surface impoundments	38	10	8	2	28	5	4	11	8
by incineration	203	28	16	12	175	21	25	63	66
by "other" means	62	8	6	2	54	5	10	7	32
total quantity stored	1556	547	426	121	1009	169	179	235	426
in tanks	231	55	42	13	176	22	28	37	89
in containers	1157	426	337	89	731	117	127	175	312
in surface impoundments	27	11	9	2	16	4	4	2	6
in waste piles	7	0	0	0	7	0	1	0	6
by "other" means	185	55	43	12	130	29	27	24	50

note - see attached lists of "U" and "P" halogenated and nonhalogenated solvents;
sbtl. refers to subtotals for halogenated and for nonhalogenated solvents;
F001,2 refers to total of F001 & F002; F004,5 refers to total of F004 & F005;
D001 has been assumed to be ignitable due to the presence of nonhalogenated solvents and is assumed to not contain halogenated solvents

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-450/3-86-009	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE RCRA TSDF Air Emissions--Background Technical Memoranda for Proposed Standards		5. REPORT DATE October 1986
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Air Quality Planning and Standards, Environmental Protection Agency, Research Triangle Park, North Carolina 27711		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO. 68-02-4326
12. SPONSORING AGENCY NAME AND ADDRESS DAA for Air Quality Planning and Standards, Office of Air, Noise, and Radiation, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711		13. TYPE OF REPORT AND PERIOD COVERED Draft
		14. SPONSORING AGENCY CODE EPA/200/04
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

Standards for the control of volatile organic (VO) air emissions from hazardous waste treatment, storage, and disposal facilities (TSDF) and waste solvent treatment facilities (WSTF) are being proposed under the authority of Section 3004(n) of the 1976 Resource Conservation and Recovery Act (RCRA). These standards would apply to certain process vents associated with distillation and stripping equipment at WSTF (and at TSDF, if applicable) and to fugitive emissions from equipment leaks at TSDF where the waste stream (or its derivatives) contain 10 percent or more total organics. This document contains a technical note and background memoranda considered in developing the proposed standards.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air pollution; Benzene; Carcinogenic; Equipment leaks; Hazardous waste; National emission standards for hazardous air pollutants; Process vents; Recycling; Treatment, storage, and disposal facilities; Volatile organics; Waste solvent treatment facilities	Air pollution control	13 B

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 124
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE